Biomedical instrumentation

المرحلة الرابعة فيزياء طبية

اعداد

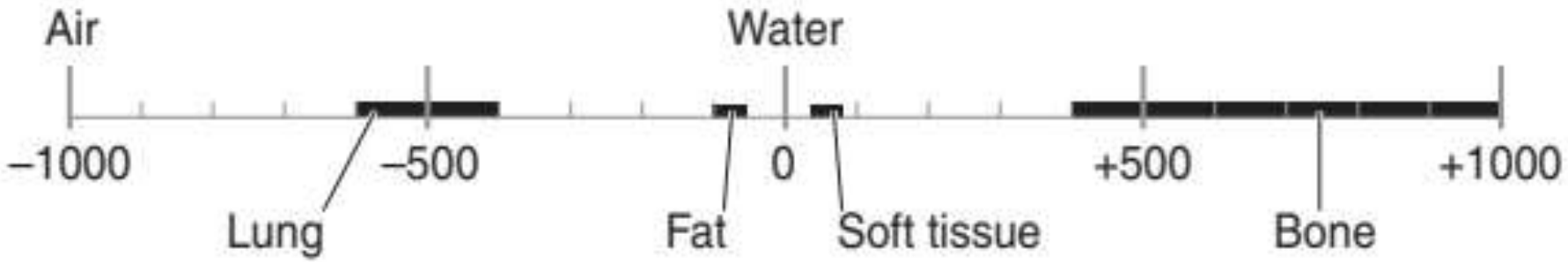
م.د. نور يعسوب

How is a CT image produced ?

- Every obtained CT slice is subdivided into a matrix of up to 1024 × 1024 volume elements (**voxels**) 3D object. Each voxel has been traversed during the scan by numerous X-ray photons and the intensity of the transmitted radiation measured by detectors.
- From these intensity readings, the **density** or **attenuation value** of the tissue at each point in the slice can be calculated. Specific attenuation values are assigned to each individual voxel.
- The viewed image is then reconstructed as a corresponding matrix of picture elements (**pixels**) 2D object.

What is a Hounsfield unit or CT number?

- Each pixel is assigned a numerical value (CT number), which is the average of all the attenuation values contained within the corresponding voxel.
- This number is compared to the attenuation value of water and displayed on a scale of arbitrary units named **Hounsfield units (HU)** after Sir Godfrey Hounsfield.
- This scale assigns water as an attenuation value (HU) of zero.
- The range of CT numbers is 2000 HU wide although some modern scanners have a greater range of HU up to 4000.
- Each number represents a shade of grey with +1000 (white) and –1000 (black) at either end of the spectrum .

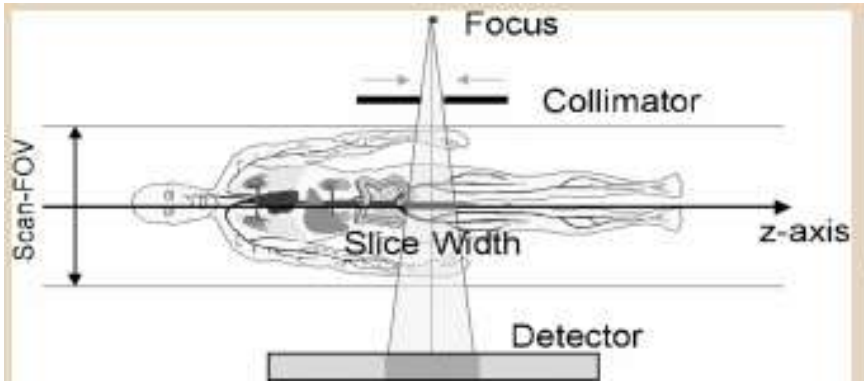


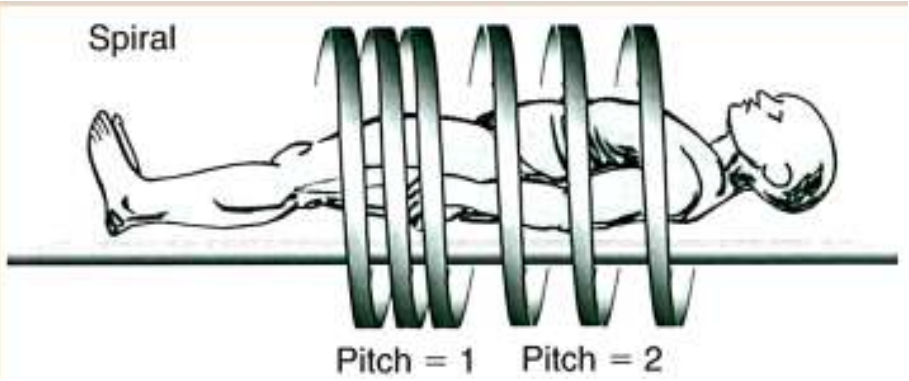
Bone	+400 → +1000
Soft tissue	+40 → +80
Water	0
Fat	–60 → –100
Lung	–400 → –600
Air	–1000

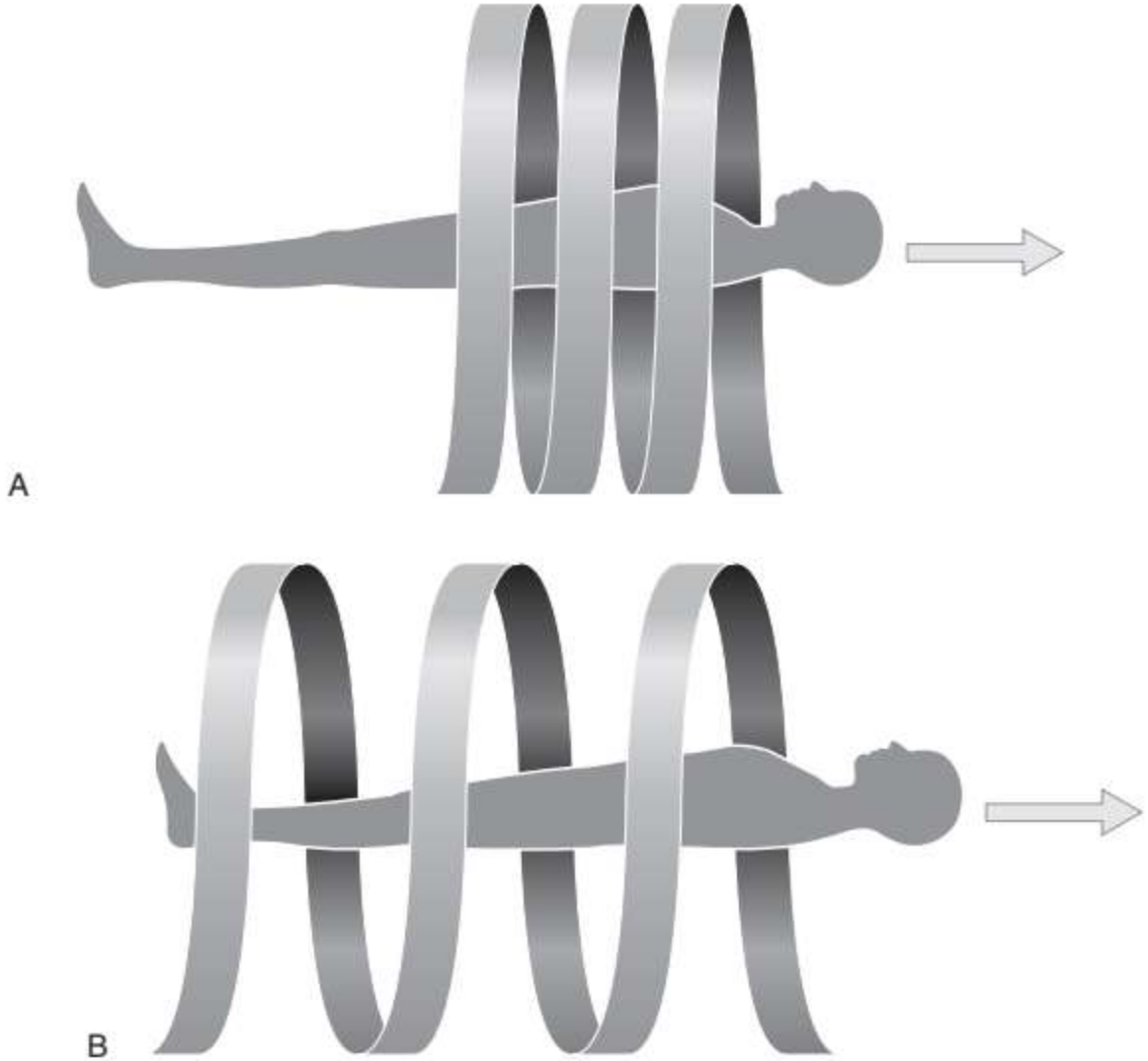
The Hounsfield scale of CT numbers.

What is pitch ?

- **Pitch** is the distance in millimetres that the table moves during one complete rotation of the X-ray tube, divided by the slice thickness (millimetres).
- Increasing the pitch by increasing the table speed reduces dose and scanning time, but at the cost of decreased image resolution.
- table travel - table movement per rotation
  - collimation - x ray beam width in z axis.
  - pitch = table travel / collimation.





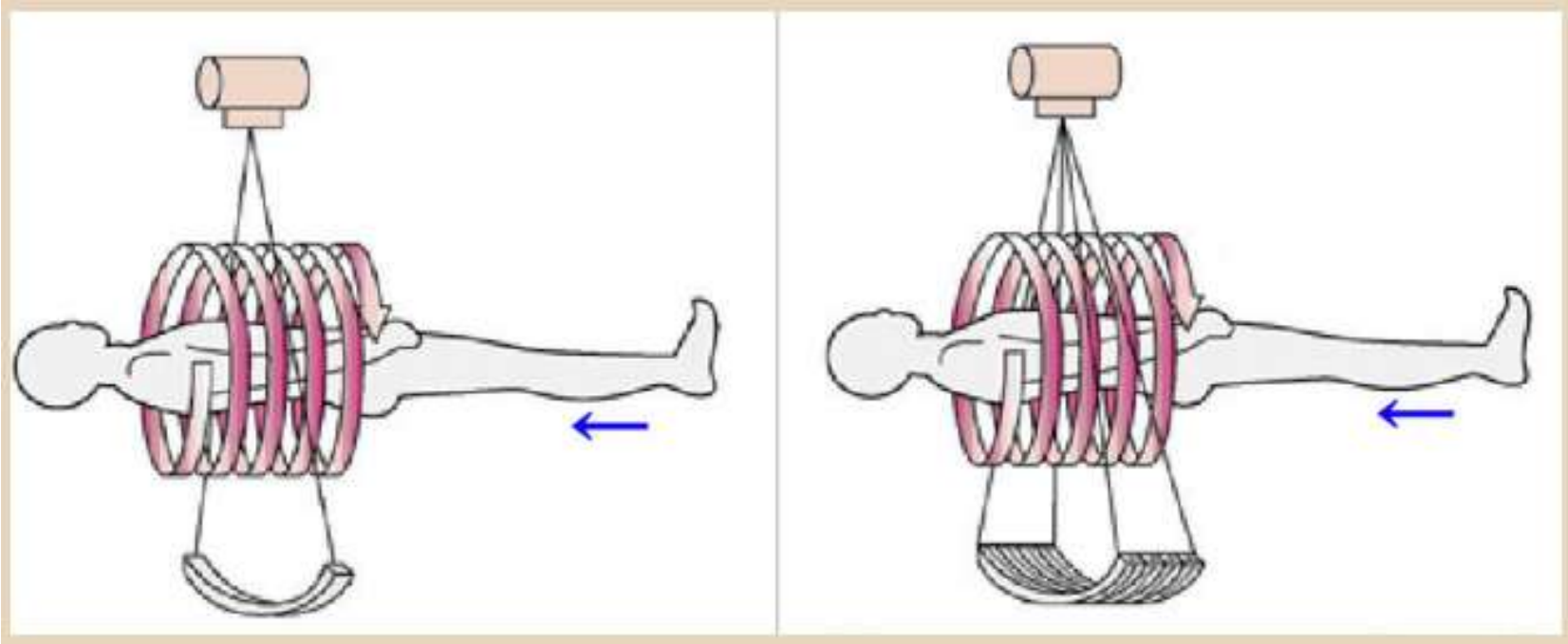


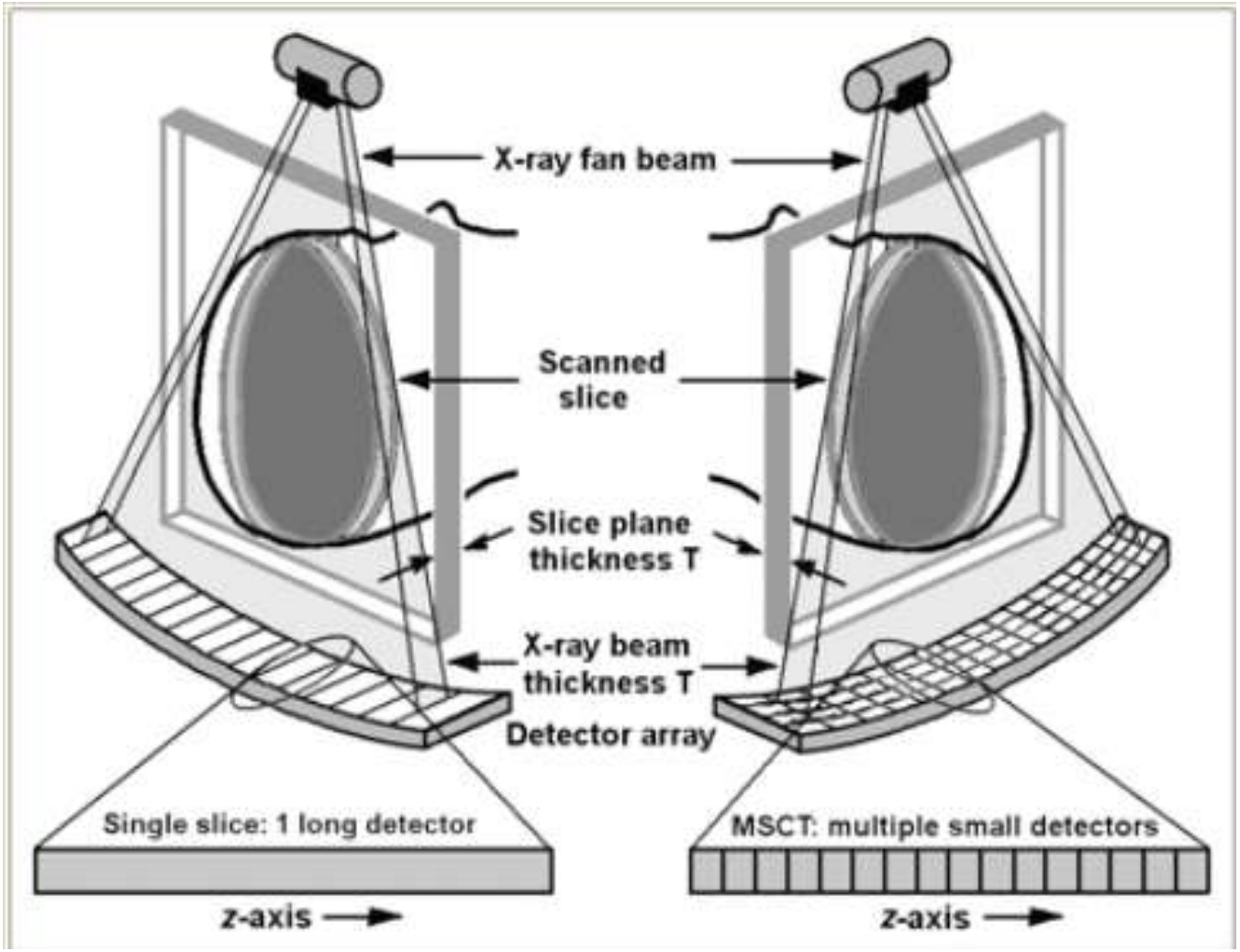
(A) Pitch is low. The table moves less for each tube revolution. The image is sharper.
(B) Pitch is high. The table moves further for each revolution so the resulting image is more blurred. The helix is stretched .

SSCT vs. MSCT

SSCT - single slice CT

MSCT - multiple slice CT




X-ray fan beam
Scanned slice
Slice plane thickness T
X-ray beam thickness T
Detector array
Single slice: 1 long detector
MSCT: multiple small detectors
z-axis
z-axis

scanning

- **sequential** - sequence of complete gantry rotation followed by table movement with the patient
- **spiral** - continuous gantry rotation and table movement.
  - volume of raw data is generated, from which axial images are reconstructed using interpolation
  - slip ring technology allowed transmission of energy to rotating gantry without the need of cables.

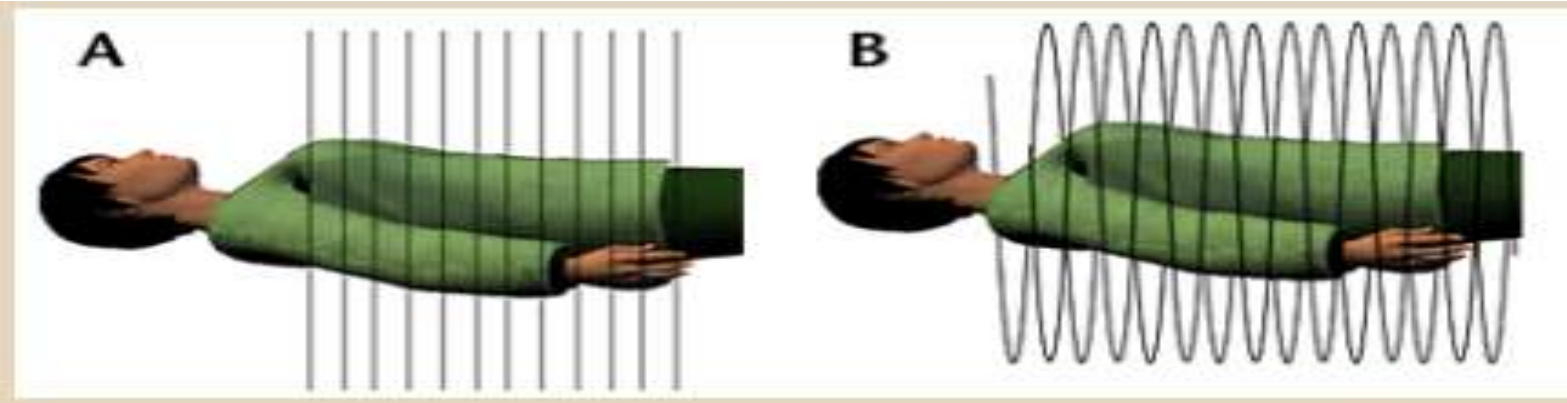
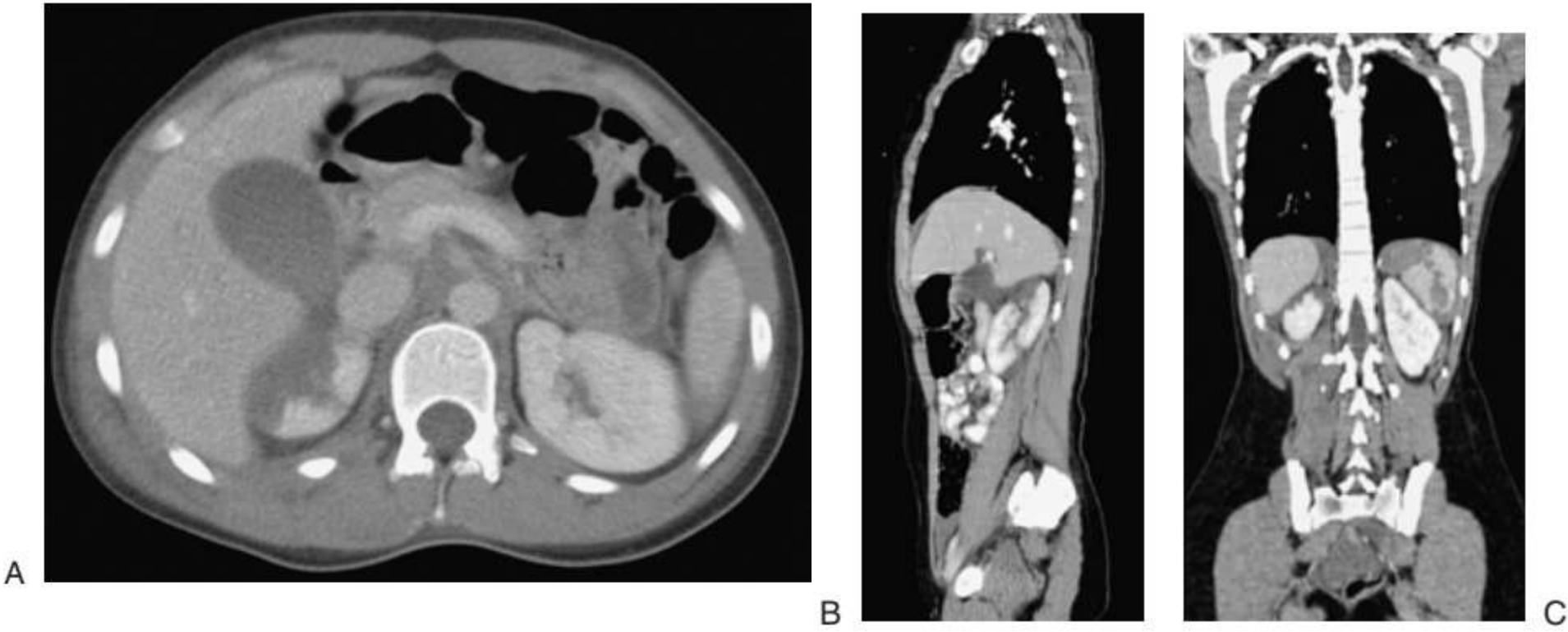
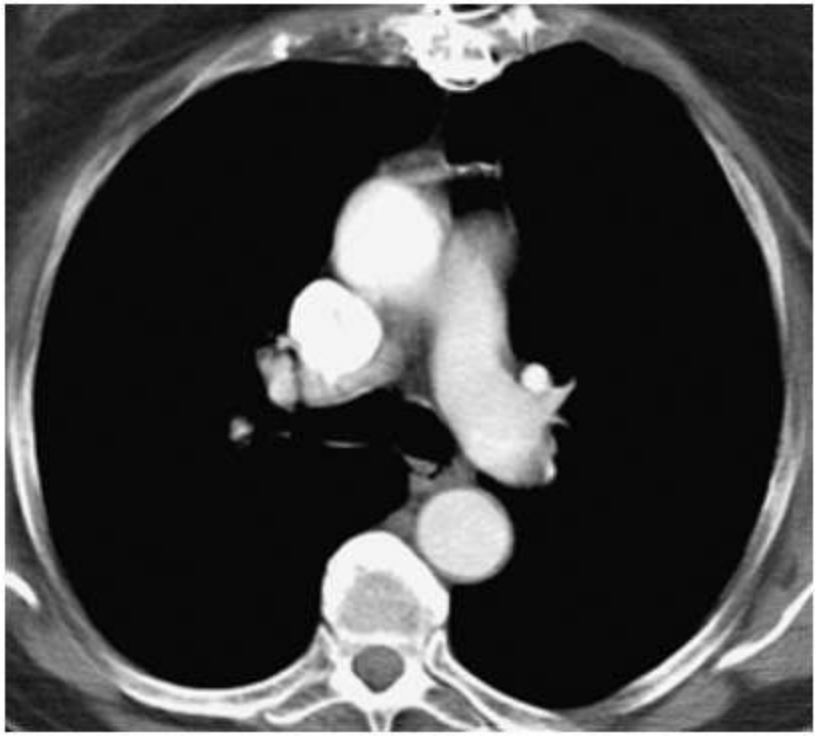


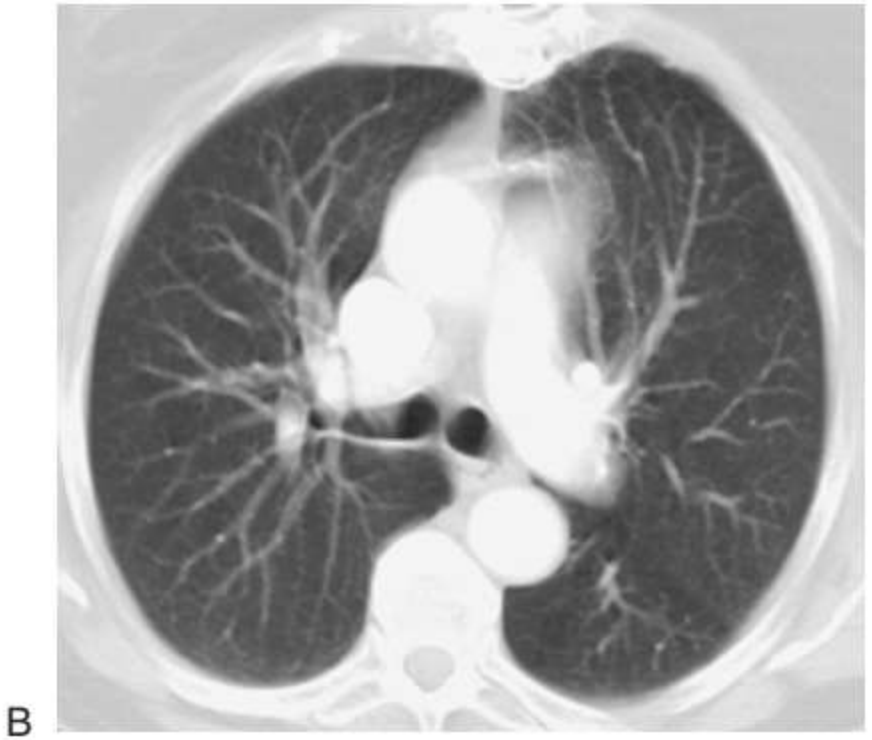
Image reconstruction

- The acquisition of volumetric data using spiral CT means that the images can be postprocessed in ways appropriate to the clinical situation.
  - **Multiplanar reformatting (MPR)** – by taking a section through the three dimensional array of CT numbers acquired with a series of contiguous slices, sagittal, frontal (coronal) and oblique planes can be viewed along with the standard transaxial plane



The three images demonstrate a hemoperitoneum, shattered right kidney and a lacerated spleen in **(A)** axial **(B)** sagittal **(C)** coronal





These two images are of the same section, viewed at different window settings.
(A) A window level of +40 with a window width of 350 reveals structures within the mediastinum but no lung parenchyma can be seen.
(B) The window level is –600 with a window width of 1500 Hounsfield units. This enables details of the lung parenchyma to be seen, at the expense of the mediastinum.

CT window

- window width
- window level (center)

- mediastinal window
  - W 350, L 50
  - lowest HU = -125 (50-350/2)
  - highest HU = 225 (50+350/2)
- lung window
  - W 2000, L -200
- bone window
  - W 1500, L 300
- brain window
  - W 80, L 3

What Is a CT Scan with Contrast?

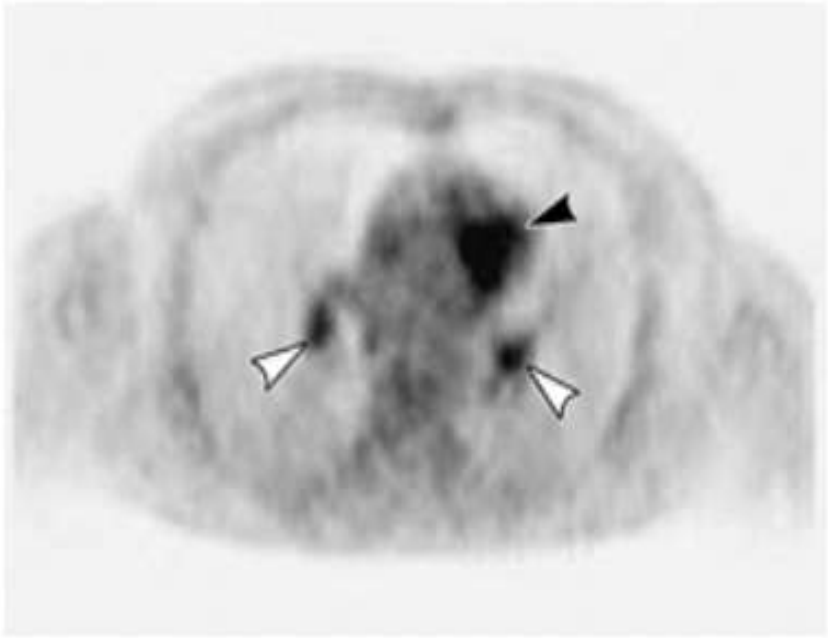
- In a CT scan, dense substances like bones are easy to see. But soft tissues don't show up as well. They may look faint in the image. To help them appear clearly, you may need a special dye called a contrast material. They block the X-rays and appear white on the scan, highlighting blood vessels, organs, or other structures.
- Contrast materials are usually made of iodine or barium sulfate. You might receive these drugs in one or more of three ways:
- **Injection**: The drugs are injected directly into a vein. This is done to help your blood vessels, urinary tract, liver, or gallbladder stand out in the image.
- **Orally**: Drinking a liquid with the contrast material can enhance scans of your digestive tract, the pathway of food through your body.
- **Enema**: If your intestines are being scanned, the contrast material can be inserted in your rectum.
- After the CT scan, you'll need to drink plenty of fluids to help your kidneys remove the contrast material from your body.

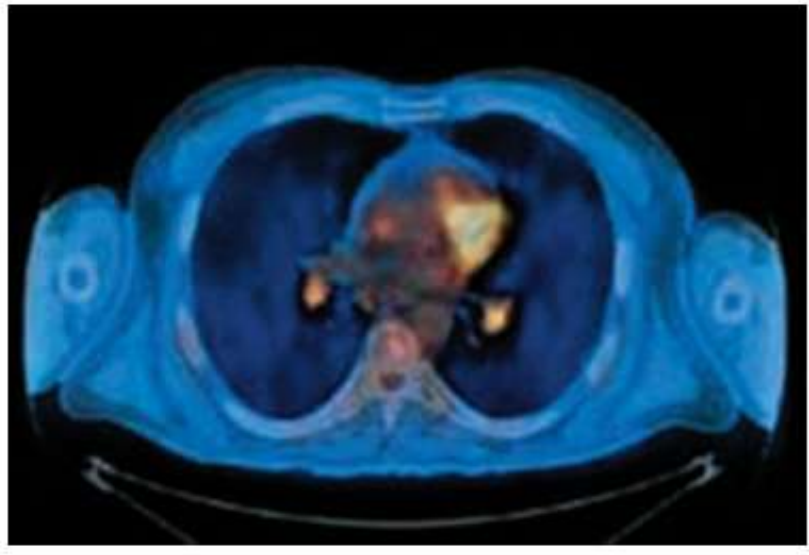
Side effect of contrast materials

- Some people are allergic to the contrast materials. Most of the time, the reaction is mild. It can lead to itchiness or a rash. In very few cases, the dye may trigger a life-threatening reaction. For this reason, the health care provider may want to monitor the patient for a short period after the CT scan test. Must be to tell the doctor about any allergies to any medications, seafood, or iodine.

Positron emission tomography (PET)/CT

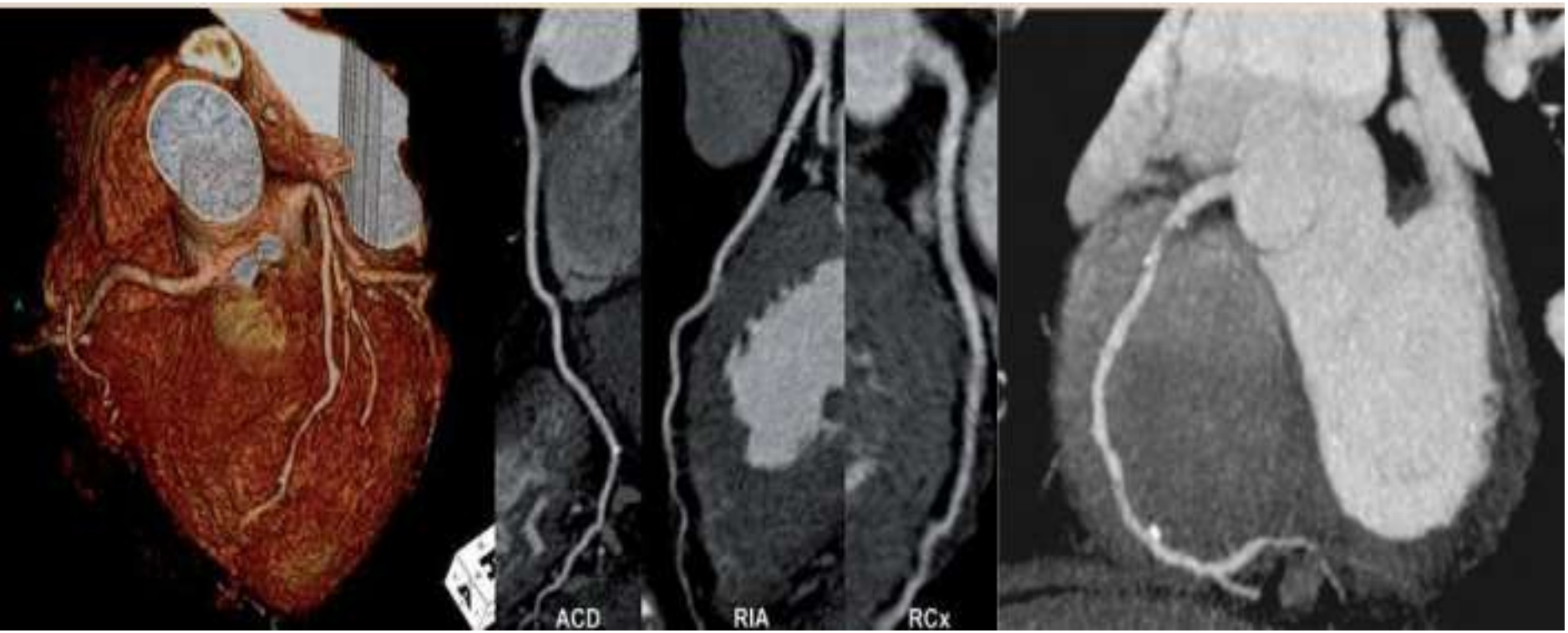
- PET allows the detection of glucose uptake in tissues. The radiopharmaceutical utilized is 18-FDG (18-fluorodeoxy-D-glucose). The technique has particular use in the detection of malignant and inflammatory lesions where glucose uptake is increased.
- PET and CT imaging can be performed in the same machine, thus providing superimposed CT and PET images of pathology in a single examination. This results in a complementary, overlapping display of anatomical and functional/ metabolic information, which can be used in the accurate and efficient diagnosis and follow-up of cancer patients .



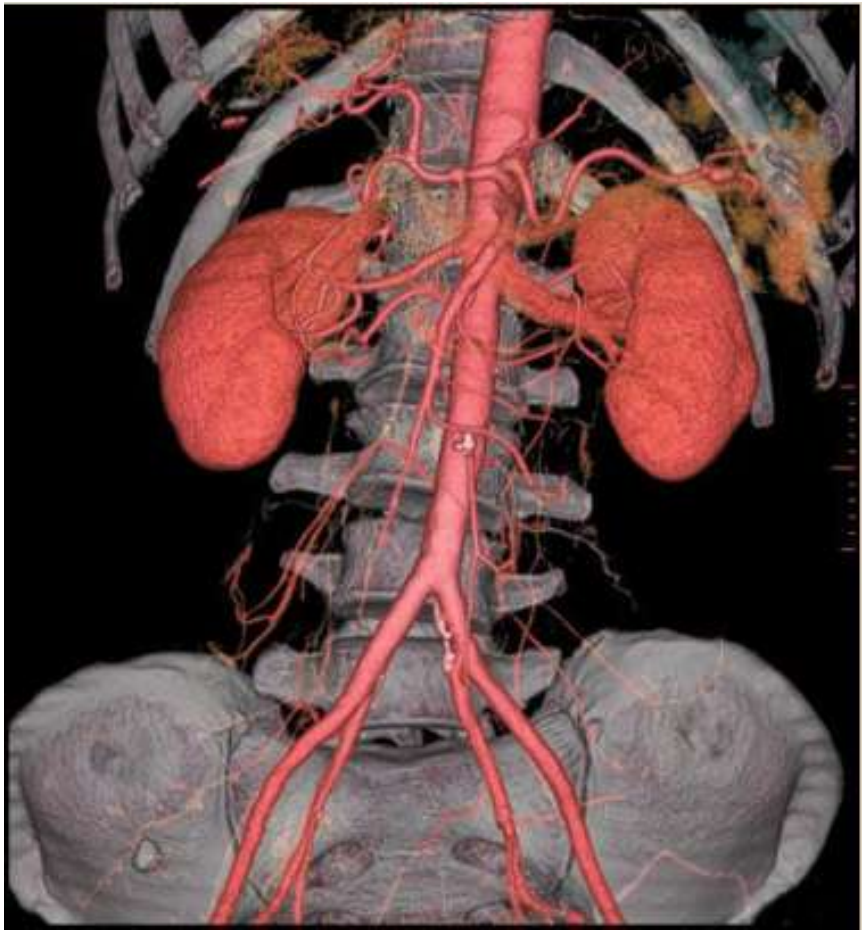


(A) *CT of thorax showing soft tissue masses (lymphadenopathy – white arrowheads) adjacent to the pulmonary vessels.* ***(B)*** *PET scan at the same axial level showing increased metabolic activity (white arrowheads).* ***(C)*** *PET/CT fused image correlating increased metabolic activity within lymph node masses implying pathological enlargement*

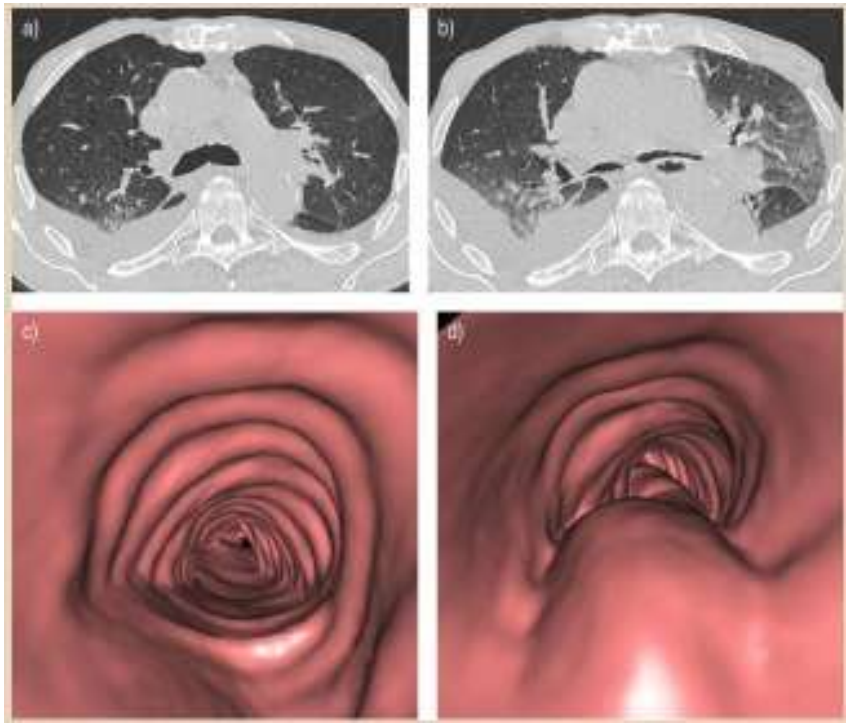
CT coronarography

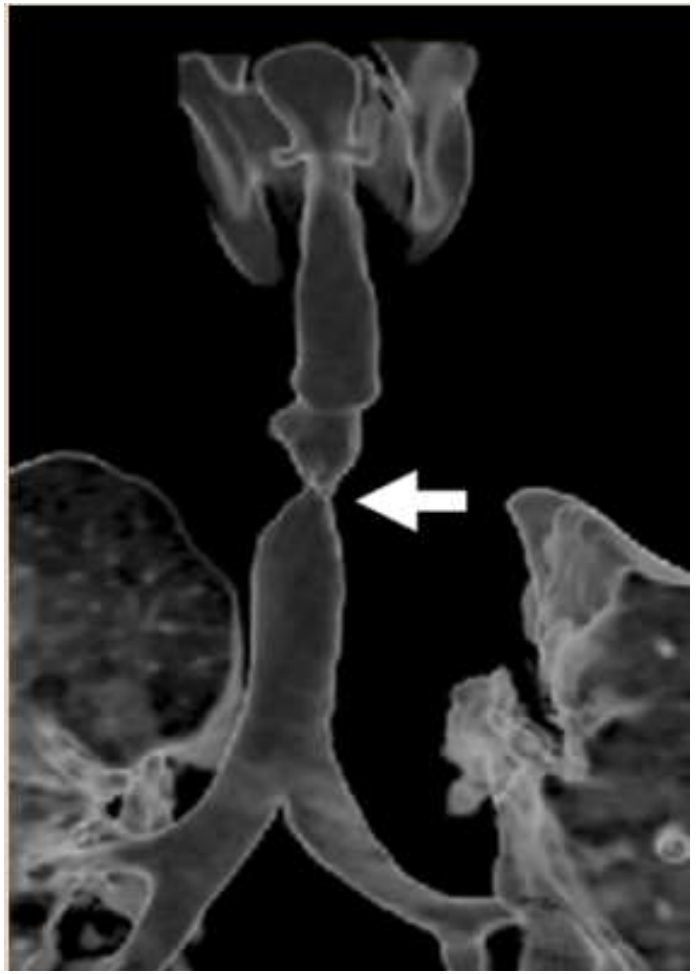


CT angiography

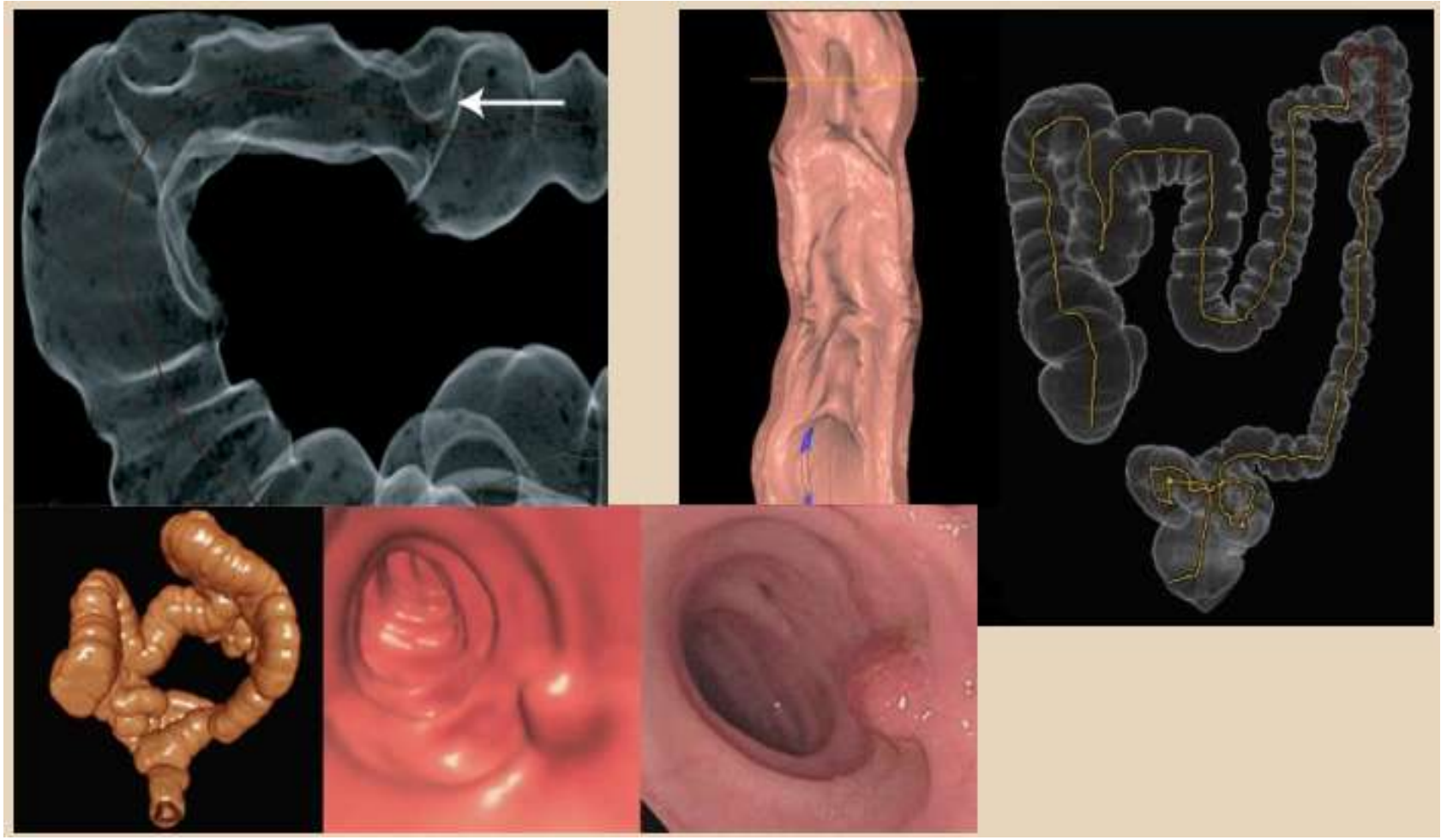


CT endoscopy

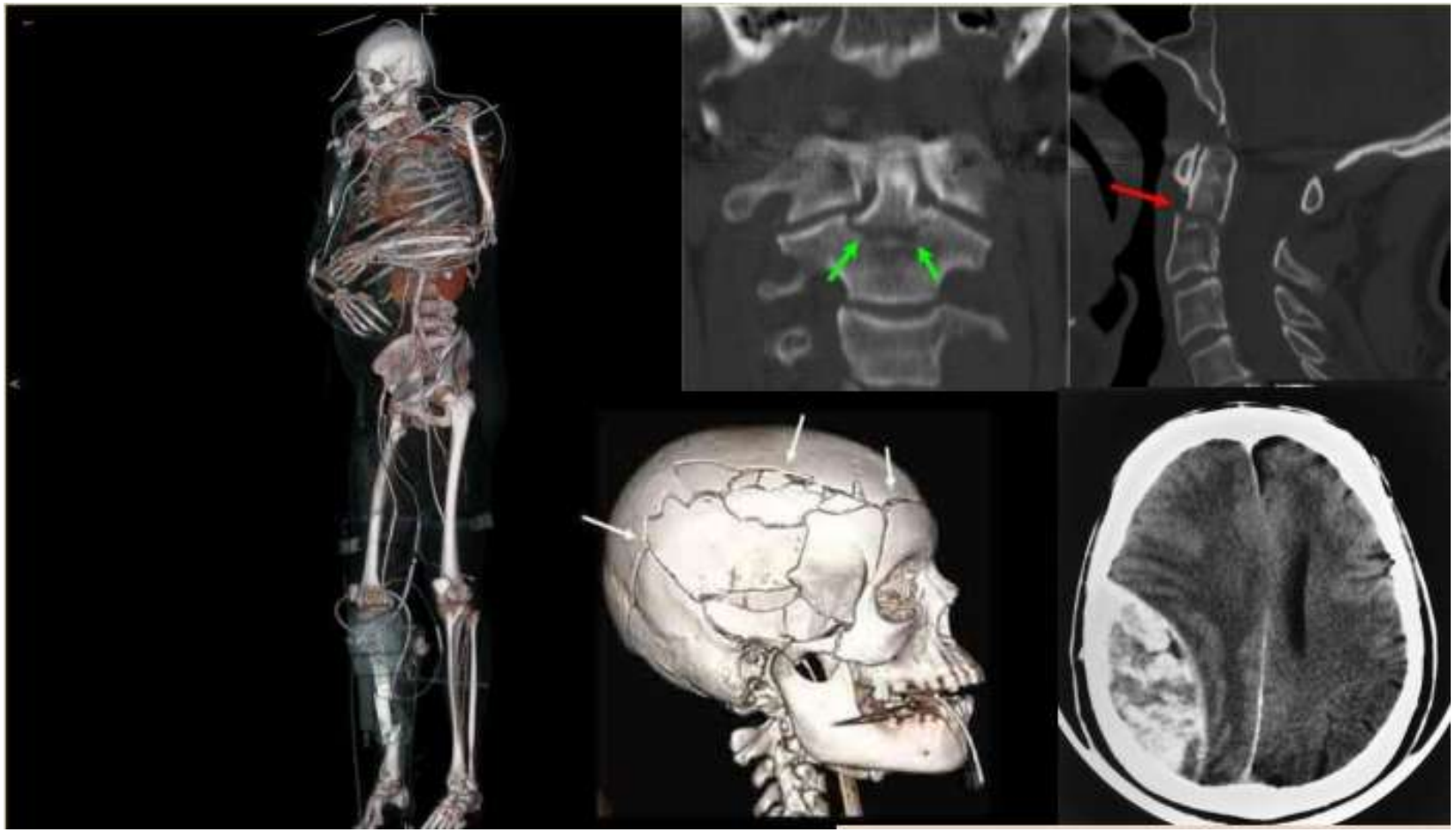




CT endoscopy



CT in polytrauma



CT in acute stroke