Anatomy of the
Gastrointestinal System

Name:
Contents

Welcome 3

Introduction to Gastrointestinal Anatomy 4

Session 9: The Anterior Abdominal Wall 5

Session 10: The Peritoneal Cavity and Peritoneum 15

Session 11: The Stomach and Lesser Sac 20

Session 12: The Small and Large Intestine 26

Session 13: The Liver and Gallbladder 37

Session 14: The Coeliac Trunk, Duodenum, Pancreas and Spleen 46

Session 15: The Nasal and Oral Cavities 53

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Welcome

Welcome to your Gastrointestinal Anatomy sessions.

As with the CVR handbook, the purpose of this handbook is to focus your learning on the core information and key points of clinical relevance. Again, you are encouraged to read more widely around the topics, but the content of this handbook should be your starting point.

We expect you to read the relevant section of this handbook before each session. Now you have undertaken the CVR anatomy classes, you will appreciate that having some familiarity with the structures that you will see in the MTU will help you to get started straight away and undertake some of the dissection and activities independently. Being prepared will allow you to fully participate in the activities and discussions with each other and with the demonstrators.

Again, this handbook does not contain detailed dissection instructions; only a brief overview of the dissection tasks for each practical session is included. Detailed dissection instructions are available in the MTU when you come for your sessions and are available via Minerva in advance. Dissection videos for this teaching block are also available via Minerva for you to watch in advance.

Once again, you will find questions at the end of each section of this handbook. Discuss the answers within your group during the practical sessions and ask a demonstrator for help if you are stuck.

We hope you enjoy the classes.

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**Introduction to Gastrointestinal Anatomy**

Patients commonly present with pathology related to the gastrointestinal system and abdominal viscera. Common presenting complaints relating to the GI tract and abdominal viscera include abdominal pain, nausea, vomiting, altered bowel habit (diarrhoea or constipation) and jaundice. The abdomen contains many structures and if a patient has abdominal pain, there could be a problem with the:

- small or large intestine e.g. ischaemia, infarction, inflammation, twisting (called volvulus)
- stomach e.g. inflammation, gastric ulcers
- liver e.g. inflammation (hepatitis), malignancy
- gallbladder e.g. infection, inflammation, gallstones
- pancreas e.g. inflammation (pancreatitis)
- kidneys e.g. infection (pyelonephritis), renal stones
- great vessels e.g. leaking or rupture of an abdominal aortic aneurysm
- muscles of the abdominal wall e.g. a tear or sprain

In time, you will learn how to undertake an examination of the gastrointestinal system and the abdomen. A sound understanding of where the abdominal viscera lie relative to each other and to the overlying abdominal wall is vital to:

- examining a patient competently
- interpreting your examination properly
- forming a differential diagnosis
- making an appropriate plan for investigation, referral, or treatment.
Session 9: The Anterior Abdominal Wall

● Dissection Video: Session 9.
● Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives
1. Identify the key landmarks that are visible or palpable on examination of the abdomen.
2. Describe the four quadrants and nine regions of the abdomen and name the major organs that lie deep to these regions.
3. Know the surface markings of the stomach, small and large intestine, liver, gallbladder, pancreas, and spleen.
4. Describe the anatomy and function of the anterior abdominal wall muscles. Know their innervations.

Clinical points
● Hernias
● Laparotomy
● Abdominal aortic aneurysm

In the MTU, you will dissect/study the:

● key anatomical/surface landmarks of the abdominal cavity
● muscles of the abdominal wall

Part 1 – Introduction to the Abdomen and the Abdominal Wall

The Abdomen

The abdominal cavity is separated from the thorax by the diaphragm. As we have learned, the diaphragm contains apertures that allow structures to pass between the thorax and abdomen. The pelvic cavity lies inferior to the abdominal cavity and is continuous with it.

The abdominal cavity contains organs of the gastrointestinal tract (stomach, small and large intestine), the hepatobiliary system (liver and gallbladder), the urinary system (kidneys and ureters) and the endocrine system (pancreas and adrenal glands). The abdomen also contains the spleen (a haematopoietic and lymphoid
organ) and of course the **great vessels** (abdominal aorta and inferior vena cava) and their branches.

**The Abdominal Wall**

The anterior, lateral, and posterior walls of the abdomen are composed of skin, subcutaneous tissue and muscles and their associated **aponeuroses** (flat tendons). Five **lumbar** vertebrae contribute to the posterior wall of the abdominal cavity.

The functions of the abdominal wall are to:
- protect the abdominal viscera
- increase intra-abdominal pressure (e.g. for defecation and childbirth)
- maintain posture and move the trunk

The internal aspect of the abdominal wall is lined with a serous membrane called **parietal peritoneum**, in the same way as the internal thoracic wall is lined with parietal pleura. We will learn more about the peritoneum in the next session.

**Part 2 – Surface Anatomy of the Abdominal Wall**

**Key Landmarks**

Several bony landmarks define the boundaries of the abdominal cavity. These are the:
- Xiphisternum
- Costal margin
- Iliac crests
- Anterior superior iliac spines (ASIS)
- Pubic tubercles
- Pubic symphysis (a fibrocartilaginous joint).

Make sure you can identify these on yourself, on the cadaver and on a skeleton.
The ‘Four Quadrants’

In clinical practice, the anterior abdominal wall can be described in terms of the four quadrants. These are the right upper and lower quadrants and the left upper and lower quadrants. The anterior abdominal wall is divided into these quadrants by two invisible lines:

- a vertical line that runs down the midline through the lower sternum, umbilicus, and the pubic symphysis
- a horizontal line that runs across the abdomen through the umbilicus.

![Figure 1. The four quadrants of the anterior abdominal wall.](image)

The ‘Nine Regions’

In clinical practice the anterior abdominal wall can also be divided into nine regions. Because these regions are smaller than the four quadrants, using them allows us to be more precise when we are describing the site of a patient’s pain or the location of tenderness, a mass, a swelling, an injury or a lesion on examination.
The abdomen is divided into nine regions by four imaginary lines:

- the right and left **midclavicular** lines, which extend vertically from the midclavicular point to the mid-inguinal point (halfway between the anterior superior iliac spine and the pubic tubercle)
- the **subcostal** line - a horizontal line drawn through the inferior-most parts of the right and left **costal margins** (through the 10th costal cartilage)
- the **intertubercular** line - a horizontal line drawn through the **tubercles** of the right and left **iliac crests** and the body of L5.

![Image of the abdomen divided into nine regions]

**Figure 2.** The nine regions of the anterior abdominal wall.

- The **central** regions, from superior to inferior, are the epigastrium, the umbilical region and the hypogastric (suprapubic) region.
- On the **right**, the regions from superior to inferior are the right hypochondrium, the right lumbar region and the right iliac fossa (region).
- On the **left**, the regions from superior to inferior are the left hypochondrium, the left lumbar region and the left iliac fossa (region).

In clinical practice, the terms right and left iliac fossa are used, rather than iliac region.
Other Landmarks

In addition to the subcostal and intertubercular planes described above, other landmarks and planes associated with the abdominal wall that you may come across are the:

**Transpyloric plane**: a horizontal line that passes through the tips of the right and left ninth costal cartilages. It lies between the superior border of the manubrium and the pubic symphysis. It transects the pylorus of the stomach, the gallbladder, the pancreas and the hila of the kidneys.

**Transumbilical plane**: this is an unreliable landmark as its position varies depending on the amount of subcutaneous fat present. In a slender individual it lies approximately at the level of L3.

**Intercristal plane**: a horizontal line drawn between the highest points of the right and left iliac crests. It cannot be palpated from the anterior aspect of the abdominal wall. It is used to guide procedures on the back (e.g. lumbar puncture).

**McBurney’s point**: the surface marking of the base of the appendix. It lies two thirds of the way along a line drawn from the umbilicus to the right anterior superior iliac spine.

Part 3 – Muscles of the Anterolateral Abdominal Wall

Four pairs of muscles comprise the anterolateral abdominal wall. These are:

- **External oblique** (diagonally orientated fibres)
- **Internal oblique** (diagonally orientated fibres)
- **Transversus abdominis** (horizontally orientated fibres)
- **Rectus abdominis** (rectus = straight).

The muscles all have individual actions.

The vertical right and left **rectus abdominis** muscles lie either side of the midline. Rectus abdominis is attached to the sternum and costal margin superiorly and to the pubis inferiorly and is surrounded by an aponeurotic **rectus sheath** – we will come back to this shortly.

Lateral to the rectus abdominis lie three sheets of muscle whose fibres run in different directions to each other:
• **External oblique** (EO) is most superficial. The fibres of EO run medially and inferiorly, towards the midline.
• **Internal oblique** (IO) lies deep to EO. The fibres of IO are orientated perpendicular to those of EO (they run medially and superiorly).
• **Transversus abdominis** lies deep to internal oblique. Its fibres are orientated horizontally.

Anteriorly, these muscles become aponeurotic (an aponeurosis is a flat tendon). The fibres of the aponeuroses fuse with each other and, in the midline, they fuse with the aponeuroses of the opposite side, forming a tough midline raphe (= seam) called the **linea alba** (‘white line’). The aponeuroses of these muscles also form the rectus sheath, which encloses the rectus abdominis.

The right and left **rectus abdominis** muscles lie either side of the linea alba.
• It is comprised of muscle segments interspersed with horizontal tendinous bands. When the muscle segments hypertrophy with exercise, they bulge either side of the tendinous bands and can been seen on the anterior abdominal wall as bulges – the ‘six-pack’.

Rectus abdominis lies within the **rectus sheath**. The anterior and posterior walls of the rectus sheath are formed by the aponeuroses of EO, IO and transversus abdominis.
• As it approaches the midline, the aponeurosis of IO splits into **anterior** and **posterior** layers.
• The EO aponeurosis and the **anterior** layer of the IO aponeurosis form the **anterior** wall of the rectus sheath.
• The **posterior** layer of the IO aponeurosis and the transversus abdominis aponeurosis form the **posterior** wall of the rectus sheath.

The **transversalis fascia** lies deep to transversus abdominis. Deep to the fascia lies the **parietal peritoneum**.

The most inferior part of the external oblique aponeurosis is attached to the anterior superior iliac spine laterally and the pubic tubercle medially, forming the **inguinal ligament**. Just above the inguinal ligament is the **inguinal canal** which we will study and dissect in the Genito-Urinary Anatomy block.
Figure 3: Muscles of the anterior abdominal wall.
Vessels of the Anterior Abdominal Wall

The anterolateral abdominal wall is supplied by the following arteries:
- **musculophrenic** artery, a branch of the internal thoracic
- **superior epigastric** artery, which is the continuation of the internal thoracic artery. It descends in the rectus sheath
- **inferior epigastric** artery, a branch of the external iliac artery. It ascends in the rectus sheath and anastomoses with the superior epigastric.

These vessels are accompanied by deep veins. An extensive network of superficial veins is found in the anterolateral abdominal wall.

Innervation of the Anterior Abdominal Wall

The muscles and skin of the anterolateral abdominal wall are innervated by:
- **Thoraco-abdominal** nerves T7 – T11. These are essentially the continuation of the intercostal nerves T7 – T11. These somatic nerves contain sensory and motor fibres.
- The **subcostal** nerve – this originates from the T12 spinal nerve (so called because it runs along the inferior border of the 12th rib).
- **Iliohypogastric** and **ilioinguinal** nerves – both are branches of the L1 spinal nerve.

Part 4 – Clinical Relevance

Hernias

A hernia is an abnormal protrusion of tissues or organs from one region into another through an opening or defect. Herniae of the anterior abdominal wall may occur if the muscles are weak or have been incised during surgery. A segment of the small intestine may protrude through a defect in the wall, forming a visible and palpable lump under the skin.

Laparotomy

This term describes the surgical opening of the anterior abdominal wall, undertaken for major operations where good access to the abdomen is needed. A midline sagittal incision of the linea alba involves minimal risk to nerves and muscles. Ideally, muscles
are split, rather than cut. Where possible, keyhole surgery (laparoscopy) is performed, as it is associated with less post-operative pain, faster wound healing and a smaller risk of wound infection and post-operative hernia.

**Abdominal aortic aneurysm (AAA or triple A)**

This is an abnormal swelling of the wall of the aorta. The affected portion of the wall becomes distended, but it is weak and prone to rupture. An aneurysm may be detected on abdominal examination, felt as a pulsatile mass in the midline of the abdomen. Examination of the abdomen must always include palpitation of the aorta, as detection can be lifesaving. Sudden rupture of an AAA carries an extremely high mortality rate.

**Part 5 – Questions to Consolidate Learning**

1. Describe the four quadrants and nine regions of the abdominal wall. Which organs lie deep to the four quadrants and nine regions?
2. Describe the innervation of the skin of the abdominal wall.
3. How is the rectus sheath formed? What are the contents of the rectus sheath?
4. Describe the surface marking of the appendix.
5. Describe the anatomy of a 'six pack'.

**Image References**

- **Figure 1**: OpenStax 2013. Download for free at [http://cnx.org/contents/17e4eea8-a005-45af-b835-f756a014cd48@3](http://cnx.org/contents/17e4eea8-a005-45af-b835-f756a014cd48@3).
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- **Figure 2**: OpenStax 2013. Download for free at [http://cnx.org/contents/17e4eea8-a005-45af-b835-f756a014cd48@3](http://cnx.org/contents/17e4eea8-a005-45af-b835-f756a014cd48@3).
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Image: 11.4 Axial Muscles of the Abdominal Wall, and Thorax - Anatomy and Physiology | OpenStax
The original image has been adapted for this resource by the removal of part b of the image, which illustrated the muscles of the posterior abdominal wall, and the removal of the caption ‘(a) Superficial and deep abdominal muscles (anterior lateral view)’.
Session 10: The Peritoneal Cavity and Peritoneum

- Dissection Video: Session 10.
- Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives
1. Identify the major organs within the abdominal cavity.
2. Describe the parietal and visceral peritoneum and the peritoneal cavity. Describe the innervation of the parietal and visceral peritoneum and its clinical significance.
3. Explain the terms 'intraperitoneal' and 'retroperitoneal' and give examples of intraperitoneal and retroperitoneal structures.
4. Understand the terms 'mesentery' and 'omentum'. Understand their functions.
5. Understand the term 'ligament' and 'fold' in relation to the peritoneum. Understand their functions.
6. Describe the locations of the greater and lesser sacs.
7. Describe the embryological / developmental processes that lead to the formation of the greater and lesser sacs, mesenteries, ligaments, and folds, and that result in the abdominal viscera reaching their 'final' positions.

Clinical points
- Peritonitis
- Peritoneal adhesions
- Ascites

In the MTU, you will dissect / study the:

- peritoneum and peritoneal cavity
- greater and lesser sacs
- mesenteries, omenta and ligaments
- organisation of the viscera within the abdominal cavity
Part 1 – The Peritoneum and Peritoneal Cavity

Peritoneum is a serous membrane that lines the abdominal wall and covers the viscera within it.

**Parietal peritoneum** lines the abdominal wall.
- It can be seen with naked eye and is innervated by the **somatic nerves** that supply the overlying muscles and skin of the abdominal wall.
- Pain from the parietal peritoneum is usually sharp, severe, and well localised to the abdominal wall.

**Visceral peritoneum** covers the abdominal viscera.
- It is adhered to the surface of the viscera and cannot be seen with the naked eye.
- The visceral peritoneum is innervated by **visceral sensory nerves**. These nerves convey 'painful' sensations back to the CNS along the path of the sympathetic nerves that innervate the organ / structure it covers.
- Pain from the visceral peritoneum can be severe. It is usually dull and diffuse (i.e. it cannot be pinpointed to a specific location).
- ‘Painful’ sensations from the visceral peritoneum may be perceived as nausea or distension.

Between the parietal and visceral peritoneum lies the **peritoneal cavity**. In a healthy abdomen, a thin film of **peritoneal fluid** lies in the peritoneal cavity. It allows the viscera to slide freely alongside each other.

The two layers of peritoneum are **continuous** with each other. The arrangement of the two layers mirrors the arrangement of the parietal and visceral pleurae.

Depending on the extent to which they are covered by peritoneum, the abdominal viscera are described as:

- **Intraperitoneal**: almost completely covered by peritoneum e.g. the stomach
- **Retroperitoneal**: posterior to the peritoneum, hence only covered by peritoneum on their anterior surface e.g. the pancreas and abdominal aorta.

Some retroperitoneal organs are described as ‘secondarily retroperitoneal’. These organs were intraperitoneal in early development but came to be ‘stuck down’ onto the posterior abdominal wall.
Part 2 – Mesenteries, Omenta, Ligaments and Folds.

These structures can be confusing, so we will approach them in the simplest way possible.

- They are all composed of peritoneum and connect organs to each other and to the abdominal wall.
- They may carry blood vessels, nerves, and lymphatics to the viscera.
- They contain a variable amount of fat; some are usually very fatty (the omenta).

Mesenteries are folds of peritoneum that contain fat and suspend the small intestine and parts of the large intestine from the posterior abdominal wall. Arteries that supply the intestine (from the abdominal aorta) and veins that drain the gut (tributaries of the portal venous system) are embedded in the mesenteries.

The greater and lesser omenta are folds of peritoneum that are usually fatty and connect the stomach to other organs.

- The greater omentum hangs from the greater curvature of the stomach and lies superficial to the small intestine.
- The lesser omentum connects the stomach and duodenum (the first part of the small intestine) to the liver. The hepatic artery, the hepatic portal vein, and the bile duct (the ‘portal triad’) are embedded within its free edge.

Ligaments are folds of peritoneum that connect organs to each other or to the abdominal wall. Some peritoneal ligaments that we will come across later are the:

- falciform ligament, which connects the anterior surface of the liver to the anterior abdominal wall
- the coronary and triangular ligaments, which connect the superior surface of the liver to the diaphragm.

Peritoneal folds are raised from the internal aspect of the lower abdominal wall and are created by the structures they overlie, like carpet running over a cable. Sometimes they are difficult to see.

- The median umbilical fold lies in the midline and represents the remnant of the urachus, an embryological structure that connected the bladder to the umbilicus.
- Lateral to the median umbilical fold lie the medial umbilical folds. These represent the remnants of the paired umbilical arteries, which returned venous blood to the placenta in foetal life.
• Lateral to the medial umbilical folds are the lateral umbilical folds. The inferior epigastric arteries lie deep to these peritoneal folds. They supply the anterior abdominal wall.

Part 3 - The Greater and Lesser Sacs

The peritoneal cavity is divided into two regions of unequal size.

• The smaller lesser sac (also called the omental bursa) is a space that lies posterior to the stomach and anterior to the pancreas.
• The larger greater sac is the remaining part of the peritoneal cavity.
• The greater and lesser sacs communicate with each other via a passageway that lies posterior to the free edge of the lesser omentum, the epiploic foramen (also called the omental foramen).

The viscera of the abdominal cavity do not develop in the locations that we see them in the adult. The gastrointestinal system develops from the embryonic gut tube which lies in the midline of the abdominal cavity, suspended from the posterior abdominal wall by the dorsal mesentery. Major branches of the abdominal aorta that supply the developing gut tube travel through the dorsal mesentery. The ventral mesentery connects the stomach to the anterior abdominal wall. As the liver grows within it, the anterior part of the ventral mesentery becomes the falciform ligament and the posterior part becomes the lesser omentum.

During development, organs grow, migrate, and rotate towards their final positions. As they do so, they ‘pull’ their peritoneal attachments with them. Growth, migration, and rotation of organs during development is responsible for the formation of the lesser sac and results in some organs being ‘pushed’ onto the posterior abdominal wall and becoming retroperitoneal.

Part 4 – Clinical Relevance

Peritonitis

Peritonitis describes infection and inflammation of the peritoneum. It may be localised (i.e. to the region of peritoneum adjacent to an inflamed / infected organ) or generalised (affecting the whole peritoneum). Peritonitis may be caused by inflammation of an organ (e.g. the pancreas) or rupture of a hollow viscus (e.g. the
stomach or bowel). Rupture of the intestine allows faecal matter and bacteria to contaminate the peritoneum. Because the peritoneum has a large surface area and is semi-permeable, peritonitis can lead to sepsis and is hence a life-threatening condition. Peritonitis is extremely painful.

**Peritoneal adhesions**

In a healthy abdomen, a thin layer of peritoneal fluid allows the abdominal viscera to slide freely alongside each other. Adhesions are pathological fibrous connections between the parietal and visceral peritoneum. When the peritoneum is irritated (e.g. by infection) it produces fibrin which causes the parietal and visceral peritoneum to adhere to each other. These connections may become fibrous. They can cause chronic abdominal pain and they increase the risk of volvulus (twisting) of the intestine, because it can no longer move freely.

**Ascites**

Ascites is an increased volume of peritoneal fluid. It occurs secondary to other pathology, such heart failure, liver failure or intra-abdominal malignancy. The abdomen may become very distended, and it is very uncomfortable. An ascitic drain can be used to remove the fluid and relieve symptoms, but fluid will usually reaccumulate.

**Part 5 – Questions to Consolidate Learning**

1. What embryological structure forms the ligamentum teres?
2. What are the greater and lesser omenta?
3. Where is the lesser sac located?
4. Why would a surgeon want to avoid cutting the lateral umbilical folds?
5. What is peritoneal dialysis?
Session 11: The Stomach and Lesser Sac

- Dissection Video: Session 11.
- Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives
1. Describe the anatomy of the distal oesophagus.
2. Describe the anatomy of the parts of the stomach.
3. Describe the location of the stomach in the abdomen.
4. Describe the anatomical relations of the stomach.
5. Know the arterial supply and venous drainage of the stomach.
6. Know the innervation of the stomach.
7. Describe the boundaries of the lesser sac and its clinical importance.

Clinical points
- Hiatus hernia
- Gastric ulcer
- Pyloric stenosis
- Gastric cancer

In the MTU, you will dissect / study the:

- gross anatomy of the stomach
- blood vessels of the stomach
- the lesser sac
- the lesser omentum

Part 1 – Distal Oesophagus

The oesophagus passes through the oesophageal hiatus in the diaphragm at the level of T10. The muscle around the hiatus functions as a sphincter that prevents reflux of stomach contents into the oesophagus. The abdominal segment of the oesophagus is less than 2 centimetres long.

The distal oesophagus is supplied by branches from the left gastric artery. Its venous drainage is towards both the systemic system of veins (via oesophageal veins that drain into the azygos vein) and to the portal venous system (via the left gastric veins). The distal oesophagus is thus a site of portosystemic anastomoses, which are clinically important. We will come back to portosystemic anastomoses in later sessions.
Part 2 - Stomach

Parts of the Stomach

The stomach is a J-shaped sac that expands to accommodate food and fluid. The stomach chemically and mechanically breaks down food into chyme. The stomach is described in four parts.

- The oesophagus travels through the diaphragm at the level of T10 and is continuous with the cardia of the stomach.
- The most superior part of the stomach is the fundus. It lies superior to the level of entry of the oesophagus and is usually filled with gas.
- The largest part of the stomach is the body.
- The pyloric part is distal to the body. The pyloric antrum is wide and tapers towards the pyloric canal, which is narrow and contains the pyloric sphincter. The sphincter is a formed of circular smooth muscle. It regulates the passage of chyme into the duodenum.
- The right border of the stomach is the lesser curvature. The longer left border is the greater curvature.

Figure 1. Parts of the stomach.
Location and Relations of the Stomach and the Lesser Sac

The stomach lies in the left upper quadrant, but its size and position are variable. It is covered with visceral peritoneum.

- Its anterior surface is related to the anterior abdominal wall, diaphragm, and left lobe of the liver.
- Its posterior surface forms the anterior wall of the lesser sac.
- The lesser sac and the structures that form its posterior wall lie posterior to the stomach: these include the pancreas, left kidney and spleen.
- The lesser omentum connects the lesser curvature to the liver.
- The free edge of the lesser omentum contains the hepatic artery, hepatic portal vein and the bile duct.
- Posterior to the free edge is the entrance to the lesser sac.
- The greater omentum hangs from the greater curvature.

Figure 2: The stomach, liver, and lesser omentum.
Blood Supply of the Stomach

The stomach is supplied by arteries that branch from the coeliac trunk. The coeliac trunk is one of three large unpaired vessels that leave the anterior aspect of the abdominal aorta (at the level of T12) to supply the abdominal viscera that are derived from the embryological foregut. The foregut comprises the stomach, the first half of the duodenum, the liver, gallbladder, and pancreas. The spleen develops in the dorsal mesentery, and is supplied by the coeliac trunk, but it is mesodermal in origin.

The coeliac trunk is only a short stump; it divides into three branches close to the aorta. These are the left gastric artery, the common hepatic artery, and the splenic artery. The left gastric is a much smaller calibre vessel than the common hepatic and splenic arteries.

The left and right gastric arteries run along the lesser curvature of the stomach and anastomose with each other.
- The left gastric artery arises from the coeliac trunk.
- The right gastric artery usually arises from the common hepatic artery.

The left and right gastro-omental (gastroepiploic) arteries run along the greater curvature of the stomach and anastomose with each other.
- The left gastro-omental artery arises from the splenic artery.
- The right gastro-omental artery arises from the gastroduodenal artery, a branch of the common hepatic artery.

Right and left gastric veins and right and left gastro-omental veins accompany the arteries described above. They ultimately drain into the hepatic portal vein (HPV). The hepatic portal vein is a large vein that carries nutrient-rich venous blood from the GI tract to the liver. We will learn more about the hepatic portal vein later.

Innervation of the Stomach

The vagus nerve conveys parasympathetic fibres to the stomach. Parasympathetic stimulation promotes peristalsis and gastric secretion.

Sympathetic fibres are conveyed to the stomach via the greater splanchnic nerve. The greater splanchnic nerve is formed of preganglionic sympathetic fibres that leave spinal cord segments T5-T9 and pass through the sympathetic trunk without synapsing. The fibres synapse in prevertebral ganglia around the coeliac trunk. The postganglionic fibres travel to the stomach and inhibit peristalsis and secretion.
**Part 3 – Clinical Relevance**

**Hiatus hernia**

The abdominal oesophagus and upper part of the stomach may herniate through the oesophageal hiatus into the thorax. If contents of the stomach reflux into the oesophagus the patient may experience heartburn (a burning feeling in the chest after eating) and acid reflux (regurgitation of bitter fluid).

**Gastric ulcer**

Mucous lines the internal wall of the stomach and protects the mucosa from the acidic stomach contents. A gastric (stomach) ulcer develops when the mucosal lining of the stomach breaks down. This is normally due to infection with Helicobacter pylori, which erodes the mucosal lining, exposing the muscular wall to gastric acid and enzymes. Erosion through the wall and into nearby blood vessels can result in catastrophic intra-abdominal bleeding.

**Pyloric stenosis**

This is a congenital malformation characterised by hypertrophy of the circular smooth muscle of the pyloric sphincter. It is more common in baby boys than girls and typically presents at approximately six weeks after birth. The typical presentation is of vomiting (sometimes projectile) after feeds, but the baby does not appear unwell and is hungry and willing to take more feeds. With continued vomiting, babies with pyloric stenosis become dehydrated and stop gaining weight. It can be treated surgically.

**Gastric cancer**

Primary cancer of the stomach may present late as some of the symptoms are non-specific. Symptoms include abdominal discomfort, early satiety (feeling full quickly), loss of appetite, nausea, weight loss, difficulty swallowing and indigestion.
Part 4 – Questions to Consolidate Learning

1. At what vertebral level does the oesophagus pass through the diaphragm?
2. Which structure(s) pass through the diaphragm alongside the oesophagus?
3. Draw and name the parts of the stomach.
4. Describe the innervation and blood supply of the stomach.
5. What structure attaches the stomach to the liver?
6. Which structures lie anterior to the stomach?
7. What lies posterior to the stomach?

Image References

- Figure 1: Servier Medical Art by Servier: smart.servier.com.
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  The original image has been adapted for this resource by the addition of arrows and labels to indicate the parts of the stomach.
- Figure 2: Olek Remesz (wiki-pl: Orem, commons: Orem) – Own work.
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  Image: https://commons.wikimedia.org/wiki/File:Lesser_omentum_EN.svg
Session 12: The Small and Large Intestine

- Dissection Video: Session 12.
- Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives
1. Describe the parts of the small and large intestine.
2. Describe the location of the small and large intestine in the abdomen.
3. Describe the anatomical relations of the small and large intestine.
4. Describe the mesenteries of the small and large intestine.
5. Know the arterial supply and venous drainage of the small and large intestine.
6. Know the innervation of the small and large intestine.

Clinical points
- Appendicitis
- Mesenteric ischaemia
- Inflammatory bowel disease
- Colon cancer
- Volvulus

In the MTU, you will dissect / study the:

- gross anatomy of the small and large intestine
- mesentery of the small intestine
- blood vessels of the small and large intestine

Part 1 – Small Intestine

The small intestine lies centrally in the abdomen and has three 'parts' that are continuous with each other; the duodenum, the jejunum, and the ileum.

Duodenum

The duodenum is continuous with the pylorus of the stomach. It is short and curved into a C-shape around the head of the pancreas. Most of the length of the duodenum is retroperitoneal.
Approximately halfway along the internal wall of the duodenum is the major duodenal papilla. This is the opening of the bile duct and the main pancreatic duct into the duodenum.
The first half of the duodenum develops from the embryological foregut and is supplied by arterial branches from the coeliac trunk. The second half of the duodenum develops from the embryological midgut and is supplied by branches from the artery of the midgut – the superior mesenteric artery. We will learn more about the duodenum in later sessions.

**Figure 1**: The duodenum forms a C-shape around the head of the pancreas.

### Jejunum and Ileum

The jejunum is continuous with the duodenum. Both the jejunum and ileum are intraperitoneal and are ‘suspended’ from the posterior abdominal wall by the mesentery of the small intestine. Blood vessels that supply the small intestine (from the superior mesenteric artery) are embedded within the mesentery. The small intestine lies centrally in the abdomen; the jejunum lying in the left upper region and the ileum lying in the right lower region. Both the jejunum and ileum are derived from the embryological midgut.

The jejunum and ileum are the sites of nutrient absorption, so have a vast surface area: the small intestine is long, the mucosa is folded (plicae circulares), the mucosal folds bear villi and there are microvilli on the luminal surface of each epithelial cell.

In the cadaver, it is difficult to differentiate the jejunum from the ileum based on their external appearances. However, there are some internal differences. The plicae are more pronounced in the jejunum. The internal ileum is characterised by Peyer’s patches, which are large submucosal lymph nodules.
In some people, the ileum bears a blind-ended diverticulum approximately one meter from its termination; Meckel's diverticulum. It is the embryological remnant of the connection that was present between the midgut loop to the yolk sac. If it becomes inflamed, it may mimic an appendicitis (inflammation of the appendix).

The terminal ileum is continuous with the caecum - the first part of the large intestine – at the ileocaecal junction in the right iliac fossa.

Figure 2: The terminal ileum, caecum, and appendix.

Part 2 – Large Intestine

The large intestine reabsorbs water from faecal material to form semi-solid faeces. It lies peripherally in the abdomen and is composed of the caecum, appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, and anal canal. Some segments are retroperitoneal, and some are intraperitoneal.

In the cadaver, the large intestine is usually easy to distinguish from the small intestine. It is peripherally located, and larger calibre. The outer longitudinal muscle layer is organised into three bands – the taeniae coli. The inner circular muscle layer forms ‘bulges’ called haustra (or haustations). The large intestine bears fatty tags called epiploic appendages (appendices epiploicae) that mark the point at which blood vessels penetrate the intestinal wall.
Caecum and Appendix

The **caecum** is the first part of the large intestine. It is a distended, blind-ended 'pouch'. The caecum is covered by peritoneum but does not have a mesentery. The **appendix** is a small diverticulum that arises from the caecum and contains lymphoid tissue. The surface marking of the base of the appendix is McBurney’s point. The appendix varies in length and the position of its tip is variable. The appendix is connected to the caecum by a small mesentery, the mesoappendix.

Ascending Colon

The ascending colon is continuous with the caecum. It runs vertically on the right side of the posterior abdominal wall in the **right paracolic gutter**. It is retroperitoneal (it is an example of a secondarily retroperitoneal organ). The ascending colon makes a 90 degree turn left in the right upper quadrant, becoming continuous with the transverse colon. The ‘bend’ in the colon here is the **hepatic flexure** (sometimes called the right colic flexure).

Transverse Colon

The transverse colon is continuous with the ascending colon. It runs horizontally in the upper abdomen but often hangs inferiorly. It is intraperitoneal and is suspended from the posterior abdominal wall by the **transverse mesocolon**. The transverse colon makes a 90 degree turn inferiorly in the left upper quadrant, becoming continuous with the descending colon. The ‘bend’ in the colon here is the **splenic flexure** (sometimes called the left colic flexure). The splenic flexure is tethered to the diaphragm by the **phrenicocolic ligament** – we will come back to the clinical importance of this later when we look at the spleen.

The transverse colon marks the transition point between the embryological **midgut** and embryological **hindgut**. The **proximal** (first) **two thirds** develop from the embryological **midgut**, whilst the **distal** (last) **third** develops from the embryological **hindgut**. This means that these two parts of the transverse colon are supplied by different blood vessels and nerves. We will learn more about this later.
Figure 3: The parts of the large intestine.

**Descending Colon**

The descending colon is continuous with the transverse colon superiorly and the sigmoid colon inferiorly. It runs vertically on the left side of the posterior abdominal wall in the **left paracolic gutter**. It is retroperitoneal (also secondarily retroperitoneal).

**Sigmoid Colon**

The sigmoid colon lies in the left lower quadrant and is named because of its sinuous shape. It is continuous with the descending colon superiorly and the rectum inferiorly. As the sigmoid approaches the midline, it makes a 90 degree turn inferiorly into the pelvis - this 'bend' is the **rectosigmoid junction**. The sigmoid colon has a mesentery - the **sigmoid mesocolon** - and is therefore intraperitoneal.
Rectum and Anal Canal

The rectum descends inferiorly into the pelvis from the rectosigmoid junction and is retroperitoneal. The rectum stores faeces until it is convenient to defecate. The rectum is continuous inferiorly with the anal canal. We will look at the anal canal when we study the pelvis.

Part 3 – Arterial Supply of the Small and Large Intestine

Overview

The gastrointestinal tract is supplied by three large unpaired arteries that leave the abdominal aorta. These are the:

- coeliac trunk
- superior mesenteric artery (SMA)
- inferior mesenteric artery (IMA)

We looked at the coeliac trunk when we looked at the stomach. It leaves the aorta at the level of T12 and gives rise to branches that supply the foregut – the oesophagus, stomach, first half of the duodenum, liver, gallbladder, bile ducts, pancreas and spleen.

The superior mesenteric is the artery of the midgut. It leaves the aorta at the level of L1. Its branches supply the midgut structures: the second half of the duodenum, the small intestine, and the large intestine as far as (and including) the first two thirds of the transverse colon. Branches also supply parts of the pancreas.

The inferior mesenteric artery is the artery of the hindgut. It leaves the aorta at the level of L3. It is a smaller calibre vessel than the coeliac trunk and SMA. Its branches supply the hindgut structures: the distal third of the transverse colon, the descending and sigmoid colon, the rectum, and the upper part of the anal canal.

Superior Mesenteric Artery

The SMA gives rise to several major branches that supply the midgut, but it is important to bear in mind that these vessels form extensive anastomoses with each other. Major branches are:
Jejunal branches – several branches to the jejunum
Ileal branches – several branches to the ileum
Ileocolic artery – supplies the caecum, appendix, and ascending colon
Right colic artery – supplies the ascending colon
Middle colic artery – supplies the transverse colon.

The jejunal and ileal branches are embedded in the mesentery of the small intestine. They anastomose with each other, forming ‘loops’ of arteries called arcades. From these arcades run the vasa recta (‘straight’ vessels), which supply the intestinal wall.

Inferior Mesenteric Artery

The IMA gives rise to several major branches that supply the hindgut. Major branches are:

- Left colic artery – supplies the transverse colon and the descending colon
- Sigmoid branches – supply the sigmoid colon
- Superior rectal artery – the terminal branch of the IMA, which supplies the upper rectum.

Branches of the middle colic artery (from the SMA) and left colic artery anastomose along the distal third of the transverse colon and the splenic flexure forming the marginal artery. Branches of the left colic and sigmoid arteries anastomose.

The lower rectum is supplied by blood vessels that originate from the internal iliac arteries in the pelvis. We will learn more about the blood supply of the rectum in the Genito-Urinary anatomy block.

Part 4 – Venous Drainage of the Small and Large Intestine

Venous blood from the gut ultimately reaches the inferior vena cava (IVC) and is returned to the heart. However, venous blood from the gut contains absorbed nutrients, so it first enters the liver via the portal venous system before being returned to the heart via the IVC.

- The inferior mesenteric vein (IMV) accompanies the IMA and drains the hindgut. The inferior mesenteric vein ascends on the left side of the abdomen and typically drains into the splenic vein from the spleen.
• The **superior mesenteric vein** (SMV) accompanies the SMA and drains the midgut. The SMV ascends and unites with the **spleenic vein** close to the liver (posterior to the neck of the pancreas) to form the **hepatic portal vein**.
• The **hepatic portal vein** enters the liver. After the nutrients are removed from the blood, it enters small hepatic veins, which unite within the liver to form two or three large **hepatic veins** that enter the IVC as it passes posterior the liver (hence the hepatic veins are **within** the liver and cannot be seen externally).

### Part 5 – Innervation of the Small and Large Intestine

**Parasympathetic fibres**

The midgut and hindgut are innervated by **parasympathetic** fibres that stimulate peristalsis and secretions. However, parasympathetic fibres travel to the midgut and hindgut via **different** nerves.
- The **foregut** and **midgut** (i.e. as far as two thirds of the way along the transverse colon) are innervated with parasympathetic fibres via the **vagus nerve**.
- The **hindgut** (the last third of the transverse colon as far distally as the upper anal canal) is innervated with parasympathetic fibres via the **pelvic splanchnic nerves**. These nerves are formed by the axons of parasympathetic neurons that lie in the **sacral** spinal cord.
  - The cell bodies of **preganglionic** parasympathetic neurons lie in sacral segments **S2 – S4**.
  - The axons of these neurons leave the spinal cord and form the **pelvic splanchnic nerves**.
  - The preganglionic axons **synapse** with a second neuron in a **ganglion**. The parasympathetic ganglia are located very close to, or even within, the walls of the viscera.

The pelvic splanchnic nerves also convey parasympathetic fibres to the pelvic viscera – we will learn more about this when we study the pelvis.

**Sympathetic fibres**

Preganglionic **sympathetic** fibres from **T5 – T12** pass through the sympathetic trunk (without synapsing) via the **greater, lesser, and least splanchnic nerves**.
- The **greater** splanchnic carries fibres from **T5 – T9** and innervates the **foregut**.
- The **lesser** splanchnic carries fibres from **T10 – T11** and innervates the **midgut**.
- The **least** splanchnic carries fibres from **T12** and innervates the **hindgut**.
The preganglionic fibres in these nerves synapse within in ganglia that lie in the abdomen, clustered around the aorta and the coeliac trunk, SMA and IMA. The postganglionic sympathetic fibres form visceral nerves that innervate the gut. These fibres that inhibit peristalsis and secretions.

The sympathetic fibres are visceral motor fibres. The gut is also innervated by visceral sensory fibres which convey visceral sensory information from the gut to the CNS. Such information usually does not reach consciousness, but painful sensations caused by ischaemia, distension or spasm do reach our conscious perception. Visceral sensory fibres from the foregut, midgut, and hindgut travel to the CNS alongside the sympathetic fibres that innervate that part of the gut, hence painful sensations from the:

- **foregut** enter spinal cord segments T5 - T9
- **midgut** enter spinal cord segments T10 – T11
- **hindgut** enter spinal cord segment T12.

These regions of the spinal cord also receive somatic sensory information from the abdominal wall.
- Segments T5 – T9 receive information from dermatomes T5 – T9 (upper abdomen and epigastrium).
- Segments T10 – T11 receive information from dermatomes T10 – T11 (the umbilical region)
- Segment T12 receives information from dermatome T12 (the suprapubic region).

So what does this mean for clinical practice?

Pain from the abdominal viscera is referred to the body wall:
- epigastric pain suggests **foregut** pathology
- central abdominal / umbilical pain suggests **midgut** pathology
- lower abdominal / suprapubic pain suggests **hindgut** pathology.

### Part 6 – Clinical Relevance

**Appendicitis**

Inflammation of the appendix is appendicitis and is a common acute surgical presentation. The pain of appendicitis typically begins in the umbilical region and is poorly localised. This is the result of irritation of the visceral peritoneum (visceral sensory afferents returning to spinal cord segment T10). As inflammation progresses,
the adjacent pari
tal peritoneum becomes involved. This causes severe, well localised pain in the right iliac fossa (which is conveyed to the CNS via somatic nerves that innervate the body wall). Therefore the history is of diffuse umbilical pain that ‘moves’ to the right iliac fossa. Symptoms can vary, depending on where the tip of the appendix lies. Tenderness is maximal over McBurney’s point. Rupture of the appendix can lead to peritonitis. Removal of the appendix (appendicectomy) is usually performed via laparoscopy (‘keyhole’ surgery).

Mesenteric ischaemia

Just like the coronary arteries, the mesenteric vessels may be occluded by a thrombus. This results in ischaemia of the intestine which may progress to infarction. Acute mesenteric ischaemia is a surgical emergency. The gut must be revascularized and any sections of necrotic intestine must be removed. Mortality is high, even when the condition is recognised and treated.

Inflammatory bowel disease

Crohn’s disease and ulcerative colitis are two types of inflammatory bowel disease. Crohn’s disease is characterised by inflammation of the gut mucosa. It can affect any part of the GI tract but typically affects the small intestine. Patients suffer with symptoms including abdominal pain, diarrhoea, bloody stools, weight loss and tiredness. Ulcerative colitis affects the colon and rectum. The mucosa becomes inflamed and ulcerated. Patients suffer with abdominal pain, bloody diarrhoea, weight loss and tiredness. Flare-ups of both diseases can be serious and may lead to life-threatening complications. If medications fail to control symptoms, the affected part of the gut may be removed.

Colon cancer

Cancer of the colon (often called bowel cancer) is common in the UK. The main symptoms of colon cancer are a change in bowel habit, blood in the stools and abdominal pain or bloating. Colonoscopy allows visualisation of the colon and biopsies can be taken if a mass is seen.
**Volvulus**

Volvulus is twisting of the gut. It affects parts of the gut that are mobile (i.e. have a mesentery) and is most common at the sigmoid colon. Twisting obstructs the passage of faeces and may cause ischaemia and infarction of the affected part of the gut.

**Part 7 – Questions to Consolidate Learning**

1. Which veins drain blood from the large intestine and where does it flow to?
2. What four anatomical features ensure the small bowel has a high surface area for absorption of nutrients?
3. Where is the ‘junction’ between the midgut and the hindgut?
4. How might you distinguish a loop of large intestine from that of small intestine?
5. What do the following terms mean: colectomy, colostomy, ileostomy.

**Image References**

- Figure 1: "MedicalGraphics - Drawing Pancreas and duodenum - no labels" at AnatomyTOOL.org by www.MedicalGraphics.de, license: Creative Commons Attribution-NoDerivatives "MedicalGraphics - Drawing Pancreas and duodenum - no labels" by www.MedicalGraphics.de, license: CC BY-ND Licence: Creative Commons — Attribution-NoDerivatives 4.0 International — CC BY-ND 4.0 Image: https://anatomytool.org/content/medicalgraphics-drawing-pancreas-and-duodenum-no-labels
- Figure 2: Servier Medical Art by Servier: smart.servier.com. Licence: Creative Commons — Attribution 3.0 Unported — CC BY 3.0 Image: https://smart.servier.com/smart_image/colon-3/ The original image has been adapted for this resource by the addition of arrows and labels to indicate the parts of the gut.
- Figure 3: Servier Medical Art by Servier: smart.servier.com. Licence: Creative Commons — Attribution 3.0 Unported — CC BY 3.0 Image: https://smart.servier.com/smart_image/colon-2/ The original image has been adapted for this resource by the addition of arrows and labels to indicate the parts of the gut.
Session 13: The Liver and Gallbladder

- Dissection Video: Session 13.
- Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives
1. Describe position of the liver, its surface marking, and its key anatomical relations.
2. Describe the gross anatomy of the liver and the key surface features of the liver.
3. Identify and name key structures that enter and exit the liver.
4. Understand that the liver is functionally organised into segments.
5. Describe the arterial supply and venous drainage of the liver.
6. Describe the location of the gallbladder and its surface marking.
7. Describe the arterial supply and venous drainage of the gallbladder.
8. Understand the innervation of, and the pathways of referred pain from, the gallbladder.

Clinical points
- Hepatomegaly
- Liver metastases
- Cirrhosis of the liver
- Portal hypertension and portosystemic anastomoses
- Gallstones, biliary colic, and cholecystitis

In the MTU, you will dissect / study the:

- gross anatomy of the liver and gallbladder
- blood vessels of the liver and gallbladder

Part 1 – Liver

The liver is a large organ that lies in the right upper quadrant and epigastrium of the abdomen. The liver is protected by the ribs and moves inferiorly with inspiration – the lowermost part of the liver may be palpable below the right costal margin in inspiration. All the products of digestion, except lipids, are transported to the liver from the gut via the hepatic portal vein. The liver also produces bile, which is transported to the gallbladder for storage. Bile emulsifies lipids in the chyme entering the duodenum from the stomach.
Surfaces and Lobes of the Liver

The liver has two surfaces:
- The diaphragmatic surface lies anterosuperior and is related to the inferior surface of the diaphragm.
- The visceral surface lies posteroinferior and is related to other organs.

The liver is mostly, but not entirely, covered by visceral peritoneum. The regions not covered by peritoneum are the:
- bare area of the liver – a region on the posterior surface that lies in contact with the diaphragm
- the region where the gallbladder lies in contact with the liver
- region of the porta hepatis – where hepatic blood vessels and ducts of the biliary system enter and exit the liver (the equivalent of the hilum of the lung).

The liver is composed of two anatomical lobes – a large right lobe and a small left lobe. They are separated by the falciform ligament, which connects the anterior surface of the liver to the internal aspect of the anterior abdominal wall. Two accessory lobes, the caudate and quadrate lobes, are located on the posteroinferior surface. These lobes do not represent the internal, functional organisation of the liver. Internally the liver is organised into eight functional segments. Each segment is served by its own branch of the hepatic artery and portal vein, and by its own hepatic duct.

Blood Vessels and Nerves of the Liver

The liver is supplied by the right and left hepatic arteries. These branches ultimately derive from the coeliac trunk.
- The coeliac trunk gives rise to the left gastric, splenic, and common hepatic arteries.
- The common hepatic artery gives rise to the gastroduodenal artery; after this point, the common hepatic artery is called the hepatic artery proper (HAP).
- The hepatic artery proper bifurcates into right and left hepatic arteries, which enter the liver at the porta hepatis.
Venous blood exits the liver via two or three large hepatic veins that lie within the liver – they are not visible external to the liver. They unite with the inferior vena cava as it passes posterior to the liver.

It is a common mistake to confuse the hepatic veins with the hepatic portal vein. To be clear:

- Nutrient-rich venous blood that leaves the gut is transported to the liver via the hepatic portal vein, which receives blood from the superior and inferior mesenteric veins and the splenic vein.
- Venous blood leaves the liver via the hepatic veins and enters the inferior vena cava.

**Figure 1**: The portal triad and porta hepatis. BD = bile duct; HA = hepatic artery; PV = portal vein.
The liver is served by the hepatic plexus, which is formed of parasympathetic fibres from the vagus nerves and sympathetic fibres. These fibres follow the paths of the hepatic vessels and ducts of the biliary tree. Because the liver is a foregut derivative, pain arising from it is referred to the epigastric region.

**Anatomical Relations of the Liver**

The liver is connected to the:
- diaphragm by the coronary and triangular ligaments
- anterior abdominal wall by the falciform ligament
- stomach and duodenum by the lesser omentum.

The hepatic artery, hepatic portal vein and the bile duct run together as the portal triad in the free edge of the lesser omentum. The portal triad and the free edge of the lesser omentum form the anterior boundary of the epiploic foramen; the entrance into the lesser sac (which lies posterior to the stomach).

There are two recesses related to the liver:
- The hepatorenal recess lies between the right kidney and the posterior (visceral) surface of the right side of the liver. Fluid flows into this space in the supine position.
- The left and right subphrenic recesses lie either side of the falciform ligament, between the anterosuperior surface of the liver and the diaphragm.

**Development of the Liver**

The liver develops from the embryological foregut. It grows from a tissue bud that develops in the ventral mesentery – a peritoneal fold in the upper abdomen that connects the stomach to the anterior abdominal wall. As the liver grows and migrates to the right side of the abdomen, its peritoneal attachments are pulled with it. The remains of the ventral mesentery form the lesser omentum and the falciform ligament. The peritoneal attachments of the liver anchor it to surrounding structures, including the diaphragm superior to it.

The free edge of the falciform ligament contains the round ligament of the liver (the ligamentum teres). It is the remnant of the umbilical vein, which, in the foetus, carries oxygenated blood from the placenta to the foetus. Another embryological remnant, the ligamentum venosum, lies on the posterior surface of the liver, in the groove between the caudate lobe and the left lobe of the liver. It is the
remains of the **ductus venosus**, which in foetal life diverts blood from the umbilical vein to the IVC, thus shunting oxygen-rich blood to the heart and bypassing the liver.

**Part 2 – Gallbladder and Biliary Tree**

**The Gallbladder**

The gallbladder stores and concentrates bile. It lies on the posteroinferior (visceral) surface of the liver and lies close to the duodenum. The gallbladder has three parts, the fundus, the body, and the neck.

![Gallbladder diagram](image)

**Figure 2:** The gallbladder and biliary tree.

The **body** forms the main part of the gallbladder which sits in the gallbladder fossa on the visceral surface of the liver. It tapers towards the **neck**, which communicates with the cystic duct. The **fundus** is the rounded end of the gallbladder, which typically extends to the inferior border of the liver.
The surface marking of the fundus of the gallbladder is at the tip of the 9th costal cartilage, at the point where the right midclavicular line intersects the right costal margin.

The Biliary Tree

Bile is continuously produced by hepatocytes in the liver and is first excreted into small channels called bile canaliculi. The canaliculi drain into bile ducts of increasing calibre, which ultimately converge to form right and left hepatic ducts that exit the liver at the porta hepatis.

- The left and right hepatic ducts converge to form the common hepatic duct.
- The common hepatic duct receives the cystic duct from the gallbladder. Distal to this point, the duct is called the bile duct (or common bile duct).
- The bile duct runs in the free edge of the lesser omentum.
- It lies posterior to the superior part of the duodenum and posterior to the head of the pancreas.
- The bile duct enters the duodenum.

If bile leaving the liver is not needed for digestion, it enters the gallbladder via the cystic duct. When needed, bile flows from the gallbladder, via the cystic duct, to the bile duct and duodenum. The spiral fold (spiral valve) lies at the junction between the gallbladder neck and the cystic duct.

Blood Vessels and Nerves of the Gallbladder

- Blood supply is via the cystic artery, which typically arises from the right hepatic artery (variation exists).
- The gallbladder is drained by cystic veins that pass directly into the liver or join the hepatic portal vein.
- The gallbladder is innervated by parasympathetic and sympathetic fibres.
- Visceral afferents from the gallbladder return to the CNS with the sympathetic fibres. Visceral pain from the gallbladder enters spinal cord levels T5 – T9 and is therefore referred to (i.e. felt in) the epigastrium.
- Gallbladder pain may also be referred to the right shoulder if gallbladder pathology (e.g. inflammation) irritates the diaphragm. The diaphragm is innervated by the phrenic nerve (C3-5). Spinal cord segments C3-5 also receive somatic sensory information from the skin over the shoulder. Therefore gallbladder pathology involving the diaphragm may be felt in the right shoulder.
If gallbladder pathology irritates the parietal peritoneum, which is innervated by somatic nerves, pain is well localised to the right hypochondrium.

Part 3 – Clinical Relevance

Hepatomegaly

Hepatomegaly is enlargement of the liver. Causes include hepatitis (inflammation of the liver from various causes), malignancy, and heart failure. When the liver is enlarged, its inferior border becomes palpable inferior to the right costal margin.

Liver metastases

Although primary cancer of the liver does occur, most cancers of the liver are metastases from cancer elsewhere in the body. Because venous blood from the gut passes through the liver, bowel cancers often metastasize to the liver.

Cirrhosis of the liver

Cirrhosis is sometimes referred to as ‘scarring’ of the liver. It is caused by chronic excess alcohol consumption, chronic infection with hepatitis B or C, or a build-up of fat in the liver. Hepatocytes are destroyed and replaced with fibrous tissue. The liver becomes shrunken, hard, and nodular. Loss of hepatocytes impairs the function of the liver and liver failure may ultimately result.

Portal hypertension and portosystemic anastomoses

Portal hypertension is high blood pressure in the portal venous system. It results when blood flow through the liver and portal vein is obstructed (e.g. in cirrhosis of the liver). Portosystemic anastomoses are communications between veins draining to the systemic circulation and veins draining to the portal circulation. For example, in the distal oesophagus, venous blood drains into both the systemic veins (via the azygos) and into the portal system (via the gastric veins). If flow in the portal system is obstructed, pressure in the portal system increases and blood is diverted from the portal veins into the systemic veins. The systemic veins become distended and varicose (in the oesophagus these are called oesophageal varices) and prone to rupture, which can result in catastrophic bleeding.
Gallstones, biliary colic, and cholecystitis

Gallstones are common in the UK population. They are mostly composed of cholesterol. They are often asymptomatic, but cause symptoms when they migrate into the biliary tree and lodge there. When a gallstone lodges in the cystic duct, contraction of the gallbladder against it causes severe pain termed **biliary colic**. If the stone moves back into the gallbladder, the pain eases. If it does not, and the stone becomes stuck, it blocks the flow of bile into the cystic duct and the gallbladder becomes inflamed (**cholecystitis**). **Cholecystectomy** is removal of the gallbladder. It is usually performed laparoscopically.

Part 4 – Questions to Consolidate Learning

1. Which artery gives rise to the cystic artery?
2. Which structures are found at the porta hepatis?
3. What structure degenerates to form the ligamentum venosum?
4. Where is the bare area of the liver?
5. With the patient in a supine position, where might fluid collect in the abdomen?
6. What is the surface marking of the fundus of the gallbladder?
7. Which nerves may relay pain from diseases of the gallbladder? For each nerve involved, where would the patient feel the pain?
8. Where do the hepatic veins drain to?

Image References

- Figure 1: "Cartoon to remember the position of the structures in the hepatoduodenal ligament - English labels" at AnatomyTOOL.org by S. Bas Blankevoort, LUMC, Andrzej Baranski, LUMC and O. Paul Gobée, LUMC, license: Creative Commons Attribution-NonCommercial-ShareAlike
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- Figure 2: OpenStax 2013. *Anatomy and Physiology*. Authors: J. Gordon Betts, Kelly A. Young, James A. Wise, Eddie Johnson, Brandon Poe, Dean H. Kruse, Oksana Korol, Jody E. Johnson, Mark Womble, Peter DeSaix. OpenStax, Houston, Texas.
Session 14: The Coeliac Trunk, Duodenum, Pancreas and Spleen.

- Dissection Video: Session 14.
- Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives
1. Describe the branches of the coeliac trunk.
2. Describe the position of the duodenum and its key anatomical relations.
3. Describe the gross anatomy of the duodenum.
4. Describe the arterial supply and venous drainage of the duodenum.
5. Describe the location of the pancreas and its surface marking.
6. Describe the arterial supply and venous drainage of the pancreas.
7. Describe the anatomy of the pancreatic ducts and the hepatopancreatic ampulla.
8. Understand the innervation of, and the pathways of referred pain from, the duodenum and pancreas.
9. Describe the location, blood supply and venous drainage of the spleen.

Clinical points
- Duodenal ulcer
- Pancreatitis
- Pancreatic cancer
- Diabetes mellitus
- Splenomegaly
- Splenic rupture

In the MTU, you will dissect / study the:

- branches of the coeliac trunk
- gross anatomy of the duodenum and pancreas
- gross anatomy and blood supply of the spleen
**Part 1 – Coeliac Trunk**

The coeliac trunk leaves the anterior aspect of the aorta at the level of T12. It gives rise to three major branches:

- The **left gastric** artery – supplies the distal oesophagus and lesser curvature of the stomach.
- The **common hepatic** artery – branches supply the liver, stomach, and duodenum.
- The **splenic** artery – branches supply the stomach, pancreas, and spleen.

**Part 2 – Duodenum**

The duodenum is the first and shortest part of the small intestine. It is continuous proximally with the pylorus of the stomach and distally with the jejunum. The pyloric sphincter regulates gastric emptying into the duodenum.

- Most of the duodenum is retroperitoneal.
- The duodenum forms a C-shape that cups the head of the pancreas.
- The duodenum is described in **four parts**. These are the superior (first), descending (second), the inferior (third) and the ascending (fourth) parts.
- The bile duct, gastroduodenal artery and the hepatic portal vein lie **posterior** to the **first** part of the duodenum.
- The **superior mesenteric** artery lies anterior to the **third** part.
- The **fourth** part meets the jejunum at the **duodenojejunal flexure**.
- Approximately halfway along the internal wall of the duodenum is a small elevation called the **major duodenal papilla** (papilla = nipple-like). This marks the point at which bile and digestive pancreatic secretions (‘pancreatic juice’) enter the duodenum. We will learn more about this shortly.

**Blood Supply of the Duodenum**

The **first half** of the duodenum is derived from the **foregut** and is supplied by branches of the **coeliac trunk** (the artery of the foregut). The **second half** is derived from **midgut** and is supplied by branches of the **superior mesenteric artery** (the artery of the midgut). Arterial branches that supply the duodenum are derived from the:

- **gastroduodenal** artery (from the common hepatic artery and hence the coeliac trunk)
- **inferior pancreaticoduodenal** arteries (from the superior mesenteric artery)
Veins follow the arteries and are tributaries of the hepatic portal vein.

**Part 3 – Pancreas**

The pancreas lies horizontally on the posterior abdominal wall at the level of L1 and is retroperitoneal. It does not have a capsule so in the cadaver its surface appears ‘bumpy’ rather than smooth.

- It forms from dorsal and ventral pancreatic buds which fuse during development.
- It is composed of four parts: the head, the neck, the body, and the tail.
- The uncinate process is a hook-like projection of the head of the pancreas.
- The head is cupped by the C-shaped duodenum and the tail extends to the hilum of the spleen.
- The pancreas forms part of the posterior wall of the lesser sac.
- The splenic artery runs towards the spleen embedded in the upper border of the pancreas. The splenic vein lies posterior to the pancreas.
- The main pancreatic duct and the accessory pancreatic duct run within the substance of the pancreas.

![Figure 1: The duodenum and pancreas.](image)

**Function of the Pancreas**

The pancreas has an endocrine and an exocrine function. It synthesizes and secretes insulin and glucagon. Insulin is released in response to high levels of glucose in the blood. The pancreas also produces pancreatic juice that contains digestive
enzymes. Pancreatic juice is transported through main pancreatic duct and the accessory pancreatic duct to the duodenum. The main and accessory pancreatic ducts usually communicate with each other.

**Relationship Between the Main Pancreatic Duct and the Bile Duct**

The duodenum receives:
- bile from the liver and gallbladder via the bile duct
- pancreatic juice from the pancreas via the main and accessory pancreatic ducts.

The bile duct and main pancreatic duct merge at the hepatopancreatic ampulla (ampulla = dilation). The hepatopancreatic ampulla opens into the second part of the duodenum at the major duodenal papilla, which is located on the internal wall of the duodenum, about halfway along its length.

The hepatopancreatic ampulla is surrounded by smooth muscle - the sphincter of Oddi. Contraction of the sphincter prevents reflux of duodenal contents into the bile and main pancreatic ducts.

The accessory pancreatic duct empties pancreatic juice into the duodenum at the minor duodenal papilla, which lies just proximal to the major duodenal papilla.

**Blood Supply of the Pancreas**

The pancreas is supplied by blood vessels derived from the coeliac trunk and blood vessels derived from the superior mesenteric artery:

- The splenic artery, a major branch from the coeliac trunk, runs along the upper border of the pancreas and gives rise to pancreatic arteries.
- The gastroduodenal artery (from the common hepatic artery and hence the coeliac trunk) gives rise to the superior pancreaticoduodenal arteries that supply the pancreas.
- The superior mesenteric artery gives rise to the inferior pancreaticoduodenal arteries that supply the pancreas.

Veins follow the arteries. The splenic vein drains the pancreas and unites with the superior mesenteric vein to form the hepatic portal vein posterior to the neck of the pancreas.
Part 4 – Spleen

The spleen is a haematopoietic and lymphoid organ that lies in the left upper quadrant, protected by ribs 9 - 11. It is covered with visceral peritoneum. It has several functions that include the breakdown of old red blood cells, the storage of red blood cells and platelets, and various immune responses, including production of IgG.

The spleen has two surfaces and four borders:

- the **diaphragmatic surface** lies adjacent to the diaphragm
- the **visceral surface** lies in contact with the stomach, left kidney and colon. The splenic vessels enter and exit the spleen at the **hilum** on the visceral surface
- the anterior and superior borders are typically **notched**
- the posterior and inferior borders are smooth.

A normal sized spleen is not palpable below the costal margin. If it is palpable, it is enlarged by at least three times its normal size.

**Figure 2**: The surfaces and borders of the spleen.

**Blood Supply of the Spleen**

The spleen is supplied by the **splenic artery**, a branch of the coeliac trunk. The splenic artery runs along the superior border of the pancreas, embedded within it. The artery divides into approximately five branches at the hilum.

Venous drainage is via the **splenic vein**, which runs posterior to the pancreas. It unites with the superior mesenteric vein to form the hepatic portal vein.
Part 5 – Clinical Relevance

Duodenal ulcer

Duodenal (peptic) ulcers are most common in the first part of the duodenum. A duodenal ulcer here may erode the duodenal wall and the gastroduodenal artery, which lies posterior to the first part of the duodenum, resulting in severe intra-abdominal bleeding.

Pancreatitis

Inflammation of the pancreas may be chronic or acute. Acute pancreatitis is a life-threatening condition. There are many causes, but in the UK, it is most commonly due to excess alcohol intake or impaction of a gallstone at the hepatopancreatic ampulla. In gallstone pancreatitis, impaction of the gallstone prevents pancreatic juice from leaving the pancreas and it starts to break down the pancreas (autolysis). It is extremely painful.

Pancreatic cancer

Pancreatic cancer can affect any part of the pancreas and typically causes pain that radiates to the back. When it affects the head of the pancreas, it can obstruct flow of bile in the bile duct. This leads to an accumulation of bile pigments in the blood and results in jaundice (yellowing of the skin).

Diabetes mellitus

Diabetes mellitus results when the insulin-producing cells of the pancreas no longer produce insulin (or produce inadequate amounts). This leads to sustained high blood glucose levels which are detrimental to many tissues of the body and are ultimately fatal if not controlled. Some patients develop diabetes secondary to pancreatitis.

Splenomegaly

Enlargement of the spleen is splenomegaly. Causes include infection (e.g. infectious mononucleosis, malaria), haematological malignancy (e.g. leukaemia) and portal hypertension. When the spleen enlarges, it does so towards the midline, in the
direction of the **right iliac fossa**, because the phrenicocolic ligament prevents its direct descent towards the left iliac fossa.

**Splenic rupture**

The spleen is soft and highly vascular and is therefore vulnerable to blunt abdominal trauma or rib fractures that may puncture the spleen. Splenic haemorrhage is life-threatening and is managed by removing the spleen (splenectomy). The spleen is not essential for life, although patients are more prone to some bacterial infections after splenectomy.

**Part 6 – Questions to Consolidate Learning**

1. Can the spleen be palpated during abdominal examination?
2. What structures might a tumour of the head of the pancreas involve?
3. What structures join to form the bile duct and what is its course?
4. Where is the sphincter of Oddi located?
5. Which artery lies behind the first part of the duodenum?
6. What lies between the pancreas and the stomach?

**Image References**

- Figure 1: "MedicalGraphics - Drawing Pancreas and duodenum - no labels" at AnatomyTOOL.org by www.MedicalGraphics.de, license: Creative Commons Attribution-NoDerivatives "MedicalGraphics - Drawing Pancreas and duodenum - no labels" by www.MedicalGraphics.de, license: CC BY-ND
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The original image has been adapted for this resource by the addition of arrows and labels to indicate the parts of the spleen.
Session 15: The Nasal and Oral Cavities

- Dissection Video: Session 15.
- Dissection Instructions: Available in the MTU and on Minerva in advance.

Aims and Objectives

1. Describe the bones of the nasal cavity.
2. Describe the anatomical features of the lateral wall of the nasal cavity.
3. Identify and name the paranasal sinuses and describe how they communicate with the nasal cavity.
4. Describe the blood supply of the nasal cavity.
5. Identify the opening of the auditory tube in the nasopharynx and understand the function of the auditory tube.
6. Describe and identify the boundaries and major anatomical features of the oral cavity.
7. Describe the function of the extrinsic and intrinsic muscles of the tongue.
8. Know the sensory and motor innervation of the tongue.

Clinical points

- Epistaxis
- Fracture of the nose
- Sinusitis
- Cleft palate
- Hypoglossal nerve palsy
- Nasal and oral cancer
- Tonsillitis and tonsillectomy

In the MTU you will dissect / study the:

- midline structures of the bisected head
- lateral wall of the nasal cavity
- paranasal sinuses
- oral cavity and tongue
Part 1 – Nasal Cavities and Paranasal Sinuses

The left and right nasal cavities form the first part of the respiratory tract. Mucosa in the upper part of the nasal cavity contains olfactory receptors. The axons of these receptors form the olfactory nerves (CN I).

The left and right nasal cavities are separated from:
- each other by a thin midline septum, formed of cartilage and bone. When the head is bisected, the septum is seen on one half only.
- the oral cavity inferiorly by the hard palate
- the brain superiorly by bone.

The nasal cavity communicates with the nasopharynx posteriorly. The nasal cavity also communicates with the paranasal sinuses, which are cavities within the skull bones.

![Figure 1. Bisected head showing the nasal septum, hard palate, and nasopharynx.](image)

The midline nasal septum is formed of cartilage anteriorly and two thin plates of bone posteriorly. The perpendicular plate of the ethmoid bone forms the superior part of the posterior septum, and the vomer forms the inferior part of the posterior septum.
The lateral wall of the nasal cavity bears three projections of bone, the superior, middle, and inferior conchae (Latin = shell), or turbinates.

- The spaces inferior to them are the meatuses: the superior meatus lies inferior to the superior concha; the middle meatus lies inferior to the middle concha and the inferior meatus lies inferior to the inferior concha.
- As inspired air travels through the meatuses it is warmed, humidified, and filtered.

![Diagram of the nasal cavity](image)

**Figure 2.** The nasal conchae.

The nasal cavity is separated from the cranium and the brain by the cribriform plate. The cribriform plate is a delicate section of bone that is perforated with tiny holes (like a sieve). The axons of olfactory neurons pass through these perforations to form the olfactory nerves, which travel to the brain. Olfactory receptors are located in the sphenoid-ethmoidal recess in the upper nasal cavity, between the superior concha and the cribriform plate.
Paranasal Sinuses

The paranasal sinuses are cavities within the skull bones and are named according to the bones within which they are located:

- **frontal** sinuses lie within the anterior part of the frontal bone
- **ethmoid** air cells lie within the ethmoid bone (superior to the nasal cavity and medial to the orbits)
- **sphenoid** sinuses lie within the sphenoid bone
- **maxillary** sinuses lie within the maxillae of the facial skeleton.

The frontal sinus and sphenoid sinus are usually clearly seen in the bisected head. The maxillary sinuses lie lateral to the lateral walls of the nasal cavity.

**Figure 3.** The locations of the paranasal sinuses.
The paranasal sinuses communicate with the nasal cavity via small ducts / channels as follows:

- the frontal sinus drains into the middle meatus
- the sphenoid sinus drains into the sphenoid-ethmoidal recess
- the ethmoid air cells drain into the superior and middle meatuses
- the maxillary sinus drains into the middle meatus.

The opening of the maxillary sinus into the middle meatus lies superomedially, therefore it cannot drain freely when the head is upright.

The nasal cavity also receives the **nasolacrimal duct** which drains the fluid (‘tears’) that lubricate the anterior surface of the eye. The duct opens into the **inferior meatus**. When we cry, we get a runny nose because excess fluid runs down the nasolacrimal duct.

The nasal cavity also communicates with the **middle ear**. The middle ear is a small cavity within the temporal bone that is modified for hearing (it contains three tiny bones that transmit sound waves to the inner ear).

- The **auditory tube** (Eustachian tube) connects the middle ear to the **nasopharynx**. The opening of the auditory tube can be seen on the lateral wall of the nasopharynx, surrounded by a slight bulge, which is formed of tonsillar tissue.
- The auditory tube allows air to pass into the middle ear so that the pressure on either side of the tympanic membrane (eardrum), which lies between the middle and external ear, is **equal**. This is important for optimal conduction of soundwaves.

**Vessels and Nerves of the Nasal Cavity**

The nasal cavity is supplied by several arteries, including branches of the **maxillary artery**, which is a terminal branch of the external carotid artery. An anastomotic network formed supplies the nasal septum and is often the site of bleeding in a nosebleed (epistaxis). The **sensory** innervation of the nose is via branches of the **trigeminal nerve** (CN V).
Part 2 – The Palate

The palate separates the nasal cavities from the oral cavity. It is composed anteriorly of bone – the **hard palate** – and posteriorly of muscle – the **soft palate**. The palate forms the **roof** of the oral cavity.

**The Hard Palate**

The hard palate is composed of two bones: the palatine bone of the maxilla and the horizontal plate of the palatine bone. The hard palate is functionally important because:

- it prevents food or fluid entering the nasal cavity
- we push our tongue up against the hard palate during the first phase of swallowing, which forces food and fluid backwards into the oropharynx
- we push our tongue up against the hard palate to articulate certain sounds.

In some people the palate does not form properly during embryological development (a **cleft palate**), causing difficulty with eating, swallowing and speech if not repaired.

**The Soft Palate**

The soft palate lies posterior to the hard palate. A midline conical projection - the **uvula** - ‘hangs’ from the posterior border of the soft palate and can be seen at the back of the mouth.

The soft palate is composed of several **muscles**, but we will not name them individually. The key point to appreciate is that the muscles of the soft palate contract during swallowing which **elevates** the soft palate. The nasopharynx is closed off from the oral cavity, preventing reflux of food and fluid into the nasal cavity.

The muscles of the soft palate are innervated by the vagus nerve.
Part 3 – The Oral Cavity

The Boundaries and Contents of the Oral Cavity

The oral cavity is bounded:

- superiorly by the hard and soft palate (the roof of the mouth)
- inferiorly by soft tissues and muscles (the floor of the mouth)
- laterally by the cheeks (which contain the buccinator muscle).

The oral cavity is continuous posteriorly with the oropharynx. It contains the tongue, teeth and gums and the openings of the salivary ducts.

We looked at the salivary glands in the previous session, so we will concentrate here on a brief look at the teeth and gums and a detailed look at the tongue.

The Teeth and Gums

It is important for doctors to have a basic understanding of the anatomy of the teeth and gums, and the systemic problems that poor dental health can cause. For example, a dental abscess could cause sepsis or spread to the deep tissues of the face. Patients sometimes present to Accident and Emergency with acute dental problems, such as severe toothache or mouth pain and swelling caused by a dental abscess. The usual course of action is to provide analgesia and ensure that the patient is not systemically unwell (e.g. rule out sepsis). If the patient is not unwell, efforts are made to try and arrange an urgent dental appointment for them. Antibiotics may be prescribed if appropriate.

As donors are often elderly, many of the cadavers do not have a full set of teeth – some cadavers may not have any teeth at all.

The basics are:

- Adults have 32 teeth – 16 embedded in the maxilla (upper jaw) and 16 embedded in the mandible.
- In the upper and lower jaws there are four incisors, two canines, four premolars and six molars.
- The teeth are composed of:
  - an inner **pulp** which contains blood vessels and nerves
  - **dentin** which surrounds the pulp
  - an outer, hard coating of **enamel**.
Enamel and dentin can be eroded by bacteria or foodstuffs (e.g. sugar and acids). This can lead to decay, inflammation, and infection of the pulp, which is painful. Infection may spread to the bone, leading to abscess formation.

**Figure 4.** Anatomy of the tooth.

**The Tongue**

The tongue is essential for normal chewing, swallowing and speech. It bears papillae on its superior surface, some of which detect taste (‘taste buds’). The anterior part of the tongue lies in the oral cavity, and the posterior part (the root) extends into the oropharynx. The space between the posterior tongue and the anterior aspect of the epiglottis is the **vallecula**.

The tongue is composed of intrinsic and extrinsic muscles.

- **Intrinsic** muscles lie entirely within the tongue. They are paired bilaterally and fuse in the midline. They change the shape of the tongue.
- **Extrinsic** muscles are attached to the tongue but originate from outside it (from the mandible and hyoid bone). They move the tongue.
The muscles are innervated by the **hypoglossal** nerve (CN XII).

The **sensory** innervation of the tongue is via three cranial nerves:
- **Taste** in the **anterior two thirds** is served by the **facial** nerve (CN VII).
- **General** sensation (touch, pain, temperature) in the **anterior two thirds** is served by the **trigeminal** nerve (CN V).
- **Taste** and **general** sensation in the **posterior third** are served by the **glossopharyngeal** nerve (CN IX).

**Vessels and Nerves of the Oral Cavity**

- The oral cavity is supplied by the lingual, maxillary, and facial arteries, which are branches of the external carotid artery.
- Innervation of the oral cavity is complex. The muscles of the soft palate are innervated by the vagus nerve. The tongue is innervated by four cranial nerves (CNs V, VII, IX and XII) as described above.

**Part 4 – The Tonsils**

Tonsillar tissue is found in several locations in the nasal and oral cavities.

- The **pharyngeal** tonsil lies in the roof and posterior wall of the nasopharynx (sometimes called the ‘adenoid’).
- The **tubal** tonsil surrounds the opening of the auditory tube on the lateral wall of the nasopharynx.
- The **palatine** tonsil lies on the lateral wall of the oropharynx. Usually referred to as ‘the tonsils’, they are visible on either side of the oropharynx when the mouth is open.
- The **lingual** tonsil is a collection of lymphoid tissue in the posterior tongue.
Part 5 – Clinical Relevance

Epistaxis (nosebleed)

Nosebleeds most commonly arise due to trauma, but they also occur spontaneously. They can usually be stopped by applying pressure, but sometimes bleeding can be profuse, especially if patients are taking anticoagulants ('blood thinners'). If bleeding cannot be stemmed by applying pressure to the nose, the bleeding vessels can be cauterised, or a nasal tampon can be inserted into the nostril which compresses the blood vessels inside the nose.

Fracture of the nose

The nasal bones or septum may be broken by blunt trauma. The nose may be deviated to one side as a result. Traumatic blows to the nose may fracture the cribiform plate and this must be considered in patients with nasal trauma.

Sinusitis

This is inflammation or infection of the mucosa lining the paranasal sinuses. It is painful. Sinusitis affecting the maxillary sinuses is problematic as they do not drain freely, unless lying down on one side. Inflammation of the maxillary sinus may cause pain in the cheek, as the sensory nerve that supplies the cheek runs in the roof of the maxillary sinus.

Cleft palate

Development of the palate is complex. If the bones of the hard palate do not develop properly or do not fuse in the midline, a cleft remains that allows communication between the nasal and oral cavities. A cleft palate is surgically repaired.

Hypoglossal nerve palsy

Injury to the left or right hypoglossal nerve results in atrophy (wasting) and weakness or paralysis of the ipsilateral tongue muscles. Because the muscles on the unaffected
side continue to function, the tongue deviates to the affected (injured) side when the patient protrudes their tongue.

**Nasal and oral cancer**

Cancer of the nasal cavity or sinuses is rare. Cancer can develop in structures associated with the mouth, including the oral mucosa, tonsils, tongue, and salivary glands. Mouth cancers may present as ulcers, lumps, or patches of discoloration on the oral mucosa.

**Tonsillitis and tonsillectomy**

Tonsillitis is inflammation of the tonsils - the palatine tonsils are commonly affected. The cause may be a viral or bacterial infection. The tonsils become enlarged, red and may be covered in pus which appears as white spots on the surface of the tonsils. Swallowing is very painful. Inflammation and enlargement of the pharyngeal tonsil (adenoid) is common in children. Enlargement may obstruct the nearby opening of the auditory tube, which can result in fluid accumulation in the middle ear and hearing impairment. Recurrent infection of the tonsils may be managed by tonsillectomy - surgical removal of the tonsils.

**Part 6 - Questions to Consolidate Learning**

1. What is the function of the auditory tube?
2. Why is the maxillary sinus more prone to infection than the other paranasal sinuses? Why may disease in the maxillary sinus cause numbness of the cheek?
3. Describe the motor and sensory nerve supply to the tongue.
4. Why would an infant with a cleft palate have difficulty feeding?
5. Explain why poor oral hygiene might lead to a dental abscess.
Image References

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- Figure 2. Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010. ISSN 2002-4436., CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons
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