

The Abdomen

The abdomen can be defined as the region of the trunk that lies between the diaphragm above and the inlet of the pelvis below.

Structure of the Abdominal Walls

Superiorly, the abdominal wall is formed by the diaphragm, which separates the abdominal cavity from the thoracic cavity (the diaphragm contains three foramina: the aortic opening, which transmits the aorta, the thoracic duct, and the azygos vein; the esophageal opening, which transmits the esophagus, the right and left vagus nerve, and the esophageal branches of the left gastric vessels; and the caval opening, which transmits the inferior vena cava, and terminal branches of the right phrenic nerve).

Inferiorly, the abdominal cavity is continuous with the pelvic cavity through the pelvic inlet.

Anteriorly, the abdominal wall is formed above by the lower part of the thoracic cage and below by the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscle and fasciae.

Posteriorly, the abdominal wall is formed in the midline by the five lumbar vertebrae and their intervertebral discs; laterally it is formed by the twelfth rib, the upper part of the bony pelvis, the psoas muscles, the quadratus lumborum muscles, and the aponeurosis of origin of the transversus abdominis muscles.

Bones

The bones of the abdomen and pelvis are the lower ribs and costal cartilage, the lumbar vertebrae, the sacrum, and coccyx, and the hip bones.

Lumbar Vertebrae

A typical vertebra consists of a rounded **body** anteriorly and a **vertebral arch** posteriorly. These enclose a space called the **vertebral foramen**, through which run the spinal cord and its covering. The vertebral arch consists of a pair of cylindrical **pedicles**, which form the sides of the arch and a pair of flattened **laminae**, which complete the arch posteriorly.

The vertebral arch gives rise to seven processes: one spinous, two transverse, and four articular.

The **spinous process**, or **spin**, is directed posteriorly from the junction of the two laminae. The transverse processes are directed laterally from the junction of the laminae and the

pedicles. Both the spinous and transverse processes serve as levers and receive attachments of muscles and ligaments.

The **articular processes** are vertically arranged and consist of two superior and two inferior processes. They arise from the junction of the laminae and pedicles, and their articular surfaces are covered with hyaline cartilage. The two superior articular processes of one vertebral arch articulate with the two inferior articular processes of the arch above, forming two synovial joints.

The pedicles are notched on their upper and lower border, forming the **superior and inferior vertebral notches**. On each side, the superior notch of one vertebra and the inferior notch of an adjacent vertebra together form an **intervertebral foramen**. These foramina serve to transmit the spinal nerves and blood vessels. The anterior and posterior nerve roots of a spinal nerve unite within these foramina with their coverings of dura to form the segmental spinal nerves.

There are five lumbar vertebrae the body of which is massive and kidney shaped, and it has to bear the greater part of the body weight. The fifth lumbar vertebra articulates with the base of the sacrum at the lumbosacral joint.

A typical lumbar vertebra has the following characteristics: the body is large and kidney shaped. The pedicles are strong and directed backward. The laminae are thick. The vertebral foramina are triangular. The transverse processes are long and slender. The spinous processes are short, flat, and quadrangular and project backward. The articular surfaces of the superior articular processes face medially and those of the inferior articular processes face laterally.

The lumbar vertebrae have no facets for articulation with ribs and no foramina in transverse processes.

The **intervertebral discs** in the lumbar region are thicker than in other regions of the vertebral column. They are wedge shaped and are responsible for the normal posterior concavity in the curvature of the vertebral column in the lumbar region (lordosis).

Sacrum

The sacrum consists of five rudimentary vertebrae fused together to form a single wedge-shaped bone, which is concave anteriorly. The upper border, or base, of the bone articulates with the fifth lumbar vertebrae. The narrow inferior border articulates with the coccyx. Laterally, the sacrum articulates with the two iliac bones to form the sacroiliac joints. The anterior and upper margin of the first sacral vertebra bulges forward as the posterior margin of the pelvic inlet and is known as the **sacral promontory**. The sacral promontory in the

female is of considerable obstetric importance and is used when measuring the size of the pelvis.

The vertebral foramina are present and form the **sacral canal**. The laminae of the fifth and sometimes the fourth, fail to meet in midline, forming the sacral hiatus. The sacral canal is the continuation of the vertebral canal posterior to the sacral vertebral bodies and contains the anterior and posterior roots of the lumbar, sacral, and coccygeal spinal nerves; the filum terminale; and fibrofatty material. It also contains the lower part of the subarachnoid space down as far as the lower border of the second sacral vertebra.

The posterior surface of the sacrum shows three longitudinal crests. The **median sacral crest** is formed by the incomplete fusion of the three or four sacral spines. The **intermediate and lateral sacral crests** lie respectively medial and lateral to the dorsal sacral foramina. The intermediate crests are formed by the fused articular processes and the lateral crests correspond to the transverse processes and form a portion of the lateral part of the sacrum.

The anterior and posterior surfaces of the sacrum possess on each side four foramina for the passage of the anterior and posterior rami of the upper four sacral nerves.

The sacrum is usually wider in proportion to its length in the female than in the male. The sacrum is tilted forward so that it forms an angle with the fifth lumbar vertebra, called the lumbosacral angle.

Coccyx

The coccyx consists of four vertebrae fused together to form a small triangular bone, which articulates at its base with the lower end of the sacrum.

The coccygeal vertebrae consist of bodies only, but the first vertebra possesses a rudimentary **transverse process** and **cornua**. The cornua are the remains of the pedicles and superior articular processes and project upward to articulate with the sacral cornua.

Hip Bone

In children, each hip bone consists of the ilium, which lies superiorly; the ischium, which lies posteriorly and inferiorly; and the pubis, which lies anteriorly and inferiorly. At puberty these three bones fuse together to form one large, irregular bone. The hip bones articulate with the sacrum at the sacroiliac joints to form the anterolateral walls of the pelvis, they also articulate with one another anteriorly at the symphysis pubis.

On the outer surface of the hip bone is a deep depression, the **acetabulum**, which articulates with the hemispherical head of the femur. Behind the acetabulum is a large notch,

the **greater sciatic notch**, which is separated from the **lesser sciatic notch** of the ischium by the **spin of the ischium**.

The **ilium**, which is the upper flattened part of the hip bone, possesses the **iliac crest**. This can be felt through the skin along its entire length. The iliac crest ends in front at the **anterior superior iliac spines** and behind at the **posterior superior iliac spines**. The iliac tubercle lies 5 cm behind the anterior superior spine. Below these spines are the corresponding anterior and posterior inferior iliac spines. Above and behind the acetabulum, the ilium possesses a large notch, the greater sciatic notch. On the inner surface of the ilium is the large **articular surface** for articulation with the sacrum. The **iliopectineal** line runs downward and forward around the inner surface of the ilium and serves to divide the false from the true pelvis.

The **ischium** is L shaped bone, possessing an upper thicker part, the **body**, and a lower thinner part, the **ramus**. The ramus together with the inferior ramus of the pubis forms the pubic arch. The ramus of the ischium expands posteriorly to form the ischial tuberosity, which gives attachment to the hamstring muscles of the thigh. Superior to the tuberosity, the ischial spine projects posteromedially and separates the lesser sciatic notch of the ischium inferiorly, from the greater sciatic notch on the posterior margin of the ilium superiorly. The sciatic notches are converted into the **greater** and **lesser sciatic foramina** by the presence of the **sacrotuberous** and **sacrospinous ligaments**.

The **pubis** can be divided into a **body**, a **superior ramus**, and an **inferior ramus**. The bodies of the two pubic bones articulate with each other in the midline anteriorly at the **symphysis pubis**. The superior ramus joins the ilium and ischium at the acetabulum, and the inferior ramus joins the ischial ramus below the **obturator foramen**. The obturator foramen in life is filled in by the obturator membrane. The **pubic crest** forms the upper border of the body of the pubis, and it ends laterally as the **pubic tubercle**.

On the outer surface of the hip bone is a deep depression, called the acetabulum, which articulates with the head of the femur to form the hip joint. The inferior margin of the acetabulum is deficient and is marked by the **acetabular notch**. The articular surface of the acetabulum is limited to a horse shoe-shaped area and is covered with hyaline cartilage. The floor of the acetabulum is nonarticular and is called the acetabular fossa.

Structure of the Anterior Abdominal Wall

The anterior abdominal wall is made up of skin, superficial fascia, deep fascia, muscles, extraperitoneal fascia, and parietal peritoneum.

For the purpose of description, the anterior abdominal wall is divided into nine regions by two vertical and two horizontal planes. The right and left vertical planes pass through the midpoint between the anterior superior iliac spine and the symphysis pubis. The **transpyloric plane** passes through the tips of the ninth costal cartilages on the two sides. It lies at the level of the body of the first lumbar vertebra. This plane passes through the pylorus of the stomach, the duodenojejunal junction, the neck of the pancreas, and the hila of the kidneys. The **subcostal plane** is a horizontal plane that joins the lower point of the costal margin on each side (at the tenth costal cartilage). The subcostal plane lies at the level of the third lumbar vertebra. The **intertubercular plane** is a horizontal plane that joins the tubercles on the iliac crest and lies at the level of the fifth lumbar vertebra.

It is common practice to divide the abdomen into quadrants by using a vertical and a horizontal line that intersect at the umbilicus. The quadrants are the upper right, upper left, lower right, lower left. The term **epigastrium** and **periumbilical** are loosely used to indicate the area below the xiphoid process and above the umbilicus and the area around the umbilicus, respectively.

Skin

The natural lines of cleavage in the skin are constant and run almost horizontally around the trunk. This is important clinically because an incision along a cleavage line will heal as a narrow scar, whereas one that crosses the line will heal as a wide scar.

The cutaneous nerve supply to the anterior abdominal wall is derived from the anterior rami of the lower six thoracic and first lumbar nerves. The thoracic nerves are the lower five intercostal and the subcostal nerves, and the first lumbar nerve is represented by the iliohypogastric and the ilioinguinal nerves.

The skin near the midline is supplied by branches of the superior epigastric artery (branch of the internal thoracic artery) and the inferior epigastric artery (a branch of the external iliac artery). The skin of the flanks is supplied by branches from the intercostal, lumbar, and deep circumflex iliac arteries.

The venous blood is collected into a network of veins that radiate from the umbilicus. The network is drained above into the axillary vein via the lateral thoracic vein and below into the femoral vein via the superficial epigastric and great saphenous vein.

Superficial Fascia

The superficial fascia can be divided into a superficial **fatty layer** and a deep **membranous layer**. The fatty layer is continuous with the superficial fat over the rest of the body and may be extremely thick (8 cm or more in obese patients). The membranous layer is thin and fades out laterally and above, where it becomes continuous with the superficial fascia of the back and thorax. Inferiorly, the membranous layer passes onto the front of the thigh, where it fuses with the deep fascia.

Deep Fascia

The deep fascia in the anterior abdominal wall is merely a thin layer of connective tissue covering the muscle, it lies immediately deep to the membranous layer of the superficial fascia.

Muscles of the Anterior abdominal wall

The muscles of the anterior abdominal wall consist of three broad thin sheets that are aponeurotic in front; from exterior to interior they are external oblique, internal oblique, and transversus. On either side of the midline anteriorly is a wide vertical muscle, the rectus abdominis. As the aponeuroses of the three sheets pass forward, they enclose the rectus abdominis to form the rectus sheath. The lower part of the rectus sheath might contain a small muscle called the pyramidalis.

The cremaster muscle, which is derived from the lower fibers of the internal oblique, passes inferiorly as a covering of the spermatic cord and enters the scrotum.

External Oblique

The external oblique muscle is a broad, thin, muscular sheet that arises from the outer surfaces of the lower eight ribs and fans out to be inserted into the xiphoid process, the linea alba, the pubic crest, the pubic tubercle, and the anterior half of the iliac crest. Most fibers are inserted by means of a broad aponeurosis.

A triangular-shaped defect in the external oblique aponeurosis lies immediately above and medial to the pubic tubercle. This is known as the **superficial inguinal ring**. The spermatic cord (or the round ligament of the uterus) passes through this opening.

Between the anterosuperior iliac spine and the pubic tubercle, the lower border of the aponeurosis is folded backward on itself, forming the **inguinal ligament**. From the medial

end of the ligament, the **lacunar ligament** extends backward and upward to the pectineal line on the superior ramus of the pubis. The lateral part of the posterior edge of the inguinal ligament gives origin to part of the internal oblique and transversus abdominis muscles. To the inferior rounded border of the inguinal ligament is attached the deep fascia of the thigh, the fascia lata

Internal oblique

The internal oblique muscle is also a broad, thin, muscular sheet that lies deep to the external oblique; most of its fibers run at right angles to those of the external oblique. It arises from the lumbar fascia, the anterior two-thirds of the iliac crest, and the lateral two-thirds of the inguinal ligament. The muscle fibers radiate as they pass upward and forward. The muscle is inserted into the lower borders of the lower three ribs and their costal cartilages, the xiphoid process, the linea alba, and the symphysis pubis. Near their insertion, the lowest tendinous fibers are joined by similar fibers from the transversus abdominis muscle to form the **conjoint tendon**, which is attached medially to the linea alba, but it has a lateral free border.

As the spermatic cord (or round ligament of the uterus) passes under the lower border of the internal oblique. It carries with it some of the muscle fibers that are called **cremaster** muscle.

Transversus Abdominis

The transversus muscle is a thin sheet of muscle that lies deep to the internal oblique, and its fibers run horizontally forward. It arises from the deep surface of the lower six costal cartilages, the lumbar fascia, the anterior two-thirds of the iliac crest, and the lateral third of the inguinal ligament. It is inserted into the xiphoid process, the linea alba, and the symphysis pubis. The lowest tendinous fibers join similar fibers from the internal oblique to form the conjoint tendon.

Note the posterior border of the external oblique muscle is free, whereas the posterior borders of the internal oblique and transversus muscles are attached to the lumbar vertebrae by the lumbar fascia.

Rectus Abdominis

The rectus Abdominis muscle is a long strap muscle that extend along the whole length of the anterior abdominal wall. It is abroad above and lies close to the midline, being separated from it fellow by the linea alba.

The rectus Abdominis muscle arises by two head, from the front of the symphysis pubis and from the pubic crest. It is inserted into the fifth, sixth, and seventh costal cartilages and the xiphoid process. When it contracts, its lateral margin forms a curved ridge that can be palpated and often seen and is termed the **linea semilunaris**. This extends from the tip of the ninth costal cartilage to the pubic tubercle.

The rectus Abdominis muscle is divided into distinct segments by three transverse **tendinous intersections**; one at the level of the xiphoid process, one at the level of the umbilicus, and one halfway between the two.

The rectus Abdominis is enclosed between the aponeuroses of the external oblique, internal oblique, and transversus, which form the rectus sheath.

The rectus sheath is separated from its fellow on the opposite side by a fibrous band called the **linea alba**. This extends from the xiphoid process down to the symphysis pubis and is formed by the fusion of the aponeuroses of the lateral muscle of the two sides. Wider above the umbilicus, it narrows down below the umbilicus to be attached to the symphysis pubis.

Pyramidalis

The pyramidalis muscle is often absent. It arises by its base from the anterior surface of the pubis and is inserted into the linea alba. It lies in front of the lower part of the rectus abdominis.

Rectus Sheath

The rectus sheath is a long fibrous sheath that encloses the rectus abdominis muscle and pyramidalis muscle (if present) and contains the anterior rami of the lower six thoracic nerves and the superior and inferior epigastric vessels and lymph vessels. It is formed mainly by the aponeuroses of the three lateral abdominal muscles.

For ease of description the rectus sheath is considered at three levels.

- Above the costal margin, the anterior wall is formed by the aponeurosis of the external oblique. The posterior wall is formed by the thoracic wall that is, the fifth, sixth, and seventh costal cartilages and the intercostal spaces.
- Between the costal margin and the level of the anterior superior iliac spine, the aponeurosis of the internal oblique splits to enclose the rectus muscle; the external oblique aponeurosis is directed in front of the muscle, and the transversus aponeurosis is directed behind the muscle.

- Between the level of the anterosuperior iliac spine and the pubis, the aponeuroses of all three muscles form the anterior wall. The posterior wall is absent, and the rectus muscle lies in contact with the fascia transversalis.

It should be noted that where the aponeuroses forming the posterior wall pass in front of the rectus at the level of the anterior superior iliac spine, the posterior wall has a free, curved lower border called the arcuate line. At this site, the inferior epigastric vessels enter the rectus sheath and pass upward to anastomose with the superior epigastric vessels.

Function of the Anterior Abdominal Wall

The oblique muscles laterally flex and rotate the trunk. The rectus abdominis muscle flexes the trunk and stabilizes the pelvis, and the pyramidalis keeps the linea alba taut during the process. The muscles assist the diaphragm during respiration.

The muscles assist in the act of forced expiration that occur during coughing and sneezing by pulling down the ribs and sternum. By contracting simultaneously with the diaphragm, with glottis of the larynx closed, they increase the intra-abdominal pressure and help in micturition, defecation, vomiting, and parturition.

Fascia transversalis

The fascia transversalis is a thin layer of fascia that lines the transversus abdominis muscle and is continuous with a similar layer lining the diaphragm and the iliacus muscle. The fascia transversalis, the diaphragmatic fascia, the iliacus fascia, and the pelvis fascia are continuous lining to the abdominal and pelvic cavities.

Extraperitoneal Fat and the Parietal Peritoneum

The extraperitoneal fat is a thin layer of connective tissue that contains a variable amount of fat and lies between the fascia transversalis and the parietal peritoneum. The walls of the abdomen are lined with parietal peritoneum. This is a thin serous membrane and is continuous below with the parietal peritoneum of the pelvis.

Nerves of the Anterior Abdominal wall

The nerves of the anterior abdominal wall are the anterior rami of the lower six thoracic and the first lumbar nerves. They pass forward in the interval between the internal oblique and

transversus muscles. They supply the skin of the anterior abdominal wall, the muscles, and the parietal peritoneum.

The lower six thoracic nerves then pierce the posterior wall of the rectus sheath to supply the rectus muscle and the pyramidalis (T12 only, known subcostal nerve). They terminate by piercing the anterior wall of the sheath and supplying the skin.

The first lumbar nerve has a similar course, but it does not enter the rectus sheath. It is represented by the iliohypogastric, which pierce the external oblique aponeurosis above the superficial inguinal ring, and by the ilioinguinal nerve, which emerges through the ring. They end by supplying the skin just above the inguinal ligament and the symphysis pubis.

Arteries of the Anterior Abdominal wall

The **superior epigastric artery**, one of the terminal branches of the internal thoracic artery, enters the upper part of the rectus sheath between the sternal and costal origins of the diaphragm. It descends behind the rectus muscle, supplying the upper central part of the anterior abdominal wall, and anastomoses with the inferior epigastric artery.

The **inferior epigastric artery** is a branch of the external iliac artery just above the inguinal ligament. It ascends behind the rectus muscle, supplying the lower central part of the abdominal wall, and anastomoses with the superior epigastric artery.

The **deep circumflex iliac artery** is a branch of the external iliac artery just above the inguinal ligament. It runs upward and laterally toward the anterosuperior iliac spine, and continues along the iliac crest. It supplies the lower part of the abdominal wall.

The lower two **posterior intercostal arteries**, branches of the descending thoracic aorta, and the four **lumbar arteries**, branches of the abdominal aorta, pass forward between the muscle layers and supply the lateral part of the abdominal wall.

Veins of the Anterior Abdominal Wall

Superficial Veins

The superficial veins form a network that radiates out from the umbilicus. Above, the network is drained into the axillary vein via the lateral thoracic vein and, below, into the femoral vein via the superficial epigastric and great saphenous veins. A few small veins, the paraumbilical veins, connect the network through the umbilicus and along the ligamentum teres to the portal vein. This forms an important portal systemic venous anastomosis.

Deep Veins

The deep veins of the abdominal wall, the superior epigastric, inferior epigastric, and deep circumflex iliac veins, follow the arteries of the same name and drain into the internal thoracic and external iliac veins. The posterior intercostal veins drain into the azygos veins, and the lumbar veins drain into the inferior vena cava.

Lymph Drainage of the Anterior Abdominal Wall

Superficial Lymph Vessels

The lymph drainage of the skin of the anterior abdominal wall above the level of the umbilicus is upward to the anterior axillary (pectoral) group of nodes, which can be palpated just beneath the lower border of the pectoralis major muscle. Below the level of the umbilicus, the lymph drains downward and laterally to the superficial inguinal nodes. The lymph of the skin of the back above the level of the iliac crests is drained upward to the posterior axillary group of nodes, palpated on the posterior wall of the axilla; below the level of the iliac crests, it drains downward to the superficial inguinal nodes.

Deep Lymph Vessels

The deep lymph vessels follow the arteries and drain into the internal thoracic, external iliac, posterior mediastinal, and para-aortic (lumbar) nodes.

Inguinal Canal

The inguinal canal is an oblique passage through the lower part of the anterior abdominal wall and is present in both sexes. It allows structures of the spermatic cord to pass to and from the testis to the abdomen in males. In female it permits the passage of the round ligament of the uterus from the uterus to the labium majus. In addition, it transmits the ilioinguinal nerve in both sexes.

The canal is about 4 cm long in the adult and extends from the deep inguinal ring, a hole in the fascia transversalis, downward and medially to the superficial inguinal ring, a hole in the aponeurosis of the external oblique muscle. It lies parallel and immediately above the inguinal ligament.

The **deep inguinal ring**, an opening in the fascia transversalis, lies about 1.3 cm above the inguinal ligament midway between the anterosuperior iliac spine and the symphysis pubis. Related to it medially are the inferior epigastric vessels, which pass upward from the external iliac vessels. The margins of the ring give attachment to the **internal spermatic fascia** (or the internal covering of the round ligament of the uterus).

The **superficial inguinal ring** is a triangular-shaped defect in the aponeurosis of the external oblique muscle and lies immediately above and medial to the pubic tubercle. The margins of the ring, sometime called the crura, give attachment to the **external spermatic fascia**.

The **anterior wall of the canal** is formed along its entire length by the aponeurosis of the external oblique muscle. It is reinforced in its lateral third by the origin of the internal oblique from the inguinal ligament.

The **posterior wall of the canal** is formed along its length by the fascia transversalis. It is reinforced in its medial third by the conjoint tendon, the common tendon of insertion of the internal oblique and transversus, which is attached to the pubic crest and pectineal line.

The **inferior wall or floor of the canal** is formed by the inguinal ligament (the rolled inferior edge of the aponeurosis of the external oblique muscle), and its medial end, the lacunar ligament.

The **superior wall or roof of the canal** is formed by the arching lowest fibers of the internal oblique and transversus abdominis muscle.

The inguinal canal is the canal through which the testis descends from within the fascia lining of the abdomen to the scrotum. The canal therefore allows the structures of the **spermatic cord** (ductus deferens, the blood and the lymph vessels, and the nerve of the testis) to pass to and from the testis to the abdomen in the male. In the female the smaller canal permits the passage of the round ligament of the uterus from the uterus to the labium majus. In both sexes the canal also transmits the ilioinguinal nerve.

Femoral Sheath and Canal

The femoral sheath is a downward protrusion into the thigh of the fascial envelope lining the abdominal walls. Its anterior wall is continuous above with the fascia transversalis, and its posterior wall with the fascia iliaca. The sheath surrounds the femoral vessels and lymphatics for about 2.5 cm below the inguinal ligament. The **femoral artery**, as it enters the thigh beneath the inguinal ligament, occupies the **lateral compartment** of the sheath. The **femoral vein**, as it leaves the thigh, lies on its medial side and is separated from it by a fibrous septum and occupies the **intermediate compartment**. The **lymph vessels**, as they leave the thigh, are separated from the vein by a fibrous septum and occupy the most **medial compartment**.

The **femoral canal** is the term used to name the small medial compartment for the lymph vessels. It is about 1.3 cm long, and its upper opening is referred to as the **femoral ring**. The **femoral septum**, which is a condensation of extraperitoneal tissue, closes the ring. The

femoral canal contains (1) fatty connective tissue, (2) all the afferent lymphatic vessels from the deep inguinal lymph node, and (3) one of the deep inguinal lymph node. A protrusion of peritoneum could be forced down the femoral canal, pushing the femoral septum before it. Such a condition is known as a **femoral hernia**.

Hernia

The presence of the femoral and inguinal canals at the lower part of the abdomen means there is a continuous pressure on these canals from the weight of the abdominal contents. Thus the erect posture makes man particularly susceptible to inguinal and femoral hernia. It is obvious that weakness of the abdominal muscles, distension of the abdomen, the presence of a chronic cough, the lifting of heavy weights, or straining to pass urine through a partially obstructed urethra may cause or aggravate a hernia.

The **inguinal hernia** may be predisposed to by the persistence of the processus vaginalis. This is the tube of peritoneum which extends from the abdomen into the scrotum and along which the testis descends. Normally the processus obliterates shortly after birth leaving only that part of it which surrounds the testis (tunica vaginalis). When the processus persists, it forms a ready made hernial sac along which a loop of intestine may pass. This inguinal hernia is thought to be congenital which traverse the inguinal canal and may enters the tunica vaginalis. It is called the **indirect inguinal hernia** and is the most common type of hernia. The other type is the **direct inguinal hernia** in which the hernial sac bulges directly anteriorly through the posterior wall of the inguinal canal medial to the inferior epigastric vessels. The direct inguinal hernia is rare in women, and most are bilateral. It is a disease of old men with weak abdominal muscles.

The **umbilical hernia** usually occurs as a result of abdominal distension (e.g. by repeated pregnancies). The umbilical sac in the linea alba in the region of the umbilicus tends to stretch and thin. Unlike the muscular parts of the abdominal wall, it does not return to its normal thickness and may subsequently bulge outwards forming a hernial sac. The **congenital umbilical hernia** is caused by a failure of part of midgut to return to the abdominal cavity from the extraembryonic coelom during fetal life.

The Male External Genital Organs

These are the penis, the scrotum and its contents, and the spermatic cord.

Spermatic Cord

The spermatic cord is a collection of structures that pass through the inguinal canal to and from the testis. It is covered with three concentric layers of fascia derived from the layers of the anterior abdominal wall. The cord begins at the deep inguinal ring lateral to the inferior epigastric artery and ends at the testis.

Structures of the Spermatic Cord

These are as follows: (1) vas deferens, (2) testicular artery, (3) testicular veins (pampiniform plexus), (4) testicular lymph vessels, (5) autonomic nerves, (6) remains of processus vaginalis, (7) cremastic artery, (8) artery of the vas deference, and (9) genital branch of the genitofemoral nerve, which supply the cremaster muscle.

Vas Deferens

This is a cordlike structure that can be palpated between finger and thumb in the upper part of the scrotum. It is a thick-walled muscular duct that transports spermatozoa from the epididymis to the urethra.

Testicular Artery

A branch of the abdominal aorta at the level of the second lumbar vertebra. It is long and slender artery and descends on the posterior abdominal wall. It traverses the inguinal canal and supplies the testis and the epididymis.

Testicular Veins

An extensive venous plexus, the **pampiniform plexus**, leaves the posterior border of the testis. As the plexus ascends, it becomes reduced in size so that at about the level of the deep inguinal ring, a single testicular vein is formed. It runs up on the posterior abdominal wall and drains into the left renal vein on the left side and into the inferior vena cava on the right side.

Lymph Vessels

The testicular lymph vessels ascend through the inguinal canal and pass up over the posterior abdominal wall to reach the lumbar lymph node on the side of the aorta at the level of the first lumbar vertebra.

Covering of the Spermatic cord

The covering of the spermatic cord are three concentric layers of fascia derived from layers of the anterior abdominal wall. Each covering is acquired as the processus vaginalis descends into the scrotum through the layers of the abdominal wall.

1. **External spermatic fascia** derived from the external oblique aponeurosis and attached to the margins of the superficial inguinal ring.
2. **Cremastric fascia** derived from the internal oblique muscle.
3. **Internal spermatic fascia** derived from the fascia transversalis and attached to the margins of the deep inguinal ring.

Scrotum, Testis, and Epididymis

Scrotum

The scrotum can be considered as an outpouching of the lower part of the anterior abdominal wall. It contains the testes, the epididymis, and the lower end of the spermatic cords.

The wall of the scrotum has the following layers: (1) skin, (2) superficial fascia, dartos muscle (smooth muscle) replacing fatty layer, (3) external spermatic fascia derived from the external oblique, (4) cremastric fascia derived from the internal oblique, (5) internal spermatic fascia derived from the fascia transversalis, and (6) tunica vaginalis.

The **skin** of the scrotum is thin, wrinkled, and pigmented and forms a single pouch. A slightly raised ridge in the midline indicates the line of fusion of the two lateral labioscrotal swelling. (In the female the swelling remain separate and form the labia majora).

The **superficial fascia** is continuous with the fatty and membranous layers of the anterior abdominal wall; the fat is, however, replaced by smooth muscle called the **dartos muscle**. This is innervated by sympathetic nerve fibers and is responsible for the wrinkling of the overlying skin. Both layers of the superficial fascia contribute to a median partition that crosses the scrotum and separates the testes from each others.

The **spermatic fasciae** lies beneath the superficial fascia and are derived from the three layers of the anterior abdominal wall on each side, as explained previously. These include the external spermatic, the cremastric, and the internal spermatic fasciae.

The cremaster muscle is supplied by the genital branch of the genitofemoral nerve. It can be made to contract by stroking the skin on the medial aspect of the thigh. this is called the

cremasteric reflex. The function of the cremaster muscle is to raise the testis and the scrotum upward for warmth and protection against injury.

The **tunica vaginalis** lies within the spermatic fasciae and covers the anterior, medial, and lateral surfaces of each testis. It is the lower expanded part of the processus vaginalis, and normally just before birth it becomes shut off from the upper part of the processus and the peritoneal cavity. The tunica vaginalis is thus a closed sac, invaginated from behind by the testis. The parietal layer lines the internal spermatic fascia, the visceral layer covers the front and the sides of the testis and epididymis and is continuous with the parietal layer near the posterior border of the testis. Normally there is a film of fluid between the two layers. In certain pathological conditions the space may be distended with fluid to form a hydrocele.

The lymph from the skin and fascia including the tunica vaginalis drains into the superficial inguinal lymph node.

Testis

The **testis** is an oval, firm, mobile organ lying within the scrotum. The left testis usually lies at lower level than the right. The upper pole of each gland is tilted slightly forward. Each testis is enclosed in a thick, dense layer of white fibrous capsule, the **tunica albuginea**. This is covered by the visceral layer of the tunica vaginalis except superiorly and posteriorly where it is directly in contact with the epididymis. The tunica albuginea projects forward into the posterior border of the testis forming a longitudinal thickened ridge, the **mediastinum testis**. The mediastinum testis is transversed by the blood and lymph vessels of the testis and by a communicating network of channels, the **rete testis**.

Extending from the inner surface of the capsule is a series of fibrous septa that divide the interior of the organ into **lobules**. Lying within each lobule are one to three coiled **seminiferous tubules**, which are lined with a thick, multi-layered germinal epithelium that produces immature spermatozoa. The convoluted tubules appear as fine, thread-like loops, which join each other and become straighter as they pass towards the mediastinum. The straight seminiferous tubules do not produce spermatozoa, but discharge them into the spaces of the rete testis. The convoluted tubules measure approximately 60 cm in length. Thus, the overall length of the seminiferous tubule is approximately 500m. The tubules open into a network of channels in the mediastinum called the rete testis. Fifteen to 20 Small, delicate **efferent ductules** connect the rete testis to the upper end of the epididymis.

Normal spermatogenesis can occur only if the testes are at a temperature lower than that of the abdominal cavity. When they are located in the scrotum, they are at a temperature about

3°C lower than that of the abdominal temperature. The control of testicular temperature in the scrotum is not fully understood, but the surface area of the scrotal skin can be changed reflexly by the contraction of the dartos and cremaster muscles. It is now recognized that the testicular veins (pampiniform plexus) together with the branches of the testicular artery, which lies close to the veins, probably assist in stabilizing the temperature of the testes by a countercurrent heat exchange mechanism. By this means, the hot blood arriving in the artery from the abdomen loses heat to the blood ascending to the abdomen within the vein.

Epididymis

The epididymis is a firm structure lying posterior to the testis, with the vas deferens lying on its medial side. It has an expanded upper end, the **head**, a **body**, and a pointed **tail** inferiorly. Laterally, a distinct groove lies between the testis and the epididymis, which is lined with the inner visceral layer of the tunica vaginalis and is called the **sinus of the epididymis**.

The epididymis is a much coiled tube nearly 6 m long, embedded in connective tissue. The tube emerges from the tail of the epididymis as the **vas deferens**, which enters the spermatic cord.

The long length of the duct of the epididymis provides storage space for the spermatozoa and allows them to go through the latter part of their maturation as they travel slowly along the duct. A main function of the epididymis is the absorption of fluid. Another function may be the addition of substances to the seminal fluid to nourish the maturing sperm.

Blood Supply of the Testis and Epididymis

The testicular artery is a branch of the abdominal aorta. The testicular veins emerge from the testis and the epididymis as a venous network, the **pampiniform plexus**, this becomes reduced to a single vein as it ascends through the inguinal canal. The right testicular vein drains into the inferior vena cava, and the left vein joins the left renal vein.

Lymph Drainage of the Testis and Epididymis

The lymph vessels ascend in the spermatic cord and end in the lymph nodes on the side of aorta (lumbar or para-aortic) nodes at the level of the first lumbar vertebra (i.e. on the transpyloric plane).

Penis

The penis has a fixed root and a body that hangs free.

Root of the Penis

The root of the penis is made up of three masses of erectile tissue called the **bulb of the penis** and the **right** and **left crura of the penis**. The bulb is situated in the midline and is attached to the undersurface of the urogenital diaphragm. It is traversed by the urethra and is covered on its outer surface by the **bulbospongiosus muscle**. Each crus is attached to the side of the pubic arch and is covered on its outer surface by the **ischiocavernosus muscle**. The bulb is continuous forward into the body of the penis and forms the **corpus spongiosum**. The two crura converge anteriorly and come to lie side by side in the dorsal part of the body of the penis, forming the **corpora cavernosa**.

Body of the Penis

The body of the penis is essentially composed of three cylinders of erectile tissue enclosed in a tubular sheath of the fascia. The erectile tissue is made up of two dorsally placed corpora cavernosa, which communicate with each other, and a single corpus spongiosum applied to their ventral (urethral) surface. It transmits the urethra and expands at the proximal extremity to form the bulb of the penis. At its distal extremity, the corpus spongiosum expands to form the glans penis, which covers the distal ends of the corpora cavernosa. The glans penis is shaped like a helmet and is much more extensive on the dorsal and lateral surfaces than on the urethral surface. The projecting margin of its base is the corona glandis. On the tip of the glans penis is the slitlike orifice of the urethra, called the **external urethral meatus**.

The **prepuce** or **foreskin** is a hoodlike fold of skin the skin that covers the glans penis. It is connected to the glans just below the urethral orifice by a fold called the **frenulum**.

The body of the penis is supported by two condensations of the deep fascia that extend downward from the linea alba and symphysis pubis to be attached to the fascia of the penis.

Dorsal Vessels and Nerves of Penis

The superficial and deep dorsal veins are both median structures. The **superficial vein** lies in the superficial fascia and divides proximally into right and left branches, which pass to the external pudendal veins of the corresponding thigh. The **deep dorsal vein** lies deep to the deep fascia. It drains to the prostatic plexus of veins by passing below the pubic symphysis into the pelvis. The vein has a thick muscular wall close to the pubis.

The two **dorsal arteries** and **nerves** are the terminal branches of the internal pudendal arteries and the pudendal nerves. The nerves are lateral to the arteries, and both supply skin and the glans of the penis.

Structures of the Posterior Abdominal Wall

The posterior abdominal wall is formed in the midline by five lumbar vertebrae and their intervertebral discs and laterally by the twelfth ribs, the upper part of the bony pelvis, the psoas muscle, the quadratus lumborum muscles, and the aponeurosis of the origin of the transversus abdominis muscles. The iliacus muscles lie in the upper part of the bony pelvis

Muscles of the Posterior Abdominal Wall

Psoas Major

the psoas minor is a small muscle with a long tendon that lies anterior to the psoas major. It is unimportant and is absent in 40% of patients.

The psoas muscle arises from the roots of the transverse processes, the sides of the vertebral bodies, and the intervertebral discs, from the 12th thoracic to the 5th lumbar vertebrae. The fibers run downward and laterally and leave the abdomen to enter the thigh by passing behind the inguinal ligament. The muscle is inserted into the lesser trochanter of the femur. The psoas is enclosed in a fibrous sheath that is derived from the lumbar fascia. The sheath is thickened above to form the **medial arcuate ligament**.

- Nerve supply: This muscle is supplied by the lumbar plexus.
- Action: The psoas flexes the thigh at the hip joint on the trunk, or if the thigh is fixed, it flexes the trunk on the thigh, as in sitting up from a lying position.

Quadratus Lumborum

The quadratus lumborum is a flat, quadrilateral-shaped muscle that lies alongside the vertebral column. It arises below from the iliolumbar ligament, the adjoining part of the iliac crest, and the tips of the transverse processes of the lower lumbar vertebrae. The fibers run upward and medially and are inserted into the lower border of the 12th rib and the transverse processes of the upper four lumbar vertebrae. The anterior surface of the muscle is covered by lumbar fascia, which is thickened above to form the **lateral arcuate ligament** and below to form the **iliolumbar ligament**.

- **Nerve supply:** This muscle is supplied by the lumbar plexus.
- **Action:** It fixes or depresses the 12th rib during respiration and laterally flexes the vertebral column to the same side.

Iliacus

The iliacus muscle is fan shaped and arises from the upper part of the iliac fossa. Its fibers join the lateral side of the psoas tendon to be inserted into the lesser trochanter of the femur. The combined muscles are often referred to as the **iliopsoas**.

- **Nerve supply:** This muscle is supplied by the femoral nerve, a branch of the lumbar plexus.
- **Action:** The iliopsoas flexes the thigh on the trunk at the hip joint, or if the thigh is fixed, it flexes the trunk on the thigh.

Fascial Lining of the Abdominal Wall

The abdominal walls are lined by one continuous layer of connective tissue that lies between the parietal peritoneum and the muscles. It is continuous below with a similar fascial layer lining the pelvic walls. It is customary to name the fascia according to the structure it overlies. For example, the **diaphragmatic fascia** covers the under surface of the diaphragm; the **transversalis fascia** lines the transversus abdominis, the **psoas fascia** covers the psoas muscle; the **quadratus lumborum fascia** covers the quadratus lumborum; and the **iliac fascia** covers the iliacus muscle.

The abdominal blood and lymph vessels lie within this fascial lining, whereas the principal nerves outside the fascia. The femoral sheath is simply a downward prolongation of the fascial lining around the femoral vessels and lymphatic for about 4 cm into the thigh, behind the inguinal ligament. Because the femoral nerve lies outside the fascial envelope, it has no sheath.

At the midpoint between the anterior superior iliac spine and the symphysis pubis, the spermatic cord pierces the fascia transversalis to form the deep inguinal ring. From the margins of the ring, the fascia is continuous over the cord as a tubular sheath, the internal spermatic fascia.

