Guide for use of these notes

First of all thank you for choosing to download these notes to study from I hope you find them useful, please feel free to email me if you have any problems with the notes or if you notice any errors. I don't promise to respond to all emails but I'll do my best.

For the Anatomy of The Abdomen and Pelvis notes I used a mixture of Gray's, Netter's and Clinically Orientated Anatomy. In addition some detail is taken from Instant Anatomy for android written by Dr. Robert Whitaker who teaches anatomy at Cambridge.

I organise my notes so that you should read the learning objectives on the left then proceed down the right hand side for a few learning objectives and then cross back over to the left and continue like that.

Anything in this highlighted green is a definition or explains basically something's function.

🌟 Text highlighted in yellow or with a star is what I would deem important and key to your learning.

Italics and bold just help to make certain terms stand out.

The notes are a bit quirky but I hope you like them and find some of the memory aides strange enough so that they stick in your head.

I provide them to you in OneNote format as that is how I created them, they can be saved as PDF but the formatting is not as nice. The one caveat with this is that these notes are freely copy able and editable. I would prefer if you didn't copy and paste my notes into your own but used them as a reference or preferably instead embellished these already existing notes by adding to them.

Good luck with first year

Stuart Taylor
Abdominal wall, inguinal region and hernias

1. **Describe the rectus sheath and its contents.**
2. **Define the linea alba and the linea semilunaris.**
3. **Demonstrate in the living subject and in dissected material the nature and course of the inguinal canal making correct use of the following terms:**
   - Superficial and deep inguinal rings
   - Pubic tubercle
   - Testicular vessels, scrotum, spermatic cord, ductus deferens, round ligament of the uterus.
4. **Distinguish between direct and indirect inguinal hernias.**
5. **Distinguish between acquired and congenital inguinal hernia.**
6. **Summarise the anatomical basis for femoral hernia.**
7. **Explain the importance of the distinction between the fatty and membranous layers of the superficial fascia.**

### General Information on hernias
- **Hernia**: A protrusion of a viscus through a defect in its containing compartment such as a hole in the abdominal wall.
  - Reducible: sac returns to containing cavity
  - Irreducible: sac cannot be returned to containing cavity
  - Obstructed: sac contains blocked bowel
  - Strangulated: sac’s contents with strangulated blood supply

- **Children** can be born with a defect in the groin.
  - 10x more common in males because of embryological descent of testes.

### Distinguish between direct and indirect inguinal hernias.
- **Direct**
  - Most common type
  - Tend to be in younger adults and children
  - Due to lax deep ring or patent processus vaginalis
  - More common on the right hand side
  - The deep ring is too large, peritoneum pushes through.
  - Indirect hernia defect is always the deep/internal ring which is always LATERAL to the inferior epigastric vessels.

- **Indirect**
  - This is the most common type
  - Tend to be in younger adults and children
  - Due to lax deep ring or patent processus vaginalis
  - More common on the right hand side
  - The deep ring is too large, peritoneum pushes through.
  - Indirect hernia defect is always the deep/internal ring which is always LATERAL to the inferior epigastric vessels.

### Distinguish between acquired and congenital inguinal hernia.
- Most often occurs in male babies due to a patent processus vaginalis.
- Processus is required for testicular descent and if it does not close properly the baby can get an indirect hernia.
- Testes descend at the back of the abdomen.
- They descend at the level of the kidneys which migrate to the scrotum.
- They descend at the back of the abdomen.
- There is a finger of peritoneum and the testes descend behind it which acts as a guide.
- The finger of peritoneum is supposed to seal off which can be filled with bowel.

### Arrangement of the sheet muscles
- Three sheet muscles, from superficial to deep, are:
  - **Proprioceptors for the chest wall**
  - **Internal oblique and Transversus abdominis layers**
  - **Rectus abdominis**
Factors associated with hernia
- Chronic cough - COPD, asthma
- Prostatic disease
- Constipation
- Muscular effort e.g. job
- Previous hernia repair
- Obesity
- Ascites

Treatment is to stitch or clip in a mesh of polypropene low chance of recurrence is 1%.

Distinguish between acquired and congenital inguinal hernia

Summarise the anatomical basis for femoral hernia.

Borders of the femoral canal
- Superior: Inguinal ligament
- Inferior: Pectineus fascia
- Medial: Lacunar ligament
- Lateral: Femoral vein

The three sheet muscles, from superficial to deep, are:
- External oblique
  - Slips off of ribs 5-12 and descends antero-inferiorly. Has an important free posterior border which runs from the anterior superior iliac spine (ASIS) to the pubic tubercle forming the inguinal ligament.
- Internal oblique
  - Originates from lumbar fascia, anterior 2/3 of iliac crest and lateral 2/3 of the inguinal ligament.
  - Highest ascend to ribs 10-12 lowest descend to the crest and medial part of pectineal line of the pubis.
- Transversus abdominis
  - Runs medially from the inner aspect of the costal margin from ribs 7-12, the lumbar fascia and from the anterior 2/3 of the iliac crest to the lateral 1/3 of the inguinal ligament.
  - Lowest fibres insert on the pubic crest and the pectineal line with the lower part of the internal oblique muscle as the conjoint tendon.

The arrangement is homologous with the three layers of muscles found in the intercostal spaces. All three originate from the margins of the anterolateral wall, turn into aponeuroses (sheet-like tendons) in the anterior abdominal wall, and insert into a tough fibrous band called the linea alba (white line) that extends in the mid-line from the xiphoid process of the sternum to the pubic symphysis.

Demonstrate in the living subject and in dissected material the nature and course of the inguinal canal making correct use of the following terms:
- Superficial and deep inguinal rings, mid-inguinal point, pubic tubercle, testis, testicular vessels, scrotum, spermatic cord, ductus deferens, round ligament of the uterus.

Inguinal canal
- A canal formed by the layers of the abdominal wall muscle.
- Approximately 4cm long.
- It runs from the deep ring to the superficial ring.
- Transmits the spermatic cord in the male and round ligament of the uterus in females.
- Also transmits into ilioinguinal nerve.

Deep ring: The deep (internal) ring is an opening in the back wall of the inguinal canal through which the canal’s contents exit.

Superficial ring: V shaped slit in the external oblique aponeurosis that allows the content of the canal to exit e.g. to the scrotum.

Summary of the borders of the inguinal canal
- Anterior: External oblique aponeurosis + internal oblique
- Floor: Inguinal ligament
- Roof: Internal oblique arching over
- Posterior: Transversalis fascia and conjoint tendon medially

(Transversalis is the same thing as transversus abdominis)

On examination femoral hernias tend to be irreducible, and hot and painful if strangulated.
On examination femoral hernias tend to be irreducible, and hot and painful if strangulated.

- They can be distinguished from inguinal hernias because they appear below and lateral to the pubic tubercle.
- Inguinal hernias are above and medial to the pubic tubercle.

**Explain the importance of the distinction between the fatty and membranous layers of the superficial fascia**

- The superficial fascia of the abdominal wall (subcutaneous tissue of the abdomen) is a layer of fatty connective tissue. It is usually a single layer similar to, and continuous with the superficial fascia throughout other regions of the body. However, in the lower region of the anterior part of the abdominal wall, below the umbilicus, it forms two layers: a superficial fatty layer and a deeper membranous layer.

**Superficial fatty layer**
- This layer contains fat and varies in thickness. It is also known as Camper’s fascia.
- It is continuous over the inguinal ligament with the superficial fascia of the thigh and with a similar layer in the perineum.
- In men, this superficial layer continues over the penis and, after losing its fat and fusing with the deeper layer of superficial fascia, continues into the scrotum where it forms a specialised fascial layer containing smooth muscle fibres (the dartos fascia). In women, this superficial layer retains some fat and is a component of the labia majora.

**Deeper Layer**
- The deeper membranous layer of superficial fascia (Scarpa’s fascia) is thin and membranous, and contains little or no fat. Inferiorly, it continues into the thigh, but just below the inguinal ligament, it fuses with the deep fascia of the thigh.
- In the midline, it is firmly attached to the linea alba and the symphysis pubis. It continues into the anterior part of the perineum where it is firmly attached to the ischiopubic rami and to the posterior margin of the perineal membrane. Here, it is referred to as the superficial perineal fascia (Colles’ fascia).
- In men, the deeper membranous layer of superficial fascia blends with the superficial layer as they both pass over the penis, forming the superficial fascia of the penis, before they continue into the scrotum where they form the dartos fascia.
- Also in men, extensions of the deeper membranous layer of superficial fascia attached to the pubic symphysis pass inferiorly onto the dorsum and sides of the penis to form the fundiform ligament of penis.
- In women, the membranous layer of the superficial fascia continues into the labia majora and the anterior part of the perineum.
Iliac tubercle is 5cm behind the Anterior Superior Iliac Spine. The Transpyloric plane is from the 9th costal cartilages across. The Subcostal plane is the horizontal plane at level of costal margin in the mid axillary line. The Supracristal plane is transverse plane running along the top of the iliac crests just below the umbilicus.

Formed from the transtubercular plane, subcostal plane and two midclavicular vertical planes.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Vertebal level</th>
</tr>
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<tbody>
<tr>
<td>Xiphisternum</td>
<td>Th/9</td>
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<tr>
<td>Transpyloric plane</td>
<td>L1</td>
</tr>
<tr>
<td>Tip of 9th costal cartilage</td>
<td>L1</td>
</tr>
<tr>
<td>Subcostal plane (Rib 10)</td>
<td>L2</td>
</tr>
<tr>
<td>Umbilicus</td>
<td>L3/4</td>
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<tr>
<td>Supracristal plane</td>
<td>L4</td>
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<tr>
<td>Iliac tubercles</td>
<td>L5</td>
</tr>
<tr>
<td>ASIS and PSIS/ Sacral Dimple</td>
<td>S2</td>
</tr>
<tr>
<td>Midpoint of sacroiliac joint</td>
<td>S2</td>
</tr>
</tbody>
</table>

Structures at Transpyloric Plane:
- L1 vertebrae
- 9th CC
- Origin of SMA
- Formation of Portal Vein
- Neck of the Pancreas
- Hilum of the Kidney
- Hilum of the Spleen
- Duodenal-jejunal flexure
- Pylorus
- Transverse Colon
- Fundus of gall bladder
- End of spinal cord

That's 12 bitches.
**Learning Objectives**

- Define parietal and visceral peritoneum and explain the functions of the peritoneum and peritoneal cavity
- Draw diagrams to explain different relationships to the peritoneum (mesenteries and retroperitoneal positions) and list the structures contained within a typical mesentery
- Describe the peritoneal reflections in relation to major parts of the gut and associated organs from the oesophagus to the rectum, with special attention to the attachments and contents of the greater and lesser omenta and the mesentery proper
- Describe the boundaries of the lesser sac and of the epiploic foramen (of Winslow)
- Name the regions of the gut from oesophagus to rectum and summarise their main functions
- Describe the sources and distribution of arteries to important structures or organs derived from the foregut, midgut and hindgut.

**Define parietal and visceral peritoneum and explain the functions of the peritoneum and peritoneal cavity**

- Normally elements of the gastrointestinal tract and its derivatives completely fill the abdominal cavity, making the peritoneal cavity a potential space, and visceral peritoneum on organs and parietal peritoneum in the adjacent abdominal wall slide freely against one another.
- The peritoneum is a epithelial like single layer of cells (the mesothelium) together with a supportive layer of connective tissue. Peritoneum is similar to the pleura and serous pericardium in the thorax.
- The peritoneum reflects off the abdominal wall to become a component of the mesenteries that suspend the viscera.
- Components of the GI tract are suspended in peritoneal reflections called mesenteries.

**Gut and Peritoneum**

- Parietal Peritoneum
- Visceral Peritoneum
- Viscera e.g. Bowel

**Peritoneal Cavity**

- Parietal peritoneum lines the abdominal wall
- Visceral peritoneum covers suspended organs.
- GI tract is suspended from the posterior/dorsal aspect.
- Peritoneal folds attaching visera to the abdominal wall.
- Filled with peritoneal fluid secreted by the mesothelium.
- Epithelial layer secretes the fluid and circulates into the lymphatic vessels especially at the inferior surface of the diaphragm.

**Intra vs. Retroperitoneal**

- Intraperitoneal - structures e.g. most of small intestine, suspended from the abdominal wall by mesenteries.
- Retroperitoneal - structures e.g. kidneys and great vessels i.e. aorta and vena cava that lie between parietal peritoneum and posterior abdominal wall.

**Draw diagrams to explain different relationships to the peritoneum (mesenteries and retroperitoneal positions) and list the structures contained within a typical mesentery**

**Intraperitoneal**

- Organs that lie within the peritoneal cavity
- Organs that lie on the anterior or posterior surface of the peritoneum

**Retroperitoneal**

- Organs that lie behind the peritoneum
- Organs that lie on the posterior surface of the peritoneum

**Retroperitoneal structures: Primary**

- Suprarenal glands (the adrenals)
- Kidneys
- Ureter
- Bladder
- Aorta
- IVC
- Esophagus
- Rectum (part, lower 3rd is extraperitoneal)

**Secondary**

- The head, neck, and body of the pancreas but not the tail which is located in the splenorenal ligament.
- Duodenum apart from the proximal first segment which is intraperitoneal
- Ascending and descending portions of colon (but not the transverse or cecum)

**In women: Uterus, Fallopian Tubes, Ovaries**

- Good memory aide is **SAD PUCKER**.

* These organs originally had a mesentery, then became secondarily retroperitoneal when the mesentery fused with the body wall.

**GI tract Basic Plan**

- Bare area of liver
- Diaphragm
- Visceral peritoneum
- Lessor omentum
- Ventral
- Faliform ligament
- Cloaca
- Limbical artery
- Vaseline duct
- Adjacent structures
- Mesentry
- Lesser omentum
- Sigmoid Colon
- Stomach
- Subarenal
- Liver
- Left renal
- Visceral peritoneum
- Liver
- Diverticulum
- Inferior peritoneum
The part of the abdominal cavity enclosed by the expanded dorsal mesentery, and posterior to the stomach, is the omental bursa (lesser sac). Access through the omental foramen to this space from the rest of the peritoneal cavity (greater sac) is inferior to the free edge of the ventral mesentery.

The greater omentum is suspended from the greater curvature of the stomach, lines every other viscus in the abdominal cavity, and is the first structure observed when the abdominal cavity is opened anteriorly.

As the liver grows it moves to the right while the dorsal mesentery and spleen move to the left. The original right side of the upper peritoneal cavity is now posterior - the lesser sac of the peritoneal cavity.

Lower part of dorsal foregut mesentery extends down as a double fold called the greater omentum anterior to the intestine.

The lesser omentum is part of the ventral foregut mesentery.

Functions of greater omentum:

i. Fat deposition, having varying amounts of adipose tissue

ii. Immune contribution, having milky spots of macrophage collections

iii. Infection and wound isolation; it may also physically limit the spread of intraperitoneal infections. The greater omentum can often be found wrapped around areas of infection and trauma.

Describe the boundaries of the lesser sac and of the epiploic foramen (of Winslow)
Describe the boundaries of the lesser sac and of the epiploic foramen (of Winslow)

• The portal vein, hepatic artery and bile duct run between the posterior abdominal wall and liver within the lesser omentum near its free edge. This free edge is present because the ventral mesentery ends at the start of the midgut.

The greater and lesser sacs of the peritoneal cavity communicate through a narrow opening called the epiploic foramen (entry to the lesser sac). This lies just below the liver, posterior to the free edge of the lesser omentum.

• The lesser omentum (small omentum; gastrohepatic omentum; omentum minus) is the double layer of peritoneum that extends from the liver to the lesser curvature of the stomach and the start of the duodenum.

• Lesser sac (Omental Bursa): It is the cavity in the abdomen that is formed by the lesser and greater omentum. Usually found in mammals, it is connected with the greater sac via the epiploic foramen (also known as the Foramen of Winslow). It is demarcated anteriorly by the caudate lobe of the liver, the stomach and lesser omentum. Posteriorly it is marked by the pancreas. Its left lateral margin is made by the left kidney and adrenal gland. Its boundary on the right is made by the epiploic foramen and lesser omentum.

• Greater sac: This is the general cavity of the abdomen or peritoneal cavity. It is connected with the lesser sac via the omental foramen also known as the Foramen of Winslow or Epiploic Foramen.

Describe the sources and distribution of arteries to important structures or organs derived from the foregut, midgut and hindgut.

3 unpaired arteries arise from the anterior of the aorta
Describe the sources and distribution of arteries to important structures or organs derived from the foregut, midgut and hindgut.

- 3 unpaired arteries arising from the anterior of the aorta
  - Coeliac trunk - Foregut, liver, pancreas and spleen.
  - Superior mesenteric artery (SMA) - Midgut
  - Inferior mesenteric artery (IMA) - Hindgut

- Splenic vein drains into the superior mesenteric which drains into the portal vein.
- The portal vein arises from the superior mesenteric and splenic veins posterior to the 1st part of the duodenum/ pylorus of the stomach. It then runs in the free edge of the lesser omentum to the liver.

Venous return, lymphatics and nerve fibres

Venous System
- All veins drain back to the liver.
- Liver will process the nutrients and pass them all back into the systemic circulation.
- Portal vein - gut → liver.

Porto-systemic anastomoses
- The portal systemic anastomoses are where veins draining to the portal vein and the IVC communicate.
- Liver or portal obstruction causes these veins to dilate widely, possibly leading to severe haemorrhage from oesophagus or rectum.

Inferior is the smallest one.

Coeliac trunk
- Supplies the entire foregut (lower oesophagus, stomach, upper duodenum) and its derivatives (liver and part of pancreas). The spleen, though not part of the alimentary system, develops close to the foregut and shares its blood supply from the coeliac trunk.
The main branches of the Coeliac trunk are the Left Gastric Artery, Splenic Artery and the Common Hepatic Artery.

**GI Overview**

- This block of structures forms the posterior relations of the liver and stomach and is part of the retroperitoneum.
- The aorta bifurcates at the level of L3 into the inferior mesenteric and then at L4 to common iliac artery which means you cannot have an abdominal aortic aneurysm below the umbilicus which rules out one diagnosis.

**Superior Mesenteric Artery**

- Branches include:
  - Middle colic artery
  - Right colic artery
  - Ileocolic artery
  - Jejunal arteries
  - Ileal arteries

**Inferior Mesenteric Artery**

- The junction of the mid and hind gut is near the left splenic flexure of the colon. There is a change from superior to inferior mesenteric artery supply at this level, but with anastomoses between them.

**Lymphatics**

As in other parts of the body, the lymphatic drainage of the bowel follows the arterial supply, not the venous drainage. This is particularly important in the gut, where the two routes are very different.

**Nerves:**

- Abdominal viscera is supplied by autonomic nervous system.
- Sensory fibres most important.
- Parasympathetic sensory (regulate reflex gut function)
  - vagus nerve
  - pelvic splanchnic nerves (S2-S4)
- Sympathetic sensory (mediate pain)
  - thoracic splanchnic (T5-T12)
  - lumbar splanchnic (L1-L2)

**Thoracic Splanchnic Ns.**

- greater splanchnic n. (T5-T9)
- lesser splanchnic n. (T10-T11)
- least splanchnic n. (T12)

- Innervation: the sensory fibres are most important.
- In the viscera the sensory fibres running with the sympathetic (T1-L2) mediate pain.
- Sensory fibres running with the parasympathetic (vagus or sacral) are involved in reflex regulation of gut function.
- L5 arteries:
  - Left colic artery
  - Superior rectal artery
  - Sigmoidal artery
Learning Objectives

- Define the anatomical and functional lobes of the liver.
- Define the term "portal triad".
- Know the names and contents of the mesenteries associated with the liver and spleen.
- Draw a basic diagram of the biliary tree.
- List the three major sites of porto-systemic anastomoses and their clinical pathology in portal hypertension.
- Know the anatomical relations of the liver and spleen.
- Draw a basic diagram of the biliary tree.

Relevant diagrams and images are included in the text to aid understanding.
1. Paraumbilical veins- Superficial veins on abdominal veins. (They can become very dilated) Caput medusae.
2. Superior rectal veins- Inferior rectal veins- haemorrhoids development
3. Left gastric vein-tributaries of azygos vein- Clinically most important, bleeding oesophageal varices massive vomiting of blood especially bad as they are likely to have liver disease therefore poor clotting factors.

Know the names and contents of the mesenteries associated with the liver and spleen.

- **Mesentery**: Two layers of peritoneum that are closely reflected to each other
- **Conduit for arteries, veins, nerves and lymphatics supplying viscera.
- **Bag metaphor** imagine pushing your hand into a bag but the outside.

**Ventral and Dorsal Mesenteries**

- **Gastro-hepatic Lig**: Contains right and left gastric arteries.
- **Hepato-duodenal Ligament**: This contains the portal triad- portal vein, hepatic artery and bile duct.
- **Falciform ligament**: Runs from 1st part of duodenum to liver.
- **Ligament teres**: Runs from liver to anterior abdominal wall
- **Gastro-splenic ligament**: The free, thickened edge of the falciform ligament and contains the remnant of the umbilical vein which is now obliterated.
- **Gastro-splenic ligament (gastrolienal)**: Contains short gastric vessels and left gastro-omental vessels.
- **Spleno-renal ligament**: Contains tail of pancreas and splenic artery and vein.

Know the vascular supply/drainage of the liver, spleen and gallbladder.

**Liver**

- **Celiac axis**: Left gastric, splenic, common hepatic.
- **Common hepatic-** runs with the bile duct and portal vein in the free edge of the lesser omentum. Branches are:
  - Cystic
  - Left hepatic
  - Right hepatic

**Spleen**

- **Calot’s triangle**: Cholecystectomy- need to be careful when you clip off the artery that you do not clip off the common bile duct. Borders are:
  - Cystic duct
  - The common and right hepatic ducts
  - The inferior edge of the liver
- **Calot’s triangle contains**:
  - Cystic artery
  - Sometimes right hepatic artery
  - Calot’s lymph node- enlarged in cholecystitis.

**Portal circulation**

- The splenic artery reaches the spleen by travelling in the spleno-renal ligament.
The portal vein is formed from the Superior mesenteric vein and Splenic vein posterior to the neck of the pancreas at L2 level.

- Filter bacteria from GI tract.
- Metabolise all carbohydrates, fats etc.
- Transport of amino acids straight to the brain causes dementia/encephalopathy due to ammonia.

- The lesser sac is in the posterior part of the peritoneal cavity and is directly in front of the retroperitoneal organs including the pancreas, great vessels, duodenum and kidneys.

- Left gastric vein drains the fundus of the stomach.
- Blood drains from the liver directly into IVC via 3 short hepatic veins.

**Portal circulation**

**Anterior/Ventral**

**Posterior/Dorsal**

**CLOCKWISE** rotation of the stomach along its longitudinal axis results in the right side of the peritoneal cavity becoming POSTERIOR – the OMENTAL BURSA (= LESSER SAC)

ANTERIORLY (originally LEFT) is the GREATER SAC.

**Lesser Omentum**

- Free edge of lesser omentum contains:
  - Portal vein
  - Bile duct
  - Hepatic artery

- Contains tail of pancreas and splenic artery and vein.
Learning Objectives

- Define the terms intraperitoneal, retroperitoneal and secondarily retroperitoneal.
- List the retroperitoneal organs.
- Demonstrate and name the major branches of the abdominal aorta.
- Draw a basic diagram of the great vessels, kidneys, duodenum and pancreas.
- Name the major abdominal lymph nodes and outline their pattern of drainage.

Define the terms intraperitoneal, retroperitoneal and secondarily retroperitoneal.

**Intraperitoneal**
- Structures suspended from abdominal wall by mesenteries (e.g. most of small bowel).

**Retroperitoneal**
- Structures lying posterior to parietal peritoneum (e.g. kidneys and great vessels).

**Secondary retroperitoneal**
- These organs originally had a mesentery, then became secondarily retroperitoneal when the mesentery fused with the body wall.

List the retroperitoneal organs.

- **Primary**
  - Suprarenal glands (the adrenals)
  - Kidneys
  - Ureter
  - Bladder
  - Aorta
  - IVC
  - Esophagus
  - Rectum (part, lower 3rd is extraperitoneal)

- **Secondary**
  - The head, neck, and body of the pancreas but not the tail which is located in the splenorenal ligament.
  - Duodenum apart from the proximal first segment which is intraperitoneal.
  - Ascending and descending portions of colon (but not the transverse or cecum)

- Good memory aide is SAD PUCKER.

Demonstrate and name the major branches of the abdominal aorta.

- **Coeliac trunk** Supplies the Foregut
- **Superior mesenteric artery** Supplies the Midgut
- **Renal arteries** Kidneys
- **Inferior mesenteric artery** Supplies the Hindgut

Draw a basic diagram of the great vessels, kidneys, duodenum and pancreas.

Veins are always anterior to arteries.

Embryology
- The pancreas develops as a ventral and dorsal bud in the ventral and dorsal foregut mesenteries respectively and therefore starts intraperitoneally.
- The smaller ventral bud rotates clockwise to become dorsal and associated with the dorsal pancreatic bud.
- Also the superior mesenteric vein becomes trapped between the two and the buds fuse to become secondary peritoneal, except for the tail which lies in the splenorenal ligament. The original ventral bud is now called the uncinate process.
- Furthermore the embryology of the pancreas also explains why there is an accessory pancreatic duct in addition to the main one.
Name the major abdominal lymph nodes and outline their pattern of drainage.

**Lymphatic drainage follows the ARTERIES.**

- Superior mesenteric vein and superior mesenteric artery are trapped between the uncinate process and the neck of the pancreas.

**Visceral relations of the Kidneys**

- **Superior Mesenteric Nodes**
- **Inf. Mesenteric Nodes**
- **Sup. Mesenteric Nodes**
- **Cisterna Chyli**
- **Thoracic Duct**
- **Coeliac Nodes**
- **R. Adrenal Gland**
- **L. Adrenal Gland**
- **Liver**
- **Stomach**
- **Spleen**
- **Pancreas**
- **Descending Colon**
- **Jejunum**

**Renal Vasculature**

- **Right Renal A.**
- **Left Renal A.**
- **Right Renal V.**
- **Left Renal V.**
- **SMA – L1**
- **IMA – L3**
- **IVC**

**Duodenum**

- **Superior / first part** – duodenal cap, common place for peptic ulcers. Passes anteriorly to bile duct, gastroduodenal artery, portal vein and IVC.
- **Descending / second part** – contains minor and major duodenal papillae where accessory pancreatic duct and bile duct enter respectively.
- **Inferior / third part** – crosses IVC and has SMA anterior to it.
- **Ascending / fourth part** – terminates at duodenojejunal flexure.

- **Renal vessels arise at approximately L1** – the transpyloric plane
- **Left renal vein is longer than right renal vein and runs posterior to SMA but anterior the left renal artery. Aneurysms of SMA cause nutcracker syndrome.**
- **Note this is slightly weird because we usually say that veins lie anterior to arteries but this is a branch of the main aorta so that’s why it is ok for it to be weird and be posterior to the SMA.**
- **Left renal vein is longer than right renal vein and runs posterior to SMA but anterior the left renal artery.**
- **Aneurysms of SMA cause nutcracker syndrome.**
- **Note this is slightly weird because we usually say that veins lie anterior to arteries but this is a branch of the main aorta so that’s why it is ok for it to be weird and be posterior to the SMA.**
- **Mesenteric areas:**
  - **Superior / first part –** duodenal cap, common place for peptic ulcers. Passes anteriorly to bile duct, gastroduodenal artery, portal vein and IVC.
  - **Descending / second part –** contains minor and major duodenal papillae where accessory pancreatic duct and bile duct enter respectively.
  - **Inferior / third part –** crosses IVC and has SMA anterior to it.
  - **Ascending / fourth part –** terminates at duodenojejunal flexure.

- **Note that tail of pancreas and the spleen are intraperitoneal structures.**
- **Duodenal areas:**
  - **Superior / first part** – duodenal cap, common place for peptic ulcers. Passes anteriorly to bile duct, gastroduodenal artery, portal vein and IVC.
  - **Descending / second part** – contains minor and major duodenal papillae where accessory pancreatic duct and bile duct enter respectively.
  - **Inferior / third part** – crosses IVC and has SMA anterior to it.
  - **Ascending / fourth part** – terminates at duodenojejunal flexure.

- **Onblock resection** – reduces rates of recurrence in malignancy.
- **Divisions of para-aortic nodes cannot be done accurately in vivo.**
- **Cisterna Chyli is a dilated sac at the inferior end of the thoracic duct which empties into the junction of the left subclavian and left internal jugular veins in the thorax. Note the thoracic duct is found in the posterior mediastinum in the thorax and enters the abdomen through the aortic hiatus.**

- **Coeliac Nodes**
  - **Superior**
  - **Inf.**
  - **Thoracic Duct**
  - **Cisterna Chyli**
  - **Coeliac Nodes**
  - **Right Renal A.**
  - **Left Renal A.**
  - **Right Renal V.**
  - **Left Renal V.**
Learning Objectives

Demonstrate and draw the principal relations of the duodenum, pancreas and kidneys including major vascular relations.

Name the main organs in contact with each of the left and right kidneys

Describe the arterial supply of the kidneys and adrenal (suprarenal) glands

Mark the likely positions of the kidneys and ureters in a living subject and demonstrate their positions in appropriate plain and contrast radiographs and in CT images.

Demonstrate how to palpate the kidneys in a living subject.

Demonstrate the main components of the posterior abdominal wall from diaphragm to pelvic inlet.

Imaging Modalities

Plain abdominal X-Ray
- Gas, fat, soft tissue and calcium/metal are the only 4 radiographic densities.
- Renal and bladder outlines only visible because of surrounding fat.
- Frequently obscured bowel gas.
- Abdominal vessels not visible unless calcified.
- Most renal and ureteric stones visible (85% calcified)

Intravenous urogram/pyelogram
- Control images essential
- Iodine containing water soluble contrast given I.V
- Filtered by the kidney into the collecting system.
- Standard sequence of images taken.
- Immediate-nephrogram phase- contrast in the glomeruli and proximal tubules.

- Delayed images- 5mins, 10mins, 15mins
- May put compression on abdomen to distend the pelviccalyeal system
- Release image to show ureters and bladder
- Post micturition image of bladder.

- Control images essential
- Iodine containing water soluble contrast given I.V
- Filtered by the kidney into the collecting system.
- Standard sequence of images taken
- Immediate-nephrogram phase- contrast in the glomeruli and proximal tubules.

Relation of kidneys: Right
- Anterior- Peritoneum, right lobe of liver, duodenum, colon, hepatic flexure
- Posterior- diaphragm, quadratus lumboorum
- Lateral- abdominal wall
- Medial- Psoas major muscle, IVC, gonadal veins, ureter.

Relation of kidney Left
- Anterior- Peritoneum, stomach, splenic flexure, tail of pancreas, small bowel, spleen
- Posterior- diaphragm, quadratus lumboorum
- Medial- Aorta, gonadal veins, psoas major, ureter.

- Veins lie anterior to the arteries and there may be multiple renal arteries.
- Veins are bigger than arteries- veins are fat and irregular arteries are nice and round.
- Right renal vein shorter than left renal vein.
- Usually quite a bit of fat in between right kidney and adrenal so a lot higher up.
- Left adrenal is usually more medial and slightly lower down.

Ureter
- Runs from renal pelvis to bladder and is approximately 25 cm long.
- Lies on the medial edge of psoas in abdomen and enters pelvis by crossing common iliac vessels.
- Urter crosses in front of veins and arteries.
- Runs along lateral pelvic wall and enters bladder posteriomedially at bladder base at edge of the trigone.

CT Urogram
- Consider radiation dose
- Is there a need for a pre contrast scan to look for stones

Ultrasound
- No contrast or radiation, good for renal size, hydronephrosis, stones , some tumours, but relies heavily on whether the operator is good or not.

Demonstrate the main components of the posterior abdominal wall from diaphragm to pelvic inlet.

Urinary bladder
- Midline structure covered superiorly by peritoneum.
- Superior relations- Small bowel and sigmoid colon
- Anteriorly- Pubic symphysis
- Laterally- Levator ani and obturator internus
- Circular muscle in the wall condenses to form internal urethral sphincter at bladder neck

Horseshoe kidney:
- The kidneys are close together in the embryonic pelvis. In approximately 1 in 600 fetuses, the inferior poles (rarely, the superior poles) of the kidneys fuse to form a horseshoe kidney.
- This U-shaped kidney usually lies at the level of L2-L5 vertebrae because the root of the inferior mesenteric artery prevented normal relocation of the kidneys.
- Horseshoe kidney usually produces no symptoms; however, associated abnormalities

The Kidney Congenital Variants

Stuart’s Anatomy of the Abdomen and Pelvis Page 17
fetuses, the inferior poles (rarely, the superior poles) of the kidneys fuse to form a horseshoe kidney. This U-shaped kidney usually lies at the level of L3–L5 vertebrae because the root of the inferior mesenteric artery prevented normal relocation of the kidneys.

- Horseshoe kidney usually produces no symptoms; however, associated abnormalities of the kidney and renal pelvis may be present, obstructing the ureter.
- Horseshoe kidney results in a higher chance of hypertension and renal calculi.

Duplex collecting system

- Embryologically, duplication occurs when two separate ureteric buds arise from a single Wolffian Duct.
- Radiographical features may include duplicated ureters extending a variable distance down to the bladder and obstruction of the upper pole moiety down to the bladder, often with a ureterocoele.
- Pain in the back may occur after drinking excessively.

Renal colic: On a radiograph black fluid will be trapped behind a stone which will be relatively white.

Cystourethrography

- Retrograde urography - inject contrast via the urethral meatus
- Antegrade urography - fill bladder with contrast (usually via a catheter as too dilute after an IVU). Fluoroscopy with spot images during voiding
- Possible to measure bladder and rectal pressures during voiding to get an idea of function.

Aorta

- Extends from diaphragmatic hiatus to bifurcation at level of 4th lumbar vertebra
- < 50 yrs - should be < 2 cm in diameter
- >50 yrs - considered aneurysmal if > 3 cm
- Divides into R and L common iliac arteries which divide into internal and external iliac arteries.
- Also midline median sacral branch

Abdominal Arteriography

- Local anaesthetic in groin over the palpable femoral artery
- Puncture femoral artery (usually Rt)
- Pass guide wire through needle up the femoral and iliac arteries into the aorta
- Remove needle leaving guide wire in place
- Pass catheter over guide wire into aorta

Aortogram - injection of contrast into aorta
- Selective renal / coeliac / mesenteric arteriogram - manipulate catheter tip into origin of the appropriate vessel and then inject contrast
- DSA (digital subtraction angiogram) - electronically subtract the background to display only contrast in the vessels.

Venous Phase

Major Paired Branches

- Renal arteries
  - May be more than one to each kidney
  - Arise anterolaterally at approximately same level as SMA - lower border of L1
  - Right renal artery passes behind IVC
  - (Left renal vein passes anterior to the aorta)
Demonstrate how to palpate the kidneys in a living subject.

- The kidneys are often impalpable. In lean adults, the inferior pole of the right kidney is palpable by bimanual examination as a firm, smooth, somewhat rounded mass that descends during inspiration. Palpation of the right kidney is possible because it is 1–2 cm inferior to the left one.
- To palpate the kidneys, press the flank (side of the trunk between the 11th and 12th ribs and the iliac crest) anteriorly with one hand while palpating deeply at the costal margin with the other. The left kidney is usually not palpable unless it is enlarged or a retroperitoneal mass has displaced it inferiorly.
Learning Objectives

- Describe the origins and pathways by which autonomic nerves reach the abdomen.
- Discriminate between the distributions and motor functions of the sympathetic and parasympathetic nerves in the abdomen.
- Compare the sensory functions of the sympathetic and parasympathetic nerve supplies in the abdomen.
- Outline the segmental pattern of pain fibre distribution to the abdominal viscera.

Describe the origins and pathways by which autonomic nerves reach the abdomen. Sympathetic nervous system: arises from the T1-L2 spinal cord segments. Parasympathetic nervous system: arises from cranial nerves, III, VII, IX, X (oculomotor, facial, glossopharyngeal and vagus) and spinal cord segments S2-S4.

Discriminate between the distributions and motor functions of the sympathetic and parasympathetic nerves in the abdomen.

<table>
<thead>
<tr>
<th>Efferent</th>
<th>Afferent</th>
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<tbody>
<tr>
<td>Motor to smooth muscle</td>
<td>Sympathetic: pain</td>
</tr>
<tr>
<td>Secretomotor to glands</td>
<td>Parasympathetic: specific functional sensation e.g. stretch</td>
</tr>
</tbody>
</table>

Referenced Pain from Midgut Structures

- Umbilical pain: pain from midgut structures (from duodenal papilla to splenic flexure) including inflamed appendix referred to periumbilical region. It is usually colicky (intermittent with bowel contractions).

Note: No C1 dermatome.

- The brain cannot localise pain sensation from structures for which there is no map in the cortex. These structures are the visceral organs and the diaphragm.
- In these cases pain is referred to the regions of skin supplied by nerves with the same segmental supply (dermatomes).
- In the abdomen, the nerve supply to the organ is autonomic.

Dermatome
- Area of skin supplied by a single spinal nerve (i.e. single segment of the spinal cord).
- Adjacent dermatomes overlap so that on the trunk, at least three spinal nerves would have to be blocked to produce a region of complete anaesthesia.
- No C1 dermatome.

- Vagus travels along oesophagus in the abdominal region.
- Ganglia are named according to the major blood vessels supplying the GI tract.

Peripheral nerves and skin - Nerves run with somatic nerves to same region (sympathetic only).

Parasympathetic: Vagus nerve (CN X) and Sacral Outflow S2-S4 are the main supplies of the viscera.

Superior mesenteric plexus
- The autonomic nerves to the abdomen are routed via plexuses surrounding the aorta and its branches.
- Sympathetic nerves synapse at ganglia associated with these plexuses.
- Plexuses and ganglia are named according to the associated blood vessels.
- Plexus and ganglia are named according to the associated blood vessels.

Stuart's Anatomy of the Abdomen and Pelvis Page 11
Umbilical pain: pain from midgut structures (from duodenal papilla to splenic flexure) including inflamed appendix referred to periumbilical region. It is usually colicky (intermittent with bowel contractions).

- When the inflammation of the appendix spreads to the surrounding peritoneum the pain becomes localised and constant at the right inguinal region. Movement of the hip joint and coughing elicits pain.

Foregut structures
- Epigastric pain: pain from foregut structures (as far as duodenal papilla) is referred to this region. Structures involved: Stomach, proximal duodenum, pancreas, liver, gall bladder. T7/T8

Hindgut structures
- Suprapubic (hypogastric) pain: pain from hindgut structures descending colon to anal canal is referred here.
Learning Objectives

- Define the pelvic floor, identify its nerve supply and indicate its importance.
- Describe the course of the ureters from the renal pelvis to the entry into the urinary bladder.
- Describe the relations of the ureters to the uterine arteries and the cervix.
- Describe the shape, position and relations of the bladder in the male and female pelvis.
- Explain the anatomical relations of the full urinary bladder.
- Describe the shape, relations and arterial supply of the rectum.

Introduction

The Pelvic Girdle

- Sacro-iliac joint is a synovial joint.
- 2 foramen: Obturator foramen and Pelvic angle.

Right Hip Bone

- All 3 bones meet in the acetabulum.
- In a child they would not all be fused.

Right Hip Bone & Sacrum

- Child during birth has to leave through pelvic inlet.
- Satic notches are the curved parts of pelvis that are divided by the sacrospinous ligament.

Abdominopelvic Cavity

- Axis of abdominal cavity
- Axis of pelvic cavity
- Pelvic inlet
- Sacrum
- Coccyx
Describe the course of the ureters from the renal pelvis to the entry into the urinary bladder

- The ureters are muscular tubes that transport urine from the kidneys to the bladder.
- They are continuous superiorly with the renal pelvis, which is a funnel-shaped structure in the renal sinus.
- The renal pelvis is formed from a condensation of two or three major calices, which in turn are formed by the condensation of several minor calices. The minor calices surround a renal papilla.
- The renal pelvis narrows as it passes inferiorly through the hilum of the kidney and becomes continuous with the ureter at the ureteropelvic junction.
- Inferior to this junction, the ureters descend retroperitoneally on the medial aspect of the psoas major muscle.
- At the pelvic brim, the ureters cross either the end of the common iliac or the beginning of the external iliac arteries, enter the pelvic cavity, and continue their journey to the bladder.

Constriction of the ureters can occur at:

1. Ureteropelvic junction
2. Where the ureters cross the common iliac vessels at the pelvic brim
3. Where the ureters enter the wall of the bladder.

As a result kidney stones (renal calculi) can become lodged at these areas.

Describe the relations of the ureters to the uterine arteries and the cervix

- In the pelvis, the ureter is crossed by:
  1. The ductus deferens in men
  2. The uterine artery in women.

Describe the shape, position and relations of the bladder in the male and female pelvis

The pelvic cavity is coloured red. Note that its axis is angled about 45º back from the abdominal cavity (blue).

Pelvic cavity
- The iliac fossae form a shallow basin containing lower abdominal viscera.
- The axis of the pelvic cavity is antero-inferiorly inclined.
- Pelvic cavity is conical or cylindrical (birth canal)
- Cavity is mainly lined by muscles and nerves.

Define the pelvic floor, identify its nerve supply and indicate its importance.

Pelvic Wall Muscles and Ligaments

Two muscles are attached to the medial surface of the greater trochanter of femur

Medial aspect of right pelvic wall

The pelvic floor is formed by the pelvic diaphragm and, in the anterior midline, the perineal membrane and the muscles in the deep perineal pouch.

- The pelvic diaphragm is formed by the levator ani and the coccygeus muscles from both sides.
- The pelvic floor separates the pelvic cavity, above, from the perineum, below.

Pelvic diaphragm - This is the muscular part of the pelvic floor
- Shaped like a bowl or funnel and attached superiorly to the pelvic walls, it consists of the levator ani and coccygeous muscles.

Table 5.2 Muscles of the pelvic diaphragm

The Pelvic Wall

Most of the pelvic bone facing the pelvic cavity is covered by the obturator internus muscle and its fascia
Lumbosacral plexus supplies the lower limbs.

Pelvis Diaphragm / Pelvic Floor

- The muscle groups are collectively known as Levator ani which is very important in determining faecal continence.
- The three muscles that make up levator ani are:
  a. Iliococcygeus
  b. Pubococcygeus
  c. Puborectalis
- Obturator internus forms a tendinous arch.

Pelvic Diaphragm consists of a bowl-like pair of skeletal muscles: Levator ani, which support the pelvic organs (bladder, cervix/uterus and rectum)

Nerve supply: Pudendal (S2-4) & directly by S4

Urethral Sphincters - female

- In females internal urethral sphincter is not well organized
- External urethral sphincter is skeletal muscle surrounding the urethra in the deep perineal pouch
- Two additional groups of muscles in females:
  1. Sphincter urethrovaginalis
  2. Compressor urethrae

- Thick fascial sheet called perineal membrane - occupies anterior part.
- Because of vagina in women the structure is weaker.
- Keystone that has to be preserved during surgery - perineal body.

Pelvic floor and perineum

- A bowl-like sheet of muscle called levator ani that forms the pelvic diaphragm.
- Slung from the pelvis and sacrum.
A bowl-like sheet of muscle called levator ani that forms the pelvic diaphragm.

- Slung from the pelvis and sacrum.
- Supports the main pelvic viscera (bladder, uterus, rectum).
- Below the diaphragm is the perineum, containing voluntary sphincters and external genitalia.

Pelvic floor and perineum

- In females, the internal urethral sphincter is not well organized.
- The external urethral sphincter is skeletal muscle surrounding the urethra in the deep perineal pouch.
- Two additional groups of muscles in females:
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The apex of the bladder is directed toward the top of the pubic symphysis; a structure known as the median umbilical ligament continues from it superiorly up the anterior abdominal wall to the umbilicus.

The Urinary Bladder

- The bladder is the most anterior of the pelvic viscera. Despite being part of the pelvic cavity when empty, it expands superiorly when full into the abdominal cavity.
- Tetrahedral when empty
- Ureters enter at supero-posterior angles
- Urethra leaves through inferior angle
- Superior surface covered in peritoneum
- Expands between transversalis fascia and lining peritoneum
- Smooth muscle sphincter (vesicae) at neck
- Skeletal muscle sphincter (urethrae) in perineum

The tetrahedral bladder has a structure at each corner

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- Smooth muscle sphincter (vesicae) at neck
- Skeletal muscle sphincter (urethrae) in perineum

Describe the shape, relations, and arterial supply of the rectum

- ‘Rectum’ is Latin for ‘straight’, but the human rectum has a double-S bend, probably functioning as an anti-gravity device keeping load off the sphincter.
- Superior rectal artery is an offshoot of the inferior mesenteric artery.
- The rectum is supplied by the autonomic NS and is mainly sensitive to filling. The anal canal is supplied by somatic nerves and is extremely sensitive to injury.

The Rectum and Anal Canal

- The skeletal muscle sphincter ani surrounding the anal canal is much less important to faecal continence than the puborectalis part of levator ani, which puts a sharp angle into the recto-anal junction. Can be injured in a badly performed episiotomy.

The Rectal and Anal Canal

- The rectum descends within concavity of sacrum
- Shows three lateral curvatures
- Right-angle bend back at recto-anal junction
- Smooth muscle (internal) and skeletal muscle (external) sphincters
- Main functional sphincter is pubo-rectalis sling of levator ani
- Nerves: rectum - visceral; anal canal - somatic

Qu. 1: Which artery supplies pelvic organs (not ovaries and testis)?

- External iliac artery
- Inferior mesenteric artery
- Obturator artery
- Internal iliac artery
- None of the above

X Mark = 6 (conf = 3)

Best Option: Obturator artery

The best answer is obturator artery. The pelvic organs are supplied by named branches of the internal iliac and the inferior mesenteric artery. The obturator and iliolumbar arteries also supply the pelvic organs.
Describe the venous drainage of the rectum and anal canal and explain the occurrence of piles.

- The rectal venous plexus surrounds the rectum and communicates with the vesical venous plexus in the male, and the uterovaginal plexus in the female.
- A free communication between the portal and systemic venous systems is established through the haemorrhoidal plexus.

Haemorrhoids
- The inferior part of the rectal plexus around the anal canal has two parts, an internal and an external.
  - The internal rectal plexus is in connective tissue between the internal anal sphincter and the epithelium lining the canal.
  - This plexus connects superiorly with longitudinally arranged branches of the superior rectal vein that lie one in each anal column.
  - When enlarged, these branches form internal hemorrhoids, which originate above the pectinate line and are covered by colonic mucosa.
  - The external rectal plexus circles the external anal sphincter and is subcutaneous. Enlargement of vessels in the external rectal plexus results in external hemorrhoids.

Venous Supply of Pelvic Organs

Arterial Supply of Pelvic Organs

The Internal Iliac Artery supplies all the pelvic organs (except the ovaries), the pelvic walls and much of the buttock (gluteal) region.
Learning Objectives

- Identify the component bones of the pelvis and the following landmarks: iliac crest, anterior superior iliac spine, anterior inferior iliac spine, pubic symphysis, pubic tubercle, superior and inferior pubic rami, obturator foramen, ischial tuberosity, ischial spine.

- Distinguish structurally and functionally between the pelvis and the perineum.

- Explain the relationships of the urethra, urethral sphincter and erectile tissue masses in the female and the male perineum.

- Explain the anatomical considerations involved in passing a urinary catheter in a male.

- Demonstrate the positions and explain the functions of the ductus deferens, seminal vesicles and the prostate gland.

- Explain the contributions of the internal iliac and the gonadal arteries to the supply of the pelvic organs and walls.

- Explain the relationships of the urethra, urethral sphincter and erectile tissue masses in the female and the male perineum.

- Explain the anatomical considerations involved in passing a urinary catheter in a male.

- Male Urethra
  - In men, the urethra is long, about 20 cm, and bends twice along its course.
  - At the base of the bladder and passing inferiorly through the prostate, it passes through the deep perineal pouch and perineal membrane and immediately enters the root of the penis.
  - As the urethra exits the deep perineal pouch, it bends forward to course anteriorly in the root of the penis. When the penis is flaccid, the urethra makes another bend, this time inferiorly, when passing from the root to the body of the penis. During erection, the bend between the root and body of the penis disappears.
  - The urethra in men is divided into preprostatic, prostatic, membranous, and spongy parts.

  - Preprostatic part
  - The preprostatic part of the urethra is about 1 cm long, extends from the base of the bladder to the prostate, and is associated with a circular cuff of smooth muscle fibres (the internal urethral sphincter).

  - Contraction of this sphincter prevents retrograde movement of semen into the bladder during ejaculation.

  - Prostatic part
  - The prostatic part of the urethra is 3–4 cm long and is surrounded by the prostate. In this region, the lumen of the urethra is marked by a longitudinal midline fold of mucosa (the urethral crest). The depression on each side of the crest is the prostatic sinus; the ducts of the prostate empty into these two sinuses.

  - Midway along its length, the urethral crest is enlarged to form a somewhat circular elevation (the seminal colliculus). In men, the seminal colliculus is used to determine the position of the prostate gland during transurethral transection of the prostate.

  - A small blind-ended pouch—the prostatic urethra (thought to be the homologue of the uterus in women)—opens onto the centre of the seminal colliculus.

  - On each side of the prostatic urethra is the opening of the ejaculatory duct of the male reproductive system. Therefore, the connection between the urinary and reproductive tracts in men occurs in the prostatic part of the urethra.

  - Membranous part
  - The membranous part of the urethra is narrow and passes through the deep perineal pouch. During its transit through this pouch, the urethra, in both men and women, is surrounded by skeletal muscle of the external urethral sphincter.

  - Spongy urethra
  - The spongy urethra is surrounded by erectile tissue (the corpus spongiosum) of the penis. It is enlarged to form a bulb at the base of the penis and again at the end of the penis to form the navicular fossa. The two bulbourethral glands in the deep perineal pouch are part of the male reproductive system and open into the bulb of the spongy urethra.

  - External urethral orifice is the sagittal slit at the end of the penis.

  - Narrowest part of the external urethral orifice: if a catheter can get through this it should go all the way to the bladder.

  - Weakest part of the urethra is the membranous part of the urethra.

- Distinguish structurally and functionally between the pelvis and the perineum.

  - Perineum
    - The perineum is a diamond-shaped area between the pubic symphysis, ischial tuberosities, and coccyx.

- Identify the component bones of the pelvis and the following landmarks: iliac crest, anterior superior iliac spine, anterior inferior iliac spine, pubic symphysis, pubic tubercle, superior and inferior pubic rami, obturator foramen, ischial tuberosity, ischial spine.

Male & Female Pelves

- Male Pelvis
  - Pelvic inlet
  - Sub pubic angle: Wide > 90 degrees
  - Ischial spine: Not projecting medially
  - Greater (false) pelvis: Shallow
  - Lesser (true) pelvis: Wide, shallow & cylindrical
  - Y-X ratio (acetabulum): Less than one

- Female Pelvis
  - Pelvic inlet
  - Sub pubic angle: Narrow, heart-shaped
  - Ischial spine: Projecting medially
  - Greater (false) pelvis: Deep
  - Lesser (true) pelvis: Narrow, deep & tapering
  - Y-X ratio (acetabulum): 1 or > 1

- Orientation of the Pelvic Girdle Male & Female

- In the anatomical position: ASIS and pubic tubercles are in the same plane

- Greater and lesser pelvis are continuous

- Orientation of the axes of the abdominal & pelvic cavities

- Contents of male pelvic cavity
  - Ureter, bladder, urethra
  - Prostate, ductus deferens, seminal vesicles, bulbourethral glands.
  - Rectum
  - Some of the abdominal GI tract spills into the greater pelvis: Caecum, appendix, parts of sigmoid colon and ileum.
  - Vessel, nerves and lymphatics.
Organs from several systems are packed in a small space. GI, urinary, reproductive, nerves, vessels and lymphatics. Note the pelvis/perineum boundary.

- Prostate gland surrounds 1st (prostatic) part of urethra
- Ductus deferens from testis passes through inguinal canal, then over, and behind ureter to enter urethra through the prostate
- Seminal vesicles on back of bladder open into ductus deferens between ampulla and ejaculatory duct.

Male: Bladder and Prostate

The male bladder ‘sits’ on the prostate, which is transfixed by the first (prostatic) part of the urethra. A urinary catheter, must negotiate a 90° bend in the urethra as it passes from the perineum to the pelvis.

Prostate & Seminal Vesicle

The ductus deferens, seminal vesicles & prostate empty into the prostatic urethra to form the semen.

- Ductus deferens run anterior to the ureter.
- There are 2 seminal vesicles which secrete fluid.
- Prostate gland has many ducts.

Prostatic Urethra

- Distinguish structurally and functionally between the pelvis and the perineum.
- The perineum is a diamond-shaped area between the pubic symphysis, ischial tuberosities, and coccyx.
- Divided into anterior (urogenital) and posterior (anal) triangles.

Perineum

- Posterior compartment: there is the ischio-anal fossae—fat-filled spaces separating anal canal and levator ani from pelvic walls.
- Anterior triangle divided into superficial and deep parts (or pouches) by the perineal membrane.

Superficial Perineal Structures of Male

- Structure within the anal triangle are the same in both sexes.
- Urine can collect in the superficial pouch if damage occurs from trauma.

Deep Perineal Structures of Male

- Ischial cavernous is a muscle.
- Bulbospongiosus is a muscle covering the body of the penis.
- Deep transverse perineal muscle help keep pelvic diaphragm intact.

**Anal triangle**
- Superior rectal artery is a branch of IMA and joins with inferior rectal artery to form a portal-systemic venous anastomosis.

**Rectum and Anal Canal**

The rectum receives one pair of arteries from the inf. mesenteric artery and two pairs from the internal iliac artery. The venous drainage is similar, thus, there is an important portal-systemic venous anastomosis around the lower rectum and anal canal.

- Perineal membrane is a thick triangular fascial structure attached to pubic arch.
- Posteriorly free margin.
- Deep perineal space: is above the PM and below fascia of pelvic diaphragm
- Superficial perineal space: is below PM and perineal fascia (subcutaneous tissue)
- These spaces are potential spaces and they become real only when e.g. fluid leaks into them.

**Superficial Perineal Pouch- Male**

Male superficial perineum. The pudendal nerve (S2-S4) provides all sensory and motor innervation.

- Median erectile tissue mass (corpus spongiosum): bulb of penis
- In females it divides round the vestibule to form vestibular bulbs
- Lateral erectile tissue masses (corpora cavernosa) attached to ischiopubic rami
- These meet to form shaft and head of penis or clitoris.
- Erectile tissue within perineum surrounded by skeletal muscles.

**Superficial Perineal Pouch- Male**

Bulb of penis dissected to show erectile tissue columns and entry of urethra from the deep perineum

- Small openings are for prostatic gland.
- Internal sphincter= smooth muscle
- External sphincter= skeletal muscle
- During ejaculation the internal sphincter is closed- retrograde ejaculation.

**Male Urethra**

- Basic arrangement
- External urethral orifice (narrowest part)

**Arterial Supply of Male Pelvis**

Testis receives arterial supply from testicular artery arising form the abdominal aorta. (not from internal iliac artery)

- External iliac goes to the lower limb.
- Internal iliac supplies the pelvic organs
- Anterior division supplies organs
- Posterior division supplies gluteal muscles.
- Pudendal supplies perineum and external genitalia.
- In a healthy man you can feel via a rectal examination the prostate gland.
- Enlarged prostate - unable to pass urine easily due to compression of urethra. They also may need to urinate frequently due to enlarging and pressing on bladder which triggers urination.

**Penis Structure**

- The crura (legs) of the corpora cavernosa attach to the ischiopubic ramus.
- MEAT IS MURDER!!!! grim.
Bulb of penis dissected to show erectile tissue columns and entry of urethra from the deep perineum

- Corpus cavernosum can be filled with blood: main artery is the pudendal artery supplying them.

### Male reproductive Tract

- Corpus cavernosum - can be filled with blood: main artery is the pudendal artery supplying them.
- Testis in scrotum
- Pelvic sympathetic trunk - L2 via hypogastric plexus
- Pelvic parasympathetic - S2-4
- Pelvic sympathetic - S2-4
- Pelvic sympathetic: T10-L2 via sympathetic ganglie

### Testis and Associated Structures

- Testis and Associated Structures
- Vas deferens
- Deep inguinal ring
- Ampulla of vas deferens
- Seminal vesicles
- Ejaculatory ducts
- Prostate gland
- Bulbospongiosus
- Urethra
- Vasa deferentia
- Testis in scrotum
- Membranous urethra
- Bulbourethral glands
- Bulbourethral gland
- Arteries of urethra
- Arterial supply of the pelvic organs and walls.

### Erection, Emission and Ejaculation

**Nerves of the penis**

- Pelvic contents supplied by autonomic nerves only.
- Sympathetic from lower thoracic and upper lumbar (T10-L2) segments via hypogastric plexus
- Parasympathetic from S2-S4
- Pelvic sensation is visceral and poorly localised - pain referred to suprapubic region and perineum.

**Blood Supply of Penis**

- Main blood supply: Internal pudendal artery from the internal iliac artery
- Deep artery - supplies corpora cavernosa
- Deep artery - supplies the skin and connective tissue
- Branches supplying the cavernous spaces are usually called helicine arteries
- Parasympathetic stimulation causes helicine arteries to relax allowing blood flow

### Nerves of Pelvis

**Pelvic and perineal nerves**: Pelvic sympathetic - T10-L2 via hypogastric plexus; Pelvic parasympathetic - sacral outflow from S2-S4; Perineum (somatic): Pudendal nerve S2-S4

**Nerves of perineum**

- Somatic nerves, mainly from sacral segments
- Most important nerve is pudendal (S2-4)
- Supplies all perineal skeletal muscles
- Sensory to penis, lower urethra, lower rectum and anal canal.

### Lumbosacral Plexus

- Somatic nerves leave the pelvis from the lumbosacral plexus:
- The main supply to the perineum is...
Somatic nerves leave the pelvis from the lumbosacral plexus:
The main supply to the perineum is from the pudendal nerve S2-S4.

‘Pudendal’ derives from Latin pudere – to be ashamed.
Stability of the Cervix and Vagina

3 sets of fibrous bands – the *cervical ligaments* – anchor the cervix in position within the pelvis. These prevent the uterus from prolapsing through the vagina.

- Cervix can herniate through vaginal wall after multiple childbirths.
- Ligaments stabilise uterus.
- Cardinal is most important.

Uterus and Uterine tubes
- Consists of fundus, body, lower segment and cervix
- Uterine tubes consist of infundibulum, ampulla, isthmus and uterine parts.
- Potential communication between peritoneal cavity and exterior via the reproductive passage: abdominal ostium of uterine tube and vaginal opening. (None exists in males)

Fimbriae grab the egg and bring it into the uterus.
Ecotopic pregnancy is very rare but means that the egg is fertilised in the uterine tube.

Female Pelvic Organs: Overview

Organs from several systems in the pelvic cavity. No sharing of reproductive and urinary passages in female.

- Female Peritoneum and Pelvic Fascia
  - Parietal peritoneum continues into pelvic cavity but does not reach the pelvic floor.
  - Uterine tubes are completely enveloped by peritoneum - the broad ligament.
  - Ovaries: suspended by mesovarium from posterior of broad ligament (not fully enveloped).
  - Pelvic fascial condensations form "ligaments" supporting viscer a.e. cervix, vagina, (prostate in males).
  - Important pouches in the female pelvis which can be palpated from the outside.
  - Ovaries are enveloped on one side or else eggs couldn’t get released.

Female Pelvic Organs

- Ovary, uterine (fallopian) tubes.
- Uterus and cervix
- Vagina
- Ureter, bladder, urethra
- Rectum
- Caecum, appendix, parts of sigmoid colon and ileum
- Vessels, nerves and lymphatics

Broad Ligament, Uterus, Uterine Tubes & Ovary

- The broad ligaments are transverse mesenteries joining the uterus to the pelvic walls.
- Their important contents are the uterine tubes and uterine arteries.

Broad Ligament, Uterus, Uterine Tubes & Ovary (another view)

- The ovary is suspended by the suspensory ligament of ovary.
- Ovary is the weird acorn looking thing.
- Recto uterine pouch - pouch of Douglas - some uterine vessels can be palpated.
The cervical canal enters the vagina through the upper part of its anterior wall, forming an angle of around 90°. Body is anteflexed on the cervix.

- **Posterior view**
  - Peritoneum covers anterior and posterior surface of uterus.
  - External or of uterus opens into cervix
  - Fimbriae are finger-like projections guard the ostium of the uterine tube.
  - Ligament of ovary is part of the round ligament.

**Arterial Supply of Female Pelvis: Internal Iliac Artery**
- Main branches to pelvic viscera are
  a. Superior vesical a.
  b. Uterine a.
  c. Middle rectal a.
- Walls of pelvis supplied by sacral, gluteal and obturator branches.
- Pudendal artery supplies perineum and recto-anal region (via inferior rectal branch).

**The Uterine Artery**
- Runs medially towards cervix.
- Crosses ureter about 1cm from cervix.
- Uterine branch runs close to uterus in broad ligament.
- Ascending branch supplies uterine tubes and ovary. (Ovary has ovarian artery from abdominal aorta.)
- Descending branch supplies vagina.
- Uterine artery runs anterior to the ureter.

**Female Pelvis: Internal Iliac Artery**
- Anterior division of internal iliac a.
- Posterior division of internal iliac a.

**Female Perineum**
- There are four fornices: the posterior and two lateral fornice are clinically important.
- The bladder is very closely associated with the vaginal canal.

**Superficial Perineal Structures of Female**
- Glands of vestibule
- Bulb of vestibule

**Female Urethra & Vagina Basic arrangement**
- Female perineum in lithotomy position
- Ureter can be tied off accidentally with uterine arteries during hysterectomy – a classic disaster.
Structures of Female
(corpus spongiosum). In females it divides round the posterior wall of the vagina and the cervix can be palpated. In the male is above the PM and below the fascia of the pelvic diaphragm.

Membranes

triangle. The erectile tissues and nerve S2

nerve S2

plexus

nerve

lymph drainage is to

Thick triangular fascial structure attached to pubic arch. Posteriorly to Pouch & Vulva to external genitalia (vestibule, labia lymph drainage and nodes follow the arteries

Pudendal

sacral outflow from

of post

subcutaneous H of high S1-S3

Deep perineal nerve

Superficial perineal nerve

Perineal N S2 – S4

Anal triangle

Nerves of Perineum

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Pelvic sympathetic

Pelvic sympathetic trunk

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Symathetic from lower thoracic and upper lumbar segments via hypogastric plexus

Parasympathetic from S2-4 Outflow

Pelvic sensation is visceral and poorly localised, instead pain is referred to suprapubic regionand perineum.

As in the male, the perineal membrane fills the urogenital triangle. The erectile tissues and associated skeletal muscles are anchored to this.

- This is similar to a male in that you have a bulb covered by the bulbospongiosus muscle. Underneath ischiocavernosus muscle you have the crus of the clitoris.

Deep Perineal Structures of Female

Opening for urethra

Opening for vagina

Anal triangle

Superficial Perineal Pouch

- Median erectile tissue masses (corpus spongiosum). In females it divides round vestibule to form vestibular bulbs. The glans of clitoris is derived from this.

Lateral erectile tissue masses (corpora cavernosum). Paired cylinders, attached to ischiopubic rami. The body of clitoris is derived from these.

Erectile tissue within perineum surrounded by skeletal muscles.

Use simple sketches to explain the relationships of the labia majora, labia minora, vestibule, clitoris and urethral orifice.

Superficial Perineal Pouch & Vulva-Female

The posterior part of the corpus spongiosum forms two large vestibular bulbs surrounding the lower vestibule and vagina.

Describe what can be felt in a normal rectal examination in both sexes.

- A digital rectal examination (DRE) is a straightforward procedure performed by a clinician and should be undertaken by all physicians at some stage during their training.

- The procedure is performed by placing the gloved and lubricated index finger into the rectum through the anus. The anal mucosa should be palpated for mass lesions knowing that a small percentage of colorectal tumors may be directly palpable.

- In the female the posterior wall of the vagina and the cervix can be palpated. In the male the prostate should be palpated. The central culcus and left and right lobes are easily felt and any extraneous nodules or masses will be easily detected.

Females get more urinary infection because their urethra is shorter.

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Pelvic lymph drainage and nodes follow the arteries

Lymphatic drainage of Pelvis and Perineum

- Pelvic organs drain mainly to external and internal iliac nodes (around the arteries)

- Ovary and testis drain to para-aortic nodes

- Perineum (including anal canal) and external genitalia drain to superficial inguinal nodes (subcutaneous below inguinal ligament)

Lymphatic drainage of Pelvis and Perineum

10 cm

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Rectum through the anus. The anal mucosa should be palpated for mass lesions knowing that a small percentage of colorectal tumors may be directly palpable.

- In the female, the posterior wall of the vagina and the cervix can be palpated. In the male the prostate should be palpated. The central sulcus and left and right lobes are easily felt and any extraneous nodules or masses will be easily detected.
- In many instances the digital rectal examination may be followed by proctoscopy or colonoscopy.
- An ultrasound probe may be placed into the rectum to assess the gynaecological structures in females and the prostate in the male before performing a prostatic biopsy.