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Introduction to Abdominal Imaging
Lecture Outline

- Objectives
- Relevance of material
- Imaging modalities
- Clinical Approach to Abdominal Anatomy
  - 4 Quadrants
  - Retroperitoneal
- Summary
Objectives

- Learn the basic modalities for imaging the abdomen
- Learn the organs found in each of the four abdominal quadrants
- Learn retroperitoneal organs
- Exposure to the presentation of common abdominal pathologies
The four main modalities used in abdominal imaging are:

1. Conventional x-ray
2. Ultrasonography
3. Computed tomography
4. Magnetic resonance
The primary imaging modalities for the abdomen and pelvis are plain film, ultrasound, and CT.

Most common indications for imaging include pain, trauma, distention, nausea, vomiting, and/or change in bowel habits.

Choice of modality depends upon clinical symptoms, patient age & gender, and findings on physical exam.

Mastery of the anatomy within each quadrant can help explain particular symptoms, clinical presentations, and/or imaging findings.
1 - Conventional x-ray

- **Use**
  - Traditionally used for screening

- **Advantages**
  - Availability and lower cost
  - Well tolerated

- **Disadvantages**
  - Lower sensitivity
  - Ionizing radiation
1. Plain X ray

- Remember the five basic densities on x rays:
  - Gas $\rightarrow$ Black
  - Fat $\rightarrow$ Dark grey
  - Soft tissue/fluid $\rightarrow$ Light grey
  - Bone/calcification $\rightarrow$ White
  - Metal $\rightarrow$ Intense white
Plain film radiograph

- Hepatic angle
- Splenic angle
- Renal shadow
- Psoas muscle
- Properitoneal fat strip
Upper abdominal calcification

➢ may be an important sign of disease

✓ Gallstones, Porcelain gallbladder
✓ Urinary Calculi
✓ Calcified adrenal glands
✓ Pancreatic calcification
✓ Tumor calcification
✓ .................
Normal Bowel Gas Pattern

- The normal distribution of gas in the stomach and duodenum
- The colon----- mottled pattern of stool
- The small bowel----a few gas collections
The supine AP film most frequently taken

- An X ray should be seriously inspected by uniform transmitted light coming through it i.e.: viewing box

Common Abdomen Films

- Antero-posterior – supine (KUB)
- Antero-posterior – erect
- Left lateral decubitus
• Plain film radiographs of the abdomen are important for the assessment of the acute abdomen
• CT, US, and MR provide comprehensive evaluation of the abdomen, including the peritoneal cavity, retroperitoneal compartments, abdominal and pelvic organs, blood vessels, and lymph nodes
X-RAY --- FOUR BASIC DENSITIES

Air.
Soft tissue.
Fat.
Bone.
Plain films

1. Black - gas
2. Dark grey - fat
3. Grey - fluid / soft tissue
4. White - calcified structures
5. Intense bright white - metallic objects
Look at the diaphragms

- Are they raised or flattened?
- Are the costophrenic angles clear?
- Is there any free intra-abdominal air? (better to be judged if erect or decubitus)
An x-ray erect abdomen reveals crescentric gas under right diaphragm in keeping with a visceral perforation.
Lateral decubitus view of an abdominal X-ray exhibiting free intra-abdominal air between the liver, right hemidiaphragm and lateral abdominal wall.
Psoas muscles

Psoas edges on abdominal X-ray

- The psoas muscles arise from the transverse processes of the lumbar vertebrae and combine with the iliacus muscles attaches to the lesser trochanter of the femur.
- An abdominal X-ray often demonstrates the lateral edge of the psoas muscles as a near straight line.
Look for the bowel gas pattern

- Where are the bowel loops located (central vs. peripheral)?
- Is there too much intraluminal gas?
- What is the distribution of the gas in the abdomen?
- What is the intraluminal caliber of the small and large bowel?
- Are there any dilatations of the small and/or large bowel?
- Identify any air-fluid levels?
Small bowel Identified by:
- Central position in the abdomen
- Valvulae conniventes – mucosal folds that cross the full width of the bowel

Large bowel normal large bowel may be identified by:
- Peripheral position in the abdomen (the transverse and sigmoid colon occupy very variable positions)
- Haustra
- Contains faeces
Reading the Abdominal Plain Film.

- Also known as the "KUB" (kidney, ureter, & bladder).
- Use a systematic approach to interpretation.
  - Lung bases & diaphragms.
  - Bones.
  - Soft tissues.
- Abnormal calcifications.
- Organs.
2. Barium Study

a. Barium swallow
b. Barium meal
c. Barium follow-through
d. Barium enema
Contrast

- Most commonly used radiological contrast is barium sulphate.

- Increases density of structure, thereby increasing amount of X-radiation absorbed.
Administering a contrast agent modifies the image to give more information. Typical ones are barium, an inert particulate contrast used in GI tract evaluation and iodine, a water soluble agent which can be injected into the vascular tree.
BARIUM SWALLOW

- It is a medical imaging procedure used to examine upper gastrointestinal tract, which include the **esophagus** and to a lesser extent the stomach.

- The contrast used is barium sulfate.
UPPER GI--(GASTRO INTESTINAL)
ORAL BARIUM CONTRAST

WITHOUT CONTRAST—plain or scout film

BARIUM ENEMA
RECTAL BARIUM CONTRAST
ESOPHAGEAL CONSTRUCTION

Superiorly: level of Cricoid cartilage, juncture with pharynx

- Middle: crossed by aorta and left main bronchi
- Inferiorly: diaphragmatic sphincter

normal sites of narrowing of Esophagus
normal impressions in the Esophagus
Barium meal

- In a barium meal test, X-ray images are taken of the stomach and the beginning of duodenum.
Barium enema

SINGLE CONTRAST STUDY
- The colon is filled with barium, which outlines the intestine and reveals large abnormalities.

DOUBLE CONTRAST with AIR
- 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 narrowed areas (strictures), diverticula, or inflammation.
Barium Enema, Double Contrast
(Right Lateral Decubitus)

Hepatic Flexure

Note the effect of gravity
Barium Enema, Double Contrast
(Supine Position)
2- Ultrasonography

- Use
  - Gallbladder, biliary tree, and female pelvis
  - Aortic aneurysm screening
  - Detection of free fluid

- Advantages
  - Availability and lower cost ($200)
  - No ionizing radiation, well tolerated
  - Can image in any plane

- Disadvantages
  - Operator dependent
  - More difficult to interpret
  - Cannot penetrate gas-filled structures
Ultrasonography (ultrasound)

- Uses sound waves of frequencies 2 to 17 MHz. (Audible sound is in the range of 20 Hz to 20 kHz).
- Like SONAR, images result from the propagation of sound waves through the body and their reflection from interfaces within the body.
- The time it takes for the sound waves to return to the transducer provides information on the position of the tissue in the body.

**No ionizing radiation**

- Uses sound waves to visualize structures
- Very operator dependent.
- Can not penetrate bone.
Ultrasound of the gastrointestinal tract

Figure 2a. Stomach. Cross section of the gastric corpus with mucosal folds protruding to the lumen.

Figure 2b. Small bowel. Longitudinal section of a jejunal segment showing the numerous valvulac conniventes.
3- Computed Tomography

- **Use**
  - Imaging of choice for most abdominal abnormalities

- **Advantages**
  - High *spatial resolution*
  - Can see most structures simultaneously
  - Can reconstruct images in other planes

- **Disadvantages**
  - Cost
  - Higher ionizing radiation dose than x-ray
  - Contrast reactions
Computed Tomography

- Axial perspective (looking through the feet)
- You view one slice at a time
- Slice thickness can vary, but is generally 5 mm
CT:

➢ focal wall thickening
➢ diffuse wall thickening
➢ a lobular mass with or without ulceration
➢ destruction of the multilayered pattern or with transmural enhancement
➢ regional lymphadenopathy; metastases
Anatomy of a CT scan

CT scanners give doctors a 3-D view of the body. The images are exquisitely detailed but require a dose of radiation that can be 100 times that of a standard X-ray.

Computed tomography scans are made by rotating an X-ray beam around the patient, imaging the body in a series of slices that a computer stitches together.
Spatial resolution ability to resolve small objects in an image

Contrast resolution ability to differentiate small density differences in an image

Non contrast CT of the abdomen include
- Urinary tract evaluation (stone protocol)
- Emergency CT for appendicitis
- Abdominal trauma
CT of abdomen without contrast. Note the lack of distinction between abdominal organs.
CT scan of abdomen with intravenous contrast. Notice how much better you can see the kidneys and blood vessels.
Normal CT anatomy

1. LHV, left hepatic vein
2. MHV, middle hepatic vein;
3. RHV, right hepatic vein;
4. IVC, inferior vena cava
5. Ao, aorta
6. Stomach
CT – computed tomography.

- Cross-sectional modality with capabilities for multiplanar reconstruction and dynamic imaging to assess vascularity
- Tube rotates around the body and a circle of stationary detectors detects the penetrating x-rays forming an image.
1. LPV, left portal vein
2. Stomach
3. Spleen
4. IVC, inferior vena cava
5. Ao, aorta
1. Gallbladder
2. RPV, right portal vein
3. Antrum
4. Duodenal bulb
1. CA, celiac axis
2. Splenic artery
3. Common hepatic artery
4. Duodenum
5. Kidney
6. Pancreas
7. Portal vein
8. Adrenal gland
✓ SMA: superior mesenteric artery
✓ CBD, common bile duct
✓ Spenic vein
✓ Pancreas
Cross-Sectional Imaging

- Duodenum
- Stomach
- Gall Bladder
- Pancreas
- Common Bile Duct
- Liver
- Spleen
- R Kidney
- IVC
- L Adrenal Gland
- Aorta
4- Magnetic Resonance

- **Use**
  - Difficult diagnoses
  - Cancer staging
  - Vascular anatomy

- **Advantages**
  - Soft tissue contrast
  - No ionizing radiation
  - No *iodinated* contrast

- **Disadvantages**
  - Cost and availability
  - Scans take much longer
  - Implanted devices can make imaging difficult
MRI - Magnetic Resonance Imaging.

- Uses a high-field magnet to image the body.
- Rapidly switching magnetic field gradients align the precession of the H protons (water and fat).
- When the gradients are turned off, a faint radiofrequency signal is produced.
- Image is reconstructed using Fourier transforms.
- Multiplanar and vascular assessment possible.
Fluoroscopy

- Dynamic radiography
  - Permits real-time evaluation of the gastrointestinal tract
  - Barium Swallow (esophagus)
  - Upper GI Series (stomach)
  - Small Bowel Follow-through
  - Barium Enema (colon)
- Barium (& air) is introduced by enema or swallowing
- Barium appears white on the images (high density attenuates the x-ray beam)
- Can assess both intrinsic (mucosal) and some extrinsic (mass-effect) abnormalities.
Nuclear Medicine - GI Bleeding Scan

- Evaluates bleeding, particularly from the lower GI tract.
- Radiopharmaceutical = Tc99m in vitro labelled RBCs.
- Sequential 5 minute images acquired over an hour.
- Looking for progressive accumulation of tracer.

Bleeding on the cecum.
The Abdominal Quadrants
Right Upper Quadrant

- RUQ Organs
- Gallbladder & biliary system
- Liver (right lobe)
- Duodenem (1/2/3 parts)
- Pancreas (head)
- Colon (Hepatic flexure/transverse)
- Right kidney & adrenal gland
RUQ Ultrasound

Normal gallbladder

Gallstone
Left Upper Quadrant

- LUQ Organs
  - Spleen
  - Stomach
  - Liver (left lobe)
  - Pancreas (body/tail)
  - Left kidney/adrenal
  - Colon (transverse/splenic flexure)
  - Jejunum/ileum
Right Lower Quadrant

- RLQ Organs
  - Ascending colon
  - Cecum/ileum
  - Appendix
  - Right ovary/fallopian tube/uterus
  - Right ureter
Right Lower Quadrant

- RLQ Organs
- Ascending colon
- Cecum/ileum
- Appendix
- Right ovary/ fallopian tube/ uterus
- Right ureter
Left Lower Quadrant

- LLQ Organs
  - Descending/sigmoid colon
  - Left ureter
  - Left ovary/fallopian tube/uterus
Left Lower Quadrant

- LLQ Organs
  - Descending/sigmoid colon
  - Left ureter
  - Left ovary/fallopian tube/uterus
Retroperitoneum
What organs are Retroperitoneal?

- Retroperitoneal Organs:
- Kidneys
- Pancreas
- Duodenum
- Ascending Colon
- Descending Colon
- Rectum

- Rocker
- Kids
- Party
- Down with
- AC
- DC
- Records
Summary

- The main imaging modalities for the abdomen are x-ray, ultrasound, CT, and MRI.
- The abdomen can be divided into four quadrants, each containing specific visceral organs.
- Abdominal organs can also be categorized as to whether are retroperitoneal.
- An understanding of the quadrant anatomy allows you to identify relevant pathology.
Muscles of the Trunk

• 3 paired flat muscles + strap muscles
  – external oblique
  – internal oblique
  – transversus abdominis

- rectus abdominis
Muscles of the Trunk

3 paired muscles
rectus abdominis
3 flat muscles

- External oblique
- Internal oblique
- Transverse abdominis
Rectus Sheath – upper ³⁄₄

- skin
- s/c tissue
- external oblique
- internal oblique
- transversus abdominis
- linea alba
- peritoneum
- extraperitoneal fat
- transversalis fascia
Normal 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.
Anatomy of the Upper GI Tract
Stomach

- Fundus
- Body
- Antrum
A well-distended stomach has a wall thickness of approximately 5 mm
Benign Ulcer(1)

- Projection beyond the lumen of stomach
- Smooth lucent line (collar) at the neck of ulcer
Gross Anatomy of the Stomach

• The stomach is divided into the 3 regions: the fundus, the body and the antrum and is able to hold up to 2 liters of food and fluid when completely filled

• When the stomach is empty, the mucosa folds into rugae
  • when filled, the expanded wall of the stomach causes these folds to disappear (flatten)
Imaging anatomy of small intestine
• Is the longest part of alimentary canal
• Extends from pylorus of stomach to ileocecal junction
• Length = 3 m in a living person & 6.5 m in a cadaver (loss of muscle tone)
• Diameter = 4 cm in gastroduodenal jn & 2.5 cm at i-c junction.
Small bowel represents 75% of the length & 90% of mucosal surface of intestinal tract.
**Site**: It occupies all abdominal regions except epigastic and hypochondriac region normally.

**Fixation**: It is stabilized by mesentery.

**Mesentery**: Peritoneal fold attaching small intestine to posterior body wall.
Small intestine anatomy

- 5 mtr long
- 3 parts: duodenum, jejunum, and ileum.
Indications for small bowel investigations

- Investigation of non-specific symptoms such as pain, distension, bloating, diarrhoea
- Suspected inflammatory bowel disease, including exclusion of small bowel disease in Crohn’s colitis
- Partial small bowel obstruction
- Obsolete G I bleeding, iron deficient anaemia or bleeding per rectum with normal upper G I endoscopy and colonoscopy
- Definition of anatomy, of fistulas or malrotation
- Exclusion of malignancy, for example, complicating coeliac disease
Techniques

- Conventional radiography
- Barium meal follow through
- Sonography
- CT
- MRI
- Capsule endoscopy
- Enteroscopy – push enteroscopy, push-pull enteroscopy [also called double-balloon] and intraoperative enteroscopy
Conventional Xrays

- Preferred initial radiographic investigation
- Diagnostic in 50-60%
- Radiographs done are
  1. Supine Abdomen-bladder should be emptied before the film and film should include area from diaphragm to hernial orifices
  2. Chest Radiograph- superior to erect abdomen to detect pneumoperitoneum
     - Chest disease may mimic SBO
  3. Erect Abdomen-air fluid level are seen .normal two may be seen at D-Jflexure and terminal ileum
Difference between large & small intestine

• large bowel  small bowel
• Haustra  present  absent
• Valvulae
 conniventes absent  present
 loops  periphereral  central
Barium meal follow through

- 500 ml of 42% w/v barium mixture is ingested, fluoroscopic and over head radiographs at 15-30 minutes intervals, continue till ileocecal valve, when barium has reached caecum, with targeted fluoroscopy of special area of interest.

Figure

• X-ray image from a small bowel series showing...
Ultrasonography

- Trans abdominal ultrasound
- Advantages
  - 1. cheap
  - 2. quick
  - 3. acceptable to patient
  - 4. no ionising radiation - important in Crohn’s disease patient who may require many investigations over a lifetime due to this popular with paediatricians
  - 5. extraluminal information
  - 6. dynamic changes
• Disadvantage
• 1. operator dependent modality
• 2. lack of standardisation
• 3. less useful in obese [images are better in children] or in the presence of large volumes of bowel gases
Doppler USG

- Evaluate changes seen in vasculature with bowel inflammation
- Increased vascularity is seen in the bowel
- Sup. Mesenteric artery images may indicate disease activity
- But there are small no. of studies therefore the role of Doppler USG is still to be established
• Ultrasound showing blood flowing from intestines into liver. Image on the left: routine. On the right with power Doppler.
CT scan

CT has central role in imaging abdomen
CT can depict bowel thickening, fistulas, abscesses and lymphadenopathy

- Bowel wall assessment during different phases of scanning with i.v. contrast allows assessment of perfusion
- Intramural gas may be detected
- MDCT can reconstruct images in any angle
CT SCAN

• Advantages
  1. quick
  2. acceptable to most of the patient
  3. major advantage is – provide extraluminal information over luminal contrast studies
Disadvantages

• Ionising radiation
• It is static rather than dynamic. This makes differentiation between skip lesions and peristalsis difficult.
• Artefact which may arise from the lack of physiological distension.
Axial pre-contrast CT image (a) shows mesenteric inflammation adjacent to the distal ileum and cecum, minimal free peritoneal fluid and free air (arrow), and extraluminal contrast material (curved arrow). Axial pre-contrast (b) and portal venous phase (c) CT images show wall thickening (c, arrow) and multiple small diverticula (c, arrowheads) in the distal ileum.
M R Imaging

- Give extra luminal information and permit multiplanar reformatting without ionising radiation
- Preferable in children and reproductive age group
- Distinguish active disease with fibrosis
- Definition of tissue planes is better than CT
- Real time functional information may be obtained with MR fluroscopy and this is a distinct advantage over CT
Disadvantage

- Patient compliance—many patient fails to complete the scan
- Long time affects image quality, as artefact may be produced by peristalsis
- Vomiting and rectal evacuation
Fast imaging with steady-state precession of MR enteroclysis. Adequate luminal distension throughout the jejunum and ileum is seen.
Enteroscopy

- Imp. Both diagnostic and therapeutic
- Ileoscopy as part of colonoscopy
- Push enteroscopy-Enteroscope which traverse the proximal jejunum. Max. distance covered 150 cm
- Push-pull or Double Balloon enteroscopy visualise entire small bowel
- Good result in obscure GI bleed
- Mucosal visualisation better than capsule endoscopy
Disadvantages

- Invasive
- Risks of bleeding & perforation
- Lower patient acceptability
- Limited expertise
**Small Intestine.**

Small Intestine, one of the most important organs for the immune defense. Largest endocrine organs of the body. Start from the pylorus and ends at the cecum.

### 3 Parts:

1. **Duodenum** (20 cm), retroperitoneal and supplied by the celiac artery and SMA.
2. **Jejunum** (100 to 110 cm). Occupies upper left of the abdomen, thicker wall and wider then the ileum. Mesentery has less fat and forms only 1-2 arcades.
3. **Ileum** (150 to 160 cm). Occupies the lower right: Has more fat and forms more arcuates. Contains Payer's patches. Ileum and jejunum and supplied by the SMA.
Duodenum is divided into four parts:
- a) First (superior) part
- b) Second (descending) part
- c) Third (horizontal) part
- d) Forth (ascending) part

First part of duodenum
It is 5 cm long
Lies anterolateral to body of L1 vertebrae
Most movable part
DUODENUM

- 25cm
- C shaped loop
- lies opp to L1,2,3
- duodenum begins at the duodenal bulb and ends at the ligament of Treitz, it is composed of four distinct parts and is neither wholly peritoneal nor retroperitoneal.
Duodenum

- **Second part:**
  - It is 8 to 10 cm long
  - Descends along right sides of L1 through L3 vertebrae

- **Third part:**
  - It is 10 cm long
  - Crosses L3 vertebra

- **Fourth part of duodenum Ascending**
  - It is 2.5 cm long
  - Begins at left of L3 & rises superiorly as far as superior border of L2 and continues with it
Ligament of trietz

- Suspensory ligament of duodenum
- Fibromuscular band arising from rt crus of diaphragm close to oesophageal opening and attaches to posterior surface of D-J Flexure
- smooth muscle lining of 1st part of duodenum is longitudinal
- plicae circularis
- (circular folds) of 2nd part of duodenum
- Major duodenal papilla is a small rounded elevation at site where bile duct & main pancreatic duct pierce medial wall of 2nd part of duodenum
Jejunum begins at duodenojejunal flexure (L2) & ileum ends at ileocecal junction.

- Jejunum & ileum = 6 to 7 m long (jejunum 2/5, ileum 3/5)
- Coils of jejunum & ileum are suspended by mesentery from posterior abdominal wall & freely movable.
- Most jejunum lies in left upper quadrant & most ileum lies in right lower quadrant.
ileum

- The ileum is 2-4 m in length
- and is separated from the caecum by the ileocaecal valve. While there is no discrete line demarcating the jejunum from the ileum
Difference between jejunum and ileum

• differences between the two:
  1. jejunum is slightly wider (< 3 cm) than ileum(<2 cm)
  2. jejunum folds (valvulae conniventes) are thicker (2-3 mm) than ileum folds (1-2 mm)
  3. jejunum folds are also more numerous and deeper than ileum folds
  4. ileal mesentery contains more fat than jejunal mesentery
  5. ileum tends to be smaller calibre than jejunum
  6. ileum tends to be lighter in colour than the jejunum
  7. ileum contains abundant Peyer's patches
Mesentery:

- Broad fan shaped fold of peritoneum that suspends jejunum and ileum from posterior abdominal wall
- Conveys nutrition and innervation
- Consists of 2 layers derived from greater sac
- Root- 15cms long extends from left side of L1 vertebrae at duodenojejunal junction to Rt Sacro-iliac joint at ileo-caecal junction.
- Free border separates to enclose jejunum n ileum
Mesentery of small intestines holds many blood vessels
Plain abdominal Radiograph:

Most common indication suspected bowel obstruction /Perforation.

Views
Supine
Erect
Lateral dorsal decubitus
Antero-posterior or posteroanterior left lat decubitus
Erect  PA chest
NORMAL GAS PATTERN

- **Stomach**
  - always

- **Small bowel**
  - 2 or 3 loops of non-distended bowel
  - normal diameter = 2.5-3 cm

- **Larger bowel**
  - in rectum or sigmoid colon - always
Gas in stomach

Gas in a few loops of small bowel

Gas in rectum or sigmoid
Usually they become visible when the small bowel is more distended, in particular the jejunum.
Compare

Valvulae conniventes
Small bowel

Haustra
Large bowel
Always air/fluid level in stomach

A few air/fluid levels in small bowel
- Sonographic appearance of an inflamed colon segment in Crohn’s disease. Characteristic appearance: thickened wall diameter (almost 1 cm), partial loss of wall stratification, prominent submucosal layer, narrowed lumen and mesenteric fat hypertrophy.
Valvulae conniventes (plicae circulares) of the small bowel. These are more easily seen when there is fluid in the lumen of the bowel.
Color Flow (Power) Doppler—CFD. It is used to estimate presence, density or absence of vascular signals in thickened segments of bowel wall, in intraluminal or extraluminal pathological structures and for imaging flow in big abdominal vessels—SMA, coeliac trunk, portal vein. CFD is part of standard abdominal and bowel sonography.
Cross-sectional images of ileum proximal to an obstructing lesion. The lumen is distended with fluid. The wall is thick, which is consistent with inflammation.

- Readily detected color
- Doppler flow and a resistive index less than 0.6 were consistent with inflammation.
Barium follow-through examination

- This is performed following a barium meal examination of the esophagus, stomach and duodenum
- 150ml 250% w/v—200ml 20-25%--250ml 40-45%
- As the barium column progresses through the small intestine large radiographs of the abdomen are taken at intervals
- First one is taken with the patient supine about 15 minutes after the barium meal and shows the proximal jejunum
Preparation

- Purgative-Dulcolax 2tab HS (not in suspected obstruction, acute Crohn's exacerbation, ileostomy)
- Low roughage high fluid intake diet 48hrs prior
- No food/fluid should be taken for 12hrs before investigation

- No antispasmodics codeine tranquilizers 24-48hrs prior
• The remaining radiographs are normally taken at half hourly intervals with the patient prone.
• When the barium column reaches the caecum spot views of the terminal ileum are taken.
• It takes from 2 to 6 hours for the head of the barium column to reach the caecum.
Indications

- Patients who have low suspicion of small bowel disease – abdominal pain and diarrhea
- Suspected complete or near complete small bowel obstruction
- Crohn’s disease
- Patients who refuse for placement of nasojejunal tube/bilbao catheter

Contraindications

- Colonic obstruction
- Suspected perforation
- Paralytic ileus
• The caecum is that part of the large intestine that lies below the level of the junction of the ileum with the large intestine.
• It is a blind-ended pouch that is situated in the right iliac fossa.
• It possesses a considerable amount of mobility, although it does not have a mesentery.
• Attached to its posteromedial surface is the appendix.
  – The appendix communicates with the cavity of the cecum through an opening located below and behind the ileocecral opening.
A large blind pouch of large intestine lying in the right iliac fossa below the ileocaecal valve and continuing distally as the ascending colon.
Length & Location

- It is a blind intestinal pouch, approximately 7.5 cm in both length and breadth, located in the right lower quadrant, where it lies in the iliac fossa inferior to the junction of the terminal ileum and cecum.
The term “vermiform” comes from Latin word and means “worm shaped”.

The **vermiform appendix** is a blind ended tube connected to the cecum from which it develops embryologically.
The appendix averages **11 cm** in length but can range from **2 - 20 cm**.

The diameter of appendix is usually between **7 and 8 mm**.
The appendix is located near the junction of the small intestine and large intestine in the right lower quadrant of the abdomen near the right hip bone.
The location of the tip of the appendix can vary.
FEATURES

- Found at the point where the taniae coli converge on the postero medial wall of caecum.
- It opens into the caecum at one end and the other end is blind.
- Mesoappendix: a peritoneal fold enclosing the appendicular vessels.
- It is the prolongation of the mesentery of the terminal ileum.
- The tip of the appendix lies at the level of the brim of the pelvis.
- For a complete study of the ileocecal region, CT is often used as it offers better analysis of bowel wall:
- Imaging could be done without oral contrast medium or after ingestion of dye (in case of CT colonography or CT enterography). However, the use of intravenous contrast is systematic.
- Oral contrast mediums used include water, air, or even an iodinated contrast medium like gastrografin.
Fig. 1: Axial and coronal sections of water-mediated CT Colonography
Fig. 2: Normal Entero-MRI: T2 and T1 weighted sequences after intravenous contrast
INFLAMMATORY AND INFECTIOUS DISEASES
Acute appendicitis
Ultrasound
1. Direct signs:
   - Diameter > 6 mm
   - Dedifferentiated wall > 3mm
   - Appendicolith
2. Indirect signs:
   - Appendiceal fat infiltration
   - Mesenteric adenomegalies
   - Localised thickening of the cecal wall
   - Highly vascularised appendiceal wall
Appendicolith (red arrow) - Infiltration of surrounding appendiceal fat (green arrow)
In practice, CT is performed in case of:
- Inconclusive diagnosis after ultrasound
- Obese patients
- Patients with acute surgical abdomen or generalized pain for which several alternative diagnoses may be considered
Fig. 3: Appendicolith (red arrow) - Infiltration of surrounding appendiceal fat (green arrow)

Fig. 4: Enlarged appendix with surrounding fat infiltration - Acute appendicitis (large arrow) - Mesocolic appendix with slight peritoneal effusion close to its distal end (small arrow)
Appendiceal abscess
Patient 27 years. Right iliac fossa pain, 10 days. Mass in right iliac fossa with guarding and fever 39 °C
Fig. 6: - Heterogeneous hypoechoic collection located in right iliac fossa (red arrow). - CT: multiloculated collection (*) with contrast enhanced wall associated with surrounding fat infiltration and appendicolith (<> Appendiceal abscess
The Large Intestine
“The colon”
Large intestine

- The large intestine extends from the cecum to the anus. It is divided into: Cecum, appendix, ascending colon, transverse colon, descending colon, and sigmoid colon, rectum and anal canal.
The colon

- The colon (large intestine) is a distal part of the gastrointestinal tract, extending from the caecum to the anal canal.

- Anatomically, the colon can be divided into four parts:
  - Ascending:
    - Caecum,
    - Vermiform appendix,
  - Transverse,
  - Descending and
  - Sigmoid.

- The colon averages 150cm in length.
Cecum

• The cecum is that part of the large intestine that lies below the level of the junction of the ileum with the large intestine.
• It is a blind-ended pouch that is situated in the right iliac fossa. It is completely covered with peritoneum.
• It possesses a considerable amount of mobility. the longitudinal muscle is restricted to three flat bands, the teniae coli.
Ileocecal junction

- The terminal part of the ileum enters the large intestine at the junction of the cecum with the ascending colon. The opening is provided with two folds, or lips, which form the so-called ileocecal valve.
- The appendix communicates with the cavity of the cecum through an opening located below and behind the ileocecal opening.
Ascending Colon

- The ascending colon extends upward from the cecum to the inferior surface of the right lobe of the liver, where it turns to the left, forming the right colic flexure, and becomes continuous with the transverse colon.
- The peritoneum covers the front and the sides of the ascending colon, binding it to the posterior abdominal wall.
Descending Colon

- The descending colon is about 10 in. (25 cm) long
- It extends downward from the left colic flexure, to the pelvic brim, where it becomes continuous with the sigmoid colon.
- The peritoneum covers the front and the sides and binds it to the posterior abdominal wall.
Rectum

- The rectum is about 5 in. (13 cm) long
- It begins in front of the third sacral vertebra as a continuation of the sigmoid colon. It passes downward, following the curve of the sacrum and coccyx,
- It ends in front of the tip of the coccyx by piercing the pelvic diaphragm and becoming continuous with the anal canal.
- The lower part of the rectum is dilated to form the rectal ampulla.
Vasculature

- **Superior mesenteric artery**: proximal jejunum to hepatic flexure of colon
- **Inferior mesenteric artery**: remainder of colon to the level of rectum
- **Superior hemorrhoidal branch of the inferior mesenteric artery**: upper rectum
- **Hemorrhoidal branches of the internal iliac or internal pudendal artery**: lower rectum
The large intestine

- The large intestine can easily be distinguished from the small intestine by:
  1. Taeniae coli, three thickened bands of longitudinal muscle.
  2. The sacculations of its walls between the taeniae, called hastra.
  3. Appendices epiploicae (omental appendages), the small pouches of omentum filled with fat.
  4. Much greater caliber.
Intestinal Distention

- The small bowel is dilated when it exceeds 2.5 to 3.0 cm in diameter.
- The colon is dilated when it exceeds 5 cm in diameter.
- The cecum is dilated when it exceeds 8 cm in diameter.
Radiological imaging of large bowel diseases.
Imaging modalities

- Plain abdominal film
- Barium/contrast studies
- Ultrasound
- Computed tomography (CT)
- Magnetic resonance imaging (MRI)
- Radionuclide imaging / PET

Angiography/interventional radiology
Radiography is the most valuable means of determining whether obstruction is present. This modality is often diagnostic; even if it is not, however, it may help determine the next most useful diagnostic procedure. Congenital anomalies causing incomplete obstruction (e.g., stenoses, webs, duplications, malrotations, peritoneal bands, aganglionosis) may not manifest until later in life, and other types of examinations (e.g., barium enema studies, ultrasonography [US], computed tomography [CT], magnetic resonance [MR] imaging) are generally needed for diagnosis.
RADIOLOGICAL INVESTIGATIONS

- **PLAIN FILMS**: *(ERECT/SUPINE)*

1. Intraluminal Colonic gas is normal

2. Close temporal proximity to either sigmoidoscopy or colonoscopy may cause excessive colonic gas – should not be mistaken for a pathology.
• BARIUM ENEMA

1. Gold standard technique for imaging fine mucosal detail.

2. Scrupulous colon cleansing is mandatory for high quality studies.

3. Barium suspensions are contra indicated if there is a risk of colonic perforation.

4. A series of films are taken to image the entire colon in double contrast.
Barium Studies of the GI Tract

Barium enema

Barium liquid is instilled into the large intestine through the anus.

Radiologic view of barium enema.

Large intestine

Anus

Endoscope
1. Rectum
2. Sigmoid colon
3. Descending colon
4. Splenic flexure
5. Transverse colon
6. Hepatic flexure
7. Ascending colon
8. Cecum
Colonic atresia. (a) Radiograph shows distended loops of bowel similar to those seen in low small bowel obstruction. (b) Image from a barium enema study demonstrates microcolon with complete obstruction to the retrograde flow of barium in the transverse portion of the colon.
• COLONIC TRANSIT STUDIES
  1. Used to investigate severely constipated patients
  2. Measurement of whole gut transit time using radio opaque markers
  3. Ingested and followed by an abdominal film after an appropriate interval

• RECTAL ULTRASOUND
  1. Uses a 360° rotating endoprobe
  2. Obtains high resolution axial images of the rectal wall
  3. Primarily used to stage tumours

• ANAL ENDOSONOGRAPHY
  1. Modified rectal endoprobe to image the anal sphincters in patients who are anally incontinent
Figure 2b. Small bowel. Longitudinal section of a jejunal segment showing the numerous valvulae conniventes.

Figure 2c. Colon. Longitudinal scan of the ascending colon with its typical haustration.
• **CT COLONOGRAPHY**

1. Facilitates a rapid complete interrogation of the colon and rectum.

2. The attenuation characteristics of any suspicious lesion helps differentiate faecal residue from polyp, as **variable attenuation** due to some **gas content** is a distinguishing feature of residue, but a **polyp** has uniform attenuation similar to the bowel wall.

3. Faecal residue tends to fall onto the dependent colon surface, whereas polyps maintain their position despite patient movement.

4. A definitive diagnosis of a **lipoma** is based on its **fat density**.
MR colonography (MRC) follows similar principles to CTC, and is most commonly performed after bowel purgation.
1. Descending colon
2. Splenic flexure
3. Hepatic flexure
4. Ascending colon
5. Cecum
6. Sigmoid colon
RADIOLOGICAL ANATOMY OF HEPATOBILIARY SYSTEM
SEGMENTAL ANATOMY OF LIVER AND RADIOLOGICAL CORRELATION
Liver-Introduction

- Also called ‘hepar’.
- Largest/heaviest solid organ in the body.
- Weighs about 1600 gm in males, 1300 gm in females.
- Occupies the right hypochondrium, epigastrium & left hypochondrium.
- Most part of the liver is covered by ribs & costal cartilages.
- It is covered by network of connective tissue (Glisson’s Capsule)
Peritoneal ligaments

These ligaments connect the liver to the undersurface of the diaphragm

**Falciform ligament** = It is a double fold of peritoneum from umblicus to liver. Contains ligamentum teres, the remnant of umblical vein, which attaches to the left portal vein.

- In the fetus, umblical vein carries oxygenated blood from the cord via the left portal vein and ductus venosus to the IVC.
- Umblical vein can recanalize in portal hypertension.

Falciform ligaments split into **coronary ligament** (which becomes the **right triangular ligament**) and left triangular ligament, between which lies the bare area of the liver.
Lobes of Liver

- Liver is divided into right & left lobes by falciform ligament.
- The Right lobe also has two minor lobes- The caudate lobe and The quadrate lobe.
Liver surfaces

- Divided into 2 anatomical regions:

1. Diaphragmatic surface:
   - Smooth and dome-shaped surface
   - Inferior to diaphragm
   - Separated from diaphragm by subphrenic recess and from posterior organs (kidney and suprarenal glands) by hepatorenal recess
   - Covered by peritoneum except on the posterior surface of liver which is not invested in peritoneum and is known as the bare area of liver.
Diaphragmatic surface

- Right lobe
- Left lobe
- Diaphragm
- Falciform ligament
- Gallbladder
- Coronary ligament
- Bare area
- Visceral surface
- Coronary ligament
- Kidney
- Posterior abdominal wall
- Hepatorenal recess
- Subphrenic recess
2. Visceral surface

- Covered by visceral peritoneum except porta hepatitis and gall bladder bed.

- The visceral surface is related to:
  - Right side of the stomach i.e. gastric and pyloric areas
  - Superior part of the duodenum i.e. duodenal area
  - Lesser omentum
  - Gall bladder
  - Right colic flexure and right transverse colon; colic area
  - Right kidney and suprarenal gland; Renal area
Visceral relations: impression of neighbouring viscera

- Left triangular ligament
- Coronary ligament
- Esophageal impression
- Hepatic veins
- Inferior vena cava
- Bare area
- Suprarenal impression
- Hepatorenal portion of coronary ligament
- Right triangular ligament
- (Common) bile duct
- Common hepatic duct
- Cystic duct
- Renal impression
- Duodenal impression
- Quadrant lobe
- Gallbladder
- Fallopian ligament
- Round ligament of liver
- Colic impression
- Fissure for ligamentum venosum
- Caudate lobe
- Papillary process
- Caudate process
- Hepatic artery proper
- Hepatic portal vein
- Fissure for ligamentum teres
Peritoneal relations of the Liver

The Lesser omentum

- Encloses the **portal triad** (bile duct, hepatic artery and portal vein)
- Passes from the liver to lesser curvature of the stomach + 2 cm of duodenum.
- Thick free edge -- **hepatoduodenal ligament**
- Sheet like remainder – **hepatogastric ligament**
Liver is now divided into segments as per **Couinaud System**.

- **Caudate lobe** = Segment I.
- Portal and hepatic veins used as landmarks to divide the remainder of the liver into eight segment.

- **Right hepatic vein** divides the right lobe into **anterior (segment V and VIII)** and **posterior segments (segment VI and VII)**.

- **Middle hepatic vein** divides the liver into right and left lobes (or right and left hemiliver). This plane runs from the inferior vena cava to the gallbladder fossa.

- **Left hepatic vein** divides the left lobe into a **medial (segment IV and lateral part (segment II and III)**.
BLOOD SUPPLY

The liver has dual blood supply: hepatic artery and portal vein.

- **Hepatic artery:**
  - Provides 15% of hepatic blood supply.
  - Branch of coelic artery.
  - Common hepatic artery passes over the head of the pancreas and gives of right gastric artery, then gives off gastroduodenal artery at the epiploic forame to become the hepatic artery proper.
  - Hepatic artery continues in the free edge of the lesser omentum, anterior to the portal vein and to the left side of the common bile duct (CBD).
  - Devides into left and right branches at the porta hepatis.
• **Portal Vein:**
  - Provides 85% of blood supply to liver.
  - Formed by the union of the splenic vein and superior mesenteric vein behind the neck of the pancreas at L1/L2.
  - Runs at the posterior aspect of free edge of lesser omentum to the porta hepatis; it lies posterior to hepatic artery and CBD.
• **Venous Drainage:**
  
  Majority of the liver is via the hepatic veins which unite into to drain into the IVC at T9 close to the diaphragmatic hiatus. Caudate lobe drains directly into the IVC and may therefore be spared in case of hepatic veinthrombosis.

• **Nerve Supply**
  
  Parasympathetic supply is by the preganglionic fibers of the vagus nerve. 
  
  Sympathetic innervation is by the postganglionic fibers from the cœliae plexus.

• **Lymphatic Drainage**
  
  Lymphatics from upper surface drain into nodes in the posterior mediastinum. 
  
  Lymphatics from lower surface drain into hepatic nodes and cœliae nodes.
IMAGING ANATOMY OF THE LIVER
RADIOLOGICAL FEATURES

Imaging modalities

- CT
- MRI
- Ultrasound
- Hepatic angiography
- CT angiography
- Portal venography
- Hepatic venography
- Hepatic scintigraphy
Liver lesions

- **FOCAL LIVER LESIONS**
  area of alteration of normal parenchyma
  Cystic, solid or complex

**Cysts**: thin walls with clear fluid, benign

**Complex**: may be malignant

**Solid**: borders, outline
  Multiple: metastases? Abscesses, hemangiomas, cirrhosis
DIFFUSE LIVER LESIONS

- hepatomegaly
- generalized parenchyma changes
  - Fatty liver
  - Hepatitis
  - cirrhosis
The hepatic veins—right (RHV), middle (MHV), and left (LHV)—are interlobar and intersegmental, separating the lobes and segments. At the level of the hepatic venous confluence with the inferior vena cava, the right hepatic vein separates the right posterior segment (segment 7) from the right anterior segment (segment 8). The left hepatic vein separates the left medial segment from the left lateral segment. The middle hepatic vein separates the right and left lobes. The hepatic veins are best seen

<table>
<thead>
<tr>
<th>Vein Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R HV (anterior branch)</td>
<td>Intra-segmental in anterior segment of right lobe</td>
</tr>
<tr>
<td>R HV (posterior branch)</td>
<td>Intra-segmental in posterior segment of right lobe</td>
</tr>
<tr>
<td>LPV (horizontal segment)</td>
<td>Anterior to caudate lobe</td>
</tr>
<tr>
<td></td>
<td>Courses centrally in anterior segment of right lobe</td>
</tr>
<tr>
<td></td>
<td>Courses centrally in posterior segment of right lobe</td>
</tr>
<tr>
<td></td>
<td>Separates caudate lobe posteriorly from medial segment of left lobe anterior</td>
</tr>
</tbody>
</table>

The diagrams illustrate the anatomical structures and their relationships in the liver.
Normal Liver Size and Echogenicity

The upper border of the liver lies approximately at the level of the fifth intercostal space at the midclavicular line. The lower border extends to or slightly below the costal margin.

Liver length of greater than 15.5 cm, hepatomegaly is present. The organ size increases with height and body surface area and decreases with age.

The **mean longitudinal diameter** of the liver in the midclavicular line in this study was 10.5 cm, with standard deviation (SD) of 1.5 cm, and the mean midclavicular anteroposterior diameter was 8.1 cm (SD 1.9 cm).

**Riedel lobe** is a tongue like extension of the inferior tip of the right lobe of the liver, frequently found in asthenic women.

The normal liver is homogeneous, contains fine-level echoes, and is either minimally hyperechoic or isoechoic compared to the normal renal cortex.
Radiograph

- Limited role
- Demonstrate-
  - hepatomegaly
  - calcification
ULTRASOUND OF THE LIVER

- Liver particularly suited for ultrasound imaging
- Also used as acoustic window for viewing other structures: right kidney and adrenal gland, gallbladder and pancreas
- Vessels and bile ducts particularly well seen
- Blood flow studied using colour flow Doppler and direction and velocity of flow in portal vein evaluated with pulsed wave Doppler
- US contrast media can help characterise lesions
USG

- Initial imaging modality for suspected liver pathology.
- Position - Supine or left decubitus
- Transducer - convex (3.5–5Mhz)
- Approach - Subcostal
  - Xiphisternal
  - Intercostal
- Normal liver is fine homogeneous
- Either hypo echoic or isoechoic compared to normal renal cortex
- Hypoechoic compared to spleen
Images obtained through the anterior axillary line show the porta hepatis along the long axis. On the gray-scale image, the portal vein is easily identified. Often, the hepatic artery (arrows) is identified only with color Doppler imaging.
CT SCAN

- Normal liver is homogenous and has density higher than spleen.
  - Normal liver parenchyma - 40–80 HU
  - 8–10 HU greater than spleen
Cross-Section Imaging
AXIAL SECTIONS ON CT
CORONAL SECTIONS
SAGITTLAL SECTIONS
MRI

- Primarily MRI has evolved as problem solving for liver lesions

- It has higher contrast resolution, multiplanar capability and lacks ionizing radiation
MRI OF THE LIVER

- Gallbladder
- Hepatic artery
- Splenic artery
- Right hepatic artery
- Portal vein
A comprehensive MRI liver protocol

- T1 weighted images
- T2 weighted images
- T1 Post contrast (Triphasic studies as CT)
- STIR
- DWI (Mainly used in tumor imaging and assessing treatment response in tumors)
ANGIOGRAPHY

- Approach—Femoral artery
- Contrast is injected in coeliac axis and SMA or one or more of their branches
- To study vascular anatomy and hemodynamics
- In order to select proper angiointerventional treatment.
HEPATIC ARTERIOGRAPHY

- Catheter introduced into aorta and coeliac trunk via femoral puncture
- Greater selectivity if contrast injected distal to origin of gastroduodenal artery
- Frequency of normal variation may make injection of SMA and left gastric arteries also necessary
- MR and CT angiography can also produce excellent images of coeliac trunk and SMA
HEPATIC ARTERIOGRAPHY

- Left hepatic artery
- Proper hepatic artery
- Common hepatic artery
- Gastro-duodenal artery
- Right hepatic artery
ARTERIAL BLOOD SUPPLY

- Left hepatic artery
- Right hepatic artery
- Portal vein
- Proper hepatic artery
- Gastro-duodenal artery
- Left gastric artery
- Splenic artery
- Common hepatic artery
- Superior mesenteric artery
Fig. 12.10: Intra-arterial DSA showing selective celiac axis injection, splenic artery (SA), left gastric artery (LGA), gastroduodenal artery (GDA), right hepatic artery (RHA), left hepatic artery (LHA)
PORTAL VENOGRAPHY
HEPATIC VENOGRAPHY

- Achieved via the IVC usually by retrograde approach through internal jugular vein
- Catheterization of three main hepatic veins in turn
- May also achieve radiographically-directed hepatic venous pressure measurements or transjugular biopsy or TIPS
PET SCAN

- The ability of FDG–PET to estimate metabolic rates make it potentially valuable tool for monitoring therapy.
- Highly sensitive for detecting hepatic metastasis.
Fig. 12.12: FDG PET image showing a metastatic lesion in the segment 8 of liver in a newly diagnosed case of carcinoma colon.
Radiological anatomy of hepatobiliary system

- Liver:
  - Variable size and shape
  - Rt upper quadrant
  - Lobes and segments
  - Falciform ligament (contains lig. Teres)
  - Portal vein and portal triads
  - Hepatic veins
LECTURE OBJECTIVE

- To be familiar with radiological anatomy and distinguish normal pictures

- To be able to sort investigations according to indications and priorities
Biliary Apparatus:

It collects bile from the liver, stores in the gallbladder & transmits to 2\textsuperscript{nd} part of duodenum.

- Gall bladder.
- Cystic duct.
- Right and left hepatic ducts which unite to form Common Hepatic Duct.
- Common Bile duct formed by the union of cystic duct and common hepatic duct.
Billiary tree

- Right posterior sectoral duct
- Left main sectoral duct
- Common hepatic duct
- Common bile duct
- Cystic duct
- Right anterior sectoral duct
- Right main sectoral duct
Gall Bladder

- Gall bladder – a pear shaped sac and reservoir of bile and is responsible for concentration of bile. It can hold up to 30-50 ml.
- 9-10 cm long, 3 cm in diameter.
- Wall thickness < 4mm.
- Hangs from inferior surface of liver – fundus usually anterior and inferior to body and neck.
- Cystic duct arises from the neck of the gallbladder.
- Neck and cystic duct has spiral appearance to the mucosal folds (spiral valve of Heister); on ultrasound it is highly echogenic and may be mistaken for gallstones.
- Covered by peritoneum on fundus and inferior surface, occasionally hangs on its own mesentry.
Parts of Gall Bladder

- Fundus
- Body
- Neck
- Infundibulum
- Cystic duct
Anatomical Relations

• Anterosuperiorly: Gallbladder bed of liver and layer of peritoneum

• Posteroinferiorly: Lesser omentum, 1\textsuperscript{st} part of duodneum and transverse colon.
Blood Supply:
- Cystic artery, a branch of the right hepatic artery.
- Cystic vein drains into portal vein.

Nerve Supply:
- Parasympathetic supply is by pre-ganglionic fibers from the vagus nerve.
- Sympathetic innervation is by post-ganglionic fibers from the coeliac plexus.

Lymphatic Drainage:
- Lymphatics drain into cystic nodes, hepatic nodes and coeliac nodes.
Billiary tree

- Right posterior sectoral duct
- Left main sectoral duct
- Common hepatic duct
- Common bile duct
- Cystic duct
- Right anterior sectoral duct
- Right main sectoral duct
Billary tree anatomy

Bile secretes at level of biliary canaliculi

These joins to form the terminal bile ductules

Which joins to form the interlobular ducts

These joins to form the sectorial ducts/segmental ducts

That joins to form the hepatic duct and right and left hepatic duct form the common hepatic duct (CHD)

That joins with cystic duct to form common bile duct (CBD)

That joins with pancreatic duct to form ampulla of vater and opens into 2nd part of duodenum.
Intrahepatic Bile duct

- The classic biliary anatomy appears in about 58% of the population.
- It consists of the right hepatic duct and left hepatic duct and drains the right and left lobes of the liver, respectively.
- The right duct branches into the right posterior hepatic duct, draining posterior segments VI and VII and the right anterior hepatic duct, draining anterior segments V and VIII. Segmental tributaries draining segments II–IV are form the left hepatic duct.
- The fusion of the right and left hepatic ducts gives rise to the common hepatic duct at porta hepatis usually.
Extrahepatic Bile Ducts (CBD)

- It includes Cystic duct and common bile duct.
- CHD is joined by the cystic duct at a variable position (usually) 3.5 cm to form the CBD.
- Diameter of CBD is variable:
  - i.e. up to 5mm till 50 yrs of age then 1mm/decade after that age.
  - Diameter can be larger in postcholecystectomy patients i.e. up to 10mm.
Divisions and Relations of CBD

- Upper: Above duodenum within the lesser omentum, anterior to portal vein and to the right of hepatic artery.
- Middle: Posterior to 1\textsuperscript{st} part of duodenum with the gastroduodenal artery, sloping away to the right from the portal vein.
- Lower: Grooves the posterior part of head of pancreas, anterior to the right renal vein. It joins the MPD at Ampulla of Vater and opens into 2\textsuperscript{nd} part of duodenum.
IMAGING ANATOMY OF THE LIVER
METHODS OF INVESTIGATION
HEPATOBLIARY SYSTEM

1. Plain x-ray film, cholecystography (historical)
2. Ultrasound
3. CT scan
4. MRI, MR cholangiopancreatography
5. ERCP (endoscopic retrograde cholangiopancreatography)
Methods of investigation of the hepatobiliary system (cont.)

1. Percutaneous transhepatic cholangiography (PTC)
2. Post-operative (t-tube) cholangiography
3. Operative cholangiography
4. Angiography (diagnostic and therapeutic)
   CTA, DSA, and MRA
5. Radionuclide imaging
ULTRASOUND OF LIVER AND BLADDER

Main clinical Indications:
1. Right upper quadrant pain
2. jaundice
3. Clinically suspected liver lesion
4. Abnormal lab tests
5. Staging for malignant diseases
6. Suspected portal hypertension
RADIOMATIC FEATURES

Imaging modalities

- CT
- MRI
- Ultrasound
- Hepatic angiography
- CT angiography
- Portal venography
- Hepatic venography
- Hepatic scintigraphy
No contraindication

Preparation:
Restrict urine to clear fluids for gall bladder study (6 – 8 hr)
ULTRASOUND MACHINE
ULTRASOUND OF LIVER AND GALL BLADDER
CT scanner
CT scan of liver and biliary tree
CT SCAN OF LIVER AND BILIARY TREE

- **Clinical Indications:**
  1. suspected liver lesion
  2. Characterization of liver lesion
  3. Staging malignancy
  4. Rt upper quadrant pain
  5. To facilitate placement of needles (biopsy, etc.)
  6. Follow up after surgical or radiological intervention
CT SCAN OF LIVER AND BILIARY TREE (CONT.)

- **Contraindications:**
  1. Pregnancy
  2. Allergy to iodinated contrast media

- Patient preparation:
  the patient fasted for at least 6 hr
MRI LIVER
MRI scan of liver

- **Indications**: 
  1. Lesion detection if US and CT not conclusive
  2. Lesion characterization after detection by US or CT

- **Contraindications**: 
  General contraindications to MRI (claustrophobia, implants, penetrating injuries, sensitivity to contrast media, early pregnancy)
MRI scan of biliary tree (MRCP)

- 2D or 3D T2 weighted, bile appears white

**Indications**:
1. Investigation of obstructive jaundice
2. Biliary stone, colic
3. Suspected cholangitis, or chronic pancreatitis
4. Prior to ERCP/PTC
MRCP
Advantages of MRCP

1. Non-invasive
2. Relatively cheap
3. No radiation, No anesthesia
4. Less operator dependant
5. Ducts prox. to obstruction seen
6. Extraductual disease may be seen
Disadvantages of MRCP

1. Decreased resolution
2. Less sensitive to subtle ductal disease
3. Not therapeutic
ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAFY (ERCP)
ERCP

- Contrast-agent is injected through endoscope after cannulation of CBD

**Indications:**
1. Diagnostic, in unsuitable or intolerant to MRCP
2. Management of bile duct stones
3. Evaluation of ampullary lesions
4. Management of biliary strictures
5. Chronic pancreatitis
(ERCP) cont.

- **Contraindications:**
  1. Upper GIT obstruction
  2. Previous gastric surgery that prevents access to duodenum
  3. Sever cardiac or respiratory distress

- **Complications:**
  - Pancreatitis 5%
  - Duodenal perforation
  - Gastrointestinal bleeding
DISEASES OF THE BILIARY SYSTEM

- **CHOLELITHIASIS**: 
  - 10–20% US population, 30% calcification
  - 40–50% asymptomatic
  - Surgery in symptomatic and diabetic
  - Cholesterol, pigment or (most are) mixed
  - Predisposition: obesity, diabetes, cirrhosis, hyperparathyroidism
CHOLECYSTITIS

- Common
- ACUTE: calculus 95%, acalculus
  Distension, walls >5mm, free fluid,
  Murphy's sign (90% specific, negative if
  gangrenous)

Acalculus: trauma, long fasting, DM, no
stone invisible, patient ill

- CHRONIC:
  Thick smaller GB, stone 95%, STIFF
PER CUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY

- Gall bladder
- Bile duct
- Stone in gall bladder
- Stones in bile duct
- Intrahepatic bile ducts
- Common bile duct
- Pancreatic duct
- Duodenum
This radiograph taken during an ERCP procedure demonstrates the hepatic ducts; common hepatic duct, cystic duct, and common bile duct are demonstrated. Note the spiral appearance of the cystic duct due to which the valve of Heister. The pancreatic ducts and ampulla of Vater are not demonstrated.
1 Common bile duct
2 Common hepatic duct
3 Cystic duct
4 Endoscope in duodenum
5 Gallbladder
6 Amper’s ampulla
7 Left hepatic duct
8 Neck of gallbladder
9 Pancreatic duct
10 Right hepatic duct
MRCP Imaging

- Left hepatic duct
- Common hepatic duct
- Common bile duct
- Pancreatic duct
- Right hepatic duct
- Gallbladder
- Cystic duct
- Sphincter of Oddi
- C loop of duodenum
Imaging Anatomy of the Pancreas
Pancreas:

- Long (around 15cm) epigastric structure extending from duodenal loop to splenic hilum.
- Comprises the head (including the uncinate process), neck, body and tail.
- Pancreatic duct:
  - Begins at the tail and runs to the head increasing in size.
  - Located in the anterior half of pancreas.
  - Joins the CBD at the ampulla of vater.
  - Accessory duct of Santorini arises from the pancreatic head and drains via the minor papilla into the duodenum, 2cm proximal to the ampulla of vater. Usually communicates with the main duct.
Blood supply:

- Arterial supply to the pancreatic head is from superior pancreaticoduodenal artery and the inferior pancreaticoduodenal artery. The remainder of the pancreas is supplied from the splenic artery.
- Venous drainage from the pancreatic head is from the SMV and the portal vein and from the rest of pancreas to the splenic vein.
Gross Anatomy

- Retroperitoneal organ
- 15cm long
- Transverse mesocolon originates from anterior surface.
- **Head**
  - C-curve of duodenum (L2)
  - Uncinate process
    - Inferior-medial extension of head under SMA (L2)
- **Neck**
  - Overlies L1 vertebral body immediately to the left of the head
- **Body**
  - Extends left and slightly superior (L1)
- **Tail**
  - Tapering portion extending to hilum of spleen (T12)
Anatomical Relations

- Anterior relations
  - Peritonium
  - 1\textsuperscript{st} part duodenum
  - Lesser sac and stomach
  - Transverse colon/mesocolon
Pancreatic duct

- Pancreatic duct measures
  - 3mm in the head
  - 2mm in the neck
  - 1mm in the tail

- Unites with the common bile duct to form the ampulla of Vater and opens into the 2nd part of duodenum
**Arterial supply**

- **Pancreas neck, body and tail**
  - Dorsal pancreatic artery (from splenic artery or coeliac trunk)
  - Pancreatrica magna artery (emerges halfway along the splenic artery)
  - Transverse pancreatic artery (travels along the length of the pancreatic duct and anastomoses with the above arteries)

- **Pancreas head**
  - Superior pancreaticoduodenal artery (anterior and posterior branches from the gastroduodenal artery)
  - Inferior pancreaticoduodenal artery (anterior and posterior branches from the superior mesenteric artery)
Venous drainage

- SMV
- Splenic vein
- Portal vein
Lymphatic drainage

- Along arterial blood supply to pre-aortic coeliac lymph nodes
PANCREAS

- Retroperitoneal, on posterior abdominal wall, L1 level

- Head, neck, body and tail, 15 cm length

- Duct (from tail to ampulla), 4mm on ERCP
PANCREAS

- Accessory duct (Santorini) drains lower part of head

- Grey on US and CT, whiter than liver on T1

- Intense enhancement, Fat infiltration: common, normal, age
RETROPERITONEUM
PANCREATITIS

- Acute mild: edema, pain, vomiting, tenderness, not progress
- Acute severe: necrosis, shock, renal failure, GI bleed
- Chronic: alcohol, stone
Pancreatitis, Rad. features

- **US**: hypoechoic due to edema, detect stone and follow up size of pseudocyst (capsule)

- **CT**: heterogeneous, focal necrosis 90% accurate, peripancreatic edema or fluid or even gas collection
# Radiological anatomy

**Dimensions of pancreas (normal ranges for age):**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Head 1 (mm)</th>
<th>Body 2 (mm)</th>
<th>Tail 3 (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–30</td>
<td>25–32</td>
<td>17–21</td>
<td>16–20</td>
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<tr>
<td>31–40</td>
<td>23–29</td>
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<td>41–50</td>
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<td>51–60</td>
<td>21–27</td>
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<td>14–17</td>
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<tr>
<td>61–70</td>
<td>20–26</td>
<td>14–18</td>
<td>13–16</td>
</tr>
</tbody>
</table>

*Rule of thumb:* head ≤ 3.5 cm, body and tail ≤ 2.5 cm

4. **Pancreatic duct:**
   - Width 1–3 mm

5. **Width of common bile duct:**
   - ≤ 8 mm (≤ 10 mm after cholecystectomy)

*Attenuation values:*
   - Pancreas: 40 ± 10 HU
US

- 3 - 7.5 MHz probe
- Sagittal, transverse and oblique planes
- Occasionally, may have non-visualization due to bowel gas which can be overcome by:
  1. Fill stomach with fluid
  2. Position patient erect (liver descends)
  3. Prone position for tail
129 Head of pancreas, vena cava, superior mesenteric vein, uncinate process, common bile duct

The common bile duct is visible at the right border of the pancreatic head in transverse section.

130 Head of pancreas, vena cava, superior mesenteric vein, uncinate process, gallbladder

The head of the pancreas lies between the liver, gallbladder, vena cava, and superior mesenteric vein.
Fig 1. Normal aspect of the pancreas: PV – portal vein; SV – splenic vein; AO – Aorta; IVC – inferior vena cava; H – head of the pancreas; B – body of the pancreas; T – tail of the pancreas;

Fig 2. Normal pancreas with the uncinate process: PV – portal vein; SMA – superior mesenteric artery; LEFT LOBE – left liver lobe; HEAD – head of the pancreas; BODY – body of the
CT

- Similar density as liver
- Density is reduced with increasing age due to normal accumulation of fat
- Homogenous enhancement post contrast
SPLEEN
LECTURE OBJECTIVE

- To be familiar with radiological anatomy and distinguish normal pictures

- To be able to sort investigations according to indications and priorities
Lecture overview

- Radiological anatomy
- Methods of investigation
- Indications, precautions and contraindication
- Patient Preparation
- Radiological features of most common diseases
- references
Spleen:

- Spleen is the largest organ of lymphatic system in human body.
- Origin: The spleen develops in the cephalic part of dorsal mesogastrium (from its left layer; during the sixth week of intrauterine life) into a number of nodules that fuse and form a lobulated spleen.
- Location: Lies along the axis of 10th rib.
- Size: normally varies from 7 to 12 cm in length, 7.5 cm broad and 2.5 cm thick.
- Weight: 150 to 200 grams normally
• Blood supply and venous drainage:
  ❖ Arterial supply: Splenic artery which is tortuous and is the largest branch of celiac trunk. Divides into multiple branches just before it enters the hilum of spleen.
  ❖ Venous drainage: Splenic vein which originates from splenic hilum joins superior mesentric vein to form portal vein behind the neck of pancreas.
• Ligaments:
  1. Gastro-splenic .(spleen enlarges in it’s direction)
  2. Spleno-renal.
  4. Spleno-colic.
• Nerve supply: Sympathetic fibers of celiac plexus
SPLENIC TRAUMA

• Spleen is the most common organ to be injured in blunt trauma to the abdomen.
• Accounts for 40% of all solid organ injuries.
• Incidence of penetrating trauma of spleen is relatively low due to low surface area of spleen, which is approx 7% of abdominal surface.
• X-ray: May show a mass in left hypochondrium with or without presence of single or multiple rib fractures. Not of much use though.
• **USG:** It has become a first line investigation for any abdominal trauma especially for splenic injury. It shows a peri-splenic hematoma with internal echoes along with one or multiple lacerations.
Normal spleen.

- Homogenous, moderately echogenic (echogenicity usually higher when compared to the liver, but may be iso or hypoechoic)
- Visualized best obliquely in the 9th or 10th intercostal spaces.
SPLEEN LESIONS

- Splenomegaly

- **Trauma** (subcapsular or parenchymal hematoma, laceration, fragmentation, delayed rupture \( \text{rare} \))

- **Cyst, Tumor** (hemangioma, metastasis)

- infarction
Splenic infarcts on USG shows no blood supply in infarcted region.
• **Isotope scanning:** Rarely used now. Used when it is difficult to identify spleen on USG/CT.

• **CT scan:** Contrast enhanced CT scan is investigation of choice. It is have high sensitivity, specificity and accuracy (>95%) in detecting splenic injury.
Grade III splenic rupture
Metastases on CT
Hydatid cyst of Spleen
Massive Splenic infarct on CT
SPLENIC CALCIFICATION (TB)
• **Angiography:** It may be used in hemodynamically stable patients with splenic injury diagnosed on CT to detect whether active extravasation is present or not. So that cases who are hemodymanically stable with active extravasation can be treated with bed rest or embolization of splenic artery distal to dorsal pancreatic artery.
Splenic angiogram shows active bleeding in the inferior pole.

Selective splenic angiogram confirms active bleeding.

Angiogram shows no active bleeding after embolization with coils.
Splenomegaly
• **X-ray:** May show a lump in splenic region with raised diaphragm.

• **USG:** Enlarged spleen is seen extending downwards, anteriorly and to the right, displacing stomach forwards and medially with left diaphragm seen pushed upwards.

• **CT scan:** Shows full extent of spleen.
Massive splenomegaly in Gaucher’s disease
MRI in SPLEEN

• Anatomy and internal structures are well shown on CT and USG, but MRI is useful in minority of cases.
(i) Portal hypertension: spleen is enlarged with no change in it’s signal intensity apart from the occasional findings of siderotic nodules (Gamna-Gandy bodies) which produce focal areas of low intensity signals.
(ii) In Transfusion haemosiderosis, the spleen shows generalized loss of signal in both T1 and T2.
(iii) Cysts: uniform low T1 signal, high T2 signals and no enhancement with gadolinium.
Splenic Scintigraphy

- Very rarely used or needed now a days.
- Physiology: Reticuloendothelial cells of spleen takes up intravenously injected colloids (99mTc) of size 30-1000nm. In normal cases about 15% of the injected colloidal activity reaches spleen, but in patients with cirrhosis or hypersplenism a much greater proportion of injected particles will reach spleen and will be trapped there due to increased blood to the spleen.
- A more specific imaging is done by injecting autologus RBC’s which have been incubated at 50° C and labelled with technetium 99. They are called Heat damaged RBCs.
Portal Venography

**Methods:**
(i) Late phase superior mesentric angiography.
(ii) Trans-splenic approach. (Discussed below)
(iii) Paraumbilical vein catheterization.
(iv) Transjugular transhepatic approach.

**Indications:**
(i) To demonstrate prior to operation the anatomy of the portal system in patients with portal hypertension.
(ii) To check the patency of a portosystemic anastomosis.
Portal Vein

- **Portal vein diameter:**

- Traditionally, enlargement of the portal vein has been considered a sign of portal hypertension.
- Main portal vein with a dimension > 13 mm in the supine position, has a sensitivity of 40% or less, with an accuracy of around only 60%.
- Several physiologic factors may cause size variation in the portal vein.
  - postprandial increment in splanchnic flow
  - Respiratory phasic change
  - Gravity
  - patient positional change

Therefore this measurement is diagnostically unreliable
• Relative change in size of the portal vein with respiration is a more sensitive, rarely assessed, finding.

• An increase of less than 20% in the diameter of the PV with deep inspiration indicates portal hypertension
  – sensitivity 80% and specificity 100%.
- **Portal Vein Doppler:**
- Normal portal venous flow is hepatopetal flow, throughout systole and diastole with mild superimposed respiratory phasicity and cardiac periodicity.
Hepatic artery (HA)

• In normal subjects the HA possesses forward flow in diastole due to a low-resistance peripheral vascular bed
  – Normal RI = 0.5 to 0.7.
  – arterial resistance index increases in cirrhosis.
Hepatic veins (HVs)

- Normal – Triphasic
- Can be biphasic with predominantly antegrade flow (hepatofugal)
• Causes of decreased phasicity and loss of triphasicity of hepatic veins are
  – cirrhosis
  – hepatic vein thrombosis (Budd-Chiari syndrome)
  – hepatic veno-occlusive disease
  – hepatic venous outflow obstruction from any cause
• normal phasicity - a wave above the baseline
Splanchnic veins

- Enlarged splanchnic veins (superior mesenteric vein (SMV) and splenic vein (SV) diameter of more than 10 mm) are suggestive of portal hypertension.
Portosystemic collateral vessels

• In portal hypertension shunting of blood away from the liver into the systemic venous system provides a mechanism of reducing portal venous pressure.
• The main sites of collateral pathways are:
  – distal oesophagus: left gastric (coronary) vein and short gastric veins to distal oesophageal veins
  – splenorenal (lienorenal) ligament: splenic vein to left renal vein - splenorenal shunt
  – retroperitoneum: superior mesenteric veins to retroperitoneal/lumbar veins to the inferior vena cava
  – anterior abdominal wall: paraumbilical vein to subcutaneous periumbilical veins (caput Medusae)
  – anal canal: superior rectal vein (from inferior mesenteric vein) to upper anal canal veins (haemorrhoids)
• Gastro-oesophageal Junction:
  - They are best visualised ultrasonically through the **left lobe of the liver**. These vessels are of particular importance as they may lead to life threatening variceal haemorrhage.

Longitudinal sonogram in a patient with cirrhosis and portal hypertension. Note the markedly enlarged and tortuous left gastric varices (V). These continue to anastomose with esophageal veins.
• Paraumbilical vein
  • This collateral originates from the left portal vein, runs in the recanalised ligamentum teres of the falciform ligament and connects with the superior and epigastric veins, of the systemic circulation, around the umbilicus.

• Hepatofugal venous flow in the ligamentum teres with velocity greater than 5 cm/sec or visualised anterior to the liver’s surface is **highly specific for presence of portal hypertension.**
**Splenorenal and gastrorenal collaterals**

- Tortuous vessels may be seen in the hilar region of the spleen and left kidney.
- These are best visualised using the enlarged spleen as an ultrasonic window.
- There will be associated asymmetrical enlargement of the left renal vein, although this can also be seen with renal arteriovenous fistula and renal tumours.
• **Intestinal:**
  • These collateral pathways occur in areas where the gastrointestinal tract is retroperitoneal (e.g., ascending and descending colon and duodenum) and they connect pancreaticoduodenal, retroperitoneal and omental veins with renal, phrenic and lumbar veins.
  • The ease with which these vessels are identified on ultrasound depends to a large degree on the amount of air in the bowel at the time of the study as well as the size of the collateral vessels.
• Haemorrhoids:
• Collaterals in this region connect the inferior mesenteric veins, via the superior rectal veins, with the middle and inferior rectal veins of the systemic circulation.
• Usually, conventional transabdominal sonography cannot detect rectal/ pararectal varices but these can be seen using transvaginal scanning.
• Detection of abnormal collateral vessels appears to be one of the most sensitive (70-83%) and specific sonographic signs of portal hypertension.

• The more severe the portal hypertension the higher the number of portosystemic pathways.
Splenomegaly

- Splenomegaly (>12 cm in longest axis) is often seen in portal hypertension.
- It is usually only mild to moderate in degree and may be the only evidence of elevated portal pressures.
- Conversely, the absence of splenomegaly does not rule out portal hypertension.
- Siderotic Gamma-gandy bodies are present in approximately 13% of cases and on ultrasound appear as multiple hyperechoic foci suggest that splenomegaly is due to portal hypertension.
Establishing the cause

- Causes can be split in their relation to the hepatic sinusoids:
  - **pre-sinusoidal**
    - portal vein thrombosis
    - extrinsic compression of portal vein
    - Schistosomiasis (*S. mansoni* or *S. japonicum*)
  - **sinusoidal**
    - cirrhosis
  - **post-sinusoidal**
    - Budd-Chiari syndrome
    - hepatic veno-occlusive disease
    - right heart failure or biventricular cardiac failure
CT Imaging

- Can demonstrate the portal venous system and portosystemic collaterals with minimum interference of bowel gas, bone or fat.
Three-dimensional reformatting techniques for 3D multi-detector row CT portal venography. MIP and SSD (shaded surface display) CT portal venograms show the portal vein and the dilated left gastric varix.
(a) Axial CT scan shows a dilated left gastric vein  (b) Coronal MIP CT portal venogram shows the left gastric vein (solid arrow) and short gastric vein (arrowhead). Esophageal varices (open arrow) are seen to communicate with the left gastric vein through the gastric fundal varix.
Abdominal wall and paraumbilical varix. (a, b) Axial (a) and sagittal oblique (b) MIP CT portal venograms show the paraumbilical vein (solid arrows) as it extends superiorly and inferiorly to the anterior abdominal wall (arrowheads in b)
MR Imaging

- **MR portography**
  - Gadolinium enhanced breathhold MR portography can now be achieved using fast imaging techniques within 20-30 s.
  - Higher dose (0.2 ml/kg) is required as contrast gets diluted by the time it reaches the portal vein.
  - Contrast enhanced MR is superior to doppler in identifying collaterals.

- **Pitfalls:**
  - Insufficient enhancement due to dilution of contrast
  - Motion artifacts due to requirement of breathholding.
Interventional radiology in the management of portal hypertension
Transjugular intrahepatic portosystemic shunt (TIPS)

- Shunt created within the liver parenchyma between the hepatic vein and the portal vein.
- Usually an 8-10 mm diameter stent is chosen to decompress the hypertensive portal circulation to achieve a final portosystemic gradient of less than 12 mm Hg.
TIPS performed in a patient with uncontrolled variceal bleed. Portal venogram (A) obtained after puncture of the portal vein shows retrograde filling of the left gastric vein and feeding of a large junctional Varix. The post-TIPS venogram (B) shows good flow across the TIPS. Adequate decompression is evident from the non-filling of the left gastric vein and varices and reduction of the portosystemic gradient to 4 mm Hg.
Budd-Chiari syndrome secondary to hepatic vein occlusion. The middle hepatic vein is obstructed close to its insertion into the inferior vena cava (A); after insertion of a balloon-expandable stent at the level of the occlusion, the hepatic venous outflow is restored (B).
Percutaneous Transhepatic Variceal Embolization (PTE)

- Earliest intervention performed for portal hypertension
- In this technique, the portal vein is catheterized by a percutaneous transhepatic approach and the gastric vein feeding the varix is embolized with ethanol, steel coils, or cyanoacrylate glue.
- Recurrent bleeding was seen in 10%–60% of cases, since the underlying portal hypertension was unaffected.
- PTE itself was responsible for inducing portal vein thrombosis in up to 36% of patients.
- The introduction of Endoscopic therapy, TIPS and BRTO antiquated the procedure, and PTE is now very rarely performed.
Balloon-occluded Retrograde Transvenous Obliteration of Varices (BRTO)

• Primarily for bleeding gastric varices
• Most isolated fundal or fundal-cardiac varices drain through a developed gastrorenal shunt.
Radiological Anatomy & Investigations of Urinary System
Objectives

To know the different types of modalities used in imaging the urinary tract

To know the anatomic location and sizes of the structures of the urinary tract

To identify the kidneys, ureters, urinary bladder and urethra on different imaging modalities
Urinary System

- Kidneys
- Ureters
- Urinary bladder
- Urethra
Imaging Modalities

Plain X-Ray
Intravenous Urogram (IVU)
US
CT
MRI
Nuclear medicine
Plain X-Ray

First imaging modality
Cheap
Useful for radio-opaque stones
Image features:

- Projectional image
- Image contrast determined by tissue density
- Good evaluation radio-opaque stones
IVU

Conventional x-ray + IV contrast

Cheap

Recently replaced by CT and MRI

Useful for radio-opaque stones
Image features:

- Projectional image
- Image contrast determined by tissue density and IV contrast
- Good evaluation of collecting system and radio-opaque stones
US

Use high frequency sound waves
Contrast between tissue is determined by sound reflection.
Image features:

Operator dependant

Projectional image

Good resolution

Used for stones, hydronephrosis, and focal lesions
CT

Same basic principle of radiography

More precise

Costly

+/− contrast

Useful for trauma, stone, tumor

and infection
Image features:

Cross sectional images

Image contrast determined by tissue density +/- contrast

Better evaluation of soft tissue
MRI

Better evaluation of soft tissue
Expensive
Useful for soft tissue pathology:
tumor, infection
Image features:

Cross sectional images
Image contrast determined by tissue properties
Excellent for soft tissue evaluation
Nuclear medicine

Utilizes a gamma camera and radioactive isotopes

*Functional test*

Less expensive

Useful for: obstruction and split function
Image features:

- Projectional image
- Image contrast by tissue uptake and metabolism
Anatomy
Kidneys

Bean shaped structure
On either side of the lower thoracic and upper lumbar spine
Usual location – between (T11-L3)
Useful when we suspect renal stone
Kidneys are retroperitoneal organs and may be obscured by bowel loops.
Kidneys

Normal size: in adults 11-12 cm
Ultrasound is the best method to measure the size of the Kidney
Kidneys

Kidneys are visualized on the X-Ray due to presence of perirenal fat.

They are contained within the renal capsule and surrounded by perirenal fat and enclosed within the Gerota’s fascia.

Perirenal hemorrhage, pus and urine are contained within the fascia and detected on CT and US.
Kidneys are surrounded by perinephric fat. Fat appears dark in CT.
MRI: Fat is bright in T2
Ultrasound of Right Kidney
ULTRASOUND OF KIDNEYS

NORMAL STUDY

DILATED RENAL PELVIS
CT Scan of the Kidneys
Renal Vasculature
Renal Vasculature

Renal arteries branch from the abdominal aorta laterally between L1 and L2, below the origin of the superior mesenteric artery.

The right renal artery passes posterior to the IVC.

There may be more than one renal artery (on one or both sides) in 20-30% cases.
Renal Vasculature

Renal veins drain into inferior vena cava

Renal veins lie **anterior** to the arteries

Left renal vein is longer and passes anterior to the aorta before draining into the inferior vena cava

The left gonadal vein will drain into the left renal vein while the right gonadal vein drains directly into the inferior vena cava
RENAL ANGIOGRAPHY

NORMAL SUPPLY OF BOTH KIDNEYS BY SINGLE RENAL ARTERY

LEFT KIDNEY SUPPLIED BY TWO RENAL ARTERIES
Left Renal Vein Passes Anterior to the Abdominal Aorta
Renal Veins Lie Anterior to the Arteries
Red: Arterial flow
Blue: Venous flow

Dark: Collecting system filled with urine
Relationships of the Kidneys
Adrenal Glands are superior to the Kidneys
Renal Structure

Cortex
- Renal cortex consists of glomeruli and renal tubules
- Normal thickness is 2.5 cm

Medulla
- Consists of multiple renal pyramids
Ultrasound of Right Kidney
Contrast enhanced CT scan through the kidneys in nephrogram phase (showing corticomedullary differentiation)

This is approximately 100 seconds following contrast administration and would show renal lesions well
Contrast enhanced CT scan through the kidneys in **pyelogram phase** (showing excretion of contrast into the collecting system)

This is approximately 8 minutes following contrast administration and would show **urothelial lesions** well, such as transitional cell carcinoma, stones, blood clots.
3D reconstructed image from CT scan of the abdomen and pelvis known as **CT urography**

*Nowadays, this exam is quickly replacing the conventional IVU*

3D reconstruction is performed through the right kidney (K) and follows the normal ureter (arrows) all the way to the ureter's insertion into the bladder.
Renal Collecting System

Calyces

- Medulla sits in the fornix of the minor calyx
- Papillae drain into minor calyces
- Minor calyces coalesce to form 3 or 4 major calyces
- Major calyces combine to form the pelvis
Renal Collecting System

Pelvis
- broad dilated part of the urine collecting system, located in the hilum
- renal pelvis drains into the ureter
Papillae positioned in the apex of pyramids drain into the fornix of the minor calyces. They join to form 3 or 4 major calyces, which join to form the renal pelvis. The renal pelvis drains into a muscular tube called the ureter.
Fat and fluid appear white in this MR sequence. Urine filled collecting system appears white.
Ureters
Ureters

25-30 cm in length and 3 mm diameter
Areas of Narrowing

Three areas of normal narrowing:

Ureteropelvic Junction
Bifurcation of the iliac vessels
Ureterovesical Junction
NOTE RELATIONSHIP OF URETERS TO PSOAS AND THE TRANSVERSE PROCESSES.
Urinary Bladder
Urinary Bladder

Size and shape vary considerably

When empty, it is completely within the pelvis

Dome is rounded in male and flat or slightly concave in female
Urinary Bladder

Bladder is relatively free to move except at the neck which is fixed by the puboprostatic ligaments (males) and pubovesicle ligaments (females).

Peritoneal reflection - Rectovesicle pouch in males and vesicouterine and rectouterine pouch in females.
Anatomy of Male Pelvis showing the Urinary Bladder
Voiding Cystourethrogram

Reflex in right ureter

Bladder

Urethra
Urinary Bladder

Unenhanced CT scan through a normal bladder (B) shows a normal fluid density structure (less than 10 Hounsfield units on CT density scale)
Urinary Bladder

3D reconstructed image of a normal bladder in the sagittal plane following CT urography.

This is a delayed image 10 minutes following IV contrast administration, excreted contrast fills an otherwise normal bladder (B).
Urinary Bladder

Transverse image through a normal urinary bladder (calipers "x" and "+" outline the bladder wall) using **ultrasound** shows normal anechoic structure (anechoic = no echoes = black)
Prostate Gland
Prostate Gland

Largest accessory gland of male reproductive system
Lies around the first part of the urethra at the base of the bladder
(Tr) 4 cm x 3 cm (height) x 2 cm (AP) in size
Surrounded by dense fibrous capsule
Prostate Gland

Base – closely related to neck of bladder
Apex
Posterior surface
Anterior surface
Anterolateral surfaces
Prostate Gland

Prostate gland can be divided into
- An inner gland – transition zone
- An outer gland – central and peripheral zones

*Transition zone* which lies in periurethral location is the site of *benign prostate hypertrophy* which can occlude the urethra

*Peripheral zone* is the *primary tumor* site in 70% patients
What are the arrows pointing to?
Prostate just anterior to rectum - easy to palpate on digital rectal exam.
TRUS - PROSTATE CANCER T 2

Note - CANCER is in Peripheral Zone
NOTE; PROSTATE CAPSULE BETTER SEEN WITH MRI

NORMAL PROSTATE MRI

TZ = transitional zone
PZ = peripheral zone
C = capsule
N = nerve
R = rectum
Radiology of the Adrenals
What is radiology?

It is a medical specialty that employs the use of imaging to both diagnose and treat disease within the human body.

What is the Adrenal glands?

The adrenal glands (also known as suprarenal glands) are endocrine glands that produce a variety of hormones including adrenaline and the steroids aldosterone and cortisol. They are found above the kidney.
Why Look at Adrenals?

- Endocrine workup in a patient with suspicious symptoms or laboratory values
  - i.e., hypertension, Cushingoid symptoms, virilism, adrenal insufficiency

- Looking for metastases in a patient with known extra-adrenal malignancy

- Post-trauma abdominal survey

- ANY reason for obtaining a scan of the abdomen
  - Incidental adrenal masses are detected in 0.35-4.4% of CT scans done for other reasons.
Items in which the adrenal not follows the rules:

1- It increases in size with age
2- It can contain mass in a patient with 1ry and we don't diagnose it as 2ry
3- Carcinoma presents in childhood as well as adults
Objective

To know:
- Normal Anatomy of Adrenal Gland.
- Imaging Modalities of Adrenal gland.
- D.D of Adrenal Masses.
- Imaging Appearance of adrenal masses.
- Imaging Work UP of adrenal incidentaloma.
- Questions.
Normal Anatomy

- The adrenal glands are two small, retroperitoneal yellowish organs located in the perirenal space, immediately anterosuperior to the upper pole of the kidneys.

- Yellow appearance because of their high lipid content.

- Gerota’s fascia connect the gland to upper pole of the kidney.
Normal Anatomy

- Right adrenal is triangular, related to upper pole Right kidney.
- Left adrenal is crescent shaped, related to upper and medial part Left kidney.
- Average size is 3-5 cm long, 2-3 cm wide and 5 mm in thickness.
- Average weight is 3-5 g of which 90 % is contributed by cortex.
Vascular Supply

Receive arterial blood from branches of the inferior phrenic artery, aorta, and renal arteries.

The right adrenal vein is short and exits the gland medially to enter the vena cava.

The left adrenal vein exits anteriorly and usually drains into the left renal vein.

As a result, adrenal venous catheterization is accomplished more easily on the left than the right.
The adrenal gland is composed of an outer cortex and thinner inner medulla.

The cortex is further subdivided into three zones: outer zona glomerulosa-site for aldosterone synthesis, middle zona fasciculata, and inner zona reticularis produce both cortisol and androgens.
The Adrenal Gland

Adrenal Medulla

Adrenal Cortex
Relations

- **RT ADRENAL**
  - Anteriorly: IVC and Liver
  - Posteriorly: Diaphragm

- **LT ADRENAL**
  - Anteriorly: Pancreas and Stomach
  - Posteriorly: Diaphragm
Imaging Modalities

1. Plain Film.
2. IVU.
3. Ultrasound.
4. CT.
5. MRI.
6. Radioisotope Scanning.
7. PET and PET-CT Imaging.
8. Interventional imaging.
9. Adrenal Biopsy
Plain Films

- Limited role.

- Demonstrate a soft tissue mass or tumefaction possibly displacing the kidney.

- Demonstrate calcifications (idiopathic, neoplasm, granuloma, cyst, old hemorrhage and Wolman’s disease).
Left: Plain film showing bilateral stippled adrenal calcification.

Right: Large left supra renal mass (M) with low fat density, mass effect on the upper pole of the left kidney is noted in this case of left adrenal myelolipoma.
The mass may cause lateral and downward displacement and flattening of the corresponding renal pelvi-calyceal system causing the drooping-lily sign.

Intravenous urogram (IVU) shows a classic drooping-lily sign involving the right kidney. This patient had a known right adrenal neuroblastoma.
Ultrasound

- Often adrenal masses are incidentally detected with abdominal ultrasound.

- Ultrasound can differentiate solid from cystic masses.

- The location, size, echopattern and vascularity of masses are assessed using color Doppler imaging.
Is the most effective technique for examining the adrenal glands.
The imaging procedure of choice for most patients with known or suspected adrenal lesions.
Perinephric fat allows the gland to be displayed clearly.
Sensitivity up to 100% in identifying tumors as small as 10 mm.
CT can demonstrate the adrenal glands in all patients and can usually identify the size, location, appearance, and presence of local or vascular invasion, lymph node involvement, and presence of distant metastases.
Axial CT scan demonstrating normal right and left adrenal glands with inverted 'Y' shapes above both kidneys.
Normal Adrenal Glands on CT

- Inverted Y, V or T shape
- Homogeneous, symmetric
- Density resembles the kidney on non-contrast CT
- Adrenal body measures < 12 mm
- Adrenal limbs measure < 6 mm
Coronal CT scan demonstrating normal right and left adrenal glands with inverted ‘Y’ and ‘V’ shapes respectively located above both kidneys.
A typical MRI protocol for adrenal imaging includes three plane localizer to make proper coverage.

High quality axial T1 and T2 weighted images (3–5 mm) sections preferably with suspended respiration are standard.

Chemical shift imaging is now standard.
Coronal T1-weighted MR image shows the normal inverted Y shape of the right adrenal gland (arrow).
The normal signal on MRI is isointense or slightly hypointense to the liver.
Loss of signal intensity indicates presence of intracellular lipid.
Radio-isotope Scanning

- Based on the uptake and accumulation of radiotracers (radio-cholesterol) in functioning adrenal tissue.
- Anatomical localization and functional characterization.
- The widespread application of adrenal scintigraphy is limited by the lack of experienced nuclear medicine center.
- $^{131}$I labeled cholesterol analog can detect functional adrenocortical tumors.
- Labeled guanethidine analog (MIBG) can detect functional adrenomedullary tumors.
Radio-isotope Scanning

- Adenomas (hypersecreting or nonhypersecreting) show radiocholesterol uptake and so appear as "hot" nodules.

- Malignant tumors (primary or secondary) appear as "cold" nodules.

- Therefore, adrenal masses can show different patterns of uptake depending on nature.
Advantages:
- High sensitivity for detecting malignancy.

Disadvantages:
- 16% of benign adrenal lesions may be positive on PET.
- Cost and insufficient data to support their routine use (not recommend).
CT and fluorodeoxyglucose (FDG)-PET scans of the tumor before and after primary surgery

Angiography

- Arteriography and venography: used in the preoperative evaluation of large adrenal lesions.

- However, due to the unique sensitivity of spiral CT and MRI scans, these invasive techniques have become obsolete.
Adrenal Venous Sampling

- Venous sampling may have a place when bilateral adrenal masses associated with endocrine hyperfunction...to localize site of hypersecretion

- An experienced interventional radiologist is required because the right adrenal vein can be difficult to catheterize.
Adrenal Biopsy is a reliable technique and is the standard for diagnosis of adrenal pathologic conditions that cannot be accurately characterized with CT, MR imaging, or PET and in whom accurate staging is mandatory.

Safe procedures with a high degree of accuracy and a low complication rate.

CT is the modality of choice for guiding adrenal biopsies.

Axial technique with a cutting core needle is useful.
Fine-Needle Aspiration Biopsy (FNAB):
- Using either CT or ultrasound guidance.
- Cannot differentiate between an adrenal cortical carcinoma and an adrenal adenoma.
- It can distinguish between an adrenal tumor and a metastatic tumor so used when there is a suspicion of cancer outside the adrenal gland.
- Invasive produces causing significant morbidity.
- Complications such as pneumothorax, septicemia, and hemorrhage have been reported in 8% to 13% of cases.
- Pheochromocytoma should always be excluded before attempting FNA biopsy of an adrenal mass.
Abdominal aorta begins at the aortic hiatus of the diaphragm, anterior to the lower border of vertebra T XII. It passes through the abdomen, anterior to the renal bodies, and by the time it ends at the level of L IV it is slightly to the left of midline. Abdominal branches of the abdominal aorta are the common iliac arteries.
Blood Supply of Posterior Abdominal Wall
1) Visceral Branches

**UNPAIRED**

1. Celiac Trunk
2. Superior Mesenteric Artery
3. Inferior Mesenteric Artery

**PAIRED**

1. Middle Suprarenal Artery
2. Renal Artery
3. Testicular or Ovarian Arteries
2) Posterior Branches

ABDOMINAL AORTA AND RIGHT EXTERNAL ILIAC ARTERY

- Celiac trunk (T12)
- Superior mesenteric (L1)
- Inferior mesenteric (L3)
- Bifurcation (L4)
- Inferior epigastric
- Deep circumflex iliac
- Internal iliac
- External iliac
- Superior pubic branch
- Common iliac
- Median sacral
- Gonadal
- Ureteric branches
- Renal
- Suprarenal
- Apical, upper, posterior, middle & lower branches of renal

Relations of aorta:
- Left lateral: sympathetic chain, Right lateral: IVC, Cysterna chyli
- Both lateral: Azygos veins, para-aortic nodes, coeliac ganglia
- Anterior: Pancreas, splenic vein, left renal vein, 3rd part-duodenum, mesentery, nodes, autonomic plexus, lesser sac, stomach, omentum, small bowel
- Posterior: T12-L4, left lumbar veins

Inguinal ligament. Artery passes under it at mid-inguinal point

- Inferior phrenic artery
- Lumbar artery
- Median sacral artery
Anterior branches of the abdominal aorta

- The abdominal aorta has anterior, lateral, and posterior branches as it passes through the abdominal cavity.
The three anterior branches supply the gastrointestinal viscera:

- the **celiac trunk**
- the **superior mesenteric** and
- the **inferior mesenteric arteries**.
The primitive gut tube can be divided into:

A. foregut,
B. midgut, and
C. hindgut regions.

The boundaries of these regions are directly related to the areas of distribution of the three anterior branches of the abdominal aorta.
Divisions of the gastrointestinal tract into foregut, midgut, and hindgut, summarizing the primary arterial supply to each segment.
The foregut

- The foregut begins with the abdominal esophagus and ends just inferior to the
  major duodenal papilla, midway along the descending part of the duodenum.
- It includes the abdominal esophagus, stomach, duodenum (superior to the major
  papilla), liver, pancreas, and gallbladder.
- The spleen also develops in relation to the foregut region. The foregut is supplied
  by the celiac trunk.
Divisions of the gastrointestinal tract into foregut, midgut, and hindgut, summarizing the primary arterial supply to each segment.
The midgut

- The **midgut** begins just inferior to the major duodenal papilla, in the descending part of the duodenum, and ends at the junction between the proximal two-thirds and distal one-third of the transverse colon.

- It includes the duodenum (inferior to the major duodenal papilla), jejunum, ileum, cecum, appendix, ascending colon, and the right two-thirds of the transverse colon.

- The midgut is supplied by the superior mesenteric artery.
Divisions of the gastrointestinal tract into foregut, midgut, and hindgut, summarizing the primary arterial supply to each segment.
The hindgut

- The **hindgut** begins just before the left colic flexure (the junction between the proximal two-thirds and distal one-third of the transverse colon) and ends midway through the anal canal.

- It includes the left one-third of the transverse colon, descending colon, sigmoid colon, rectum, and upper part of the anal canal.

- The hindgut is supplied by the inferior mesenteric artery.
Celiac trunk

□ The celiac trunk is the anterior branch of the abdominal aorta supplying the foregut.
□ It arises from the abdominal aorta immediately below the aortic hiatus of the diaphragm, anterior to the upper part of vertebra L1.
□ It immediately divides into the:
  A. left gastric,
  B. splenic, and
  C. common hepatic arteries.
Radiological vascular anatomy of the vascular anatomy of the abdomen.

Celiac axis (trunk, artery)

a. First unpaired branch off abdominal aorta (~ L-1).
b. Originates from ventral surface.
c. Gives rise to splenic, common hepatic, & left gastric arteries.
Figure 1. Sagittal 3D multi-detector row CT scan demonstrates the normal anatomy of the celiac axis (thick solid arrow) and SMA (curved arrow). The SMA courses over the left renal vein (open arrow). The origin of the left renal artery is also visualized (thin solid arrow).
Superior Mesenteric Artery

a. Second, unpaired branch of abdominal aorta.
b. Originates ~ lower L-1 body.
c. 1 – 2 cm below celiac axis.
d. Supplies small intestines, pancreas, omentum, ascending and transverse colon.
a. Second unpaired branch  
b. Arises 1 – 2 cm below celiac artery  
c. May have common origin  
d. After ~6”,  
   1. courses parallel to aorta  
   2. then turns oblique toward right iliac fossa  
      Numerous branches that sometimes anastomose  

e. Supplies:  
   1. small intestines  
   2. cecum  
   3. appendix  
   4. ascending & transverse colon.  
   5. pancreas
Coronal maximum intensity projection of the superior mesenteric artery and its branches. This image was created on a workstation with CT data from a state-of-the-art 16-slice multidetector CT scanner. Note the fine detail that is visible of the end-organ arteries of the jejunum and ileum.
Inferior Mesenteric Artery

a. Arises just above the bifurcation of the aorta (~L-3/4)
b. Last unpaired branch of aorta
c. Supplies jejunum, descending and sigmoid colon, rectum
Distribution of the Superior and Inferior Mesenteric Arteries

- Transverse colon
- Celiac trunk
- Superior mesenteric artery
- Intestinal arteries (cut) to jejunum and ileum
- Left colic artery
- Inferior mesenteric artery
- Aorta
- Descending colon
- Sigmoidal arteries
- Left common iliac artery
- Superior rectal artery
- Sigmoid colon
- Rectum
- Middle colic artery
- Right colic artery
- Ileocolic artery
- Ascending colon
- Ileum
- Cecum
- Appendix
Figure 12. (a) Sagittal 3D multi-detector row CT scan demonstrates the normal anatomy of the IMA (arrows). On axial scans, it is very difficult to follow the course of the IMA. With 3D CT angiography, however, the vessel can be seen in its entirety as it enters the pelvis and branches into the superior hemorrhoidal arteries. (b) Coronal 3D multi-detector row CT scan demonstrates the normal branching pattern of the IMA (arrows).
Renal arteries

The **renal arteries** normally arise off the side of the **abdominal aorta**, immediately below the **superior mesenteric artery**, and supply the **kidneys** with **blood**. Each is directed across the **crus of the diaphragm**, so as to form nearly a right angle with the aorta.

Due to the position of the **aorta**, the **inferior vena cava**, and the kidneys in the body, the right renal artery is normally longer than the left renal artery.

The right passes behind the **inferior vena cava**, the right **renal vein**, the **head of the pancreas**, and the descending part of the **duodenum**.

The right is somewhat lower than the left; it lies behind the left renal vein, the **body of the pancreas** and the **splenic vein**, and is crossed
- Middle suprarenal vein

The **middle suprarenal arteries** (middle capsular arteries; suprarenal arteries) are two small vessels which arise, one from either side of the **abdominal aorta**, opposite the **superior mesenteric artery**.

- They pass laterally and slightly upward, over the **crura** of the **diaphragm**, to the **suprarenal glands**, where they anastomose with suprarenal branches of the **inferior phrenic and renal arteries**.
- Gonadal arteries
  - *gonadal artery* is a generic term for a paired *artery*, with one arising from the *abdominal aorta* for each *gonad*
- Lumbar arteries
- *lumbar arteries* are *arteries* located in the *lumbar region*. The lumbar arteries are in parallel with the *intercostals*.
- They are usually four in number on either side, and arise from the back of the *aorta*, opposite the bodies of the upper four *lumbar vertebrae*
INFERIOR PHRENIC ARTERY

The inferior phrenic arteries are two small vessels, which supply the diaphragm but present much variety in their origin.

They may arise separately from the front of the aorta, immediately above the celiac artery, or by a common trunk, which may spring either from the aorta or from the celiac artery. Sometimes one is derived from the aorta, and the other from one of the renal arteries; they rarely arise as separate vessels from the aorta.
- **median sacral artery** (or **middle sacral artery**) is a small vessel that arises posterior to the abdominal **aorta** and superior to its bifurcation.

- It descends in the middle line in front of the fourth and fifth **lumbar vertebrae**, the **sacrum** and **coccyx**, ending in the **glomus coccygeum** (coccygeal gland).
COMMON ILIAC ARTERY

- The abdominal aorta terminates at the level of L4 by dividing into the two common iliac arteries
Renal arteries

a. First major paired branches from aorta.

b. Arise opposite each other 1-2 cm below SMA (L-2).

c. Multiple renal arteries occur in 20% of patients.
5. Renal Arteries/Veins:
   a. First major paired branch of abdominal aorta
   b. Arise ~L-2
   c. more later
Renal Arteries.

- Hiatus (opening) for inferior vena cava
- Hiatus (opening) for esophagus
- Adrenal (suprarenal) gland
- Celiac trunk
- Kidney
- Abdominal aorta
- Lumbar arteries
- Ureter
- Diaphragm
- Inferior phrenic artery
- Middle suprarenal artery
- Renal artery
- Superior mesenteric artery
- Gonadal (testicular or ovarian) artery
- Inferior mesenteric artery
- Common iliac artery
- Median sacral artery
Normal renal arteries. Axial MIP image, obtained to evaluate for renal artery stenosis, clearly shows the renal arteries (arrows), which are normal and demonstrate no evidence of stenosis.
MIP of the renal arteries.
Volume Rendering images demonstrate the normal anatomy of renal arteries (arrows). The renal arteries typically arise from the aorta at the level of L1, L2 intervertebral disc below the origin of the superior mesenteric artery (arrowhead).
Major branches of the abdominal aorta.
Inferior Vena Cava

a. Formed at ~ L-5
b. by union of Common Iliac Veins
c. Largest vein in body
d. Dilation may be due to:
   1. right-sided CHF
   2. Portal hypertension
Blood Vessels.

Abdominal Aorta
- Visceral branches
- Posterior branches
- Terminal Branches

Inferior Vena Cava
- Common iliac veins
- Lumbar veins
- Right testicular or ovarian vein
- Renal veins
- Right suprarenal vein
- Inferior phrenic veins
- Hepatic veins
Major Veins of the Abdomen.

- Hepatic veins
- Inferior vena cava
- Right suprarenal vein
- Renal veins
- Left suprarenal vein
- Left ascending lumbar vein
- Lumbar veins
- Left gonadal vein
- Common iliac vein
- External iliac vein
- Internal iliac vein
Veins of Portal Circulation

a. SMV: joins with splenic vein.
1. runs parallel to SMA.
2. On right side of abdomen.
b. IMV: terminates in splenic vein.
c. Portal Vein: enters liver.
Veins of the Hepatic Portal System.

- Hepatic veins
- Liver
- Hepatic portal vein
- Spleen
- Gastric veins
- Inferior vena cava
- Splenic vein
- Right gastroepiploic vein
- Inferior mesenteric vein
- Superior mesenteric vein
- Small intestine
- Large intestine
- Rectum
d. Renal Veins – run parallel to renal arteries
6. IVC: arises ~L-5

a. lies to right of lumbar vertebrae

b. Largest vein

c. Occupies a fossa on posterior surface of liver

d. Receives hepatic veins
A porto-systemic anastomosis is a connection between the veins of the portal venous system, and the veins of the systemic venous system. The major sites of these anastomoses include:

1. Oesophageal – Between the oesophageal branch of the left gastric vein and the oesophageal tributaries to the azygous system.
2. Rectal – Between the superior rectal vein and the inferior rectal veins.
3. Retroperitoneal – Between the portal tributaries of the mesenteric veins and the retroperitoneal veins.
4. Paraumbilical – Between the portal veins of the liver and the veins of the anterior abdominal wall.
Imaging anatomy of peritoneum
Peritoneum

- The peritoneum is a thin, translucent, serous membrane and is the largest and most complexly arranged serous membrane in the body.

- The peritoneum that lines the abdominal wall is called the parietal peritoneum.

- Whereas the peritoneum that covers a viscus or an organ is called a visceral peritoneum.
Both types of peritoneum consist of a single layer of simple low-cuboidal epithelium called a mesothelium

A capillary film of serous fluid (approximately 50-100 mL) separates the parietal and visceral layers of peritoneum from one another and lubricates the peritoneal surfaces
Peritoneal cavity

- The peritoneal cavity is a potential space between the parietal peritoneum, which lines the abdominal wall, and the visceral peritoneum, which envelopes the abdominal organs.

- In men, the peritoneal cavity is closed, but in women, it communicates with the extraperitoneal pelvis exteriorly through the fallopian tubes.
Normal Peritoneal Anatomy

- The peritoneal spaces are potential spaces that are not normally visualized unless they are distended with fluid or the fascia is thick.

- Folds of peritoneum, called *ligaments*, connect and provide support for structures within this cavity.

- Knowledge of the anatomic spaces is critical for the diagnosis, staging, and treatment of fluid collections by either surgical or radiologic methods.
Various imaging modalities

Plain radiography has been superseded by crosssectional imaging techniques and the peritoneal cavity is visualized only via contrast herniography.

US

Ultrasound is widely used to detect intraperitoneal collections, but is limited by bowel gas and body habitus.
Fig. 9.1 Plain abdominal radiograph - the anterior abdominal wall and peritoneal cavity cannot be assessed.
CT/MRI

Contrast-enhanced CT (with or without oral contrast medium) is the method of choice to evaluate the peritoneal spaces, reflections and their contents.

MRI provides good visualization of the peritoneal spaces and reflections; however, bowel peristalsis and respiratory movement can degrade the images.
Peritoneal spaces

The two main peritoneal compartments are separated by the transverse mesocolon.

Supramesocolic compartment

Divided arbitrarily into right and left supramesocolic peritoneal spaces, which can be further subdivided into a number of subspaces that are in communication.
- Right supramesocolic space

Three subspaces
- Right subphrenic space
  extends over the diaphragmatic surface of the right lobe of the liver to the right coronary ligament
  posteroinferiorly and the falciform ligament medially (which separates it from the left subphrenic space)
- Right subhepatic space
Anterior right subhepatic space is limited inferiorly by the transverse colon and its mesentery
Posterior right subhepatic space (hepatorenal fossa or Morison’s pouch)

Extends posteriorly to the peritoneum overlying the right kidney

Bounded superiorly by the inferior surface of the right lobe of the liver

Communicates freely with the right subphrenic space and the right paracolic gutter
Peritoneal spaces

Morison pouch (subhepatic or hepatorenal space),
Coronal reconstruction (anterior to posterior)

1. liver
2. body of stomach.
3. transverse colon.
Coronal image of the anterior abdomen in a patient with dilute contrast material injected into the Peritoneum

The right subphrenic space (RSP) extends from the falciform ligament (F) laterally between the abdominal wall and the liver.

This space then communicates with the right pericolic space (RC) and the right subhepatic space (RS).

The left subphrenic space (LSP) communicates with the left subhepatic space (Ish).
- **Lesser sac**
  - Posterior to the lesser omentum, stomach, duodenal bulb and gastrocolic ligament; anterior to the pancreas

  - Communicates with the rest of the peritoneal cavity through the epiploic foramen (of Winslow), which lies between the inferior vena cava and the free margin of the hepatoduodenal ligament

  - Lesser sac divided into two recesses by the pancreatico gastric fold (peritoneal fold over the left gastric artery):
Lesser sac
Lesser sac
Smaller superior recess completely encloses the caudate lobe of the liver and lies posterior to the portal vein at the porta hepatis. Superiorly, it extends deep into the fissure for the ligamentum venosum and posteriorly lies adjacent to the right diaphragmatic crus.

Larger inferior recess lies between the stomach and the pancreas; it is bounded inferiorly by the transverse colon and its mesentery, but can extend for a variable distance with in the greater omentum; to the left it is bounded by the gastroepiploic and splenorenal ligaments.
The anatomic boundaries of the lesser sac are noted. The sac (L) is anterior to the pancreas (P) and extends posteriorly behind the stomach (ST) as the splenic recess (SR).

The margin of the foramen of Winslow (w) contains the portal vein, the hepatic artery, and the common bile duct.
This level demonstrates the attachment of the coronary ligaments of the right lobe of the liver (straight arrows).

The recesses of the lesser sac, the superior recess (S) adjacent to the vena cava (v), and the splenic recess (SP) behind the stomach are seen.
Left supramesocolic space

- Four arbitrary subspaces, which are in communication with each other in normal individuals:

  Anterior left perihepatic space
  - Bounded medially by the falciform ligament, posteriorly by the liver surface and left coronary ligament, and anteriorly by the diaphragm
  - Communicates superiorly and to the left with the left anterior subphrenic space, and inferiorly with the greater peritoneal cavity over the surface of the transverse mesocolon
Posterior left perihepatic space (gastrohepatic recess):

- Surrounds the lateral segment of the left hepatic lobe extending into the fissure for the ligamentum venosum on the right anterior to the main portal vein
- Posteriorly, the lesser omentum separates this space from the superior recess of the lesser sac. Bounded on the left by the lesser curvature of the stomach
- Communicates anteroinferiorly with the anterior left perihepatic space
- **Anterior left subphrenic space**
  - This lies between the stomach and the left hemidiaphragm
  - Communicates on the right with the left anterior perihepatic space, and posteriorly with the posterior subphrenic (perisplenic) space

- **Posterior left subphrenic (perisplenic) space**
  - Superior to gastric fundus and spleen
  - Covers the superior and inferolateral surfaces of the spleen
• Limited inferiorly by the splenorenal and phrenicocolic ligaments, and more superiorly by the gastrosplenic ligament

• Partially separated from the rest of the peritoneal cavity by the phrenicocolic ligament which extends from the splenic flexure to the diaphragm
Sagittal image close to midline. The liver (LL) and adjacent structures are seen, including the anterior left subphrenic space (alsp), the superior recess of the lesser sac (*small angled arrow*), and the “bare area” of the liver (*horizontal arrow*).
Inframesocolic compartment
- Divided into two unequal spaces posteriorly by the root of the small bowel mesentery

Right inframesocolic space
- Bounded by the transverse mesocolon superiorly and to right, and by the root of the small bowel mesentery inferiorly and to left

Left inframesocolic space
- In free communication with the pelvis to the right of the midline
- Sigmoid mesocolon forms a partial barrier to the left of the midline
Paracolic gutters

- Peritoneal recesses on the posterior abdominal wall lateral to the ascending and descending colon

- **Right paracolic gutter**: continuous superiorly with the right subhepatic and subphrenic spaces; larger than the left

- **Left paracolic gutter**: partially separated from the left subphrenic spaces by the phrenicocolic ligament.

- Both paracolic spaces are in continuity with the pelvic peritoneal spaces.
Paracolic gutters

RIGHT PARACOLIC GUTTERS
LEFT PARACOLIC GUTTERS

The paracolic gutters (paracolic recesses) are spaces between the colon and the abdominal wall. These gutters are clinically important because they allow a passage for infectious fluids from different compartments of the abdomen. For example, fluid from an infected appendix can track up the right paracolic gutter to the hepatorenal recess.

LATERAL PELVIC RECESS
Pelvic peritoneal spaces

- Inferiorly the peritoneum is reflected over the dome of the bladder, the anterior and posterior surface of the uterus and upper posterior vagina in females, and on to the front of the rectum at the junction of its middle and lower thirds.

- The urinary bladder subdivides the pelvis into right and left paravesical spaces.
In men, there is only one potential space for fluid collection posterior to the bladder, the rectovesical pouch.

In women there are two potential spaces: posterior to the bladder, the uterovesical pouch and, posterior to the uterus, the deeper rectouterine pouch (of Douglas).

The layers of peritoneum on the anterior and posterior surfaces of the uterus are reflected laterally to the pelvic side walls as the broad ligaments, containing the fallopian tubes.
**peritoneal reflections**

- **Terminology**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Peritoneal ligament</td>
<td>Formed by two folds of peritoneum that enclose and support structures within the peritoneal cavity. Named according to the structures it joins.</td>
</tr>
<tr>
<td>Omentum</td>
<td>Peritoneal ligament that joins the stomach to another structure.</td>
</tr>
<tr>
<td>Mesentery</td>
<td>Two folds of peritoneum that attach a loop of bowel to the retroperitoneum.</td>
</tr>
</tbody>
</table>
Peritoneal ligaments

1. Right coronary ligament
   - Formed by the reflection of the peritoneum from the diaphragm to the posterior surface of the right lobe of the liver
   - The triangular area of liver enclosed by these layers is the bare area devoid of peritoneal covering and is continuous with the anterior pararenal space

2. Left coronary ligament (left triangular ligament):
   - Fimsy structure formed by apposition of the peritoneal reflections between the left lobe of liver and diaphragm
   - Little clinical significance
3. Gastroplenic ligament
- Extends from the greater curve of the stomach to the spleen
- Continuous with the greater omentum
- Contains the left gastroepiploic and short gastric vessels

4. Falciform ligament
- Extends from the anterosuperior surface of the liver to the diaphragm and anterior abdominal wall, carrying the ligamentum teres (obliterated left umbilical vein) in its free edge, in continuity with the fissure for the ligamentum venosum and coronary ligaments
Fig. 7.6 Abdominal cavity CT. Same patient of Fig. 7.4. The *arrow* shows the falciform ligament separating the left subphrenic space (*star*) from the right one (*double star*)
The falciform ligament is the remnant of the most ventral part of the ventral mesentery and contains the obliterated umbilical vein. It is a relative (incomplete) barrier to the transfer of fluid from the right subphrenic space to the left subphrenic space.
Omenta

1. Greater omentum (gastrocolic ligament)
   - Largest peritoneal fold consisting of a double sheet folded on itself (i.e. made up of four layers)
   - Two layers of peritoneum descend from the greater curve of the stomach and proximal duodenum passing inferiorly, anterior to the small bowel for a variable distance, and then turn superiorly again to insert into the anterosuperior aspect of the transverse colon
• The left border is continuous with the gastroplenic ligament

• The right border extends to the origin of the duodenum

• Contains adipose tissue which is easily identified on CT anterior to the transverse colon superiorly and loops of small bowel inferiorly
FIGURE 7.10 Anterior view of mesentry and peritoneal ligaments.
2. Lesser omentum (gastrohepatic ligament)

- Extends from the lesser curvature of the stomach and proximal 2 cm of the duodenum to the liver (attached to the fissures for the porta hepatis and ligamentum venosum)

- Forms the anterior surface of the lesser sac

- The free edge forms the hepatoduodenal ligament
Figure 37-10 Lesser omentum. Axial CT scan shows the lesser omentum (black arrows) as a thin line in the fissure for the ligamentum venosum extending from the lesser curvature of the stomach to the umbilical portion of the left portal vein (white arrow).
- Generally wedge-shaped and contains adipose tissue, the gastric artery, the coronary vein, and the left gastric nodal chain

- Identified on cross-sectional imaging by finding the fissure for the ligamentum venosum immediately inferior to the gastro-oesophageal junction
The peritoneum is continuous in the male pelvis. In women the peritoneum is discontinuous at the ostia of the oviducts. Through this opening disease can spread from the extraperitoneal pelvis into the peritoneal cavity. For example, pelvic inflammatory disease (PID).
The **pelvic peritoneal space** is the inferior reflection of the **peritoneum** over the fundus of the **urinary bladder** and the front of the **rectum** at the junction of its middle and lower thirds. In females, the reflection is also over the anterior and posterior surface of the **uterus** and in males there is only one potential space for fluid collection posterior to the **rectovesical pouch**.

In females there are two potential spaces posterior to the bladder, the **uterovesical pouch**, and posterior to the uterus the deeper **rectouterine pouch** (pouch of Douglas).

The layers of peritoneum on the anterior and posterior surfaces of the uterus are reflected laterally to the pelvic side walls as the **broad ligaments**, containing the **fallopian tubes**.
Pelvic peritoneal space

- Peritoneal cavity
- Rectouterine pouch
- Vesicouterine pouch
- Uterus
- Rectum
- Bladder (B)
- Pocket of Douglas (POD)
- Vagina
The **retroperitoneum** is the part of the **abdominal cavity** that lies between the posterior **parietal peritoneum** and anterior to the transversalis **fascia**.

It is divided into three spaces by the **perirenal fascia** and is best visualised using CT or MRI. The three spaces are: **anterior pararenal space**, **perirenal space**, and **posterior pararenal space**.

A fourth space, the **great vessel space**, is defined in the recent literature.
Retroperitoneal Spaces

**Figure 1.** Drawing of the anatomy of the retroperitoneal spaces at the level of the kidneys. The anterior pararenal space (APRS) is located between the parietal peritoneum (PP) and the anterior renal fascia (ARF) and contains the pancreas (Pan), the ascending colon (AC), and the descending colon (DC). The posterior pararenal space (PPRS) is located between the posterior renal fascia (PRF) and the transversalis fascia (TF). The perirenal space (PRS) is located between the anterior renal fascia and the posterior renal fascia.
Retroperitoneal Spaces
**Retroperitoneal organs**

S = Suprarenal (adrenal) Glands  
A = Aorta/IVC  
D = Duodenum (except the duodenal cap- first 2 cm)  
P = Pancreas (except the tail)  
U = Ureters  
C = Colon (ascending and descending parts)  
K = Kidneys
Cross Sectional Anatomy of the Abdomen
Anatomy

- Abdominal cavity
  - Borders
    - Diaphragm superiorly
    - Pelvis inferiorly
    - Spine posteriorly
    - Abdominal wall anteriorly
CT cross sectional anatomy.

- Rt Ventricle
- Lt Ventricle
- Rt Atrium
- Lt Atrium
- IVC
- Esophagus
- Aorta
- Azygous


1. Right lung
2. Portal vein
3. Liver
4. Caecum
5. Bladder
6. Sigmoid colon
7. Small bowel
8. Colon
9. Heart
1. Right lung
2. Liver
3. Gallbladder
4. Caecum
5. Bladder
6. Heart
7. Stomach
8. Colon
9. Small bowel
10. Sigmoid colon


1. Heart
2. Liver
3. Rectus abdominis muscle
4. Left lung
5. Stomach
6. Psoas muscle
MRI anatomy images of the abdomen.


1. Liver
2. Portal vein
3. Inferior vena cava
4. Splenic vein
5. Aorta
6. Celiac trunk
7. Body of the pancreas
8. Pancreatic tail
9. Spleen
10. Right adrenal
11. Left adrenal
12. Diaphragm
13. Lung

1. Liver
2. Inferior vena cava
3. Splenic vessels
4. Aorta
5. Superior mesenteric artery
6. Spleen
7. Diaphragm
8. Lung
9. Small bowel
Atlas of MRI Anatomy of the Abdomen. Axial T1-weighted image after gadolinium. Image 17:


1. Left lobe of the liver.
2. Portal vein.
3. Ligamentum venosum.
4. Right lobe of the liver.
5. Abdominal aorta.
7. Crus of diaphragm.
8. Spleen.
10. Left lung.
Hepato-biliary scan.
BILIARY TRACT SCAN
HIDA SCAN.

- RT. LOBE OF LIVER
- GALLBLADDER
- LT. LOBE OF LIVER
- COMMON BILE DUCT
- DUODENAL "C" LOOP
MRA.
What is this contrast containing structure posterior to the liver?

What are these contrast containing structures dumping into the IVC?

The right, middle and left hepatic veins
What anatomically divides the liver into lobes (right and left) and segments.

The hepatic veins. Middle hepatic vein divides the right and left lobes. The right hepatic vein splits the right lobe into anterior and posterior segments. The left hepatic vein divides the left lobe into medial and lateral segments.
What lobe of the liver is marked with the arrow

The caudate lobe
Can you identify the bright structure surrounded by the black arrows?

This is the left portal vein
Can you identify the bright structure marked by the black arrows?

This is the right portal vein.
Can you identify the low attenuating structure marked by the black arrows?

This is the common hepatic duct.

What are the branches of the celiac trunk?

Common hepatic, splenic and left gastric.

What branch of the aorta is marked?

This is the celiac trunk.
This is a sagittal image from a CT angiogram. Can you identify the vessels coming off of the aorta?

Solid arrow--celiac trunk.
Dotted arrow--SMA
This is a CT angiogram of the abdominal vessels.

Can you pick out the celiac trunk?

Can you see the 3 branches: common hepatic, splenic and left gastric?

- Celiac trunk
- Splenic artery
- Common hepatic
- Left gastric
These are 2 sequential coronal images from a CT angiogram showing the pancreatic blood supply.

This is the common hepatic artery off the celiac trunk.

What branch is this extending inferiorly?

Gastroduodenal artery

This artery is anatomizing with which artery coming off the SMA?

Inferior pancreaticoduodenal
What is this fluid and air filled structure between the liver and spleen?

This is the stomach
What portion of the colon do you see anterior to the spleen and next to the stomach?

What part of the pancreas is this?

What part of the pancreas is this?

This is the splenic flexure.

The body

This is the tail and it usually extends further over towards the spleen.
What is this low attenuation structure (black arrows) adjacent to the pancreas (white arrows)?

What is this vein just behind the pancreas?

What venous structure does this join to make up the portal vein?

What are the tiny metallic structures anterior to the common bile duct? Hint: does this person have a gallbladder?

These are clips from a cholecystectomy.

Common bile duct

Splenic vein

The splenic vein joins the superior mesenteric vein to make up the portal vein.
What is the structures anterior and near the superior aspects of the left kidney?

This is the left adrenal gland.
This is an MRI cholangiogram
Can you find the dilated common bile duct?

Do you see the more normal appearing pancreatic duct?
This is an ERCP on a different patient. Can you find the common bile duct?

ERCP=endoscopic retrograde cholangio-pancreaticogram.

Can you find the pancreatic duct?

What is this large structure?

This is the endoscope use to inject the contrast in the common bile duct and the pancreatic duct for the ERCP.
Do you see the SMV on this image?

*Hard question*
What part of the pancreas are these arrows defining?  

Hint, it is the most inferior portion of the pancreas.

What is this small pointed area medial to the head of the pancreas.

What is this high attenuating structure (artery) just anterior to the uncinate process?

This is the pancreatic head.

This is the uncinate process.

Superior mesenteric artery (SMA)
What is this low attenuation structure in the pancreatic head?

This is the intrapancreatic portion of the common bile duct.

What is this tiny low attenuating structure in the pancreas?

Pancreatic duct
What are these 2 vascular structures?

Why is the aorta filled with contrast and the IVC is not?

Hint, do we give our injections in the artery or vein? And do we inject in the upper or lower extremity?

We inject intravenously in the upper extremity (arm), so the blood goes to the SVC to heart to arterial system then to lower extremity venous system.
Do you see this patient’s tumor?

It is very subtle, it is right where the CBD enters the duodenum at the ampulla.

If you picked up that tumor, you have a promising career in radiology!!
What part of the colon is this? It is anterior on a long mesentery. This is the transverse colon.
This is a double contrast BE (barium enema). For this test we put a small amount of contrast in the colon to coat the surface and then distend the colon with air.

Can you identify the sigmoid colon?

What are these small saculations in the sigmoid colon?

These are sigmoid diverticula.
What is the main reason we perform a double contrast BE?

To look for colon cancer.

This an oblique view. The patient is lying on his left side. Do you seen all of the contrast on the dependent side of the colon?

What do we have to do to make sure that there is no polyps or cancers hiding in the dense contrast?

Flip the patient on to his right side. See next slide.
This is a single contrast BE (no air only contrast). Can you see the narrowing in the transverse colon? (Large circle)
Do you know what this is?

This is an adenocarcinoma. This is what is classically described as an apple core lesion.

Do you see the resemblance?
This is the preliminary image from an abdominal CT. Can you see the contrast filling the colon?
The image on the right shows the level at which the axial CT slice was taken.

What is this high attenuation structure in the liver?

This is the left portal vein. Do the portal veins divide the liver into segments?

No, the hepatic veins do.
What is this black line that runs through the liver?

This is the fissure for the ligamentum teres. What structure ran through this region?

The umbilical vein

What is this fissure anterior to the caudate lobe?

This is the fissure for the ligamentum venosum
What part of the colon is this?

This is the distal transverse extending to the splenic flexure.

Why does the colon look white?

The patient was given oral contrast.
What portion of the pancreas is this?

This is the tail
What portion of the colon is this?

Hepatic flexure
What is this venous structure extending from the left kidney to the IVC?

This is the left renal vein
What portion of the colon is labeled by this arrows?

Ascending colon

Descending colon
What is this vessel coming of the aorta?

Hint, it is colonic supply and below the level of the SMA.

Inferior mesenteric artery
Look at the small bowel without contrast (white arrows) and the colon (black arrows) with contrast and note that the bowel wall is extremely thin. Normally approximately 3 mm.
What is this small tubular structure partially filled with contrast on this and the subsequent image. (see next slide for answer)
This is the appendix. Note this is normal; thin walled, filled with contrast and no inflammatory changes in the adjacent fat.
What portion of the colon is labeled with arrows?

Sigmoid colon
What vascular structures are marked by the arrows?

The external iliac arteries and veins
What is this fluid filled structure?

The bladder

What portion of bowel is this located posterior to the bladder and anterior to the sacrum?

The rectum

What is the significance of the space between the bladder and the sacrum?

This is the most dependent portion of the peritoneal cavity in a male.
This is the first of sequential, coronal images illustrating branches of the SMA.

This is aorta (black arrows) and proximal SMA (white arrows)
Which branch off the SMA is marked with the black arrow? Hint, it comes off anteriorly.

Middle colic artery

Which branch is this?

ileocolic
Which branch is this? (kind of subtle in this patient)
Right colic artery
Which vessel is this coming off the aorta?
IMA
This is a 3D image showing the branches of the SMA.
This is a clip from a virtual colonoscopy. This is reconstructed data from a CT scan. The holes at the bottom of the image are diverticula.
This is another image from reconstructed data from a CT scan. Do you see the cancer. Hint, remember the apple core.
Conclusions

- The primary imaging modalities for the abdomen and pelvis are plain film, ultrasound, and CT.
- Basic anatomic knowledge can improve the diagnostic value of the radiological imaging.
- Correct use of anatomic terms facilitates communication with referring clinicians.
- Choice of modality depends upon clinical symptoms, patient age & gender, and findings on physical exam.
- Mastery of the anatomy within each quadrant can help explain particular symptoms, clinical presentations, and/or imaging findings.
subjects

- Introduction
- Pelvic girdle
- Pelvic cavity
  - pelvic inlet
  - pelvic walls
  - pelvic outlet
- Perineal membrane and deep perineal pouch
Introduction

- The **pelvic cavity** is a continuation of the abdominal cavity into the pelvis through the pelvic inlet.
- The **perineal region** refers to the area of the trunk between the thighs and the buttocks, extending from the pubis to the coccyx.
- The perineum is a shallow compartment lying deep to this area and inferior to the pelvic diaphragm.
Pelvic inlet

* It is the superior boundary of pelvic cavity.
Pelvic inlet

- Pelvic inlet
- Sacro-iliac joint
- Anterior superior iliac spine
- Coccyx
- Obturator foramen
- Ischiopubic ramus
- Pubic symphysis
- Ischial spine
- Pubic tubercle
- Ischiopubic ramus
- Alae of sacrum
- SI body
Pelvic outlet

* The pelvic outlet (inferior pelvic aperture)
Pelvic girdle

- Ring bones that connect the vertebral column to the lower limbs ...

- Composed of
  1. Hip bones
  2. Sacrum
  3. Coccyx
Shape of pelvic inlet

- In male, it is heart shaped.

* In female, it is oval or rounded.
Greater & lesser pelvises

The greater pelvis (1) is
Superior to the pelvic inlet
Bounded by the abdominal wall anteriorly, the ala of ilium laterally, and the L5 and S1 vertebrae posteriorly
The location of some abdominal viscera, such as the sigmoid colon and some loops of ileum

The lesser pelvis (2) is
Between the pelvic inlet and the pelvic outlet
The location of the pelvic viscera—urinary bladder and reproductive organs, such as the uterus and ovaries
Bounded by the pelvic surfaces of the hip bones, sacrum, and coccyx
Limited inferiorly by the muscular membranous diaphragm (levator ani)
1- sacro-iliac J.
2- pubic symphysis
3- lumbosacral J.
4- sacro-coccygeal j.
True pelvis

True pelvis is cylindrical and lies between the pelvic inlet & outlet ...

Pelvic inlet is open while the pelvic outlet is closed by the pelvis floor ..

• Pelvis has >Inlet
  >Outlet ( floor )
  > walls

□ Notice the orientation pelvic cavity ... of
Pelvic walls

* The walls of the pelvic cavity consist of

1. the sacrum
2. The coccyx
3. the pelvic bones inferior to the linea terminalis
4. Two ligaments (sacrotuberous and sacrospinous)
5. two muscles (piriformis & obturator internus)
Pelvic outlet

* The pelvic outlet is diamond shaped, with the anterior part of the diamond defined predominantly by bone and the posterior part mainly by ligaments. Terminal parts of the urinary and gastrointestinal tracts and the vagina pass through the pelvic outlet.
Pelvic floor

* Separates the pelvic cavity from the perineum,

* It is composed of

* 1- pelvic diaphragm
* 2- perineal membrane (in anterior midline)
* 3- muscles in deep perineal pouch
Pelvic diaphragm
*
Bowel-like muscular structure of pelvic floor..
*
It is composed of:

1. Levator ani muscle

2. Coccygeus muscle
Perineal membrane

* triangular structure attached to the bony framework of the pubic arch.

- This membrane is related above to a pouch called deep perineal pouch.
Muscles of deep perineal pouch

** compressor urethrae in female arise from ischiopubic ranus...**
Perineal body

* Connective tissue structure.

* Located at the posterior margin of perineal membrane

* It is an important structure for attachment of perineal & pelvic floor muscles.

* Posterior margin of urogenital hiatus is attached to it.

* Muscles attached to it:

1. The deep transverse perineal muscles
2. the sphincter urethrovaginalis
3. the external anal sphincter
4. the superficial transverse perineal muscles.
5. the bulbospongiosus muscles of the perineum.
EVALUATION OF PELVIC FLOOR
PELVIC FLOOR

1. ANTERIOR COMPARTMENT:
   Bladder & Urethra

2. MIDDLE COMPARTMENT:
   Vagina, Cervix & Uterus

3. POSTERIOR COMPARTMENT:
   Rectum
The support for these structures arises from the attachment of the muscles, fascia, and ligaments to the bony pelvis.

These are the primary supporting structures of the female pelvis.
The **pubo-rectalis** forms a sling around the rectum and plays an important role in apposing the orifices of the pelvic floor as well as elevating the bladder neck and compressing it against the pubic symphysis.
IMAGING OF PELVIC FLOOR

Traditional imaging methods in assessment of pelvic floor weakness include,

a. Urodynamics
b. Voiding cysto-urethrography
c. Ultrasonography of the bladder neck and anal sphincter
d. Fluoroscopic cysto-colpo-defecography.
e. MRI
MRI

- MRI is routinely used in **preoperative planning** before pelvic floor surgery.
- It allows concomitant visualization of all three compartments of the pelvic floor and at the same time allows direct visualization of the pelvic support muscles and organs.
T2W AXIAL SHORT FIELD OF VIEW
The ileococcygeus and the pubococcygeus muscles (white arrows) are seen in the coronal plane, closely aligning with puborectal muscle fibers of the anal sphincter (black arrowheads), and having a horizontal orientation.
Posteriorly, the fibres fuse anterior to the coccyx to form a midline structure (arrow), the levator plate, seen in the (b) coronal and (c) sagittal planes. The perineal body (*) is located between the vaginal introitus and anal canal.
Axial view shows the puborectalis muscle (white arrowheads) arising from the body of the pubic bone and forming a sling around the rectum, aligning with the external anal sphincter.
3D volume ultrasound adds not one, but several, dimensions to pelvic floor imaging. The technology opens up entirely new possibilities for observing functional anatomy and examining muscular and fascial structures of the pelvic floor.
Ultrasound imaging of the pelvic floor. Part I: two-dimensional aspects
Ultrasound imaging of the pelvic floor. Part II: three-dimensional or volume imaging
Sigmoid colon, anal canal & rectum
**Ascending colon**
- ~13 cm long
- Peritoneum coverage: front & sides
- Adhered to abd wall

**Transverse colon**
- ~About 38 cm long (suspended by the transverse mesocolon from the pancreas - mobile)

**Caecum**
- A blind-ended pouch situated in the RIF
- Rest on iliacus muscle.
- ~6 cm long
- Completely covered with peritoneum.
- No mesentery but quite mobile
- Teniae coli converge on the base of the appendix.

**Descending colon**
- ~About 25 cm long
- Smaller diameter than asc.
- Peritoneum coverage: the front and the sides
- Adhered to abd wall

**Sigmoid colon**
- ~25 – 38 cm long
- Continuous with the rectum in front of S3
- Extremely mobile
- Attached to the posterior pelvic wall by the fan-shaped sigmoid mesocolon.
RADIOLOGICAL INVESTIGATIONS

- **PLAIN FILMS:** (ERECT/SUPINE)

1. Intraluminal Colonic gas is normal

2. Close temporal proximity to either sigmoidoscopy or colonoscopy may cause excessive colonic gas – should not be mistaken for a pathology.
• BARIUM ENEMA

1. Gold standard technique for imaging fine mucosal detail.

2. Scrupulous colon cleansing is mandatory for high quality studies.

3. Barium suspensions are contra indicated if there is a risk of colonic perforation.

4. A series of films are taken to image the entire colon in double contrast.
1. Images rectal configuration during evacuation of a barium paste.
2. The subject is seated upright on a specifically designed radio opaque commode.
3. Used to investigate difficult rectal evacuation.
4. May be modified by the addition of bladder, vaginal and small bowel contrast – the entire pelvic floor.
• COLONIC TRANSIT STUDIES
  1. Used to investigate severely constipated patients
  2. Measurement of whole gut transit time using radio opaque markers
  3. Ingested and followed by an abdominal film after an appropriate interval

• RECTAL ULTRASOUND
  1. Uses a 360° rotating endoprobe
  2. Obtains high resolution axial images of the rectal wall
  3. Primarily used to stage tumours

• ANAL ENDOSONOGRAPHY
  1. Modified rectal endoprobe to image the anal sphincters in patients who are anally incontinent
X-ray abdomen, supine view shows a **HUGELY DILATED LOOP** arising from the pelvis with the "**COFFEE-BEAN**" **SIGN** in a case of **SIGMOID VOLVULUS**
CT COLONOGRAPHY OF A LARGE SIGMOID POLYP WITH HOMOGENEOUS ATTENUATION
BARIUM ENEMA- SEVERE SIGMOID DIVERTICULAR DISEASE WITH A COMPLICATING FISTULA TO THE VAGINA.
THE RECTUM

• The rectum is the last segment of the gastrointestinal tract and is bounded by the sigmoid colon and the anus.
• The proximal portion located within the peritoneal cavity and the distal portion being extraperitoneal.
• The inferior aspect of the rectum, or the anorectal junction, is defined anatomically by the dentate line, which spans 5–10 mm of the anal canal and marks the transitional zone.
Rectum

- Terminal part of large intestine before anal canal
- Cardinal features of large intestine – absent
- Length – 12 cm
- Diameter – upper part 4 cm, lower part dilated as rectal ampulla
- Curved in both sagittal and coronal planes
- Function – temporary storage of fecal matter; distension causes desire to defecate
ANATOMY OF THE RECTUM

- **Arterial supply:**
  - Superior rectal artery: branch of the inferior mesenteric artery.
  - Middle rectal artery: branch of internal iliac artery.
  - Inferior rectal artery: branch of the pudendal artery.

- **Venous drainage:**
  - Internal rectal plexus lies in the submucosa, draining to the superior rectal v. which is a tributary of the inferior mesenteric v. (portal circulation).
  - External rectal plexus: lies outside the external muscle coat, drain to the middle rectal v., a branch of the internal iliac v. (systemic circulation).
Blood supply

- Superior rectal artery
- Internal iliac artery
- Middle rectal artery
- Internal pudendal artery
- Levator ani
- Inferior rectal artery
Applied anatomy

RECTUM: DOUBLE CONTRAST STUDY

- Sacral promontory
- Sacrum
- Presacral (retrorectal) space
- Rectum (inflated)
- L5 - S1 disc space
- Contrast medium in sigmoid colon
- Acetabular margin (surrounding head of femur)
Fig. S3 Normal MR appearance of the rectum in a male on a sagittal T2w TSE image. S: Sacral fracture (1) anorectal structure (2); anal canal (3); rectum (4); urinary bladder (5); prostate (6)
Fig. 6.3 Normal appearance on axial T2w TSE image. Note good delineation of the intersosseous (*) and rectovaginal fascia (arrowheads). Stool is present in the rectum (arrow).

Fig. 6.4a, b: Normal anatomy: a) Coronal TSE image. b) Axial DD TSE image. Curved arrows indicate the intersosseous fascia, open arrows the para-anal space, and straight arrows the subcutaneous space. The coronal image (a) clearly depicts the levator ani muscle on both sides (arrowheads).
Figure 1 Standard transperineal ultrasound images. A: Midsagittal View; B: Upper anal canal in the transversal view; C: Transversal view of the middle anal canal. SP: Symphysis pubis; U: Urethra; B: Bladder; V: Vagina; UT: Uterus; R: Rectum; A: Anal canal; PR: Puborectalis muscle; IAS: Internal anal sphincter; EAS: External anal sphincter.

In patients with perianal fistulas, the probe is placed in the external orifice to follow the fistula to the internal orifice. Cannulation and instillation with hydrogen peroxide will improve the assessment.

Compartment evaluation

There are different possibilities on image orientation, and in the literature several options were
ANAL CANAL

- **Anatomy of the anal canal:**
  - **Length:** 4 cm in adults.
    - It passes downwards and backwards.
    - Its anterior wall is shorter than the posterior wall.
  - **Divisions:**
    - Upper 2/3 derived from the endoderm.
    - Lower 1/3 derived from ectoderm.
  - **This account for the division of:**
    - Mucous membrane lining.
    - Blood supply.
    - Lymphatic drainage.
Fig. 3C — Sonography of normal anal canal in three patients. A and B are transanal scans obtained with biplane 9-MHz transducer. C and D were obtained on curved transducer, and E and F were obtained at anorectal junction with traditional end-fired transvaginal probe. Axial image of healthy 40-year-old woman shows prominent hypoechoic ring of internal anal sphincter (IS).

Fig. 3D — Sonography of normal anal canal in three patients. A and B are transanal scans obtained with biplane 9-MHz transducer. C and D were obtained on curved transducer, and E and F were obtained at anorectal junction with traditional end-fired transvaginal probe. Rotating transducer by 90° from position in C shows anal sphincter in longitudinal view. Anal verge is on right and anorectal junction (arrow) on left of image. Internal anal sphincter (IS) appears as two longitudinal substantial hypoechoic bands.
The internal anal sphincter shows contrast enhancement after intravenous gadolinium-DTPA administration. Contrast enhancement is normally associated with high tissue vascularity, high permeability of capillaries, and increased metabolic or physical activity. Any one of these factors either individually or in combination could be responsible.

Unlike the situation with ultrasound, the oblique coronal plane can be readily visualised with MRI and is of particular value in showing the components of the external sphincter and its relations to the surrounding muscles and other structures.

In general, MRI has a high sensitivity to soft-tissue abnormality. Infection and fluid collections are associated with an increase in T1 and T2, while established scars usually show a reduction in T1 and T2. As a result, T2 weighted sequences abscesses appear high signal and scars have low signal intensity. The cases in this study show that this high sensitivity applies to tissue abnormality in anal disease. Anatomical changes associated with hypertrophy and atrophy were also readily shown.

The use of an anal coil causes discomfort but was acceptable and well tolerated in nine of 10 subjects. The patient with anal stenosis experienced some pain during the examination but it was possible to scan him in the lateral decubitus position. Anal stenosis is a relative contraindication to the technique. Artefact from coil motion was satisfactorily controlled by the use of a clamp to maintain the coil position. The main disadvantages with MRI are the time required and the cost of an examination, which are both greater than for endorectal ultrasound.

To define the detailed anatomy of the sphincter and fully assess the clinical value of this technique, further studies will be necessary.
HAEMORRHOIDS (PILES)

- **Definition:** Enlarged, congested or prolapsed patches of the mucosa and submucosa (anal cushions) at the level of anorectal junction.

- **Definition:** Haemorrhoids are varicosities of tributaries of superior rectal vein (internal piles) or external plexus of veins (external piles).

- **Aetiology:**
  - **Primary (Idiopathic): No known cause:** Predisposing factors:
    - Hereditary (congenital)
    - Prolonged straining as with:
    - Chronic constipation.
    - Childbirth: straining during labour.
    - Senile enlarged prostate.
    - Relaxation of anal sphincter: old age.
Male Reproductive System
Male Reproductive System

- The reproductive system in men has components in the abdomen, pelvis, and perineum.
Male Reproductive System

- The major components are:
  1. *testis*,
  2. *epididymis*
  3. *ductus deferens*,
  4. *ejaculatory duct* on each side, and in the midline
  5. *penis*.
  6. *urethra*
Three types of accessory glands are associated with the system:
1. A single prostate;
2. A pair of seminal vesicles;
3. A pair of bulbourethral glands.
Male Reproductive System

- Ureter
- Seminal vesicle
- Ejaculatory duct
- Rectum
- Prostate gland
- Bulbourethral gland
- Anus
- Urethra
- Penis
- Ductus deferens
- Epididymis
- Testis
- Scrotum
- Urinary bladder
- Urethra
- Glands penis
- Prepuce
The scrotum

- The scrotum is an outpouching of the lower part of the anterior abdominal wall.
- It contains the testes, the epididymides, and the lower ends of the spermatic cords.
Lymph Drainage of the Scrotum

• Lymph from the skin and fascia, including the tunica vaginalis, drains into the superficial inguinal lymph nodes.
1. Testis

Testis has ellipsoid shaped.
Testes develop in the abdomen and move before birth into the scrotum.
The left testis usually lies at a lower level than the right.
Testes

Sperms

Testes covered by parietal layer of tunica vaginalis

Ectopic testes

Ouclus of the testes

Septum of tunica vaginalis

Cavity of tunica vaginalis

Cavity of the parietal layer of tunica vaginalis

Ureter

Urethra

Straight tunica

Septum

Visceral layer of tunica vaginalis

Cavity of parietal layer of tunica vaginalis

Tunica vaginalis

A) Lateral view

B) Lateral view
2. Epididymis

- The **epididymis** is a single, long coiled duct that courses along the posterolateral side of the testis.
- The tunica vaginalis covers the epididymis with the exception of the posterior border.
Epididymis

Structurally, epididymis divided into:
- Head
- Body
- Tail
Arterial Blood Supply of the Testis and Epididymis

- The testicular artery is a branch of the abdominal aorta.
Venous drainage of the Testis and Epididymis

- The testicular veins emerge from the testis and the epididymis as a venous network, the pampiniform plexus.
- This becomes reduced to a single vein as it ascends through the inguinal canal.
- The right testicular vein drains into the inferior vena cava, and the left vein joins the left renal vein.
Lymphatic Drainage of The Testes

- Lymphatic drainage of the testes is to the paraaortic lymph nodes.
3. Ductus deferens

• (Latin: "carrying-away vessel"), also called *vas deferens*.

• The ductus deferens is a long muscular duct that transports spermatozoa from the tail of the epididymis to the ejaculatory duct.
Ductus deferens course

- The vas arises from the tail of the epididymis and traverses the inguinal canal to the deep ring, passes downwards on the lateral wall of the pelvis almost to the ischial tuberosity and turns medially to cross the ureter posterior to the bladder.
- It continues inferomedially along the base of the bladder, anterior to the rectum, almost to the midline, where it is joined by the duct of the seminal vesicle to form the ejaculatory duct.
Ductus deferens course

The terminal part of the vas deferens is dilated to form the **ampulla** of the vas deferens.

The **ejaculatory duct** penetrates through the **prostate gland** to connect with the prostatic urethra.
4. Ejaculatory Ducts

- The two ejaculatory ducts are each less than 1 in. (2.5 cm) long and are formed by the union of the vas deferens and the duct of the seminal vesicle.
- The ejaculatory ducts pierce the posterior surface of the prostate and open into the prostatic part of the urethra, close to the margins of the prostatic utricle; their function is to drain the seminal fluid into
5. Penis

- The penis is a pendulous organ suspended from the front and sides of the pubic arch and containing the greater part of the urethra.
Penis

It consists of internal root, external shaft, & glans.

- **Root**: the portion of the penis that extends internally into the pelvic cavity.
- **Shaft**: the length of the penis between the glans and the body.
- **Glans**: the head of the penis; has many nerve endings.

**Foreskin**: a covering of skin over the penile glans.
Penis

- Shaft of penis
- Root
- Crura
- Urethral opening
- Gians
- Cavernous bodies
- Spongy body
- Penile urethra
The root of penis consists of the two crura, which are proximal parts of the *corpora cavernosa* attached to the pubic arch, and the bulb of penis, which is the proximal part of the *corpus spongiosum* anchored to the perineal membrane.
Analagous structures in male and female sexual anatomy

**Male**
- Glans
- Foreskin
- Shaft
- Scrotal sac
- Testes

**Female**
- Clitoris
- Clitoral hood
- Labia minora
- Labia majora
- Ovaries
Male infertility.

**Definition:**
Inability to conceive 1 year of unprotected sexual intercourse.

**Incidence of Infertility**

- 50% are due to the female factor.
- 30% are due to the male factor.
- 20% are due to combined factors.
Male Infertility Disorder

- Varicocele: 37%
- Idiopathic: 25%
- Testicular failure: 10%
- Semen disorders: 9%
- Other: 7%
- Obstruction: 6%
- Chryptorchidism: 6%
ULTRASOUND EVALUATION

Paratesticular evaluation

Evaluation of the seminal vesicle, ejaculatory ducts and vasaal ampulla

Testicular evaluation
<table>
<thead>
<tr>
<th>Imaging method</th>
<th>Diagnostic criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>Tortuous anechoic tubular structures adjacent to the testis. R2 prominent veins in pampiniform plexus. Expand with Valsalva manoeuvre and upright position with at least one &gt; 2–3 mm in diameter</td>
</tr>
<tr>
<td>Colour Doppler</td>
<td>Reflux in the spermatic vein, which increases with Valsalva manoeuvre, may be identified. Doppler sonography can be used to grade venous reflux as static (grade I), intermittent (grade II), or continuous (grade III)</td>
</tr>
<tr>
<td>Venography</td>
<td>Enlargement of the internal spermatic vein with reflux into the abdominal, inguinal, scrotal or pelvic portions of the spermatic vein. Venous collateralisation present. Incompetent spermatic vein</td>
</tr>
<tr>
<td>MRI</td>
<td>Gadolinium-enhanced imaging useful. Delayed imaging in venous phase identifies mass of dilated vessels and prominence of the pampiniform plexus</td>
</tr>
<tr>
<td>Scintigraphy</td>
<td>Static images show intra-scrotal accumulation of the labelled red cells. Supine and erect imaging is obtained. Reflux may be shown on dynamic images</td>
</tr>
</tbody>
</table>
(a) There is a varicocele on the left side of the pampiniform plexus.

(b) After Valsalva manoeuvre there is marked engorgement and prominence of the varicocele. Initially the patient is in the supine position and then erect. Valsalva is attempted in both.
On grey scale imaging a varicocele is seen as serpiginous tubules posterior to the testis (a). Colour flow Doppler confirms flow within varicocele.
Varicocele with a dilated venous plexus with reflux during straining. The testis is normal.
Figure 5  Selective venography of left testicular vein demonstrates dilatation of pampiniform plexus around the left testes in keeping with a varicocele.

Figure 6  Coronal T1-weighted MRI image post-gadolinium shows left-sided varicocele.
34-year-old man with bilateral cryptorchidism. Sagittal sonograms show both testes to be located in the inguinal canals and diminutive. Testicular volume measured 2–3 mL each (normal range, 18–20 mL).
Ultrasound image of the groin in a patient with undescended testis demonstrates a hypoechoic, small testis in keeping an infracted undescended testis.
Scrotal ultrasound demonstrating thickening and enlargement of the epididymal body (arrow) in a case of infective epididymitis. The testis is spared from the infective process.
A transrectal ultrasound examination demonstrating calcification within the ejaculatory duct (short arrow) with dilatation of the vas deferens proximally (long arrow).
Twenty five years infertile man with azospermia. A: Multiple calculi within the SV and V; B: Bilateral echogenic calculi impacted within the ejaculatory ducts (arrows).
34-year-old hypospermic male. Axial (A) and coronal (B) T2-weighted MR images using an endorectal coil show a normal left seminal vesicle (arrows) but none on the right.
Percutaneous right vasography in a patient with obstructed infertility shows complete obstruction of the ejaculatory duct with retention of the dye in the vas (arrowhead) and SV and non opacification of the urinary bladder.
A 27-year-old with primary infertility. A: TRUS shows a 3 cm × 2 cm thin walled midline intraprostatic urogenital cyst; B: TRUS-guided contrast opacification of the cyst revealed that the cyst was blind with no communication with the seminal tract. Semen analysis showed improvement of the sperm count 3 d after complete cyst aspiration.
A 33-year-old asymptomatic, hypospermic man undergoing infertility evaluation. Transverse sonogram of the right testicle shows multiple hypoechoic masses in the parenchyma, consistent with multifocal tumor. Pathology at surgical resection revealed seminoma.
Longitudinal ultrasound image of a testicular mass demonstrating increased Doppler flow within the lesion; a histologically proven seminoma.
20-year-old man after scrotal trauma 1 week previously who presents with swelling of the scrotum. Transverse sonogram of the scrotum reveals a large amount of fluid surrounding the testicle, consistent with a hydrocele.
37-year-old man with infertility and painful erections who was found on physical examination to have a palpable abnormality along the shaft of the penis. Contrast-enhanced axial (B) and sagittal (C) T1-weighted MR images of the penis show enhancing plaque (arrows) along the anterior aspect of both the corpora cavernosum in B and the anterior and posterior aspects of the left corpus cavernosum in C.
Axial fast SE MR image shows atrophic seminal vesicles (arrows) secondary to a low testosterone level.
Conclusion

Given the prevalence of male infertility, the radiologist's familiarity with its appropriate imaging workup and recognition of the commonly involved pathologic processes is critical. Imaging plays a key role in the evaluation of the hypospermic or azoospermic man. It can detect correctable abnormalities, which can lead to a successful conception. It can also reveal potentially life-threatening disorders in the course of an infertility evaluation.
6. THE URETHRA

- is Fibromuscular tube.
- Extends from the internal urethral sphincter at the neck of the bladder to the external urethral orifice at the tip of the penis.
- Conducts urine to the exterior.
- Channel through which semen is ejaculated.
GROSS ANATOMY

About 20cm (8 inches) long.

Divided into posterior and anterior parts.

a. Posterior Urethra consist of:
   a) prostatic urethra (3cm)
   b) membranous urethra (2cm)

b. Anterior urethra consist of:
   a) bulbous urethra
   b) penile urethra
1. Fluoroscopy:
   a. Retrograde Urethrography
   b. Micturating Cystourethrography

2. Sonography:
   a. Retrograde Urethrography
   b. Micturating Urethrography

3. Cross Sectional Imaging:
   CT

4. MRI
   a. Conventional
Radiological imagings

1. Fluoroscopic Urethrography
   a) retrograde urethrography (RUG)
   b) Micturating Cystourethrography (MUG)

2. Sonourethrography

3. CT

4. MRI
   a. Conventional
   b. Urethrography
Primary modality of choice

Demonstrate the anterior urethra/membranous

Ant urethra seen as a contrast opacified tubular structure with smooth and regular outline

Change in course at the penobulbar junction

Change in calibre at the intrabulbar fossa
RETROGRADE URETHROGRAPHY

It refers to a special radiological procedure for demonstrating the urethra by a contrast medium injected retrogradely through the urethral catheter.

Also referred to as:

- Ascending urethrography/urethrogram.
Fluoroscopic RU

- Posterior urethra tapers from the BMJ to the internal sphincter
- Short membranous urethra

P-penile b-Bulbar
m-membranous
pr-prostatic B-Urinary
bld
b. Fluoroscopic MCUG

Demonstrate the posterior urethra particularly the prostatic urethra

> Opacified bladder is seen in continuity with entire urethra while voiding

> Bladder neck funneling

> Dilated prostatic urethra
CYSTOURETHROGRAPH

- Contrast study - outlines posterior urethra during voiding

- INDICATIONS
  a) Vesicoureteric reflux
  b) study of the urethra during micturation
  c) Abnormalities of the bladder
  d) Recurrent infection
To image the anterior urethra (saline filled).
SONOURETHROGRAPHY

INDICATION

* Intraluminal mass lesions
* To evaluate stricture
  i) location
  ii) length and thickness
  iii) Plan treatment
Longitudinal view of the ant urethra.
b. SONO - MCUG

- To image the posterior and ant urethra while voiding
- Funneling of the bladder neck
- Luminal content of the bladder is seen continuous with the dilated prostatic urethra
Advantages of USS over RUG

- Simple and convenient
- No risk of allergy
- No radiation involved
- It characterises anterior strictures in terms of the following:
  1) length
  2) diameter
  3) periurethral pathology
- Intraluminal filling defect is more convincingly interpreted
- SET BACKS

Can’t demonstrate intravasation OR reflux into prostatic and cowper's gland
Comparing sono RUG to fluro
3.

> The limited soft-tissue contrast on CT depicts the urethra as isodense to adjacent prostate and corporal tissues and therefore indistinguishable unless it is dilated, catheterized or contains contrast.

> Calcifications representing urethral stones can be identified.
4.M RI

> Useful for evaluating peri-urethral structures

> For staging urethral tumours >
i) Axial T2Weighted image through the mid- prostate

2) Sagittal T2 weighted image

P = prostatic urethra

M = membranous urethra

B = Bulbous urethra
Accessory Glands

1. Seminal Vesicle

- The seminal vesicles are an accessory gland of the male reproductive system.
- The seminal vesicles are two lobulated organs about 2 in. (5 cm) long lying on the posterior surface of the bladder.
2. Prostate

• The prostate is an unpaired accessory structure of the male reproductive system that surrounds the urethra in the pelvic cavity.

• It lies immediately inferior to the bladder, above the urogenital diaphragm, posterior to the pubic symphysis, and anterior to the rectum.
Prostate

- Seminal Vesicle
  - Surface view
- Prostatic urethra
- Base of prostate
- Apex of prostate
- Vas Deferens
  - Vasa deferens
- Seminal Vesicle (cutaway view)
Prostate

- The two ejaculatory ducts pierce the upper part of the posterior surface of the prostate to open into the prostatic urethra at the lateral margins of the prostatic utricle.
Structure of the Prostate

Prostate divided into:

- Two lateral lobes
- One median lobe obstruct urethra when enlarged usually in case of benign prostatic hypertrophy (BPH)
- Anterior and posterior lobes
Structure of the Prostate

- Lateral lobes
- Anterior lobe
- Median lobe
- Posterior lobe
- Frosstatic capsule
- Urethra
- Ejaculatory ducts
3. A pair of bulbourethral glands.
Ureter
Ejaculatory duct
Prostatic artery
Prostatic ducts
Levator ani muscle (cut)
Bulbourethra
Intermediate (membranous part of the urethra
Corpus cavomosum (cut)

Deferential artery (ane to ductus deferens)
Inferior vesicle artery
Ampulla of ductus de'orens
Arteres to seminal jlancj
Ejaculatory duct
Prostatic artery
Prostatic
Levator ani muscle
Bulbourethra
Intermediate (membranous part of the urethra
Corpus cavomosum (cut)

Ductus deferens
Unnary bladder
Seminal gland

Prostat
Prostatic venous plexus
External urethral sphincter
Compressor urethrae muscle (cut)
Perineal membrane
Spongy urethra
Bulb of penis covered by bulbospongiosus muscle

Cut edge of pentoneum

Posterior view
IMAGING ANATOMY OF FEMALE REPRODUCTIVE SYSTEM
At birth: male development

At birth: female development
Parts of FEMALE REPRODUCTIVE SYSTEM
1. UTERUS
2. FALLOPIAN TUBE
3. CERVIX
4. VAGINA
5. OVARY
1. UTERUS

- Thick walled fibromuscular organ
- Composed of myometrium and endometrium
- 2 divisions
  - Body (Corpus Uteri)
    - Fundus
    - Isthmus
    - Cornua
- Endometrium - mucosal lining
- Myometrium: smooth muscle + connective tissue and elastic fibers
UTERUS

MENSTRUAL CYCLE

- **Menstrual Phase**
  - Sloughing of functionalis layer of endometrium

- **Proliferative Phase**
  - D1-D14
  - Estrogen dependent - proliferation of functionalis layer
  - Correspond to FOLLICULAR phase of Ovary

- **D15 - Menstruation**
  - Progesterone dependent - endometrium secrete glycogen and mucus
  - Correspond to LUTEAL phase of ovary
  - Endometrial glands hypertrophy
UTERUS

SUPPORTING STRUCTURES

• 1. Broad Ligament - Laterally to pelvic wall
• 2. Round Ligament
• 3. Transverse cervical ligaments (Cardinal Ligaments)
• 4. Uterosacral ligaments
• 5. Vesicouterine/vesicocervical ligaments - lateral margin of cervix and vagina to bladder
2. FALLOPIAN TUBE

- Connects uterine cavity to peritoneal cavity
- Attached to mesosalpinx
- 8-14cm in length
- 4 segments: interstitial, isthmus, ampulla and infundibulum
infundibulum

uterine (fallopian) tube

ampulla

isthmus

myometrium

endometrium

ovarian medulla

ovarian cortex

cervix

ovary
3. CERVICAL ANATOMY

CERVIX UTERI

Fibromuscular caudal segment of the uterus that communicates with
2 segments
- Supravaginal segment - internal Os
- Vaginal segment - External Os

Size
- 2.5-3 cm in non gravid
- <6cm in pregnancy
4. VAGINAL ANATOMY

Fibromuscular tube with mucosal lining

Interposed between bladder/urethra and rectum
  • Separated from bladder/urethra by connective tissue (vesicovaginal septum)
  • Separated from rectum by rectovaginal septum

Morphology
  • classic "H" morphology on axial imaging
  • Upper vagina folds around cervix to form recessed vaginal fornices
VAGINAL ANATOMY

Vagina divided into 3 thirds

1. Upper 1/3: At level of vaginal fornices
2. Middle 1/3: At level of bladder base
3. Lower 1/3: Below bladder base, at level of urethra

Size: 4-12 cm in length

- Anterior wall: 4-8 cm (shorter in length)
- Posterior wall: 8-10 cm (longer)
5. OVARIAN ANATOMY

- Paired intraperitoneal reproductive ova producing organs

- Size
  - Premenarche: 3cc
  - Pre menopausal: 4-16cc
    - Multiple bilateral developing follicles
    - Volume increase in follicular phase
    - Peaks at ovulation
  - Post menopausal: 6cc
    - Follicles and cysts less common
IMAGING ANATOMY
Reference radiologic method for assessing tubal patency

Indications

- Infertility and recurrent miscarriages
- Congenital uterine anomalies
- Uterine tube pathologies

Contraindications

- Metrorrhagia
- Acute and sub acute PID
- Contrast allergy
- Pregnancy
Right isthmic segment

Right ampullary segment

Free spillage of contrast

Interstitial/intramural segments

Left infundibular segment

Hysterosalpingogram catheter and balloon
2. ULTRASOUND

- Trans-abdominal and trans-vaginal USG TAS
- Equipment: 3.5-5Mhz curved transducer
- Wide field of view
- Requires a filled bladder
Atcerxavg branch ot utahne afte.
Vaginal branch af iliac artery
ULTRASOUND

FALLOPIAN TUBES

Normally not seen

Seen in hydrosalpinx/ascites

Seen as continuation of uterine body
ULTRASOUND

UTERUS

• Size: 7 x 5 x 4cm

• Echogenicity
  
  Myometrium:
  • Thin hypoechoic inner layer
    - subendometrial halo
  • Thicker echogenic middle layer
  • Thinner hypoechoic outer layer
  
  • No change with menstrual cycle
VAGINA

- Normal Length: 7-10cm
- Trilaminar appearance
- Vaginal wall hypoechoic and uniformly thin
Clitoral body/glans
Urethra
Vaginal introitus
Decompressed vagina
Echogenic coapted vaginal mucosal layers
Hypoechoic vaginal wall muscular layer
Bladder
3. COMPUTED TOMOGRAPHY

• Less often use due to decrease soft tissue resolution
• Used to see calcification in various lesions (ex: leiomyoma) and in lymph nodes

TECHNIQUE

• Partially distended bladder required
COMPUTED TOMOGRAPHY

OVARY

• During acute pelvic pain
• Identified by following ovarian vessels
• Ovoid structures with decreased attenuation
• Ovarian ligaments in presence of free fluid
• Corpus luteum may shows prominent thickened enhancing wall
COMPUTED TOMOGRAPHY

UTERUS

Uterus : homogenous soft tissue density
Endometrium : hypodense
Central hypodense endometrium

Cesarean section scar

Urinary bladder

Cervix

Fundal myometrium

Thin subendometrial enhancement

Endometrium

Cervix
CERVIX

Cervix is of homogeneous soft tissue density

- Cervix often displays diffuse hypoenhancement compared to uterine body
VAGINA

- Mucosa may show prominent smooth, early enhancement in premenopausal patients
COMPUTED TOMOGRAPHY

PARAMETRIUM

• Visible on CT are
  • Round ligament (ribbon like appearance)
  • Uterine ligaments (thickened post RT)
  • Broad Ligament

Cardinal ligament (less often visualized)
- Round ligaments of the uterus
- External iliac artery
- External iliac vein
- Uterus
- Ovary
4. MAGNETIC RESONANCE IMAGING

Indications

• Better soft tissue resolution
• Characterization of pelvic masses
• Staging of pelvic malignancies
• Evaluation of congenital (mullerian) anomalies
• Treatment follow-up
• Pelvic floor assessment (dynamic)
• Evaluation of pelvic lymphadenopathy
• Pelvimetry
• Evaluation of pelvic pain in pregnancy
MAGNETIC RESONANCE IMAGING

CONTRAINDICATIONS

1. Metallic implants
2. Anxiolytics
3. Anti-peristaltic agents
MAGNETIC RESONANCE IMAGING

PATIENT PREPERATION

- Empty Bladder
- Reduce motion artefacts
  - Fasting 4-5 hrs
  - Anti-peristaltic agents
- Bacteriostatic vaginal surgical lubricant
  - Intra luminal contrast
- Improved visualization of Cx and Vagina
IMAGING PLANE

- Axial: pelvic anatomy and parametrial assessment
- Sagittal: Uterine zonal anatomy
- Coronal: complementary information in assessment of uterus, cervix, parametrium, vagina, and ovaries
- Oblique: evaluation of parametria in cervical Ca
  - Characterisation of mullerian duct anomalies
MRI PLANNING
MAGNETIC RESONANCE IMAGING
MAGNETIC RESONANCE IMAGING - OVARY

Post menopausal - difficult to identify

- Decreased size
- Fewer/smaller cysts
- Iso to hypoenhancing to myometrium
PARAMETRIUM

- Loose connective tissue between layers of broad ligament
- Contains blood vessels and lymphatics
- Other ligaments seen better in presence of ascites
MAGNETIC RESONANCE IMAGING

UTERUS

Uterus and cervix have uniform intermediate signal.

- Three zones - Endometrial cavity, Junctional zone, myometrium.
MAGNETIC RESONANCE IMAGING

UTERUS

• Junctional Zone
  • Hypointense layer
  • Deepest zone of myometrium
  • Greater concentration of smooth muscle cells compared to periphery

• Myometrium
  • No significant change in size during the cycle
MR

UTERINE APPEARANCE

• Premenarche: body is small and zonal anatomy is indistinct

• Premenopausal (postmenarche)
  • Endometrium thickens throughout proliferative and secretory phase
  • Myometrial T2 signal increase in secretory phase - inc water content and vascular flow
  • Menstruation: Thickness and T2 signal decrease
  • Junctional zone shows no change

• Post menopausal: endometrial and myometrial atrophy, Decreased T2 signal
MAGNETIC RESONANCE IMAGING

CERVIX

• Three zones

1. Cortical Zone - Hyperintense zone (mucus secretions)
2. Intermediate zones - Hypointense (deep part of fibromuscular stroma)
3. Peripheral zone - iso/hypointense (smooth muscle cells prevail)
MAGNETIC RESONANCE IMAGING

PARAMETRIUM
MAGNETIC RESONANCE IMAGING

VAGINA

MR is preferred modality

- superior soft tissue differentiation
- Allows for delineation of vulvar anatomy
- Superior evaluation of vaginal wall and characterization of associated lesions

CT is most useful in

- Staging of vaginal/vulvar malignancy
- Evaluation for nodal and metastatic disease
MAGNETIC RESONANCE IMAGING

VAGINA

- 1. Endoluminal secretions
- 2. Mucosal Layer
- 3. Submucosal and muscular layers
3D/4D USG
PELVIC MRA

Vascular involvement in pelvic malignancy
Prior to uterine artery embolization
PELVIC VASCULAR TREE

1. ABDOMINAL AORTA
2. INTERNAL ILIAC ARTERY
3. EXTERNAL ILIAC ARTERY
4. LUMBAR ARTERY
5. COMMON FEMORAL ARTERY
6. COMMON ILIAC
Aortic Bifurcation
Internal and External Iliac Arteries
Pelvic peritoneal space

- Peritoneal cavity
- Rectouterine pouch
  - "Pouch of Douglas"
- Vesicouterine pouch
- Uterus
- Rectum
- Vagina
- POD
- U
- B
- P
Female Pelvis

- Cecum
- Lt Ureter
- Descending Colon
- Lt Common Iliac V
- Lt Vertebral Foramen
- Sacral Canal
- Rt Ilium
- Rt SI Joint

Additional Labels:
10. Cecum
11. Rt ext & int iliac A
1. Lt ureter
2. Descending colon
3. Lt common iliac A
4. Lt common iliac V
9. Ala of rt ilium
Female Patient Ant. to Post.

- Rt/Lt Common Iliac Art.
- Sm. Bowel
- Sig. Colon
- Bladder
- R. Iliacus M
- Fem. Head
- Labia Majora

Diagram showing anatomical structures including:
- Abdominal aorta
- Loops of small bowel
- Sigmoid colon
- Lt ilium
- Lt pubis
- Lt labium majora
- Rt common iliac A
- Rt psoas M
- Rt iliacus M
- Bladder

Note: Activate Windows Go to Settings to activate Windows.
The breast is an appendage of skin & is modified sweat gland, the shape of the female breast is due to the fat contained within fibrous septa.

In the adolescent & young adults the breast is firm & prominent, with the age the glandular & fibrous element atrophies, the skin stretch & breast sags.

The breast lies between the skin & pectoral fascia to which it is loosely attached. It extends from the 2nd to the 6th ribs & from the lateral border of the sternum to the mid-axially line.

A prolongation of parenchymatous tissue, *the axillary tail*, runs up-ward between the pectorals major and latissimus dorsi muscles to blend with the fat of the axilla.

**Anatomy of the Breast**

- clavicle
- 2nd rib
- suspensory ligament
- fat (adipose tissue)
- areola
- nipple
- ampulla
- 6th rib
The breast glandular tissue consists of 15 to 20 lobules (clusters of milk forming glands, or acini) that enter into branching and interconnected ducts. The ducts widen beneath the nipple as lactiferous sinuses and then empty via nipple openings.

The primary secretory unit is a group of saccular alveoli draining into ductless (the terminal duct-lobular unit). In the resting state, this secret watery fluid, which is believed to be reabsorbed through the walls of large ducts.

The alveoli ducts are lined by a single layer of epithelial cells. Myoepithelial surround the ducts, but not the lobules; they are contractile and move secretion along the duct system.

Anatomy of the Breast

- Fascia
- Fatty tissue
- Pectoralis major
- Pectoralis minor
- Lactiferous duct
- Breast lobule
- Coopers ligaments
- Lactiferous sinus
- Areola
- Clavicle
Radiological imaging of benign breast diseases.
Imaging modalities.

Breast Studies

- Film-Screen Mammography: Screening and Diagnostic
- Ultrasound
- Digital Mammography: Computer Aided Diagnosis
- Nuclear Medicine
- MRI
- CT
- Galactography
Diagnostic Mammography

Indications

- Mass(es): palpable or detected on screening mammography
- Microcalcifications
- Architectural distortion
- Parenchymal asymmetry
- Palpable abnormality
- Focal tenderness
- Spontaneous nipple discharge

Symptoms of Breast Cancer
Breast Density

- The breasts are almost entirely fatty
- There are scattered areas of fibroglandular density
- The breasts are heterogeneously dense, which may obscure small
- The breasts are extremely dense, which lowers the sensitivity of
Another example of a small breast cancer detected on screening mammogram which was non-palpable.
Example of a patient with no prior screening mammogram who presented with complaints of right upper abdominal pain shown to have liver masses on CT. Liver biopsy showed metastatic cancer to the liver. Patient was sent for mammography and ultrasound for suspected breast carcinoma after breast exam.
Breast Ultrasound Indications

- Cystic vs. solid masses
- Characterization of solid masses
  - Benign vs. malignant
- Further evaluation of mammographic densities
- Evaluate palpable masses in women who are pregnant, lactating, < 30 years old
- Guide interventional procedures
Fibrocystic disease of the breast.
Example of an ultrasound guided biopsy (arrows show course of biopsy needle)
- Islands of residual parenchyma are clearly visible as small, hypoechoic “pores” within the dense, hyperechoic connective tissue.
- Cooper ligaments are thickened.
- Development of small retention-type cysts may be seen due hormonal alterations.
- Central dilatations of the main ducts (up to 10mm) are commonly seen.
Breast MRI

- Adjunct to mammography & sonography
- Not for populations with low prevalence of breast cancer
  - High sensitivity
  - Low specificity: unnecessary workups
- False positive enhancement:
  - fibroadenomas, fat necrosis, radial scars, lymph nodes, mastitis, atypical hyperplasia
- MRI guided breast biopsies
Fibrocystic disease of the left breast
Patient’s breast MRI
Fatty tissue has a high signal intensity

Residual parenchyma and connective-tissue structures have low signal intensity
APPENDICULAR SKELETON

Upper limb bones (upper extremity bones)

pectoral girdle

Scapula
Clavicle

Bones of the arm

Humerus

Bones of the forearm

Radius
Ulna

Bones of the hand

Carpal
Metacarpal
Phalanges
• Bones of the two pectoral girdle:- Scapula + Clavicle

• pectoral girdle is also called shoulder girdle.
Bones of Pectoral Girdle:-Clavicle

S- shape bone located at the root of the neck and has two ends:

the rounded medial (curved anteriorly) (sternal end) which articulates with sternal manubrium at sternoclavicular joint

the flat lateral end (curved posteriorly) (acromial end) articulates with acromion process of Scapula.
Bones of the two pectoral girdle: - Scapula

The shoulder blade, located on the posterior thoracic wall between the 2nd and 7th rib, is a flat triangular bone that has an oblique oriented process called the spine. This process divides the posterior surface to the supra and infra spinous fossa, providing attachment sites for muscles moving the arm.

The spine ends in a large flat process called the acromion, which articulates with the lateral part of the clavicle. Anterior to the acromion is another process named the coracoid process.

The lateral angle of the scapula has a cavity called the glenoid cavity (glenoid fossa), which articulates with the head of the humerus.
Posterior Shoulder Anatomy Showing Major Muscle (Supra & Inferspinatus Muscle)
Joints of the shoulder
1. sternoclavicular joint
2. acromioclavicular joint
3. Glenohumeral joint
Joints of the upper limb:-

- **Shoulder joint**, between the head of humerus and glenoid fossa of Scapula.

- **Elbow joint**, between humerus and Radius and Ulna.

- **Wrist joint**, between Radius / Ulna and Carpal bones.
Shoulder joint (Glenohumeral joint)

- Shoulder joint is a ball and socket articulation
- The articulation is between the head of humerus and glenoid fossa of Scapula.
**Bones of the arm:** Humerus is the largest longest bone of the upper limb located between shoulder and elbow
Deltoid muscle inserts onto the humerus
The **Elbow Joint**

The humerus articulates with the radius and ulna.
- **Radius** which has rounded head (disk shape head)
- Proximally articulates with humerus
- radius is located laterally on the thumb side
Ulna

- Ulna is the longer of the two bones extends between elbows and wrists.
- Ulna has large depression, serving for articulation with the humerus.

Radiological anatomy of the wrist.

Osseous Anatomy

The osseous structures of the wrist are the distal portions of the radius and ulna, the proximal and distal rows of carpal bones, and the bases of the metacarpals.
Bones of the hand

Carpal

Metacarpal

Phalanges
(b) Right wrist and hand, posterior view
Muscles Associated with pectoral girdle and upper limbs can be divided into 4 groups:

1. muscles that position the pectoral girdle
2. muscles that move the glenohumeral joint/arm
3. arm and forearm muscles that move the elbow joint/forearm and hand
4. forearm muscles that move the wrist joint, hand, and fingers
- intrinsic muscles of the hand
1-Muscles That Move the Pectoral Girdle

- Originate on the axial skeleton and insert on the clavicle and scapula.
- Stabilize the scapula and move it to increase the arm’s angle of movements.
- Some of the superficial muscles of the thorax are grouped together according to the scapular movement they direct.
  - elevation, depression, protraction, or retraction
Protraction of the shoulder by the anterior muscles: *pectoralis minor* and the *serratus anterior*
Retraction of the shoulder (adduction) by posterior muscles are the:
- trapezius,
- rhomboid major, and rhomboid minor.
2-Muscles that move the Arm (the glenohumeral joint)

- Deltoid: arm abductor

**Deltoid muscle** attaches the scapula and the clavicle to the humerus
Muscles that move the Arm

- **Pectoralis major** muscle which adducts the arm.
3-Arm and Forearm Muscles that Move the Elbow Joint/Forearm and hand

- 1-The dorsal / posterior compartment (in which the extensor muscle group resides). Primarily contains elbow extensors: muscles that extend the elbow joint
  - Triceps brachii

2-The ventral compartment/ anterior (in which the flexor muscle group resides). Primarily contains elbow flexors
  - the principal flexor is biceps brachii
Pronation and supination are movements possible only in the forearms and hands, allowing the human body to flip the palm either face up or face down.

Supination allow palm to face anteriorly.

The supinator muscle of the forearm and the biceps brachii of the upper arm supinate the forearm by pulling on the radius.
4-Forearm Muscles That Move the Wrist Joint, Hand, and Fingers

- Muscles in the forearm move the hand at the wrist and/or the fingers.

- A- Extrinsic muscles of the wrist and hand originate on the forearm, not the wrist or hand.

- Have long tendons connecting them to bones in the hand, where they exert their action.
B-Intrinsic Muscles of the Hand

- Small muscles that both originate and insert on the hand.
- They are housed entirely within the palm.
Arteries Of The Upper Limb

- Axillary artery
- Right subclavian artery
- Left subclavian artery
- Brachial artery
- Radial artery
- Ulnar artery
- Palmar arches
The Subclavian Artery

- The **right** artery originates from the brachiocephalic artery.
- The **left** artery originates from the arch of the aorta.

Cotinues as Axillary artery at the lateral border of the 1st rib
Circulation of blood to upper limb, (Arterial supply)

- axillary arteries become brachial arteries.
- brachial artery runs the medial aspect of the upper arm passes the elbow then branch into radial and ulnar arteries.
- radial and ulnar arteries passes to the hand and form anastomoses called superficial and deep palmer arches
Veins of the Upper Limb

- The veins of the upper limb are divided into two sets: **Superficial** and **Deep**
- The two sets anastomose frequently with each other.
- A. The **superficial veins** are placed immediately beneath the skin, in the superficial fascia.
- B. The **deep veins** accompany the arteries, and constitute the *venae comitantes* of those vessels
A. Superficial Veins of the Upper Limb

Dorsal Venous Arch (network)

- The dorsal digital veins drain into dorsal metacarpal veins, which unite to form a dorsal venous arch or network.
- Dorsal venous network lies on the dorsum of the hand, in the subcutaneous tissue, proximal to the metacarpophalangeal joints.
- Drains into the cephalic vein laterally, and basilic vein medially.
Cephalic Vein
- Arises from the lateral end of the dorsal venous arch of hand.
- Ascends on radial side of the forearm to the elbow and continues up the arm in the deltopectoral groove.
- Pierces clavipectoral fascia to drain into the axillary vein.

Basilic Vein
- Arises from the medial side of the dorsal venous arch of hand.
- Ascends on the ulnar side of forearm to the elbow, in the middle of the arm, it pierces the deep fascia and joins the brachial vein or axillary vein.

Median Cubital Vein
- Links cephalic vein and basilic vein in the cubital fossa.
- Is a frequent site for venipuncture.
• Nerves of the upper limb
• Upper limb is supplied by branches of the **brachial plexus**, formed by the ventral rami of the spinal nerves C5, 6, 7, 8, and T1

• Since the spinal nerves are mixed nerves carrying **sensory**, **motor** and **autonomic** fibers, their injuries result in sensory, motor and autonomic disturbances
Roots join to form Trunks! (in neck)

- Ventral Rami

  - C5
  - C6
  - C7
  - C8
  - T1

  Trunks

  - Upper Trunk
  - Middle Trunk
  - Lower Trunk
Trunks Split to form Divisions
Divisions Join to form Cords! (in axilla)
Cords Give off Branches!! (in exilis)
Radiological anatomy of the upper limb joints.
Radiological imaging of the upper limb joints:

1- Plain X-Ray.
2- Ultrasonography.
3- Computerized tomography (CT Scan).
4- Magnetic resonance imaging (MRI) study.
Anatomy of the Shoulder.

The shoulder comprises bones, ligaments, tendons, and muscles that connect the arm to the axial skeleton. The three bones that make up the shoulder joint include the clavicle (collarbone), scapula (shoulder blade), and humerus (long bone of the arm). The shoulder has 3 joints that work together to allow arm movement.

1. The acromioclavicular (AC) joint is a gliding joint formed between the clavicle and the acromion.
The **acromion** is the projection of the scapula that forms the point of the shoulder. The AC joint gives us the ability to raise the arm above the head.

2. The glenohumeral joint, or shoulder joint, is a ball-and-socket type joint. The "ball" is the top, rounded part of the humerus, and the "socket" is the bowlshaped part of the scapula, called the **glenoid**, into which the ball fits. This joint allows the arm to move in a circular rotation as well as towards and away from the body.
The shallowness of the glenoid fossa and relatively loose connections between the shoulder and the rest of the body allows the arm to have tremendous mobility, at the expense of being much easier to dislocate than most other joints in the body. Approximately its 4 to 1 disproportion between the large head of the humerus and the shallow glenoid cavity. The capsule is a soft tissue envelope that encircles the glenohumeral joint and attaches to the scapula, humerus, and head of the biceps. It is lined by a thin, smooth synovial membrane.
The labrum is a piece of cartilage that cushions the humerus head and the glenoid. This cartilage also helps to stabilize the joint. The rotator cuff is a group of four muscles that pull the humerus into the scapula. The rotator cuff muscles stabilize the glenohumeral joint and help with rotation of the arm. Two sac-like structures called bursae are also located in the shoulder. The bursae secrete a lubricating fluid, which helps reduce friction between the moving parts of the joint. Together, all of these structures create one of the most flexible joints in the body.
3. Sternoclavicular joint:

The **sternoclavicular** occurs at the medial end of the clavicle with the **manubrium** or top most portion of the sternum.
Anatomy.

- Coracoid process
- Amnion
- Greater tuberecle
- Intercal
- Scapula
- Medial border
- Lateral border
- Superior angle
- Sternal end
- Inlet ilor angle
- Debid. tutwraelly
- Humtui

Surgical
IN THE SHOULDER WE HAVE:

3 Bones
1— Humerus.
2— Scapula.
3— Clavicle.

3 Joints
1— Glenohumeral.
2— Acromio-clavicular.
3— Sternoclavicular.
- **Humerus**
  - **Head.**
  - **Anatomic neck.**
  - **Surgical neck.**
  - **Greater tubercle.**
  - **Lesser tubercle.**
  - **Intertubercular groove.**
  - **Deltoid tuberosity.**
  - **Shaft.**
Scapula

- Body
  - Ventral (Costal) surface
  - Dorsal surface

- Borders
  - Superior
  - Lateral (Axillary)
  - Medial (Vertebral)

- Angles
  - Superior
  - Inferior
  - Lateral (Head)
- **Scapula**
  - Glenoid
  - Acromion
  - Coracoid
  - Subscapular fossa
  - Scapular spine
  - **Supraspinatus fossa**
  - **Infraspinatus fossa**
(f) Right scapula, lateral aspect
**AP View of the Shoulder.**

- **"Routine" AP View**
  - Clavicle
  - Scapula
    - Acromion & scapular spine
    - Coracoid
    - Borders & angles
  - AC & SC joints
  - Glenoid
  - Humerus
    - Head & necks
    - Gr & Lsr tuberosities
• AP View in External Rotation
  — Greater tuberosity & soft tissues profiled and better visualized
  — Best w/ Scapular AP

• AP View in Internal Rotation
  — May demonstrate Hill-Sachs lesions
    • GH instability
  — Best w/ Routine AP
Axillary Lateral View of the Shoulder.

- **Good view of anterior-posterior relationship of GH joint**
- **Coracoid**
- **Acromion**
- **Humerus**
- **Glenoid**
- **GH joint**
Scapular "Y" Lateral View of the Shoulder.

- Relationship b/w humeral head and glenoid.
- Acromion.
- Coracoid.
- Scapular body.
- Scapular spine.
Ultrasonography.

• **Advantages:**
  — no ionizing radiation,
  — no contrast agent,
  — relatively inexpensive,
  — readily available
  — Dynamic evaluation
  — Guided aspiration / injection possible

• **Limitations:**
  — Less sensitive for detecting partial thickness rotator cuff tears
  — Cannot accurately evaluate the labral-ligamentous complex
• Superior to plain radiographs in evaluation of complex fractures and fracture-dislocations involving the head of the humerus
MRI

- Highly accurate for evaluation of rotator cuff pathologies
- Indicated when further investigation of rotator cuff pathology is needed.

Advantages:
- No ionizing radiation
- Non-invasive
- Multi-planar imaging
- Demonstrates other lesions such as ACJ osteoarthritis and avascular necrosis.
- Comprehensive display of soft tissue anatomy
- Demonstration of the causes for impingement

Useful in characterization and staging of bone tumors.
Glenohumeral Joint

1- Anterior labrum
2- Subscapularis
3- Infraspinatus
4- Posterior labrum
5- Humerus
6- Glenoid cavity
Rotator Cuff (Sagittal)

Supraspinatus; Infraspinatus; Teres Minor; Subscapularis
Elbow Joint:

The elbow is a complex synovial joint formed by the articulations of the humerus, the radius and the ulna.
Adult Elbow - Lateral Radial Head View, in 10 years old.
Elbow Ultrasound.

For examination of the anterior elbow, the patient is seated facing the examiner with the elbow in an extension position over the table.
arrows, distal biceps tendon; asterisk, coronoid fossa and anterior fat pad; Br, brachialis muscle; HC, humeral capitellum; RH, radial head; s, supinator muscle
arrow, ulnar nerve; asterisk, triceps tendon; ME, medial epicondyle; O, olecranon process; void arrowhead, ulnar head of the flexor carpi ulnaris muscle; white arrowhead, humeral head of the flexor carpi ulnaris muscle; 1, cubital tunnel retinaculum (Osborne ligament); 2, arcuate ligament; 3, flexor carpi ulnaris muscle
3.C
T
Magnetic resonance imaging (MRI) provides excellent delineation of the bones of the elbow and the surrounding soft tissue structures. The components of the elbow can be divided into osseous structures, the joint capsule and ligaments, muscles and tendons, and nerves.
Radiological anatomy of the wrist.

Osseous (bony) Anatomy
The osseous (bony) of the wrist are:
1. the distal portions of the radius and ulna,
2. the proximal and distal rows of carpal bones, and
3. the bases of the metacarpals.
Wrist bones - Normal X-ray (PA)
(n) Transverse sonogram shows the dorsal aspect of the proximal carpal row, just distal to the level of the Lister tubercle. Note the echogenic fibrillar appearance of the dorsal scapholunate ligament, which underlies the extensor digitorum (ED) tendons.

(12) Transverse sonogram at the same level as 11 but on the ulnar side of the dorsal carpus shows the echogenic dorsal aspect of the lunatotriquetral ligament and, above it, the extensor digiti minimi (EDM) tendon.
Normal sonographic appearances of the carpal tunnel. (a) Transverse sonogram over the carpal tunnel shows the hypoechoic flexor retinaculum (arrowheads) with the median nerve immediately beneath it. The long flexor tendons of flexor digitorum superficialis (FD5) flexor digitorum profundus (FDP) are located deep to the nerve. Note the presence of a normal variant median artery (curved arrow) alongside the median nerve, (b) Extended-field-of-view transverse sonogram of the carpal tunnel shows the bones that mark its boundaries.
The most useful bony landmarks to identify the proximal carpal tunnel are the pisiform at its ulnar side and the scaphoid at its radial side.
Computerized Tomography (CT).

As with plain radiography and arthrography, CT employs ionizing radiation. It allows three-dimensional visualization of the carpal bones and provides soft tissue detail.
Magnetic resonance (MR) imaging is the optimal modality for characterizing the ligaments, tendons, muscles, and neurovascular structures of the wrist joint. Continued refinement in pulse sequence and coil design permits high-resolution examination of the many small structures and complex anatomy of this region.
Capitate
Hamate
Triquetrum
Ulnar styloid
Ext carpi ulnars tendon
Lunate
Distal radioulnar joint
Trapezoid
Trapezium
Scaphoid
Radial stylod
Scaphomate ligament
The lower Limb

The lower Limb bones consist of 1. femur, 2. patella, 3. tibia, 4. fibula, 5. tarsal bones, 6. metatarsal, and 7. phalanges.

1. **Femur** bone which is the largest, heaviest, and the strongest.

Located in the body between hip bone and knee joint.
Bones of the thigh: Patella

- **Patella** bone is a small bone at the anterior side, it protects the knee.

- It is formed within the tendon of the quadriceps femoris muscle.

- Note: a bone formed within a tendon of a muscle is called sesamoid bone.

- **Patella** is the largest sesamoid bone in the body.

3. **Tibia is** located at the anterior and medial part of leg between the Knee joint and ankle joint.

Tibia is the **only** bone that articulates with the femur at the knee joint.
Bones of the leg: Tibia

- The distal end of the tibia
- Articulates with the tarsal bone (talus) to form the larger part of the ankle joint.

4. **Fibula** is a long slender bone parallel and lateral to tibia.

Its proximal end articulates with tibia and its distal end articulates with talus.
Bones of the foot:-

Consist of three groups of bones:

5. **Tarsal** bones (7 short bones)
6. **Metatarsal** bones (5 bones)
7. **Phalanges** 14 in number 3 phalanges in each digit except the big toe which has 2 phalanges
Muscles That Move the Pelvic Girdle and Lower Limb

- Can be divided into 3 groups:
  1. That Move the Thigh
  2. That Move the leg
  3. That Move the feet and toes
LOWER LIMB RADIOLOGY
ANATOMY
Imaging Techniques in Orthopaedics

1. Conventional Radiography
2. Fluoroscopy
3. Computed Tomography
4. Arthrography
5. Angiography
6. Ultrasound
7. Scintigraphy
8. Magnetic Resonance Imaging
Imaging Techniques in Orthopaedics.

- Use of Radiological Techniques methods in evaluating the presence, type, and extents of various bone, joints and soft tissue abnormality.
- Indications
- Limitations
- Appropriate imaging approach
The question

• “What modalities should I use for this particular problem” is frequently asked by Radiologists and Orthopaedic Surgeons alike.

• Conventional Radiograph

• The choice of imaging technique is dictated by the type of suspected abnormality
CONVENTIONAL RADIOGRAPHY:

- The most frequently used modality for evaluation of bone and joint disorder
- The radiologist should obtain at least two (2) views of the bone involved at 90° angles to each other
- with each view including two adjacent joints
2. Uses of CT

- Trauma
  - Intraarticular abnormalities
  - Detection of small bony fragments
CT Vs. Xray

• Advantages:
  – Excellent contrast resolution.
  – Measures the tissue attenuation coefficient
  – Obtain transaxial images
  – Reformation

• Disadvantages:
  – Radiation
  – Inability to make a specific diagnosis
Uses - Tumors

- Delineates tumors extent
- Soft tissue extension.
- Presence of Calcification
- Biopsy
3. Arthrography

- Arthrography is the introduction of contrast agent positive contrast iodine iodide solution negative contrast, air or combination of both into the joint space.

- Advantages:
  - Simple
  - Effective
Arthrography

- Any joint
  - Shoulder
  - Ankle
  - Elbow
  - Knee
4. Angiography

• Advantages:
1. Map-out bone lesions
2. Demonstrate the vascularity of the lesion.
3. Demonstrate the vascular supply of a tumor
4. Locate vessels suitable for pre operative intraarterial chemotherapy.
5. Demonstrating the area suitable for open biopsy.
5. ULTRASOUND:

- Rarely used
- Advantages:
  - inexpensive
  - allows comparison with the opposite side, normal side
  - uses no ionizing radiation,
  - performed at bed side or in the operating room.
  - It is a non invasive modality
Applications

- Evaluation of the rotator cuff
- Injuries to various tendons, e.g. the achilles tendons.
- Evaluation of the infant hip for which ultrasound has become the imaging modality of choice
Shoulder US
6. SCINTIGRAPHY
RADIONUCLIDE BONE SCAN

- image the entire skeleton at once.
- It provides a metabolic picture.
- It is particularly helpful in condition such as fibrodysplasia, Langerhans Cell Histocytosis or metastatic cancer.
Prostate Mets
7. MRI

- Magnet
- RF coils
- Computer
MRI

- The musculoskeletal system is ideally suited for evaluation by MRI since different tissue displayed different signal intensities on T1 & T2 weighted images. The images displayed may have a low signal intensity, intermediate signal intensity, or high signal intensity.
MRI-uses

• Traumatic & non-traumatic conditions
  – Bone
  – Soft tissue
  – Contusions
  – Microfractures
Relation to neurovascular bundle
Tumor composition
MRI Contraindications

• **ABSOLUTE**
  – Patients with cardiac pacemakers
  – Cerebral aneurysm clips

• **RELATIVE:**
  – Claustrophobia
PELVIS
pelvis anatomy - Normal AP

The 2 hemi-pelvis bones and the sacrum form a bone ring bound posteriorly by the sacroiliac joints and anteriorly by the pubic symphysis. Each obturator foramen is also formed by a ring of bone.
The hip joint is located where the thigh bone (femur) meets the pelvic bone. It is a ball and socket joint. The upper end of the femur is formed into a round ball (the head of the femur). A cavity in the pelvic bone forms the socket (acetabulum). The ball is normally held in the socket by very powerful ligaments that form a complete sleeve around the joint (the joint capsule). The capsule has a delicate lining (the synovium). The head of the femur is covered with a layer of smooth cartilage which is a fairly soft, white substance about 1/8 inch thick. The socket is also lined with cartilage (also about 1/8 inch thick). The cartilage cushions the joint, and allows the bones to move on each other with very little friction. An x-ray of the hip joint usually shows a space between the ball and the socket because the cartilage does not show up on x-rays. In the normal hip this joint space is approximately 1/4 inch wide and fairly even in outline.
Hemi-pelvis anatomy - Normal AP

Each hemi-pelvis bone comprises 3 bones:
- the ilium (white), pubis (orange) and ischium (blue)

The 3 bones fuse to form the acetabulum - the pelvic portion of the hip joint

ASIS = Anterior Superior Iliac Spine = attachment site for sartorius muscle

AIIS = Anterior Inferior Iliac Spine = attachment site for rectus femoris muscle
Hip X-ray anatomy - Normal AP

Shenton's line is formed by the medial edge of the femoral neck and the inferior edge of the superior pubic ramus. Loss of contour of Shenton's line is a sign of a fractured neck of femur.
1. Anterior superior iliac spine
2. Ilium
3. Anterior inferior iliac spine
4. Pelvic brim
5. Acetabular fossa
6. Head of femur
7. Fovea
8. Superior ramus of pubis
9. Obturator foramen
10. Inferior ramus of pubis
11. Pubic symphysis
12. Ischium
13. Lesser trochanter
14. Intertrochanteric crest
15. Greater trochanter
16. Neck of femur
1. Greater trochanter
2. Intertrochanteric crest
3. Lesser trochanter
4. Neck of femur
5. Head of femur
6. Acetabular fossa
7. Superior ramus of pubis
8. Obturator foramen
9. Inferior ramus of pubis
10. Ischium
CT
1- Sacroiliac joint
2- Sacrum
3- Sacral neural foramen
4- Iliac bone
5- Femur head
6- Symphysis pubis
7- Ischium
8- Greater trochanter
9- Femur neck
10- Pubic bone (inferior ramus)
11- Femur shaft
CONGENITAL HIP DISLOCATION
Ultrasound (US) has always had a relatively limited role in the evaluation of the hip due to the deep location of this joint. However, many hip diseases are well detectable at US, but before approaching such a study it is necessary to be thoroughly familiar with the normal anatomy and related US images. The study technique is particularly important as optimization of various parameters is required, such as probe frequency, focalization, positioning of the probe, etc.
US scans obtained at the proximal tendon of the rectus femoris (A) and at the proximal myotendinous junction (B). (B, D) T1-weighted MRI images corresponding to the US scans. US provides visualization of the direct tendon (black arrows) and the indirect tendon (white arrows) of the rectus femoris. In A, the posterior shadow cone of the tendon is an indirect consequence of its obliquity. At the rectus femoris myotendinous junction (DA), it is inserted onto the lateral surface of the direct tendon.

TFL: tensor fasciae latae muscle; Sa: sartorius muscle; RF: rectus femoris; IP: iliopsoas muscle; PGL: small gluteal muscle.
US images on the left): US Sagittal scan obtained at the direct tendon (black arrows) and indirect tendon (white arrows) of the rectus femoris muscle (RF). The image on the top was obtained by scanning at the medial level as compared to the image below. (MR images on the right): T1-weighted MR image corresponding to the US scans. The direct tendon shows a homogeneous and hyperechoic appearance. Its insertion on to the anterior-inferior iliac spine is well visible on the US image. In physiological conditions the tendon is thicker just before insertion. In B, the indirect tendon appears hypoechoic because of anisotropy.
Hip MRI Anatomy: T1-weighted axial view. Image 16. 1. Tensor fasciae latae m. 2. Rectus femoris m. 3. Femoral vessels. 4. Sartorius m. 5. Gluteus maximus m. 6. Obturator internus m. 7. Quadratus femoris m. 8. Greater trochanter.
Hip MRI Anatomy: T1-weighted coronal view. Image 1. 1. Iliac crest. 2. Iliacus m. 3. Gluteus medius m. 4. Tensor fasciae latae m. 5. Pectineus m. 6. Urinary bladder. 7. Symphysis pubis. 8. Gluteus minimus m.
KNEE
Radiographic Anatomy

The knee joint is composed of three articulations: the medial and lateral femorotibial and patellofemoral articulations. Although they share a common joint capsule, these articulations are often referred to separately as the medial, lateral, and patellofemoral compartments or joints. An anteroposterior (AP) knee radiograph shows the femoral condyles and tibial plateaus. The medial and lateral compartment radiolucent “joint spaces” or “cartilage spaces” should be equal with the knee extended; asymmetry usually indicates cartilage loss, ligamentous laxity, or both.
1. AP & lat x-ray

[Image of an x-ray of a knee joint, labeled with numbers 1 to 7 on the left and 1 to 6 on the right.]
1- Femur
2- Lateral condyle
3- Medial condyle
4- Patella
5- Tibia
6- Fibula
7- Lateral tibial spine
8- Medial tibial spine
9- Intercondylar notch
1- Femur
2- Femur condyle
3- Patella
4- Tibia
5- Fibula
6- Tibial teberosity
7- Tibial spine
SEVERE OSTEOARTHRITIS
Role of Ultrasound

Ultrasound is essentially used for the external structures of the knee. Ultrasound is a valuable diagnostic tool in assessing the following indications: Muscular, tendinous and ligamentous damage (chronic and acute) Bursitis Joint effusion Popliteal vascular pathology Haematomas Masses such as Baker’s cysts, lipomas Classification of a mass e.g. solid, cystic, mixed Post surgical complications e.g. abscess, edema Guidance of injection, aspiration or biopsy Relationship of normal anatomy and pathology to each other Some boney pathology.

Limitations

It is recognised that ultrasound offers little or no diagnostic information for internal structures such as the cruciate ligaments. Ultrasound is complementary with other modalities, including plain X-ray, CT, MRI and arthroscopy.
Transverse suprapatella region:
- RF: Rectus Femoris
- VL: Vastus intermedius
- VM: Vastus Medialis

Longitudinal suprapatella region showing the suprapatella bursa and quadriceps tendon.
Confirm both arterial and venous flow and exclude a popliteal artery aneurysm. If a popliteal aneurysm is discovered, always extend the examination to the other leg and the abdomen. There is a risk of bilateral and high association with aortic aneurysm.
CT
surfaces can slide easily over each other. Cartilage ensures smooth movement. 

Menisci 

Particular disks of the knee-joint are called menisci because they fill the joint space. These two disks, the medial meniscus and the lateral meniscus, are connective tissue with extensive collagen fibers containing cartilage.
Ligaments:

Intracapsular.

The knee is stabilized by a pair of cruciate ligaments. The anterior cruciate ligament (ACL) stretches from the lateral condyle of femur to the anterior intercondylar area. The ACL is critically important because it prevents the tibia from being pushed too far anterior relative to the femur. It is often torn during wisting or bending of the knee. The posterior cruciate ligament (PCL) stretches from medial condyle of femur to the posterior intercondylar area. Injury to this ligament is uncommon but can occur as a direct result of forced trauma to the ligament. This ligament prevents posterior displacement of the tibia relative to the femur.

The transverse ligament stretches from the lateral meniscus to the medial meniscus. It passes in front of the menisci. It is divided into several strips in 10% of
Extracapsular.

The **patellar ligament** connects the **patella** to the **tuberosity of the tibia**.

The **medial collateral ligament** (MCL a.k.a. "tibial") stretches from the **medial epicondyle of the femur** to the **medial tibial condyle**. It is closely associated with the **semimembranosus** and partly covered by the **pes anserinus**. The MCL is partly covered by the **pes anserinus** and the **semimembranosus** passes under it. It protects the medial side of the knee from being bent open by a stress applied to the lateral side of the knee (a **valgus** force). The **lateral collateral ligament** stretches from the **lateral epicondyle of the femur** to the **head of fibula**. It is separate from both the joint capsule and the lateral meniscus.
THIGH
1- Vastus lateralis muscle
2- Vastus intermedius muscle
3- Vastus medialis muscle
4- Rectus femoris muscle
5- Sartorius muscle
6- Gracilie muscle
7- Adductor magnus muscle
8- Adductor longus muscle
9- Semimemranous muscle
10- Semitendinosus Muscle
11- Biceps femoris muscle
12- Femur
13- Femoral artery
The knee joint joins the thigh with the leg and consists of two articulations: one between the femur and tibia, and one between the femur and patella.
ANKLE
The ankle joint or “talocrural joint” is a synovial hinge joint that is made up of the articulation of 3 bones. The 3 bones are the tibia, the fibula and the talus. The articulations are between the talus and the tibia and the talus and the fibula.
1- Tibia
2- Medial malleolus
3- Fibula
4- Lateral malleolus
5- Dome of talus
1- Fibula
2- Tibia
3- Talus
4- Calcenous
5- Navicular
Ultrasound of the ankle:

For specific indications, ultrasound (US) is an efficient and inexpensive alternative to magnetic resonance (MR) imaging for evaluation of the ankle. In addition to the tendons and tendon sheaths, other ankle structures demonstrated with US include the anterior joint space, retrocalcaneal bursa, ligaments, and plantar fascia. Ankle US allows detection of tenosynovitis and tendinitis, as well as partial and complete tendon tears. Joint effusions, intraarticular bodies, ganglion cysts, ligamentous tears, and plantar fasciitis can also be diagnosed.
Peroneus longus and brevis tendons. Transverse at the medial malleolus.

Peroneus brevis insertion onto the base of the 5th metatarsal.
Ligaments.
The ankle joint is bound by the strong deltoïd ligament and three lateral ligaments: the anterior talofibular ligament, the posterior talofibular ligament, and the calcaneofibular ligament.
The deltoïd ligament supports the medial side of the joint, and is attached at the medial malleolus of the tibia and connect in four places to the sustentaculum tali of the calcaneus, calcaneonavicular ligament, the navicular tuberosity, and to the medial surface of the talus.
MRI of ankle, coronal view, image 24.

1. Soleus muscle
2. Achilles tendon
3. Calcaneus
1-Medial cuneiform bone
2- Intermediate cuneiform bone
3- Lateral cuneiform bone
4- Cuboid bone
5- Navicular bone
6- Calceneal bone
7- Talus
8- Metatarsal bone (1st toe)
9- Proximal phalanx (1st toe)
10- Distal phalanx (1st toe)
Lateral View of the Foot

- talus
- neck of talus
- navicular
- first metatarsal
- phalanges
- cuboid
- calcaneus
MRI of ankle, axial view, image 20.

1. 1st metatarsal. 2. 3rd metatarsal. 3. 4th metatarsal. 4. Cuboid. 5. Abductor digiti minimi muscle. 6. Calcaneus. 7. Abductor hallucis muscle. 8. Quadratus plantae muscle.
MRI of ankle, axial view, image 22. 1. Abductor hallucis muscle. 2. 4th metatarsal. 3. 5th metatarsal. 4. Abductor digiti minimi muscle. 5. Calcaneus. 6. Flexor digitorum brevis muscle.
LOWER LIMB ARTERIES
• Circulation of blood to Pelvis and lower limb, (Arterial supply)
• right and left common iliac arteries each divide into the external and internal iliac arteries.
• internal iliac arteries supply the organs within the pelvic cavity.
Circulation of blood to Pelvis and lower limb, (Arterial supply)

• The external iliac artery pass into the thigh where it becomes femoral artery.
• femoral artery becomes popliteal artery, which supply the thigh, knee joint (where the pulse can be felt). Then it divides into anterior and posterior tibial arteries.
1- Popliteal artery
2- Anterior tibial artery
3- Peroneal artery
4- Posterior tibial artery
VEINS OF LOWER LIMB

• 1. SUPERFICIAL VEINS
• 2. DEEP VEINS
• 3. PERFORATING VEINS
1. SUPERFICIAL VEINS

- They lie in the superficial fascia
- They possess many valves along their course
- They communicate with deep veins by perforating veins
- They consist of:
  1. Dorsal venous arch
  2. Great saphenous vein & its tributaries
  3. Small saphenous vein & its tributaries
2. DEEP VEINS

- They consist of:
  1. Venae comitantes to anterior & posterior tibial arteries + their tributaries
  2. Popliteal vein + its tributaries
  3. Femoral vein + its tributaries
3. PERFORATING VEINS

- They are communicating vessels between superficial & deep veins
- They are found mainly in region of ankle & medial side of lower part of leg
- They possess valves that prevent flow of blood from deep to superficial veins
VARICOSE VEINS OF LOWER LIMB

• A condition in which superficial veins of lower limb are elongated & tortuous

• Causes:
  1. Weakness of the walls of veins & incompetence of their valves
  2. Incompetence of valves in perforating veins
  3. Lack of power of calf muscles
  4. Treatment: ligation & division of superficial veins