MEDICAL IMAGING OF THE VERTEBRAE

"Vertebrae are your friends"

Matthew Harper

MS-IV

LECTURE OBJECTIVES

- **INTRODUCE THE MOST COMMON MODALITIES OF MEDICAL IMAGING AND BASIC TECHNIQUES FOR READING THESE IMAGES**
  - **Conventional Radiograph (CR or X-Ray)**
  - **Computed Tomography (CT)**
  - **Magnetic Resonance Imaging (MRI)**

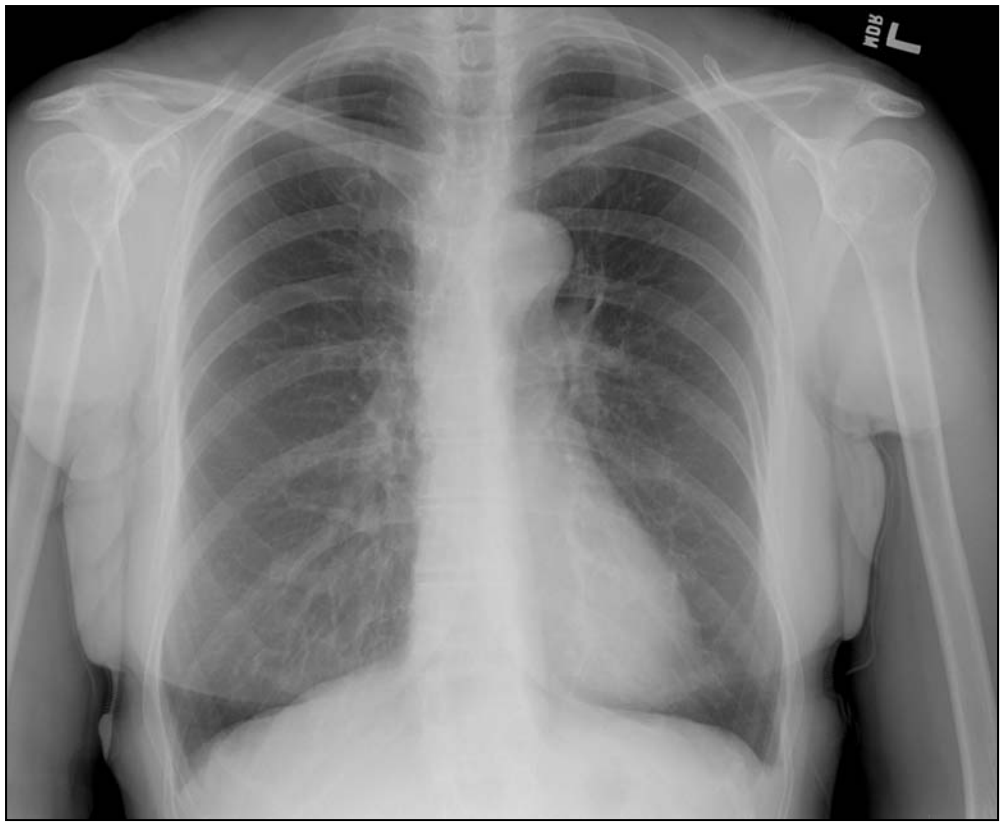
- REVIEW THE ANATOMY OF THE VERTEBRAL COLUMN AND ASSOCIATED CLINICAL COMPLICATIONS

CONVENTIONAL RADIOGRAPH (CR or X-RAY)

- X-Rays are produced by an emitter and pass through the body onto a detector.
- The detector can be an electronic sensor to produce a digital image or a physical film that is sensitive to X-rays.

CONVENTIONAL RADIOGRAPH

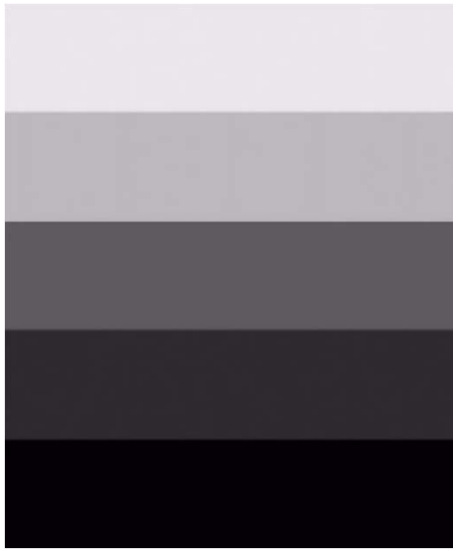
- As the detector is exposed to X-Rays the image turns BLACK.
- DENSE matter blocks X-Rays, so these areas appear WHITE.
- BRIGHT areas are termed RADIOPAQUE because X-Rays do not pass through.
- DARK areas are termed RADIOLUCENT because they allow the transmission of X-Rays.



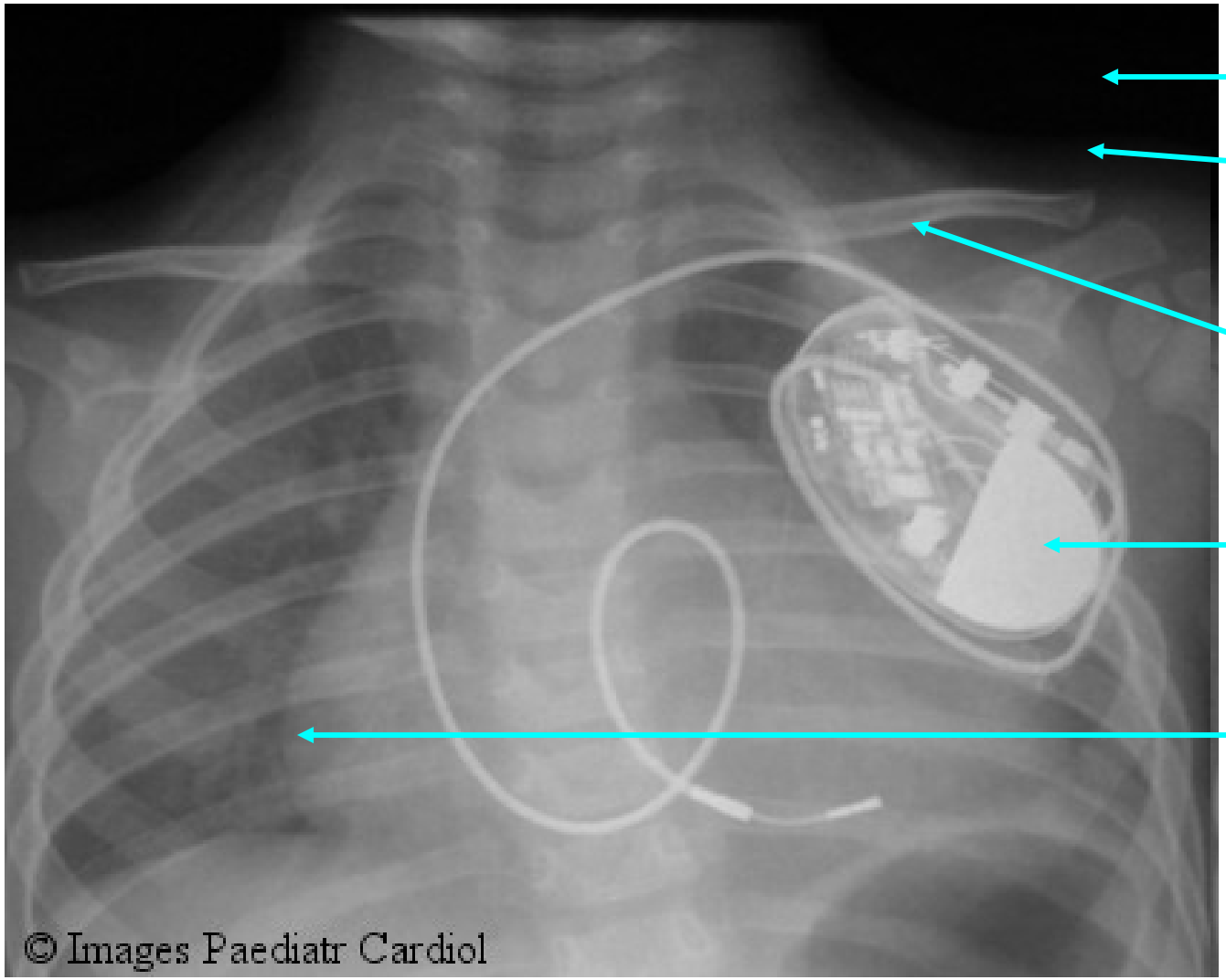
CONVENTIONAL RADIOGRAPH

- The 5 Radiographic Densities:

1) METAL (WHITE)
2) BONE / CALCIUM
3) SOFT TISSUE / FLUID
4) FAT
5) AIR (BLACK)



THE 5 RADIOGRAPHIC DENSITIES



AIR

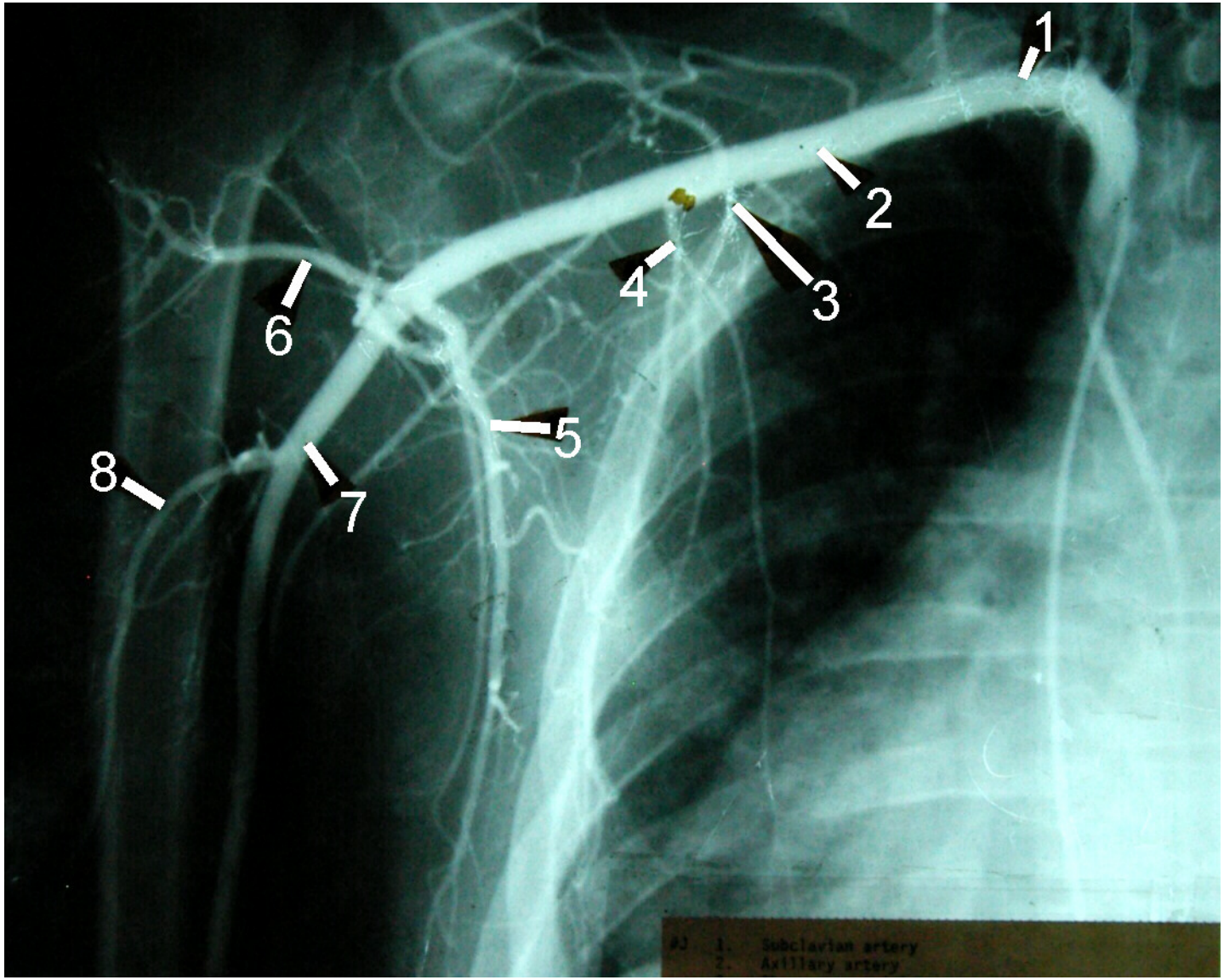
FAT
(SUBCUTANEOUS)

BONE
(CLAVICLE)

METAL
(PACEMAKER)

SOFT TISSUE
(RIGHT HEART
BORDER)

ANGIOGRAMS ARE PRODUCED BY INJECTING RADIOPAQUE DYES INTO THE CIRCULATORY SYSTEM. THESE DYES GIVE VESSELS A HIGH CONTRAST DENSITY ON RADIOGRAPHIC IMAGES.



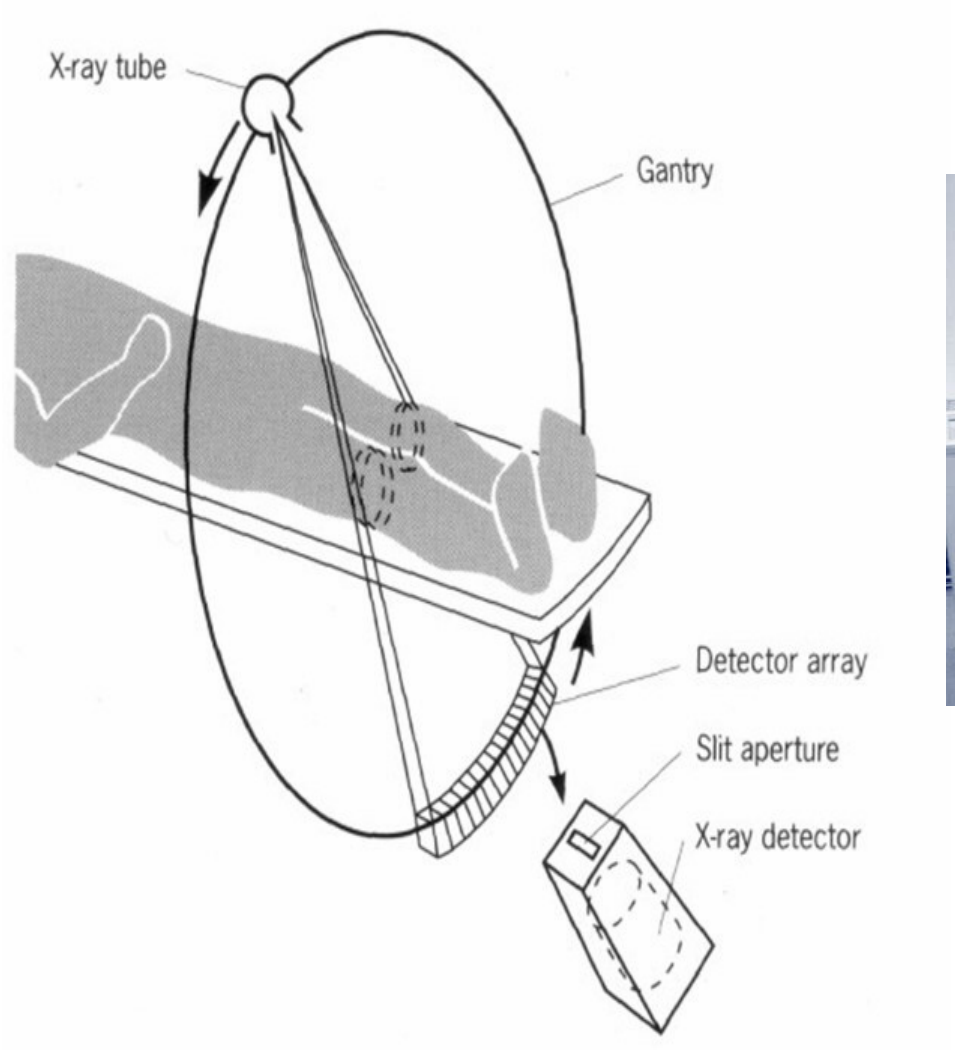
ANGIOGRAM OF AXILLARY ARTERY

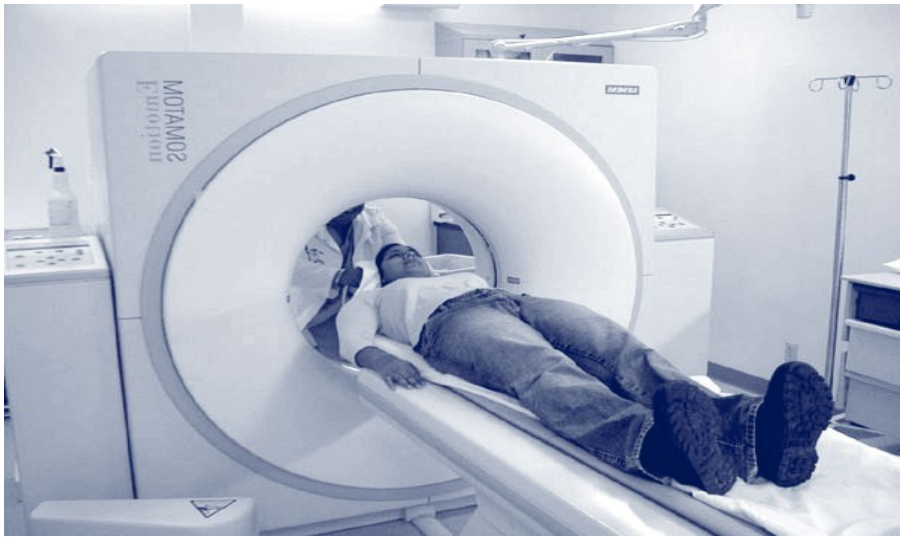
1- Subclavian a.
2- Axillary ax.
3- Thoracoacromial a.
4- Lateral Thoracic a.
5- Subscapular a.
6. Post. Humeral Circumflex a.
7- Brachial a.
8- Profunda brachii (Deep brachial) a.

COMPUTED TOMOPGRAPHY (CT)

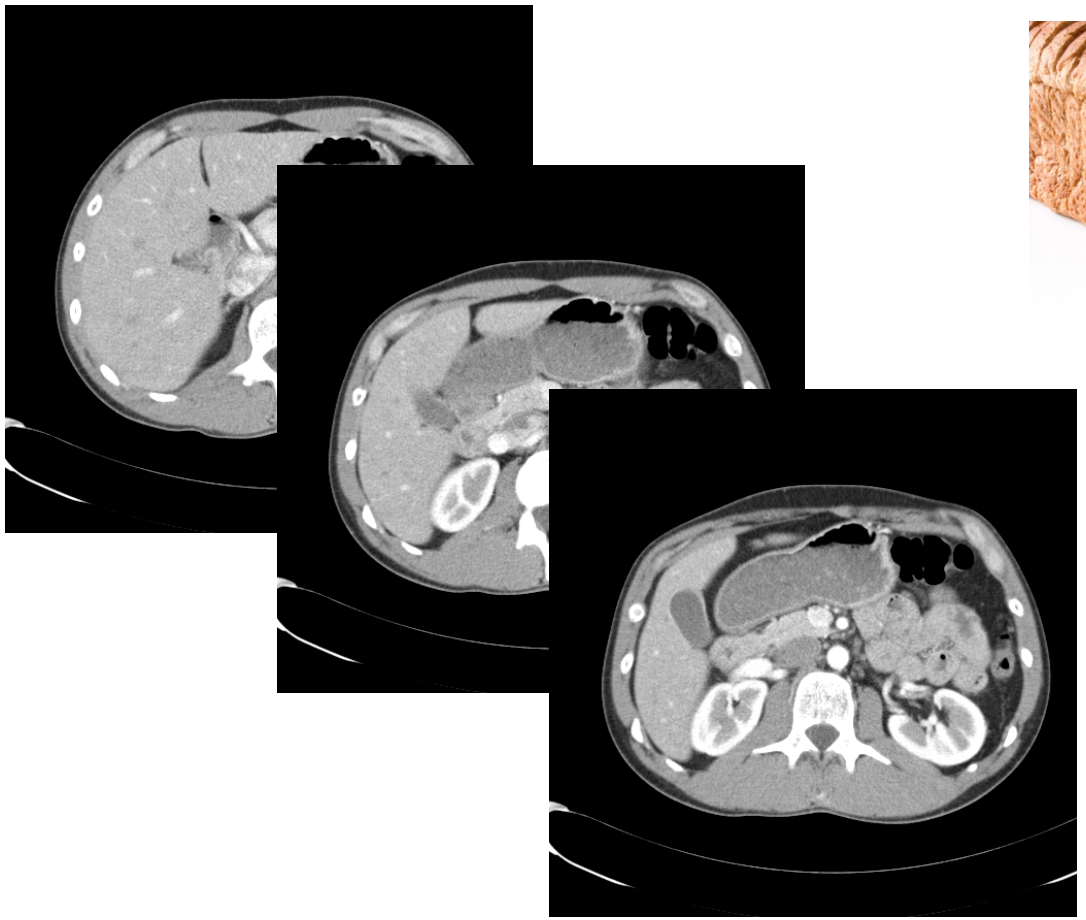
- TOMOGRAPHY comes from the Greek *tomos* (slice) and *graphein* (to write).
- Basically, it is a method to produce images of the inside of the body by using a large number of X-Ray slices.
- The slices are made using a rotating X-Ray device to take 360° imaging of a single plane. The patient is then moved back and forth along the machine to get multiple slices.

COMPUTED TOMOGRAPHY (CT)





A SLICE IS PRODUCED AT EACH PRESET LEVEL DURING THE SCAN. BY “STACKING” THE IMAGES A SENSE OF THE WHOLE BODY CAN BE OBTAINED.

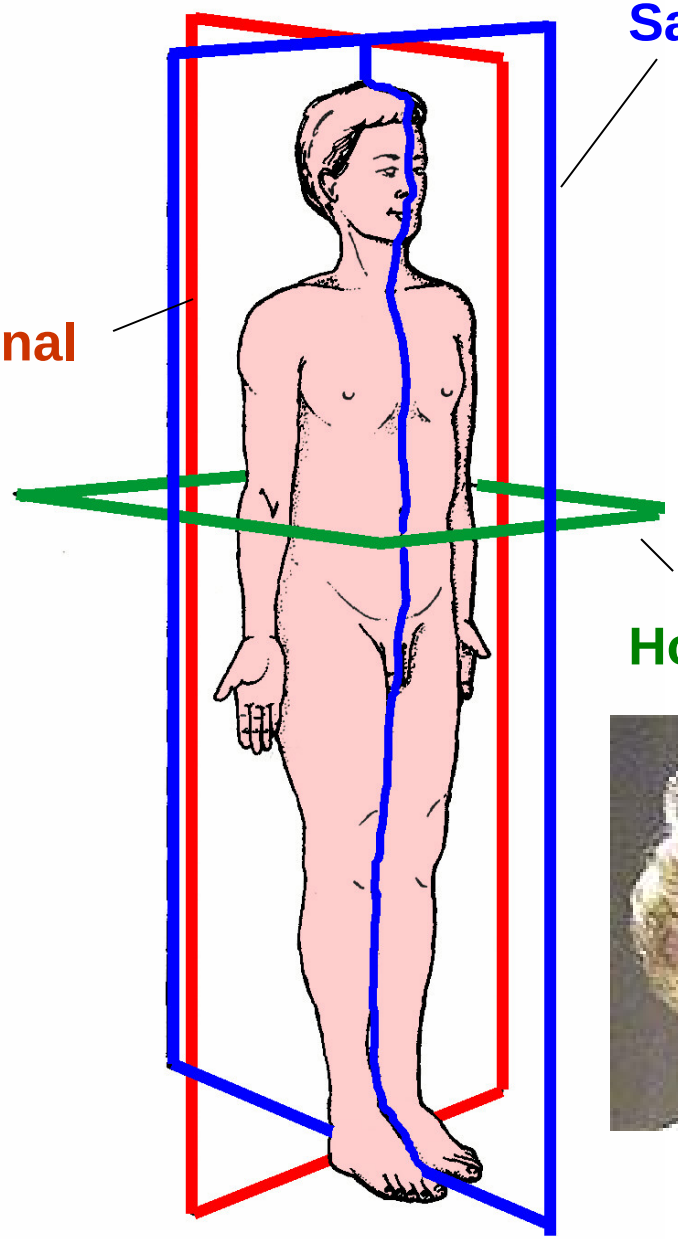


ANATOMICAL PLANES

1) SAGITTAL PLANE - divides body in RIGHT and LEFT parts (Median Sagittal Plane-divides body into right and left halves)

2) CORONAL PLANE - divides body into FRONT and BACK parts

3) HORIZONTAL PLANE Plane = transverse plane - cross section-divides body into TOP and BOTTOM parts perpendicular to long axis of body



Corona = crown

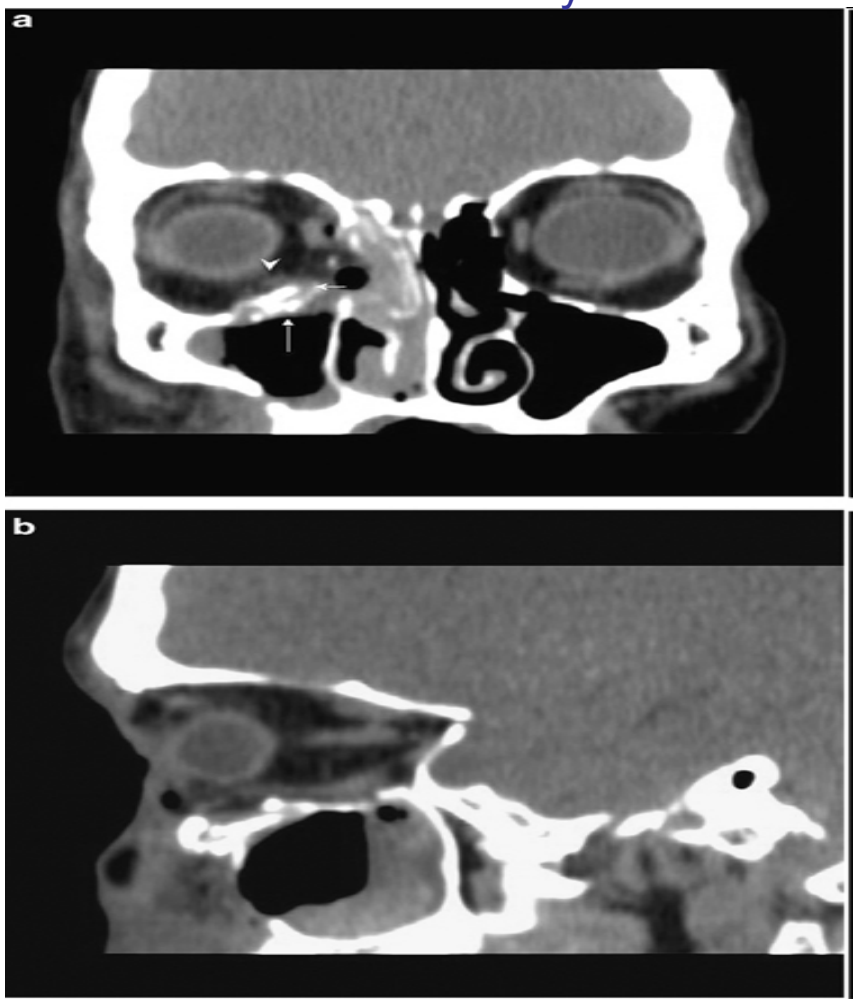
COMPUTED TOMOGRAPHY (CT)

- Standard CT Images are taken in the HORIZONTAL PLANE. Since this is a view along the long axis of the body, it is also called an AXIAL image.
- Hence, Computed Axial Tomography or “CAT Scan”

COMPUTED TOMOGRAPHY (CT)

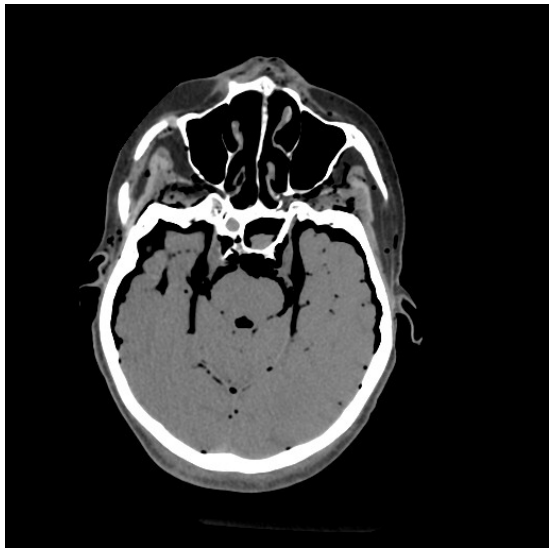
- With more modern computers, AXIAL data can be used to make reconstructions in the CORONAL or SAGITTAL PLANES.
- Oblique reconstructions in non-anatomical planes are also possible, allowing the body to be visualized from any angle the physician wants to see.

Coronal CT of Eyes

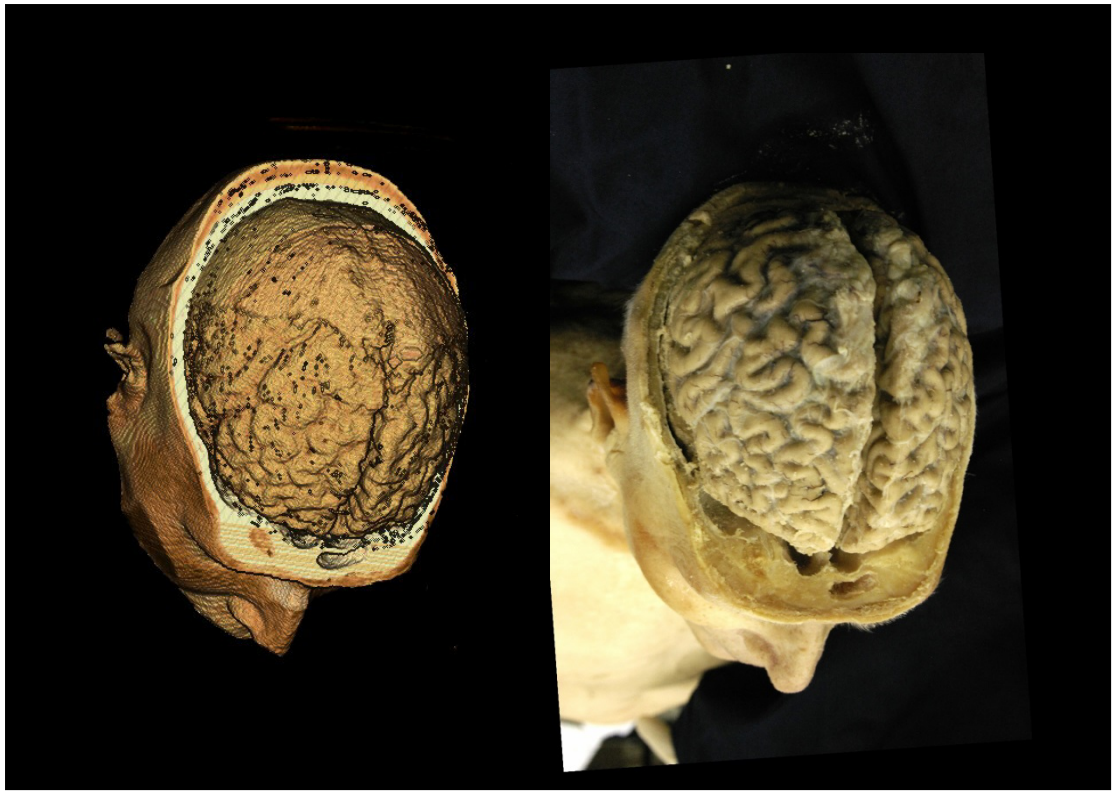


Sagittal CT of an Eye

INTERSLICE DISTANCE = 0.625 mm



HIGH RESOLUTION 3D RECONSTRUCTION OF BODY STRUCTURES FROM CT OF CADAVERS

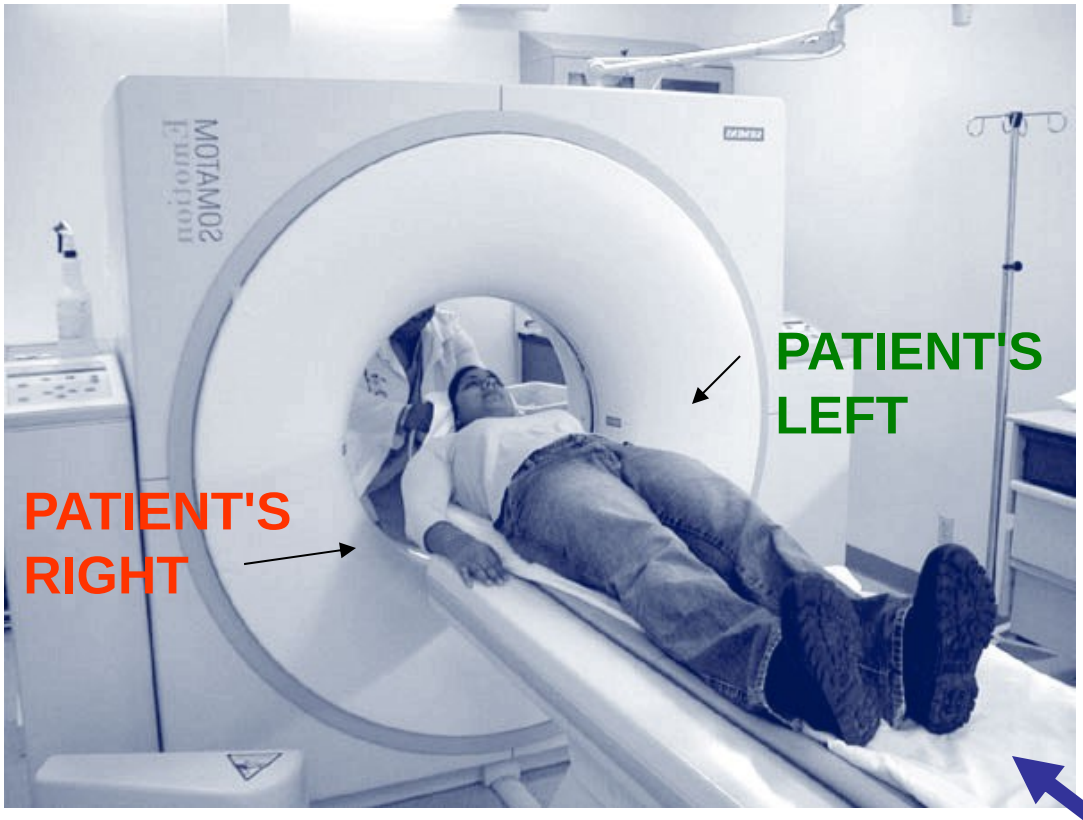


RECONSTRUCTION

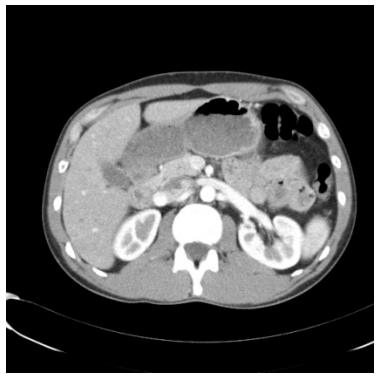
PHOTO OF PROSECTION IN GROSS LAB: SEE IN HEAD AND NECK

RECONSTRUCT BREAD FROM SLICES

BY CONVENTION, THE VIEW OF AXIAL CT IMAGES IS LIKE VIEWING PATIENT FROM FOOT OF HOSPITAL BED



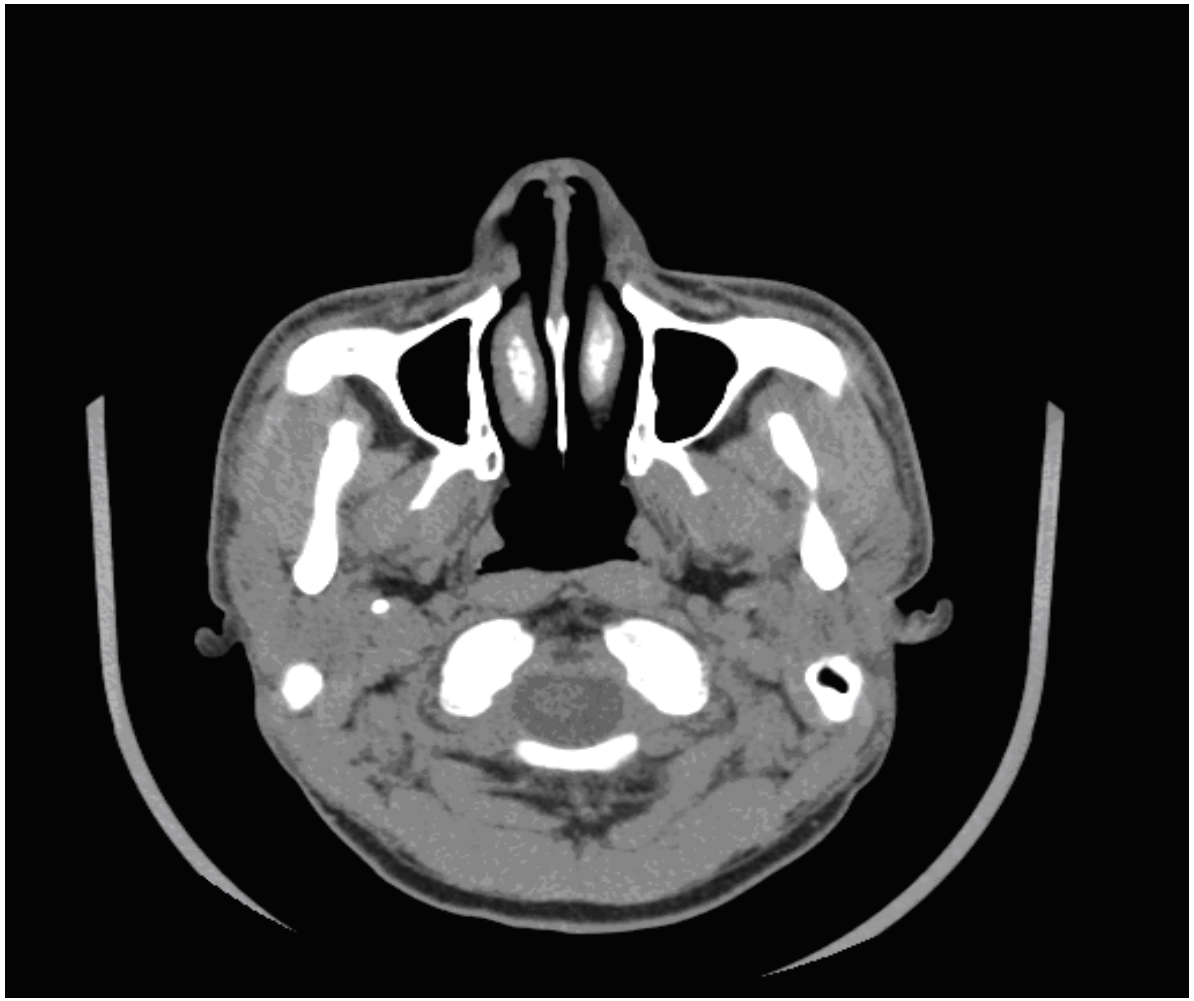
VIEW PATIENT FROM FEET



CT ORIENTATION

ANTERIOR

NOSE



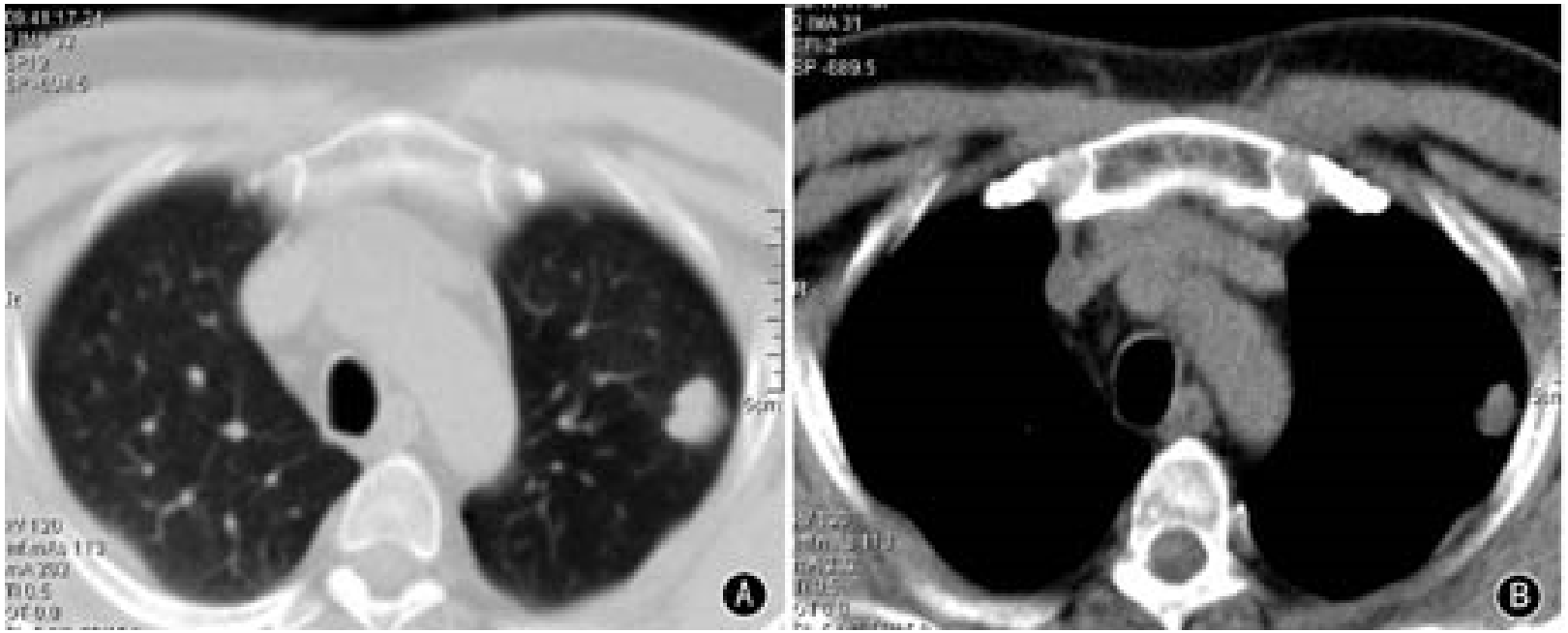
PATIENT'S RIGHT

PATIENT'S LEFT

POSTERIOR

COMPUTED TOMOGRAPHY (CT)

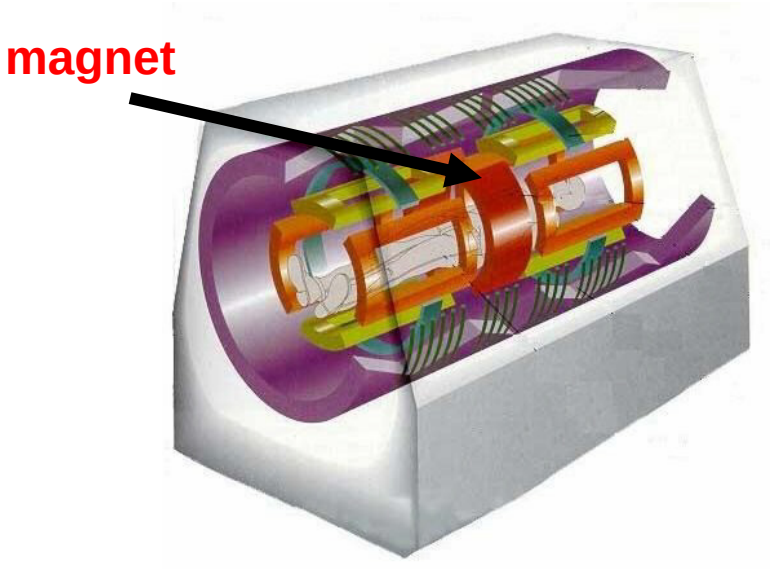
CT images can be digitally manipulated to enhance the appearance of certain tissue types. This process is called “WINDOWING”. Below, the same CT is seen in a LUNG WINDOW and a SOFT TISSUE WINDOW.
NOTE THE INCREASED DETAIL IN THE RESPECTIVE TISSUES.



LUNG WINDOW

SOFT TISSUE WINDOW

MAGNETIC RESONANCE IMAGING (MRI)

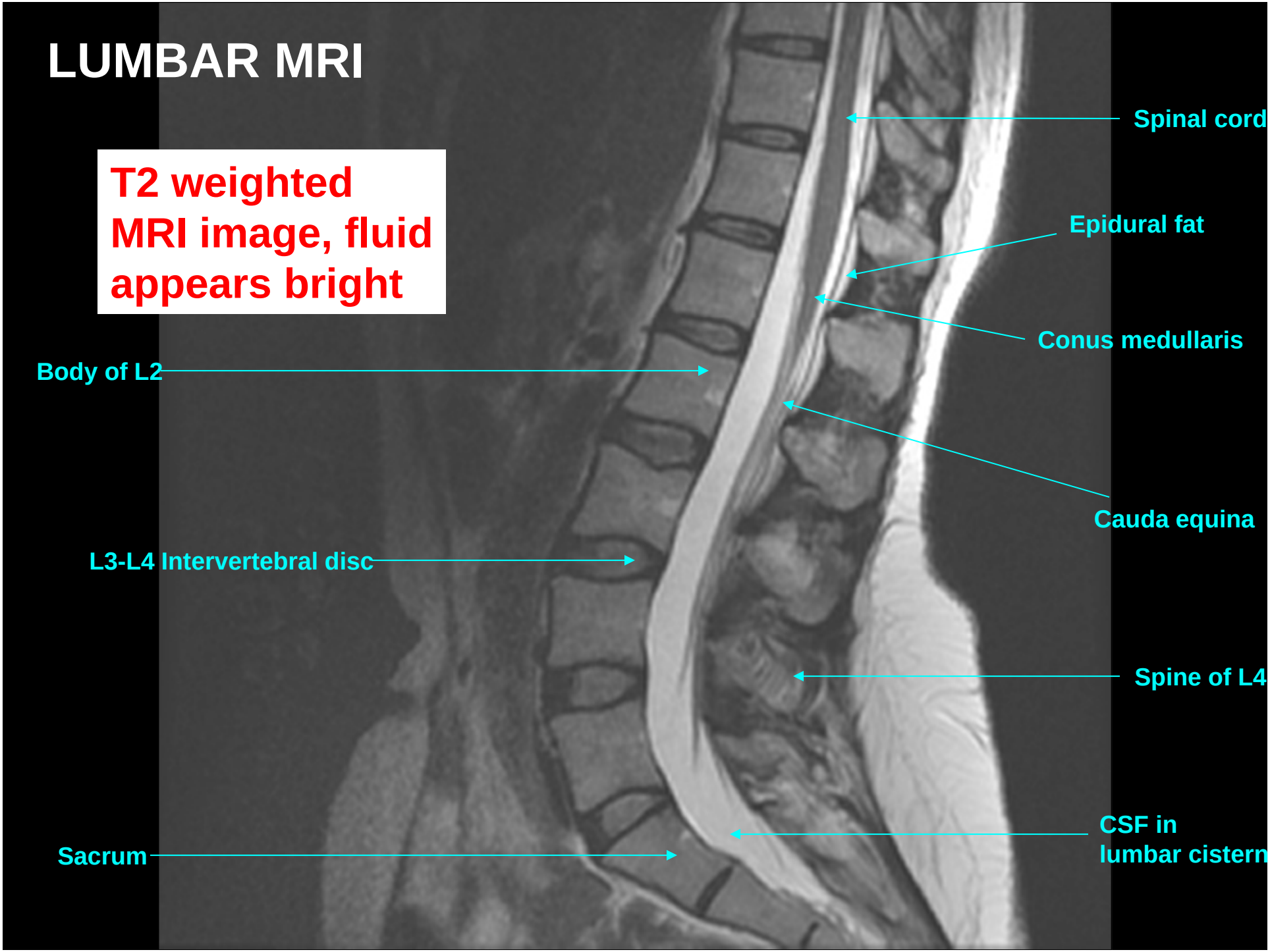


- MRI is very complicated. It uses a strong magnetic field which causes molecules in the body to align. A radiofrequency transmitter emits radio waves at a resonance frequency, causing some of the aligned molecules to flip. When the transmitter is turned off, the flipped molecules re-align and emit radio waves that can be picked up by the detector. This is used to create the image.

MAGNETIC RESONANCE IMAGING

metal hospital bed pulled into MRI machine

- No radiation exposure! Uses magnetic fields and radio waves.
- Metal in the body can move when placed in the magnetic field so MRI cannot be used in people with metallic implants such as pacemakers or in people with old metal injuries such as shrapnel or buckshot.
- There are many different ways to manipulate MRI images, but the most common are T1 weighted and T2 weighted images.
- In T1 images, fluid appears dark.
- In T2 images, fluid appears bright.


LUMBAR MRI
T2 weighted MRI image, fluid appears bright
Spinal cord
Epidural fat
Conus medullaris
Body of L2
Cauda equina
L3-L4 Intervertebral disc
Spine of L4
CSF in lumbar cistern
Sacrum

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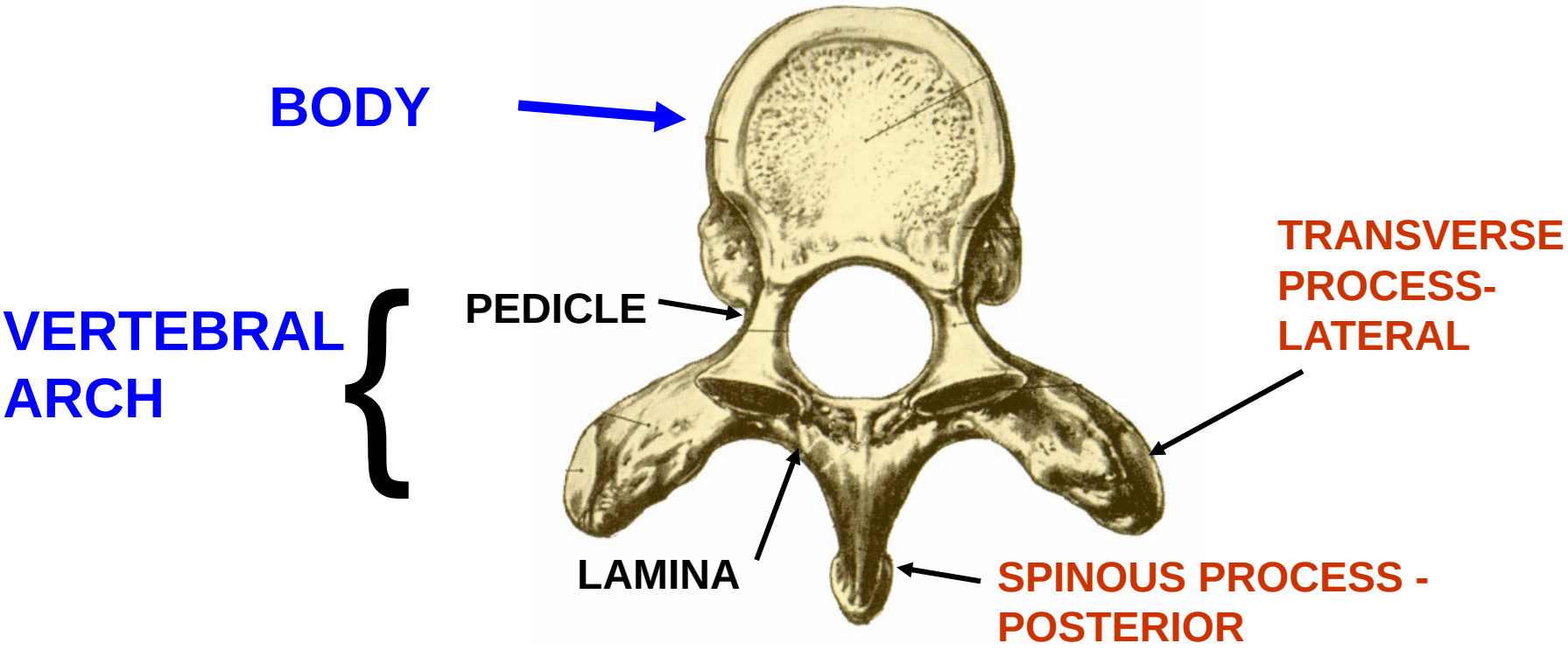
- **REVIEW THE ANATOMY OF THE VERTEBRAL COLUMN AND ASSOCIATED CLINICAL COMPLICATIONS**

TYPICAL VERTEBRA – by convention thoracic

1. BODY – anterior, solid transmits weight
2. VERTEBRAL ARCH – posterior, surrounds vertebral canal, spinal cord; consists of a) PEDICLES – project from body
   b) LAMINAE – unite to form arch posteriorly

ant.

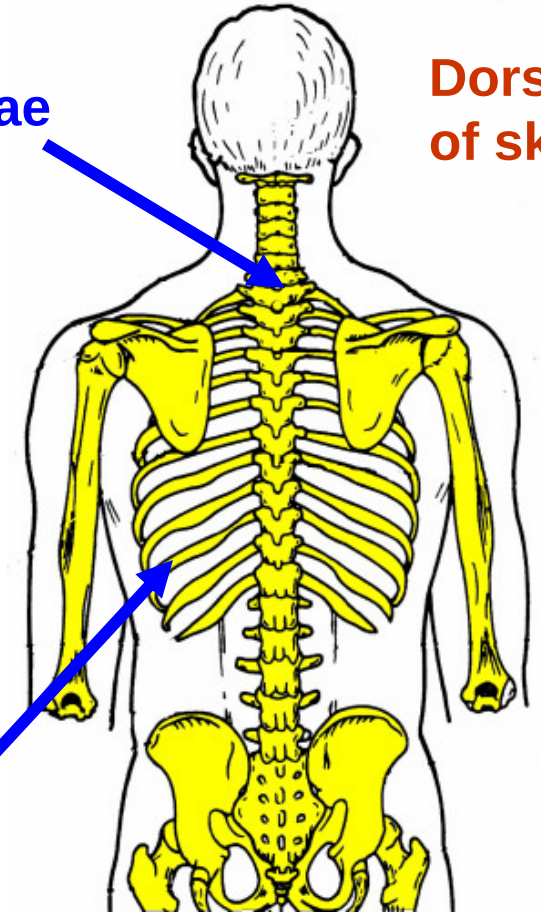


3. TRANSVERSE AND SPINOUS PROCESSES - projections from arch for muscle, ligament attach

RIBS- have bumps for articulation with vertebra

Vertebrae

Dorsal view
of skeleton

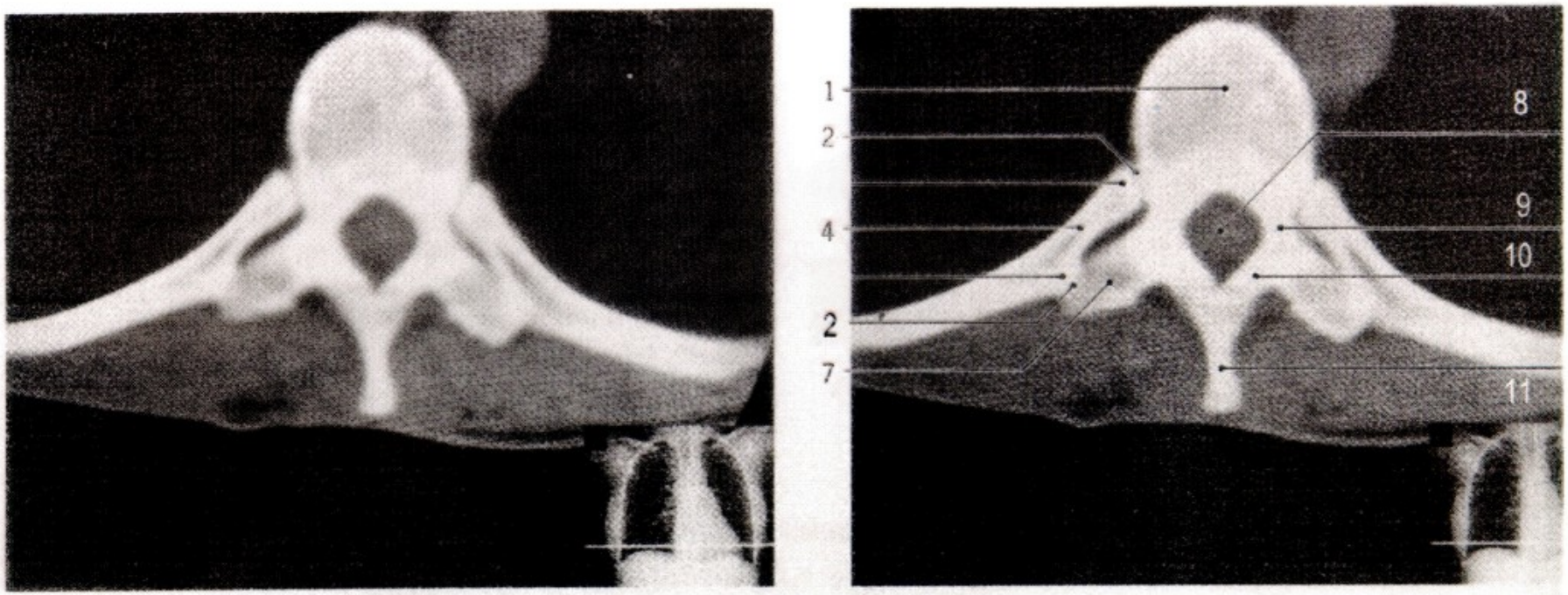


Ribs

Tubercle –
Articulates
with facet on
Transverse process

Head –
Articulates
with facet on Body

CT OF THORACIC VERTEBRA



Thoracic spine, axial CT

Level of vertebral body Th XI

1: Body of vertebra Th XI
2: Costovertebral joint

4: 11th rib

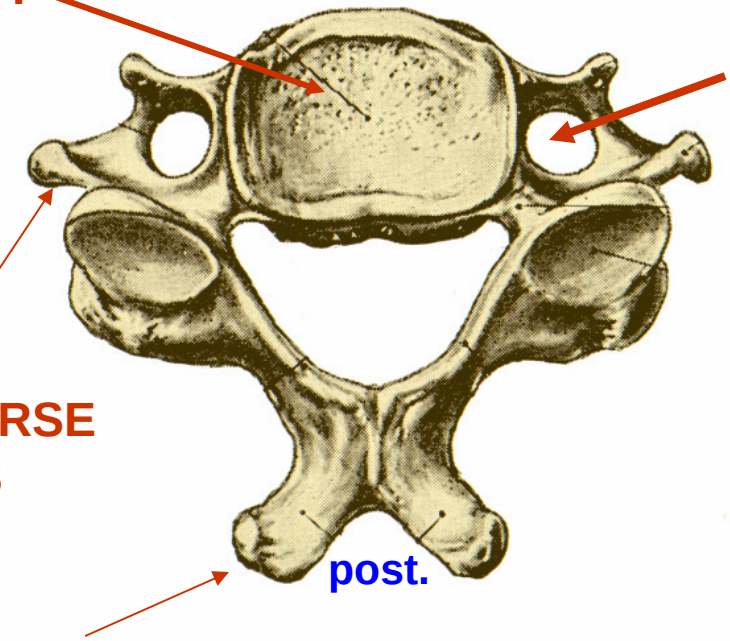
7: Transverse process Th XI
8: Vertebral foramen

9: Pedicle of vertebral arch
10: Lamina of vertebral arch
11: Spinous process of Th XI

NOSE

ID MUSCLES IN CT OF THORAX

CERVICAL VERTEBRA



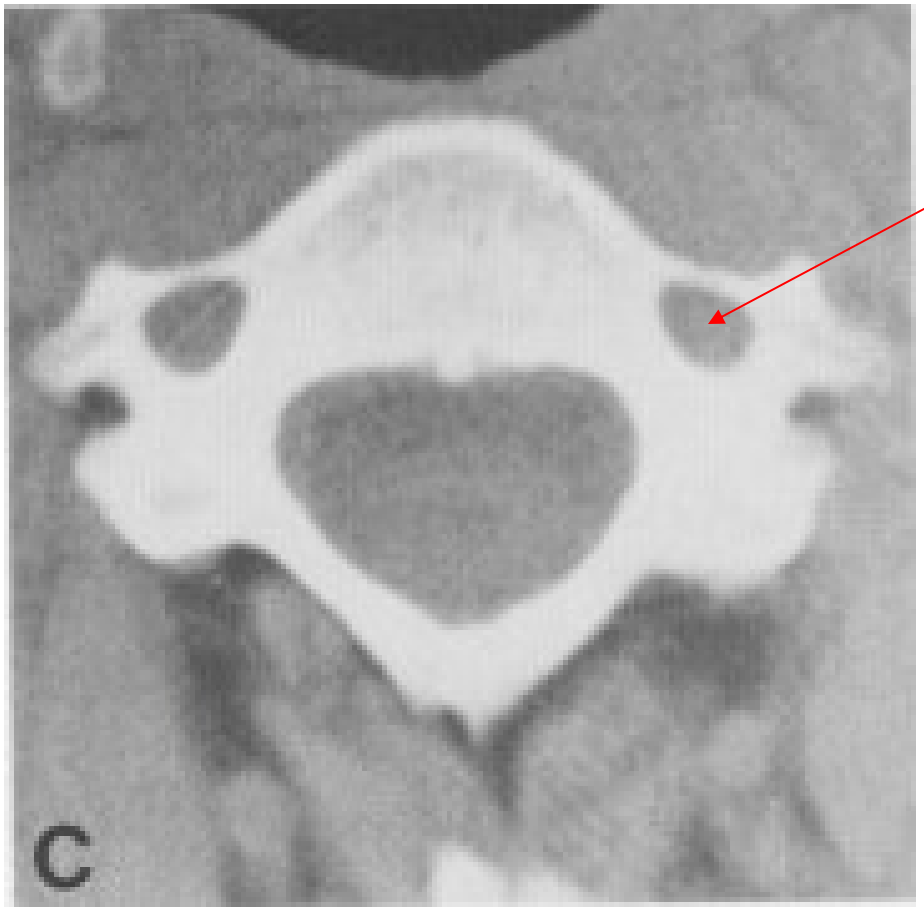
– body is small

Foramen Transversarium - in transverse process (C1-C7) for vertebral artery & veins

SPINOUS PROCESS – bifid (divided) for Ligamentum nuchae

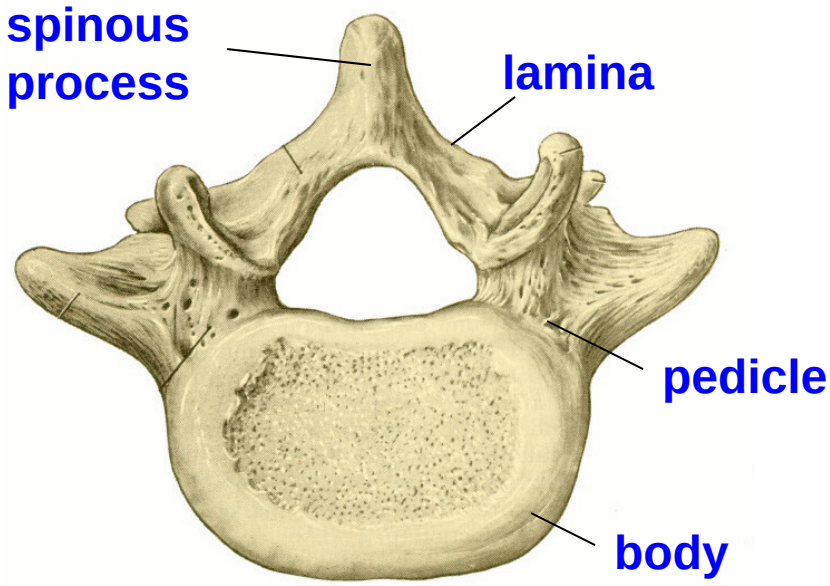
CERVICAL VERTEBRA - CT

Body - small

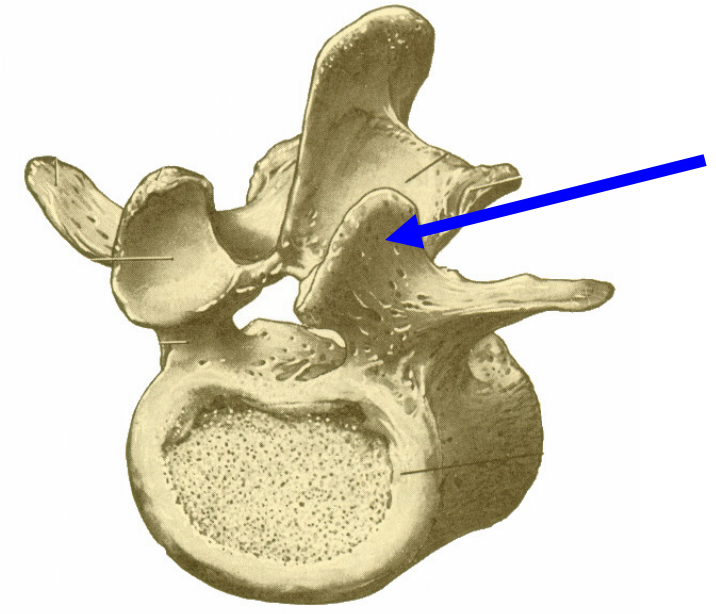


Foramen Transversarium

LUMBAR VERTEBRA



Bodies - hefty
Pedicles - stout
Lamina - thick
Spinous Processes- broad



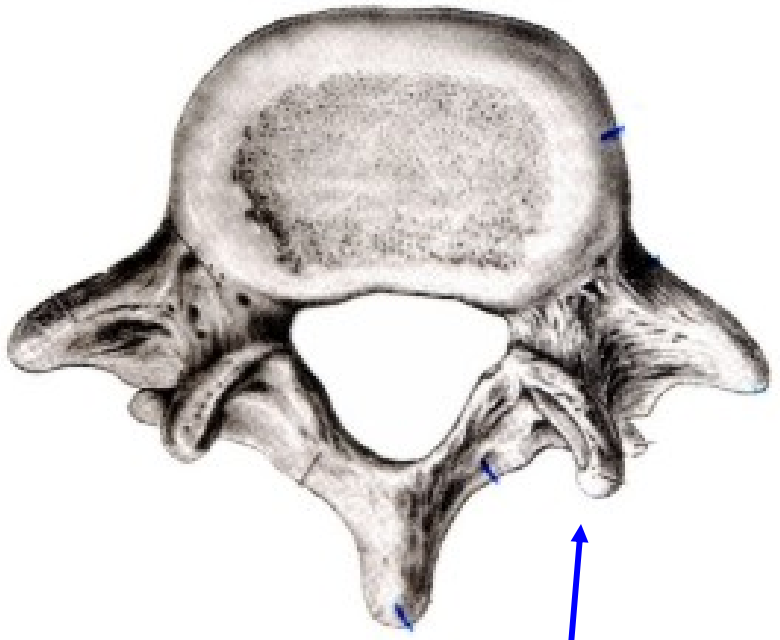
Articular processes in sagittal plane

LUMBAR VERTEBRA AXIAL CT

L3

Articular process

L5

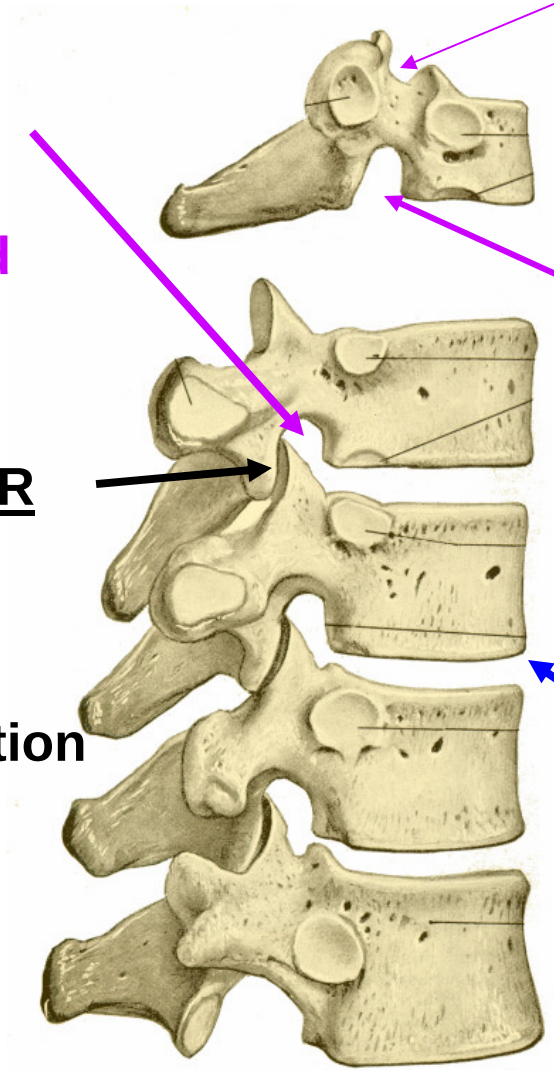


Articular process

LATERAL VIEW OF VERTEBRA

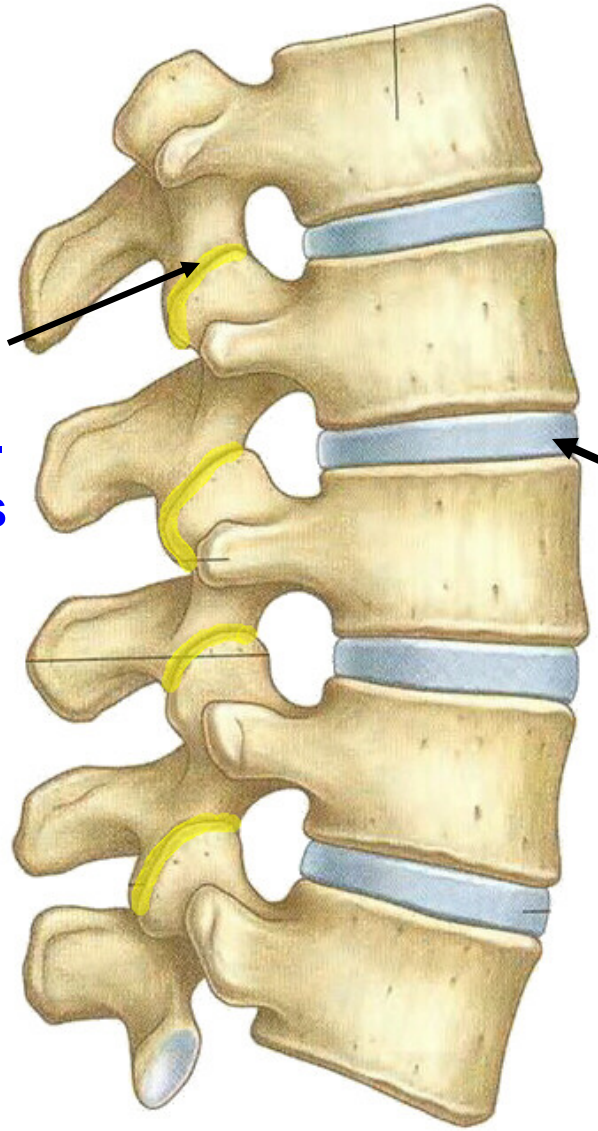
4. Spinal nerves leave vertebral canal via <u>INTERVERTEBRAL FORAMINA</u> - between vertebrae;
bordered by – Superior and Inferior Vertebral Notches

5. <u>SUPERIOR AND INFERIOR ARTICULAR PROCESSES</u> - (zygapophyses) - Articular facets form joints between adjacent vertebrae (Orientation of facets determines movement)



JOINTS BETWEEN VERTEBRAE

1. Joints between articular processes - synovial plane joints permit Sliding Movements

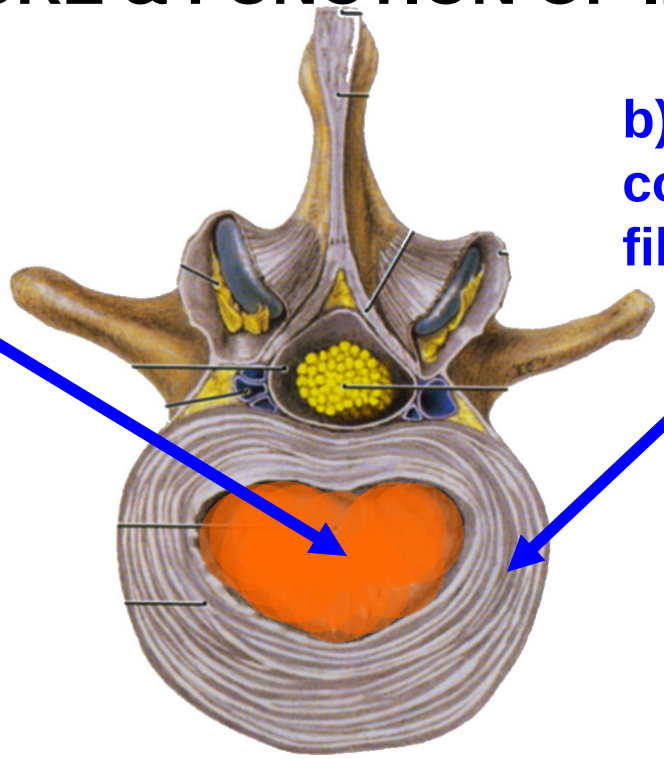


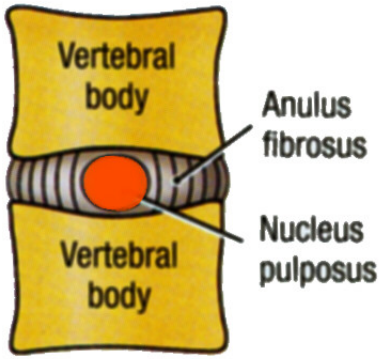
2. Intervertebral Disc- interposed between bodies

STRUCTURE & FUNCTION OF INTERVERTEBRAL DISC

a) Nucleus pulposus- inner gelatinous core

b) Anulus fibrosus - collagen fibers & fibrocartilage





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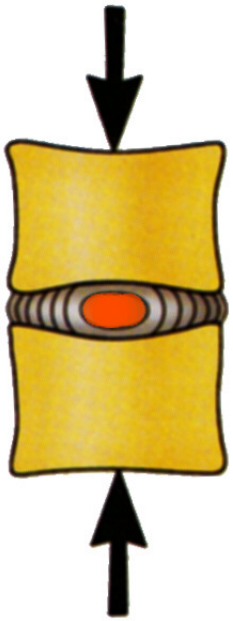
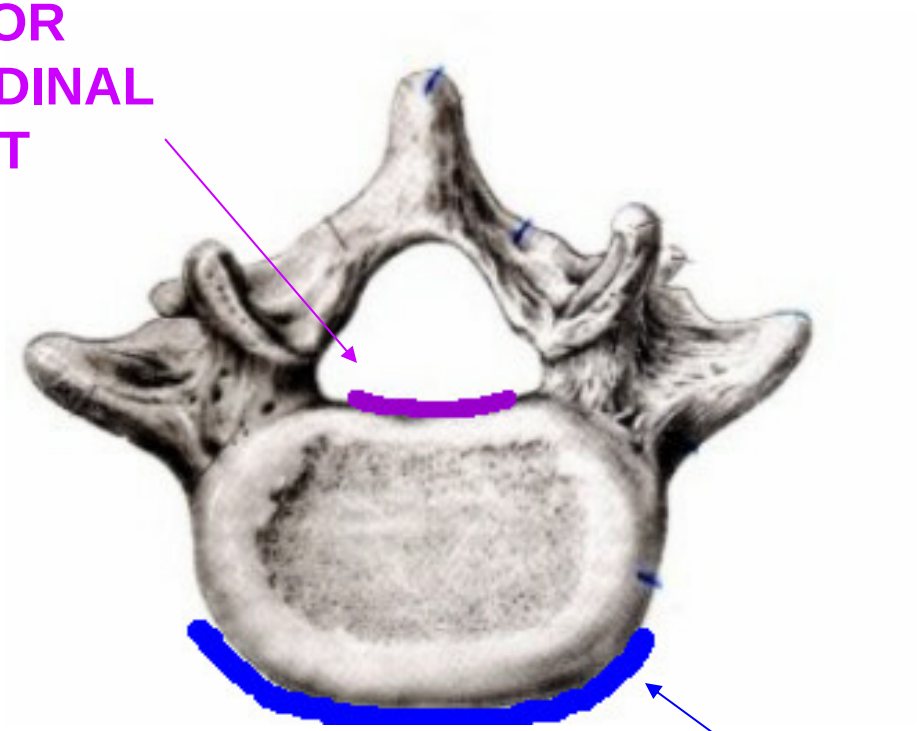


Shock absorbers in young. Quite strong. Trauma to vertebra produces fractures.

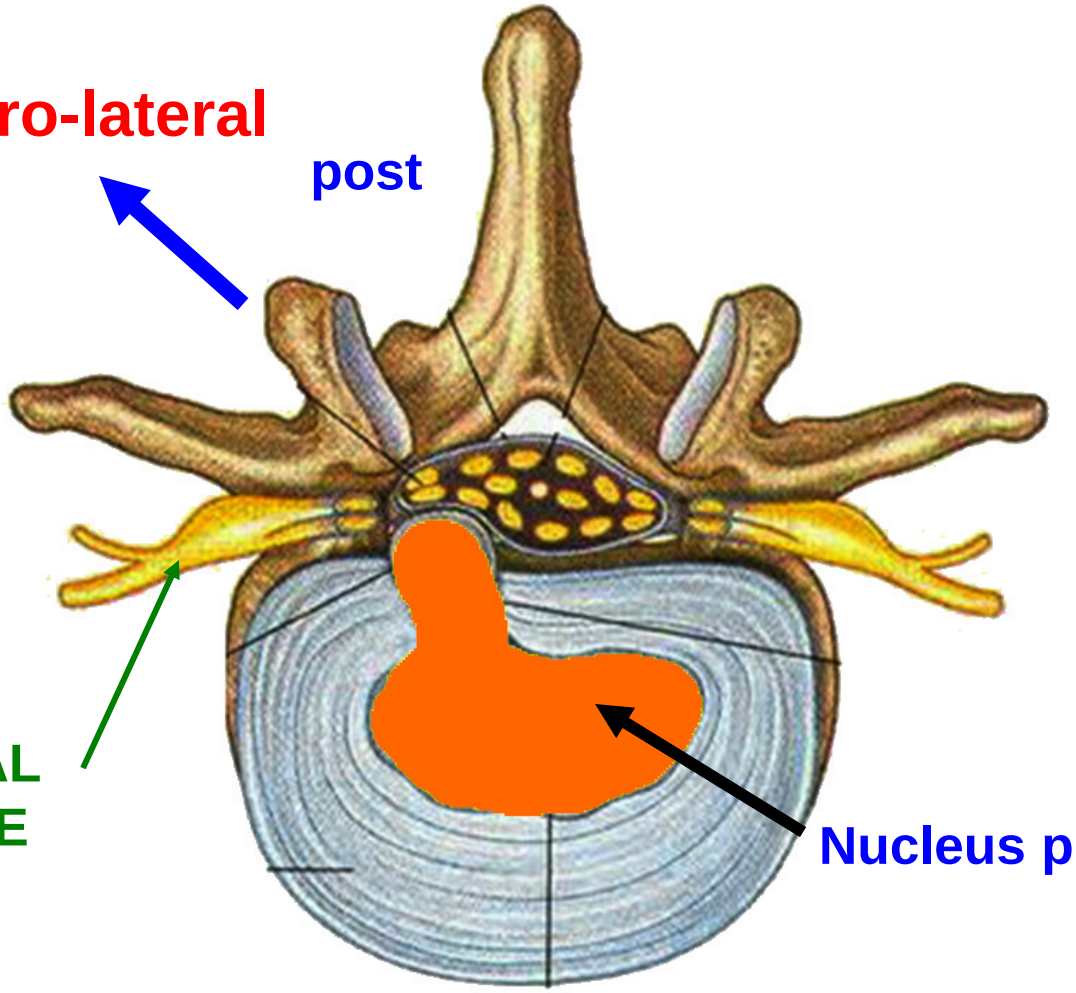
DAMAGE TO INTERVERTEBRAL DISC

POSTERIOR
LONGITUDINAL
LIGAMENT



ANTERIOR
LONGITUDINAL LIGAMENT

DAMAGE TO INTERVERTEBRAL DISC



In older people.

1) degenerative changes in anulus fibrosus (start in teens)

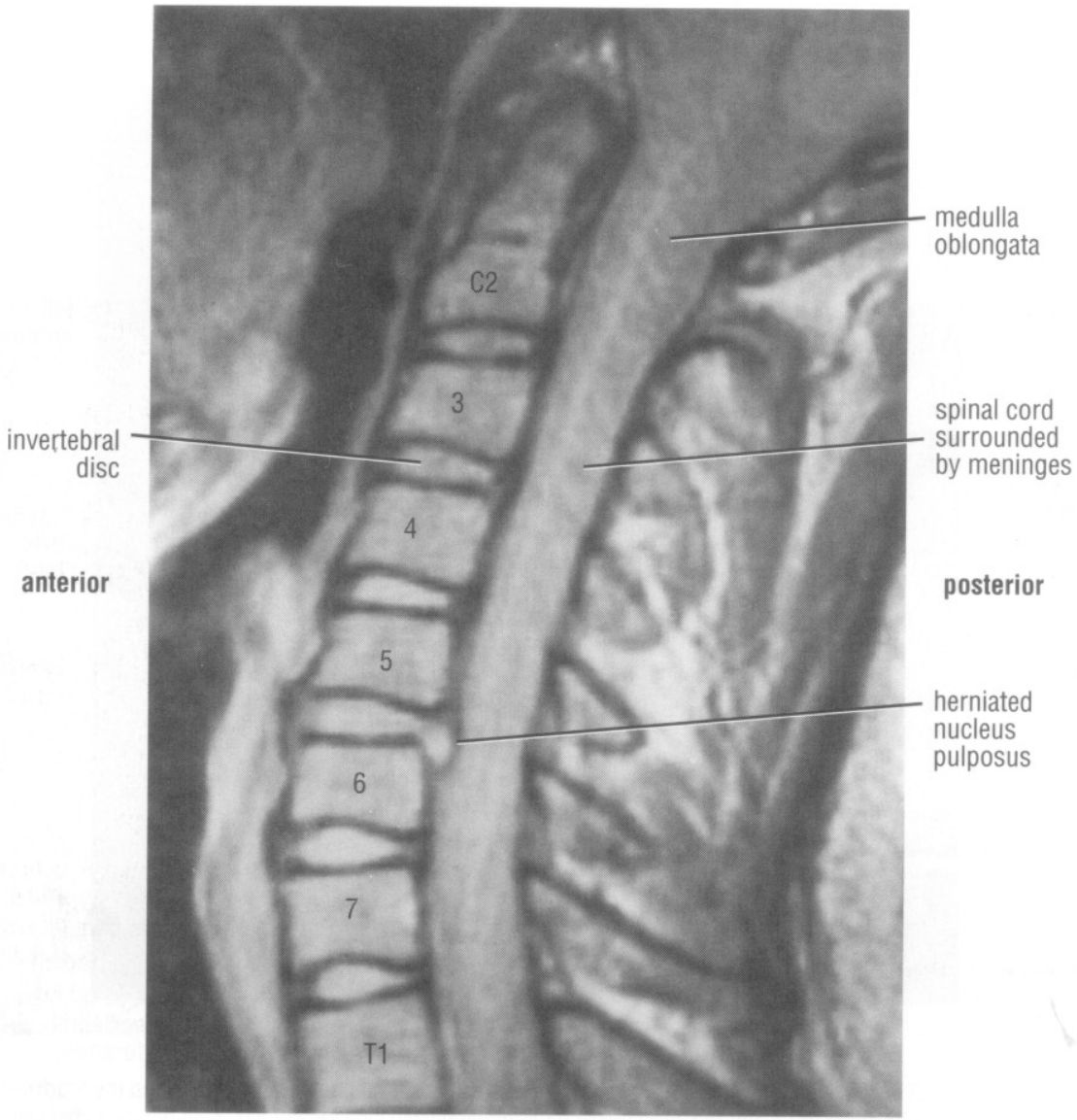
2) strain back can cause herniation of nucleus pulposus = 'Slipped Disc'

Typically in Postero-Lateral Direction, lateral to Posterior Longitudinal Ligament; often L4-L5 or L5-S1; can lead to nerve compression at intervertebral foramen

MRI OF 'SLIPPED DISK' FROM SNELL'S TEXTBOOK

ANTERIOR

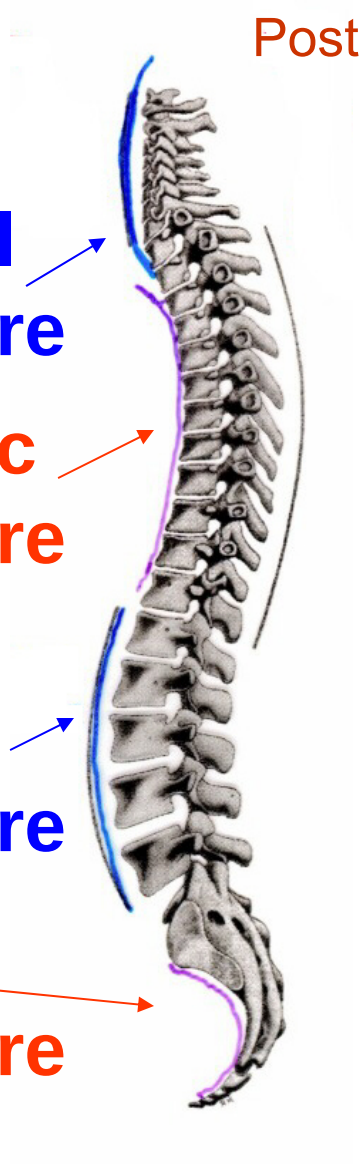
POSTERIOR



HERNIATION OF NUCLEUS PULPOSUS

FIGURE 12-21 Sagittal MRI scan of the cervical part of the vertebral column. A herniated disc between the fifth and sixth vertebrae is shown. Note the position of the spinal cord and its meningeal coverings relative to the herniated disc. (Courtesy of Dr. Pait.)

NORMAL CURVATURES OF VERTEBRAL COLUMN



Primary - concave anterior - remains
In thorax and sacrum

Secondary - concave posterior

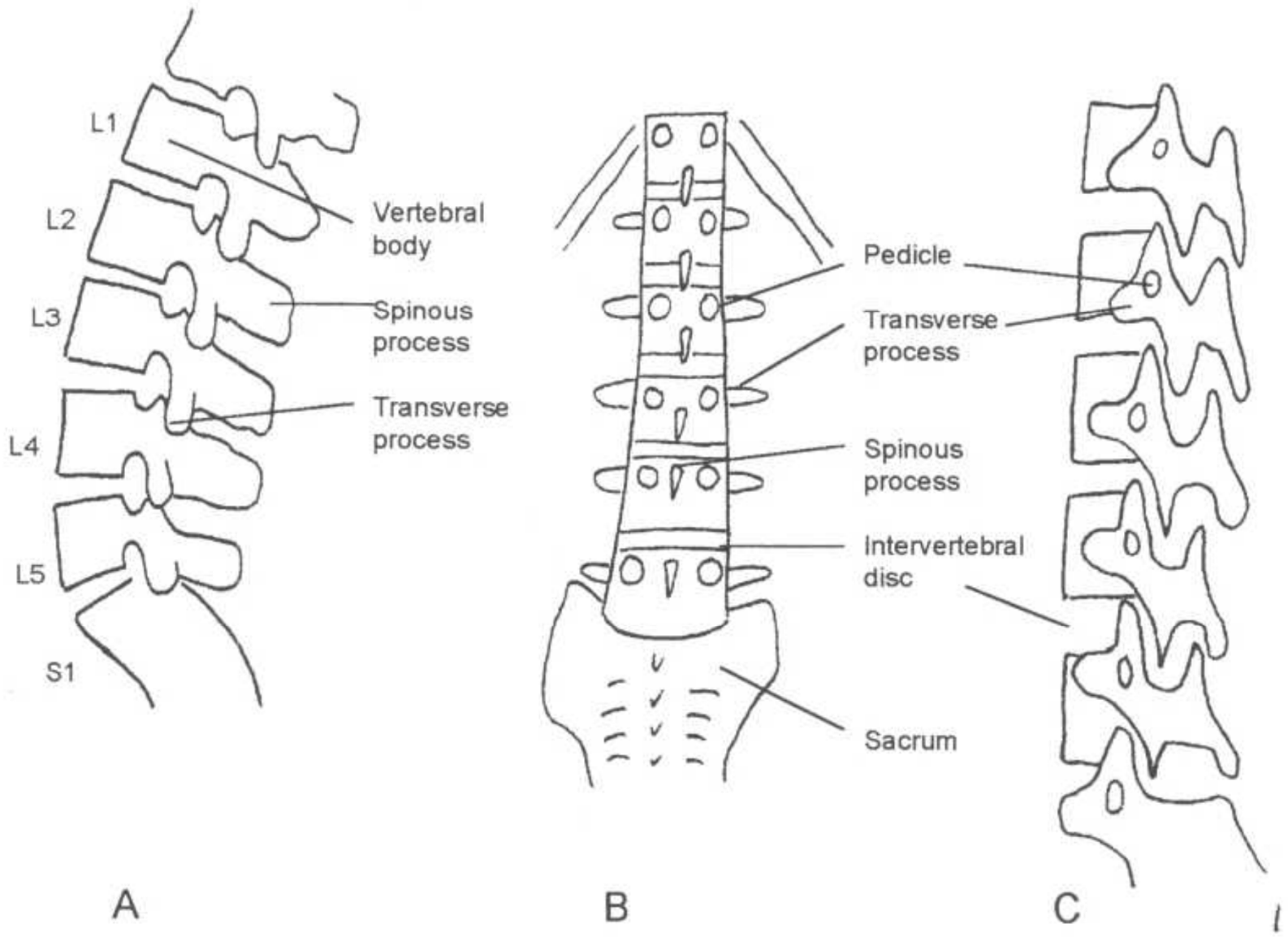
a. **Cervical curvature** - concave posteriorly - help support head

b. **Lumbar curvature**
- concave posteriorly
- develops with walking
- helps support trunk, upper body

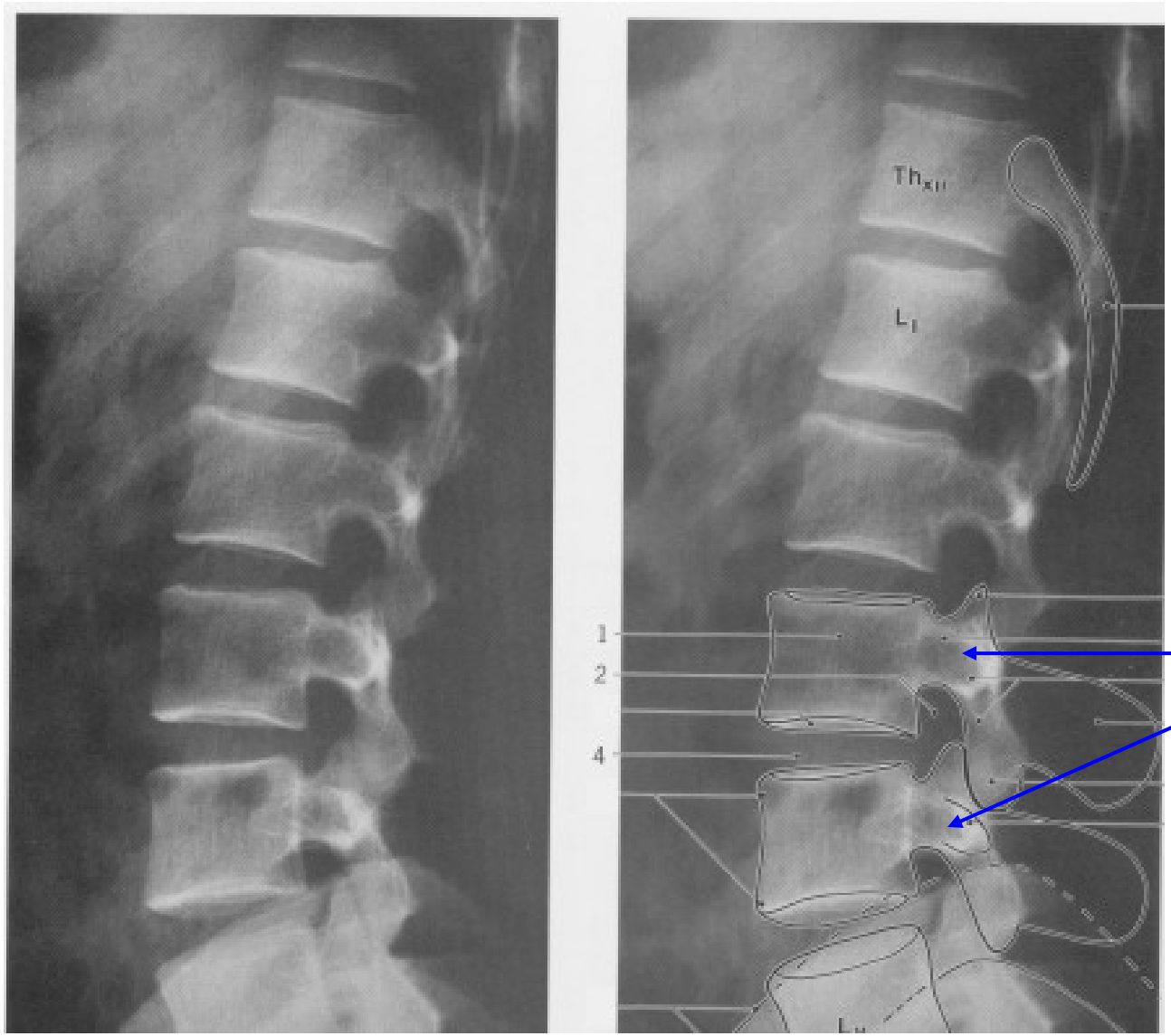
c. **Lateral curvature** - concave to side opposite handedness - helps to carry bags of money

Right handed

LUMBAR X-RAY VIEWS: LATERAL (A), FRONTAL (B), and OBLIQUE (C)



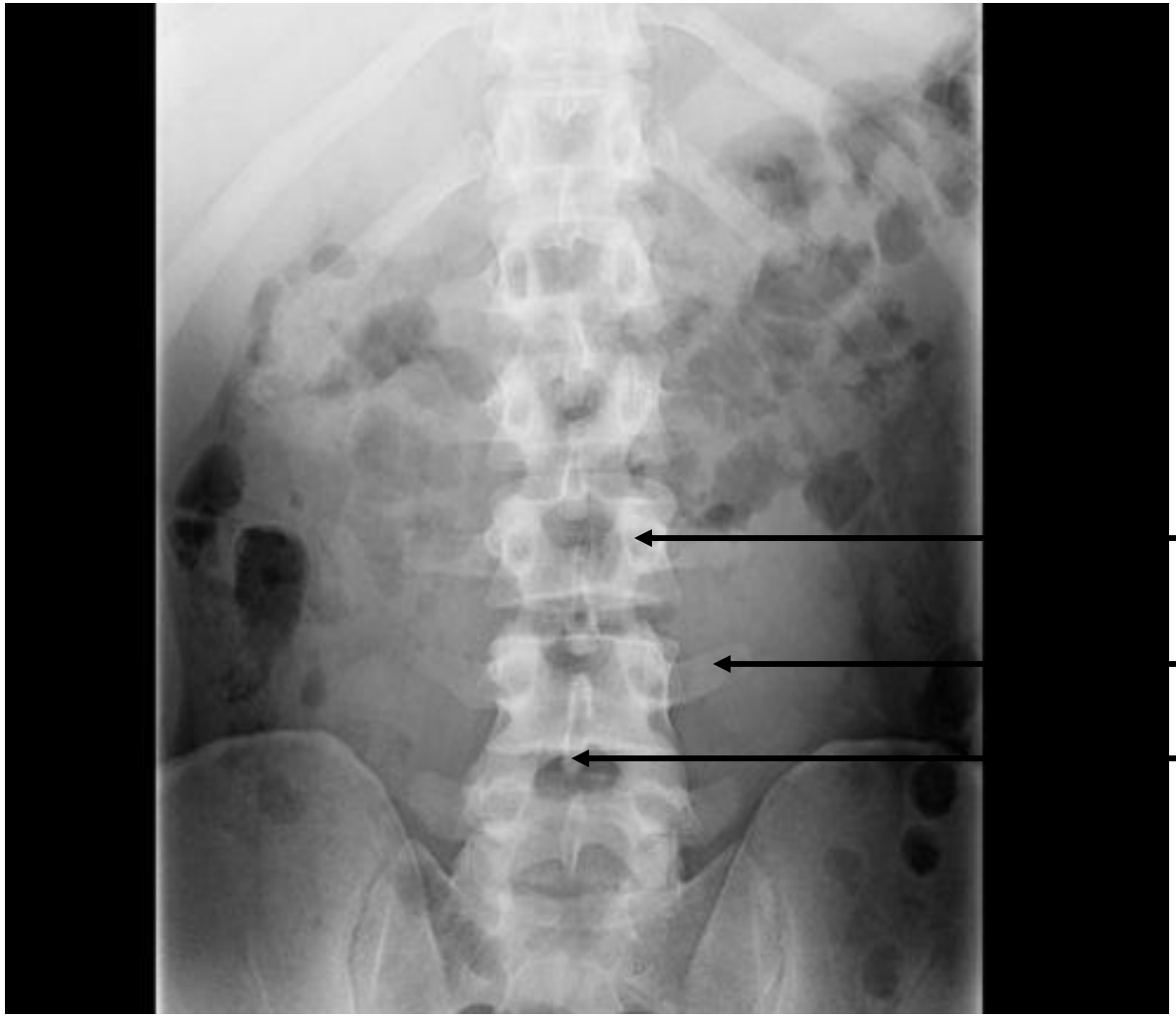
LUMBAR CURVATURE ON LATERAL X-RAY



LATERAL X-RAY - TRANSVERSE PROCESSES LOOK LIKE RINGS

Transverse process

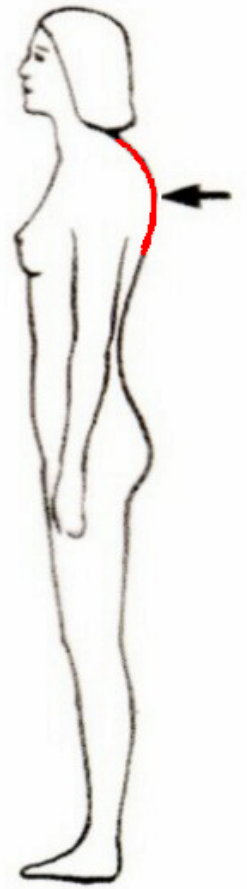
FRONTAL LUMBAR SPINE – "OWLS"



OBLIQUE LUMBAR SPINE – "SCOTTY DOGS"

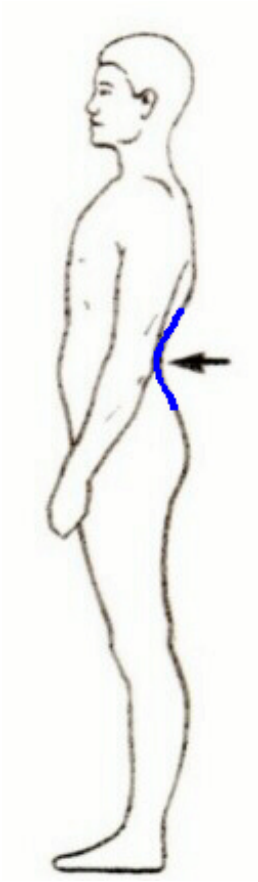
(A) Superior Articular Process, (B) Pedicle,
(C) Transverse Process, (D) Inferior Articular Process

ABNORMAL CURVATURES



KYPHOSIS ‘hump’ back, exaggerated curvature; often in thorax of elderly; concave anteriorly

SCOLIOSIS abnormal lateral curvature (‘kink’ in spine); can be due to hemivertebra

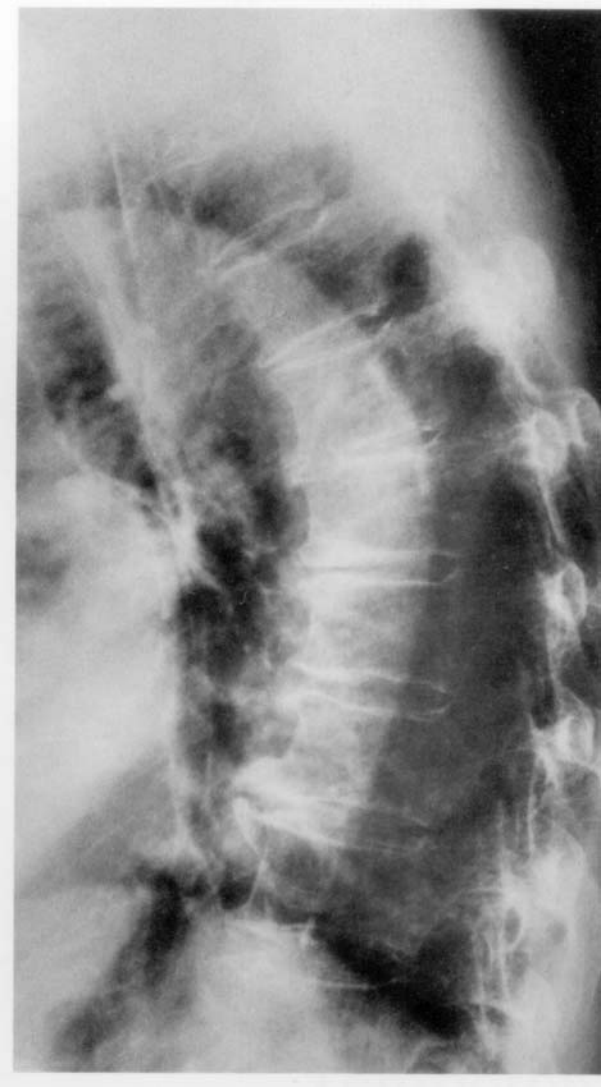


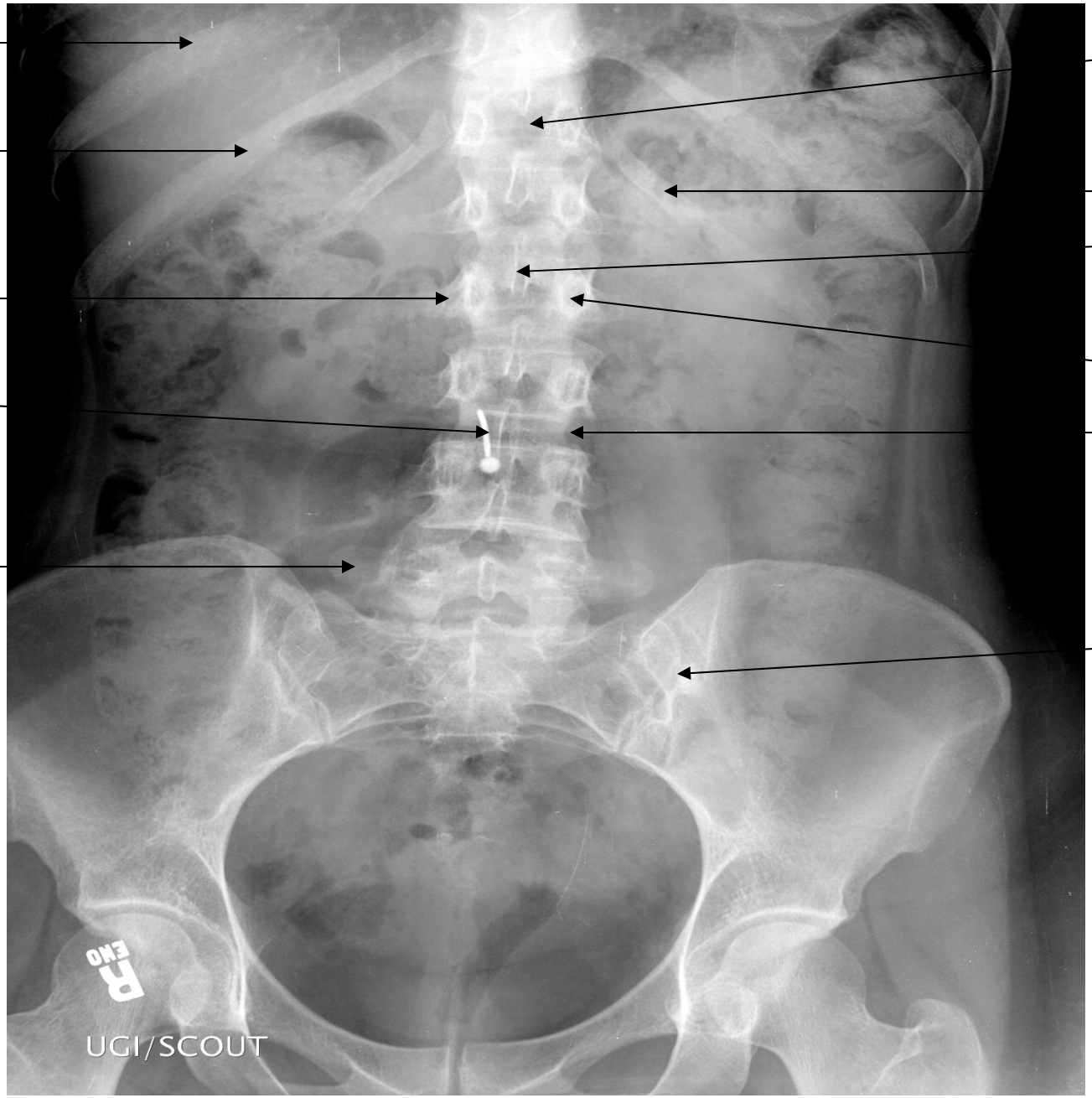
LORDOSIS exaggerated lumbar curvature concave posteriorly

LATERAL X-RAY THORACIC SPINE

NORMAL ADULT

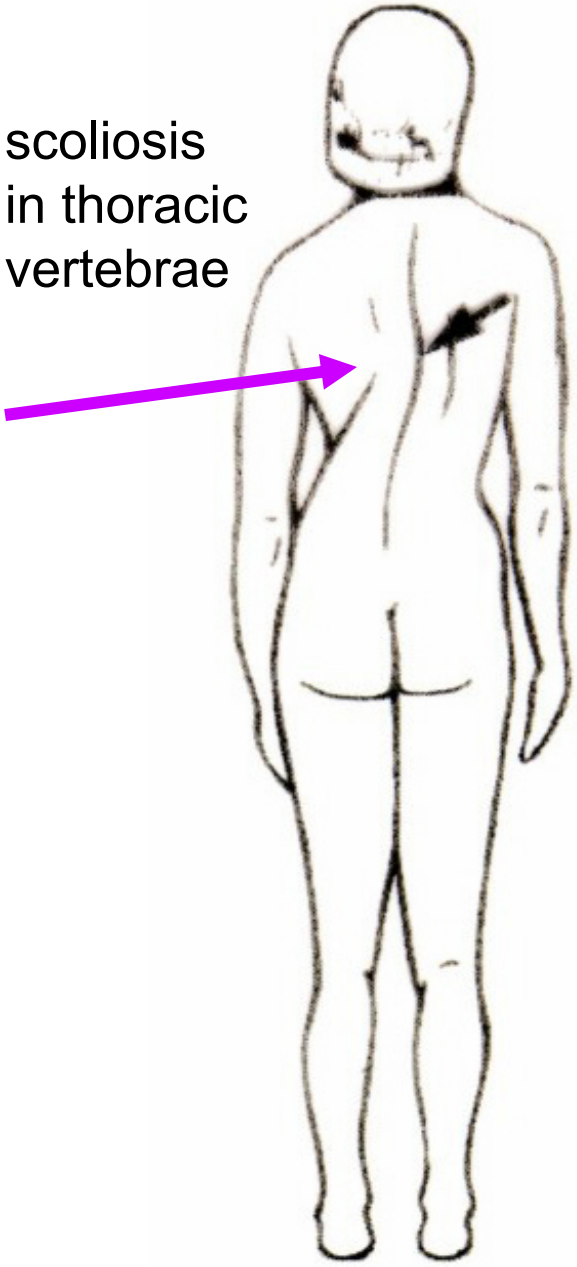
ELDERLY PATIENT



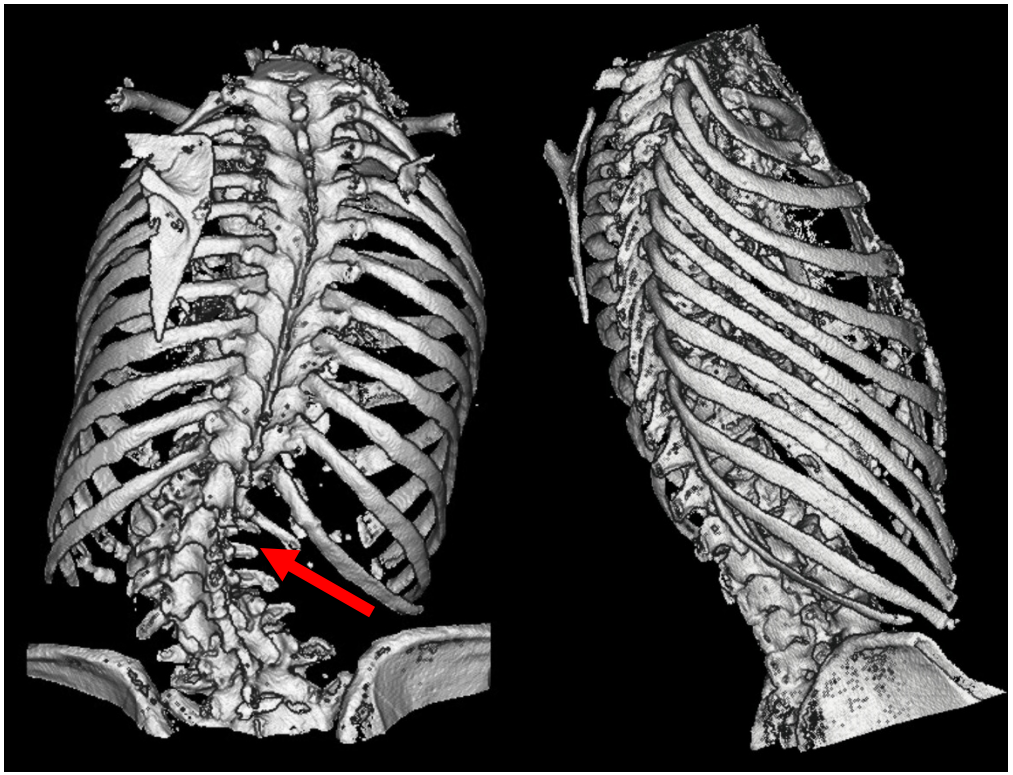

Tenth Rib
Eleventh Rib
Transverse process of L2
Body Jewelry
Transverse process of L5
Body of T12
Twelfth Rib
Spine of Vertebra
Pedicle
Space for Intervertebral disc
Sacroiliac joint
UGI/SCOUT

b. SCOLIOSIS - abnormal lateral curvature ('kink' in spine)

scoliosis
in thoracic
vertebrae



Prosection – severe scoliosis
in lumbar vertebrae



VIEW OF POSTERIOR SIDE

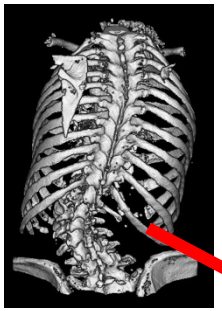
POSTEROLATERAL VIEW

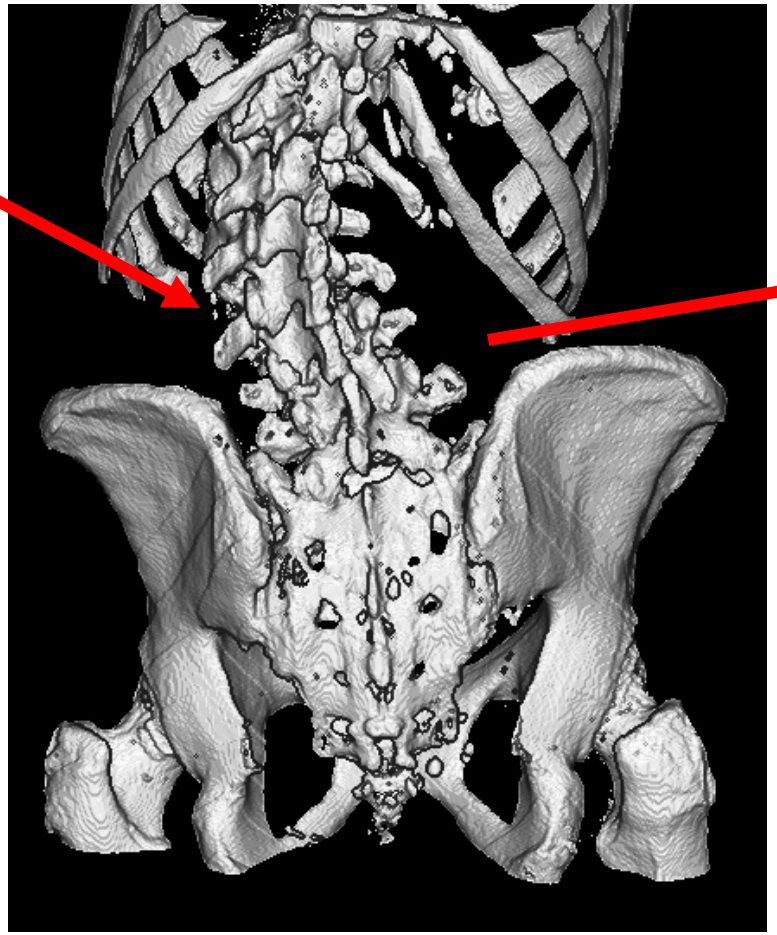
VIEW OF SKELETON RECONSTRUCTED FROM CT IMAGES OF CADAVER

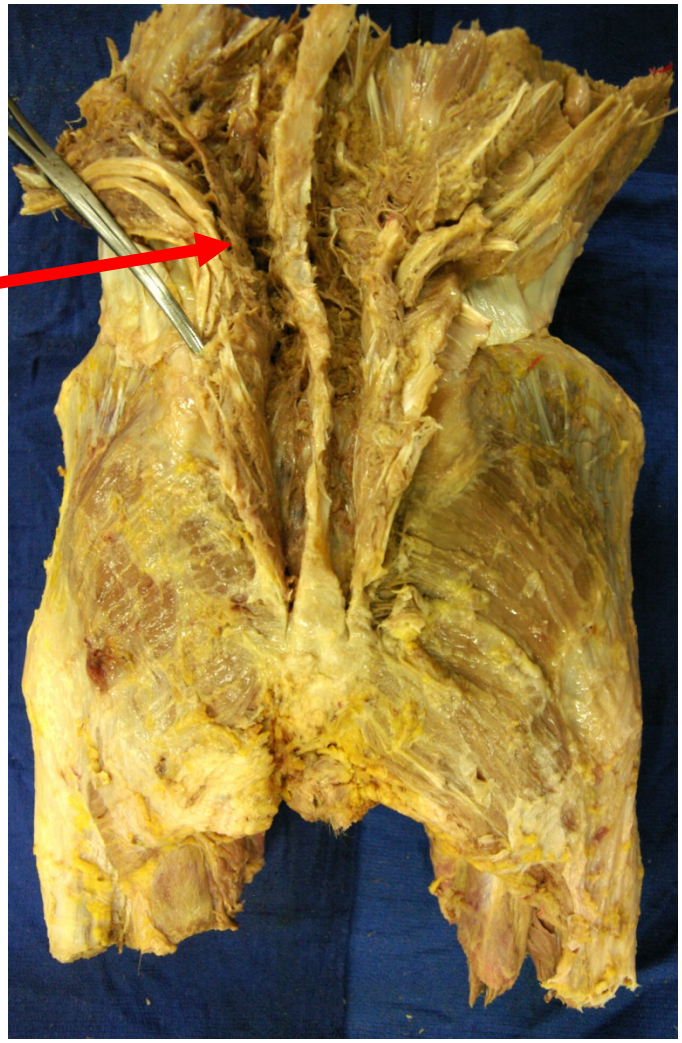
CLINICAL PROSECTION: SCOLIOSIS OF LUMBAR SPINE

SKELETON RECONSTRUCTED FROM CT SERIES

CADAVER DISSECTED



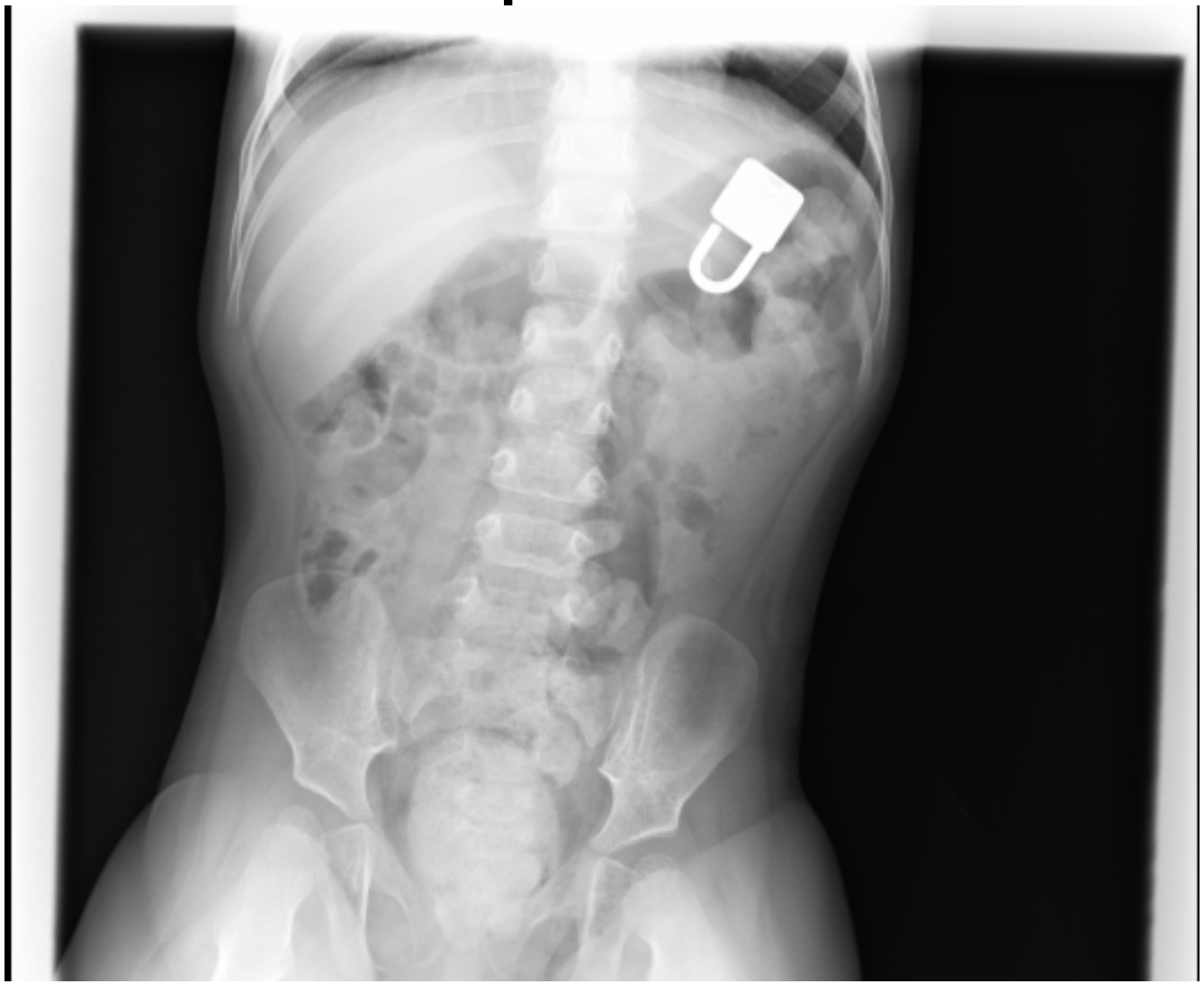




POP QUIZ!

HINT: Think about the 5 radiographic densities.

Can you identify what is wrong with this patient?



THE END!

- ANY QUESTIONS OR COMMENTS?
- My e-mail is Harper114@marshall.edu if you have any concerns about this lecture, radiology, or medical school in general.