DIAGNOSTIC IMAGING OVERVIEW

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Introduction

- Diagnostic Imaging is the study of healthy and diseased organs and tissues by imaging. The interventional branch provides treatment to certain disease processes.
- The information acquired makes it a primary tool in clinical medicine at primary, secondary and tertiary care.
- The images are an extension of patient examination
- The practicing physician must know from physical examination when to opt for an imaging Test, which imaging modality to order and its contribution to patient management.

Introduction cont..

Indeed every speciality of medicine utilizes imaging at one point or other to

- help establish a diagnosis
- assess disease extend
- and more often than not, provide information on prognosis especi ally in cases of malignancies and their spread to other areas.

Introduction cont.

As a student in your clinical years of study you should be able to answer the following questions in every given clinical case.

- Does the patient require an imaging examination?
- If so which imaging modality will be most suitable and cost effective.
- What is the selected imaging modality likely to confirm or exclude

Introduction cont..

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Imaging in medicine

- Imaging joined the practice of medicine with th e discovery of X-rays by Roentgen in 1895

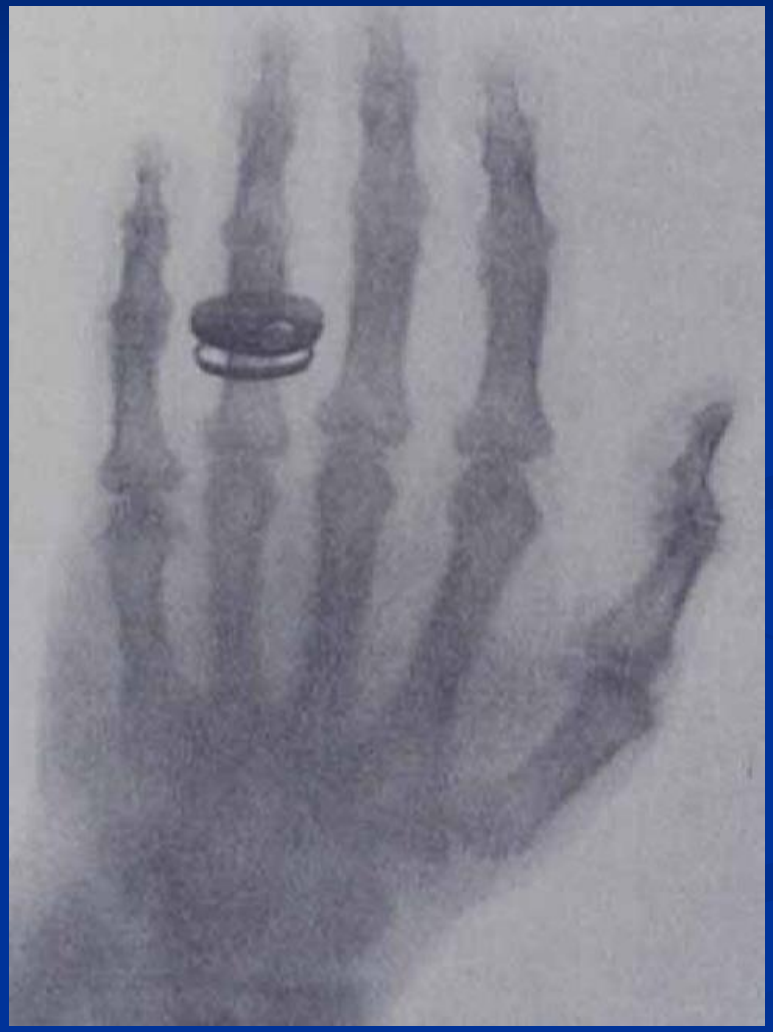
Wilhelm Conrad Roentgen 1845-1923

- discovered X-rays November 8, 1895

Won Nobel Prize in 1901

Jan. 13, 1896 – Images needle in patient's hand – X-ray used presurgicaly

The first radiograph January 1896



Radiograph of the han
of Roeontgen's wife

January 1896 - First x-ray made in public

Comparison of initial 1896 radiograph and cur rent

January 1896 - First x-ray made in public

Routine x-ray current technology

It is from this early beginnings that imaging has grown such that it now plays two major roles in Diagnostic and Interventional imaging procedures

Imaging Equipment

Imaging equipment use electromagnetic radiation or sound waves.

- Electromagnetic Radiation
  - X-ray & Computed Tomography (CT)
  - Magnetic Resonance Imaging (MRI)-radio-waves
  - Nuclear Scintigraphy (Nuclear Medicine)
- Sound Waves (not radiation)
  - Ultrasound

Imaging Modalities.

- **Conventional modalities**

  1 Plain X-rays --conventional and Digital

  2 Contrast studies

- **Newer cross sectional Modalities**

  1 Computerised tomography(CT)

  2 Ultrasound

  3 Magnetic resonance imaging(MRI)

- **Radionuclide Imaging**

1 SPECT and PET

Modalities that use Xrays

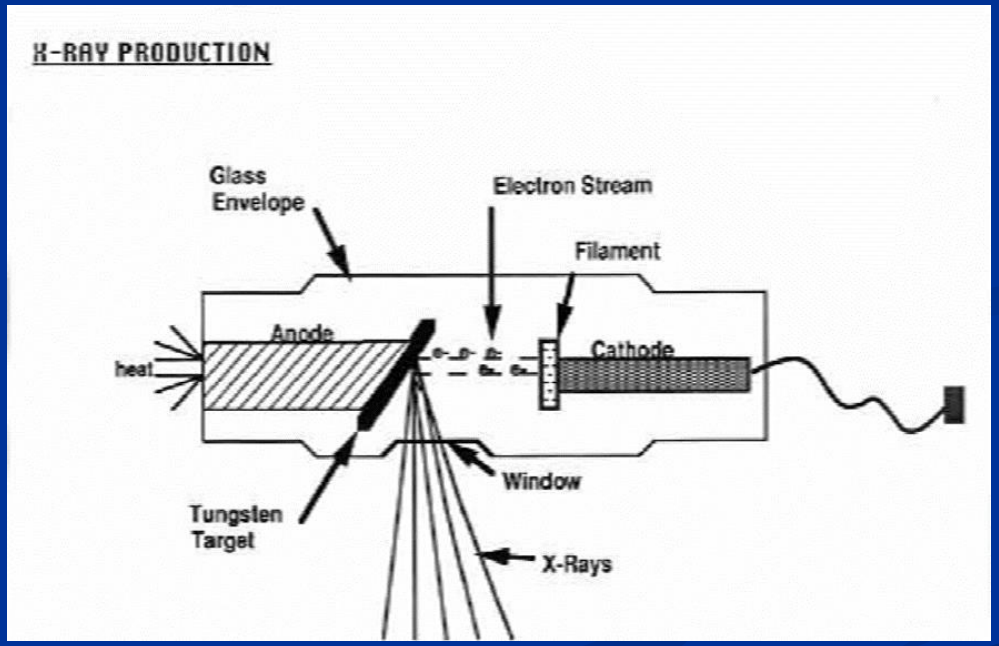
Plain Radiography
- X RAY PRODUCTION
- inherent contrast
- film
- digital

Contrast Radiography
barium
iodine

Fluoroscopy

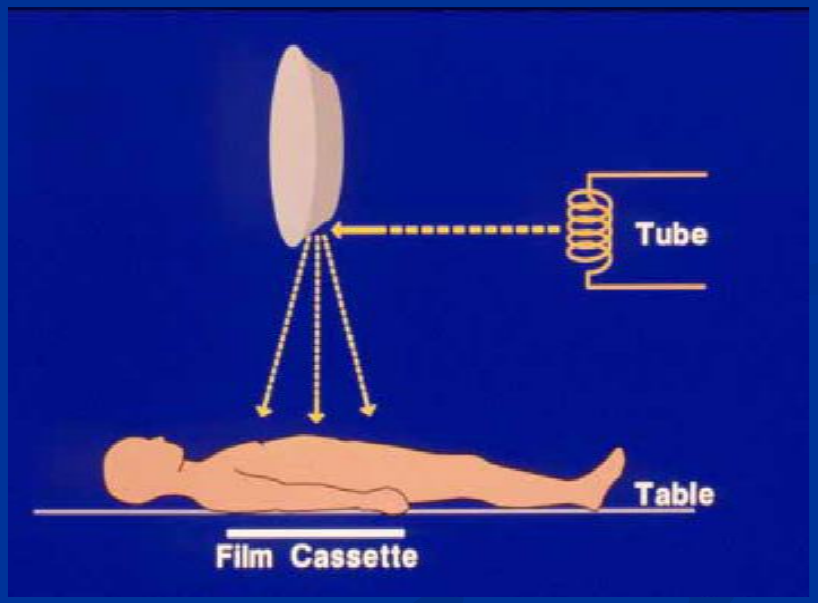
CT (Computed Tomography)

Mammography



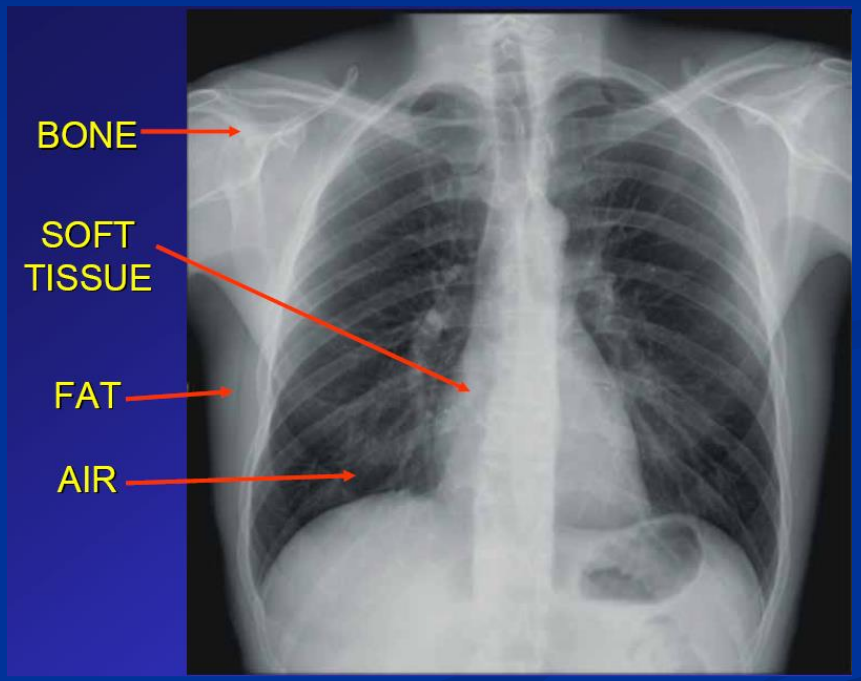
X-ray production and interaction with body tis sues

- Electrons generated at filam ent
- Negatively charged electron s move toward anode and st rike target at high speed
- 99% result in heat dissipate d by the rotating target
- 1% create x-rays which are d irected through the window
- X-rays pass through patient to a receptor (film, digital, fl uorescent screen, etc



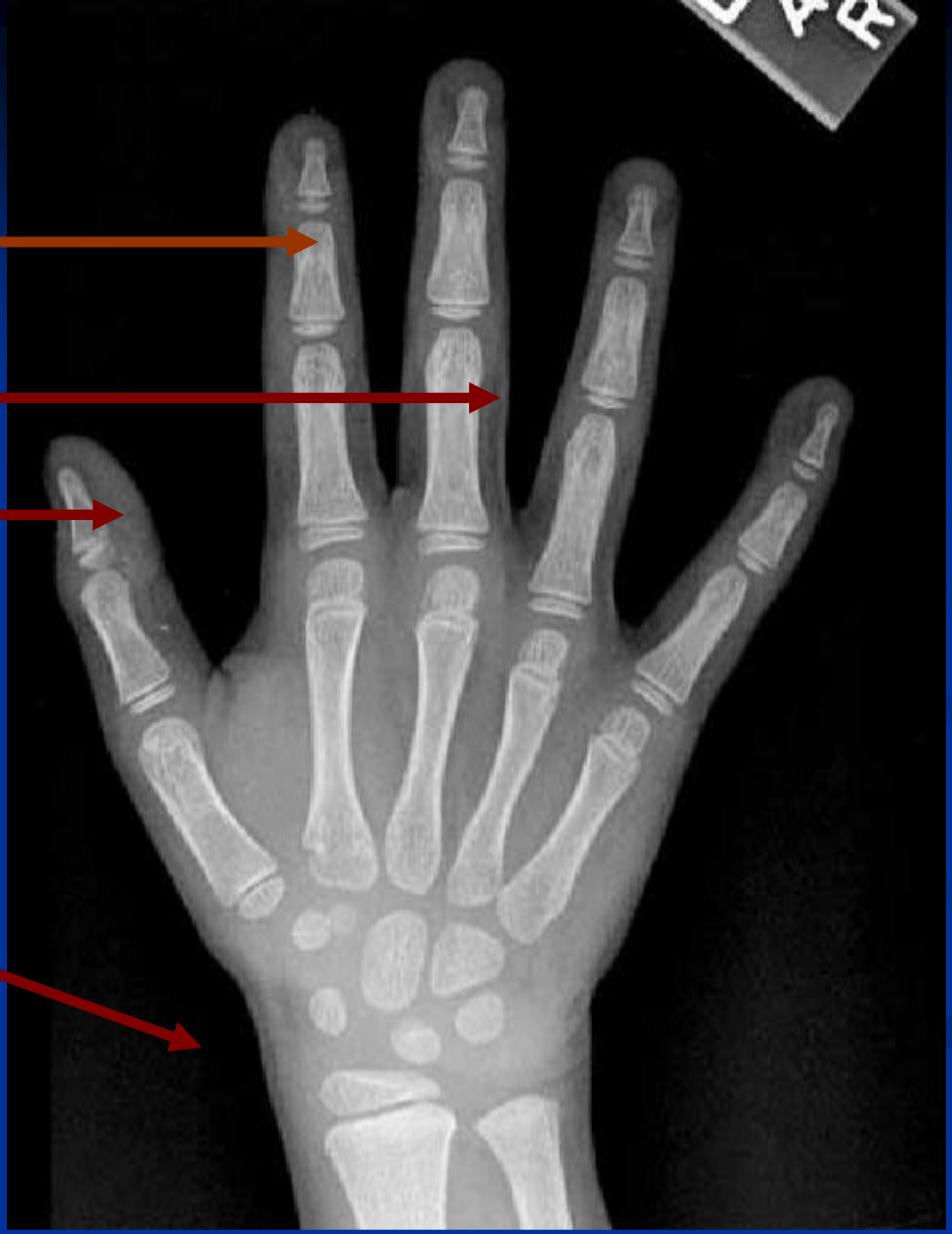
X-ray image

- A diagnostic image is co mposed of differences i n contrast between tiss ues which result from di fferences in radiation in teraction in the tissues



Inherent Contrast

Tissue	Appearance on XRAY
Air	Black
Fat	Dark Gray
Soft Tissues	Gray
Bone, Calcium	White
Metal	Really White


BONE
FAT
SOFT TISSUE
AIR

‘Digital’ Radiography

Two types

- Computed radiography, called CR
  - Uses existing equipment to make exposures
  - Film cassette is replaced with a charged metal plate
  - After exposure, plate is ‘read in a special device
- Digital radiography, called DR
  - Requires conversion of the entire x-ray room
  - Film cassette is replaced by a CCD sensor (like in a d igital camera or video camera)

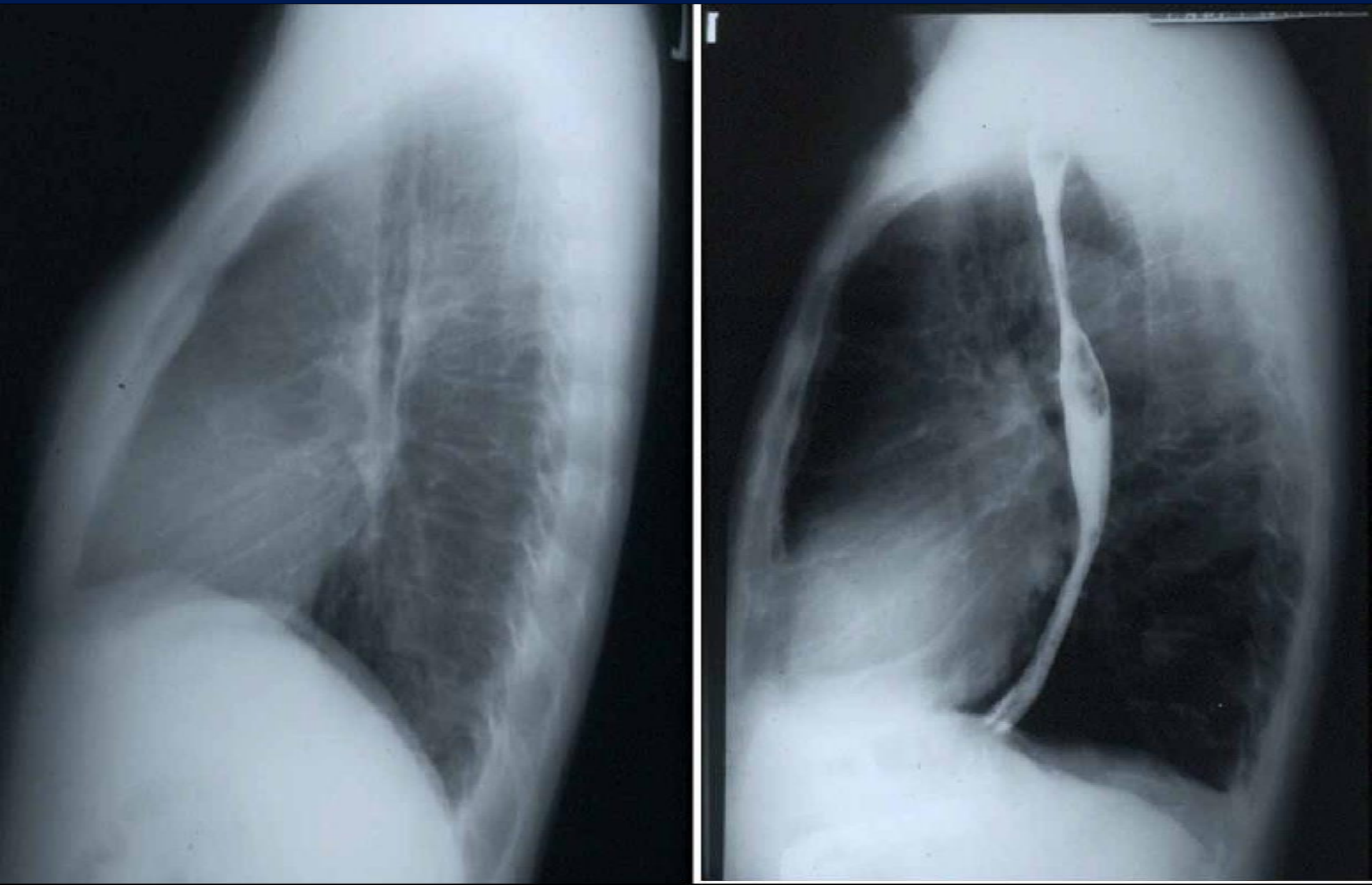
Contrast Agents

Anything that enhances the differences between tissues of similar densities is a contrast agent

- For XRAY there are TWO commonly used contrast agents: Note they are both METALS
  - Barium
  - Iodine
- Ways in which they are introduced
  - Swallowed: barium swallow, upper GI
  - By enema: barium enema
  - In vein: Intravenous urogram
  - In artery: Arteriogram

CHEST: LATERAL VIEW

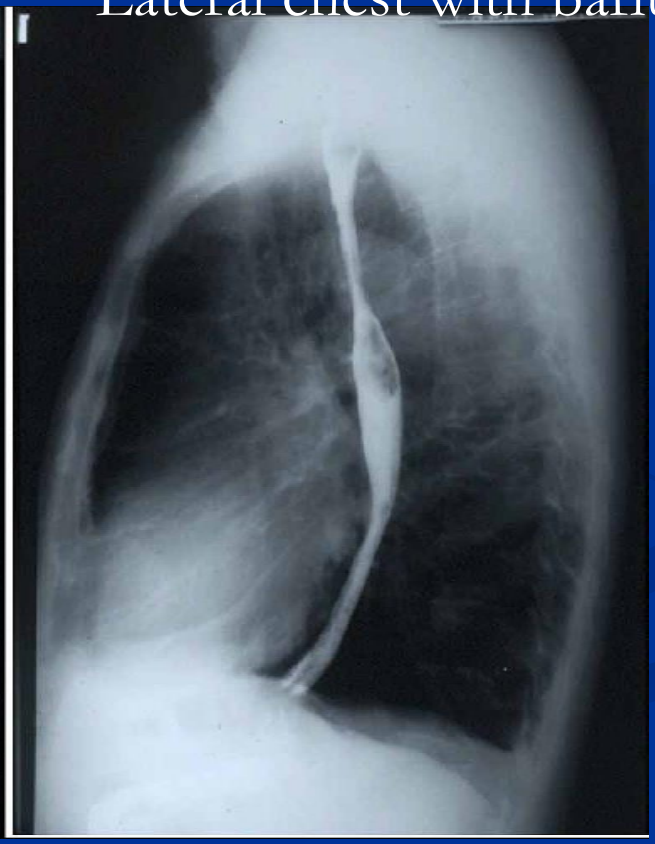
BARIUM SWALLOW



Use of contrast in radiography

Plain lateral chest radiograph

Lateral chest with barium



PLAIN RADIOGRAPH OF ABDOMEN

BARIUM ENEMA

Iodine:
Intravenous urogram
Intravenous pyelogram
(IVU or IVP)

KIDNEYS

URETERS

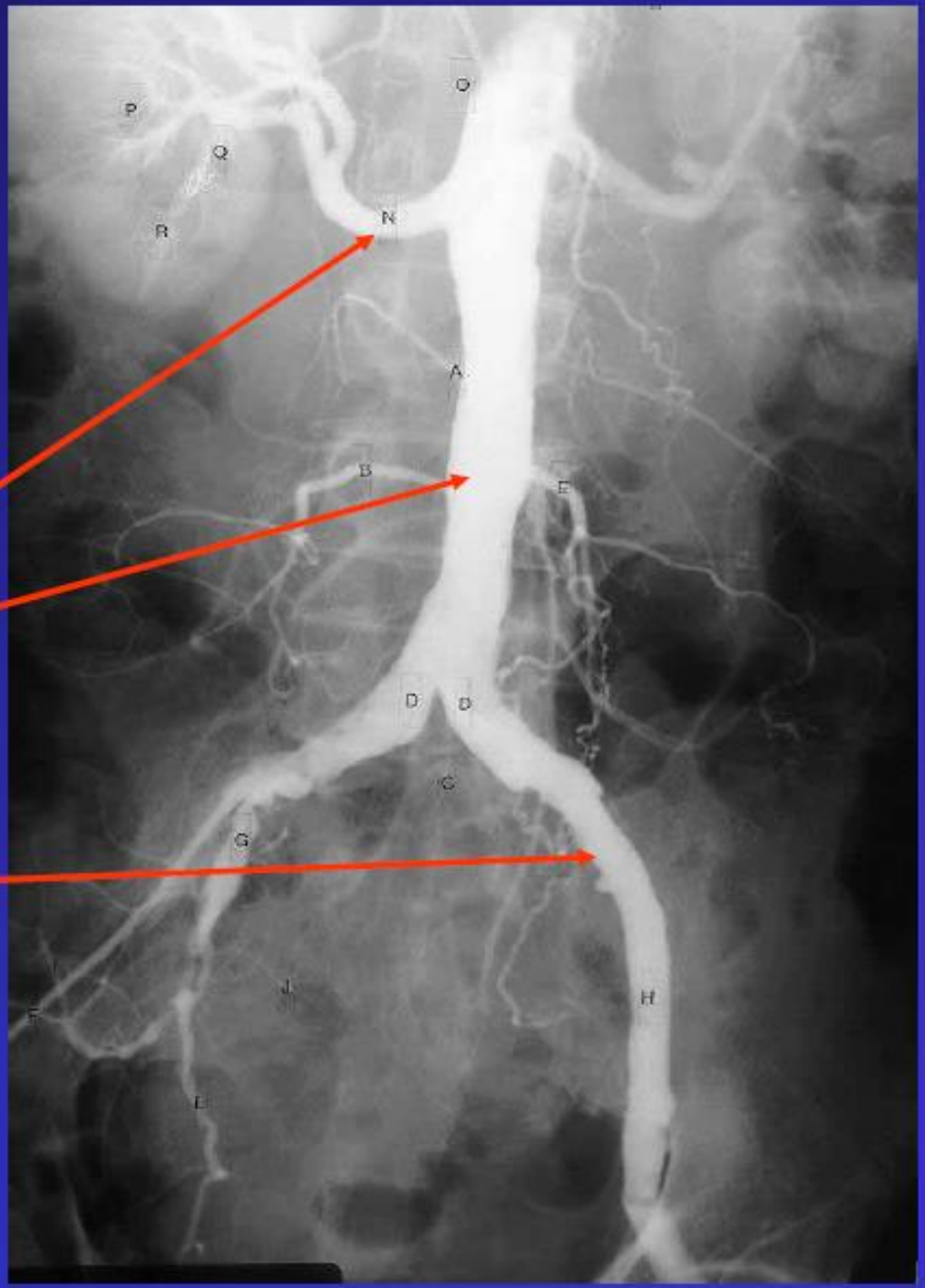
BLADDER

Iodine:
Arteriogram through a catheter (tube) in the leg

RENAL ARTERY

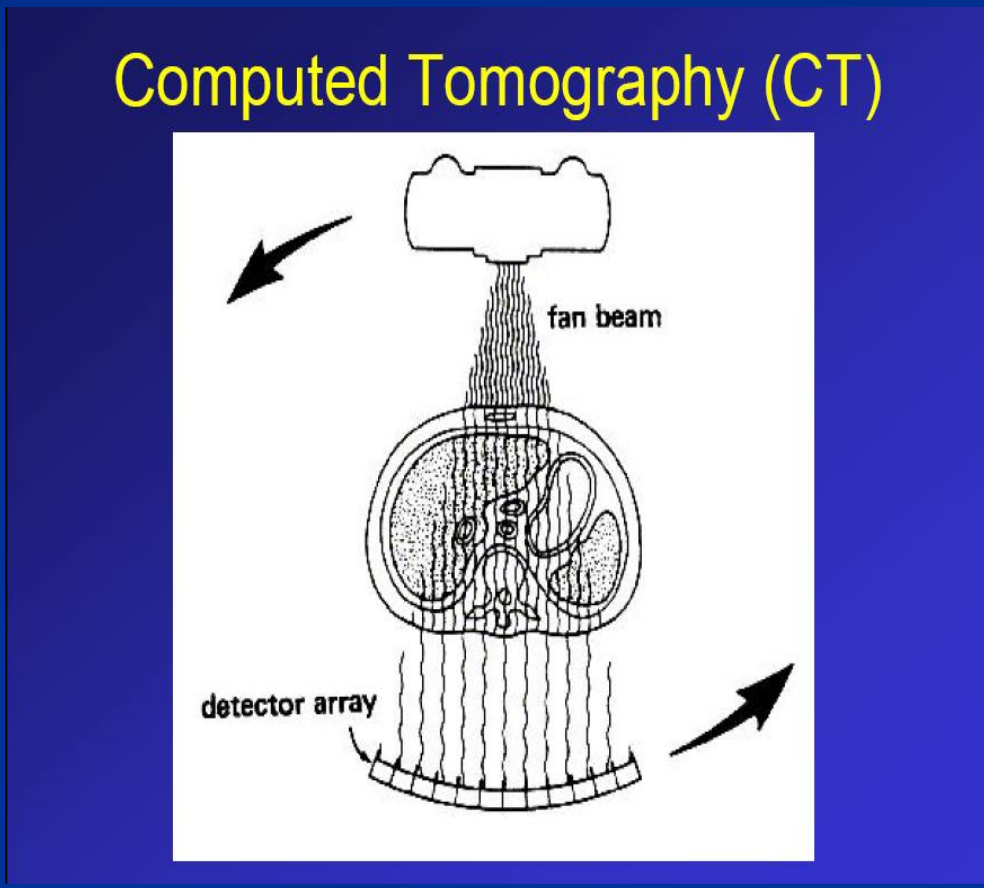
AORTA

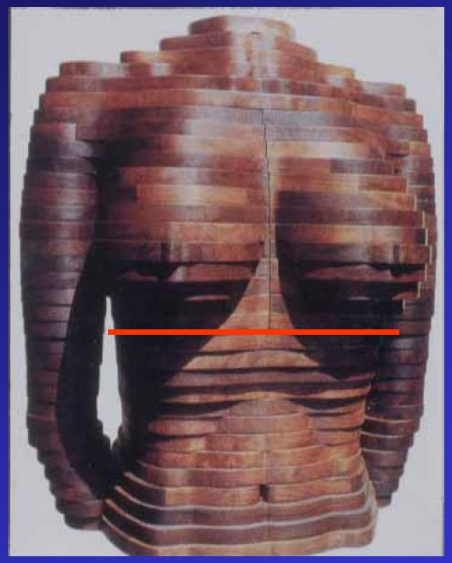
ILIAC ARTERY

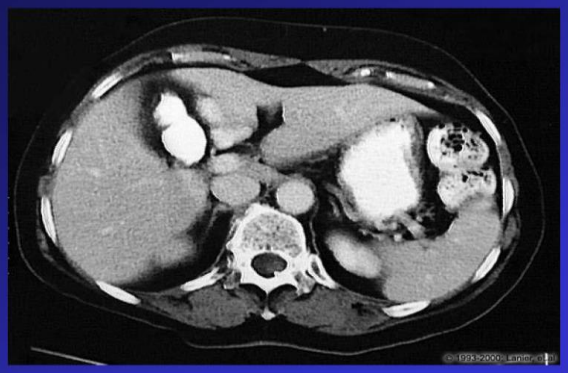


Computerised Tomography(CT)

- CT uses X.rays to produce images
- In the initial equipments, the x-ray tube spins around the patient while detectos moved around the patient in opposite direction to the tube
- A computer then performs calculations of densities in each square of a slice to produce the images







In computerised tomography (CT) the X-ray source rotates around a plane of the body, taking serial pictures with a detector (instead of a film) which are synthesized by a computer.

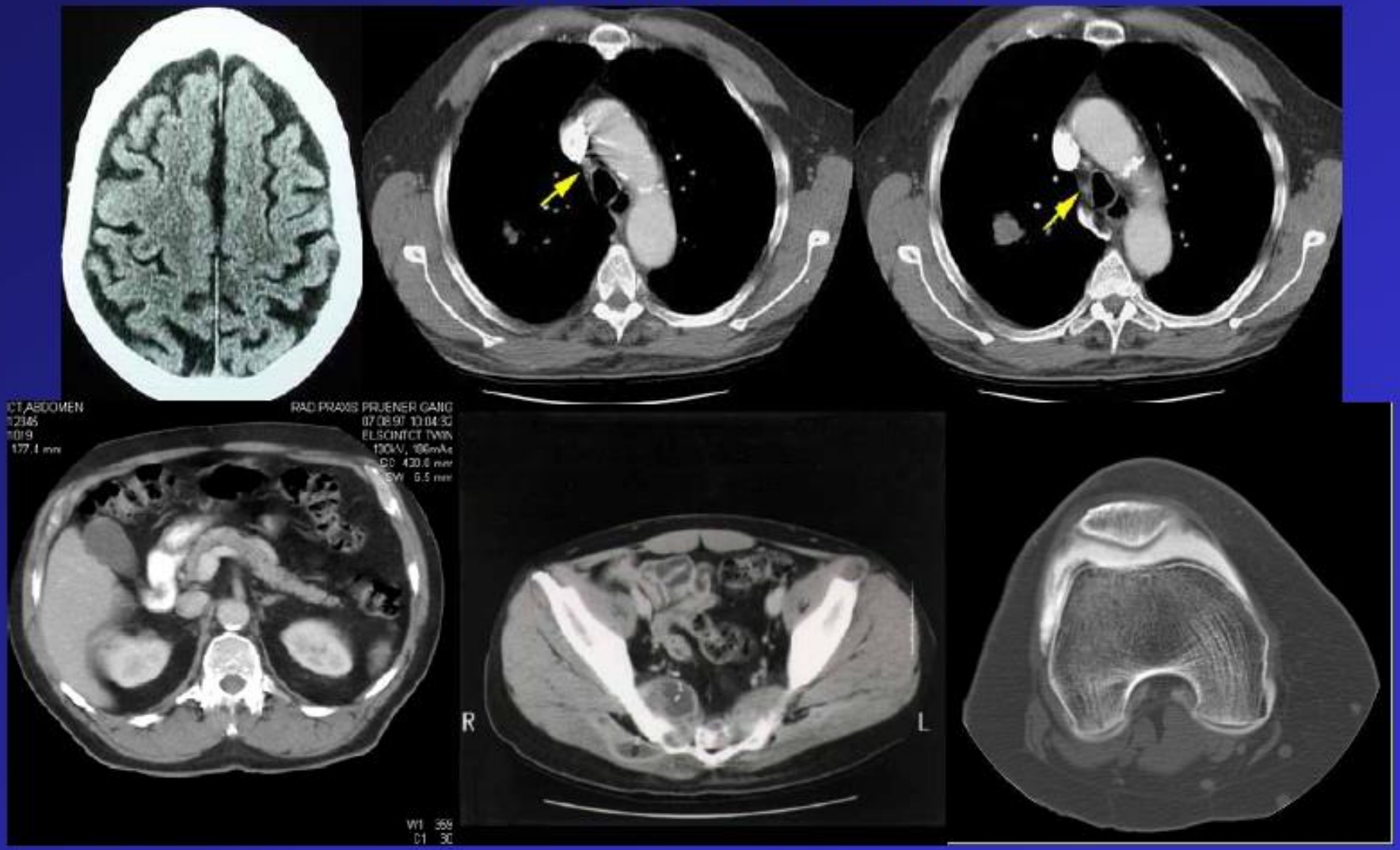
The resulting picture created by the computer is like a section of the body and can be recorded on a film. CT pictures are therefore like X-ray images.

CT Equipment

Technological advancements of CT

- The first generation CT scanners used in the !970s and !980 were slow each slice taking a minute to pr oduce an image.
- Marked technological advancements have been ma de to this single slice equipments to multislice equipments upto 640 slice in which the whole body can be scanned in a minute and image reconstructi ons can be achieved

CT Of The Entire Body In 2 Minutes

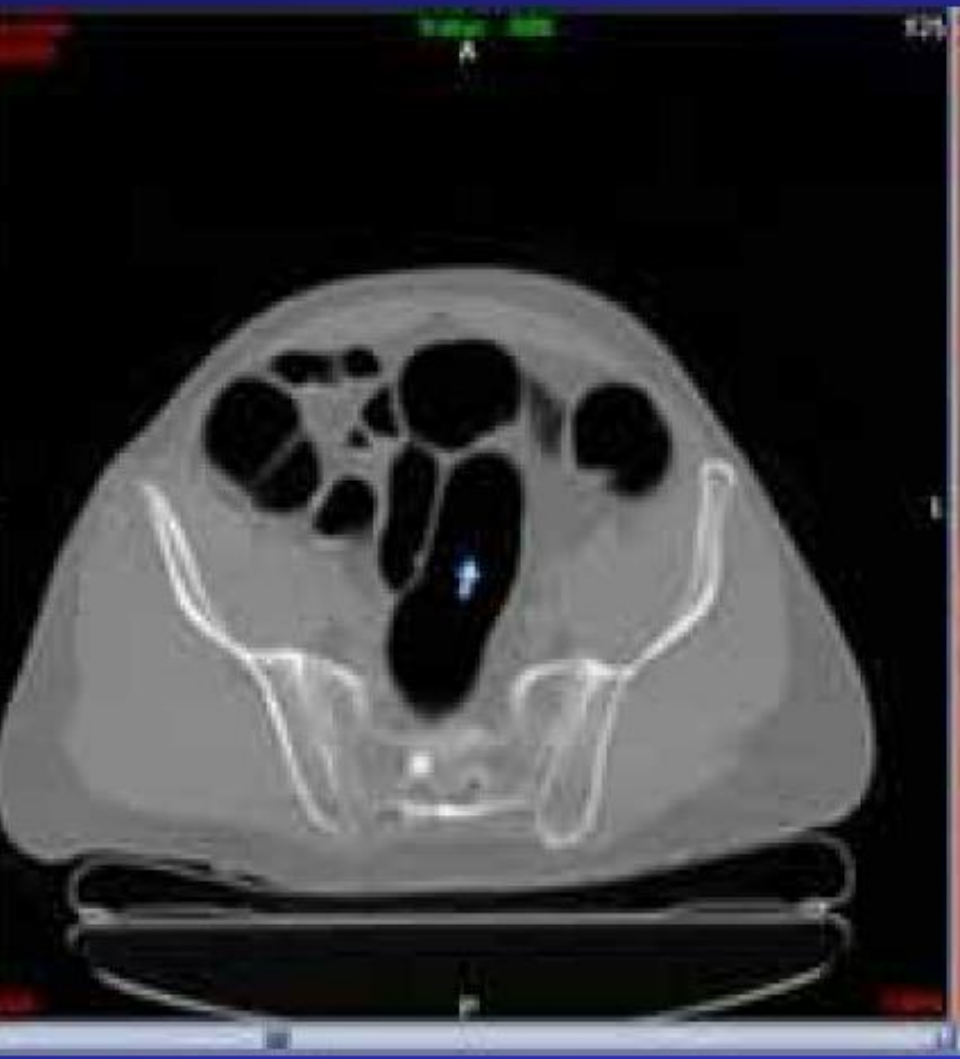


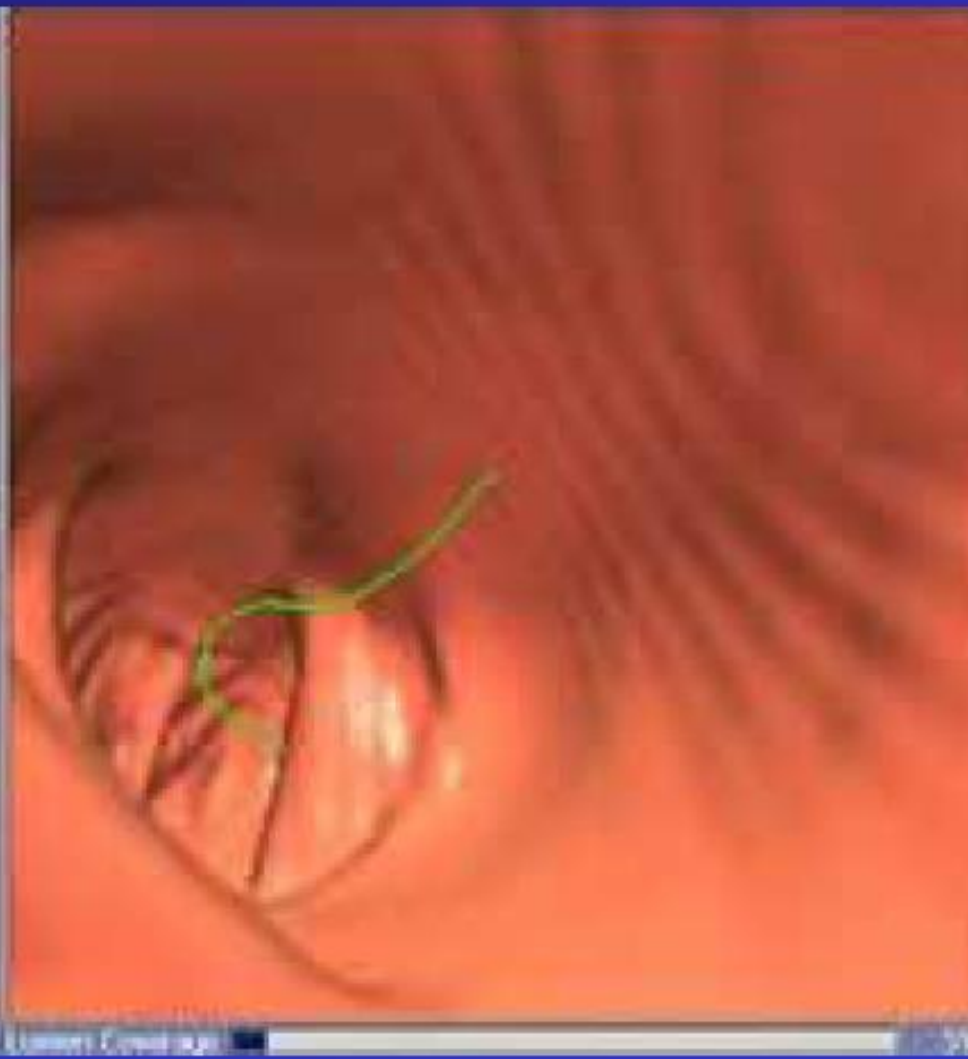
What more can we can do with CT these days?

- **CT Angiography**
  - Scan rapidly during Iodine injection in vein
- **CT Colonography**
  - Scan colon after filling with air
- **CT Bronchoscopy**
  - Scan chest air is already in bronchi
- Construct 3D Images
  - Computer reconstruction

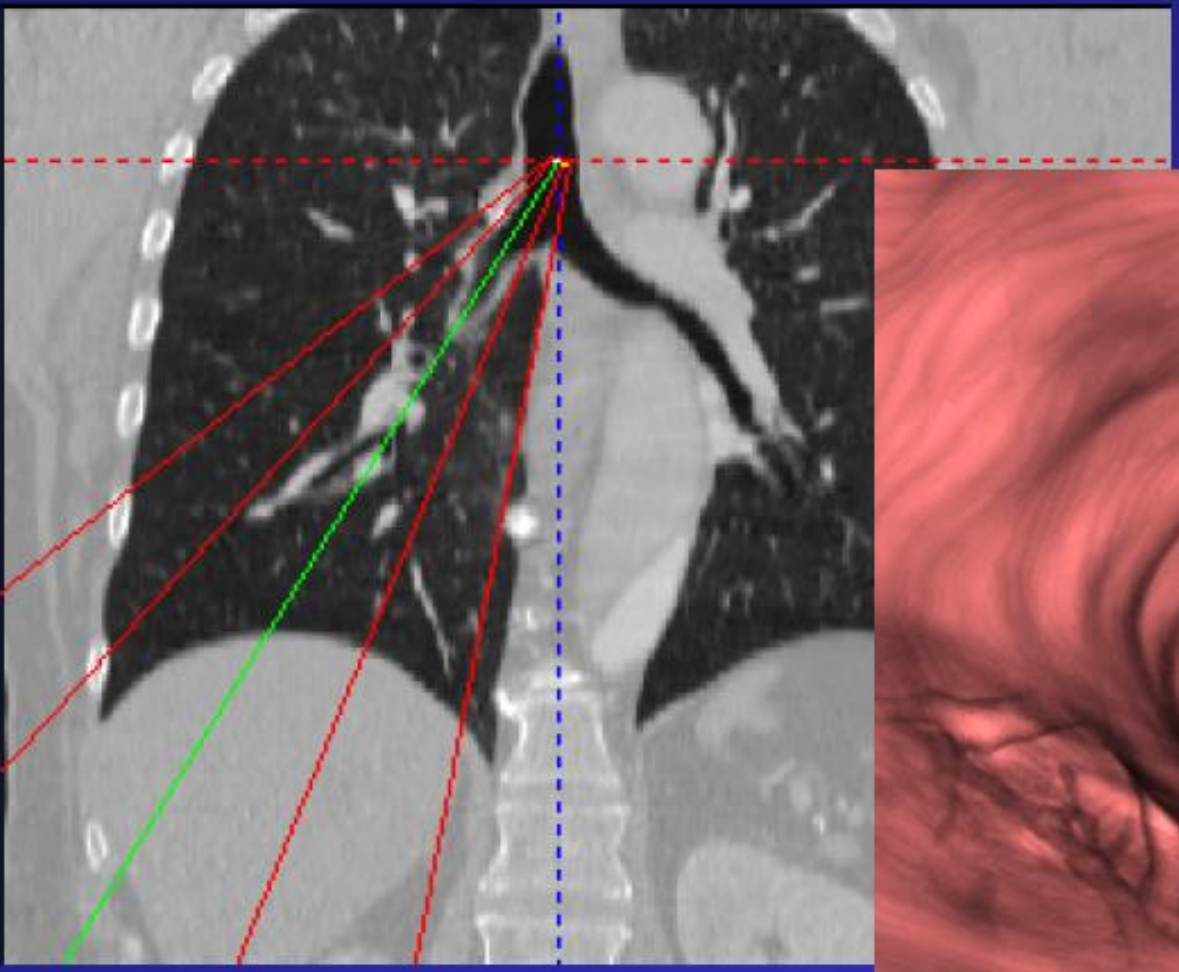
CT Angiograms

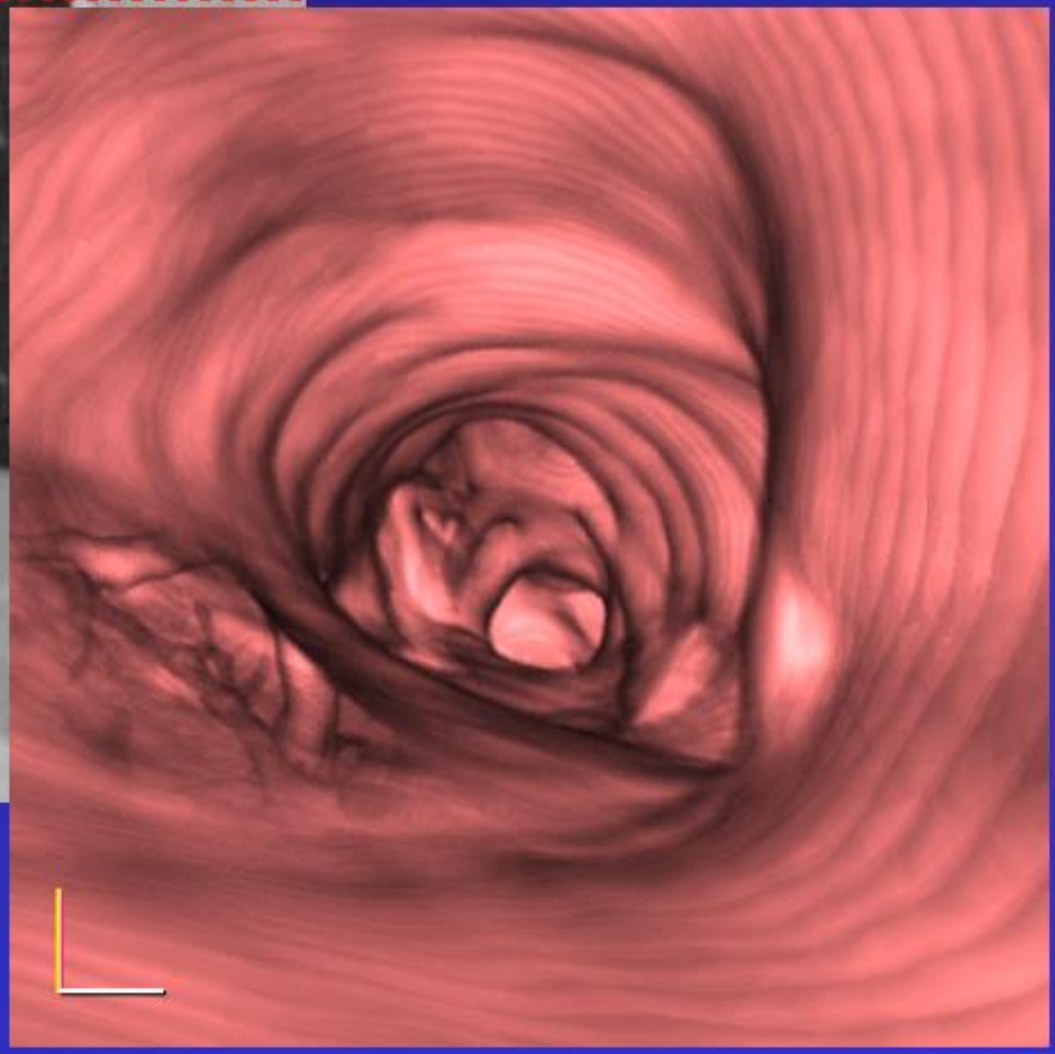
CT Colonography



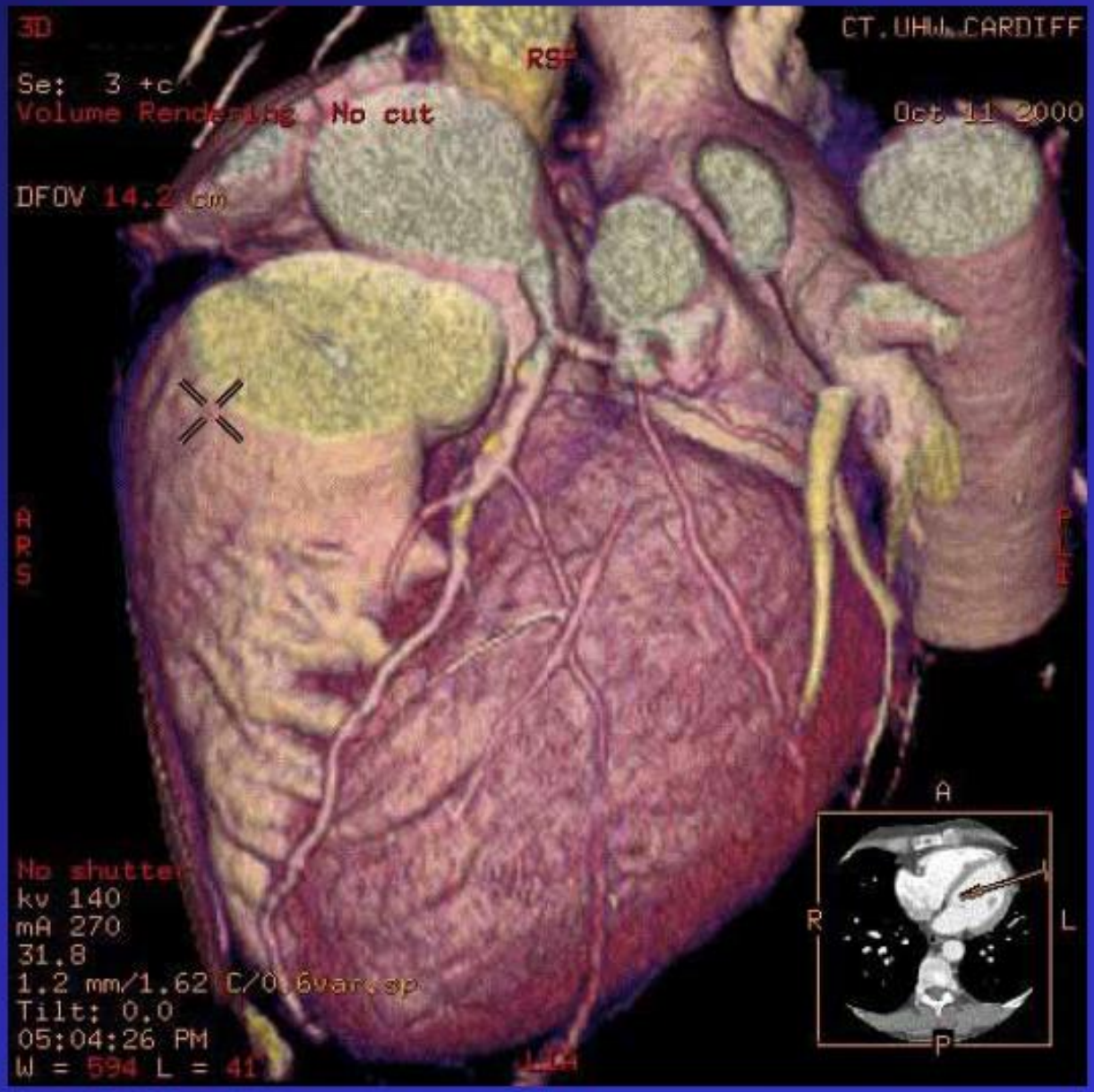


CT Bronchoscopy

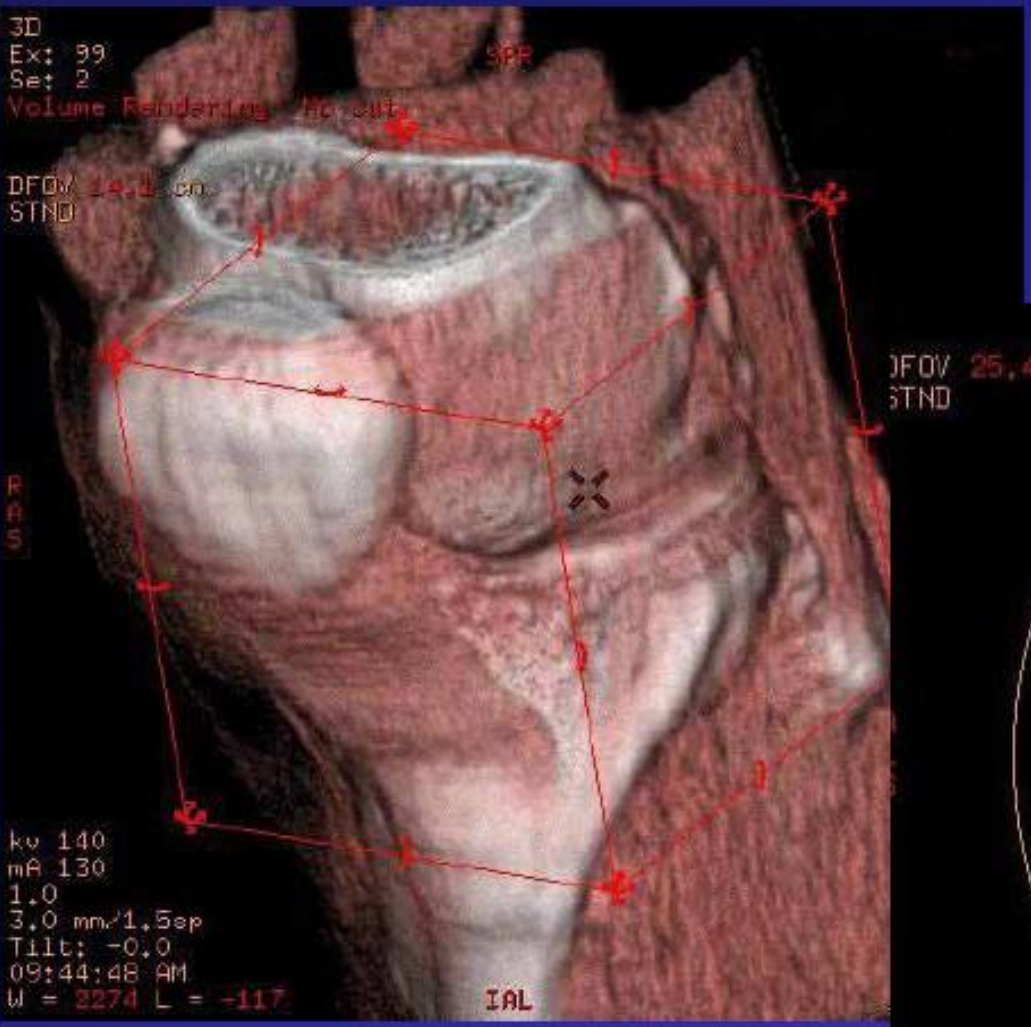




3D CT of the heart



3D CT of the knee and leg



Ultrasound

- Uses high frequency sound to make images
  - 2-15 MHz typically used
- The sound is produced and detected with the same device: TRANSDUCER
- Transducer
  - Speaker: sound into patient
  - Microphone: sound coming back from patient
- Analogous to SONAR used in undersea warfare

Ultrasound

- Ultrasound uses mechanical waves of frequencies b eyond the audible range.
- These waves are reflected to various degrees from ju nctions of tissues of different nature.
- Ultrasound pictures require considerable skill to Pr oduce and interpret.
- Ultrasound has a great advantage – it does not caus e cellular damage when used in quantities required f or imaging

Ultrasounds equipments

Obstetric Ultrasound

4D ultrasound of fetal face

Magnetic Resonance Imaging(MRI)

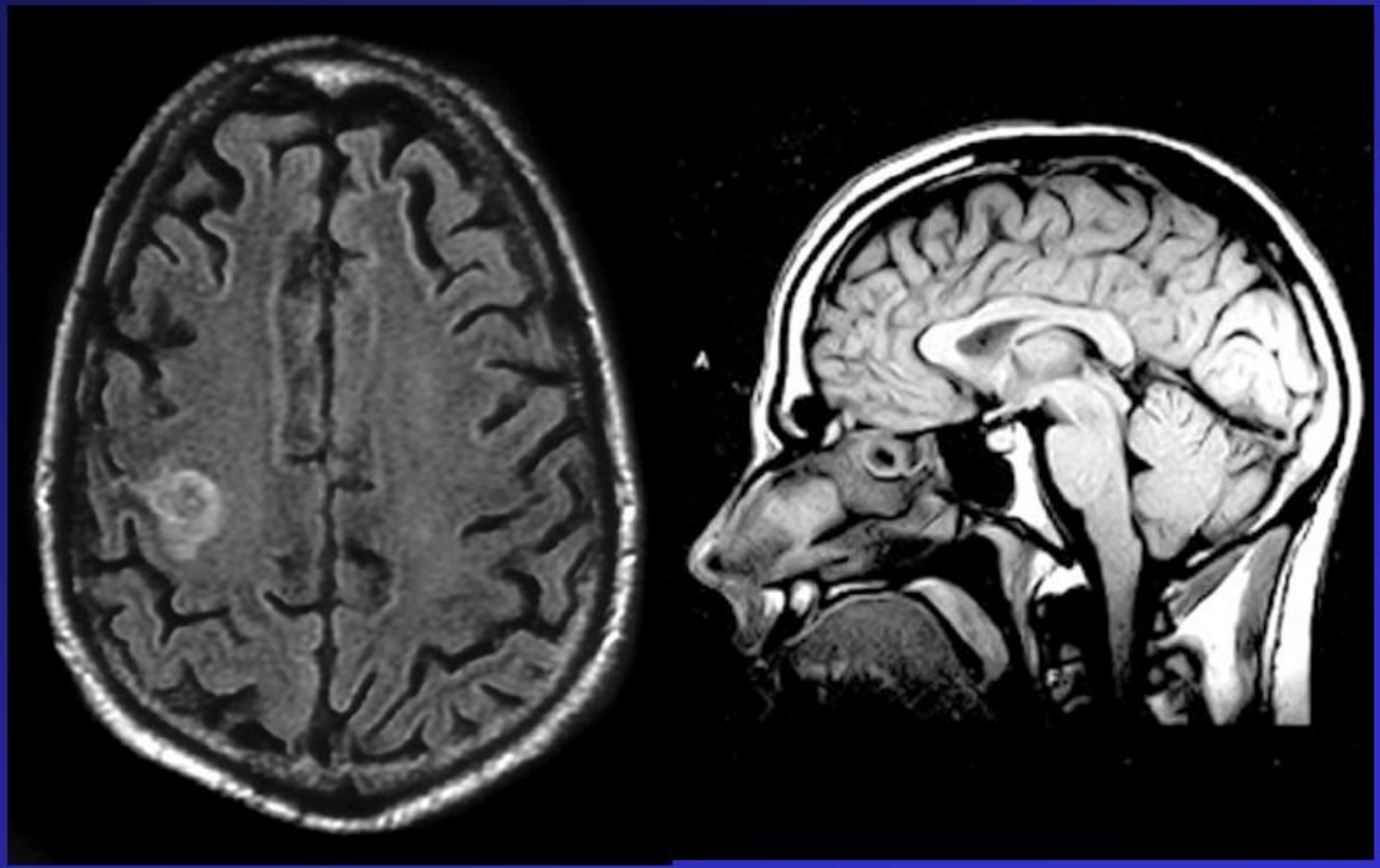
Magnetic resonance imaging exploits the existence of induced nuclear magneti sm in the patient.

Magnets with an odd number of photons or neutrons possess a weak but obser vable nuclear magnetic moment.

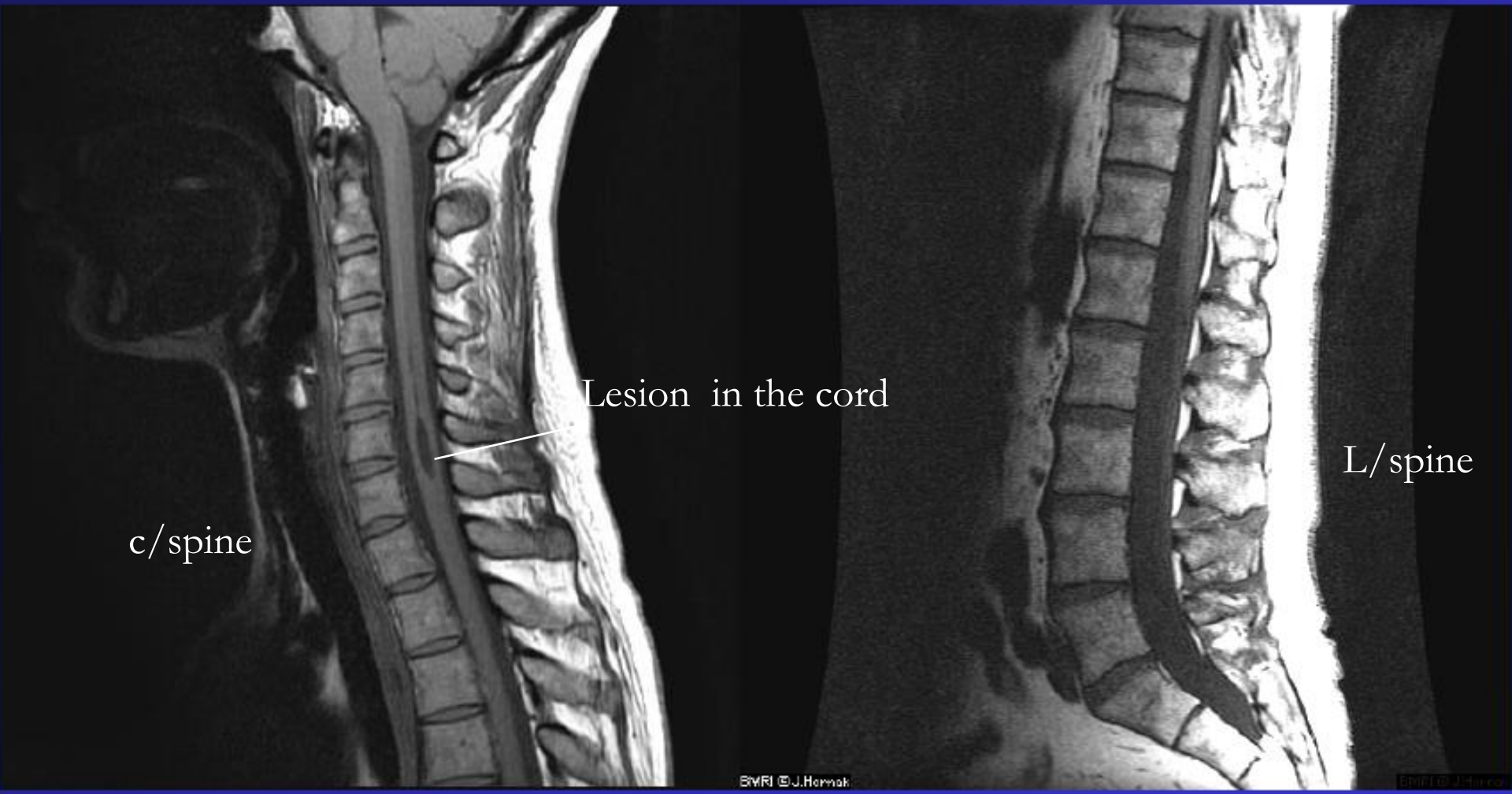
Hydogen nucleus is the most commonly imaged, although
(13C, Phosphorous (P) sodium (Na) and Fluorine (F) are also of significant int erest.

The nuclear moments are normally randomly oriented, but they align when pla ced in a strong magnetic field (typically 0.2-1.5 T).

The NMR signal from a human is due predominantly to water protons.
frequency.



Axial and sagittal MRI images of the brain



Sagittal MRI scans of the spine

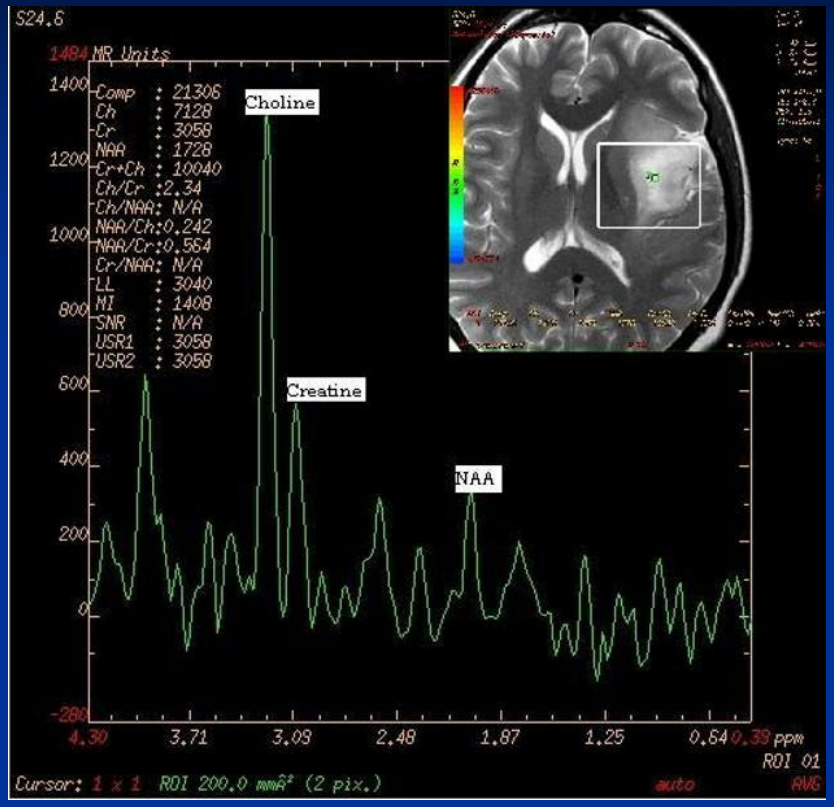
MR Angiography (MRA)

MR SPECTROSCOPY

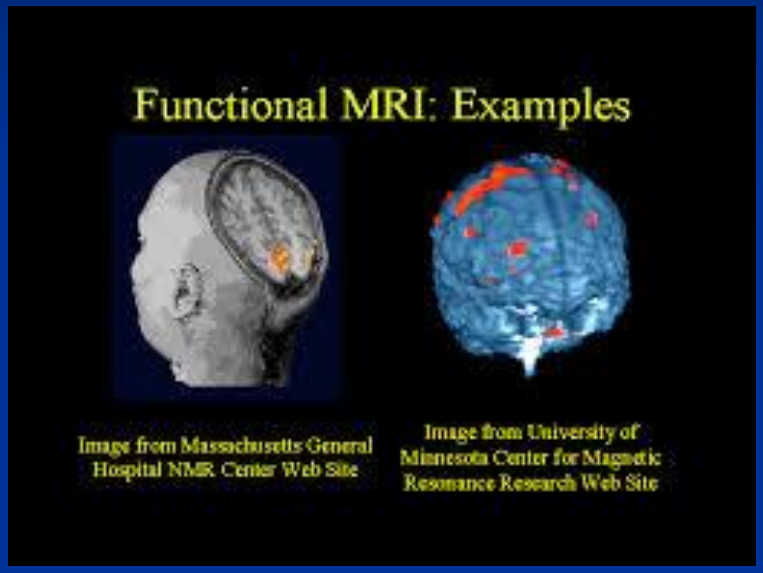
How does MR spectroscopy work?

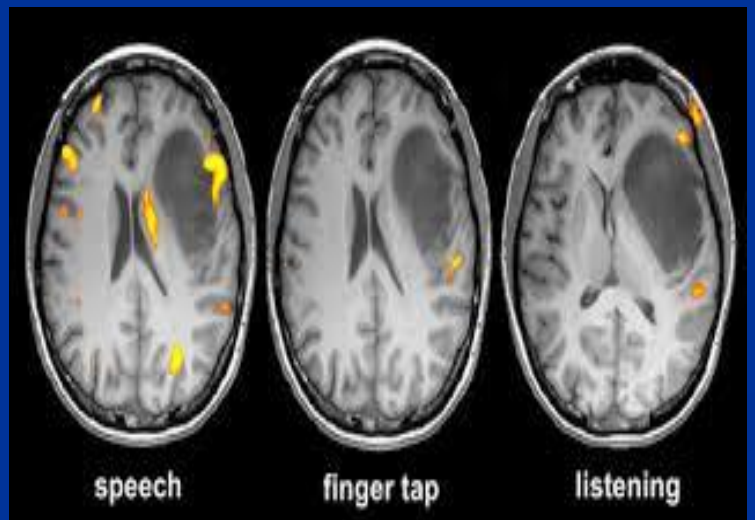
- MR spectroscopy is conducted on the same machine as conventional MRI.
- Spectroscopy is a series of tests that are added to the MRI scan of brain or spine to *measure the chemical metabolism of a suspected lesion*.
- There are several different metabolites, or products of metabolism, that can be measured to differentiate between tumor types.

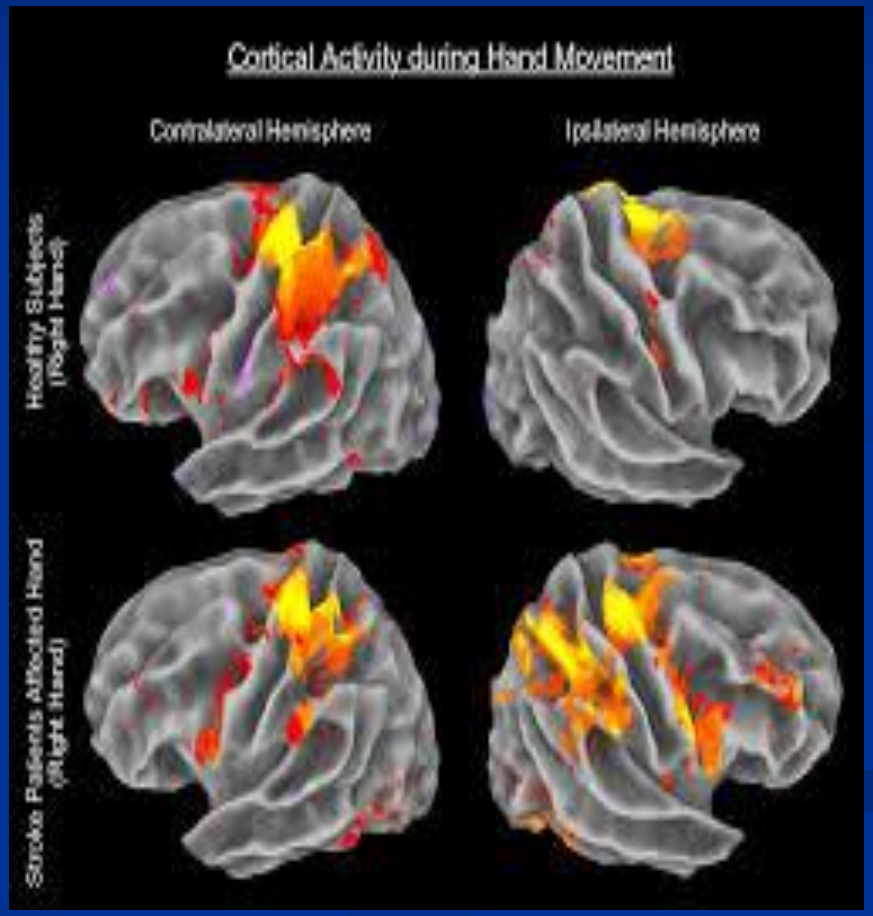
MRI spectroscopy



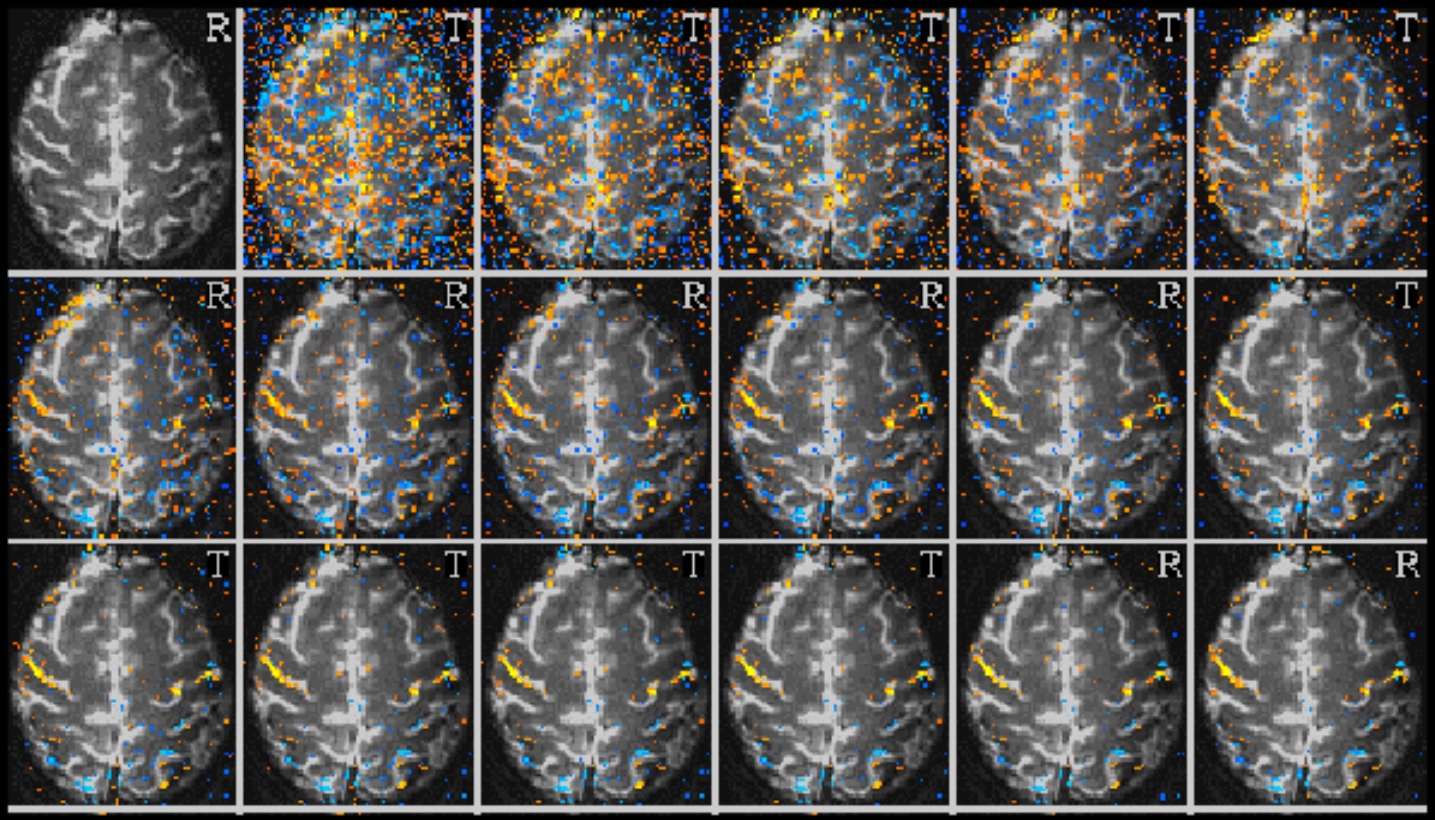
Funtional MRI







Functional MRI: Examples

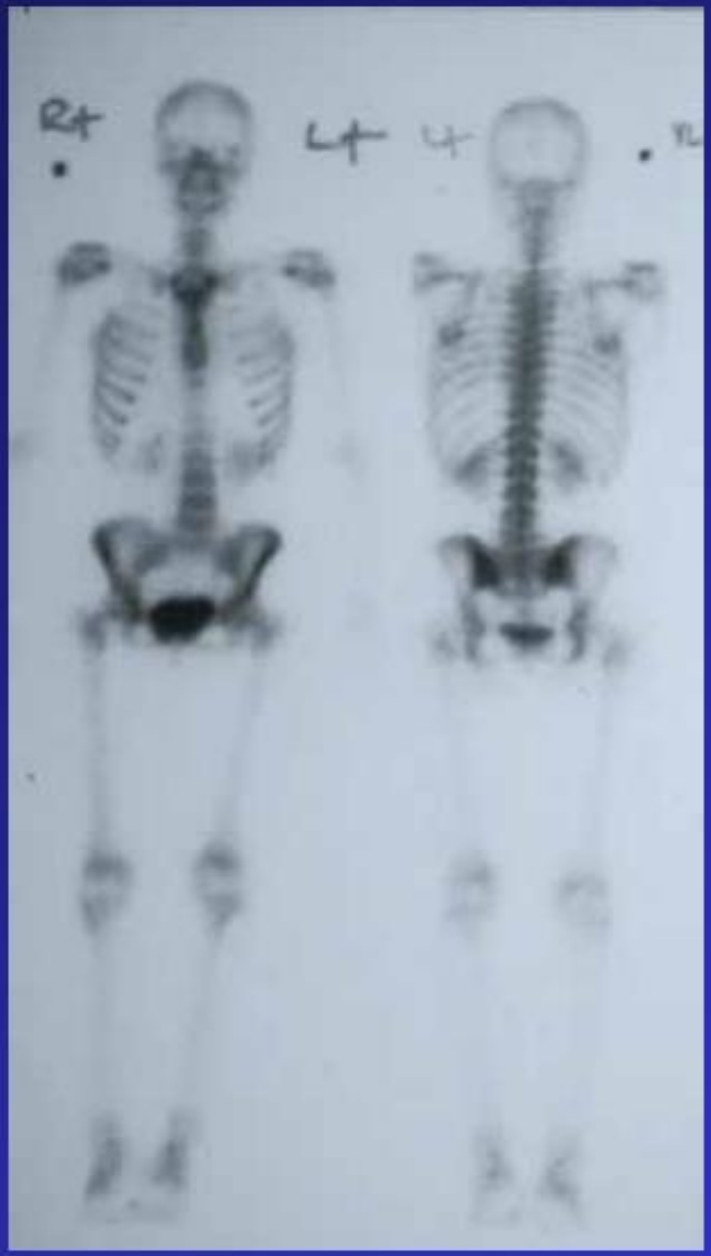


Taken from Medical College of Wisconson's web page, part of a real time fMRI study. R = resting, T = finger tapping. See R.W. Cox, A. Jesmanowicz and J.S. Hyde, "Real-time functional magnetic resonance imaging", MRM 33, 230-236 (1995).

Nuclear Scintigraphy

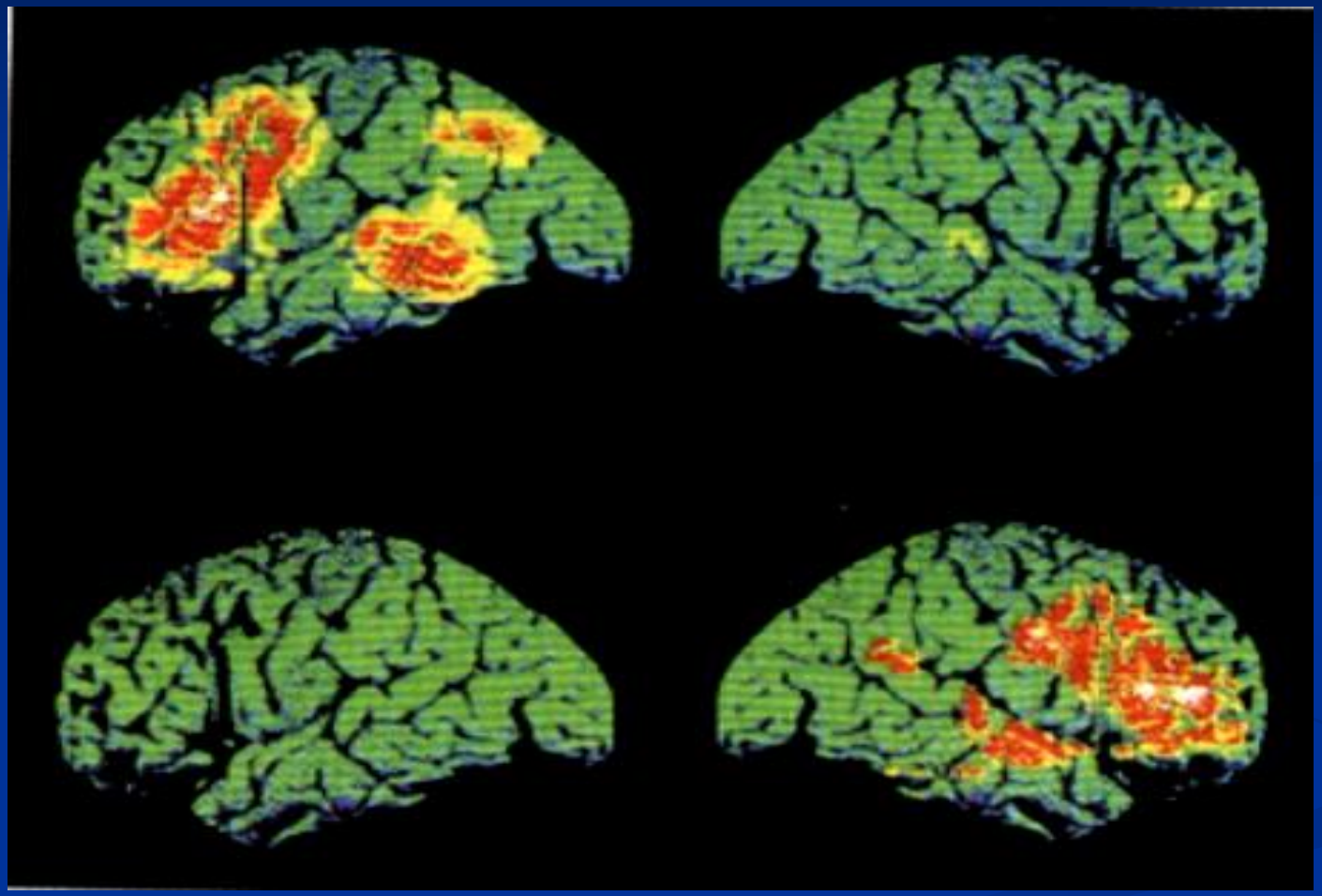
- Often called NUCLEAR MEDICINE
- Uses radioactive tracers that emit radiation
  - Electromagnetic OR particulate
- Often these are injected into the vein
- Different tracers go to different organs or parts of the body
- Images are made by detecting the radiation coming out of the patient

NORMAL BONE SCAN



ABNORMAL BONE SCAN

POSITRON EMISSION TOMOGRAPHY (PET)

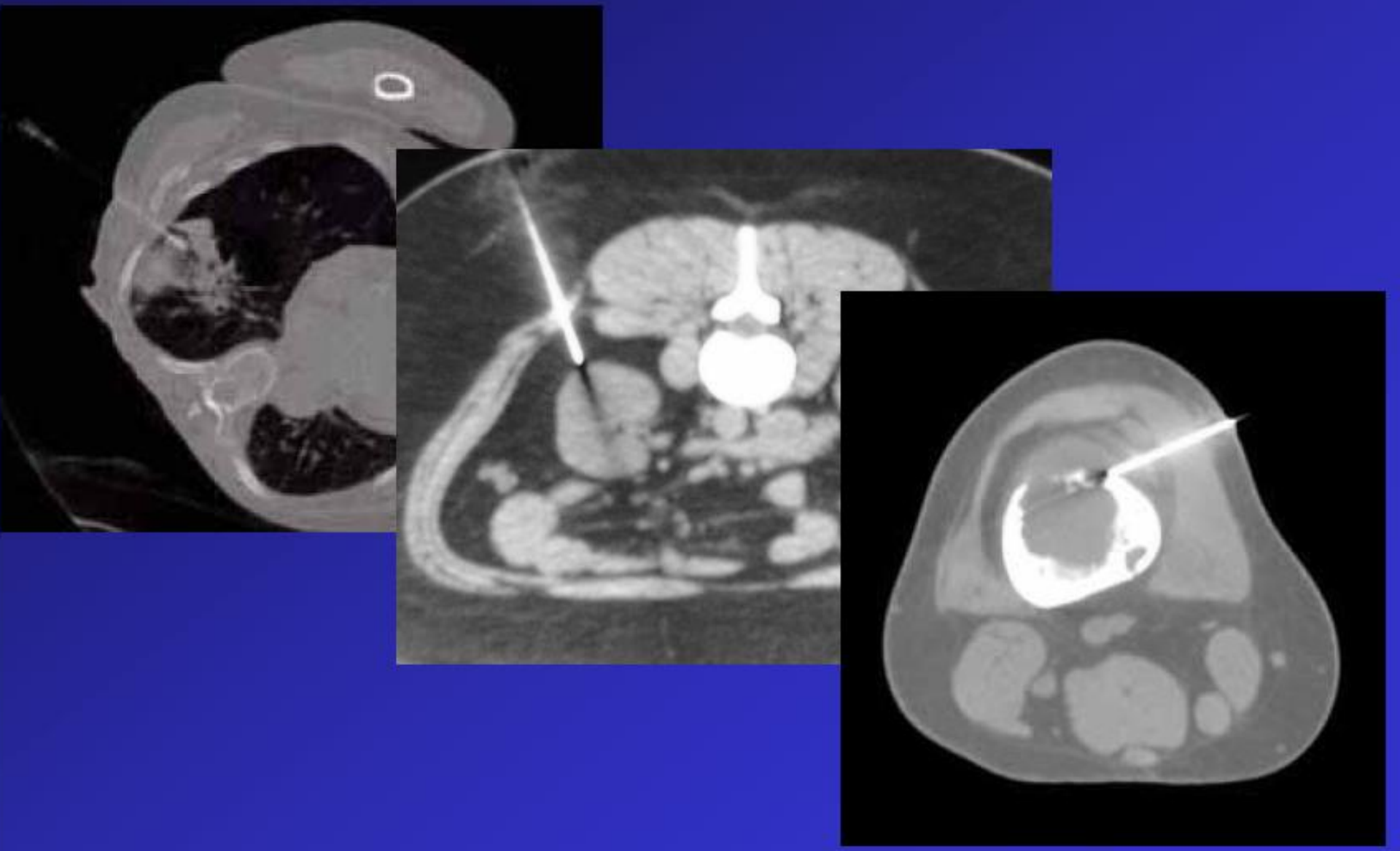


PET scan of the brain active in word recognition.

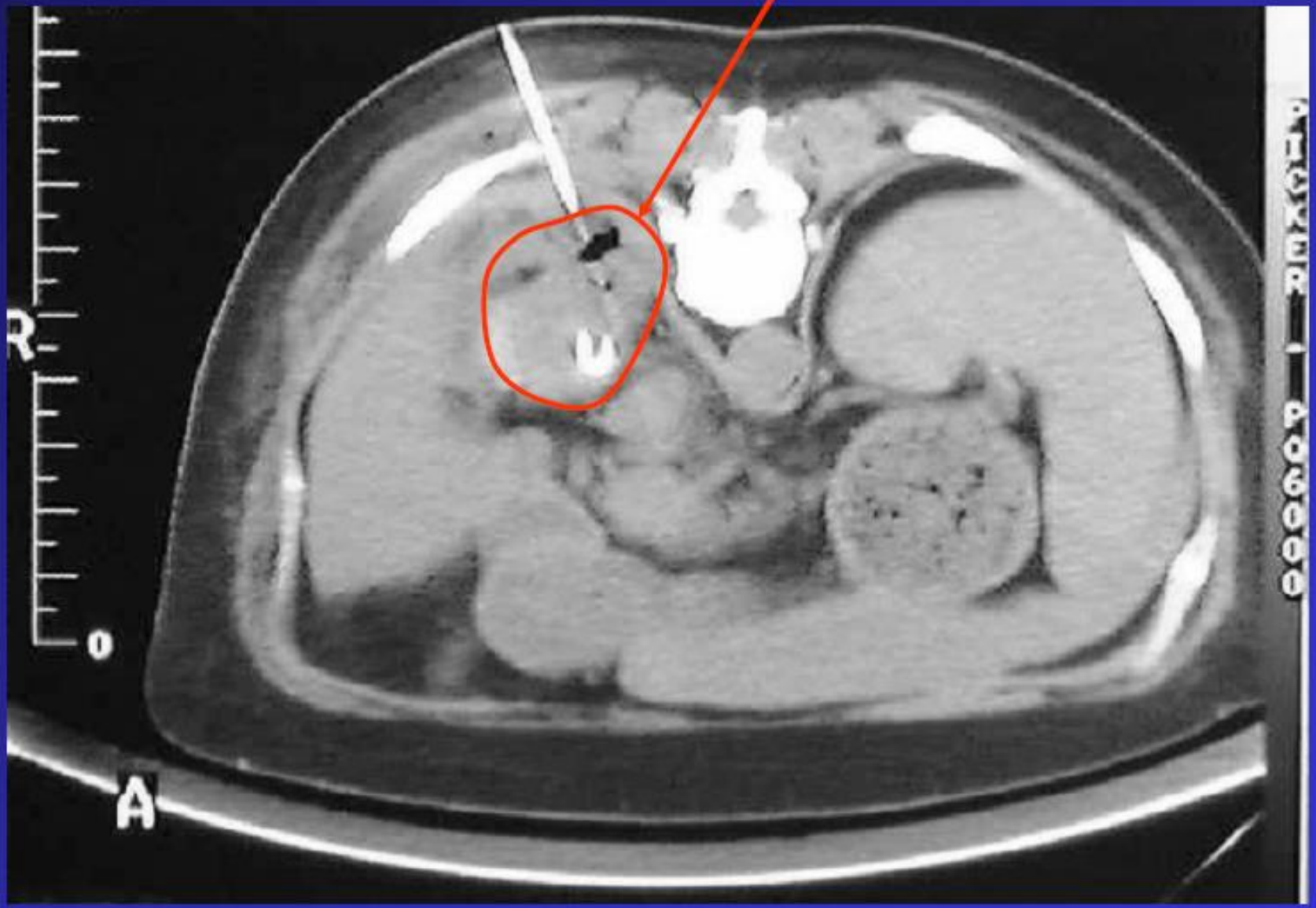
Interventional Radiology

- Radiologists do invasive procedures guided by images for either diagnosis or treatment
- Basically anything that breaks the skin
  - Needles for biopsy or fluid removal
  - Catheters to make angiograms
  - Catheters with balloons to open blood vessels
  - Stents to hold blood vessels open
  - Coils and material to block blood vessels
  - Catheters to drain abscesses
  - Tubes for feeding
  - etc etc

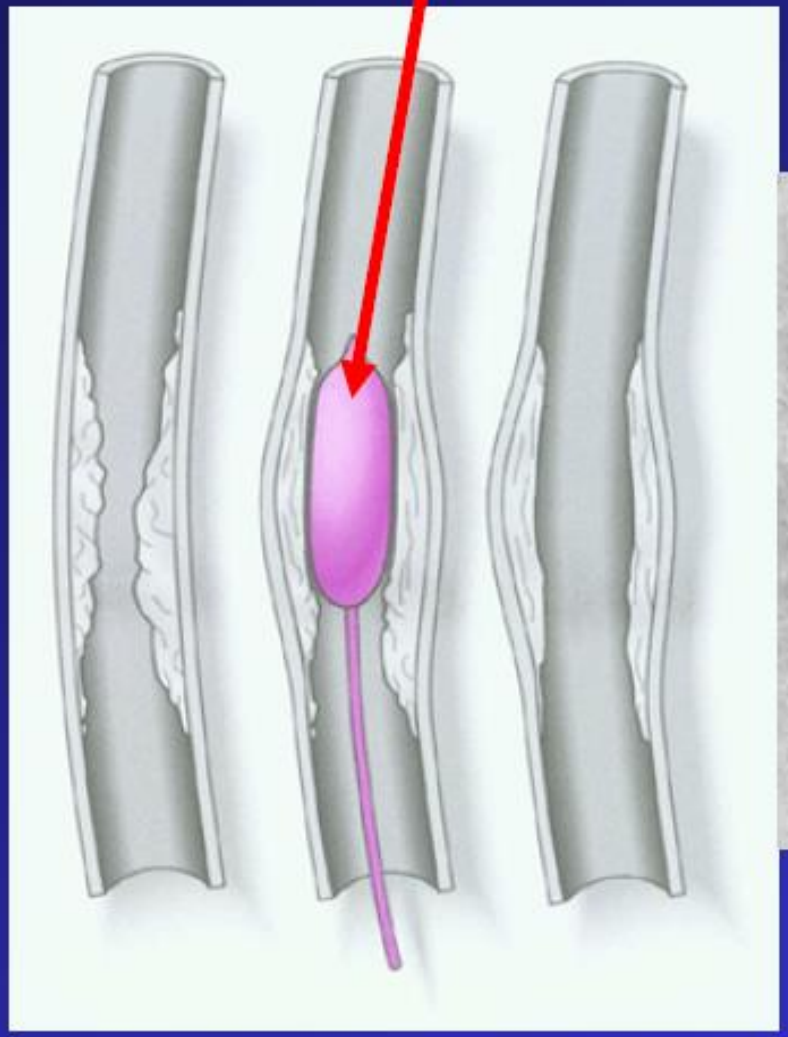
Non Surgical Biopsy

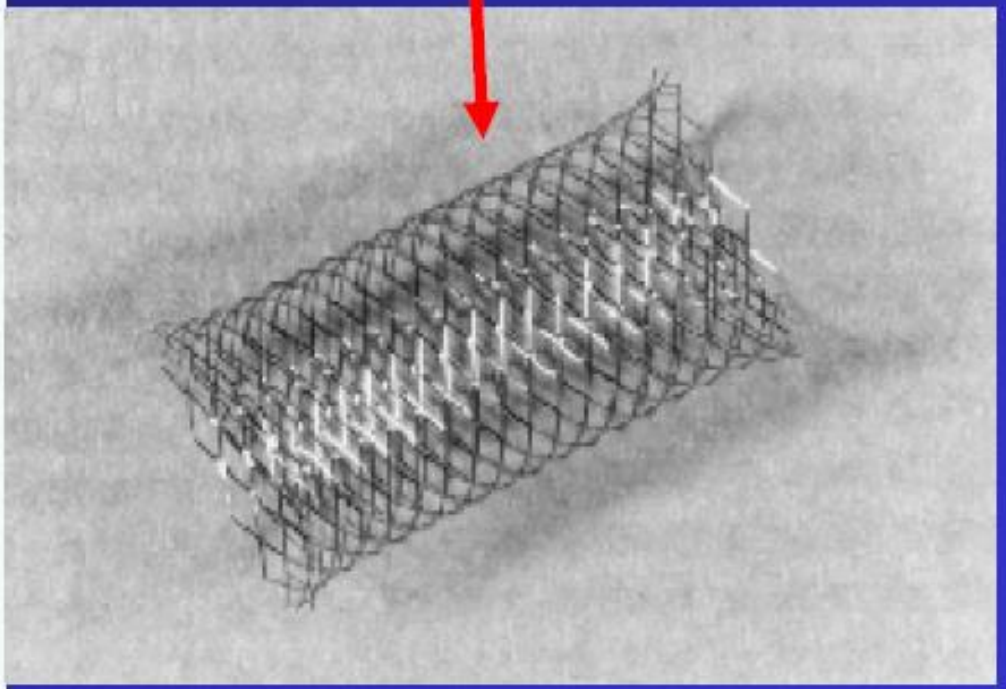


Draining Abscess



Angioplasty Balloon
Vascular Stent





Angiogram of normal kidney

Angiogram of kidney cancer

Angiogram after embolization

NO BLOOD FLOW TO THE MASS NOW IT CAN BE REMOVED WITHOUT EXCESSIVE BLEEDING

Imaging despite all this advances we are still seeing more in the future