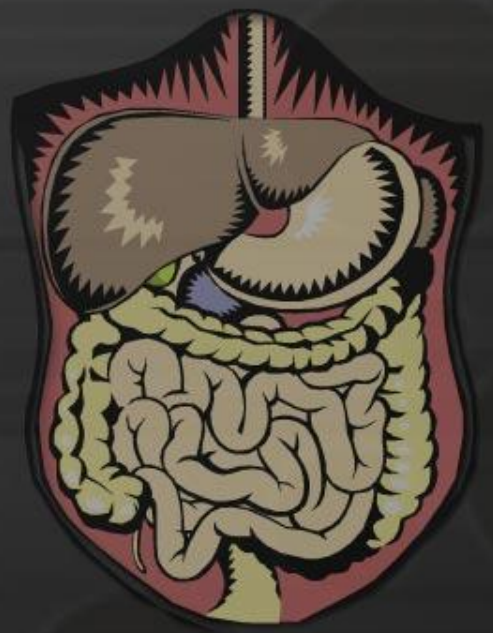
IMAGING OF GASTROINTESTINAL SYSTEM



Please bring at your seminars:

- White coat (you will not be allowed to enter the department without a white coat)
- Hospital shoes (you will not be allowed to enter the department without hospital shoes; bahillas are NOT acceptable)
- Notebook with your personal notes on the topic

Please do NOT bring at your seminars:

- Begs and other personal belongings
- Electronic devices (your phones should be turned off).

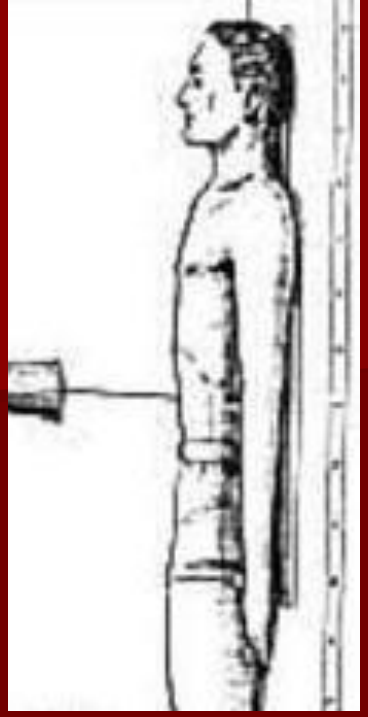
IMAGING MODALITIES

for investigation of gastrointestinal tract

IMAGING MODALITIES

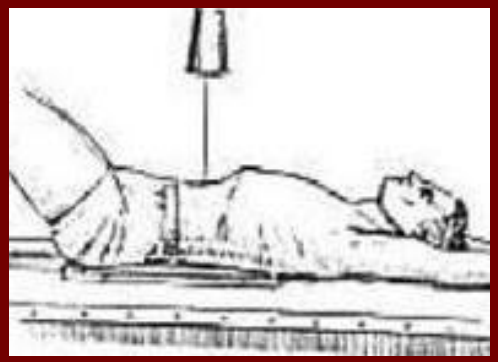
1. **Plain Radiograph of the abdomen**
2. **Fluoroscopy (radioscopy)**
3. **Barium studies** (barium swallow, barium meal, barium follow through, barium enema)
4. **Ultrasonography**
5. **Computerized tomography (CT)**
6. **Magnetic Resonance Imaging (MRI)**
7. **Angiography** (aorta, celiac trunk, mesenteric arteries)
8. **Radionuclide imaging:**
   - **Scintigraphy** (hepatobiliary scintigraphy, gastric emptying, gastrointestinal bleeding study, octreotide scintigraphy)
   - **Positron Emission Tomography** (PET/CT) (tumor imaging, etc)

PLAIN ABDOMINAL X-RAY

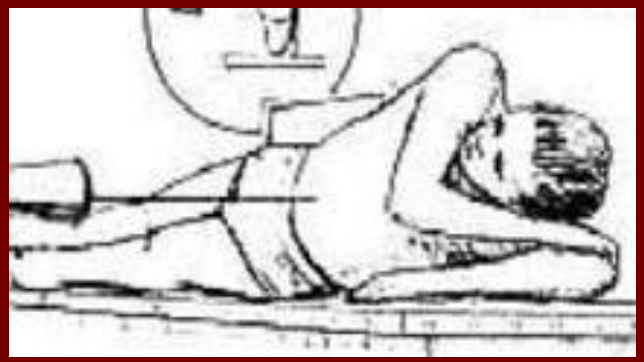


Antero-posterior (AP) Erect

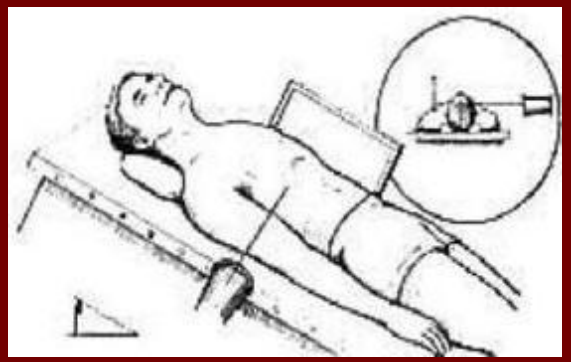
Chest X-ray (postero-anterior)



KUB (Kidneys, Ureters & Bladder)



Left Lateral Decubitus (*pneumoperitoneum, etc*)



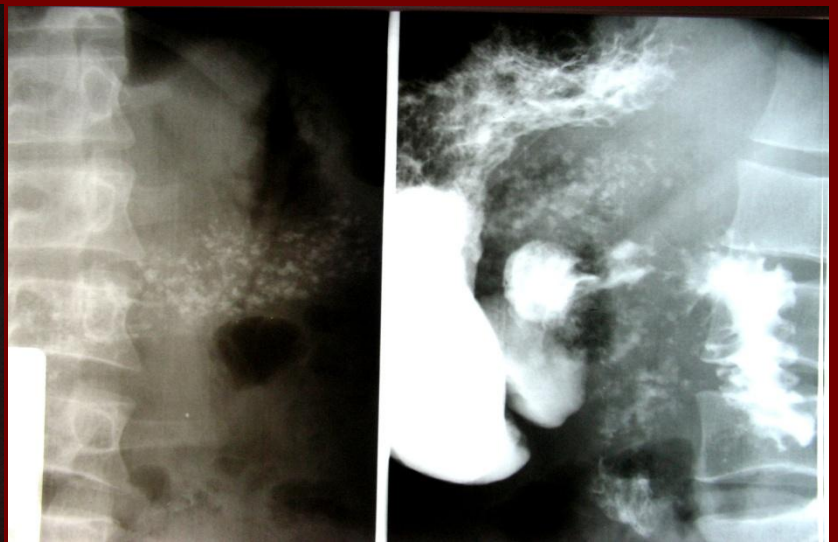
Semi recumbent (*critically ill patients*)

Indications for abdominal radiography

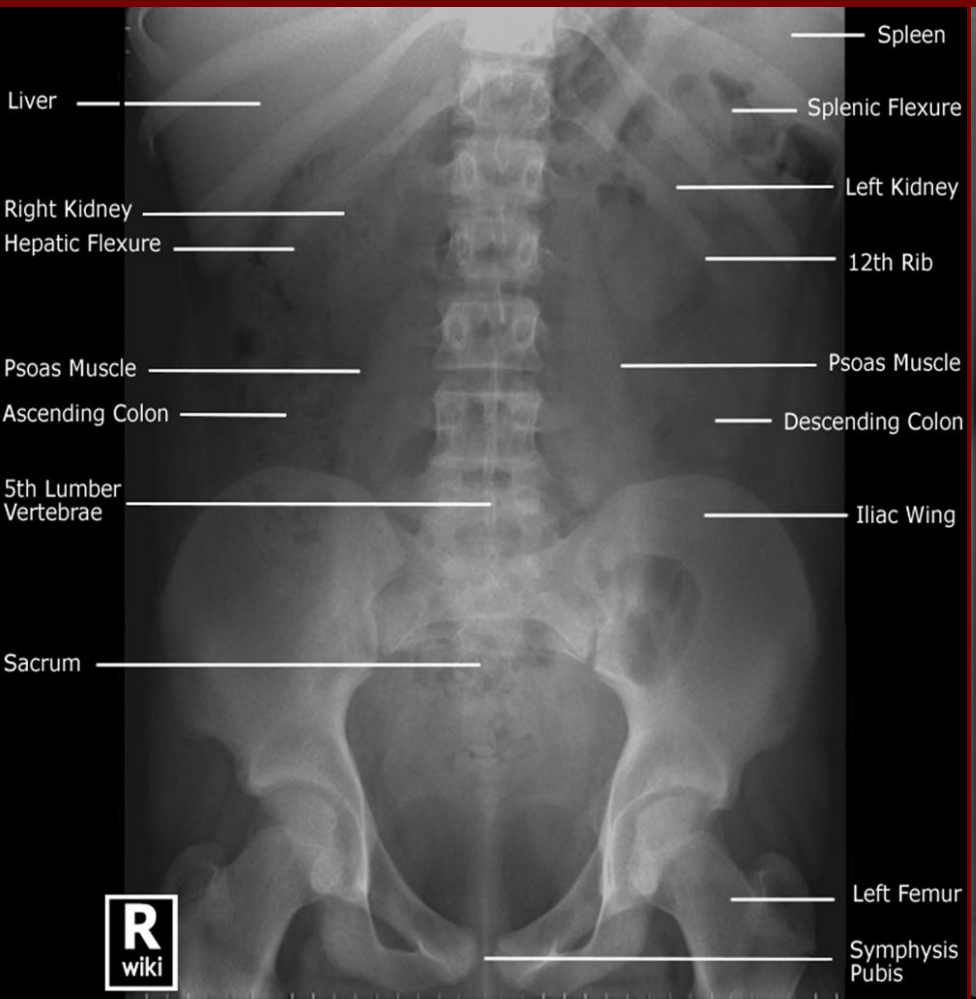
- Bowel obstruction
- Perforation
- Renal pathology
- Acute abdomen
- Foreign body localization
- Toxic megacolon
- Control or preliminary films for contrast studies
- Detection of calcification or abnormal gas collection
- Blunt or stab abdominal injury

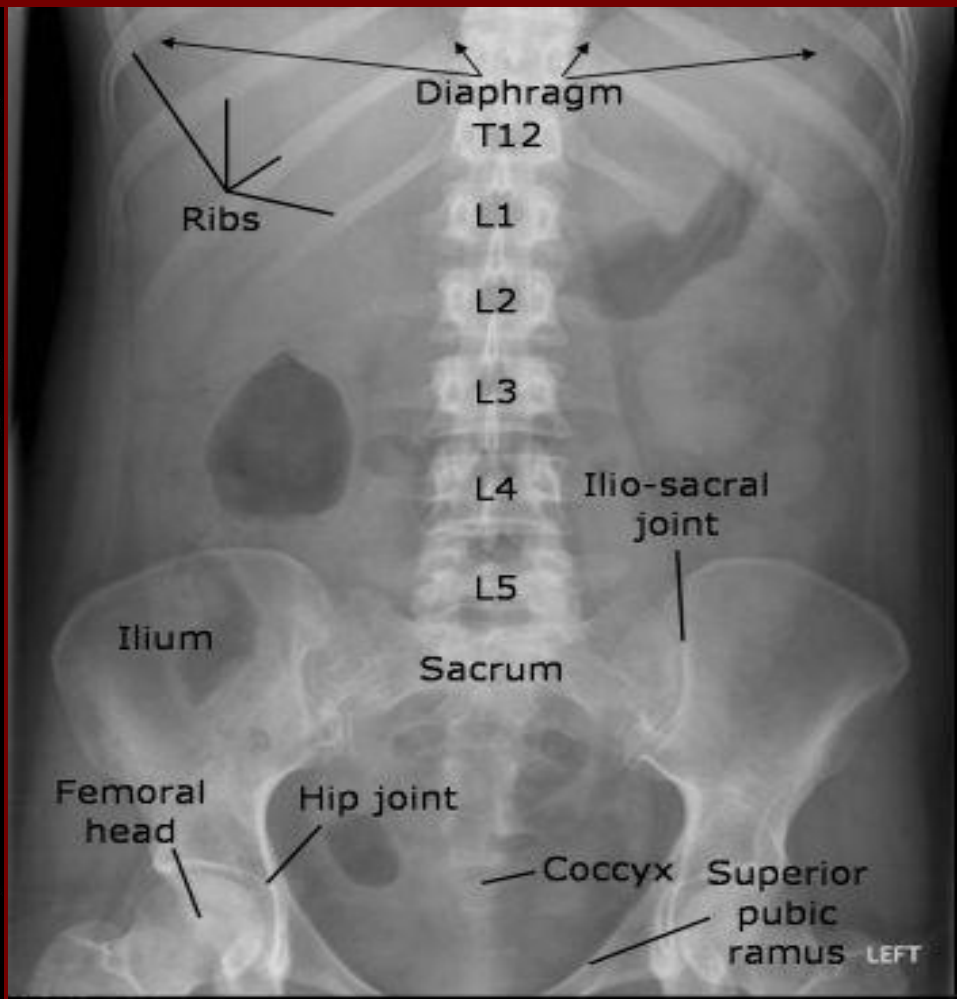
5 basic densities on x rays:

- Gas - - - - - - - - - - - - - - > Black
- Fat - - - - - - - - - - - - - - > Dark grey
- Soft tissue/fluid - - - - > Light grey
- Bone/calcification - - - > White
- Metal - - - - - - - - - - - - - > Intense white



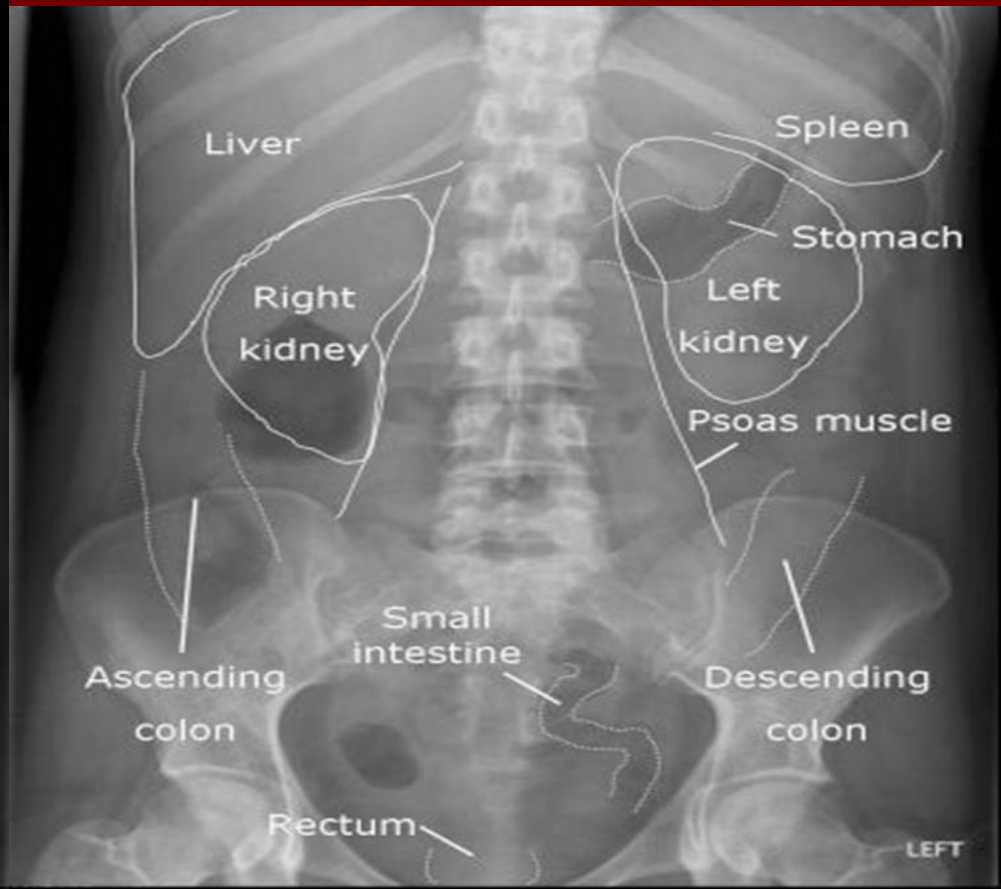
Structures seen on X-ray





What to examine?

- Air (bowel gas)
- Bone density
- Calcifications
- Soft tissues



Air:

- Look at the stomach:
  - If the stomach contains air it may be visible in the left upper quadrant of the abdomen. The lowest part of the stomach crosses the midline.
- Look at the diaphragms:
  - Are they raised or flattened?
  - Are the costophrenic angles clear?
- Is there any free intra-abdominal air? (better evaluated if erect or decubitus)

Air:

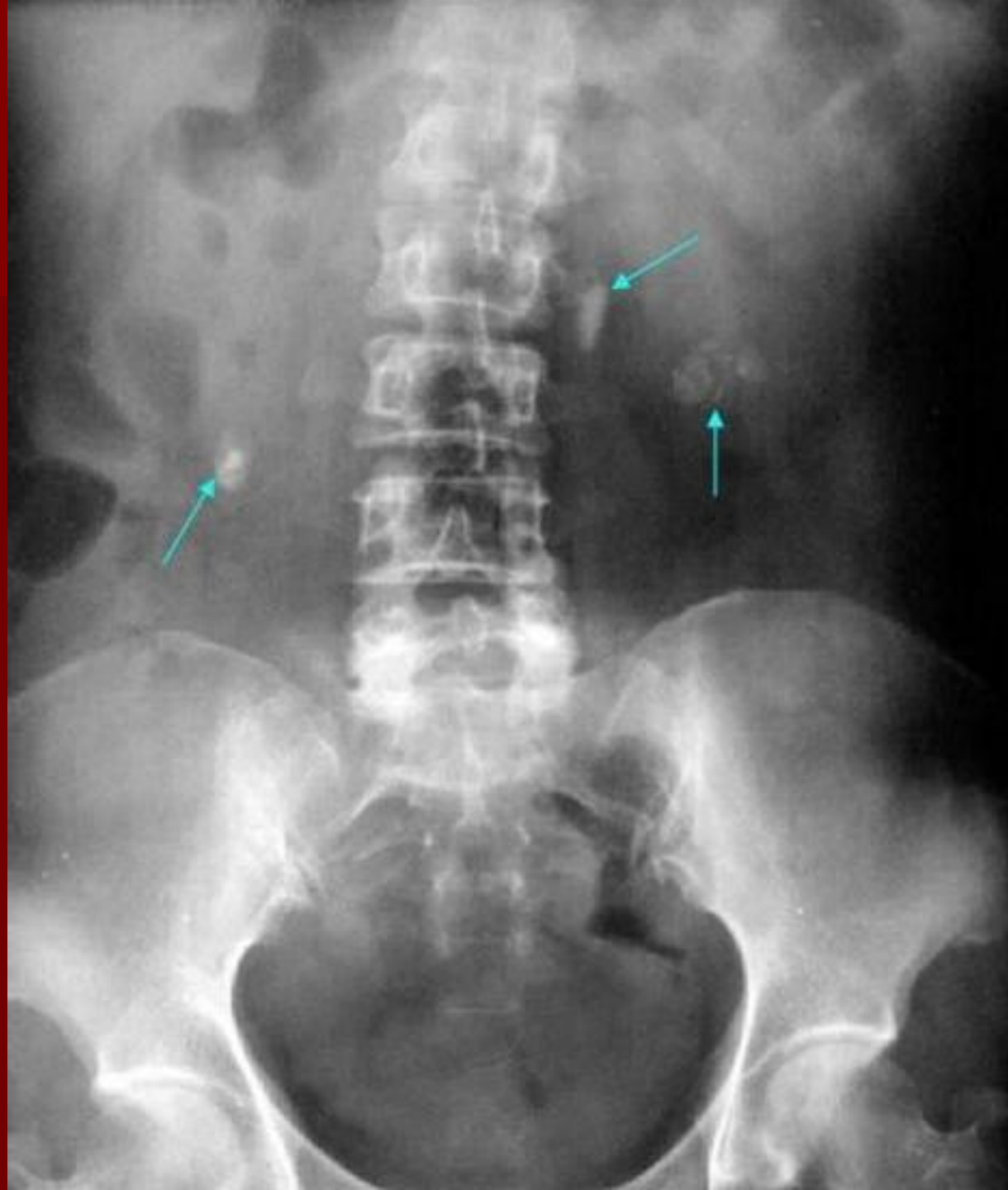
Free air under the diaphragm ➔ visceral perforation

Crescentic gaz under the right hemidiaphragm ➔ visceral perforation

Calcifications:

Chronic pancreatitis

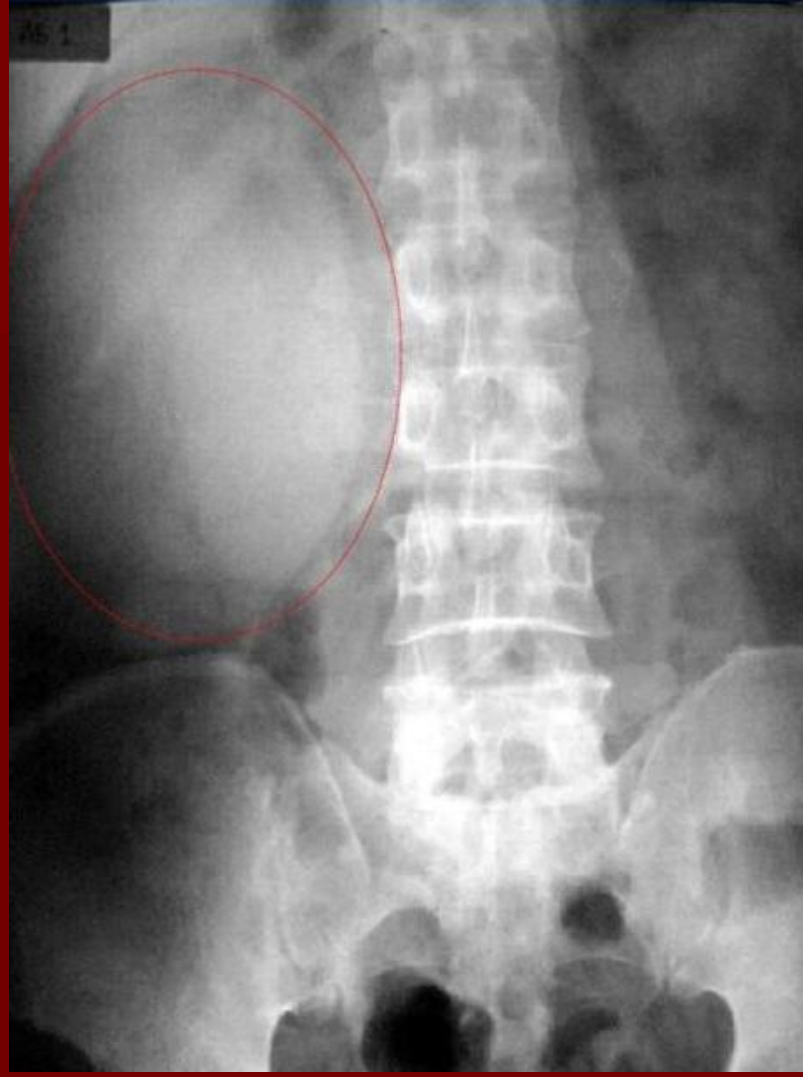
Calcifications, stones



Soft tissues

- Look at the liver:
  - Is it enlarged, shrunk or displaced?
  - Are there any calcifications?
- Look at the spleen:
  - Is it enlarged, shrunk or removed?
  - Are there any calcifications?
- Look at the kidneys, ureters and bladder:
  - Are they enlarged, shrunk or displaced?
  - Are there any calcifications?

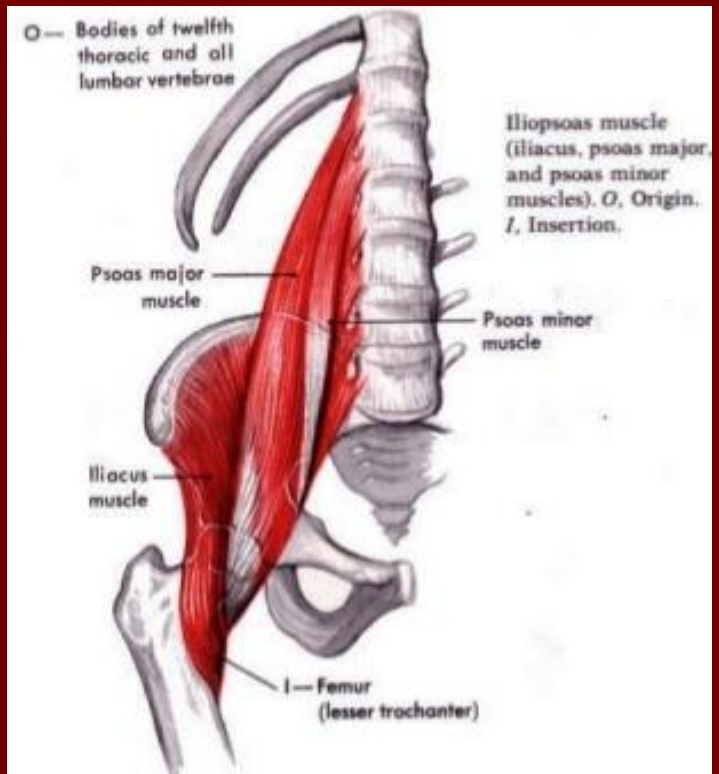
An enlarged liver (*) displacing the ascending and transverse colon downward.

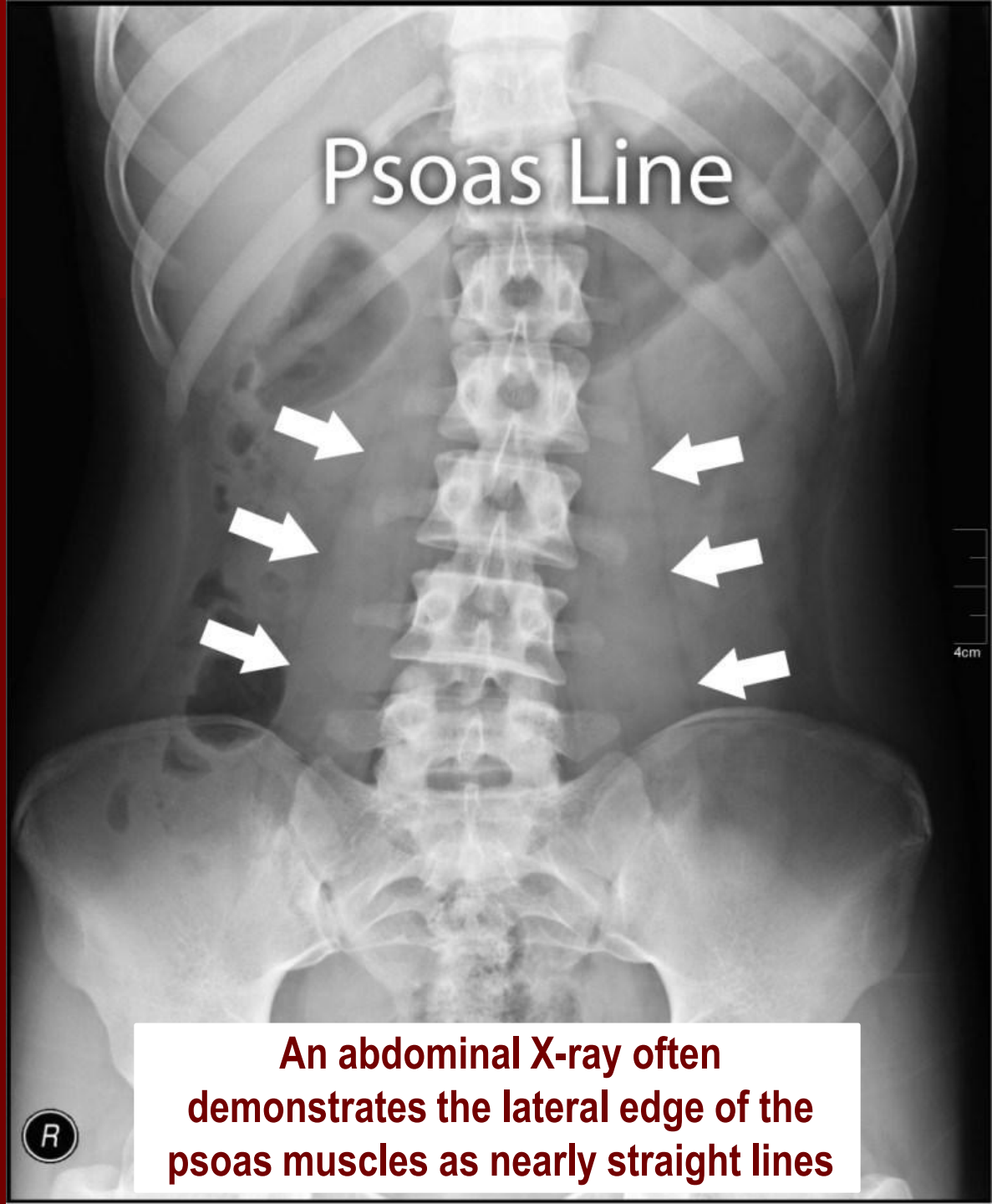


A large soft tissue mass in the right abdomen

Psoas muscles

- arise from the transverse processes of the lumbar vertebrae, join the iliacus muscle on each side to form the iliopsoas and attaches to the lesser trochanter of the femur.





An abdominal X-ray often demonstrates the lateral edge of the psoas muscles as nearly straight lines

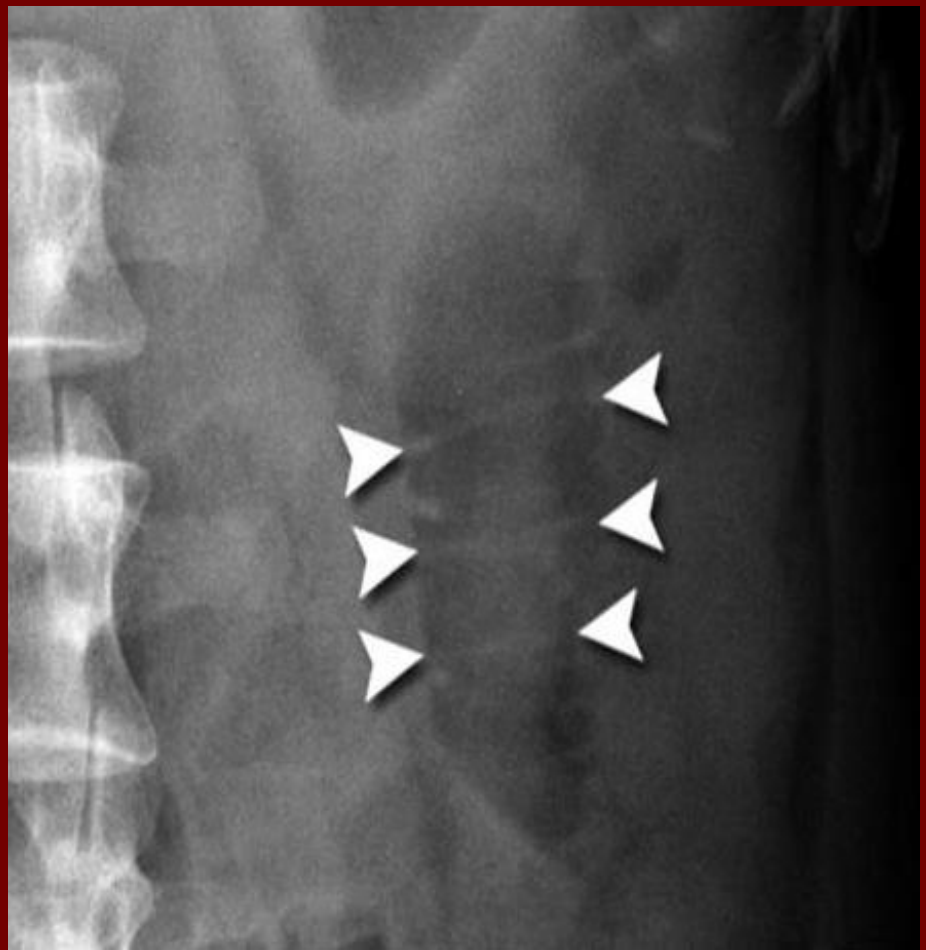
Bowel gas pattern

- Look at the bowel gas pattern:
  - Where are the bowel loops located (central vs. peripheral)?
  - What is the distribution of the gas in the abdomen?
  - Is there too much intraluminal gas?

- What is the intraluminal caliber of the small and large bowel?
- Are there any dilatations of the small and/or large bowel?
- Are there any air-fluid levels?

Small bowel

- Central position in the abdomen
- Valvulae conniventes - mucosal folds that cross the full width of the bowel. Usually they become visible when the small bowel is more distended, particularly in the jejunum.



Large bowel

- **Peripheral position in the abdomen** (although the location of the transverse and sigmoid colon may vary)
- **Haustra** - small pouches, giving the colon its segmented appearance. **Haustra don't reach around the entire circumference of the intestine, in contrast to circular folds of the small bowel (valvulae conniventes).**
- Loss of haustra is a sign of chronic ulcerative colitis.
- Large bowel also contains feces (in contrast to the small intestine)

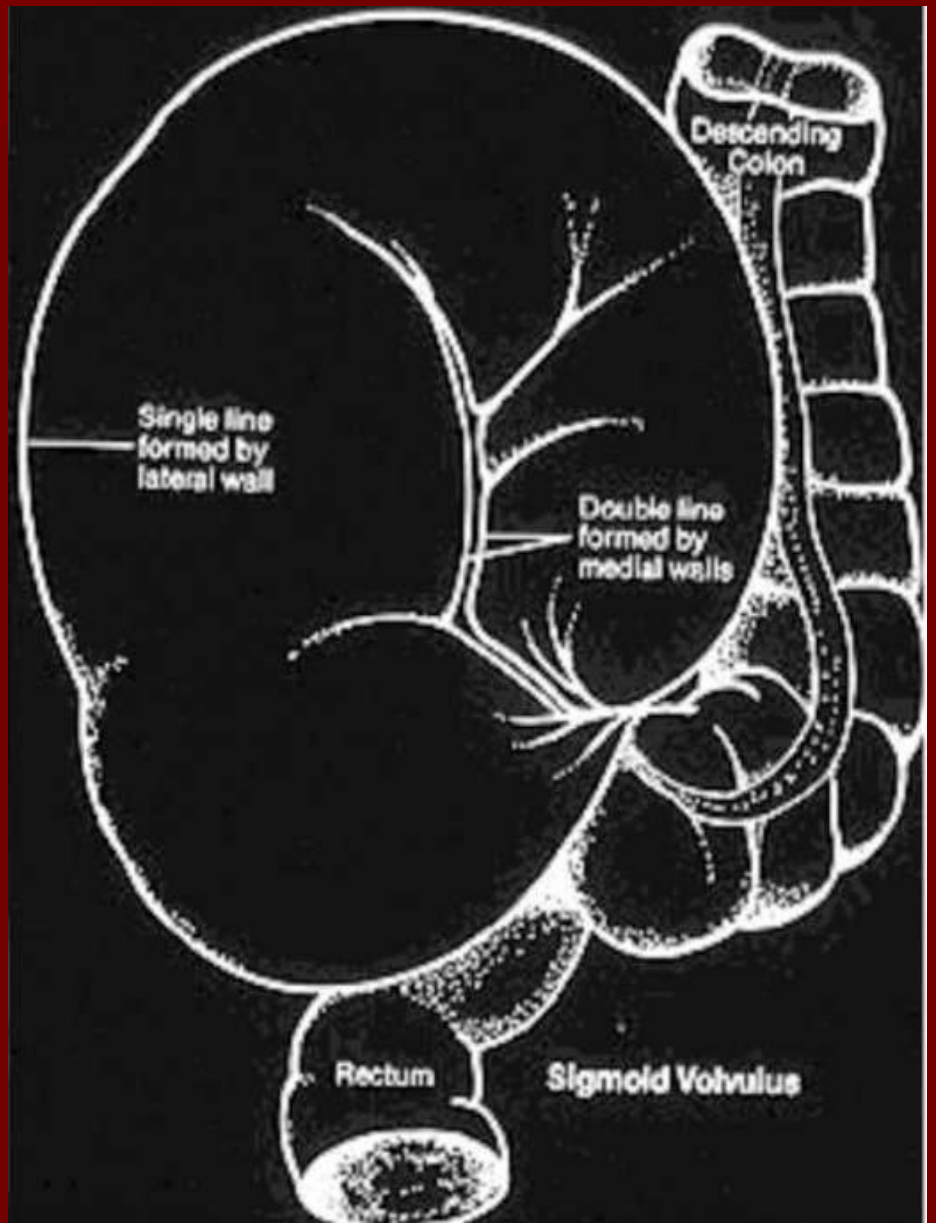
Bowel obstruction

Normal

Bowel obstruction

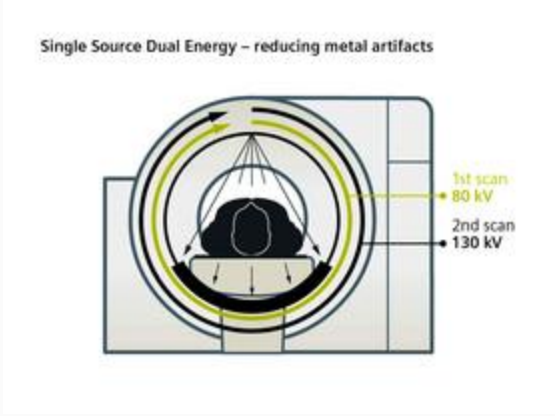
Bowel obstruction (air-fluid levels)

Sigmoid volvulus (“coffee bean sign”)



Computed tomography (CT)

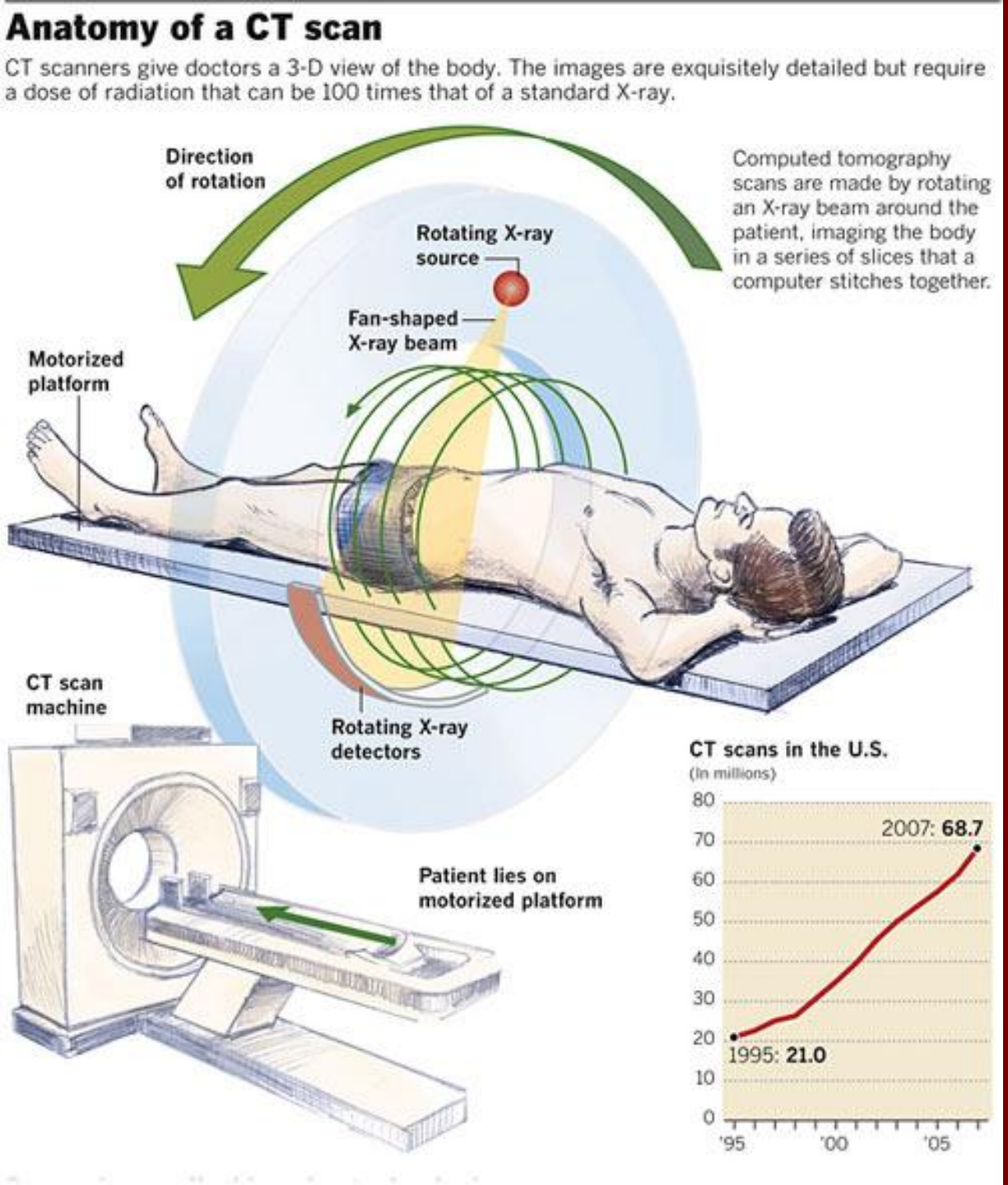
- **is a sensitive method for diagnosis of abdominal diseases**
- **the first line for detecting solid organ injury after trauma.**
- **useful for investigating acute abdominal pain** (especially of the lower quadrants, whereas ultrasound is the preferred first line investigation for right upper quadrant pain), **i.e. renal stones, appendicitis, pancreatitis, diverticulitis, abdominal aortic aneurysm, bowel obstruction etc.**
- **frequently used to determine stage of cancer and to follow its progress.**



SIEMENS

SOMATOM
Definition AS

Computed tomography (CT)



- **Spatial resolution** - ability to resolve **small objects** in an image

- **Contrast resolution** - ability to differentiate **small density differences** in an image

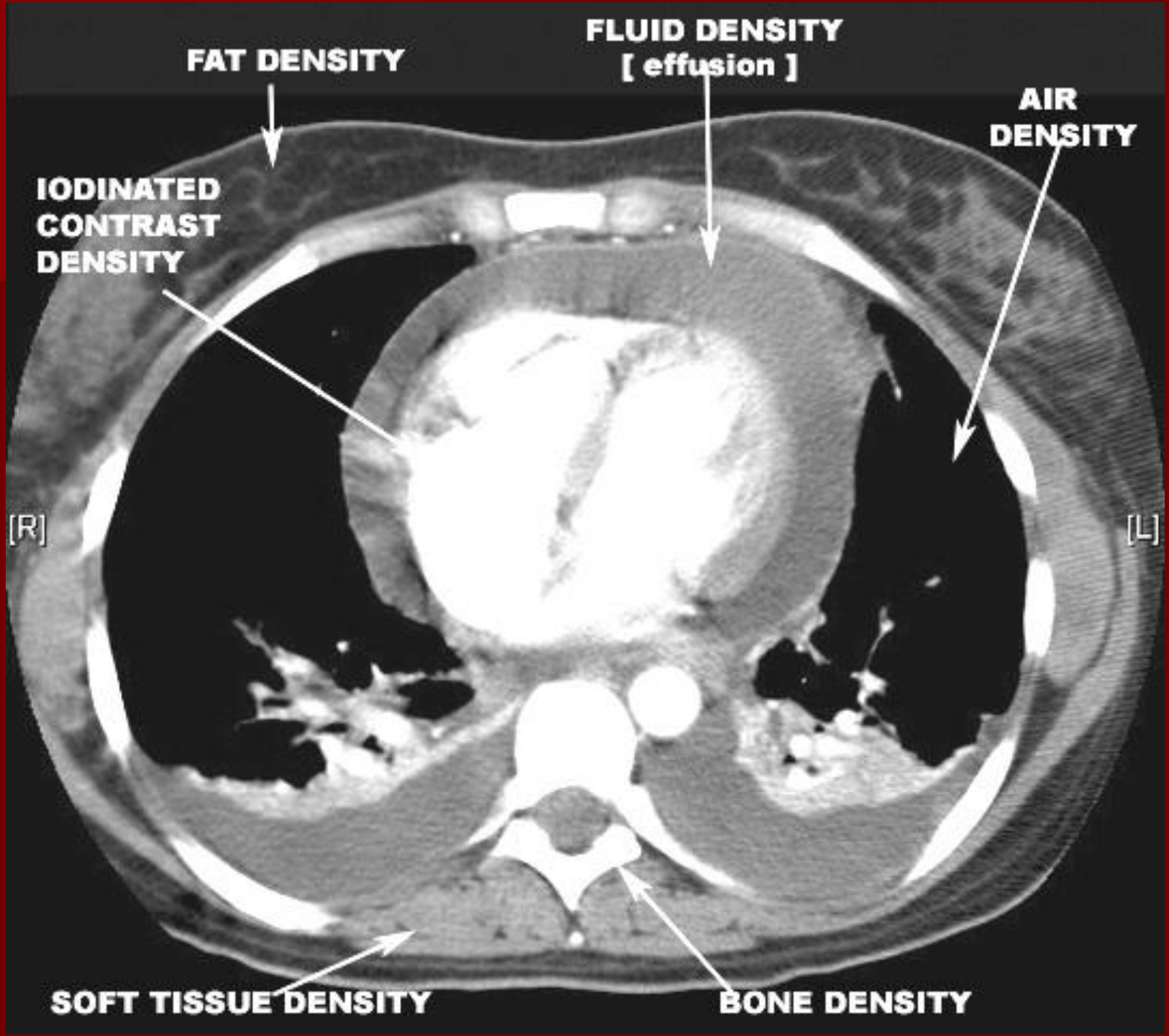
CT of abdomen **without contrast**.

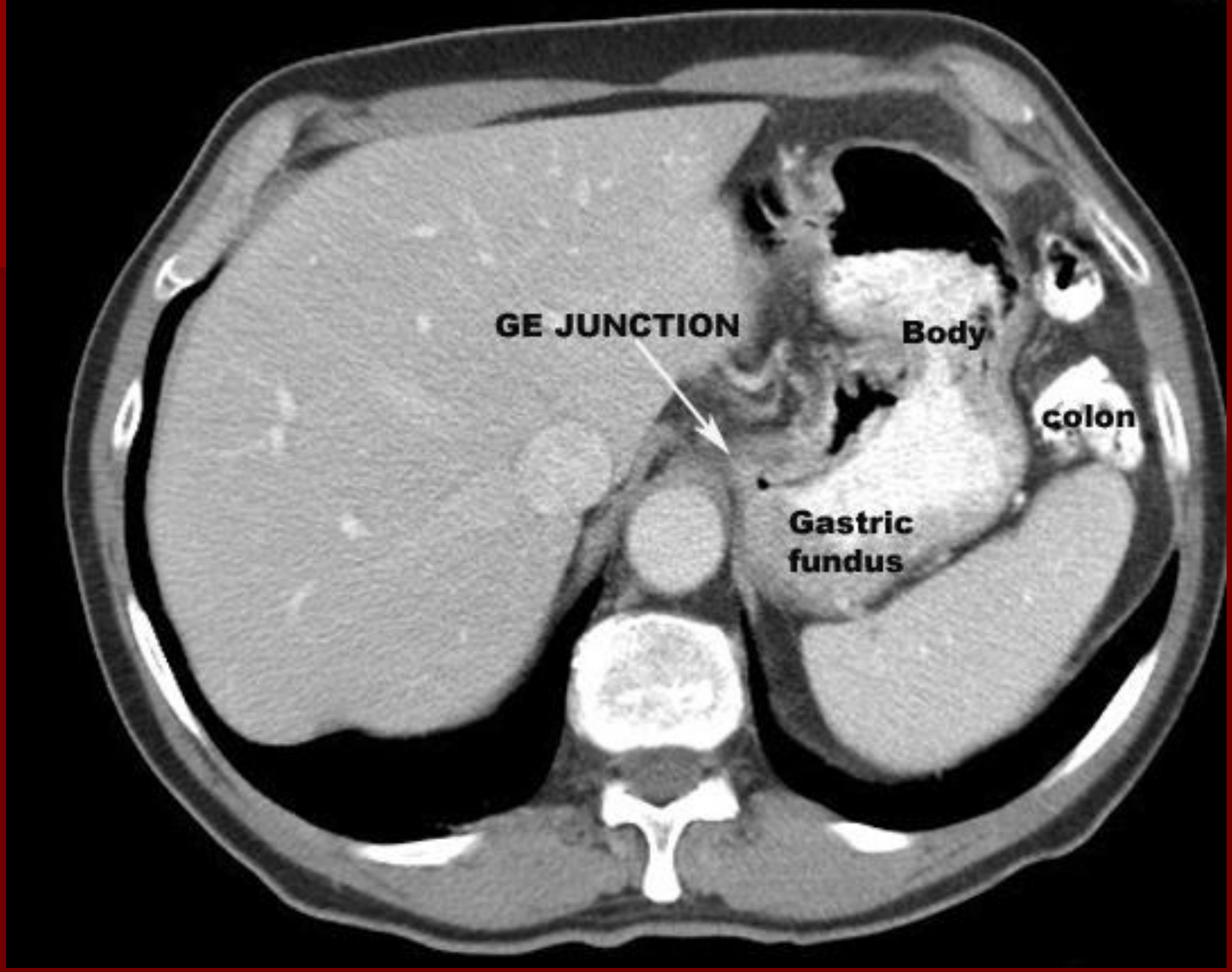
CT scan of abdomen **with intravenous contrast.**

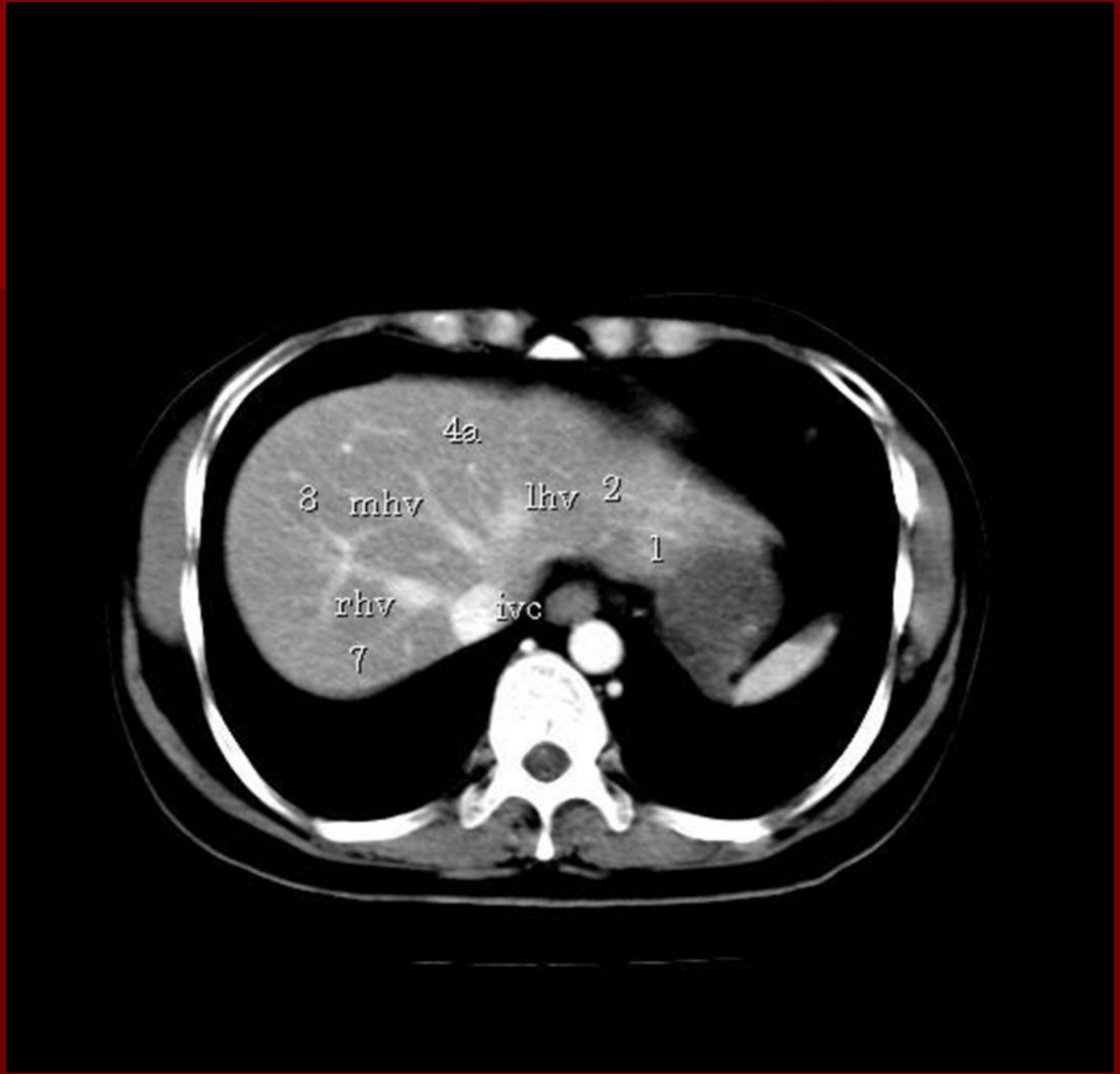
Notice how much better you can see the kidneys and blood vessels.

Contrast enhanced CT

- **Intravenous iodinated contrast** is used in CT to help highlight blood vessels and to enhance the tissue structure of various organs.
- **Oral and/or rectal contrast** may be used to help highlight GI system. A dilute (2%) suspension of Barium sulfate is most commonly used for this purpose. The concentrated barium sulfate preparations used for fluoroscopy, e.g., barium enema, are too dense and cause severe artifacts on CT.
- Iodinated contrast agents may be also used *per os* if barium is contraindicated (for example, suspicion of bowel injury).


FAT DENSITY
FLUID DENSITY
[effusion]
AIR
DENSITY
IODINATED
CONTRAST
DENSITY
[R]
[L]
SOFT TISSUE DENSITY
BONE DENSITY


GE JUNCTION
Body
colon
Gastric
fundus


4a
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mhv
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mhv
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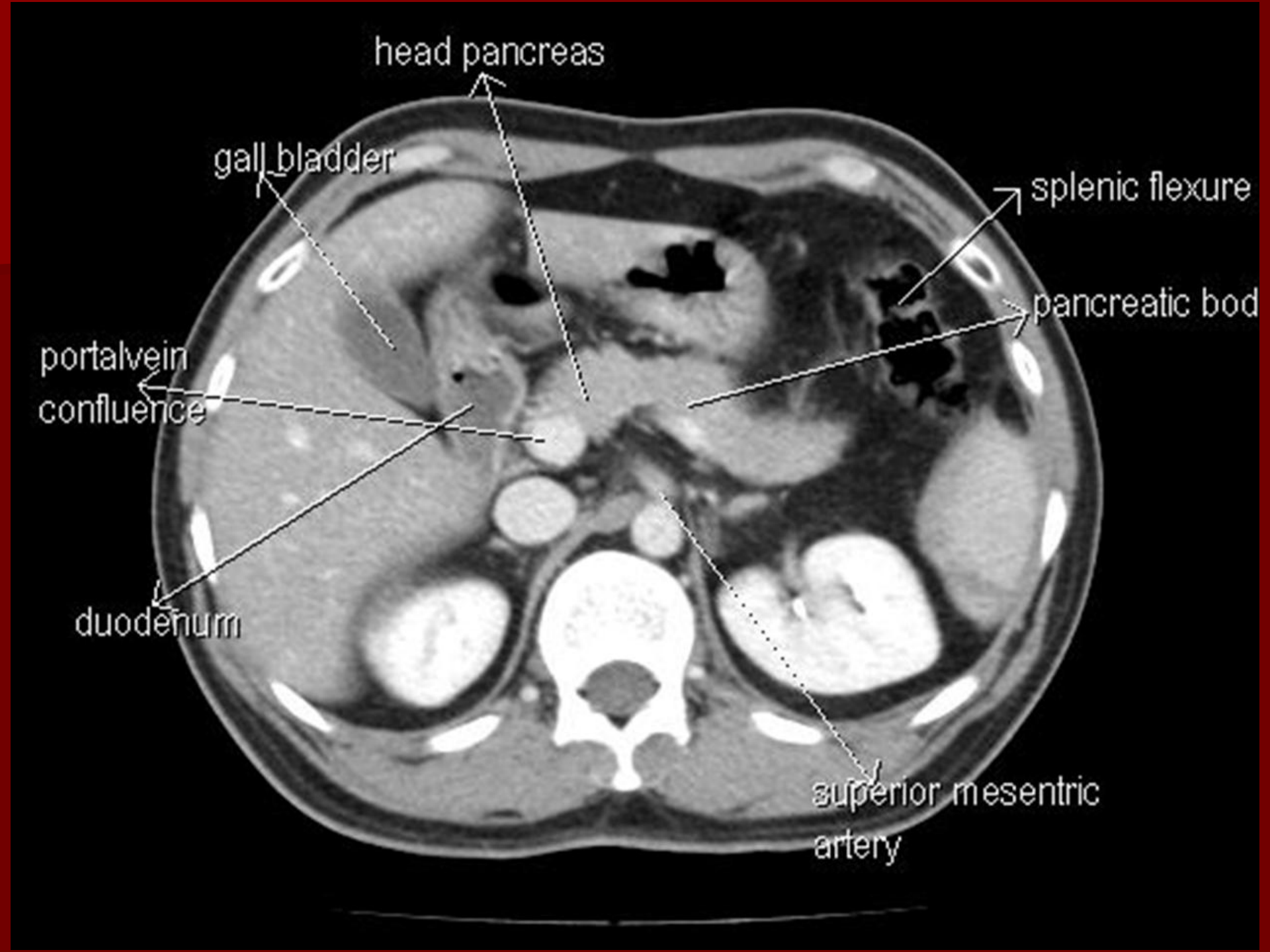
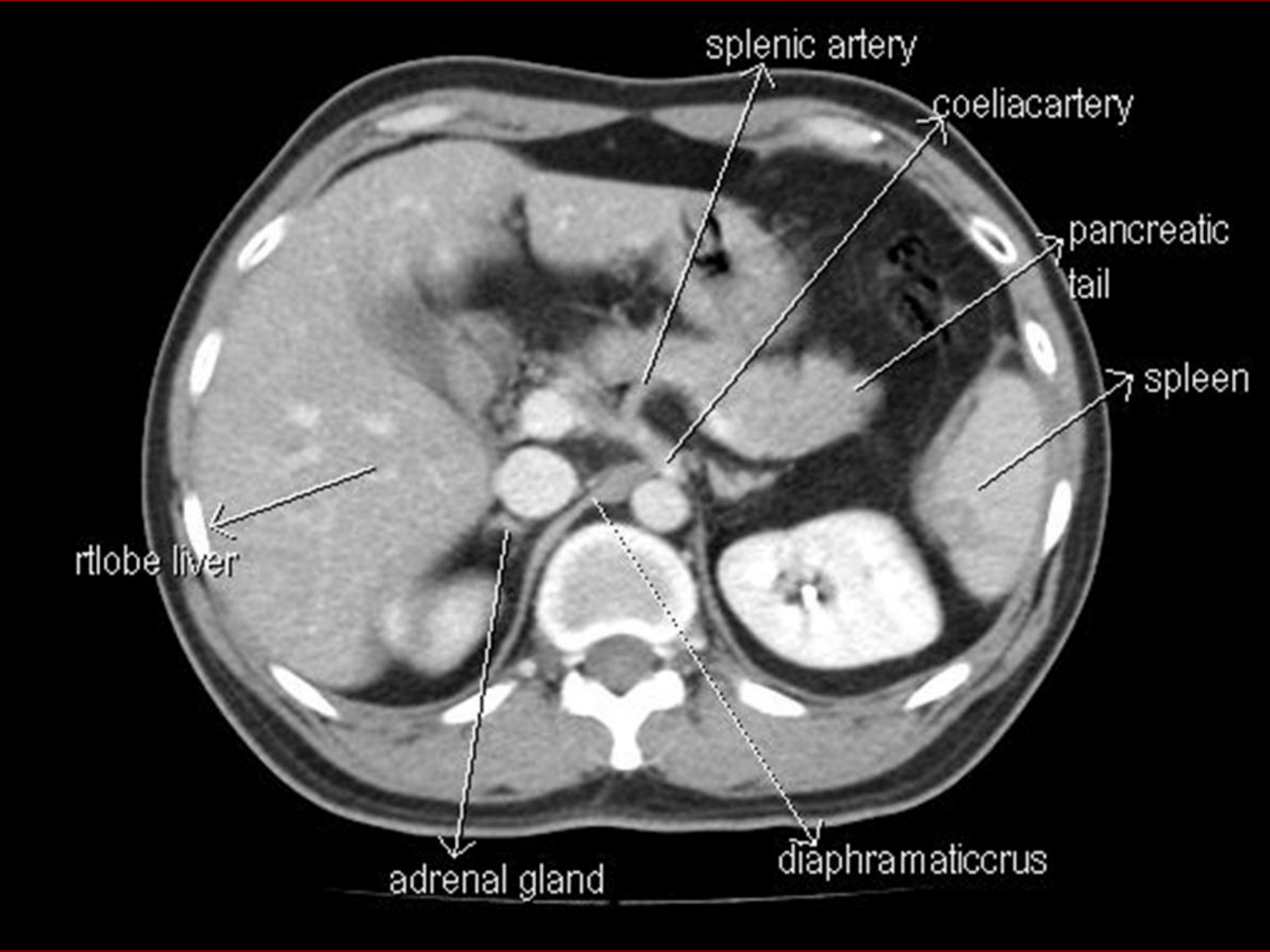
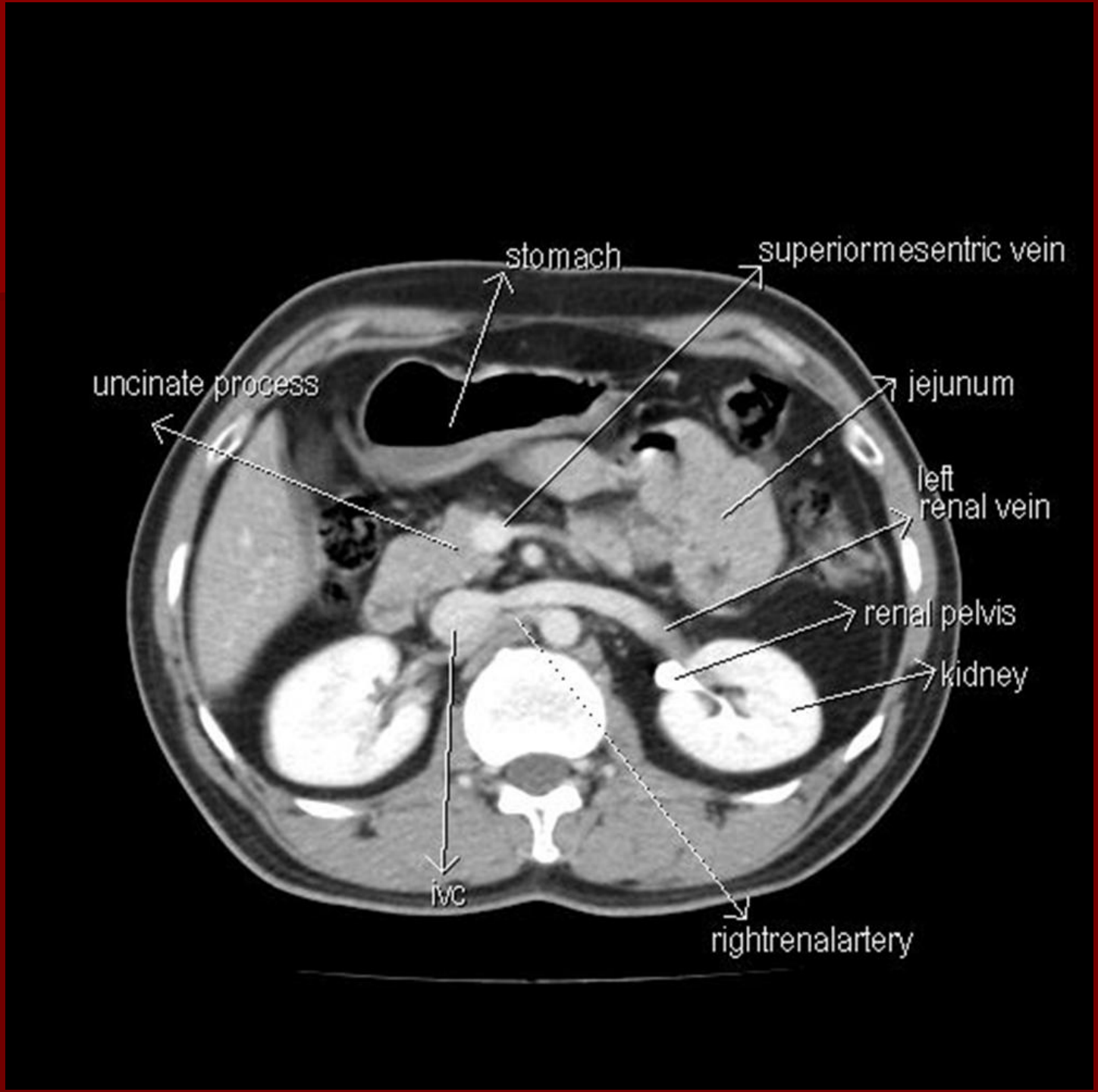
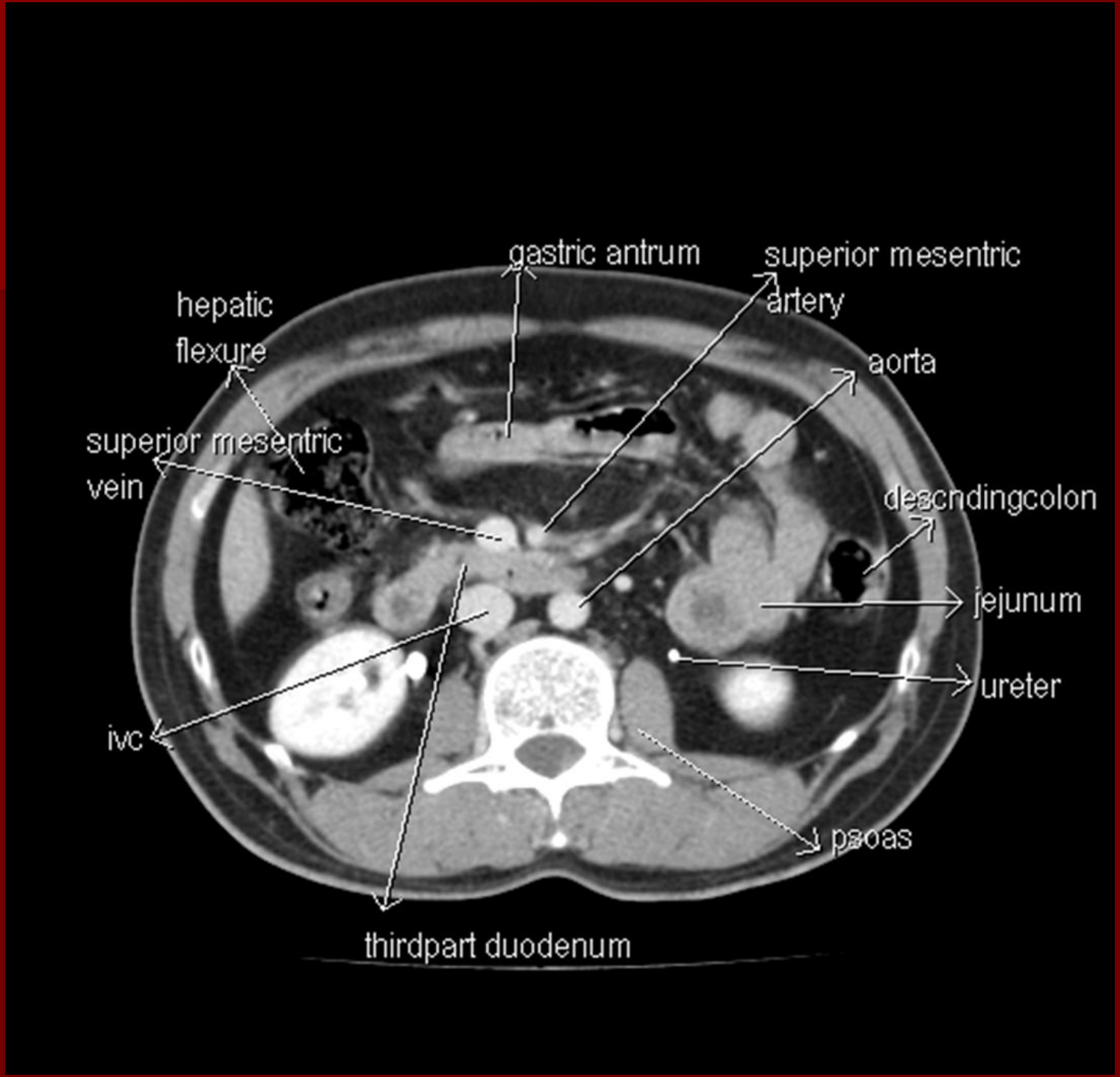
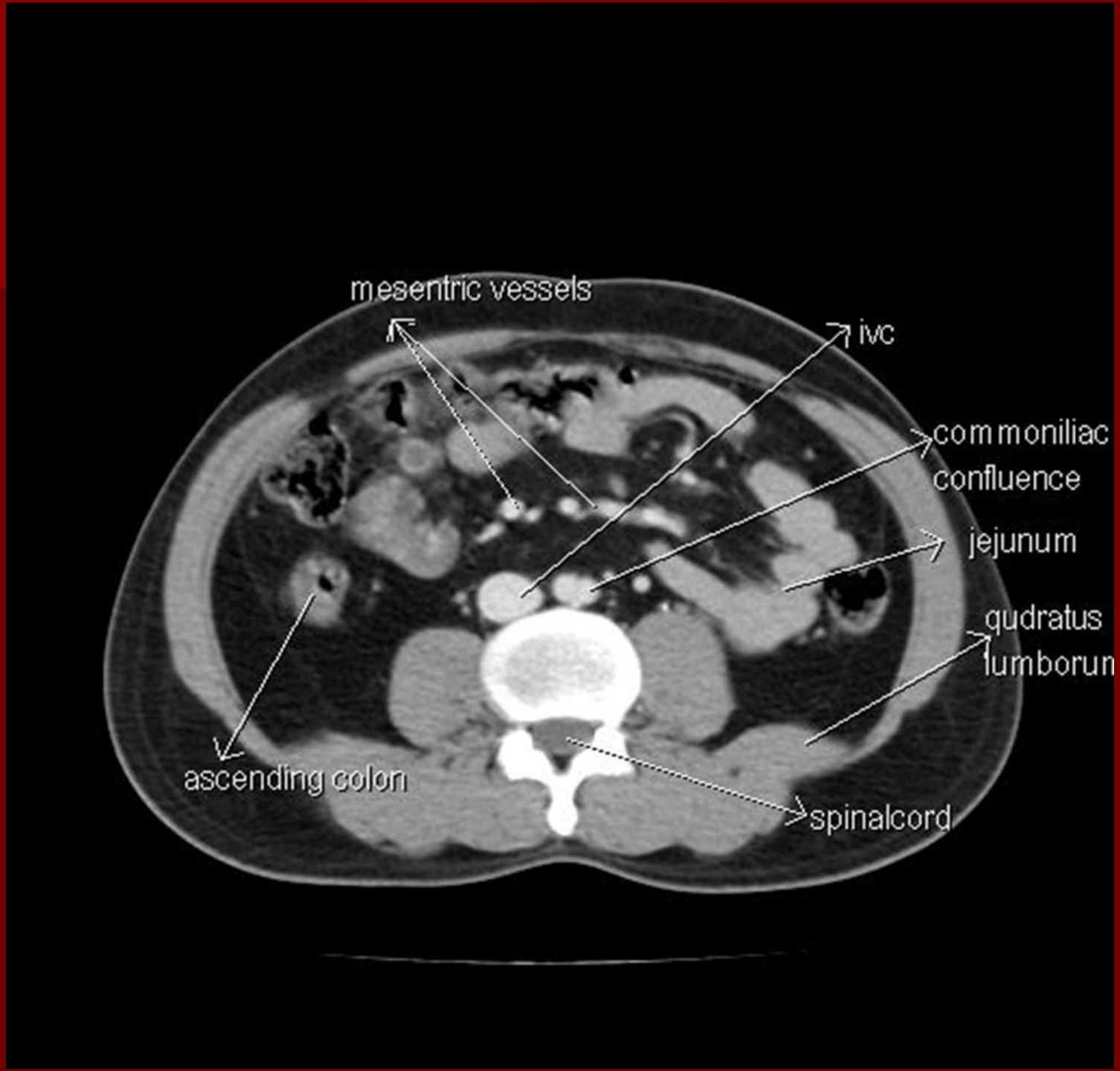

head pancreas
gall bladder
splenic flexure
pancreatic bod
portalvein
confluence
duodenum
superior mesentric
artery


splenic artery
coeliacartery
pancreatic tail
spleen
rtlobe liver
adrenal gland
diaphramaticcrus


stomach
superiormesentric vein
uncinate process
jejunum
left
renal vein
renal pelvis
kidney
ivc
rightrenalartery


gastric antrum
superior mesentric artery
hepatic flexure
aorta
superior mesentric vein
descndingcolon
jejunum
ureter
ivc
psoas
thirdpart duodenum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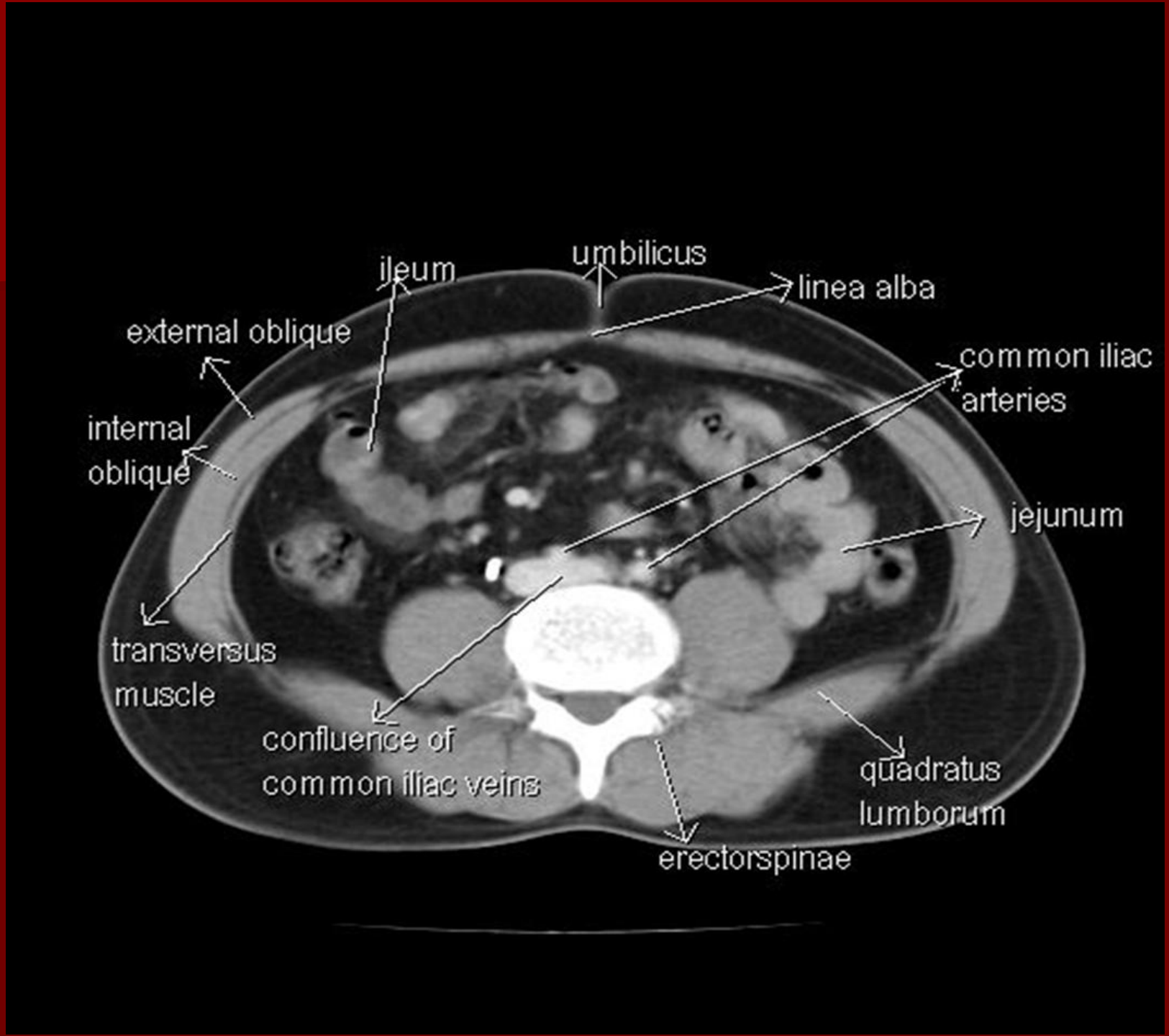
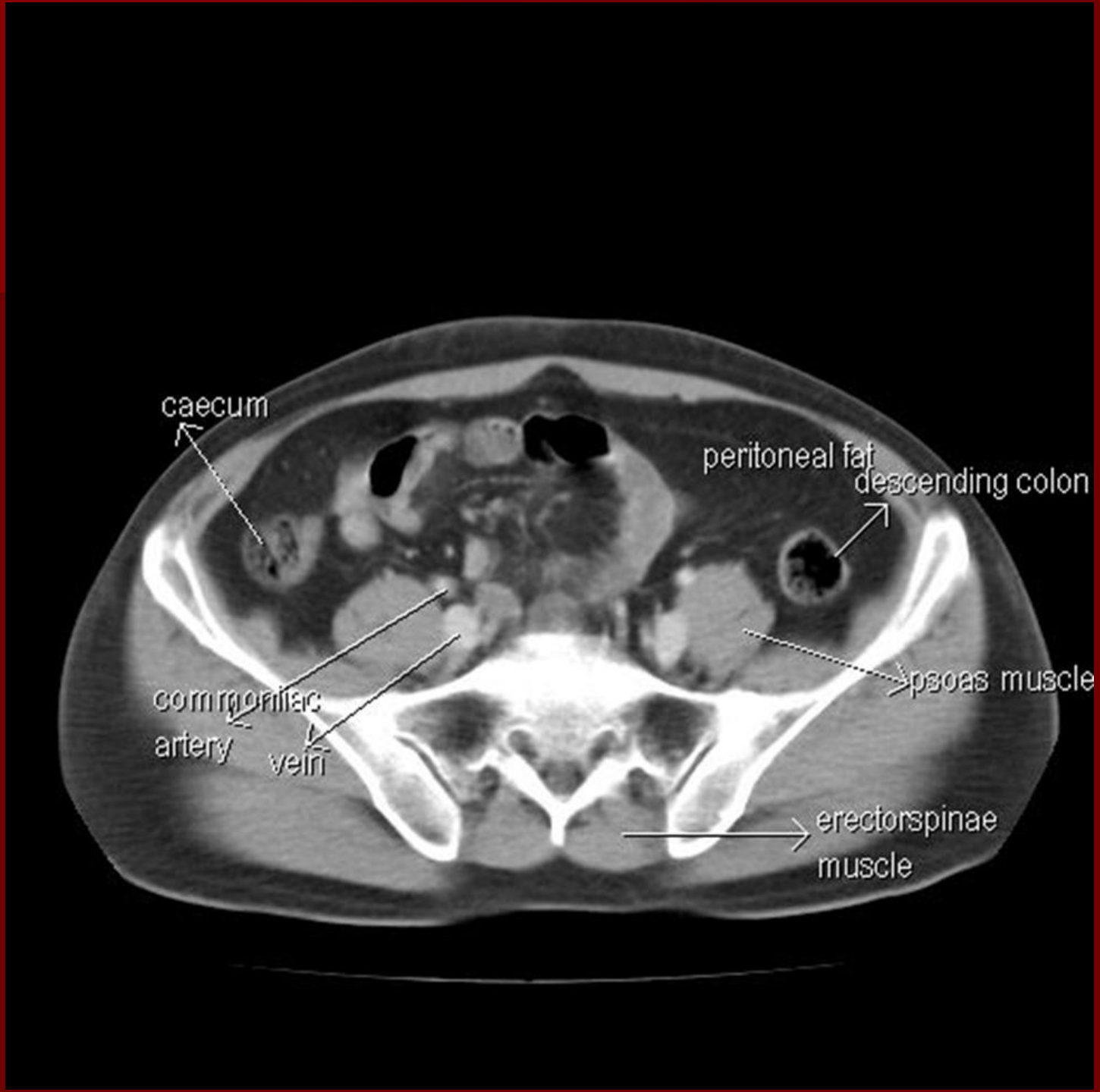
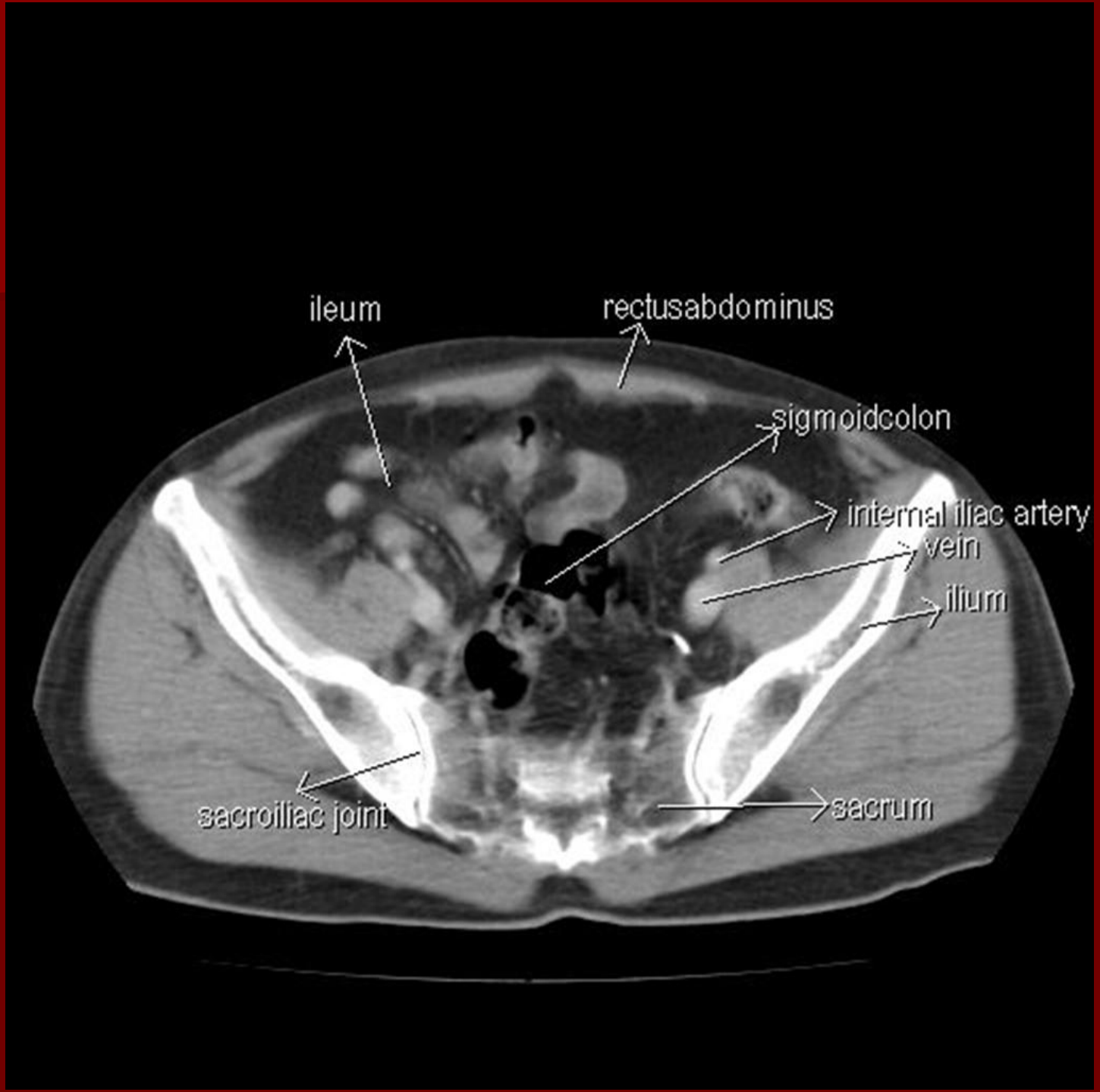
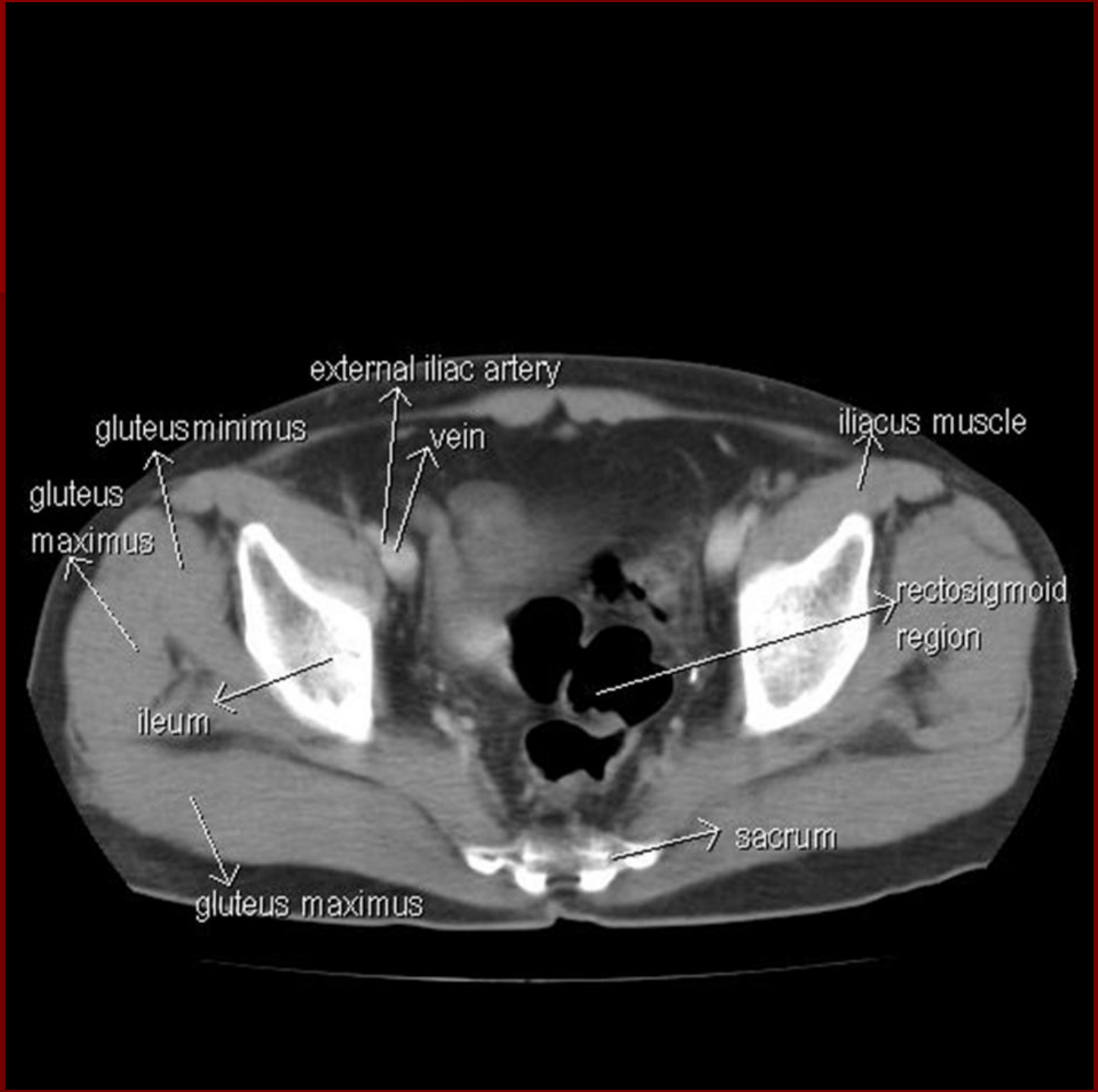
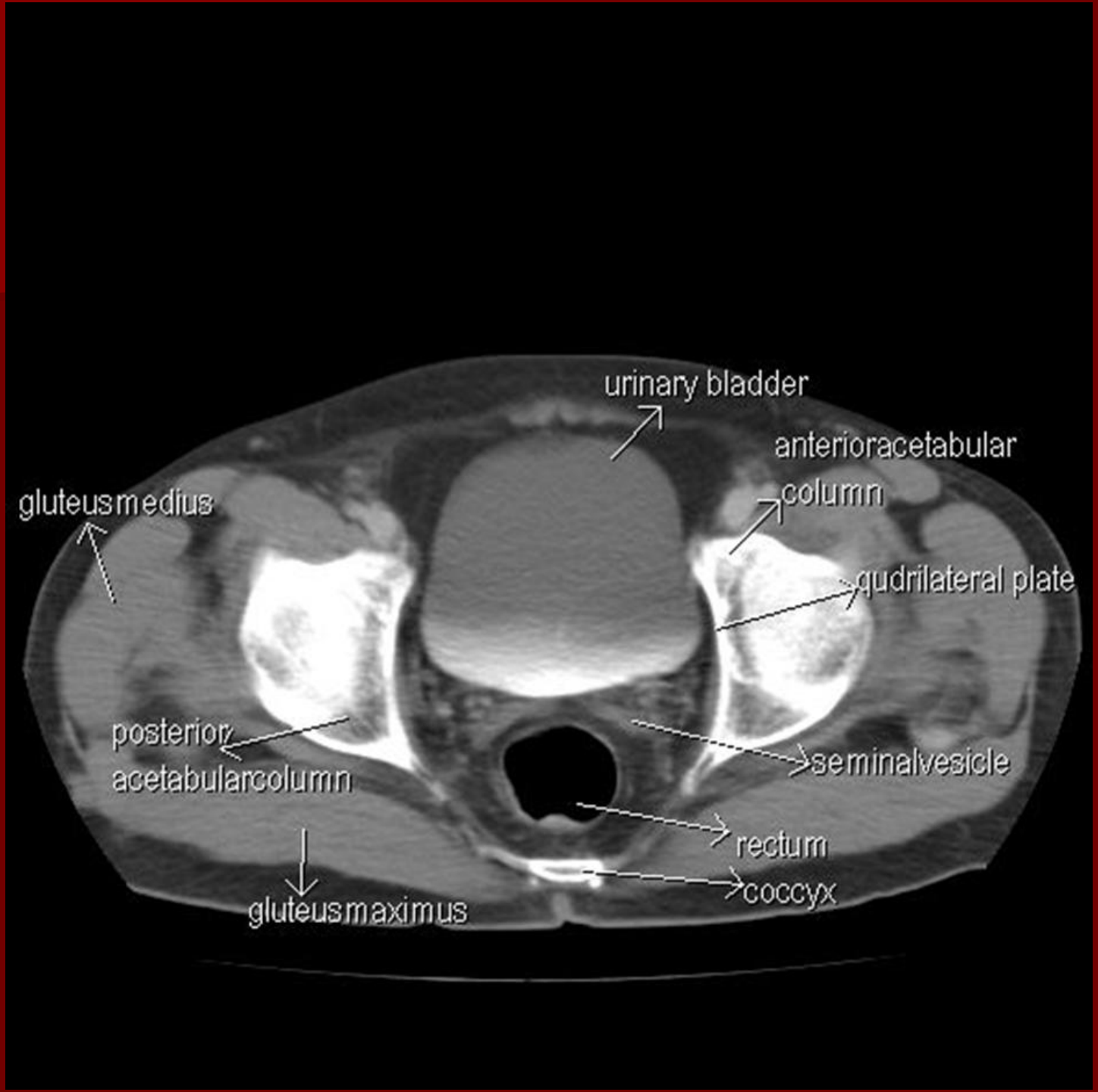
confluence
jejunum
qudratus
lumborun
ascending colon
spinalcord

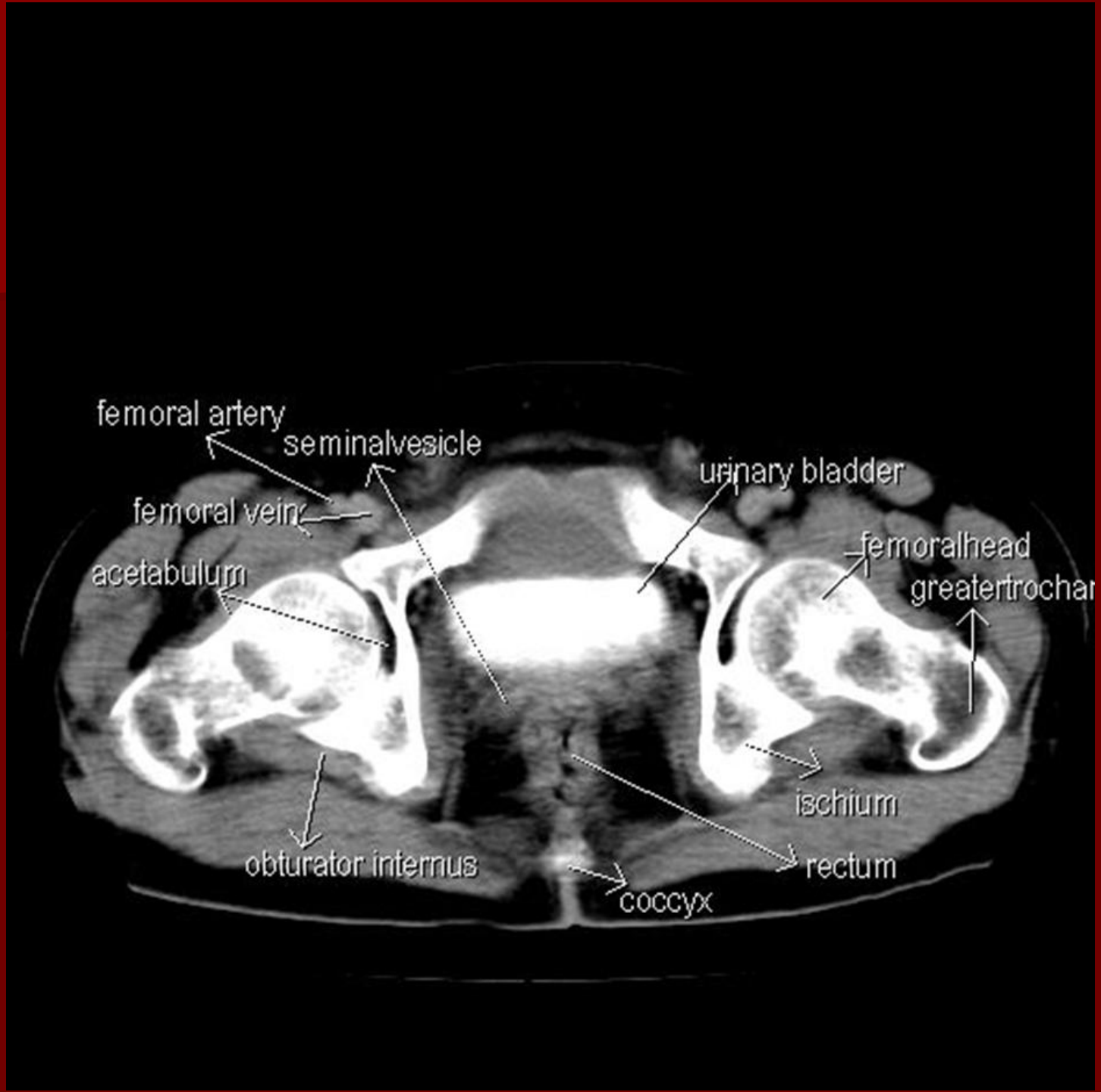

ileum
umbilicus
linea alba
external oblique
common iliac arteries
internal oblique
jejunum
transversus muscle
confluence of common iliac veins
quadratus lumborum
erectorspinae

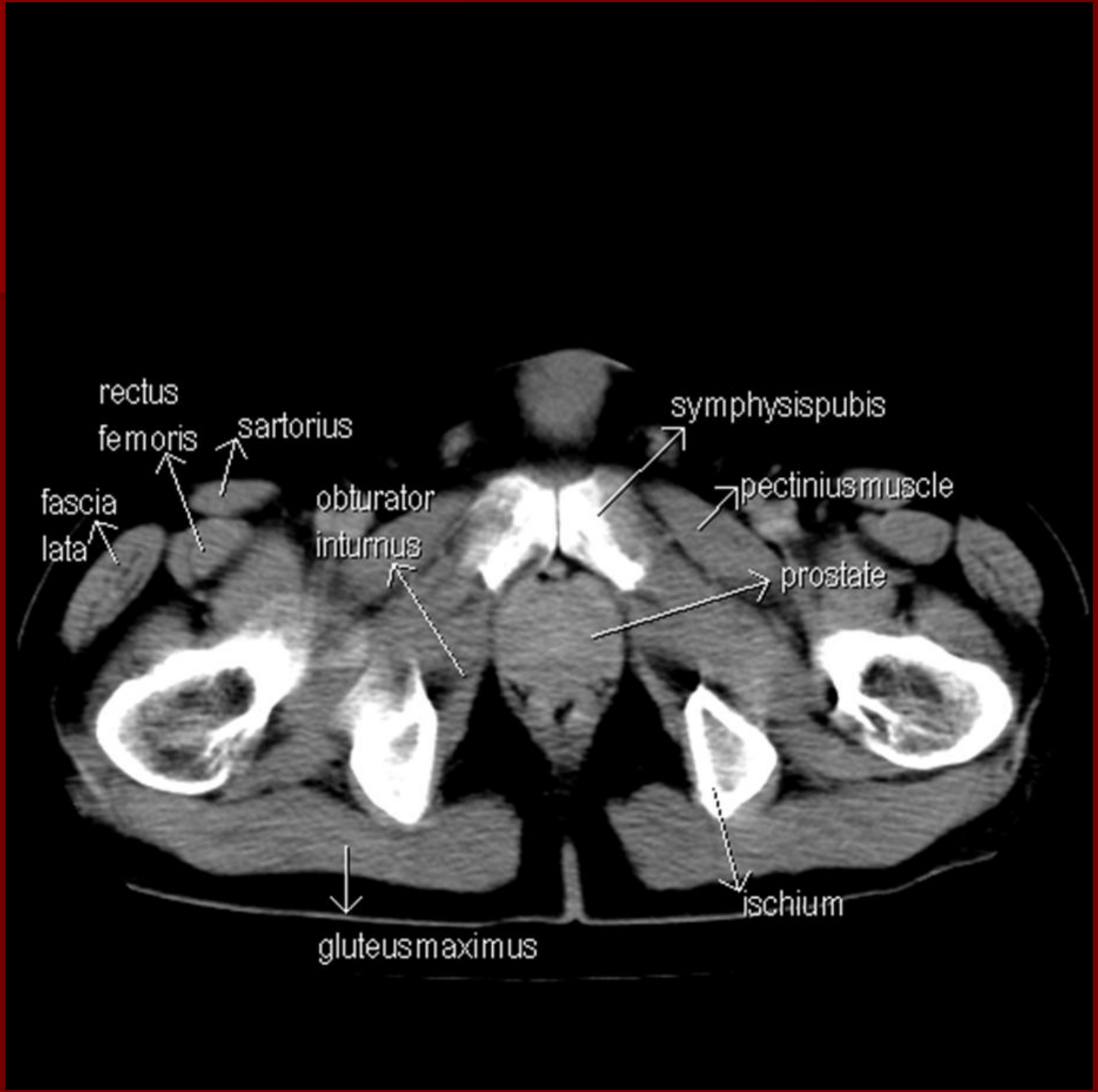

caecum
peritoneal fat
descending colon
psoas muscle
common iliac artery
vein
erectorspinae muscle


ileum
rectusabdominus
sigmoidcolon
internal iliac artery
vein
ilium
sacroiliac joint
sacrum

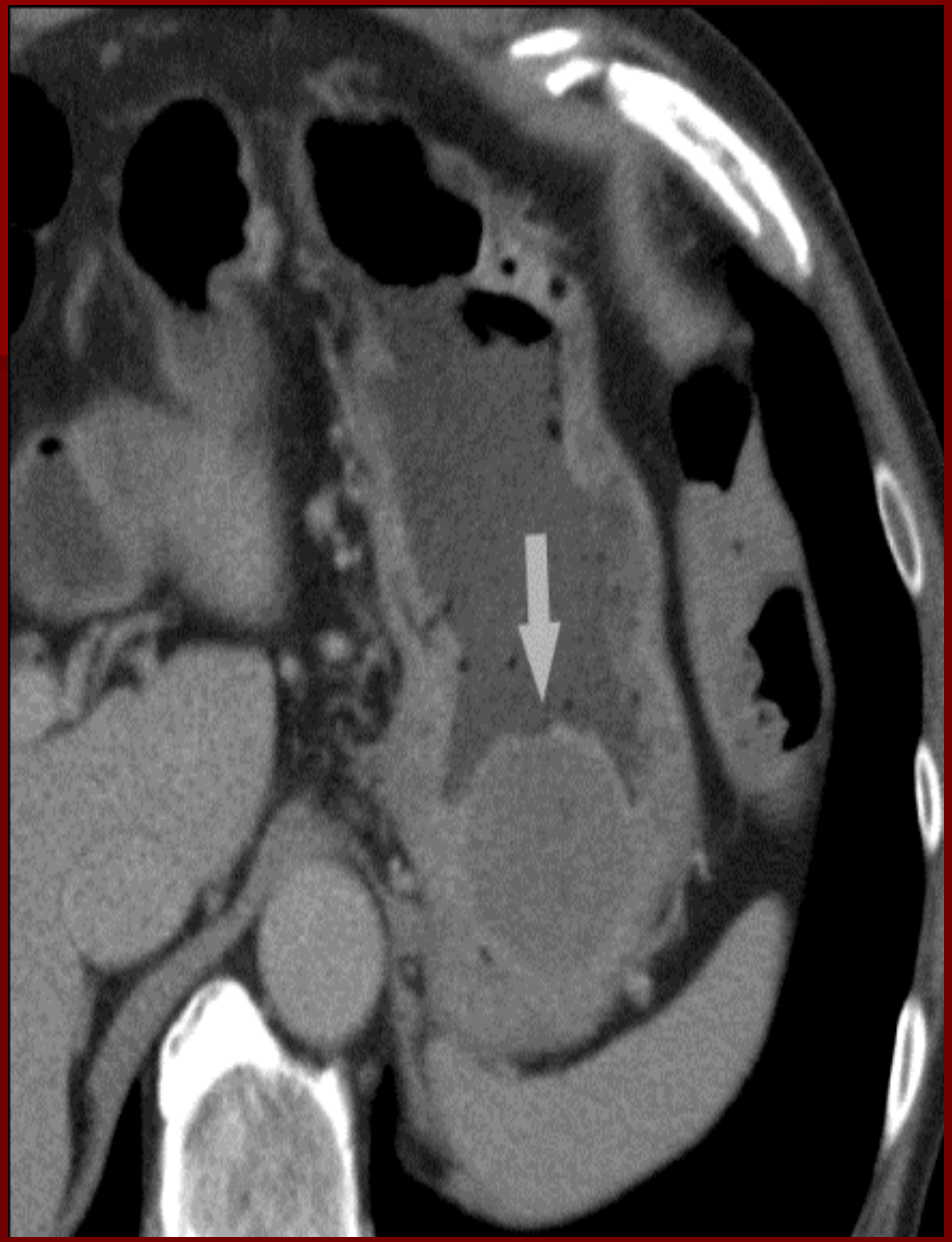

external iliac artery
gluteus minimus
vein
iliacus muscle
gluteus maximus
rectosigmoid region
ileum
sacrum
gluteus maximus


urinary bladder
anterioracetabular column
gluteus medius
qudrilateral plate
posterior acetabular column
seminal vesicle
rectum
coccyx
gluteus maximus


femoral artery
seminalvesicle
urinary bladder
femoral vein
femoralhead
acetabulum
greatertrochan
ischium
obturator internus
rectum
coccyx

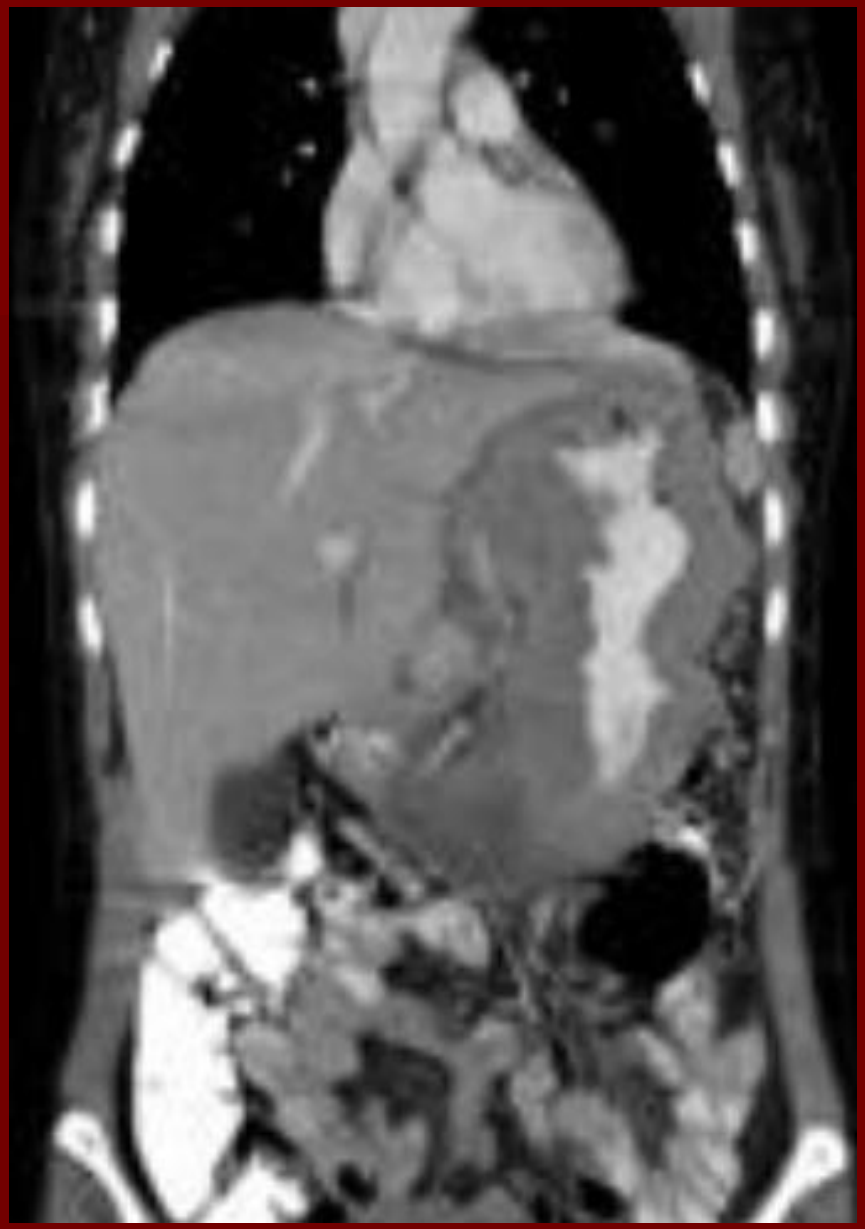

rectus
femoris
sartorius
fascia
lata
obturator
inturnus
symphysispubis
pectiniusmuscle
prostate
ischium
gluteusmaximus

Gastric adenocarcinoma: axial contrast-enhanced CT (CECT) showing tumour arising from the lesser curvature of the stomach (asterisk) associated with enlarged regional gastrohepatic nodes

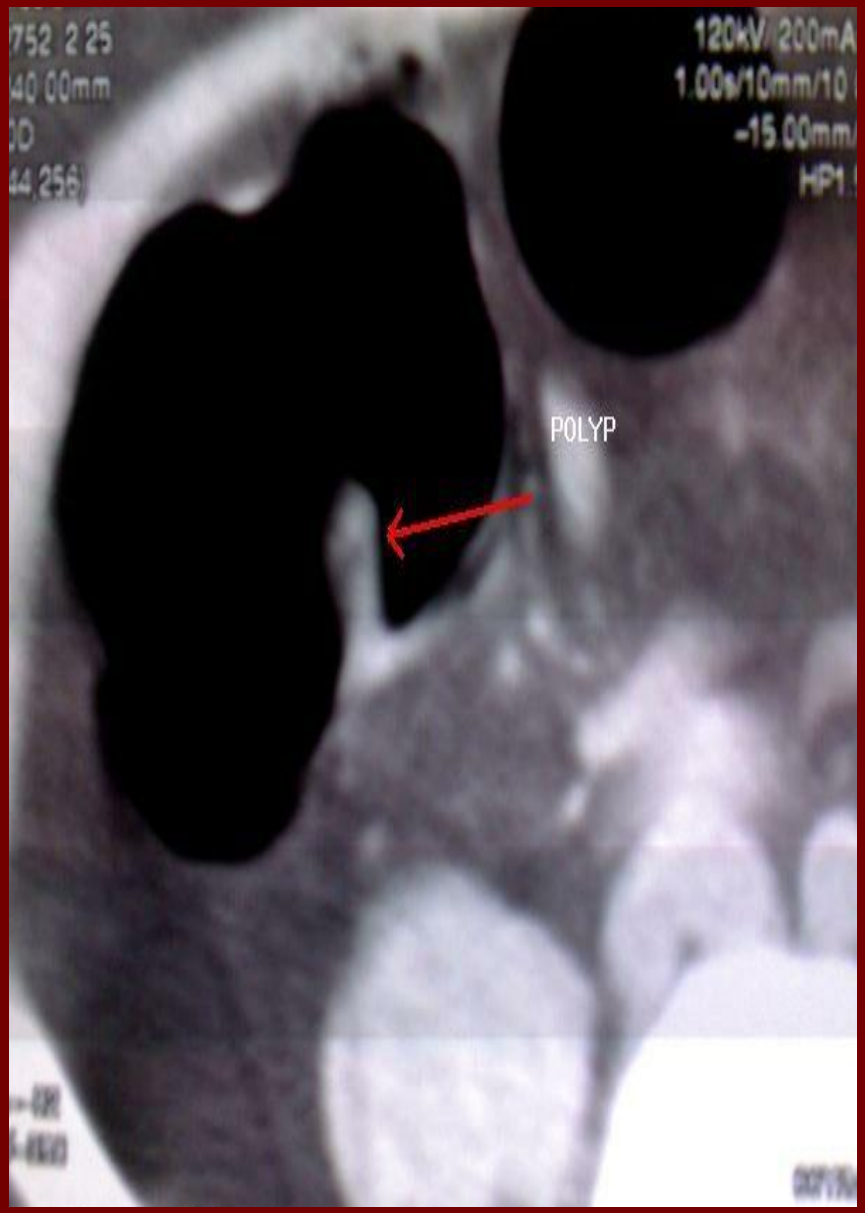


Low -grade GIST

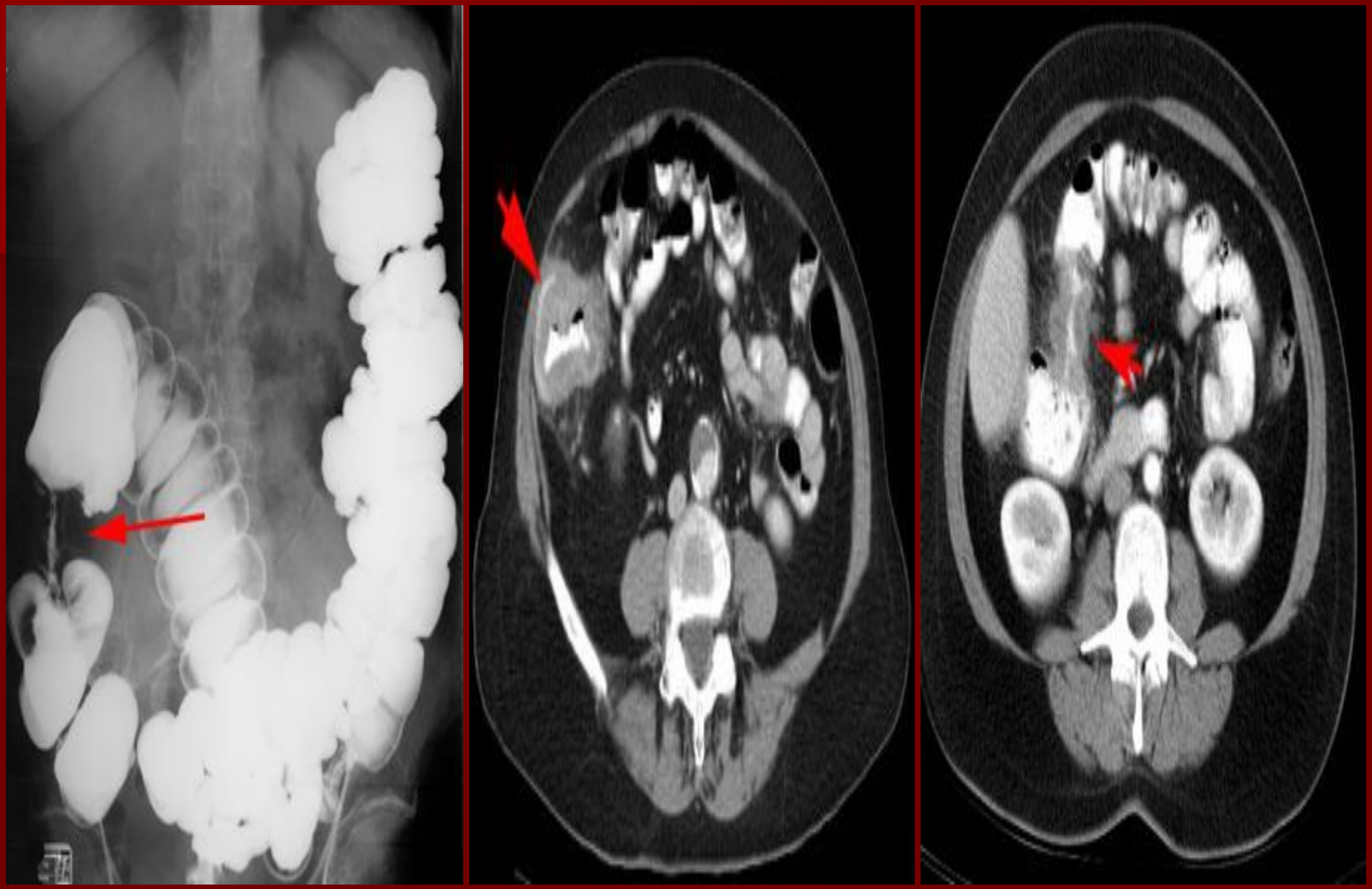
High-grade GIST



Gastric lymphoma.

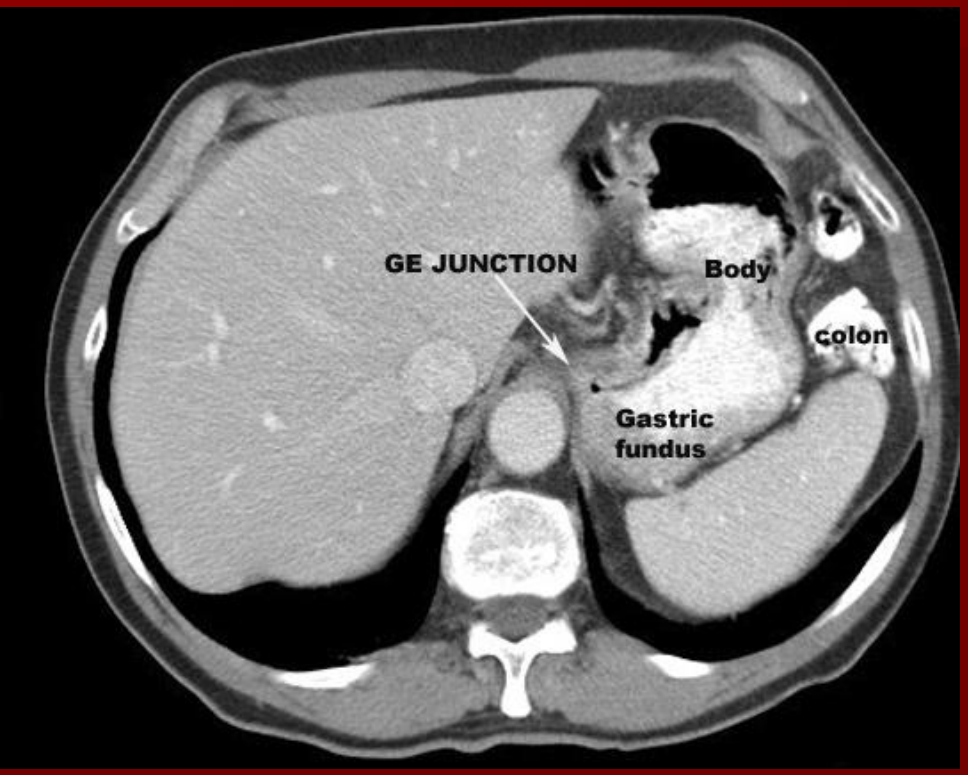


Colonic polyp



Colon Adenocarcinoma.

Carcinoma of the ascending colon.

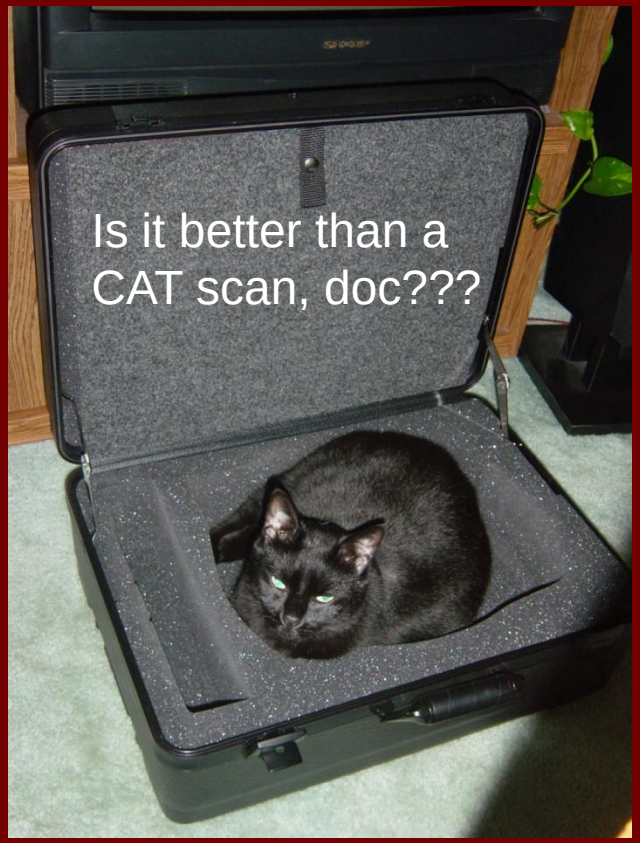


Normal liver parenchyma

Liver metastases

Abdominal Ultrasonography

- Uses transmission and reflection of ultrasound waves to visualize internal organs through the abdominal wall



Common indications for abdominal ultrasound

- In patients with abdominal pain can diagnose a variety of conditions such a cholecystitis, apendicitis, gallbladder or bile duct diseases, cholestasis, tumors, etc.
- In patients with abnormal pancreatic enzymes for evaluation of pancreatic pathology.
- Evaluation of abdominal aortic and other vascular aneurysms.
- It is very useful for detecting gallstones, because they create a distinct ultrasound shadow behind the stone.
- It is used to guide procedures such as extracorporeal shock wave lithotripsy, needle biopsies or paracentesis.

Advantages:

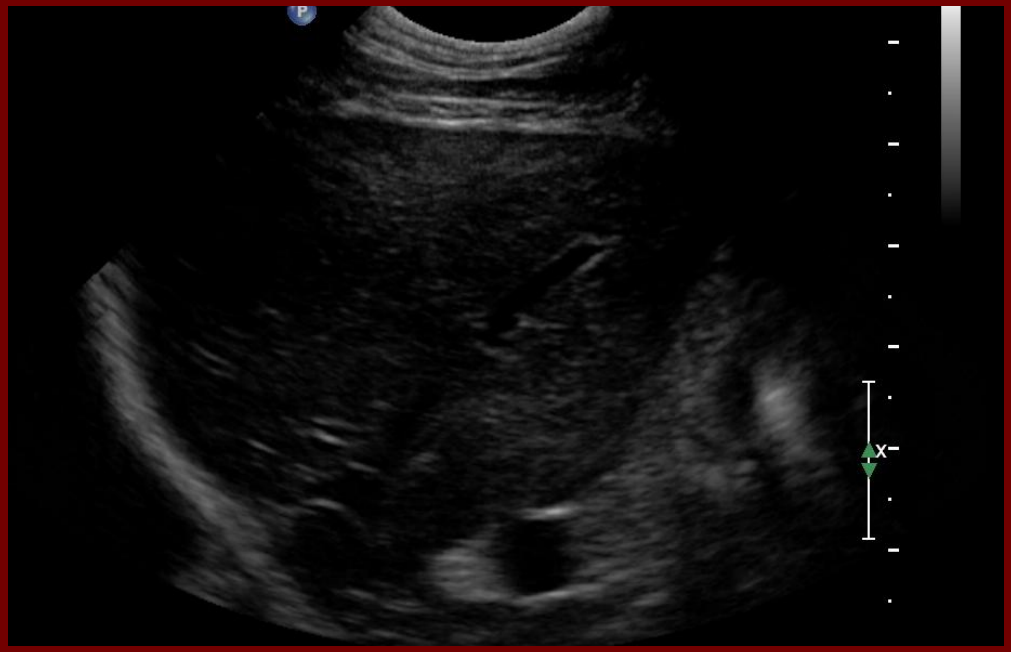
- **can be performed quickly, including at the bed-side**
- **involves no exposure to X-rays, making it also useful in pregnant patients**
- **inexpensive compared to other imaging modalities such as CT or MRI-based techniques**

Disadvantages:

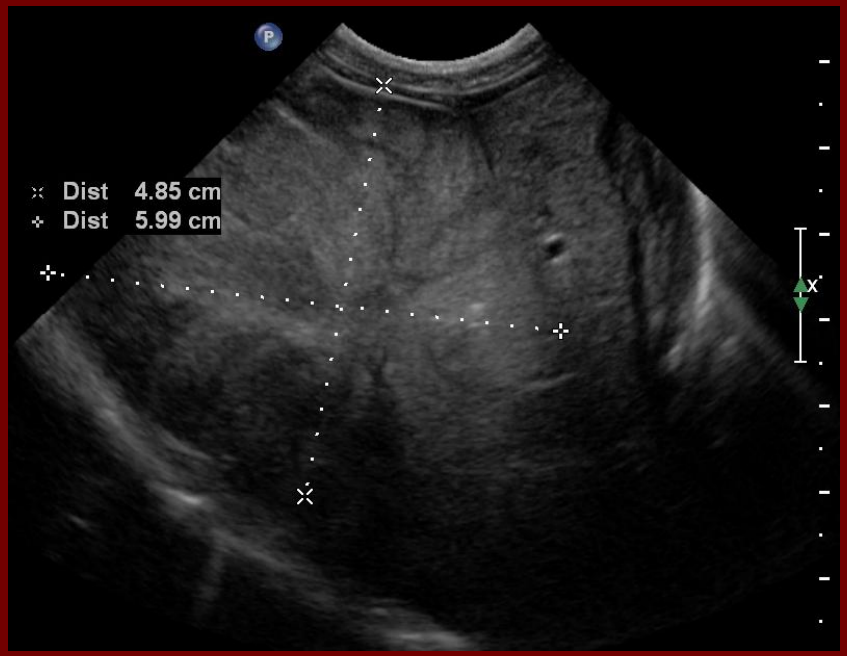
- **troublesome imaging if a lot of gas is present inside the bowels of if there is a lot of abdominal fat**
- **is highly operator-dependent** (i.e. the quality of the imaging depends on the experience of the person performing it)

Patient preparation:

- The patient should be fasting for 12 hours.
- Optimum conditions for the ultrasound examination of the abdominal organs require a fluid-filled gallbladder and as little gas in the gastrointestinal tract as possible.



Normal liver parenchyma



Liver mass

Abdominal MRI

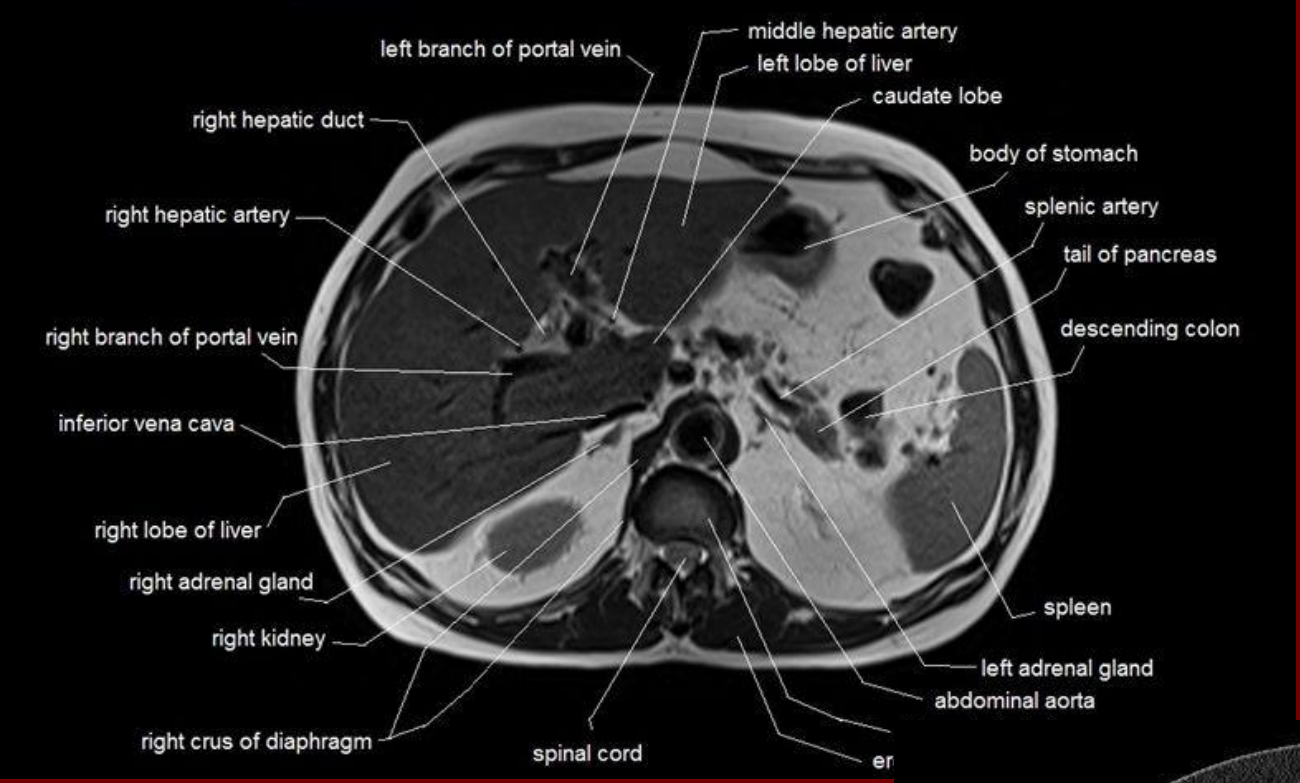
- Uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, and virtually all internal body structures.
- MRI is particularly useful for the imaging of soft tissues and is increasingly being used for diagnosis and follow up.
- MRI of the abdomen and pelvis – commonly used for evaluation of tumours, vascular pathologies, infection, inflammation, congenital abnormalities and metabolic disorders.
- Particularly useful for detection of liver, bowel and rectal tumors as well as for assessing peri-anal fistulas.

Advantages of MRI:

- MRI is non-invasive and does not use radiation
- MRI contrast agents are less likely to produce allergic reactions
- gives extremely clear, detailed images of soft-tissue structures

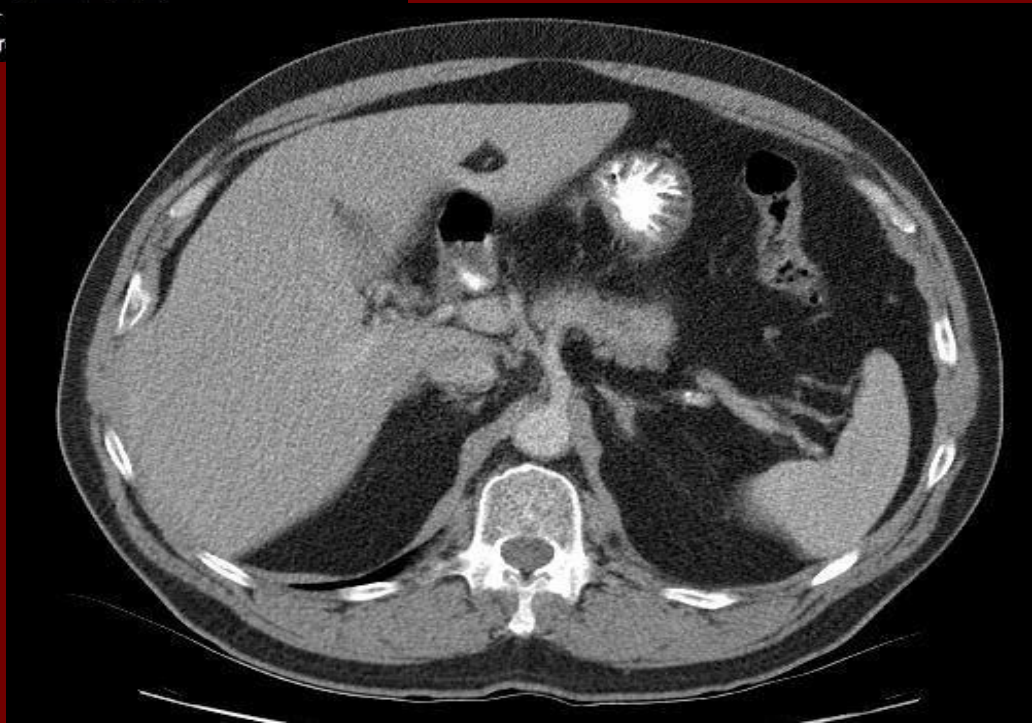
Disadvantages of MRI:

- it is a lengthy procedure, relatively expensive and involves really loud noises
- cannot be performed in patients with metallic foreign bodies or implants (pacemakers, aneurysm clips, cardiac stents, etc)
- patients with claustrophobia may require general anesthesia



Axial MRI image of the upper abdomen

Axial CT image of the upper abdomen



BARIUM CONTRAST INVESTIGATION OF THE UPPER GASTROINTESTINAL TRACT.

Technique, indications and imaging findings in common gastrointestinal pathology.

BARIUM STUDIES

- Barium sulfate - an inert contrast agent that can be seen clearly on a radiograph. If it is swallowed before radiographs are taken, the barium within the esophagus, stomach or bowel shows the shape of the lumen of these organs.

a) **Barium swallow** (examination of the esophagus)
b) **Barium meal** (examination of the esophagus & stomach)
c) **Barium follow-through** (examination of the esophagus, stomach and small intestine)
d) **Barium enema** (examination of the colon)

Barium swallow

- This is a fluoroscopic examination to visualize the esophagus and its function (and to a leser extent the stomach).
- The patient is required to be fasting for 8 hours prior to the exam.
- During the exam, the patient swallows a cup of barium sulfate. Using the fluoroscopy machine, the radiologist will study the transit of the barium through the esophagus.

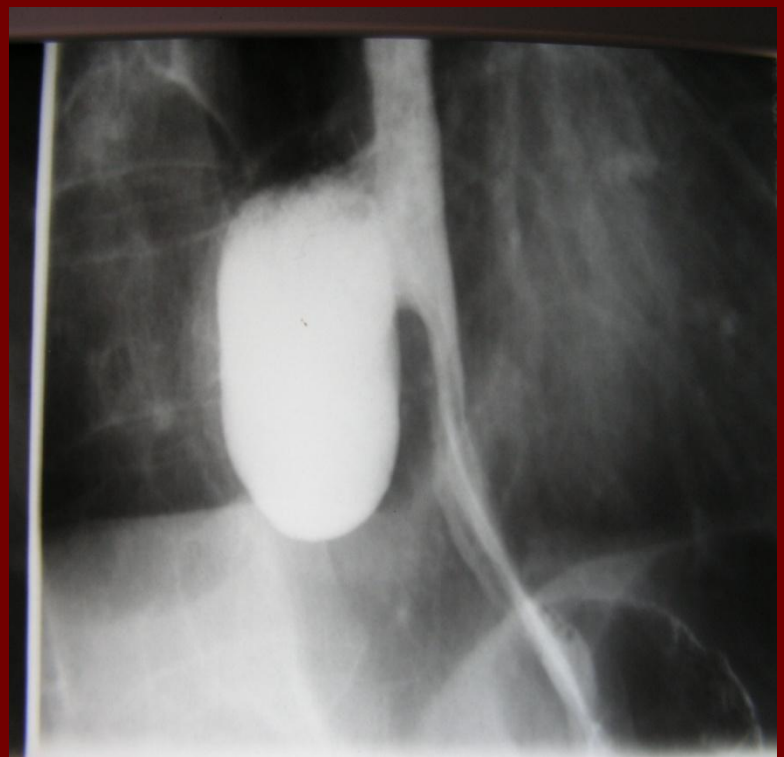
Achalasia

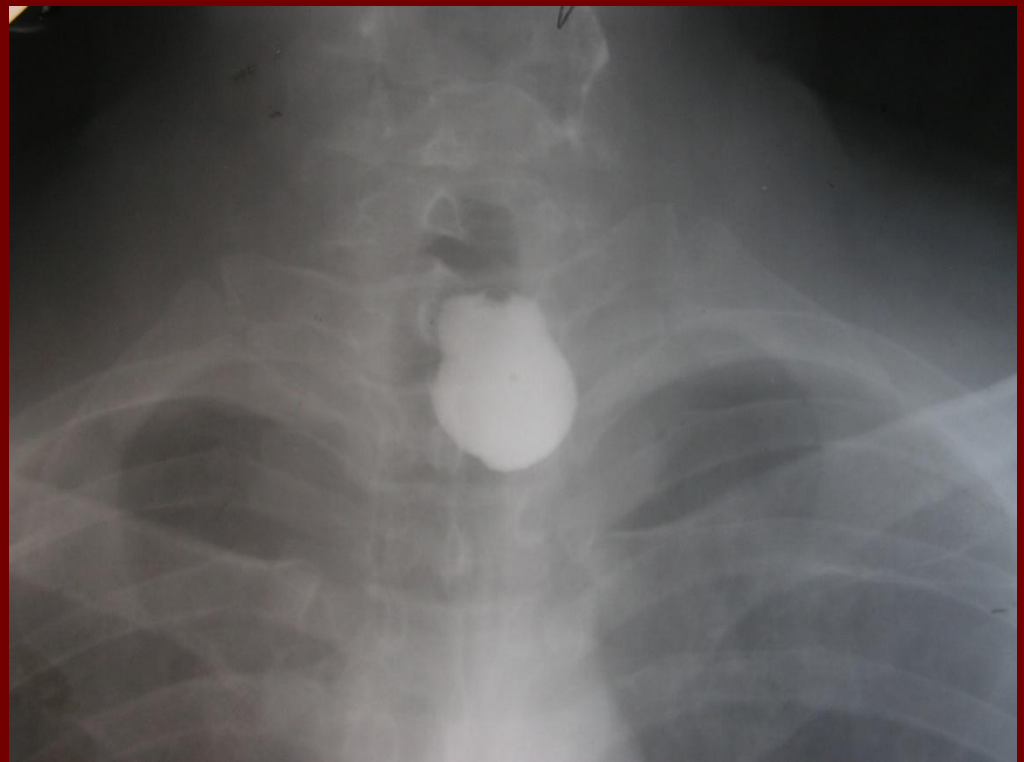
- An esophageal motility disorder characterized by incomplete lower esophageal sphincter (LES) relaxation, increased LES tone, and lack of peristalsis of the esophagus.
- Acute tapering at the lower esophageal sphincter and narrowing at the gastro-esophageal junction, producing a "bird's beak" or "rat's tail" appearance.
- Dilatation of the esophagus above the narrowing is also present.

Esophageal diverticula

- **True diverticula** involve all layers, including muscularis propria and adventitia.
- **False diverticula** involve only the submucosa and mucosa without affecting the muscular layers or adventitia.

- **Traction esophageal diverticula** usually occur due to scarring from mediastinal or pulmonary tuberculosis





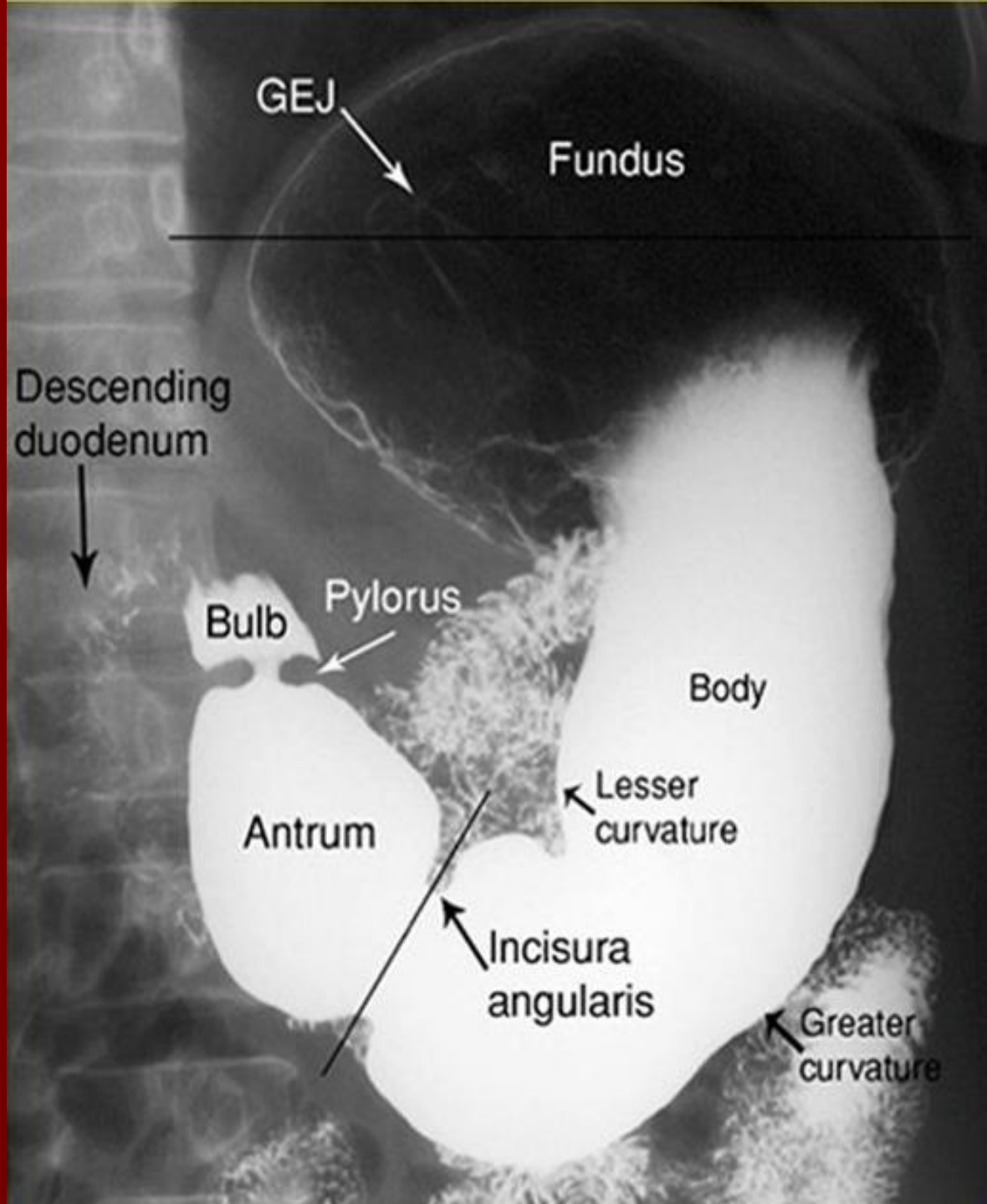
Esophageal diverticula

- A Zenker's diverticulum is also called pharyngeal pouch, pharyngoesophageal diverticulum, hypopharyngeal diverticulum
- Is a diverticulum of the mucosa of the pharynx, just above the cricopharyngeal muscle (i.e. above the upper sphincter of the esophagus).
- It is a pseudo diverticulum (not involving all layers of the esophageal wall).
- When there is excessive pressure within the lower pharynx, the weakest portion of the pharyngeal wall balloons out, forming a diverticulum which may reach several centimetres in diameter.

Barium meal

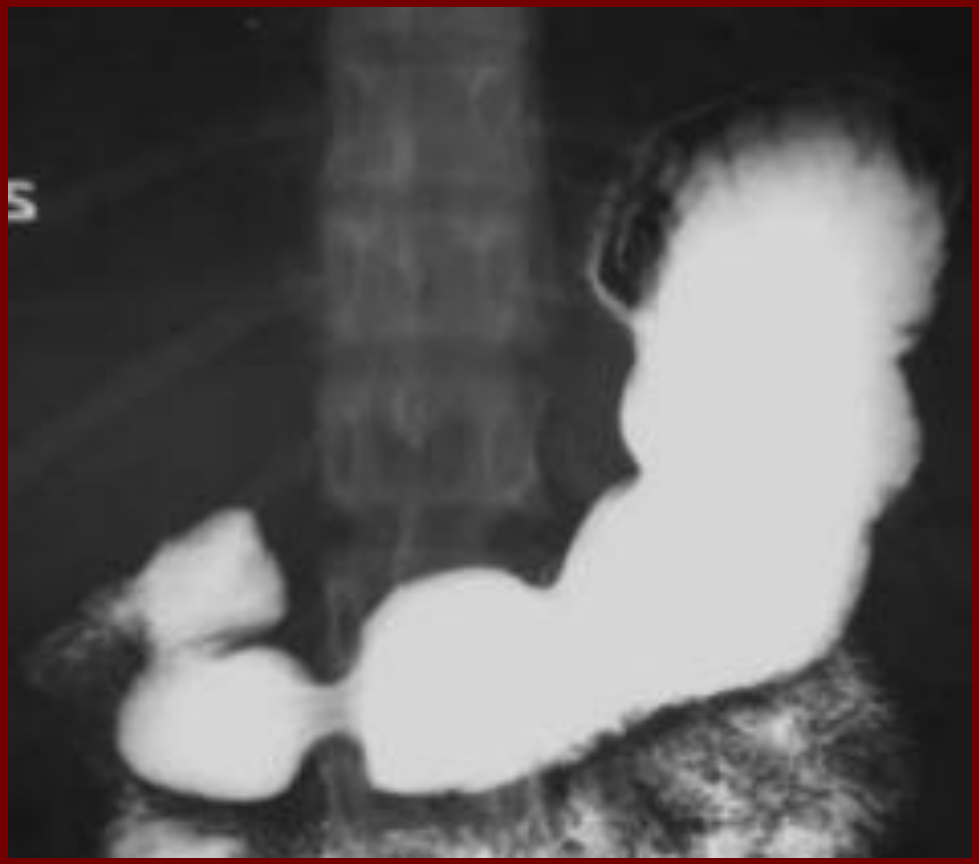
This is a fluoroscopic examination of the stomach and its function following *per os* administration of barium sulfate.

The patient needs to fast for 8 hours prior to the exam.



Barium meal

- Single contast Barium meal – uses only barium sulfate.
- Double contrast Barium meal – uses barium sulfate and a negative contrast agent (such as air, nitrogen or carbon dioxide) for a better visualization of gastric mucosa and small mucosal lesions.



Single contrast

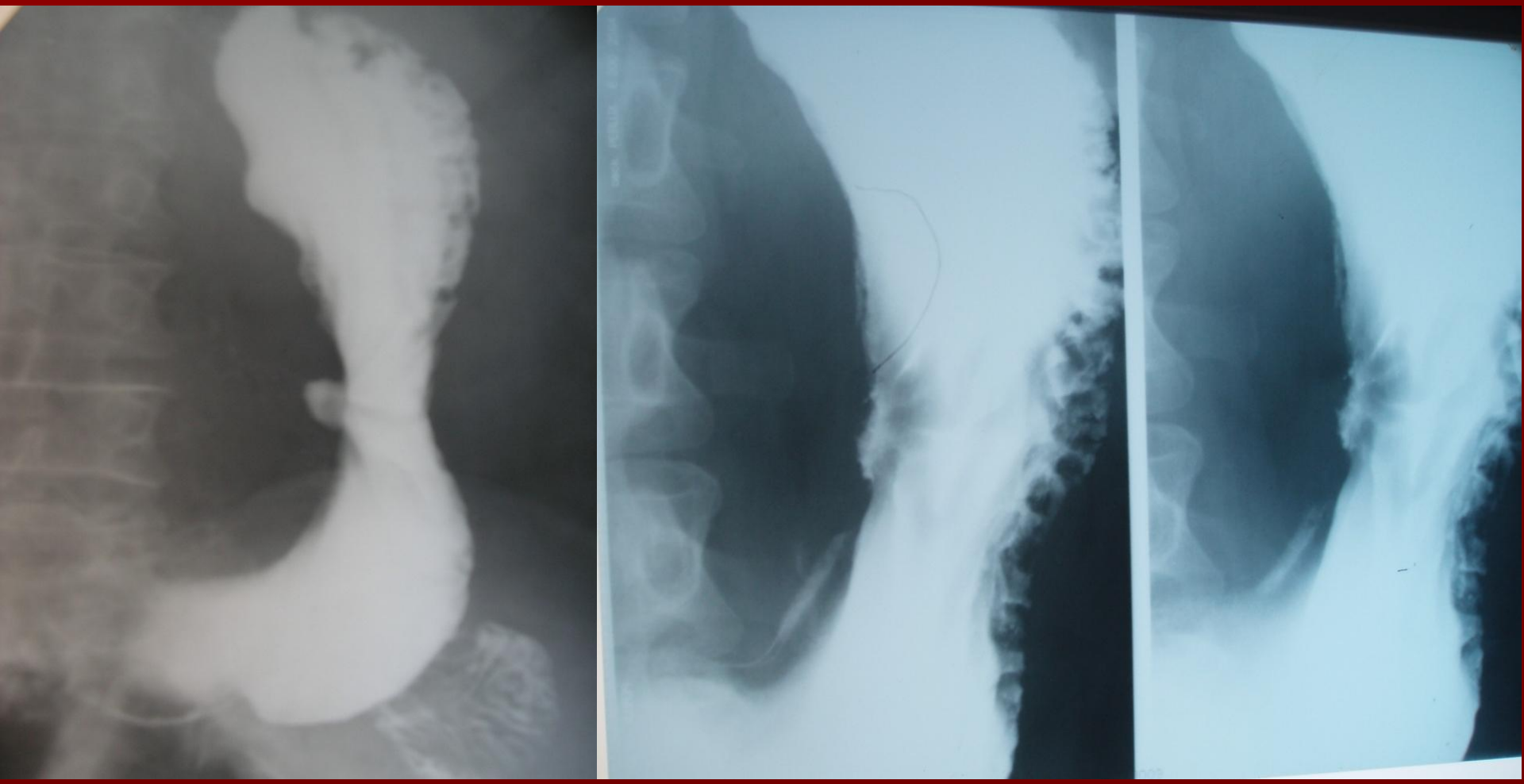
Double contrast

Barium meal

Gastric polyp

Gastric diverticulum

Barium meal

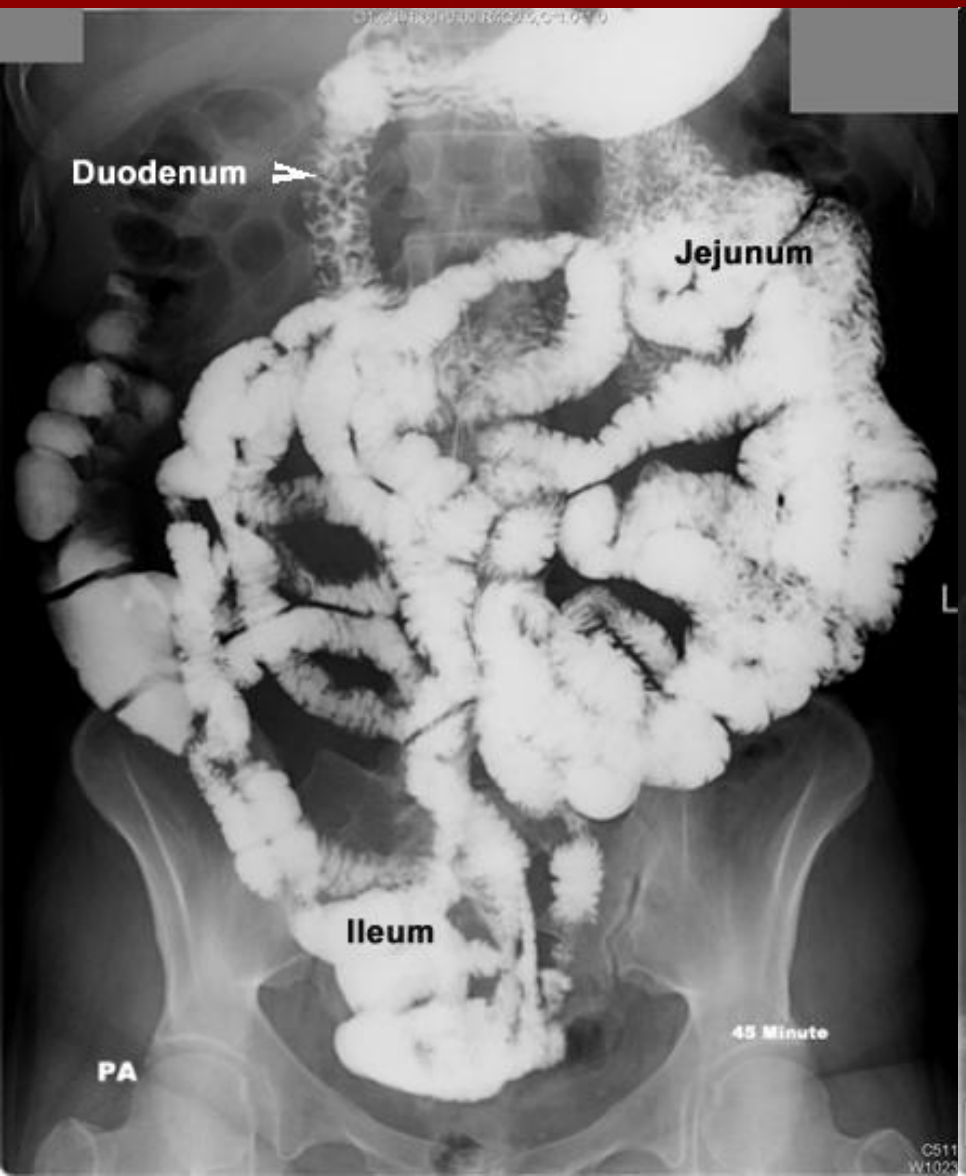


Gastric ulcers

Barium follow-through

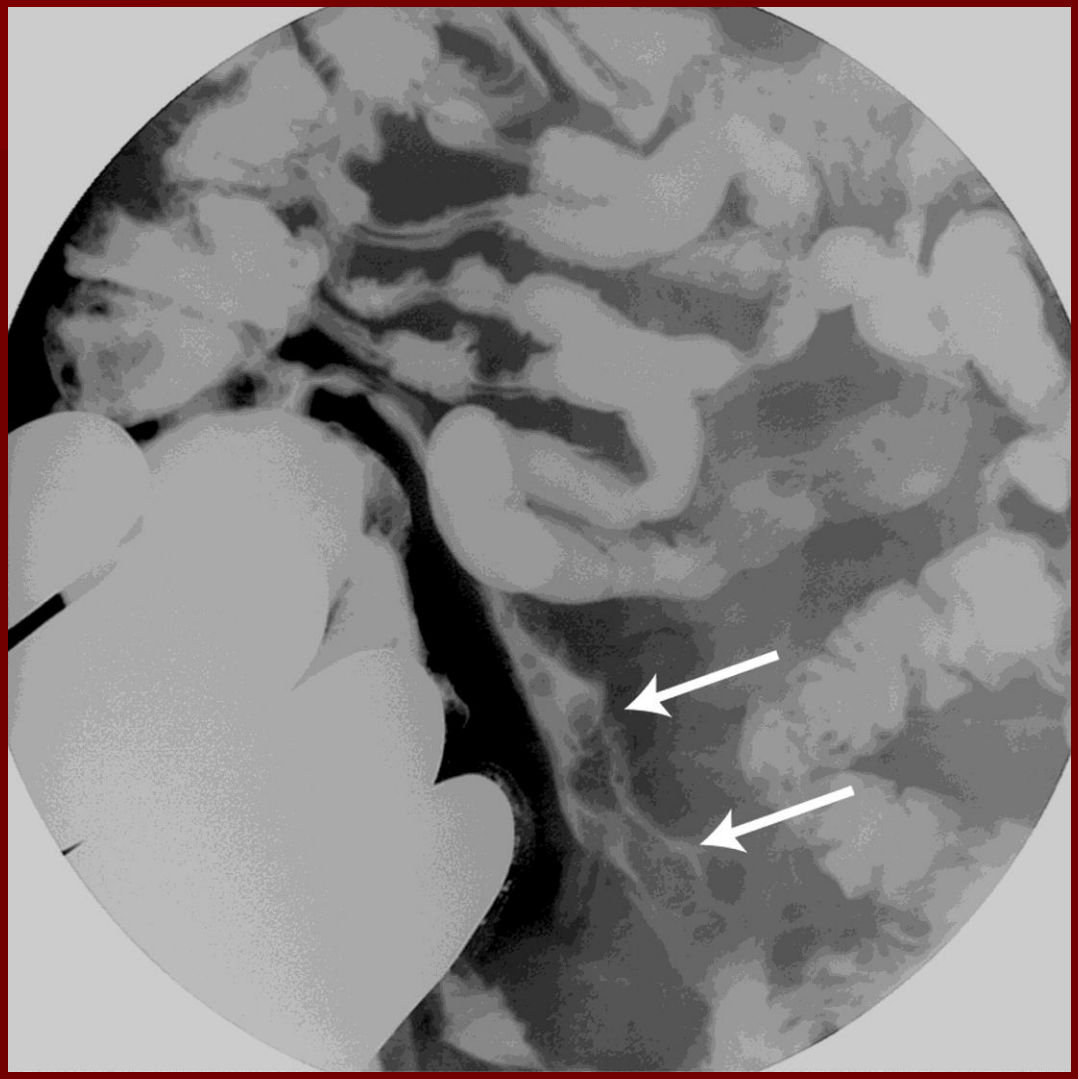
- X-ray images are taken as the contrast moves through the intestine, commonly at 0 minutes, 20 minutes, 40 minutes and 90 minutes.
- The test is completed when the Barium is visualised in the terminal ileum and caecum. This is one of the most common places for pathology of the bowel to be found, therefore imaging of this structure is crucial.
- The test length varies from patient to patient as bowel motility is highly variable.
- It is used to diagnose various conditions of the small bowel such as Crohn's disease, ulverative colitis, bowel cancer.

Barium follow-through



Barium follow-through

Meckel's diverticulum



Early Crohn's disease

BARIUM CONTRAST INVESTIGATION OF THE LOWER GASTROINTESTINAL TRACT.

Technique, indications and imaging findings in common gastrointestinal pathology.

Barium enema (Irrigoscopy)

- Also known as a **lower gastrointestinal series**
- X-ray pictures are taken while barium sulfate fills the colon via the rectum.
- A large balloon at the tip of the enema tube may be inflated to help keep the barium sulfate inside.
- The flow of the barium sulfate is monitored by the health care provider on an X-ray fluoroscope screen (like a TV monitor).

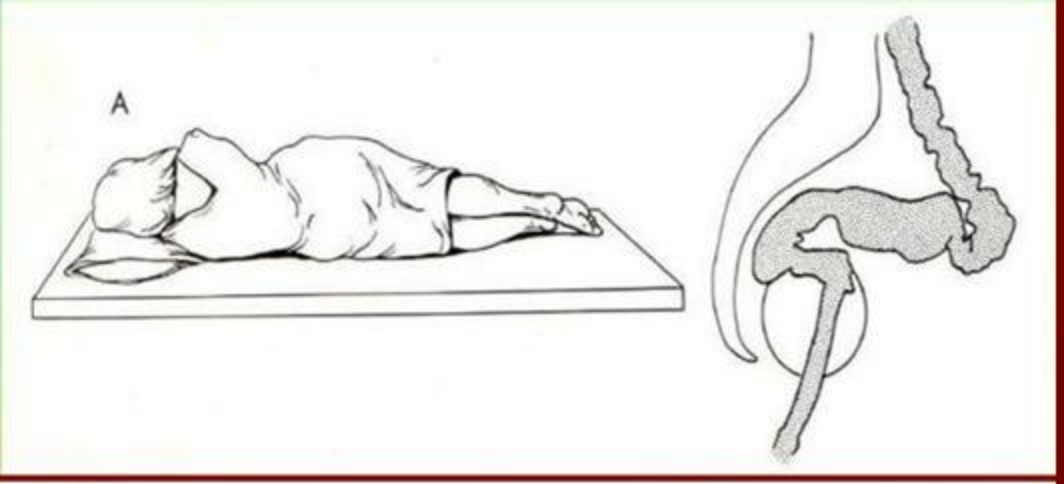
Barium enema (Irrigoscopy)

- **Single contrast Barium enema** - The colon is filled with barium, which outlines the intestine.
- The flow of the barium sulfate is monitored by the health care provider on an X-ray fluoroscope screen.

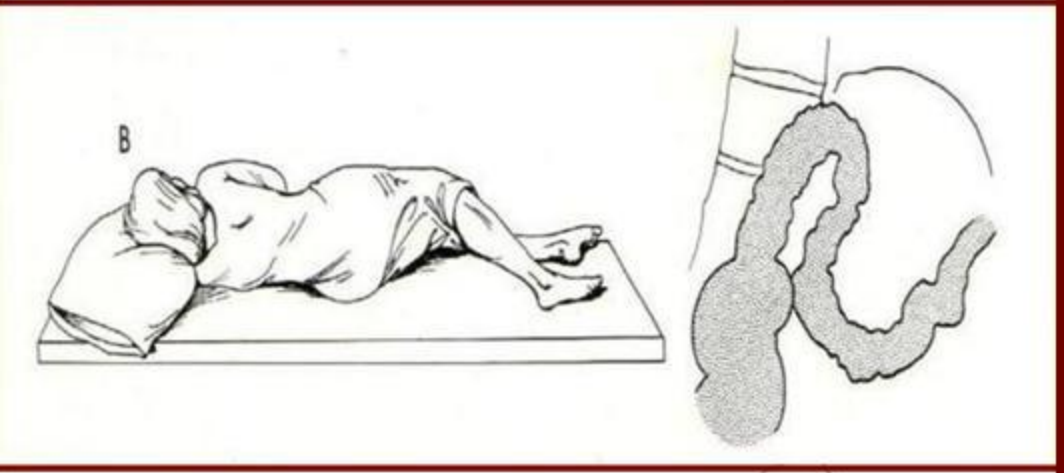
- **Double contrast Barium enema** - the colon is first filled with barium; then the barium is drained out, leaving only a thin layer of barium on the wall of the colon.
- The colon is then filled with air. This provides a detailed view of the inner surface of the colon, making it easier to see strictures, diverticula, or inflammation.

Patient preparation for barium enema

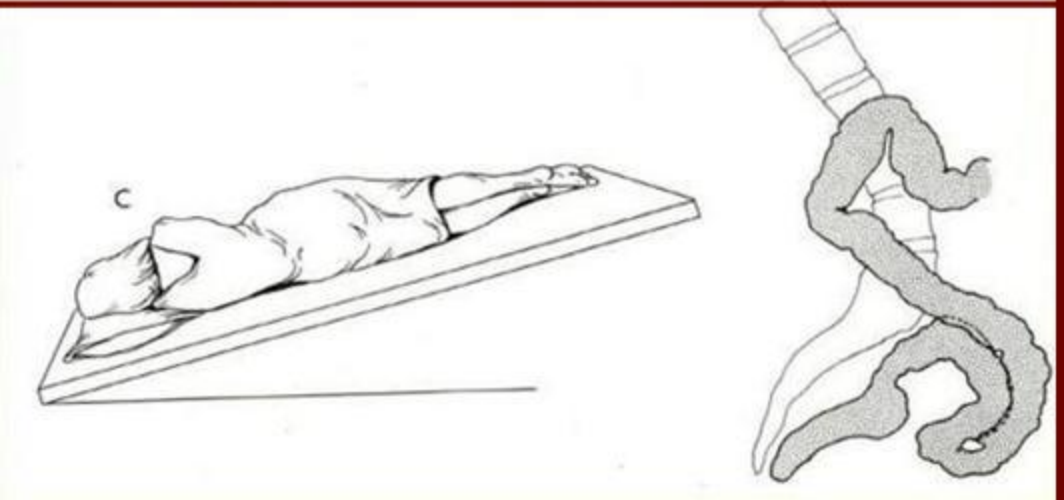
- Follow a special diet the day before the exam, with NO solid foods and NO milk products.
- Fast after midnight before the exam.
- Administering a laxative the night before the exam. A laxative in a pill or liquid form will help empty the colon.
- Administering a cleansing enema the night before the exam and/or in the morning before the exam will help clean the colon.



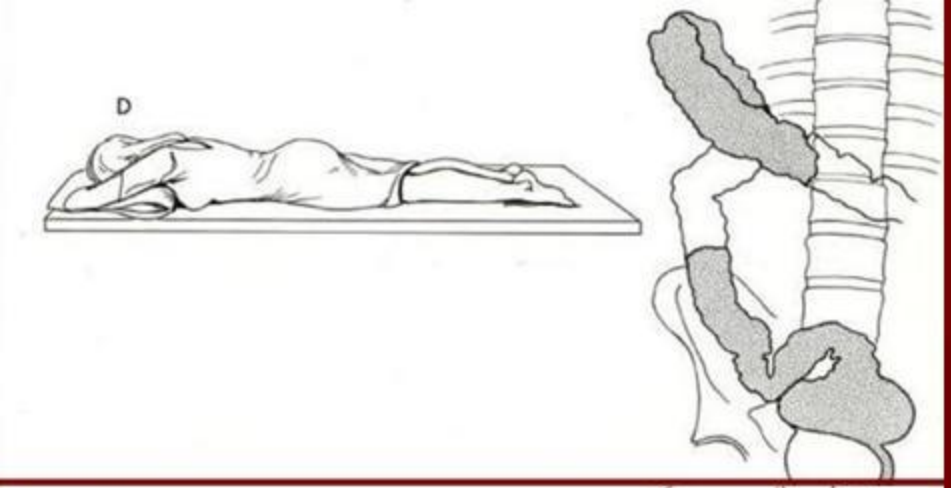
- **A - Left lateral position:**
  contrast filling of the **rectum** and **rectosigmoid**



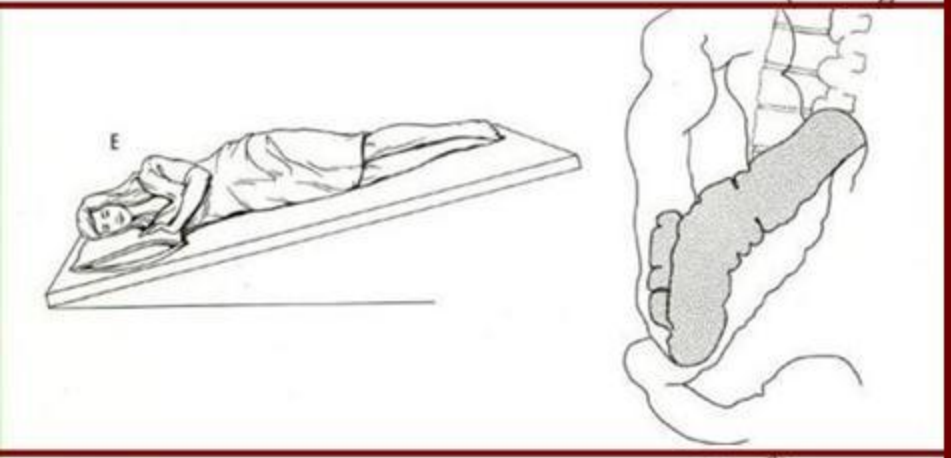
- **B - Left posterior oblique position:**
  contrast filling of the **sigmoid**



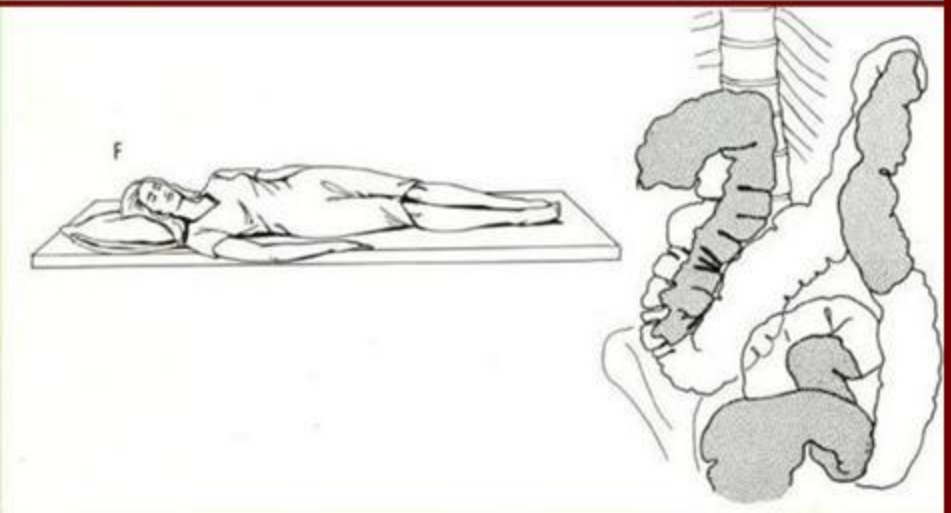
- **C - Left lateral with 15° Trendelenburg position:**
  contrast flow to **descending colon** and **splenic flexure**



- **D - turning clockwise from C to prone position:**
  contrast filling of the **transverse colon**



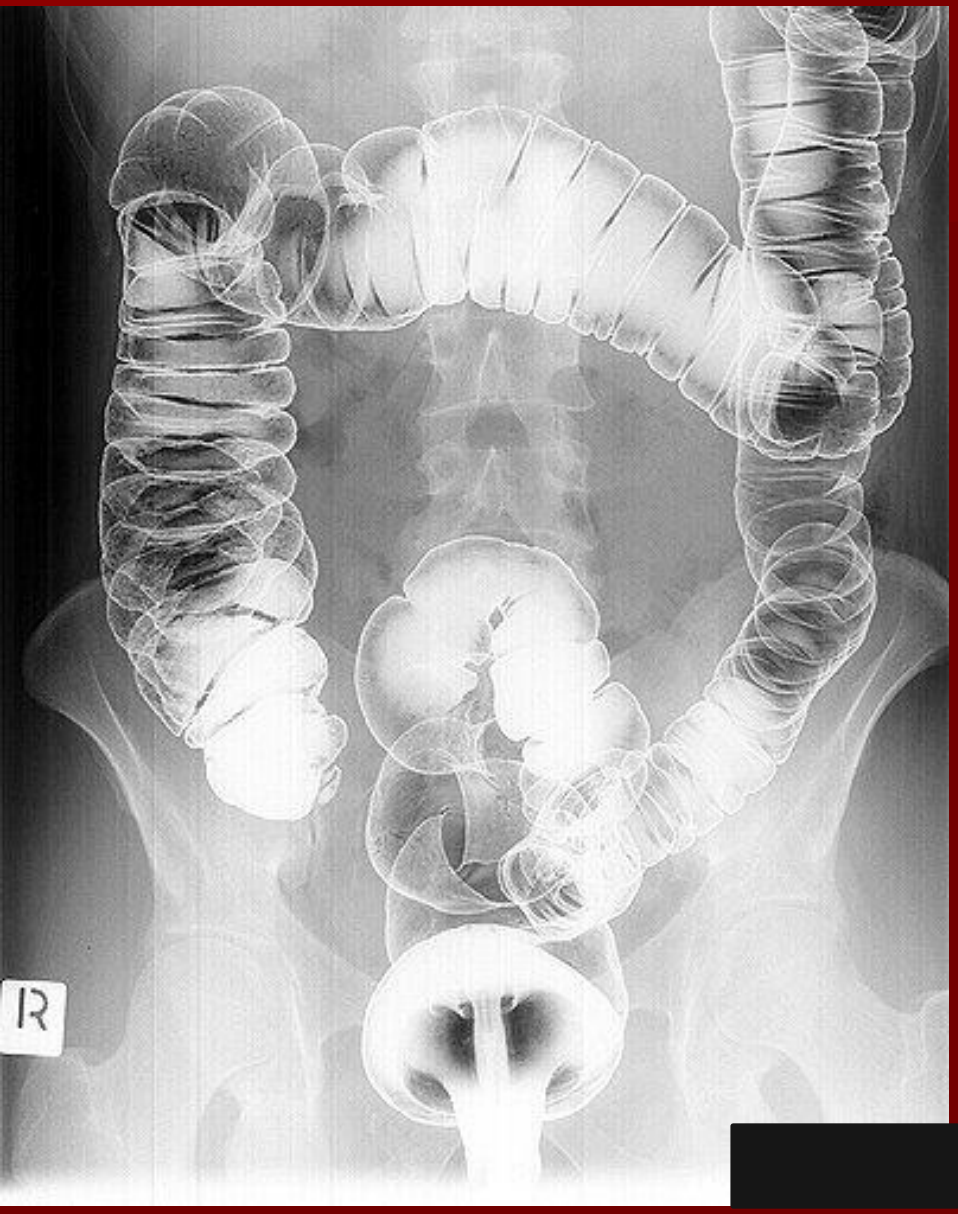
- **E - turning clockwise from D to right lateral with 15° Trendelenburg position :**
  contrast filling of the **hepatic flexure**



- **F - turning clockwise from E to supine position:**
  contrast filling of the **hepatic flexure and ascending colon**

Barium Enema, Single Contrast

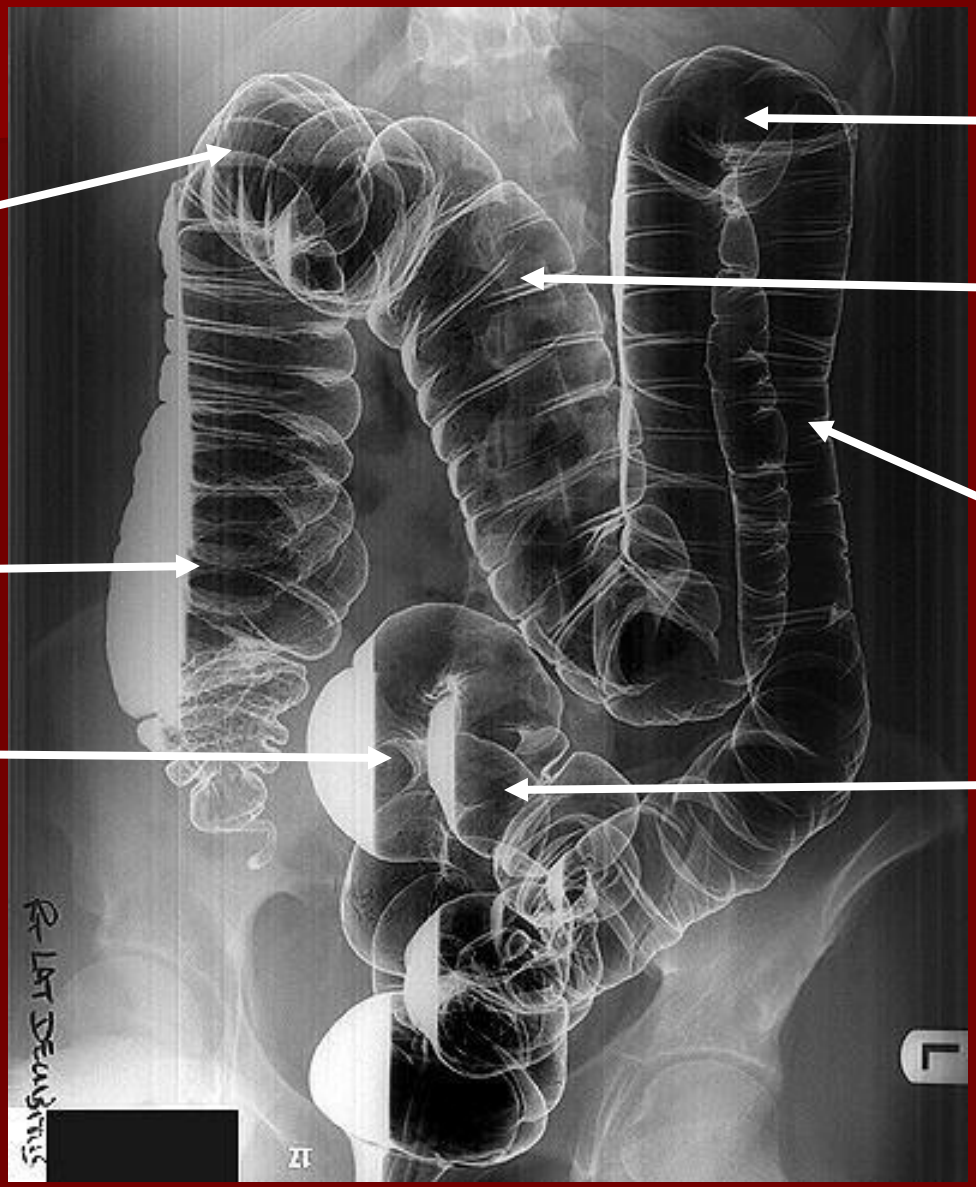
Barium Enema, Double Contrast



Prone position.

Supine position.

Barium Enema, Double Contrast
(Right Lateral Decubitus)



Colon Adenocarcinoma

Colon Adenocarcinoma

Indications

- **Single contrast Barium enema:**
  - Intussusception
  - Hirschprung's disease
  - Fatique / old / debilitated patient
  - Suspected pelvic metastases

- **Double contrast Barium enema:**
  - Melena (bloody stools)
  - Suspected colonic polyps or colon cancer
  - Family history of colonic polyps or colon cancer
  - Chronic diarrhea / bowel habit change
  - Inflamatory bowel disease (IBD)
  - Abdominal pain and discomfort
  - Diverticulosis

Irrigoscopy contraindications

- Suspected bowel perforation
- Toxic megacolon
- After colonic biopsy
- Pregnant patient

Irrigoscopy complications

- Gas pain
- Colonic perforation
- Intramural barium
- Stool impaction
- Bacterial contamination
- Allergy / hypersensitivity

FUNCTIONAL ABNORMALITIES OF THE GASTROINTESTINAL TRACT

I. Functional muscular abnormalities

- **Dystonia** (changes in the tonus of gastrointestinal tract):
  - **Hypertonia** => increased GI tone
  - **Hypotonia** => decreased GI tone
  - **Atonia** => absent GI tone (usually occurs in such conditions as peritonitis, severe inflammation or distention of the GI tract)
- **Spasm** (or cramps) – sudden involuntary muscular contraction or twitching. Examples include:
  - **Diffuse esophageal spasm (DES) =>** uncoordinated contractions where several sections of the esophagus can contract at once, the food gets stuck into esophagus and cannot reach the stomach. Radiographically => "***rosary bead*** " or "***corkscrew***" esophagus
  - **Nutcracker esophagus (NE)** also known as hypertensive peristalsis, where the contractions are coordinated but with an excessive amplitude, the bolus movement causes severe pain

I. Functional muscular abnormalities

- **Changes in gastrointestinal peristalsis:**
  - **Hyperkinesia** => increased GI peristalsis
  - **Hypokinesia** => decreased GI peristalsis
  - **Akinesia** => absent GI peristalsis (usually occurs in such conditions as peritonitis, severe inflammation or distention of the GI tract)
- **Transit abnormalities** (evacuation disturbances):
  - **Accelerated emptying**
  - **Delayed emptying**

II. Functional mucosal abnormalities

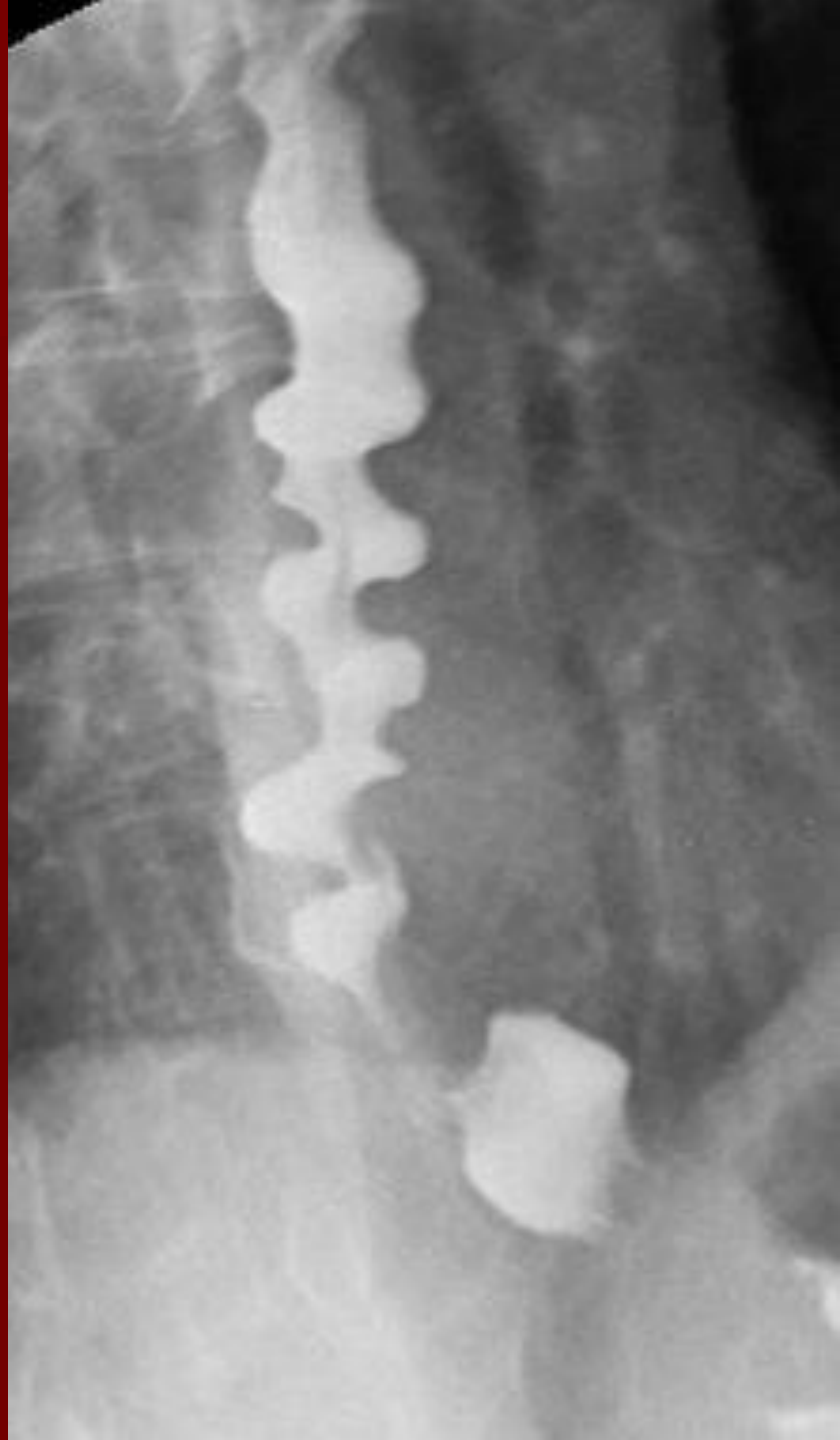
- **Hypersecretion**
- **Hyposecretion**

Diffuse esophageal spasm

- uncoordinated contractions where several sections of the esophagus can contract at once
- the food gets stuck into esophagus and cannot reach the stomach.
- On barium imaging commonly presentsas as a "***corkscrew esophagus***" or "***rosary bead***" appearance

Corkscrew

Rosary beads



MORPHOLOGICAL ABNORMALITIES OF THE GASTROINTESTINAL TRACT

Morphological abnormalities of the GI tract

- **Abnormalities of position and shape**
  - Ptosis (descendancy)
  - Ascension (elevation)
  - Impingement (displacement)
  - Volvulus
  - Dislocation
  - Traction
  - Torsion
- **Volume abnormalities**
  - Dilations
    - Diffuse
    - Local
  - Stenosis
    - Diffuse
    - Local

Morphological abnormalities of the GI tract

- **Size abnormalities of GI segments (compartments):**
  - **Dolichosegments** (longer than normal)
  - **Brachysegments** (shorter than normal)
  - **Megasegments** (larger than normal)

- **Mucosal abnormalities**
  - **Changes in the size of mucosal/submucosal folds**
    - **hypertrophy**
    - **hypotrophy**
    - **atrophy**
  - **Orientation (direction) abnormalities of mucosal/submucosal folds**
    - **deviation**
    - **convergence**
    - **interruption**

Common radiological signs reflecting morphological abnormalities of GI tract

- **Lacuna** (defect of filling, “gap”)
  - solitary
  - multiple
- **Niche** (a hollow or recess in the GI wall, usually caused by ulceration)
- **Diverticulum** (protrusion of the GI wall to form a small pouch with a narrow neck)
- **Pneumatosis intestinalis** (gas within the bowel wall)
- **Air fluid levels** in the bowel or abdominal cavity
- **Pneumoperitoneum** (presence of gas in the peritoneal cavity)

Morphological abnormalities of the GI tract

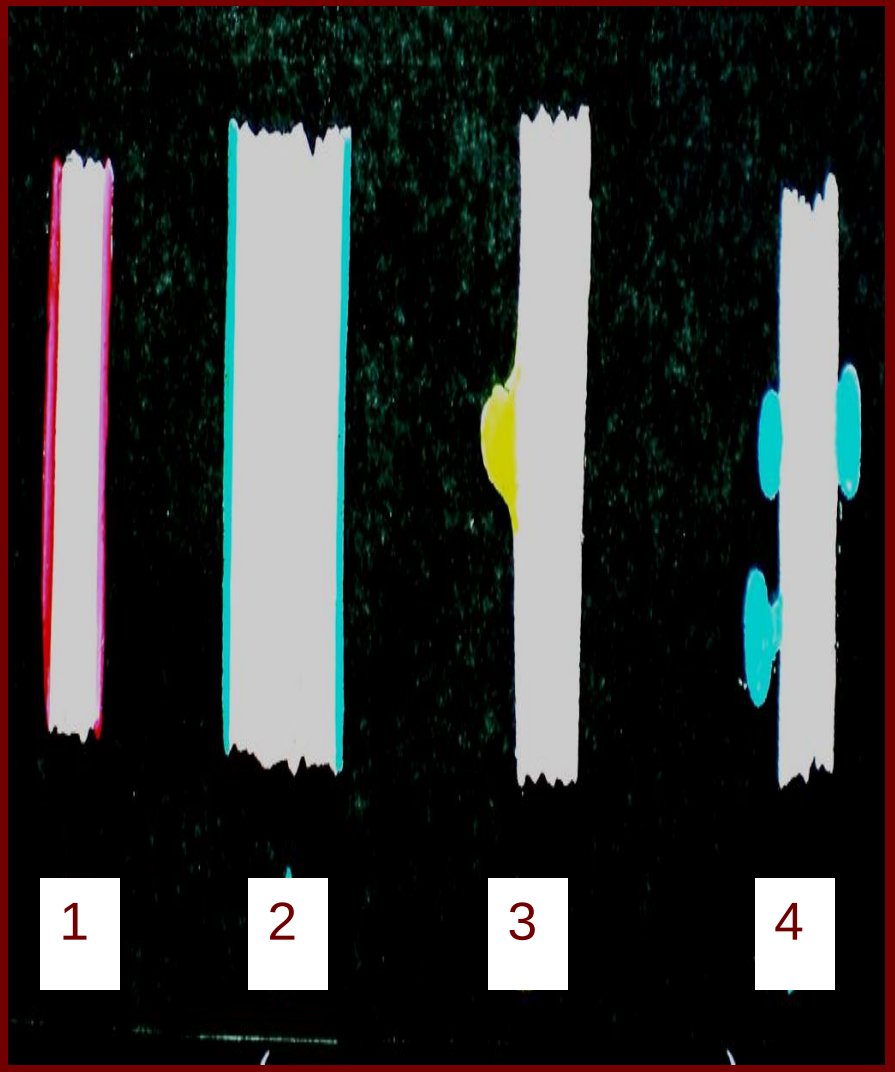
Lacuna

Niche

Esophageal diverticula

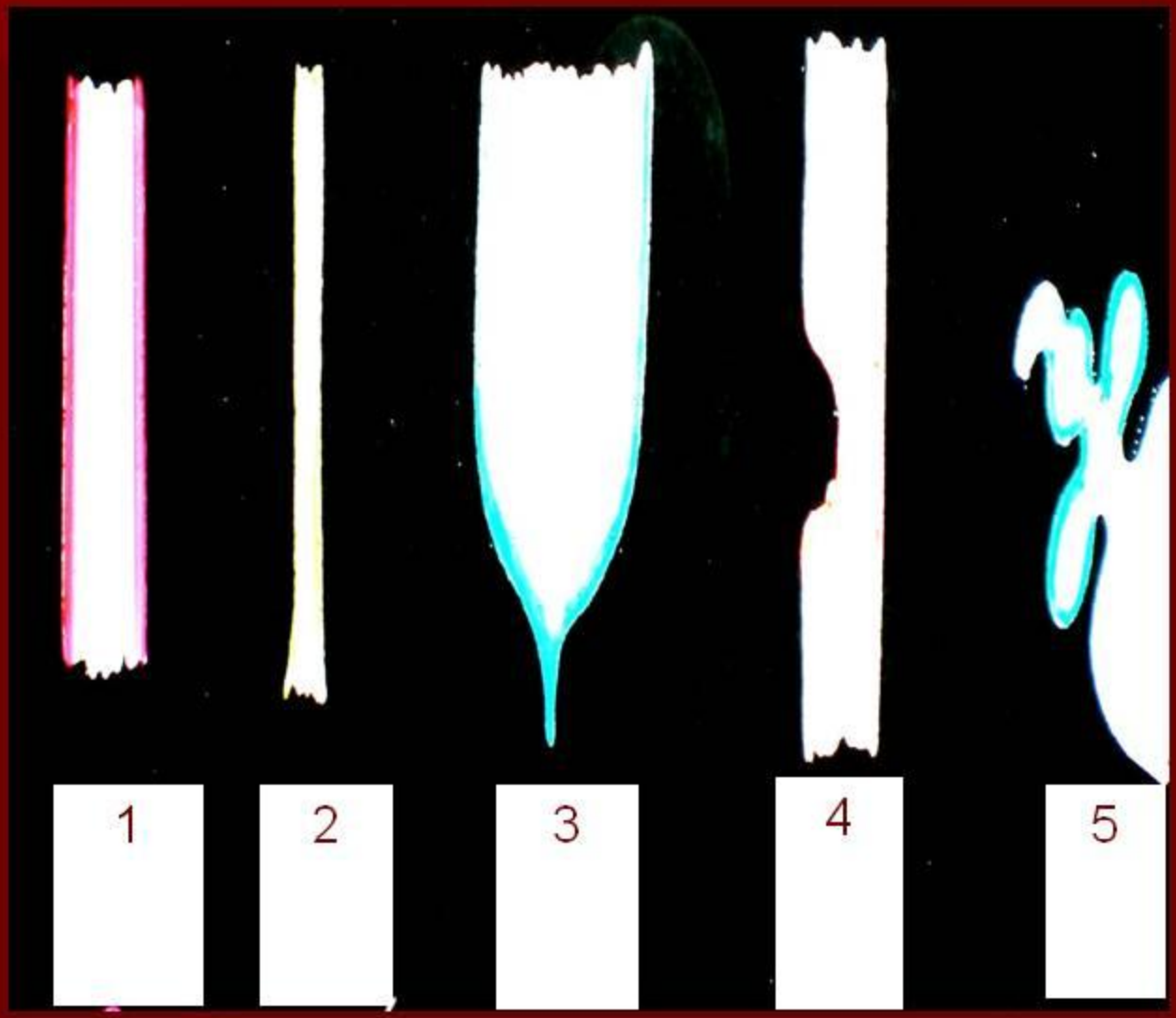
Types of dilations of GI tract

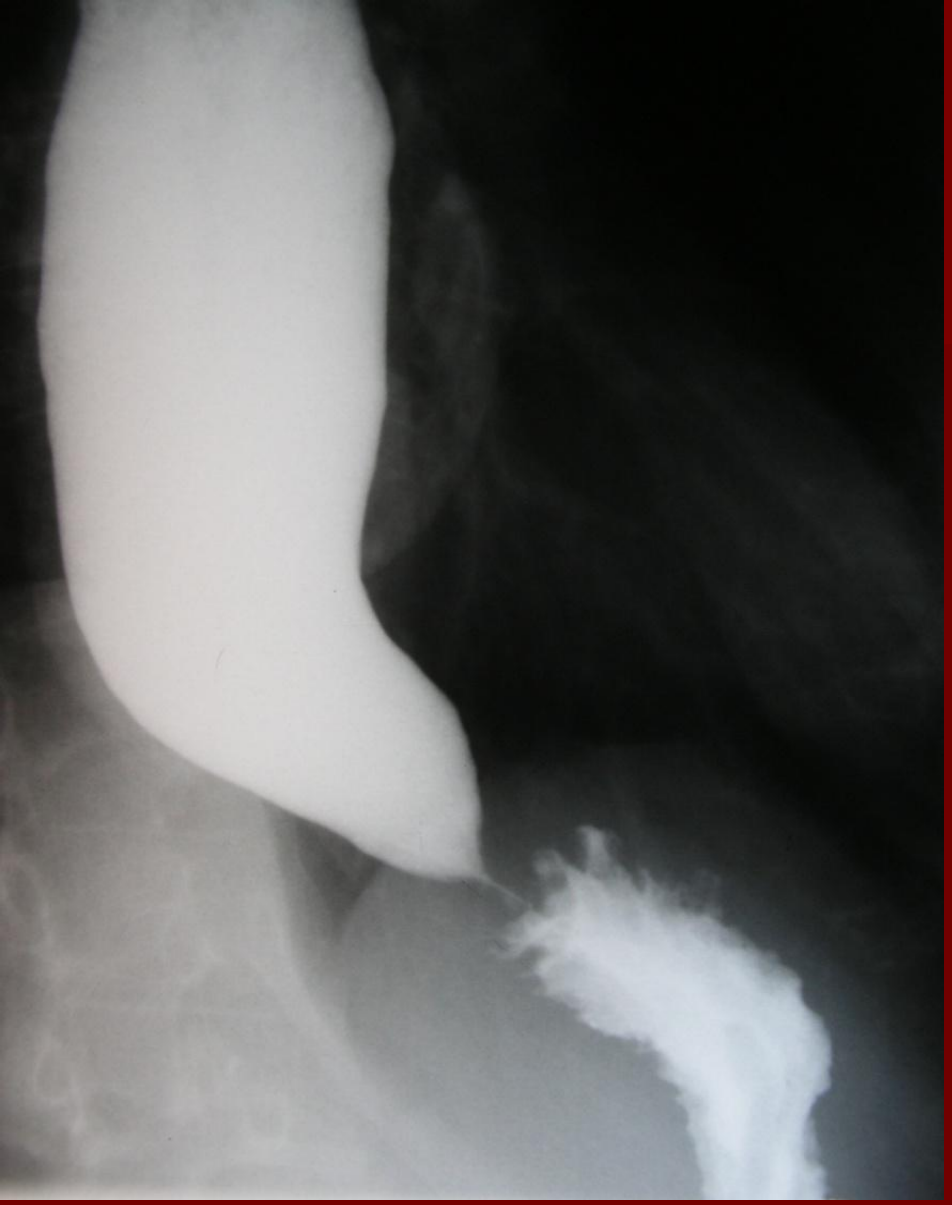
1. Normal lumen
2. Diffuse dilation
3,4. Local dilation



Types of stenosis of GI tract

1. Normal lumen
2. Diffuse stenosis
3. Local stenosis with suprastenotic dilation
4. Local stenosis by defect of filling (eccentric)
5. Local stenosis with deformation





Local stenosis with suprastenotic dilation in esophageal achalasia

Local stenosis of the ascending colon in colon carcinoma

Morphological changes in a malignant esophageal tumor:

- stenosis
- irregular contour
- rigid walls
- suprastenotic dilation

THE END

- **Please bring at your seminars:**
  - White coat (you will not be allowed to enter the department without a white coat)
  - Hospital shoes (you will not be allowed to enter the department without hospital shoes; bahillas are NOT acceptable)
  - Notebook with your personal notes on the topic

- **Please do NOT bring at your seminars:**
  - Begs and other personal belongings
  - Electronic devices (your phones should be turned off).