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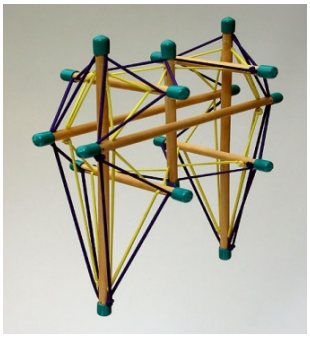

PELVILOGY Program

PELVILOGY 1

Handout 1

By

Guy VOYER DO

The Pelvic Girdle

Contents

The pelvic girdle is a ring-like structure, located in the lower part of the trunk. It connects the axial skeleton to the lower limbs.

In this article, we shall look at the structures of the pelvis, its functions, and the applied anatomy.

1- Structure of the Pelvic Girdle

The bony pelvis consists of the two **hip bones** (also known as innominate or pelvic bones), **sacrum** and **coccyx**.

There are four articulations within the pelvis:

- **Sacroiliac Joints (x2) -** Between the ilium of the hip bones, and the sacrum
- **Sacrococcygeal symphysis -** Between the sacrum and the coccyx.
- **Pubic symphysis** – Between the pubis bodies of the two hip bones.

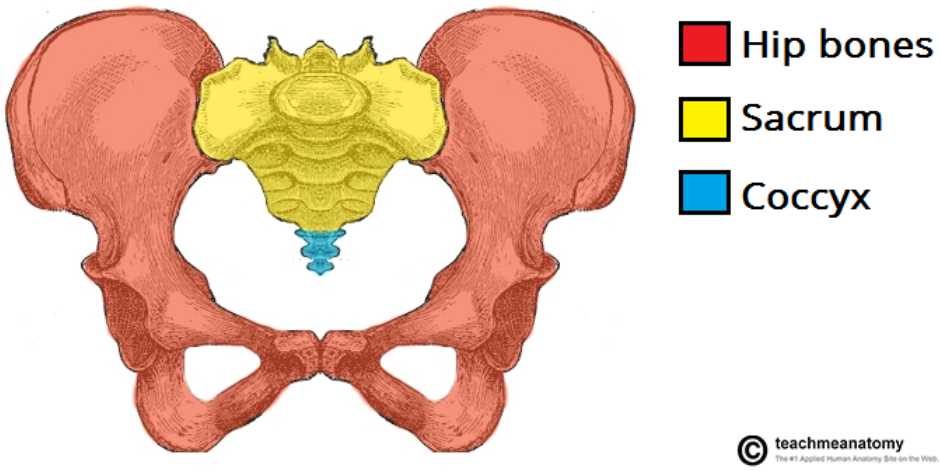

Fig 1.0 – The parts of the pelvic girdle.

Ligaments attach the lateral border of the sacrum to various bony landmarks on the bony pelvis to aid **stability**.

2- Functions of the Pelvis

The strong and rigid pelvis is adapted to serve a number of roles in the human body. The main functions being: -

- **Transfer of weight** from the upper axial sketeton to the lower appendicular components of the skeleton, especially during movement.
- **Provides attachment** for a number of muscles and ligaments used in locomotion.=
- **Contains and protects** the abdominopelvic and pelvic visera.

3- The Greater and Lesser Pelvis

The osteology of the pelvic girdle allows the pelvic region to be divided into two:

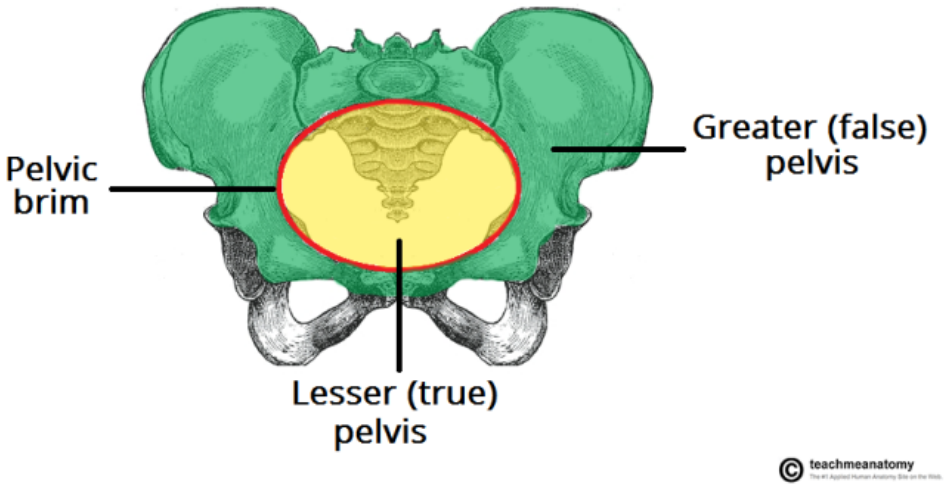

Fig 1.1- The true pelvis

- The superior portion of the pelvis is known as the **greater pelvis** (or false pelvis). It provides support for the lower abdominal viscera (ileum and sigmoid colon), and has no obstetric relevance.
- The inferior portion of the pelvis is known as the **lesser pelvis** (or "true" pelvis). Within which resides the pelvic cavity and pelvic viscera.

The junction between the greater and lesser pelvis is known as the **pelvic inlet**. The outer bony edges of the pelvic inlet are called the **pelvic brim**.

4- Pelvic Inlet

The pelvic inlet marks the boundary between the greater pelvis and lesser pelvis. Its size is defined by its edge, the **pelvic brim**.

The borders of the pelvic inlet:

- **Posterior**: The sacral promontory (the superior portion of the sacrum).
- **Lateral**: The arcuate line on the inner surface of the ilium, and the pectineal line on the superior ramus.
- **Anterior**: The pubic symphysis.

The pelvic inlet determines the size and shape of the birth canal, with the prominent ridges key areas of muscle and ligament attachment.

Some alternative descriptions terminology can be used in describing the pelvic inlet:

1. **Linea Terminalis –** Refers to the combined pectineal line, arcuate line and sacral promontory.
2. **Iliopectineal line –** Refers to the combined arcuate and pectineal lines.

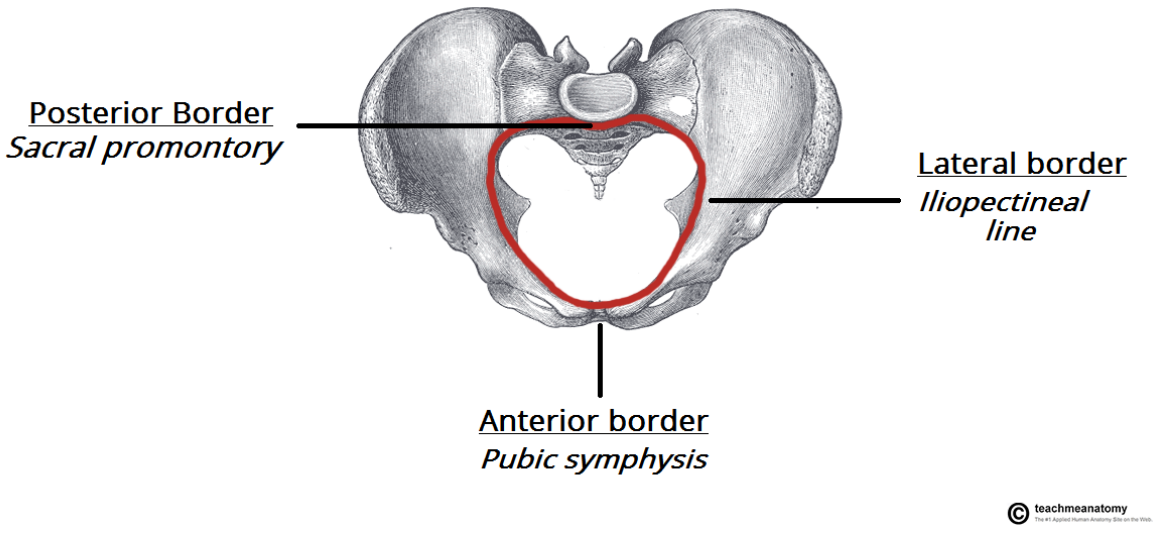

Fig 1.2 – Looking down onto the pelvis, the borders of the pelvic brim.

5- Pelvic Outlet

The pelvic outlet is located at the end of the lesser pelvis, and the beginning of the pelvic wall.

Its borders are:

- **Posterior**: The tip of the coccyx
- **Lateral**: The ischial tuberosities and the inferior margin of the sacrotuberous ligament
- **Anterior**: The pubic arch (the inferior border of the ischiopubic rami).

The angle beneath the pubic arch is known as the **sub-pubic angle** and is of a greater size in women.

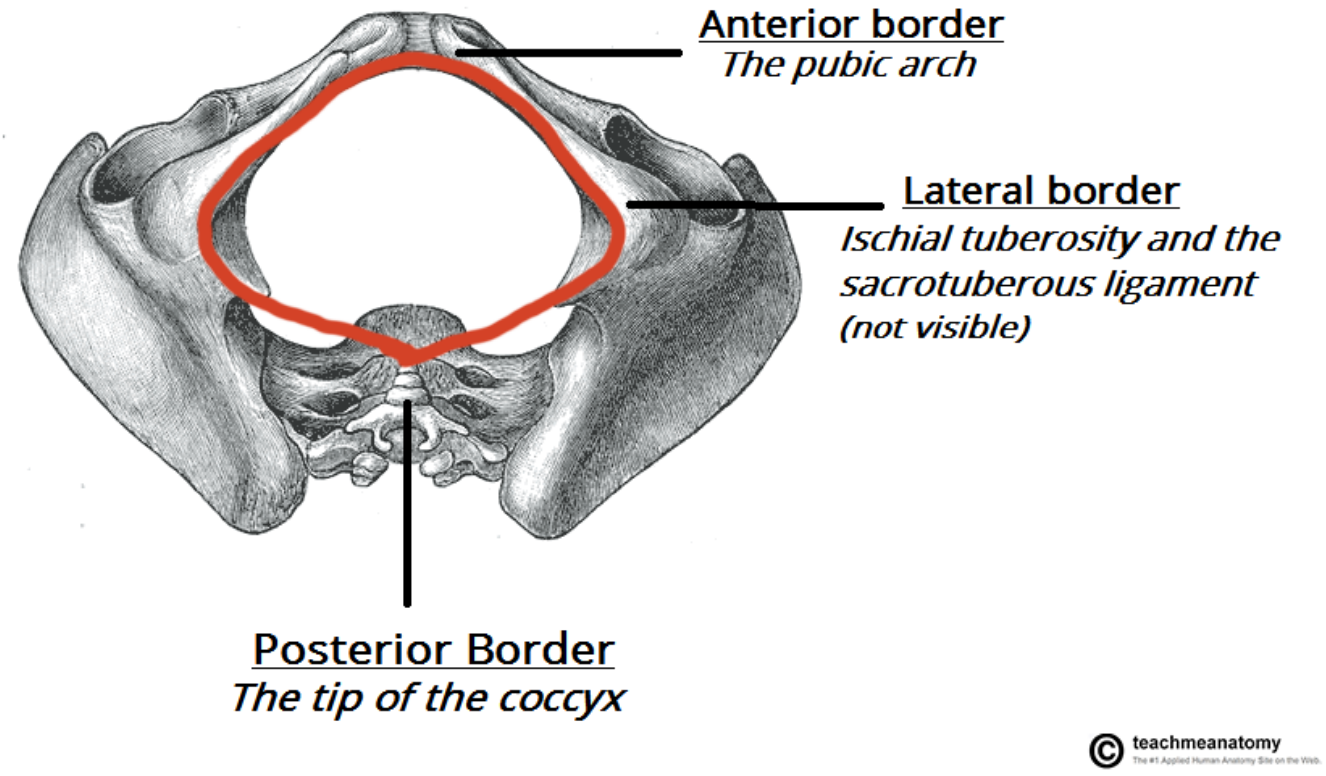

Fig 1.3 – The borders of the pelvic outlet.

6- Adaptation for Childbirth

The majority of women have a **gynecoid** pelvis, as oppose to the male **android** pelvis. The slight differences in their structures creates a greater pelvic outlet, adapted to aid the process of childbirth. When comparing the two, the gynecoid pelvis has: -

- A **wider** and **broader** structure yet it is **lighter** in weight
- An **oval-shaped inlet** compared with the heart-shaped android pelvis.
- Less prominent Ischial spines, allowing for a **greater bispinous diameter**
- A greater angled sub-pubic arch, more than **80-90 degrees**.
- A sacrum which is shorter, more curved and with a **less pronounced sacral promontory**.

In addition to the bony adaptations, the sacrotuberous and sacrospinous ligaments can stretch under the influence of progesterone and increase the size of the outlet further.

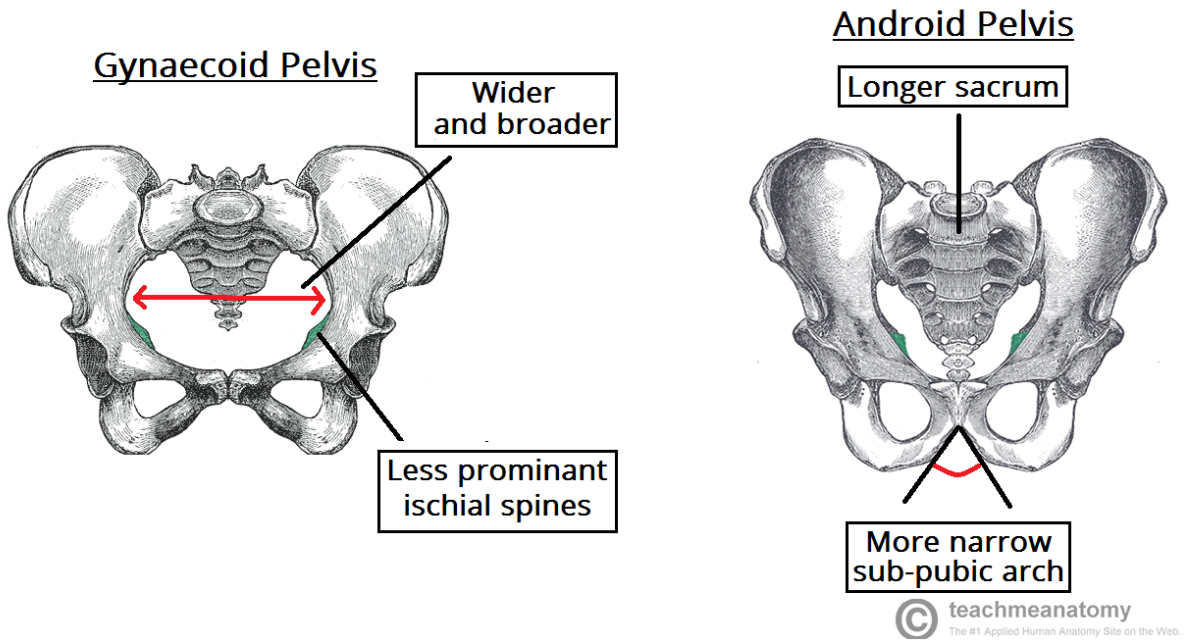

Fig 1.4 – Gynaecoid pelvis vs the android pelvis.

7- Clinical Relevance: Assessment of the Female Bony Pelvis

The lesser pelvis is the bony canal through which the foetus has to pass during childbirth. It is therefore of great importance to determine the diameter of this canal and therefore the childbearing capacity of the mother.

The diameter can be determined by a **pelvic examination** or radiographically. There are two measurements that are of importance:

Obstetric Conjugate

In order to determine the narrowest fixed distance that the foetus would have to negotiate, the minimum **antero-posterior diameter** of the pelvic inlet is measured.

This distance is between the sacral promontory and the midpoint of the pubic symphysis (where the pubic bone is thickest) and is known as the **obstetric conjugate** (or true conjugate). However, this measurement cannot be taken clinically, due to the presence of the bladder.

Diagonal Conjugate

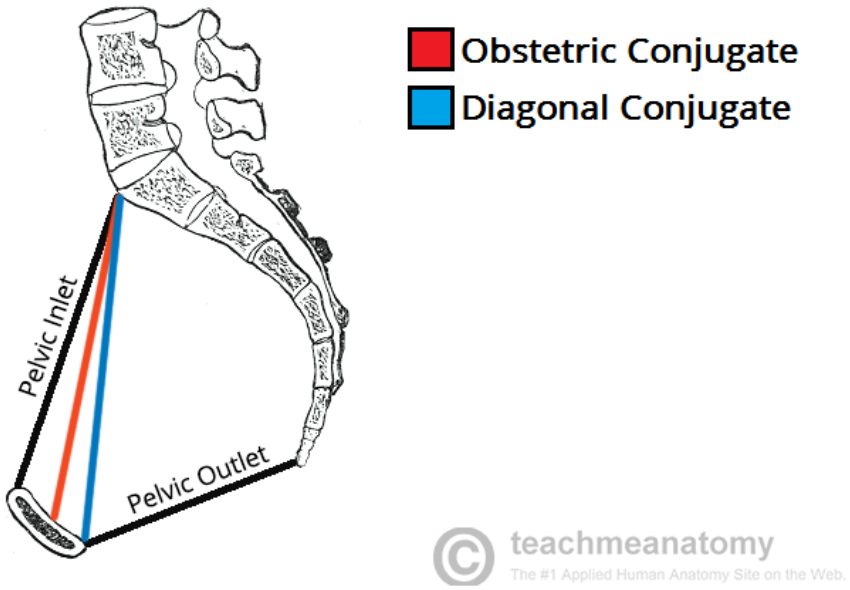

Fig 1.5 – Assessment of the female pelvis, via the diagonal conjugate

The diagonal **conjugate** is the alternative, measuring from the inferior border of the pubic symphysis to the sacral promontory and can be measured manually via the vagina.

(To do this you use the tip of your middle finger to measure the sacral promontory and then using the other hand to mark the level of the inferior margin of the pubic symphysis on the examining hand. You then use the distance between the index finger and the pubic symphysis to measure the obstetric conjugate, ideally 11cm or greater.)

In addition to measuring the diagonal congjugate, a **mid-pelvis check** is carried out. Here, the clinician is testing for straight side walls and measuring the bispinous diameter which is narrowest part of the pelvic canal. The width of the subpubic angle at the pelvic outlet can be determined by the distance between the ischial tuberosities.

The Hip Bone -Ilium

Contents

The two symmetrical **hip bones** (also known as the innominate bones, or pelvic bones) are part of the **pelvic girdle**, the bony structure that attaches the axial skeleton to the lower limbs (for more information about the anatomy of the pelvic girdle, click here)

The hip bones have three articulations:

- **Sacroiliac joint** – articulation with sacrum.
- **Pubic symphysis** – articulation with the corresponding hip bone.
- **Hip joint** – articulation with the head of femur.

In this article, we shall look at the osteology of the hip bones – their constituents, bony landmarks, and applied anatomy.

1- Structure of the Hip Bone

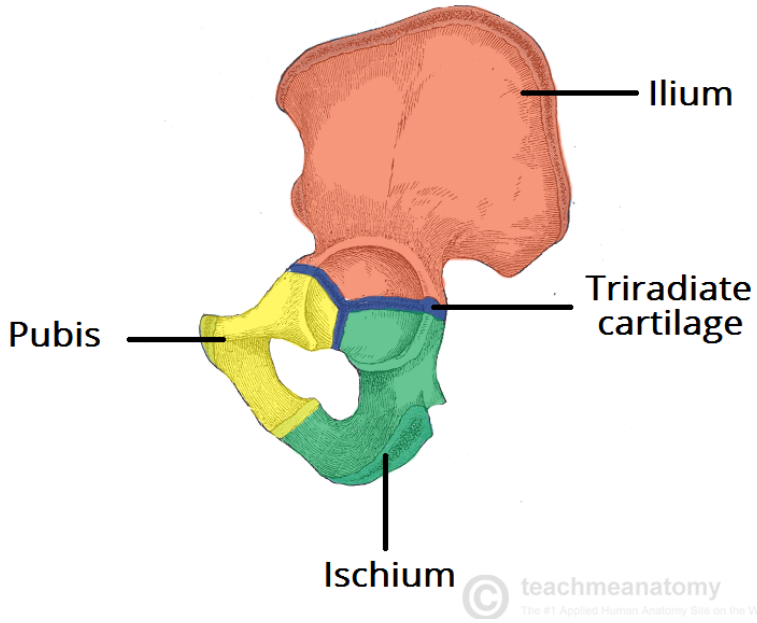

Fig 1.2 – The hip bone of a 5 year old, with triradiate cartilage still present.

The hip bone is made up of the three parts – the **ilium**, **pubis** and **ischium**. Prior to puberty, the **triradiate cartilage** separates these constituents. At the age of 15-17, the three parts begin to fuse.

Their fusion forms a cup-shaped socket known as the **acetabulum**, which becomes complete at 20-25 years of age. The head of the **femur** articulates with the acetabulum to form the hip joint.

We shall now look at the individual parts of the hip bone, and their respective bony landmarks.

The Ilium

The superior part of the hip bone is formed by the **ilium**, the widest and largest of the three parts. The body of the ilium forms the superior part of the **acetabulum**. Immediately above the acetabulum, the ilium expands to form the **wing** (or ala).

The wing of the ilium has two surfaces. The inner surface is concave, and known as the **iliac fossa**, providing origin to the iliacus muscle. The external surface is convex, and provides attachments to the gluteal muscles. Hence it is known as the **gluteal surface**.

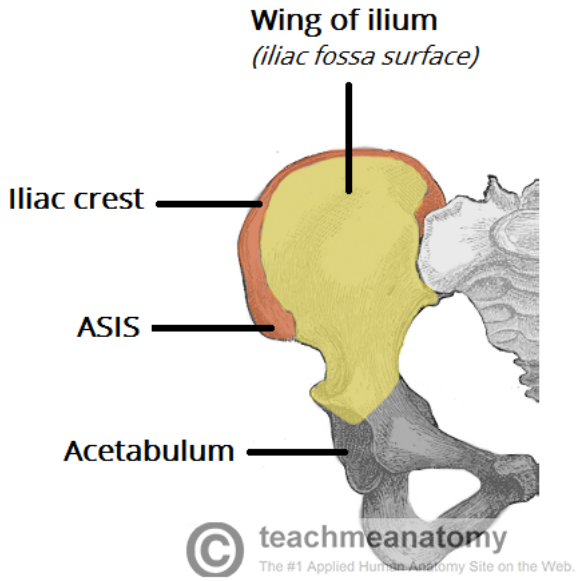

Fig 1.3 – View of the anterior and interior surfaces of the ilium

The superior margin of the wing is thickened, forming the **iliac crest.** It extends from the anterior superior iliac spine to the posterior superior iliac spine.

Muscles attaching to the Ilium: -

- **Gluteal muscles** attach to the external surface of the Ilium at the anterior, posterior and inferior gluteal lines.
- The **iliacus muscle** attaches medially at the iliac fossa.

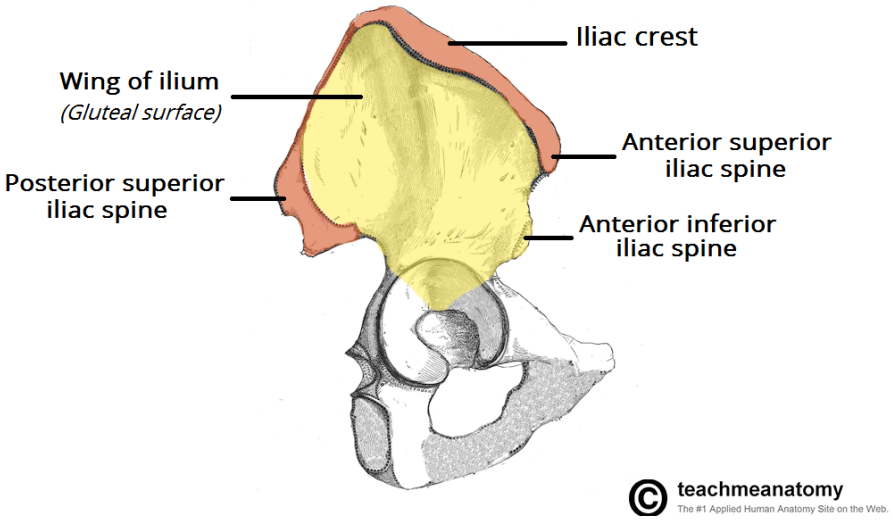

Fig 1.4 – View of the external surface of the ilium

Clinical Relevance: Anterior Superior Iliac Spine

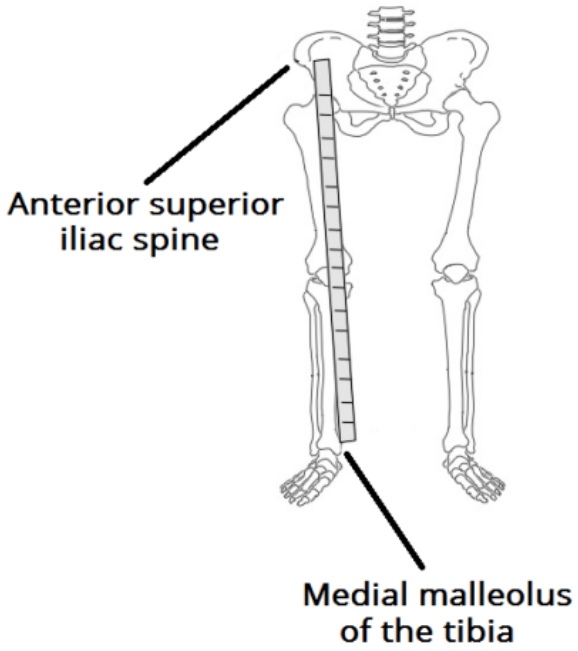

Fig 1.5 – Measuring true leg length

The anterior superior iliac spine (ASIS) is an important landmark, serving as the attachment site of the **inguinal ligament,** which runs from the ASIS to the pubic tubercle.

Midway along the inguinal ligament, the **femoral artery** can be palpated, with the femoral vein lying laterally.

In clinical practice, a patient's **"true" leg length** is measured from the ASIS to the medial malleolus at the ankle joint. This is distinct from **"apparent" leg length**, which is measured from the umbilicus to the medial malleolus. True leg length **discrepancy** can seen in various hip disorders.

The Pubis

The **pubis** is the most anterior portion of the hip bone. It consists of a body and superior and inferior **rami** (branches).

The body is located medially, articulating with its opposite pubic body, at the **pubic symphysis**.

The **superior rami** extends laterally from the body, forming part of the **acetabulum**. The inferior rami projects towards, and joins the **ischium**. Together, the two rami enclose part of the **obturator foramen**, through which the obturator nerve, artery and vein pass through to reach the lower limb.

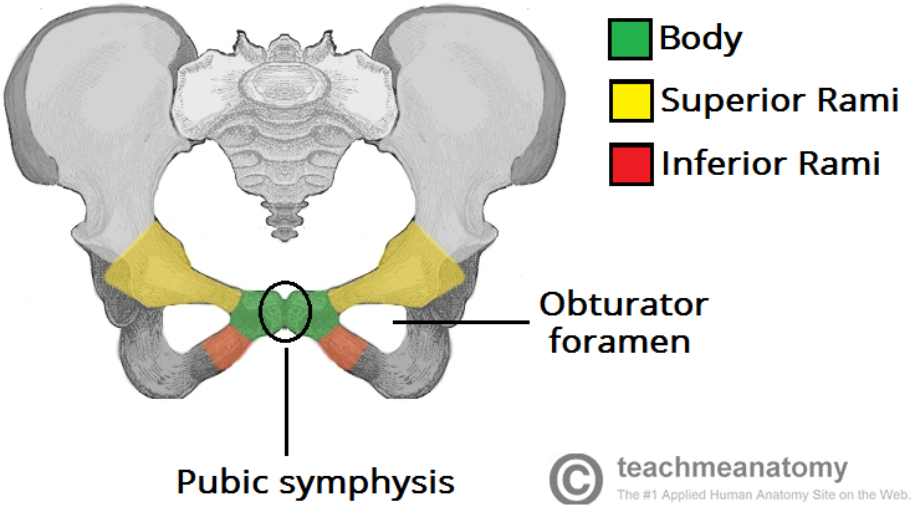

Fig 1.6 – Anterior view of the pelvic girdle. Note how the pubis contributes greatly to the obturator foramen

The Ischium

The posterioinferior part of the hip bone is formed by the **ischium.** Much like the pubis, it is composed of a body, an inferior and a superior ramus.

The **inferior ischial ramus** combines with the inferior pubic ramus forming the ischiopubic ramus which encloses part of the obturator foramen. The posterorinferior aspect of the ischium forms the **ischial tuberosities** and when sitting, it is these tuberosities on which our body weight falls.

On the posterior aspect of the ischium there is an indentation known as the **greater sciatic notch**, with the **ischial spine** at its most inferior edge.

The important ligaments attach to the ischium:

- The **sacrospinous ligament** runs from the the ischial spine to the sacrum, thus creating the greater sciatic foramen through which lower limb neurovasculature (including the sciatic nerve) and the piriformis muscle transends.
- The **sacrospinous ligament** and the **sacrotuberous ligament** run from the sacrum to the ischial tuberosity, forming the lesser sciatic foramen.

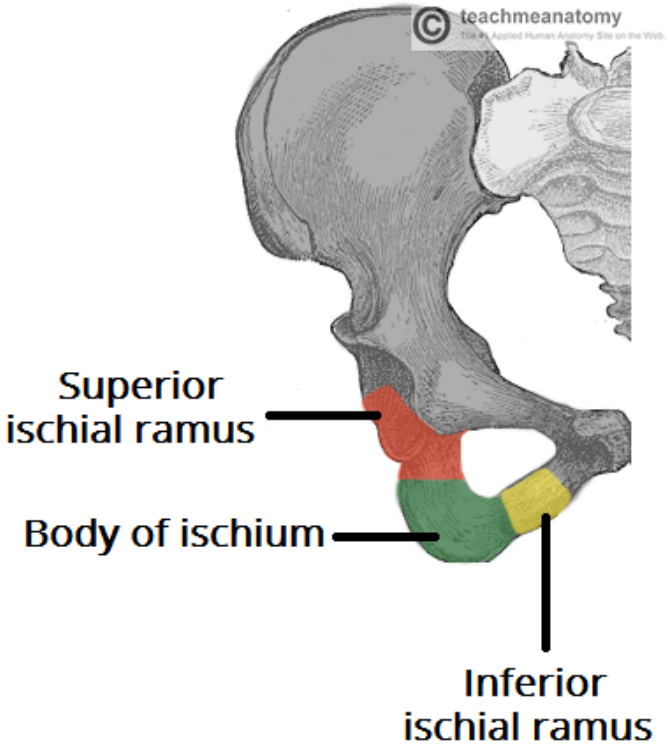

Fig 1.7 – Parts of the ischium.

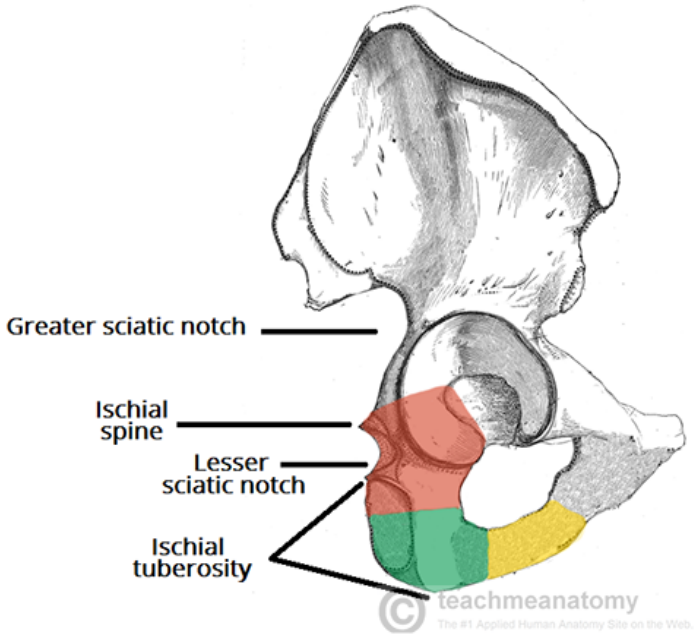

Fig 1.8 – The bony landmarks of the ischium

2- Clinical Relevance: Fractures of the Pelvic Bones

There are two common ways of fracturing the innominate bones:

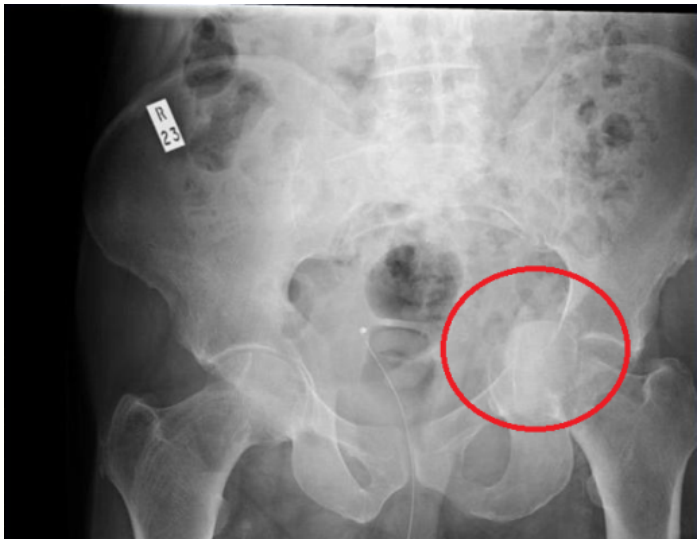

Fig 1.8 – X-ray of a fracture of the left pelvic bone. The femoral head has been driven through the acetabulum

Direct trauma to the pelvic bones, for example from a vehicular accident

- **Forces transmitted from the lower limb**, for example a heavy fall on the feet.

Fractures often occur at the weaker points of the bones. These are the **pubic rami**, the **acetabulum** or in the region of the **sacroiliac joint**.

A common complication of pelvic fractures is **soft tissue injury**. In particular, the bladder and urethra are at high risk of damage.

The Pelvic Floor

Contents

The pelvic viscera, (bladder, rectum, pelvic genital organs and terminal part of the urethra) reside within the **pelvic cavity** (or the true pelvis). This cavity is located within the lesser part of the pelvis, beneath the pelvic brim (see here for more information).

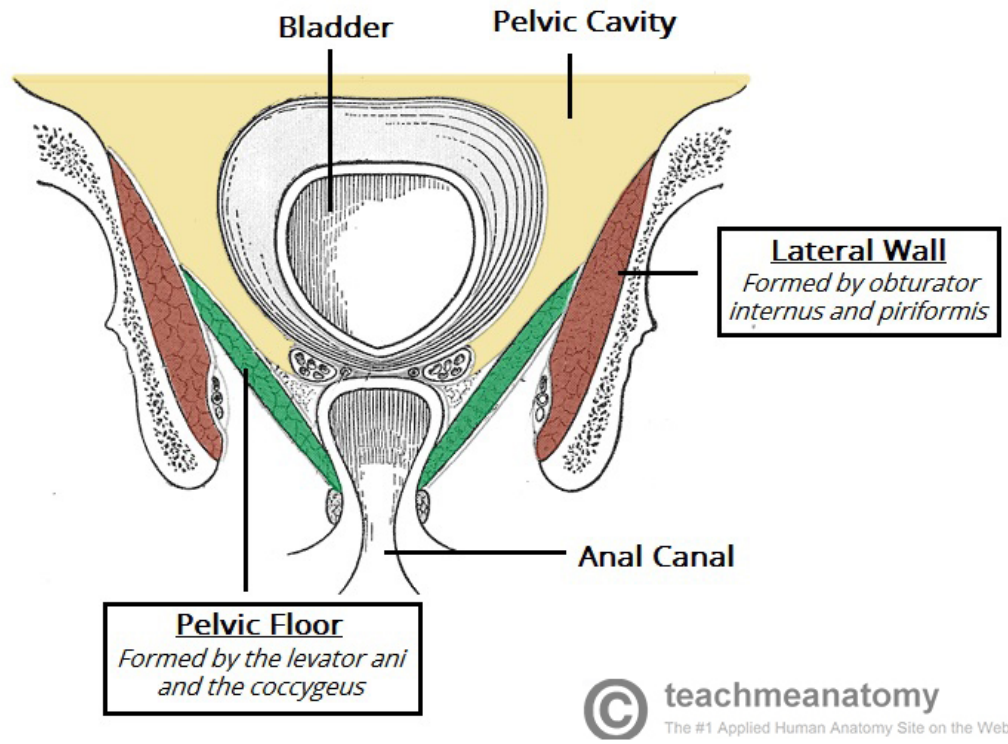

Fig 1.0 – An overview of the pelvic cavity and its walls. Note the funnel shape of the pelvic floor.

A number of muscles help make up the walls of the cavity; the lateral walls include the **obterator internus** and the **pirformis** muscle, with the latter also forming the posterior wall

This article is concentrating on the muscles that make up the inferior lining of the cavity, the **pelvic floor muscles**. The pelvic floor is also known as the **pelvic diaphragm.**

We shall look at the individual roles of these muscles, their innervation and blood supply, and any clinical correlations.

Note – some texts consider the pelvic floor to include the perineal membrane and deep perineal pouch. We have considered these as a distinct and separate structures.

1- Structure of the Pelvic Floor

The **pelvic floor** is a funnel-shaped musculature structure. It attaches to the walls of the lesser pelvis, separating the **pelvic cavity** from the inferior **perineum** (region which includes the genitalia and anus).

In order to allow for urination and defecation, there are a few gaps in the structure. There are two 'holes' that are have significance:

- **The urogeninital hiatus** – An anteriorly situated gap, which allows passage of the urethra (and the vagina in females).
- **The rectal hiatus** – A centrally positioned gap, which allows passage of the anal canal.

Between the urogenital hiatus and the anal canal lies a fibrous node known as the **perineal body** which joins the pelvic floor to the perineum (it's function is described in the perineum article.

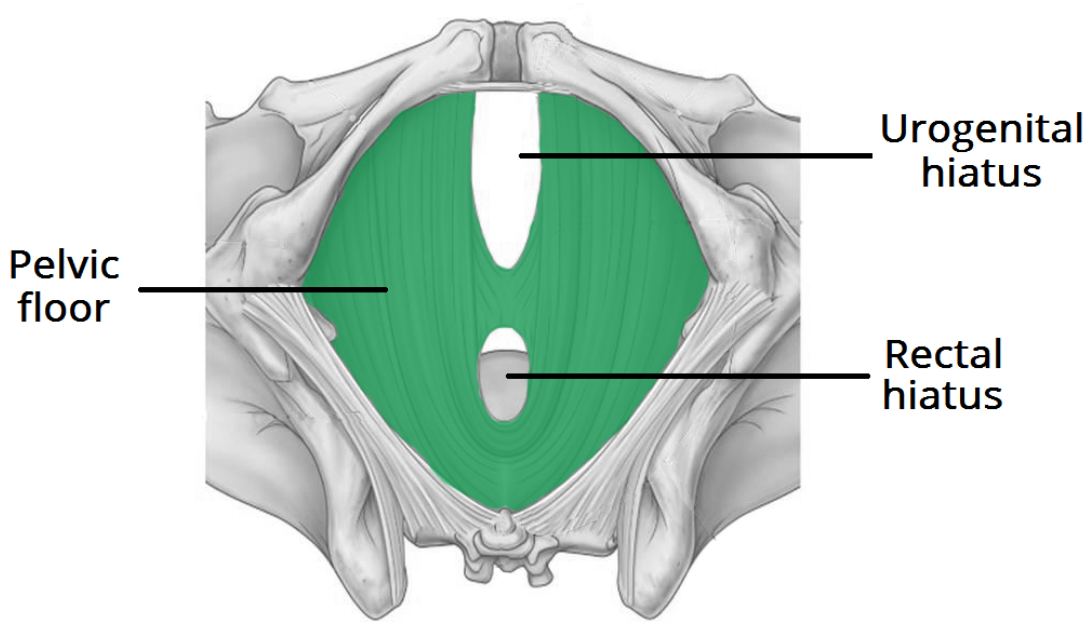

Fig 1.1 – Inferior surface of the pelvic floor. The urogenital and rectal hiatuses are labelled.

2- Functions of the Pelvic Floor

As the floor of the pelvic cavity, the muscles have important roles to play in the correct functions of the pelvic and abdominal viscera.

The roles of the pelvic floor muscles are:

- **Support of abdominopelvic viscera** (bladder, intestines, uterus etc.) through their tonic contraction.
- **Resistance to increase in intra-pelvic/abdominal pressure** during activities such as coughing or lifting heavy objects.
- **Urinary and fecal continence.**The muscle fibers have a sphincter action on the rectum and urethra. They relax to allow urination and defecation.

3- Muscles of the Pelvic Floor

It is important to remember the funnel shaped structure when looking at the diaphragm in more detail. There are three components of the pelvic floor:

- Levator ani muscles (largest component).
- Coccygeus muscle.
- Fascia coverings of the muscles.

We shall now consider each of these components in more detail.

Levator Ani Muscles

Innervated by branches of the pudendal nerve, roots S2, S3 and S4.

The levator ani is a broad sheet of muscle. It is composed of three separate paired muscles, called the **pubococcygeus**, **puborectalis** and **iliococcygeus**.

These muscles have attachments to the pelvis as follows:

- **Anterior** – The pubic bodies of the hip bone.
- **Laterally** – Thickened fascia of the obturator internus muscle, known as the tendinous arch.
- **Posteriorly** – The ischial spines of the hip bone.

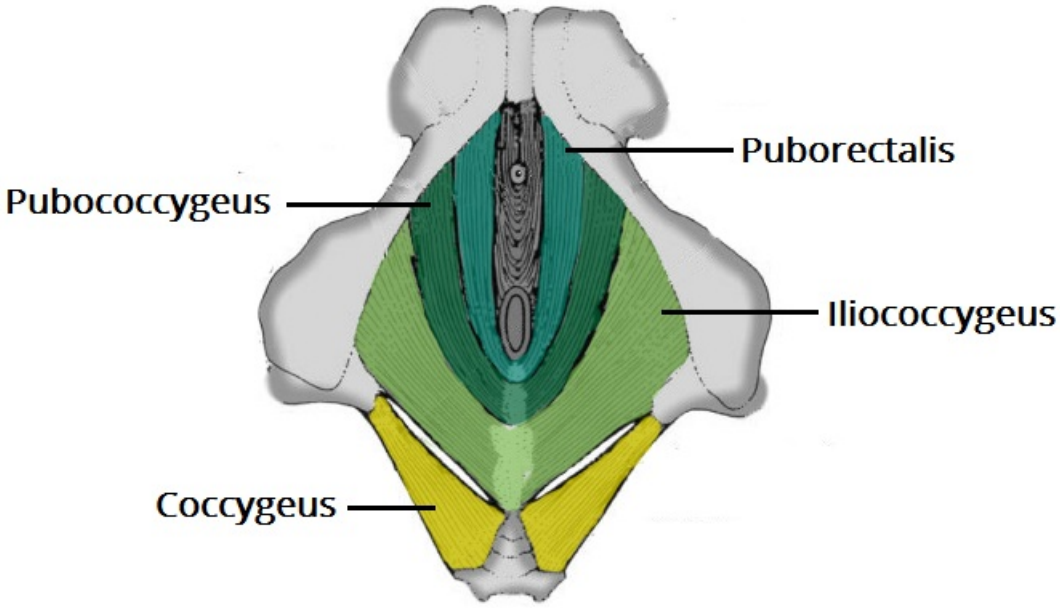

Fig 1.2 – View of the inferior surface of the pelvic floor, with the muscles labelled.

Puborectalis

The puborectalis muscle is a U-shaped sling, extending from the bodies of the pubic bones, past the **urogenital hiatus**, around the anal canal. Its tonic contraction bends the canal anteriorly, creating the anorectal angle (90degrees) at the **anorectal junction** (where the rectum meets the anus).

The main function of this thick muscle is to maintain faecal continence – during defecation this muscle relaxes.

Pubococcygeus

The muscle fibres of the pubococcygeus are the main constituent of the levator ani. They arise from the body of the **pubic bone** and the anterior aspect of the **tendinous arch**. The fibres travel around the margin of the urogenital hiatus and run posteriomedially,attaching at the **coccyx** and **anococcygeal ligament**.

As the fibres run inferiorly and medially, some fibres divide and loop around the prostate in males (**levator prostatae**) and around the vagina in females (**pubovaginalis**). Some also terminate in the perineal body.

Iliococcygeus

The iliococcygeus has thin muscle fibres, which start anteriorly at the **ischial spines** and posterior aspect of the **tendinous arch**. They attach posteriorly to the coccyx and the anococcygeal ligament.

Coccygeus Muscle

Innervated by the anterior rami of S4 and S5.

The coccygeus is the smaller, and most posterior, pelvic floor component. The levator ani muscles situated anteriorly. It originates from the **ischial spines** and travels to the lateral aspect of the sacrum and coccyx, along the **sacrospinous** ligament.

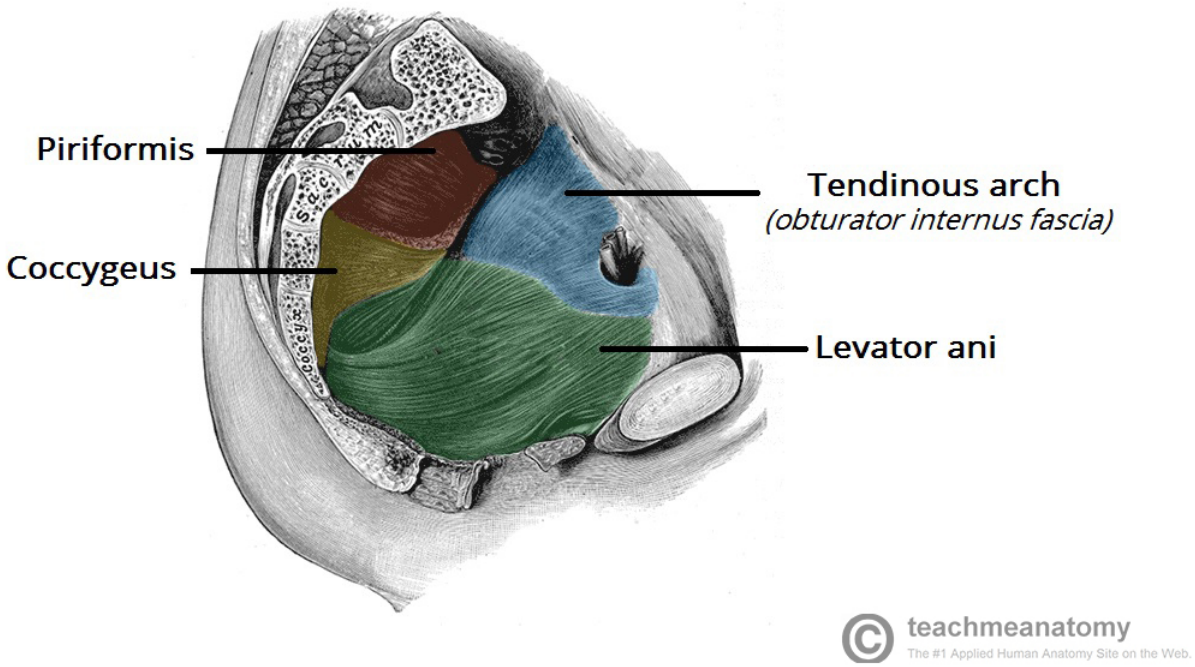

Fig 1.3 – Sagittal cut through the pelvis, showing a lateral view of the pelvic floor and walls.

4- Clinical Relevance: Pelvic Floor Dysfunction

The pelvic floor support acts to support the pelvic viscera, and assist in their functions. If the muscles of the floor become damaged, then dysfunction of these viscera can occur.

The levator ani muscles are involved in supporting the **foetal head** during cervix dilation in childbirth. During the second phase of childbirth, the levator ani muscles and/or the **pudendal nerve** are at high risk of damage. **Pubococcygeus** and **puborectalis** are the most prone to injury due to them being situated most medially.

Due to their role in supporting the vagina, urethra and anal canal, injury to these muscles can lead to a number of problems. The primary problems include **urinary stress incontinence** and **rectal incontinence**. Urinary incontinence is most noticeable during activities where there are increased abdominal pressure – coughing, sneezing and lifting heavy objects.

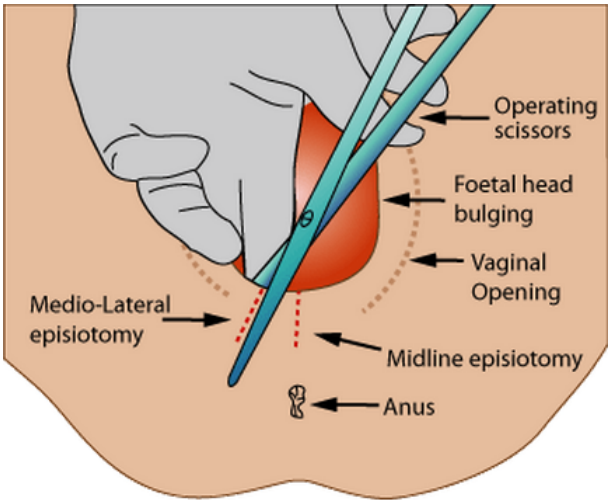

Fig 1.4 – An episiotomy is delivered to avoid tearing of the perineum and/or the pelvic floor. There are two different episiotomies that can be performed.

Prolapse of the pelvic viscera (such as the bladder and vagina) can occur if there is trauma to the pelvic floor or if the muscle fibres have poor tone. Prolapse of the vagina can also occur if there is damage to the **perineal body** in childbirth.

This may be avoided by **episiotomy** (surgical cut in the perineum), which itself can cause damage to the vaginal mucosa and submucosa but helps prevent uncontrolled tearing of the perineal muscles. If the medial fibres of the puborectalis are torn within the perineal body, then **rectal herniation** can also occur.

There are a number of risk factors which can increase the chances of prolapse: -

- Age
- Number of vaginal deliveries
- Family history of pelvic floor dysfunction
- Weight
- Chronic coughing (e.g from a lung disorder)

The pelvic floor can be repaired surgically, however a way to generally strengthen the muscles is to carry out **pelvic floor exercises** on a regular basis (Kegel exercises).

The Perineum

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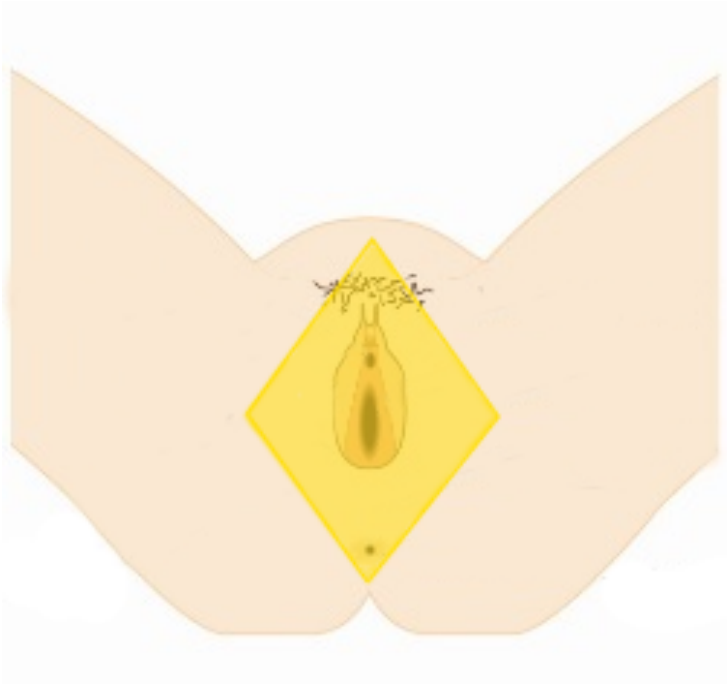

Fig 1.0 – The perineum.

The perineum is an anatomical region located in the pelvis. It is the most inferior part of the pelvic outlet, located between the thighs. It is separated from the pelvic cavity superiorly by the pelvic floor.

Functionally, the perineum contains structures that support the urinary, genital and gastrointestinal viscera. They play a vital role in micturition, defectation, sexual intercourse and childbirth.

In this article, we shall look at boundaries, contents and clinical correlations of the perineum.

1-Boundaries

The perineum is a diamond shaped structure. There are two ways in which the boundaries of the perineum can be described. The **anatomical borders** refer to the its exact bony margins. The **surface borders** describe the surface anatomy which marks the borders of the perineum.

Anatomical Borders

- **Anterior** – Pubic symphysis.
- **Posterior**- The tip of the coccyx.
- **Laterally** – Inferior pubic rami and inferior ischial rami, and the sacrotuberous ligament.
- **Roof** – The pelvic floor.
- **Base** – Skin and fascia.

The perineum can be subdivided by a theoretical line drawn transversely between the ischial tuberosities. This split forms the **anterior urogenital** and **posterior anal triangles**. These triangles are associated with different components of the perineum.

Surface Borders

For clinical purposes, it is important to be aware of the surface anatomy which marks the boundaries of the perineum. These boundaries are best shown when the lower limbs are abducted, and a diamond shape is depicted. The skin boundaries of the perineum:

- **Anteriorly**: Mons pubis in females, base of the penis in males.
- **Laterally**: Medial surfaces of the thighs.
- **Posteriorly**: Superior end of the intergluteal cleft.

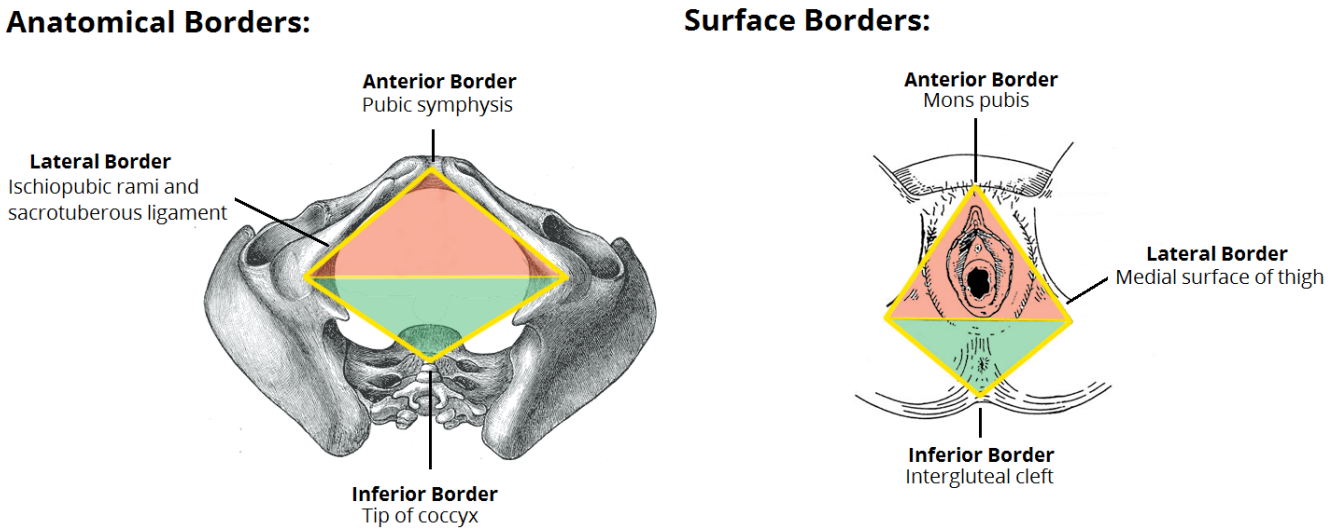

Fig 1.1 – Anatomical and surface borders of the perineum.

2- Contents

The perineum can be subdivided by a theoretical line drawn transversely between the ischial tuberosities. This split forms the **anterior urogenital** and **posterior anal triangles**. These triangles are associated with different components of the perineum – which we shall now look at in more detail.

Anal Triangle

The anal triangle is the posterior half of the perineum. It is bounded by the coccyx, sacrotuberous ligaments and an imaginary line between the ischial tuberosities. The components of the anal triangle are:

- **Anal aperture** - the opening of the anus.
- **External anal sphincter muscle** – voluntary muscle responsible for opening and closing the anus
- **Two ischioanal fossae** - spaces located laterally to the anus.

The anal aperture is located centrally in the triangle with the ischioanal fossae either side. These fossae contain fat and connective tissue, which aid expansion of the anal canal during defecation. They extend from the skin of the anal region inferiorly to the pelvic diaphragm superiorly.

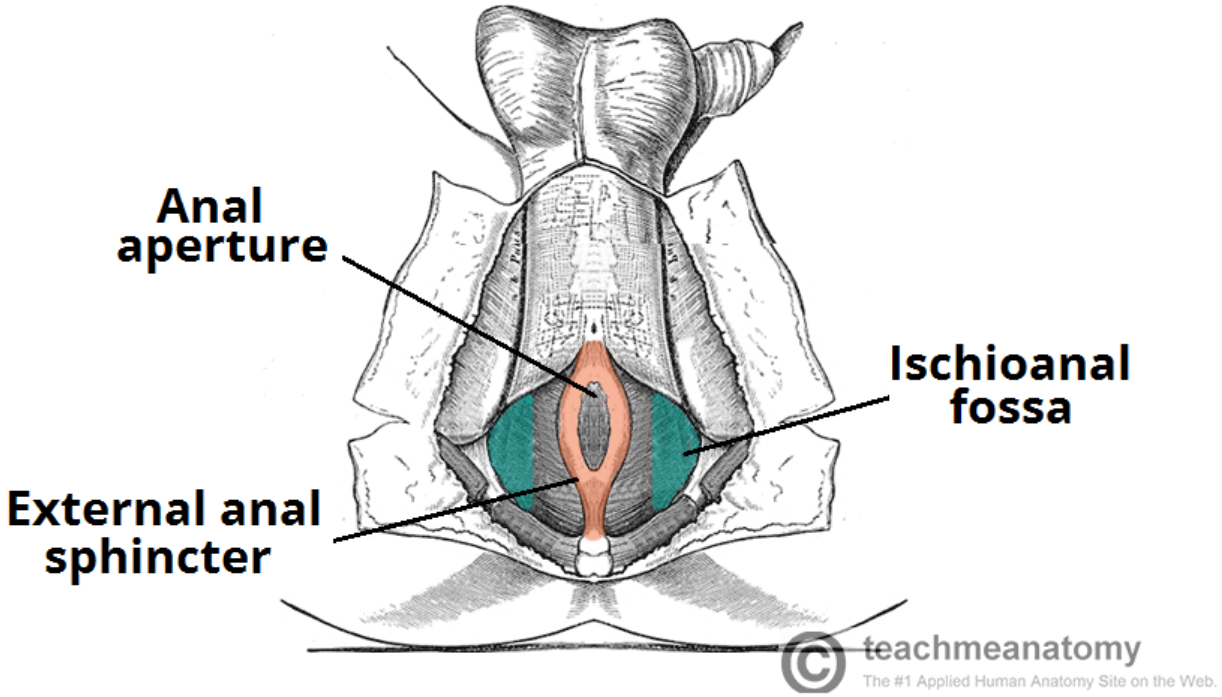

Fig 1.2 – Contents of the anal triangle.

Urogenital Triangle

The urogenital triangle comprises of the anterior half of the perineum. It is bounded by the pubic symphysis, ischiopubic rami, and an imaginary line between the two ischial tuberosities. The triangle is associated with the structures of the urogenital system – the **external genitalia** and **urethra**.

Structurally, the urogenital triangle is complex, with a number of fascial layers and pouches. Unlike the anal triangle, the urogenital triangle has an additional layer of strong deep fascia, known as the **perineal membrane.** This membrane has **pouches** on its superior and inferior surfaces. We shall explore each layer of the urogenital triangle in more detail (deep to superficial):

- **Deep perineal pouch** - A potential space between the pelvic floor superiorly, and the perineal membrane inferiorly. It contains part of the urethra and the external urethral sphincter. In males, it also contains the the bulbourethral glands and the deep transverse perineal muscles.

- **Perineal membrane** - A layer of tough fascia, which is perforated by the urethra and vagina. The role of the membrane is to provide attachment for the muscles of the superficial external genitalia, and to help support the pelvic viscera.

- **Superficial perineal pouch** - A potential space between the perineal membrane superiorly, and the perineal fascia inferiorly. It contains the erectile tissues that form the penis and clitoris, and three muscles – the ischiocavernosus, bulbospongiosus and superficial transverse perineal muscles. The greater vestibular glands (Bartholin's glands) are also located in the superficial perineal pouch.

- **Deep perineal fascia** - Fascia covering the superficial perineal muscles.

- **Superficial perineal fascia** - It is continuous with the superficial fascia of the abdominal wall. The superficial fascia itself can be divided into superficial and deep layers. The superficial layer is fatty in structure, forming the labia majora and mons pubis in women.

- **Skin** - The urethral and vaginal orifices open out onto the skin.

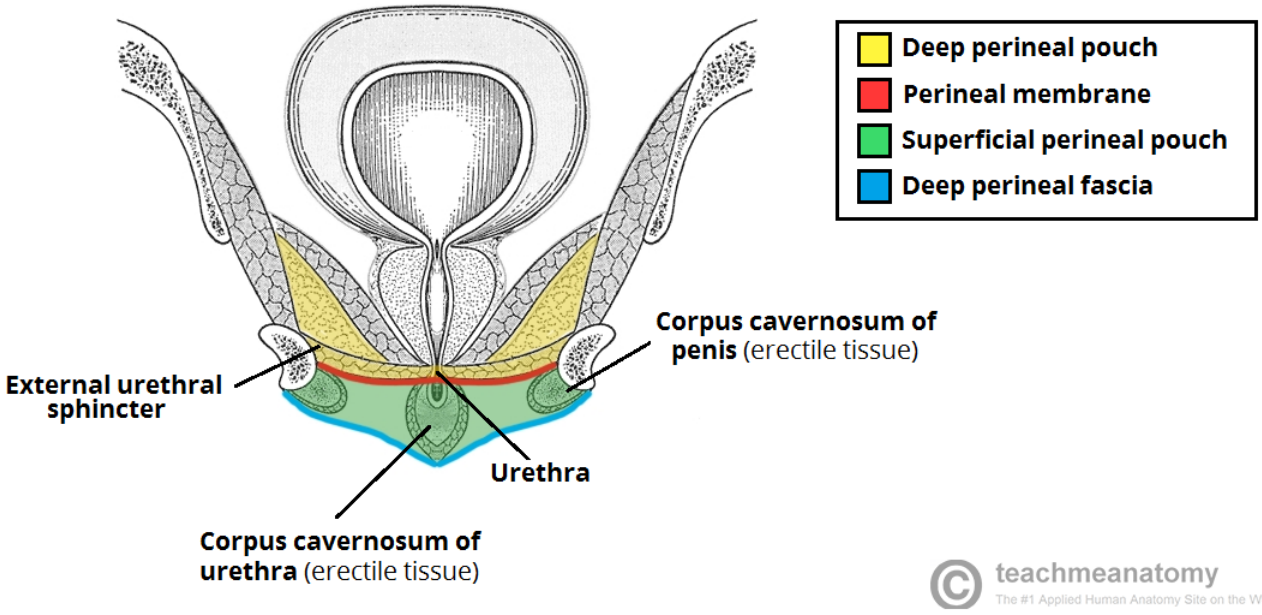

Fig 1.3 – Coronal section of the male pelvis, showing the initial layers of the urogenital triangle, and some of their contents.

The Perineal Body

The perineal body is an irregular and fibromuscular mass. It is located at the junction of the urogenital and anal triangles – the **central point** of the perineum. This structure contains skeletal muscle, smooth muscle and collagenous and elastic fibres.

Anatomically, the perineal body lies just deep to the skin. It functions as a point of **attachment** for muscle fibres from the pelvic floor and the perineum itself:

- Levator ani (part of the pelvic floor).
- Bulbospongiosus muscle.
- Superficial and deep transverse perineal muscles.
- External anal sphincter muscle.
- External urethral sphincter muscle fibres.

In women, it acts as a **tear resistant** body between the vagina and the external anal sphincter, supporting the posterior part of the vaginal wall against prolapse. In men it lies between the bulb of penis and the anus.

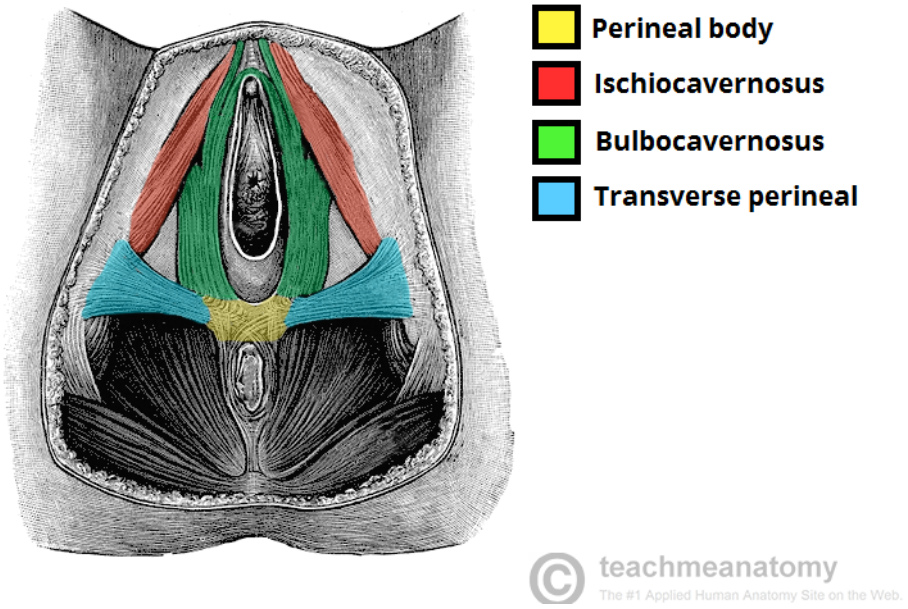

Fig 1.4 – Muscles attaching to the perineal body.

3- Nerve and Arterial Supply

The major neurovasculature supply to the perineum is from the **pudendal nerve** (S2 to S4) and the **internal pudendal** artery.

4- Clinical Relevance: Disorders of the Perineum

Damage to the Perineal Body

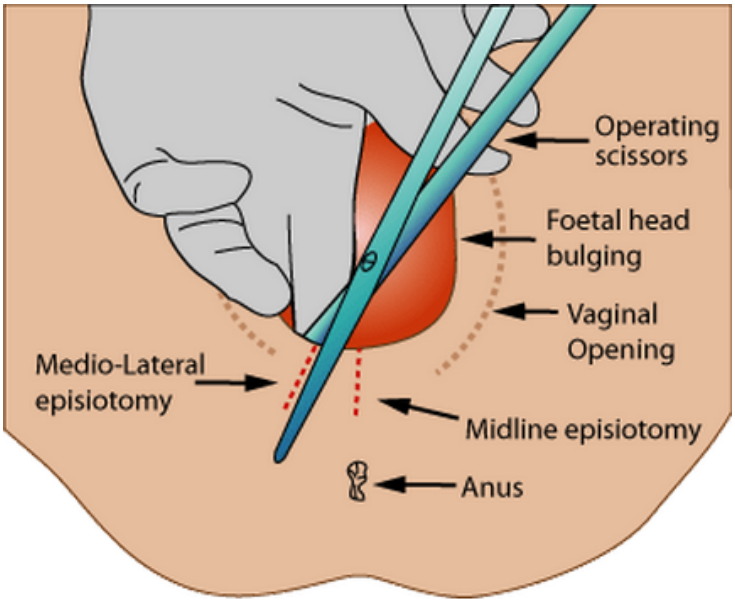

Fig 1.5 – An episiotomy is delivered to avoid tearing of the perineum and/or the pelvic floor.

The perineal body is a central attachment for perineal muscles, and functions to support the pelvic floor.

Childbirth can lead to damage (stretching/tearing) of the perineal body, thus leading to possible prolapse of pelvic viscera. This may be avoided by an **episiotomy** (a surgical cut in the perineum). This inevitably causes damage to the vaginal mucosa, but prevents uncontrolled tearing of the perineal body.

Other causes of perineal body damage include inflammatory disease, infection or trauma.

Bartholin's Gland Cysts

The bartolin's glands are located within the superficial perineal pouch of the urogenital triangle. The role of these glands is to make a small amount of mucus-like fluid, which maintains a moist vagina.

Normally these are not detected on examination, however if the duct becomes **blocked** then these glands swell, forming fluid-filled cysts. These cysts can become infected and inflamed, a condition known as **bartholinitis**. The most common causes of infection are from the bacteria which cause skin and uterine infections, such as *Staphylococcus spp.* and *Escherichia coli.*

Ligaments

of the

Female Reproductive Tract

Contents

The ligaments of the female reproductive tract are a series of structures that support the internal female genitalia in the pelvis.

The ligaments of the female reproductive tract can be divided into three categories:

- **Broad ligament** - a sheet of peritoneum, associated with both the uterus and ovaries.
- **Uterine ligaments** - ligaments primarily associated with the uterus.
- **Ovarian ligaments** - ligaments primary associated with the ovaries.

Collectively, these ligaments are tough and non-extensible. They act to **support** the female viscera and provide a **conduit** for neurovascular structures.

In this article, we shall look at the attachments and anatomical relations of the ligaments of the female reproductive tract.

1- Broad Ligament

The broad ligament is a flat sheet of **peritoneum**, associated with the uterus, fallopian tubes and ovaries. It extends from the lateral pelvic walls on both sides, and folds over the internal female genitalia, covering their surface anteriorly and posteriorly.

Subdivisions

Anatomically, the broad ligament can be divided into three regions:

- **Mesometrium** – Surrounds the uterus and is the largest subsection of the broad ligament. It runs laterally to cover the external iliac vessels, forming a distinct fold over them. The mesometrium also encloses the proximal part of the round ligament of the uterus.
- **Mesovarium** – Part of the broad ligament associated with the ovaries. It projects from the posterior surface of the broad ligament and attaches to the hilum of the ovary, enclosing its neurovascular supply. It does not, however, cover the surface of the ovary itself.
- **Mesosalpinx** – Originates superiorly to the mesovarium, enclosing the fallopian tubes.

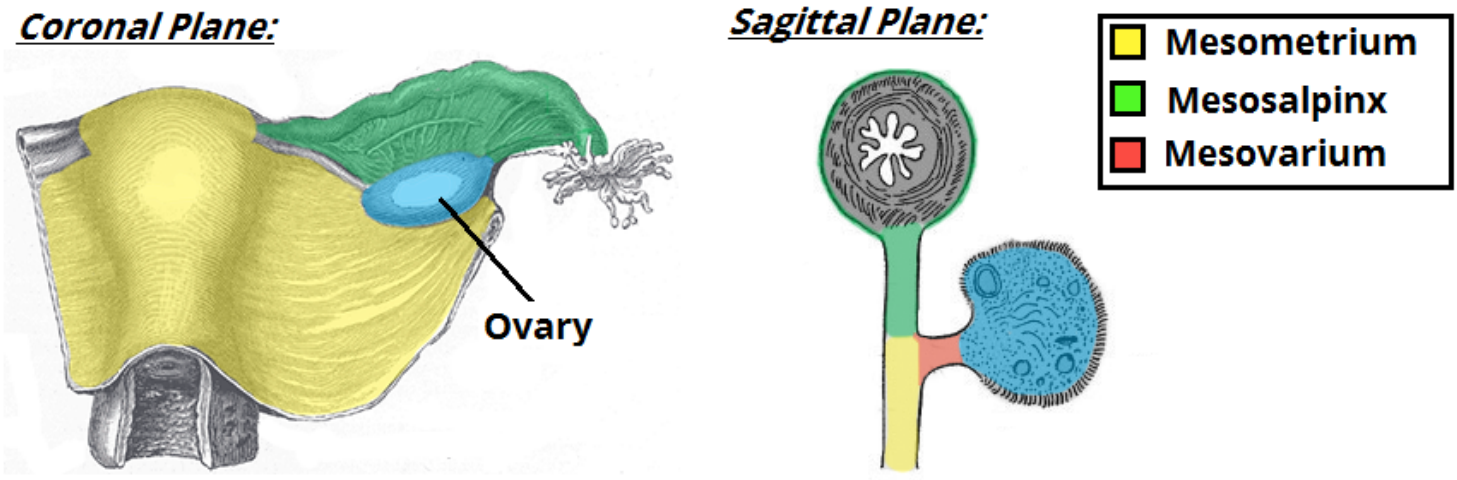

Fig 1.0 – The three parts of the broad ligament.

Anatomical Relations

The broad ligament is related to many structures within the female pelvis. It is attached to the uterus, fallopian tubes and ovaries. These organs are supplied by the **ovarian** and **uterine** arteries, which are also contained within the broad ligament.

Three other ligaments of the female reproductive tract are located **within** the broad ligament:

- Ovarian ligament.
- Round ligament of uterus.
- Suspensory ligament of ovary (also known as the infundibulopelvic ligament).

(These ligaments shall be explored in more detail later in the article).

2- Ligaments Associated with the Ovary

There are two main ligaments that attach to the ovary – the ovarian ligament and suspensory ligament of ovary.

The Ovarian Ligament

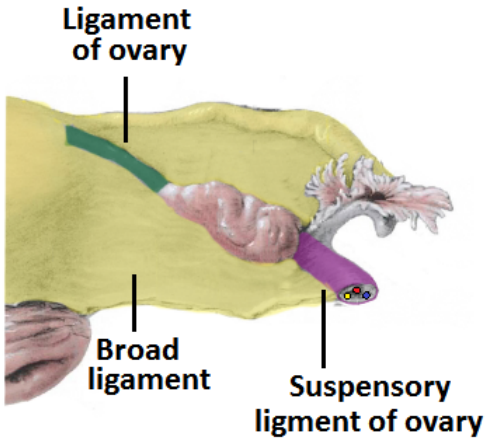

Fig 1.1 – The major ligaments of the ovary.

The ovarian ligament is attached to the ovary inferiorly. It connects the ovary to the side of the uterus. Structurally, it is a fibrous band of tissue that lies within the broad ligament. It joins the uterus just below the origin of the fallopian tubes.

The Suspensory Ligament of Ovary

The suspensory ligament of ovary extends outwards from the ovary to the lateral abdominal wall. It consists of a fold of peritoneum, thus some sources consider it to be part of the broad ligament. The function of this ligament is to contain the ovarian vessels and nerves (ovarian artery, ovarian vein, ovarian nerve plexus and lymphatic vessels).

3- Ligaments Associated with the Uterus

There are quite a number of ligamental structures that attach to the uterus. They can be divided by where they attach to the uterus:

- **Superior aspect** – supported by the broad ligament and the round ligaments.
- **Middle aspect** - supported by the cardinal, pubocervical and uterosacral ligaments.

The inferior aspect of uterus is supported by the structures in the pelvic floor – the levator ani, perineal membrane and perineal body.

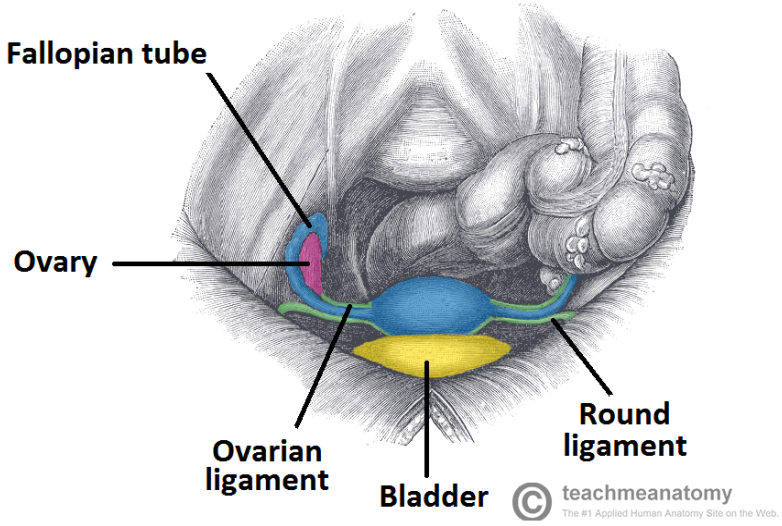

Fig 1.2 – Overview of the uterus and fallopian tubes, and associated ligaments

The Round Ligament

The round ligament is a remnant of the embryonic gubernaculum.

It originates at the uterine horns (the points at which the fallopian tubes enter the uterus), and attaches to the labia majora, passing through the inguinal canal.

The round ligament can be a source of pain during pregnancy, due to the increased force placed on the ligament by the expanding uterus.

Cardinal Ligaments

The cardinal ligaments are also known as the lateral, transverse cervical, or Mackenrodt's ligaments. They are situated along the inferior border of the broad ligament and house the uterine artery and uterine veins.

These ligaments arise from the side of the cervix and the lateral fornix of the vagina. They provide an extensive attachment on the lateral pelvic wall at the level of the ischial spines. Some fibres of the cardinal ligaments interdigitate with fibres from the uterosacral ligaments.

When a hysterectomy is being performed due to a malignancy, the cardinal ligaments are often removed as they are common reservoir of cancerous cells.

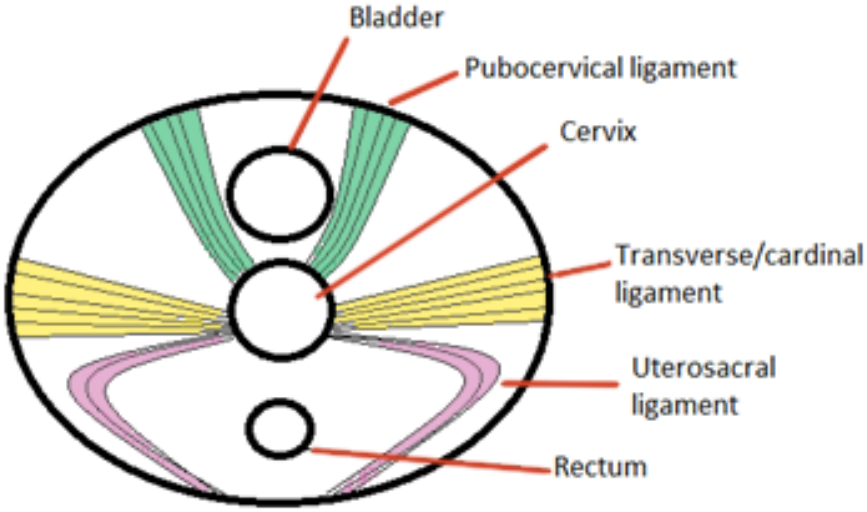

Fig 1.3 – The major ligaments of the cervix.

Pubocervical Ligaments

The pubocervical ligaments are bilateral structures, which attach the cervix to the posterior surface of the pubic symphysis. They function to support the uterus within the pelvic cavity.

Uterosacral Ligaments

The uterosacral ligaments are also bilateral fibrous bands, which attach the cervix to the sacrum. They are also known as the recto-uterine ligaments or sacrocervical ligaments. This supports the uterus and holds it in place.

The Femoral Canal

Contents

The femoral canal is an anatomical compartment, located in the anterior thigh. It is the smallest and most medial part of the femoral sheath. It is approximately 1.3cm long.

In this article, we shall look at the borders, contents and clinical relevance of the femoral canal.

1- Borders

The femoral canal is located in the anterior thigh, within the femoral triangle. It can be thought of as a **rectangular** shaped compartment.

It has four borders and an opening:

- **Medial border** – Lacunar ligament.
- **Lateral border** – Femoral vein.
- **Anterior border** – Inguinal ligament.
- **Posterior border** – Pectineal ligament and superior rami of the pubis.

The opening to the femoral canal is located at its superior border, known as the **femoral ring**. The femoral ring is closed by a connective tissue layer – the **femoral septum**. This septum is pierced by the lymphatic vessels exiting the canal.

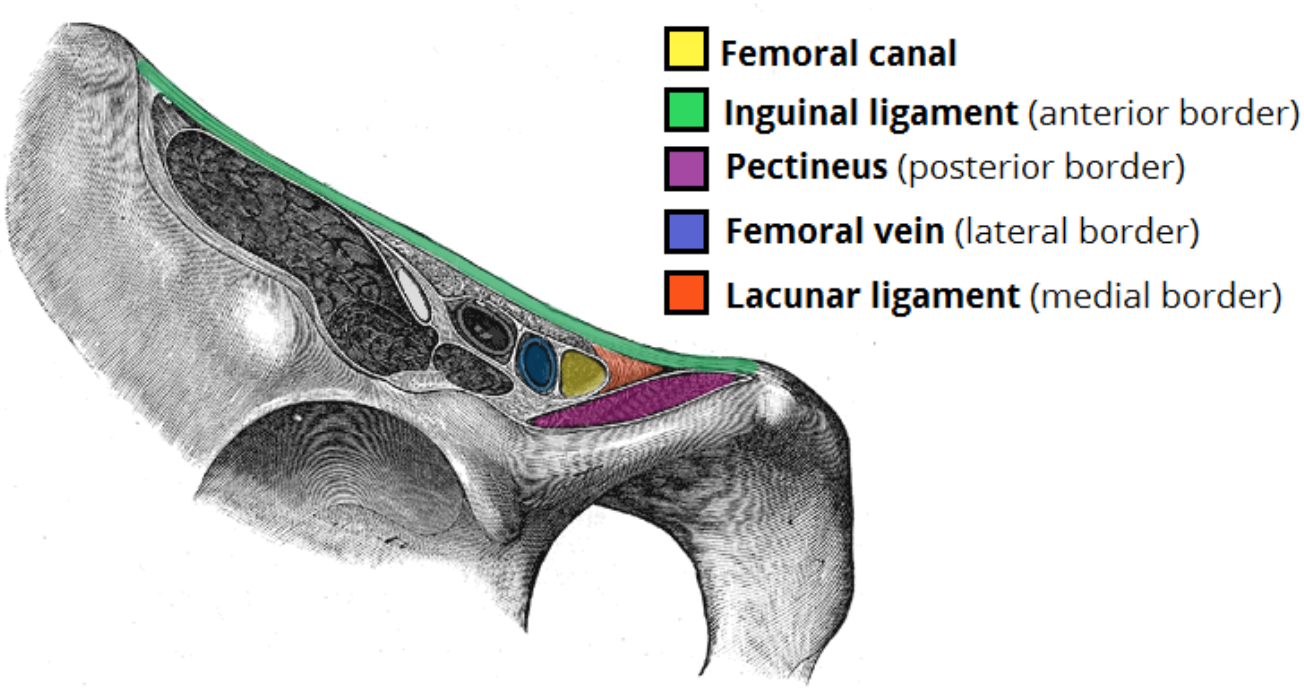

Fig 1.0 – Borders of the femoral canal.

2- Contents

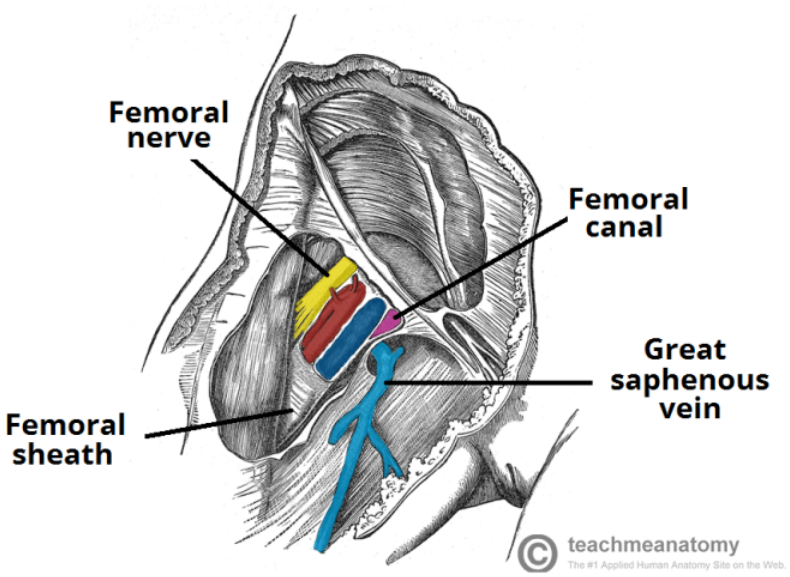

Fig 1.1 – The relation of the femoral canal to other structures in the anterior thigh.

The femoral canal contains:

- Lymphatic vessels – draining the deep inguinal lymph nodes.
- Deep lymph node – the lacunar node.
- Empty space.
- Loose connective tissue.

The empty space allows **distension** of the adjacent femoral vein, so it can cope with increased venous return, or increased intra-abdominal pressure.

3- Clinical Relevance: Femoral Hernia

The femoral canal is of particular clinical importance, as it a common site of **bowel herniation**.

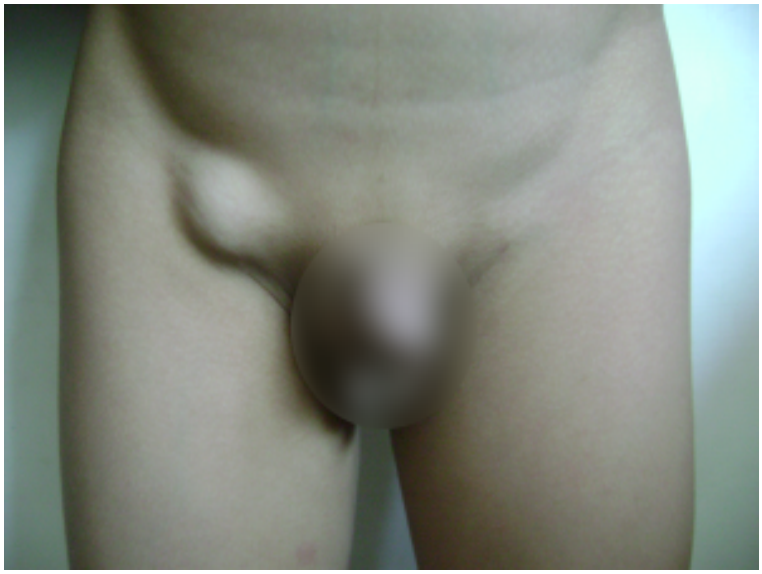

Fig 1.3 – Femoral hernia

A hernia is defined as '*where an internal part of the body pushes through a weakness in the muscle or surrounding tissue wall*'. In a femoral hernia, part of the small intestine protrudes through the **femoral ring**.

It presents as a lump situated inferolaterally to the **pubic tubercle**. This type of herniation is more common in women, due to their wider bony pelvis.

The borders of the femoral canal are tough, and not particularly extendible. This can compress the hernia, interfering with its blood supply. A hernia with a compromised blood supply is known as a **strangulated** hernia.

The Inguinal Canal

Contents

The inguinal canal is a short passage that extends inferiorly and medially, through the inferior part of the **abdominal wall**. It is superior and parallel to the **inguinal ligament**.

It acts as a **pathway** by which structures can pass from the abdominal wall to the **external genitalia**.

The inguinal canal also has clinical importance. It is a potential weakness in the abdominal wall, and therefore a common site of **herniation**.

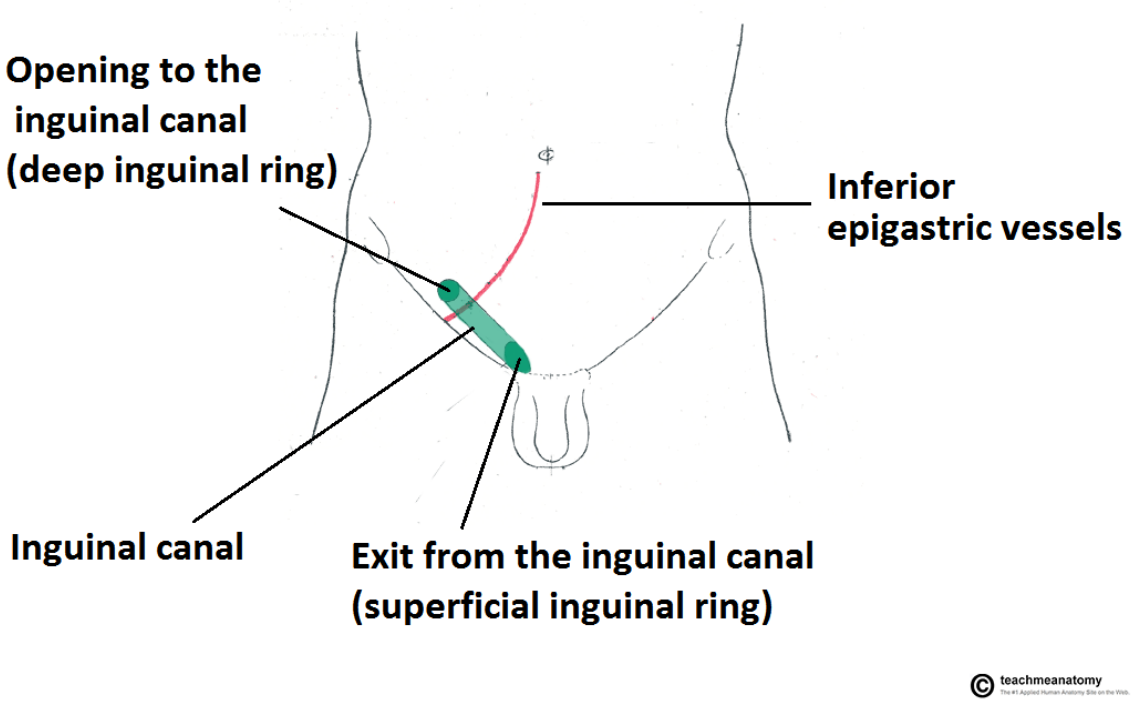

Fig 1.0 – Overview of the inguinal canal. Clinically it is important to note that the opening to the inguinal canal is located laterally to the inferior epigastric artery.

1- Development of the Inguinal Canal

In order to fully comprehend the anatomy of the inguinal canal, we must first look at its development, and the role the inguinal canal plays in the development of the genitalia. We shall explore the inguinal canal in the context of male development.

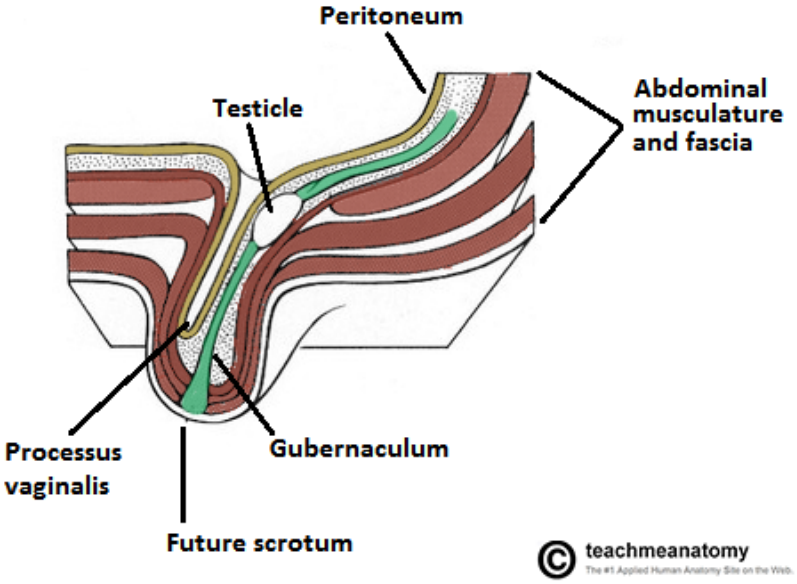

Fig 1.1 – The descent and embrylogical development of the testes. Note that the processus vaginalis regresses after the descent of the testes

During development, the testes establish in the **posterior abdominal wall**, and descend into the scrotum. A fibrous cord of tissue called the **gubernaculum** attaches the inferior portion of the gonad to the future scrotum, and guides them during their descent.

The inguinal canal is the pathway by which the testes are able to leave the abdominal cavity and enter the scrotum. In the embryological stage, the canal is flanked by an outpocketing of the **peritoneum**, and the abdominal musculature. This outpocketing, the **processus vaginalis**, normally degenerates, but a failure to do so can result in an indirect inguinal hernia.

In women, there is also a gubernaculum, this attaches the **ovaries** to the uterus and future labia majora. Because the ovaries are attached to the uterus by the gubernaculum, they are prevented from descending as far as the testes, instead moving into the **pelvic cavity**. The gubernaculum then becomes the ovarian ligament, and round ligament of uterus.

2- ‘Mid-Inguinal Point’ and ‘Midpoint of the Inguinal Ligament’

These two terms are mentioned frequently in this article, and are often (mistakenly) used interchangeably.

The **mid-inguinal point** is halfway between the pubic symphysis and the anterior superior iliac spine. The **femoral artery** crosses into the lower limb at this anatomical landmark.

The **midpoint of the inguinal ligament** is exactly as the name suggests. The inguinal ligament runs from the pubic tubercle to the anterior superior iliac spine, so the midpoint is halfway between these structures. The opening to the **inguinal canal** is located just above this point.

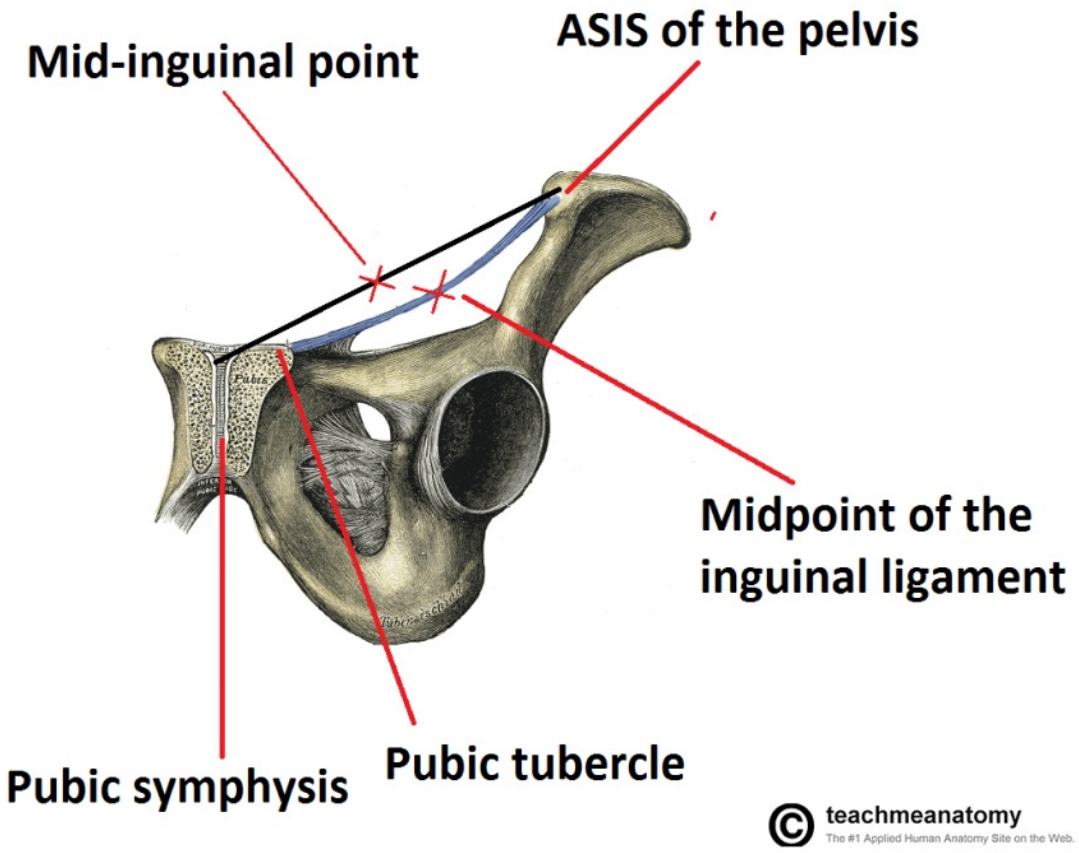

Fig 1.0 – Coronal view of the pelvis.

3- Boundaries

The inguinal canal is made up of:

- Anterior and posterior walls
- Superficial and deep rings (openings)
- Roof and floor (or superior and inferior walls)

We shall go through each component in turn.

- The **anterior wall** is formed by the aponeurosis of the external oblique, and reinforced by the internal oblique muscle laterally.
- The **posterior wall** is formed by the transversalis fascia.
- The **roof** is formed by the transversalis fascia, internal oblique and transversus abdominis.
- The **floor** is formed by the inguinal ligament (a 'rolled up' portion of the external oblique aponeurosis) and thickened medially by the lacunar ligament.

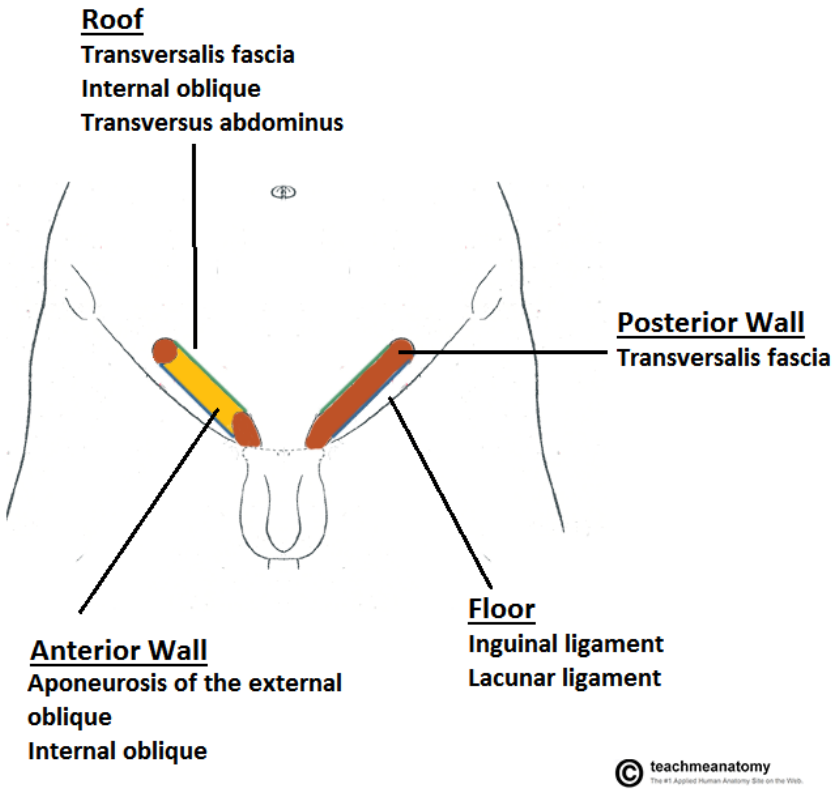

Fig 1.2 – The borders of the inguinal canal. The anterior wall of the left inguinal canal has been removed.

During periods of increased **intra-abdominal** pressure, the abdominal viscera are pushed into the inguinal canal. To prevent herniation, the muscles of the anterior and posterior wall **contract**, and 'clamp down' on the canal.

The two openings to the inguinal canal are known as rings. The **deep (internal) ring** is found above the midpoint of the inguinal ligament. which is lateral to the **epigastric vessels**. The ring is created by the **transversalis fascia**, which invaginates to form a covering of the contents of the inguinal canal.

The **superficial (external) ring** marks the end of the inguinal canal, and lies just superior to the pubic tubercle. It is a triangle shaped opening, formed by the evagination of the external oblique, which forms another covering of the inguinal canal contents. This opening contains **intercrural fibres**, which run perpendicular to the aponeurosis of the **external oblique** and prevent the ring from widening.

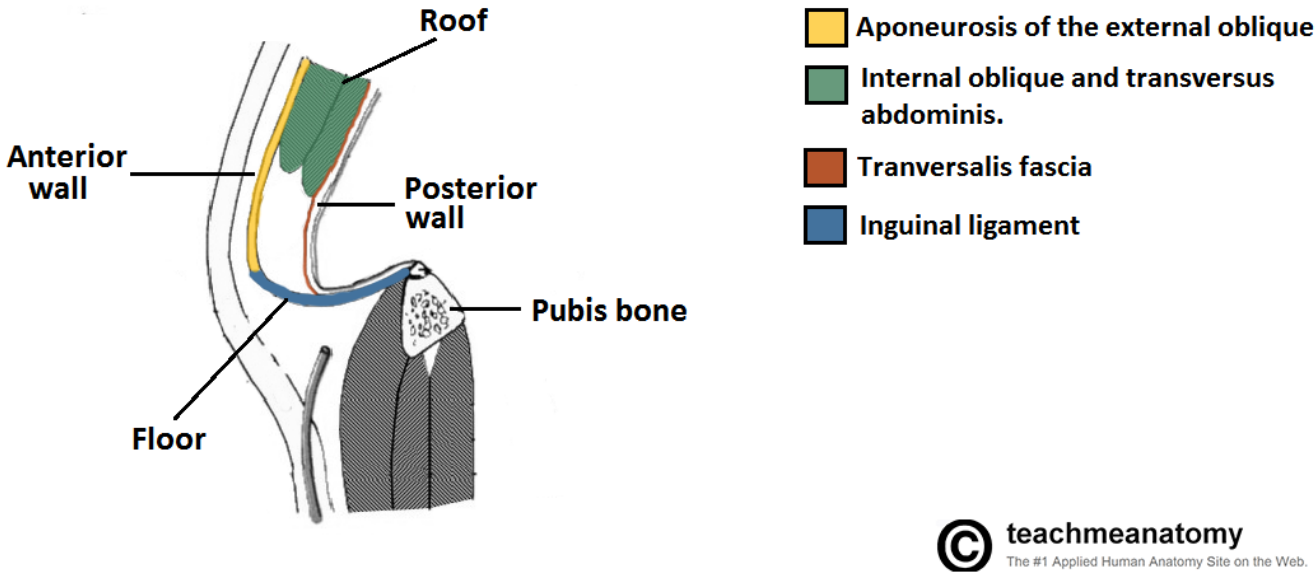

Fig 1.3 – Sagittal view of the inguinal canal, showing the borders. Image adapted, with permission, from www.dartmouth. edu/humananatomy.

4- Contents

In men, the spermatic cord passes through the inguinal canal, to supply and drain the testes. In women, the **round ligament** of uterus traverses through the canal.

The walls of the inguinal canal are usually **collapsed** around their contents, preventing other structures from potentially entering the canal and becoming stuck.

5- Clinical Relevance: Direct and Indirect Inguinal Hernias

A hernia is defined as *the protrusion of an organ of fascia through the wall of cavity that normally contain it*.

Hernias involving the inguinal canal can be divided into two main categories:

- **Indirect** – where the peritoneal sac enters the inguinal canal through the deep inguinal ring.
- **Direct** - where the peritoneal sac enters the inguinal canal though the posterior wall of the inguinal canal.

Both the hernias can present as lumps in the scrotum or labia majora.

Indirect Inguinal Hernias

This classification of hernia is the more common. It has a congenital origin – due to the failure of the processus vaginalis to **regress**.

The peritoneal sac enters the inguinal canal via the deep inguinal inguinal ring. The degree to which the sac herniates depends on the amount of processus vaginalis still present.

As the sac moves through the inguinal canal, it acquires the same three coverings as the contents of the canal.

Direct Inguinal Hernias

In contrast to the indirect hernia, this is acquired in origin, due to **weakening** in the abdominal musculature.

The peritoneal sac originates from an area **medial** to the epigastric vessels and bulges into the inguinal canal via the posterior wall.

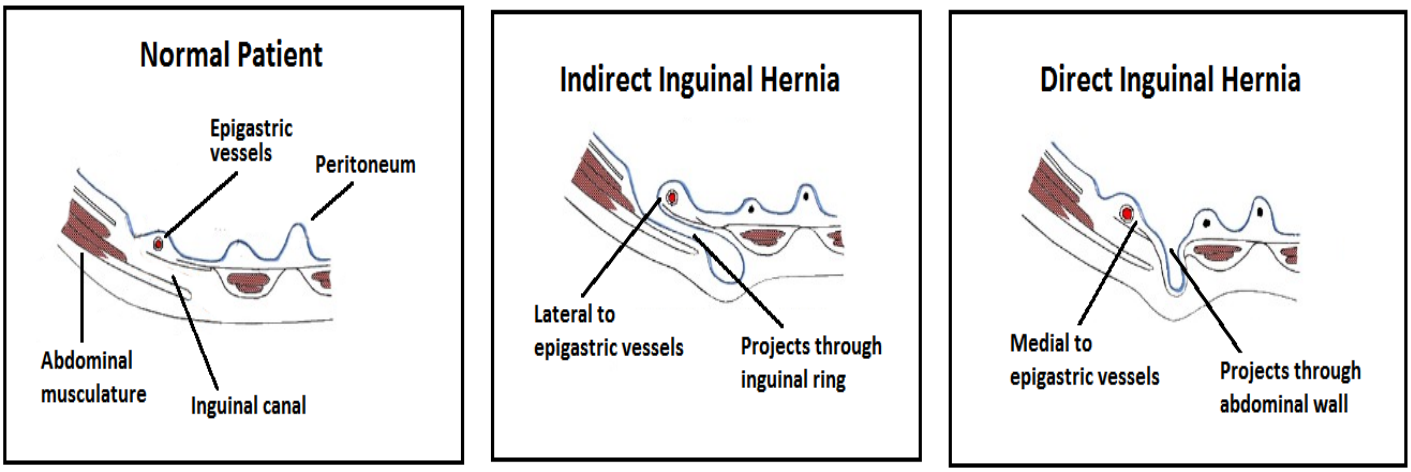

Fig 1.3 – Transverse view of the inferior abdominal cavity. Compares normal anatomy with indirect and direct herniation.

The Femoral Triangle

Scarpa's Triangle

Contents

The femoral triangle is a hollow in the anterior thigh region.

Many large neurovascular structures pass through this area, and can be accessed relatively easily. Thus, it is an area of both anatomical and clinical importance.

In this article, we shall look at the borders, contents and clinical correlations of the femoral triangle.

1- Borders of the Femoral Triangle

As this area is a triangle, it has three borders:

- **Superior border** - Formed by the **inguinal ligament**, a ligament that runs from the anterior superior iliac spine to the pubis tubercle.
- **Lateral border** - Formed by the medial border of the **sartorius** muscle.
- **Medial border** - Formed by the medial border of the **adductor longus** muscle. The rest of this muscle forms part of the floor of the triangle.

It also has a floor and a roof:

- Anteriorly, the **roof** of the femoral triangle is formed by the fascia lata
- Posteriorly, the **base** of the femoral triangle is formed by the pectineus, iliopsoas and adductor longus muscles.

The inguinal ligament acts as a **flexor retinaculum**, supporting the contents of the femoral triangle during flexion at the hip.

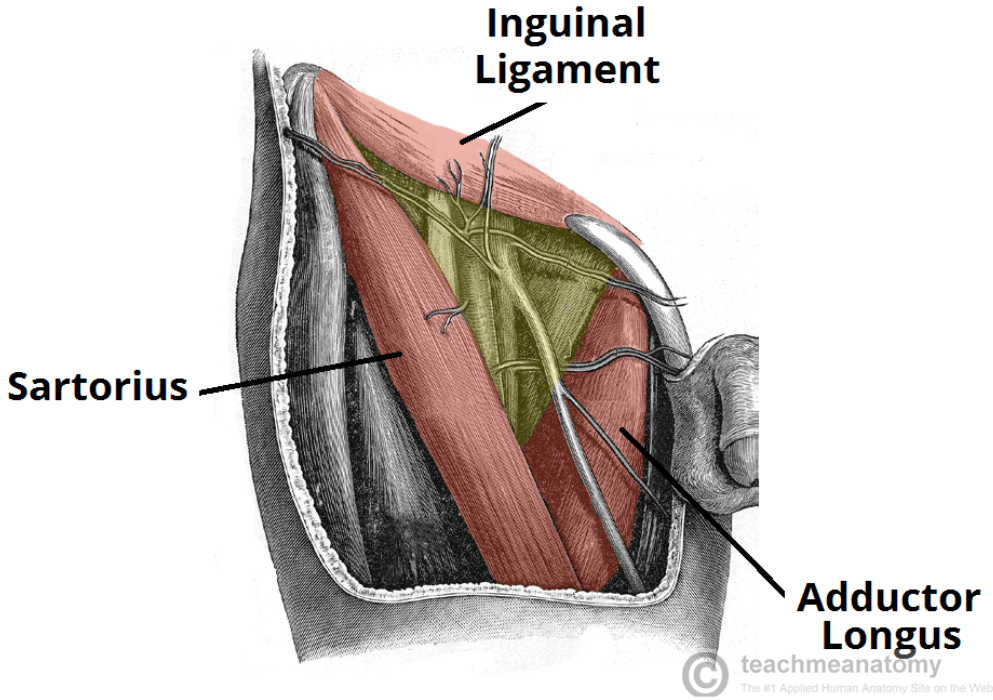

Fig 1.1 – The borders of the right femoral triangle.

2- Contents of the Femoral Triangle

The femoral triangle contents some of the major **neurovascular** structures of the lower limb.

The contents of the femoral triangle (lateral to medial) are:

- **Femoral nerve** – Innervates the anterior compartment of the thigh, and provides sensory branches for the leg and foot.
- **Femoral artery** – Responsible for the majority of the arterial supply to the lower limb.
- **Femoral vein** – The great saphenous vein drains into the femoral vein within the triangle.
- **Femoral canal** - A structure which contains deep **lymph nodes** and vessels.

The femoral artery, vein and canal are contained within a fascial compartment – known as the **femoral sheath**.

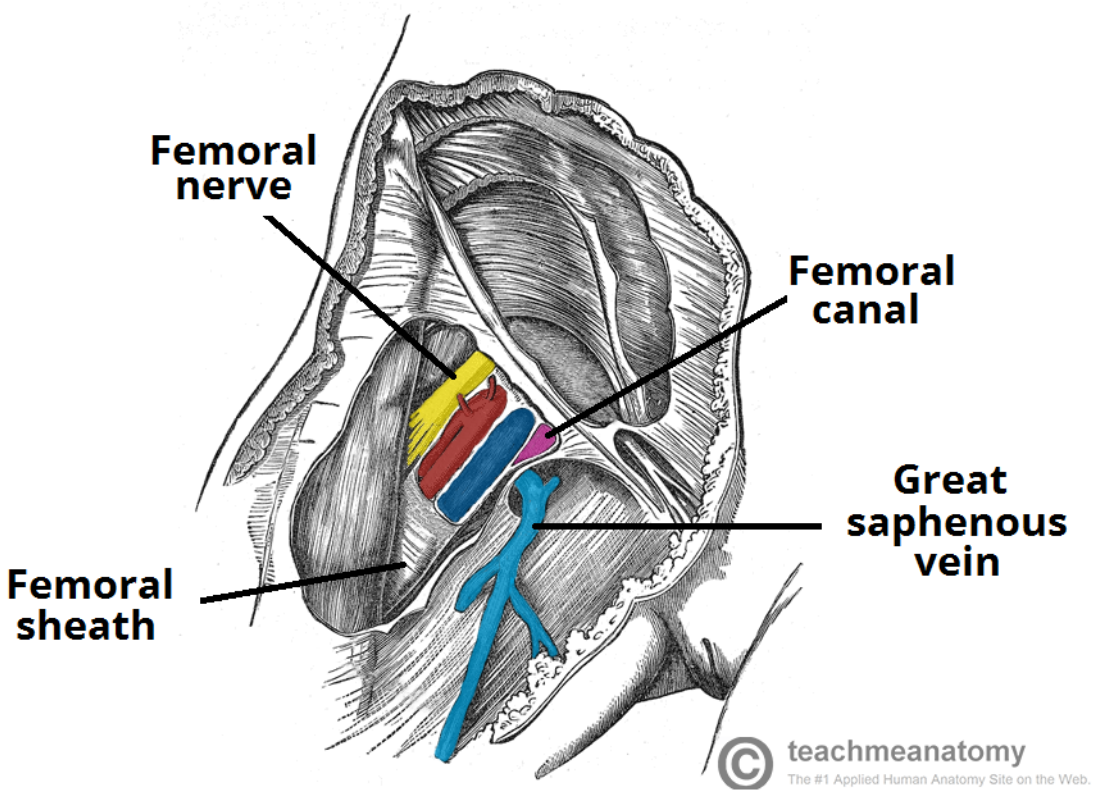

Fig 1.2 – The contents of the femoral triangle.

A good way of remembering the contents is using the acronym NAVEL:

N: *Nerve.*

A: *Artery.*

V: *Vein.*

E: *Empty space (this is important as it allows the veins and lymph vessels to distend, so they can cope with different levels of flow).*

L: *Lymph canal.*

3- Clinical Relevance of the Femoral Triangle

Femoral Pulse

Just inferior to where the **femoral artery** crosses the inguinal ligament, it can be palpated to measure the femoral pulse. The femoral artery crosses exactly midway between the **pubis symphysis** and **anterior superior iliac spine**. The presence of a femoral pulse means that blood is reaching the lower extremity.

Access to the Femoral Artery

Within the femoral triangle, the femoral artery is located **superficially**, and thus easy to access. This makes it suitable for a range of clinical procedures.

One such procedure is **coronary angiography.** Here, the femoral artery is **catheterised** with a long, thin tube. This tube is navigated up the external iliac artery, common iliac artery, aorta, and into the **coronary vessels**. A radioactive dye is then ejected into the coronary vessels, and any wall thickening or blockages can be visualised via x-ray imaging. The femoral artery can also be catheterised to draw blood for **arterial blood gases.**

Muscles of the Gluteal Region

Contents

The gluteal region is an anatomical area located posteriorly to the pelvic girdle, at the proximal end of the femur. The muscles in this region move the lower limb at the hip joint.

The muscles of the gluteal region can be broadly divided into two groups:

- **Superficial abductors and extenders** - A group of large muscles that abduct and extend the femur. It includes the gluteus maximus, gluteus medius and gluteus minimus.
- **Deep lateral rotators** - A group of smaller muscles, that mainly laterally rotated the femur. It includes the quadratus femoris, piriformis, gemellus superior, gemellus inferior and obturator internus.

In this article, we shall examine the two groups of gluteal muscles – their attachments, innervations and actions. We shall also look at the clinical consequence of gluteal muscle disorder.

1- The Superficial Muscles

The superficial muscles in the gluteal region consist of the three glutei. They act mainly act to abduct and extend the lower limb at the hip joint.

Gluteus Maximus

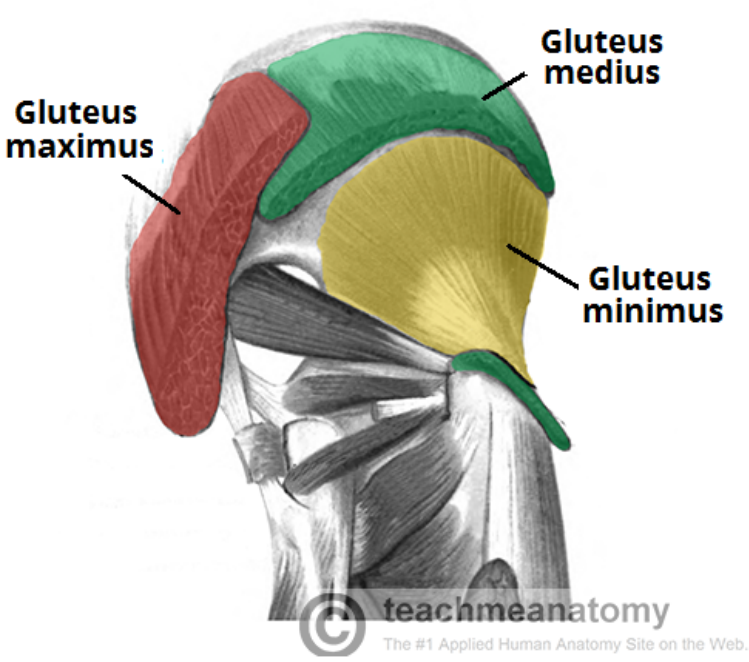

Fig 1.0 – The superficial muscles of the gluteal region. The gluteus maximus and medius have been partly removed.

The gluteus maximus is the largest of the gluteal muscles. It is also the most the most superficial, producing the shape of the buttocks.

- **Attachments**: Originates from the gluteal (posterior) surface of the ilium, sacrum and coccyx. It slopes across the buttock at a 45 degree angle, then inserts into the iliotibial tract and gluteal trochanter of the femur.

- **Actions**: It is the main extensor of the thigh, and assists with lateral rotation. However, it is only used when force is required, such as running or climbing.

- **Innervation**: Inferior gluteal nerve.

Gluteus Medius

The gluteus medius muscle is fan shaped and lies between to the gluteus maximus and the mnimus. It is similar is shape and function to the gluteus minimus.

- **Attachments**: Originates from the gluteal surface of the ilium and inserts into the lateral surface of the greater trochanter.
- **Actions**: Abducts and medially rotates the lower limb. During locomotion, it secures the pelvis, preventing pelvic drop of the opposite limb.
- **Innervation**: Superior gluteal nerve.

Gluteus Minimus

The gluteus minimus is the deepest and smallest of the superficial gluteal muscles. It is similar is shape and function to the gluteus medius.

- **Attachments**: Originates from the ilium and converges to form a tendon, inserting to the anterior side of the greater trochanter.
- **Actions**: Abducts and medially rotates the lower limb. During locomotion, it secures the pelvis, preventing pelvic drop of the opposite limb.
- **Innervation**: Superior gluteal nerve.

Clinical Relevance: Damage to the Superior Gluteal Nerve

The **superior gluteal nerve** innervates the gluteus medius and the gluteus minimus. These muscles have an important role in stablising the pelvis during walking. In a standing person, gluteus minimus and medius contract when the contralateral leg is raised, preventing the unsupported pelvis from dropping on that side.

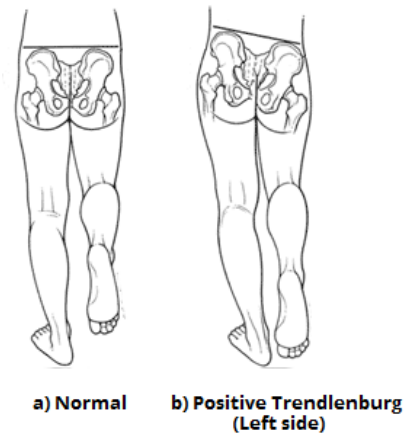

Fig 1.1 – Positive Trendelenburg test, a sign of left superior gluteal nerve palsy.

If the superior gluteal nerve is lesioned, and the muscles are paralysed, the pelvis becomes unsteady. The characteristic finding of gluteal muscle weakness is a positive Trendlenberg test.

Trendelenberg Test

In the Trendelenberg test, the patient is asked to stand unassisted on each leg in turn. In a positive test, **pelvic drop** will occur on the unsupported leg. Pelvic drop is can be recognised by looking for the level of the **iliac crests** on both sides.

For example, if the left gluteal muscles are weak, the right side of the pelvis will drop when the patient stands on their left leg (and the right leg is unsupported).

2- The Deep Muscles

The deep gluteal muscles are a set of smaller muscles, located underneath the gluteus minimus. The general action of these muscles is to laterally rotate the lower limb. They also stablise the hip joint by 'pulling' the femoral head into the acetabulum of the pelvis.

Piriformis

The piriformis muscle is a key landmark in the gluteal region (see 'clinical relevance' below). It is the most superior of the deep muscles.

- **Attachments**: Originates from the anterior surface of the sacrum. It then travels infero-laterally, through the greater sciatic foramen, to insert into the greater trochanter of the femur.
- **Actions**: Lateral rotation and abduction.
- **Innervation**: Nerve to piriformis.

Obturator Internus

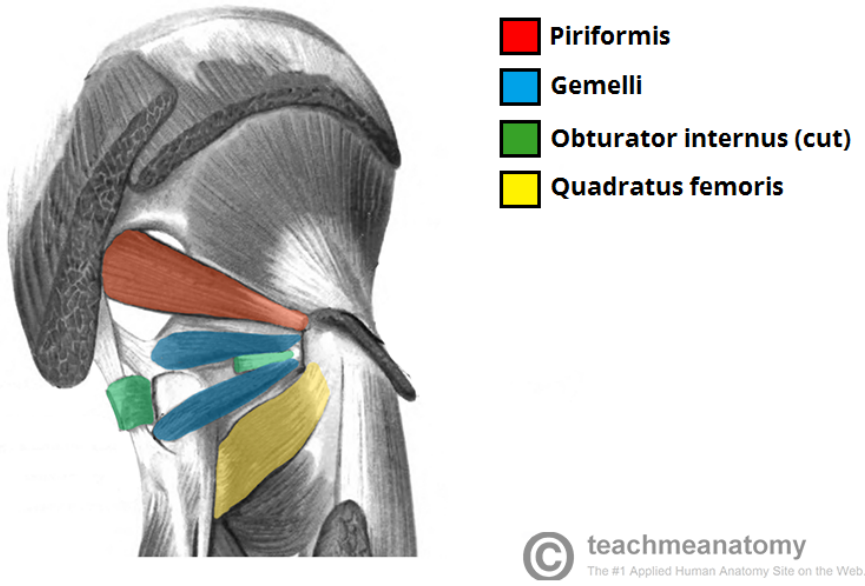

Fig 1.2 – The deep muscles of the gluteal region.

The obturator internus forms the lateral walls of the pelvic cavity. In some texts, the obturator internus and the gemelli muscles are considered as one muscle – the triceps coxae.

- **Attachments**: Originates from the pubis and ischium at the obturator foramen. It travels through the lesser sciatic foramen, and attaches to the greater trochanter of the femur.
- **Actions**: Lateral rotation and abduction.
- **Innervation**: Nerve to obturator internus.

The Gemelli – Superior and Inferior

The gemelli are two narrow and triangular muscles. They are separated by the obturator internus tendon.

- **Attachments**: The superior gemellus muscle originates from the ischial spine, the inferior from the ischial tuberosity. They both attach to the greater trochanter of the femur.
- **Actions**: Lateral rotation and abduction.
- **Innervation**: The superior gemellus muscle is innervated by the nerve to obturator internus, the inferior gemellus is innervated by the nerve to quadratus femoris.

Quadratus Femoris

The quadratus femoris is a flat square shaped muscle. It is the most inferior of the deep gluteal muscles, located below the gemelli and obturator internus.

- **Attachments**: It originates from the lateral side of the ischial tuberosity, and attaches to the quadrate tuberosity on the intertrochanteric crest.
- **Actions**: Lateral rotation.
- **Innervation**: Nerve to quadratus femoris.

Clinical Relevance: Landmark of the Gluteal Region

The piriformis is a important **anatomical landmark** in the gluteal region.

As the muscle travels through the greater sciatic foramen, it effectively divides the gluteal region into an inferior and superior part. This division determines the name of the vessels and nerves that supply the area. The **superior gluteal nerve** and vessels emerge into the gluteal region superiorly to the piriformis (and vice versa for the inferior gluteal nerve).

In addition, the piriformis can be used to locate the **sciatic nerve** (a major peripheral nerve of the lower limb). The sciatic nerve enters the gluteal region directly inferior to the piriformis, and is visible as a flat band, approximately 2cm wide.

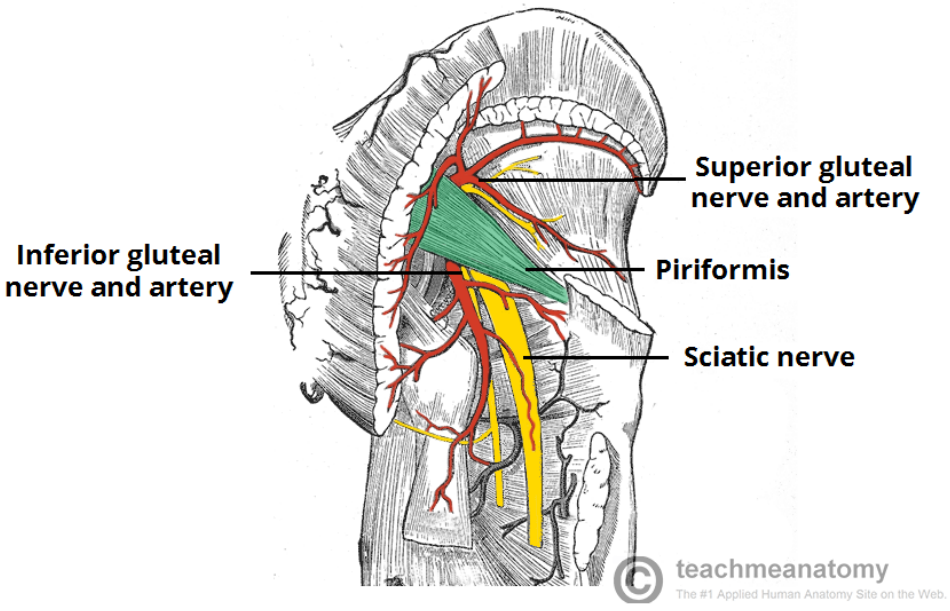

Fig 1.3 – The piriformis as an anatomical landmark in the gluteal region.

Muscles in the Medial Compartment of the Thigh

Contents

The muscles in the medial compartment of the thigh are collectively known as the **hip adductors**. There are five muscles in this group; gracilis, obturator externus, adductor brevis, adductor longus and adductor magnus.

All the medial thigh muscles are innervated by the **obturator nerve**, which arises from the lumbar plexus. Arterial supply is via the **obturator artery.**

1- Muscles of the Medial Thigh

Adductor Magnus

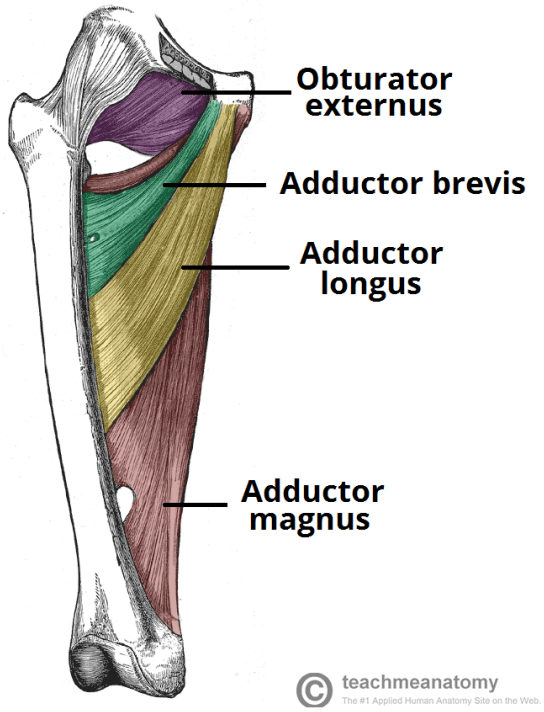

Fig 1.0 – Muscles of the medial thigh. The overlying muscles in the anterior compartment have been removed.

The adductor magnus is the largest muscle in the medial compartment. It lies posteriorly to the other muscles.

Functionally, the muscle can be divided into two parts; the adductor part, and the hamstring part.

- **Attachments**: The adductor part originates from the inferior rami of pubis and the rami of ischium, attaching to the linea aspera of the femur. The hamstring portion originates from the ischial tuberosity and attaches to the adductor tubercle on the distal and medial side of the femur.
- **Actions**: They both adduct the thigh. The adductor component also flexes the thigh, with the hamstring portion extending the thigh.
- **Innervation**: Adductor part is innervated by the obturator nerve (L2-L4), the hamstring part is innervated by the tibial nerve (L4-S3).

Adductor Longus

The adductor longus is a large, flat muscle. It partially covers the adductor brevis and magnus. The muscle forms the medial border of the femoral triangle.

- **Attachments**: Originates from the pubis, and expands into a fan shape, attaching broadly to the linea aspera of the femur
- **Actions**: Adduction and medial rotation of the thigh.
- **Innervation**: Obturator nerve (L2-L4).

Adductor Brevis

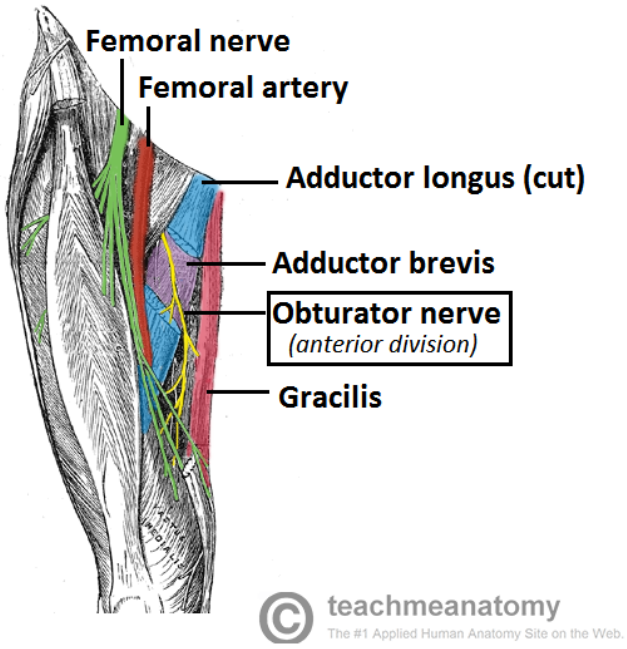

Fig 1.1 – View of the medial thigh, with the course of the obturator nerve highlighted

The adductor brevis is a short muscle, lying underneath the adductor longus.

It lies in between the anterior and posterior divisions of the obturator nerve. Therefore, it can be used as an anatomical landmark to identify the aforementioned branches.

- **Attachments**: Originates from the body of pubis and inferior pubic rami. It attaches to the linea aspera on the posterior surface of the femur, proximal to the adductor longus.
- **Actions**: Adduction of the thigh.
- **Innervation**: Obturator nerve (L2-L4).

Obturator Externus

This is one of the smaller muscles of the medial thigh, and it is located most superiorly.

- **Attachments**: It originates from the membrane of the obturator foramen, and adjacent bone. It passes under the neck of femur, attaching to the posterior aspect of the greater trochanter.
- **Actions**: Laterally rotates the thigh.
- **Innervation**: Obturator nerve (L2-L4).

Gracilis

The gracilis is the most superficial and medial of the muscles in this compartment. It crosses at both the hip and knee joints. It is sometimes transplanted into the hand or forearm to replace a damaged muscle.

- **Attachments**: It originates from the inferior rami of the pubis, and the body of the pubis. Descending almost vertically down the leg, it attaches to the medial surface of the tibia, inbetween the tendons of the sartorius (anteriorly) and the semitendinosus (posteriorly).
- **Actions**: Adduction of the thigh at the hip, and flexion of the leg at the knee.
- **Innervation**: Obturator nerve (L2-L4).

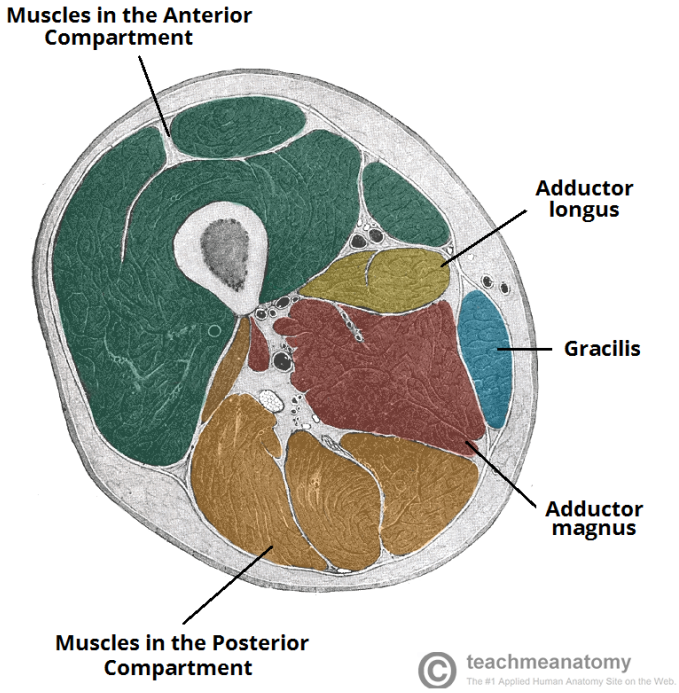

Fig 1.2 – Cross section of the inferior thigh, showing some of the medial thigh muscles. The adductor brevis and obturator externus attach superiorly in the thigh, and so are not visible in this cross-section.

2- Clinical Relevance: Injury to the Adductor Muscles

Strain of the adductor muscles is the underlying cause of what is colloquially known as a '**groin strain**'. The proximal part of the muscles are most usually affected, tearing near their bony attachments in the pelvis.

Groin injuries usually occur in sports that require explosive movements or extreme stretching. Treatment of any muscle strain should use the **RICE protocol** – rest, ice (at the beginning), compression and elevation.

Muscles in the Posterior Compartment of the Thigh

Contents

The muscles in the posterior compartment of the thigh are collectively known as the **hamstrings**. They consist of the biceps femoris, semitendinosus and semimembranosus – as a group they act to extend at the hip, and flex at the knee. They are innervated by the **sciatic nerve**.

The hamstrings form prominent tendons medially and laterally at the back of the knee. This explains the phrase 'hamstringing the enemy' – whereby these tendons are cut.

In this article, we shall look at the attachments, actions and clinical relevance of the muscles in the posterior thigh.

1- Muscles in the Posterior Compartment

Biceps Femoris

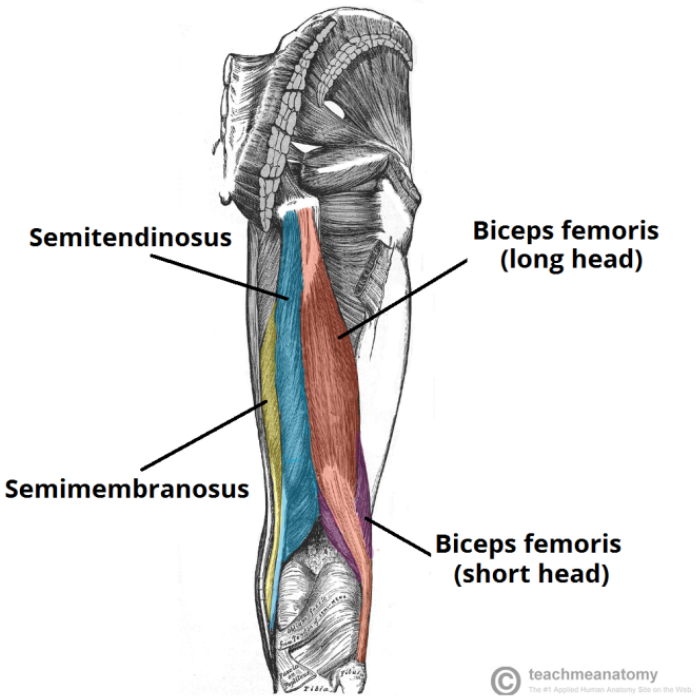

Fig 1.0 – Posterior view of the hamstrings.

Like the biceps brachii in the arm, the biceps femoris muscle has two heads – a long head and a short head.

It is the most lateral of the muscles in the posterior thigh – the common tendon of the two heads can be felt laterally at the posterior knee.

- **Attachments**: The long head originates from the ischial tuberosity of the pelvis. The short head originates from the linea aspera on posterior surface of the femur. Together, the heads form a tendon, which inserts into the head of the fibula.
- **Actions**: Main action is flexion at the knee. It also extends the leg at the hip, and laterally rotates at the hip and knee.
- **Innervation**: Sciatic Nerve.

Semitendinosus

The semitendinosus is a largely tendinous muscle. It lies medially to the biceps femoris, and covers the majority of the semimembranosus.

- **Attachments**: It originates from the ischial tuberosity of the pelvis, and attaches to the medial surface of the tibia.
- **Actions**: Flexion of the leg at the knee joint. Extension of thigh at the hip. Medially rotates the thigh at the hip joint and the leg at the knee joint.
- **Innervation**: Sciatic nerve.

Semimembranosus

The semimembranosus muscle is flattened and broad. It is located underneath the the semitendinosus.

- **Attachments**: It originates from the ischial tuberosity, but does so more superiorly than the semitendinosus and biceps femoris. It attaches to the medial tibial condyle.
- **Actions**: Flexion of the leg at the knee joint. Extension of thigh at the hip. Medially rotates the thigh at the hip joint and the leg at the knee joint.
- **Innervation**: Sciatic nerve.

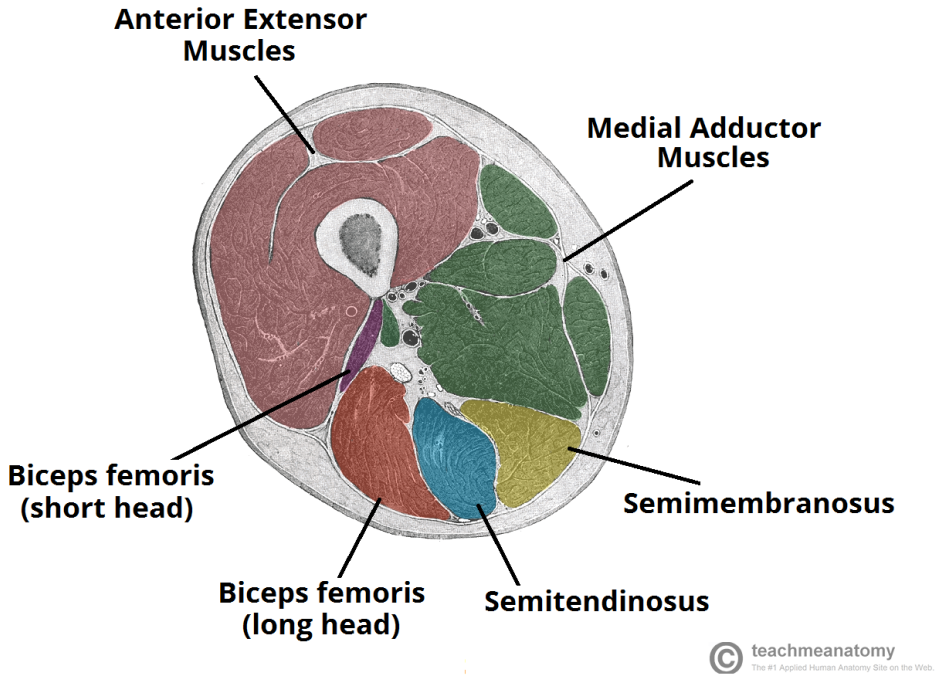

Fig 1.1 – Cross section of the thigh, showing the position of the major muscle groups.

2- Clinical Relevance: Damage to the Hamstrings

Muscle Strain

A hamstring strain refers to **excessive stretch** or **tearing** of the muscle fibres. They are often seen athletes involved in running or kicking sports. Damage to the muscle fibres is likely to rupture the surrounding blood vessels – producing a **haematoma** (a collection of blood). The haematoma is contained by the overlying fascia lata.

Treatment of any muscle strain should use the **RICE protocol** – rest, ice (at the beginning), compression and elevation.

Avulsion Fracture of the Ischial Tuberosity

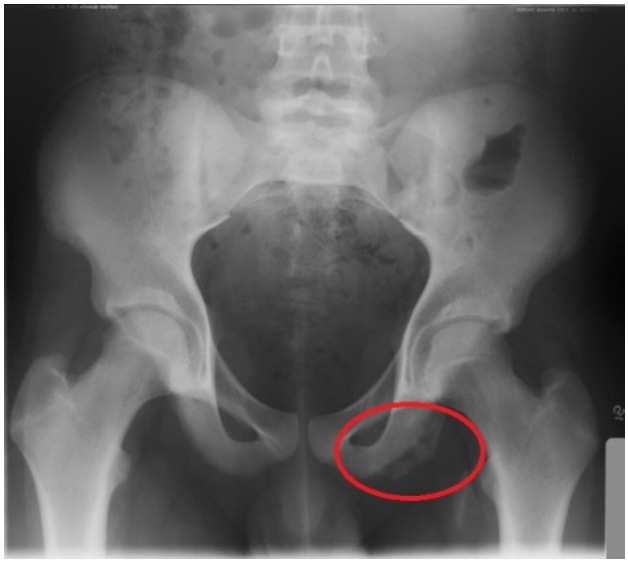

Fig 1.2 – Avulsion fracture of the left ischial tuberosity.

An avulsion fracture occurs when a fragment of bone breaks away from the main body of bone.

In an avulsion fracture of the **ischial tuberosity**, the hamstring tendons 'tear off' a piece of the ischial tuberosity. Such an injury usually occurs in sports that require rapid contraction and relaxation of the muscles – such as sprinting, football and hurdling.

Muscles in the Anterior Compartment of the Thigh

Contents

The musculature of the thigh can be split into three sections; anterior, medial and posterior. Each compartment has a distinct innervation and function.

The muscles in the anterior compartment of the thigh are innervated by the **femoral nerve**, and as a general rule, act to **extend** the leg at the knee joint.

There are three major muscles in the anterior thigh – the **pectineus**, **sartorius** and **quadriceps femoris**. In addition to these, the end of the **iliopsoas** muscle passes into the anterior compartment.

This article will cover the attachments, actions, innervations and clinical correlations of these muscles.

1- Iliopsoas

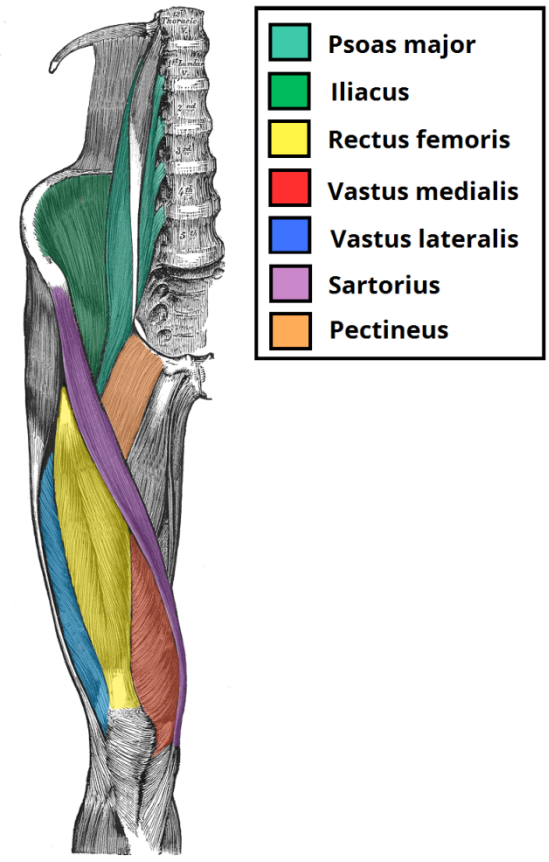

Fig 1.0 – The muscles of the anterior thigh.

The iliopsoas is actually two muscles, the **psoas major** and the **iliacus**. They originate in different areas, but come together to form a tendon, hence why they are commonly referred to as one muscle.

Unlike many of the anterior thigh muscles, the iliopsoas does not extend the leg at the knee joint.

- **Attachments**: The psoas major originates from the lumbar vertebrae, and the iliacus originates from the iliac fossa of the pelvis. They insert together onto the lesser trochanter of the femur.
- **Actions**: The iliopsoas flexes the lower limb at the hip joint and assists in lateral rotation at the hip joint.
- **Innervation**: The psoas major is innervated by anterior rami of L1-3, while the iliacus is innervated by the femoral nerve.

2- Quadriceps Femoris

The quadriceps femoris consists of four individual muscles; three **vastus** muscles and the **rectus femoris**. They form the main bulk of the thigh, and collectively are one of the most powerful muscles in the body.

The quadriceps femoris attaches to the patella via a tendon. The patella attaches to the tibia by the **patella tendon**. The quadriceps femoris is the main extensor of the knee.

Vastus Muscles

There are four vastus muscles – vastus medialis longitudinalis, vastus medialis oblicus, vastus intermedius and vastus lateralis.

They are located exactly where their names suggest; the medialis lies on the medial side of the anterior thigh, and the lateralis lies on the lateral side. The intermedius is found deep to the other muscles.

Collectively, the vastus muscles extend at the knee joint, and are innervated by the femoral nerve.

Rectus Femoris

- **Attachments**: Originates from the ilium, just superior to the acetabulum. It runs straight down the leg (the latin for straight is rectus), and attaches to the patella by the quadriceps femoris tendon.
- **Actions**: This is the only muscle of the quadriceps to cross both the hip and knee joints. It flexes the leg at the hip joint, and extends at the knee joint.
- **Innervation**: Femoral nerve.

3- Sartorius

The sartorius muscle in the longest muscle in the body. It is long and thin, running across the thigh in a inferomedial direction. It is found more superficially to the other muscles in the leg.

- **Attachments**: Originates from the anterior superior iliac spine, and attaches to the superior, medial surface of the tibia.
- **Actions**: At the hip joint, it is a flexor, abductor and lateral rotator. At the knee joint, it is also a flexor.
- **Innervation**: Femoral nerve.

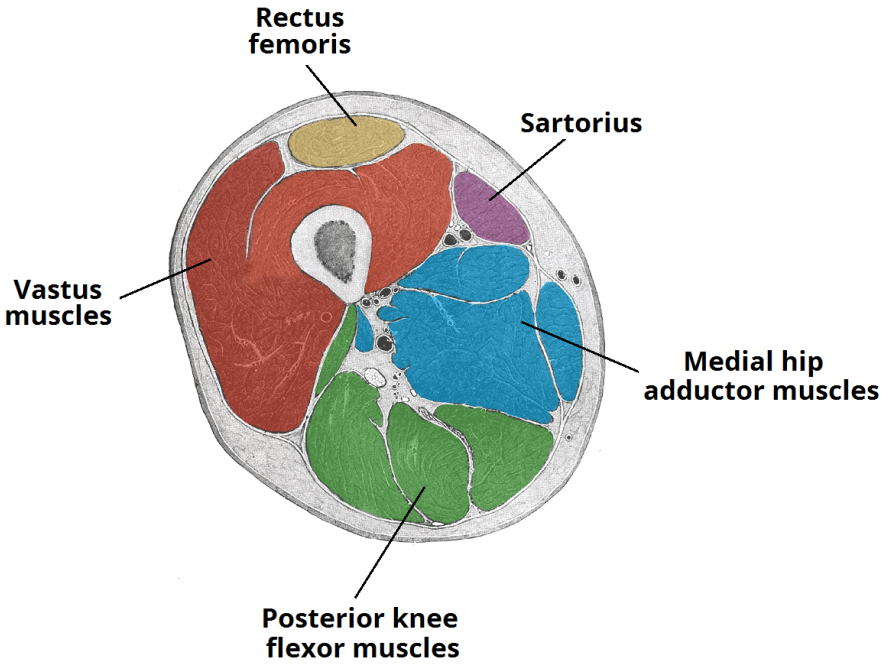

Fig 1.1 – Cross section of the distal thigh. The iliopsosas and pectineus muscles originate and attach in the proximal thigh, and hence are not included in this diagram.

4- Pectineus

This muscle can be classified into either the anterior or medial compartments or the thigh. It is innervated by the femoral nerve, a characteristic of the anterior compartment, but its actions are typical of a muscle from the medial compartment. It forms part of the base of the femoral triangle

- **Attachments**: It originates from the pectineal line on the anterior surface of the pelvis, and attaches to the pectineal line on the posterior side of the femur, just inferior to the lesser trochanter.
- **Actions**: Adduction and flexion at the hip joint.
- **Innervation**: Femoral nerve.

5- Clinical Relevance: Testing the Quadriceps Femoris

In suspected **femoral nerve** damage, the quadriceps femoris muscles can be tested.

This is achieved by asking the patient to lie in a supine position, with the knee slightly flexed. Ask the patient to extend the leg, and resist the movement – the contraction of the quadriceps femoris should be visible.

The Obturator Nerve

Contents

The obturator nerve is a major **peripheral** nerve of the lower limb. In this article, we shall look at its anatomical course, motor and sensory functions, and its clinical significance.

1- Overview

Nerve roots: L2-L4

Motor: Innervates the medial (adductor) compartment of the thigh.

Sensory: Cutaneous branch innervates the skin of the medial thigh.

2- Anatomical Course of the Obturator Nerve

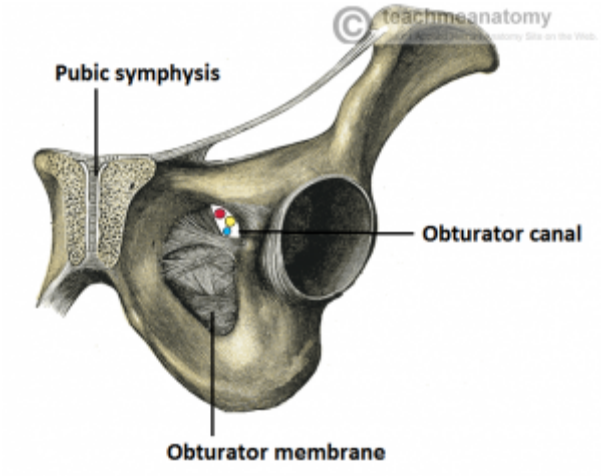

Fig 1.0 – A diagram of the obturator canal, with the obturator artery, nerve and vein passing through

The obturator nerve is formed by the anterior divisions of the second, third and fourth lumbar nerves.

It descends through the fibres of the **psoas major** muscle and emerges from its medial border, running posteriorly to the **common iliac arteries** and laterally along the pelvic wall to the **obturator foramen**. It then enters the thigh through the **obturator canal** and splits into anterior and posterior divisions.

The anterior division descends between the **adductor longus** and **adductor brevis** muscles towards the femoral artery, giving off branches to the adductor longus, adductor brevis and gracilis muscles. In rare cases it also gives off a branch to the pectineus muscle. It then pierces the **fascia lata** to become the cutaneous branch of the obturator nerve.

The posterior division descends through the **obturator externus** muscle before passing anteriorly to **adductor magnus** and giving off branches to supply it.

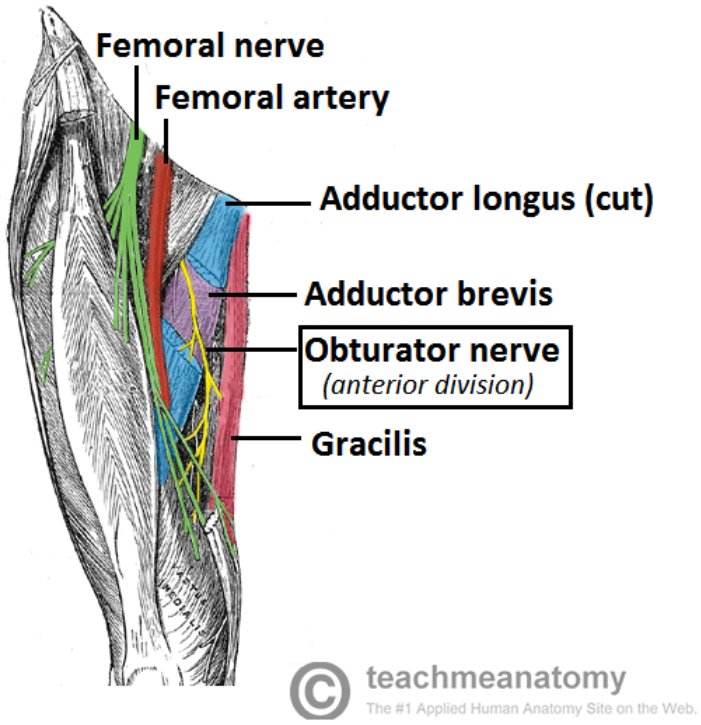

Fig 1.1 – View of the medial thigh, with the course of the obturator nerve highlighted.

3- Motor Functions of the Obturator Nerve

The obturator nerve innervates all the muscles in the medial compartment of the thigh except the hamstring part of the adductor magnus, which is innervated by the tibial nerve.

- **Adductor Longus** – adducts thigh
- **Adductor Brevis** – adducts thigh
- **Adductor Magnus** – adductor part adducts and flexes thigh, hamstring part extends thigh
- **Gracilis** – adducts thigh
- **Obturator Externus** – laterally rotates thigh

4- Sensory Function of the Obturator Nerve

The cutaneous branch of the obturator nerve supplies the skin of the middle part of the medial thigh.

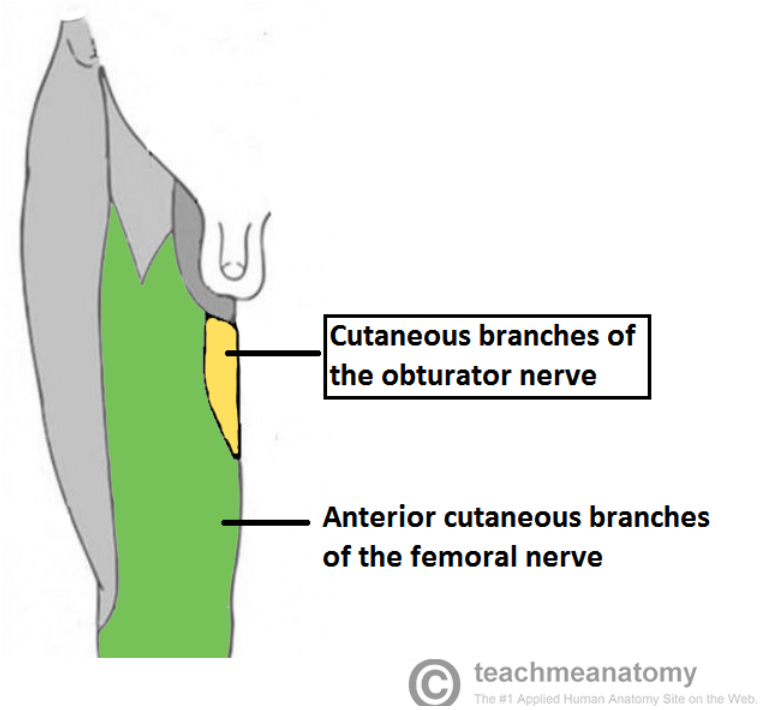

Fig 2.0 – Image of the cutaneous distribution of the anterior thigh, with the area supplied by the obturator nerve highlighted.

5- Clinical Relevance of the Obturator Nerve

Damage to the Obturator Nerve

The obturator nerve can be damaged during surgery involving the pelvis or abdomen. Symptoms include numbness and paraesthesia on the medial aspect of the thigh and weakness in adduction of the thigh. Alternatively, the patient could present with posture and gait problems due to the loss of adduction.

Obturator Nerve Block

Obturator nerve block is used in the management of pain after lower limb surgery or for chronic hip pain. The anaesthetic is injected inferior to the pubic tubercle and lateral to the tendon of the adductor longus muscle. The procedure can also be carried out under ultrasound guidance.

The Sciatic Nerve

Contents

The sciatic nerve is one of the major nerves of the lower limb. It is the largest nerve in the body, a thick flat band 2cm wide.

In this article, we shall look at the anatomy of the sciatic nerve – its anatomical course, motor and sensory functions, and any clinical relevance.

1- Overview

Nerve Roots: L4-S3.

Motor: Innervates the muscles of the posterior thigh, and the hamstring portion of the adductor magnus. Indirectly innervates (via its terminal branches) the muscles of the leg and foot.

Sensory: No direct sensory function. Indirectly innervates (via its terminal branches) the skin of the lateral leg, heel, and both the dorsal and plantar surfaces of the foot.

2- Anatomical Course

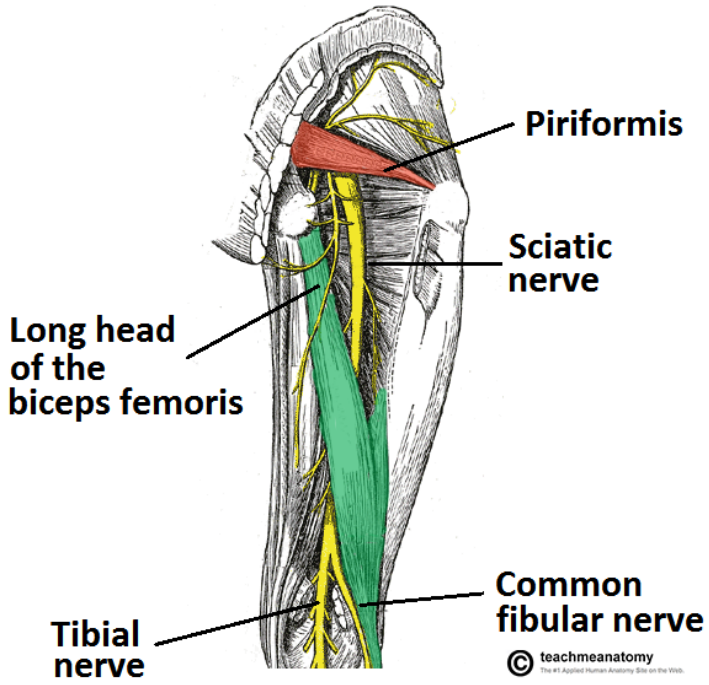

Fig 1.0 – View of the posterior thigh. The gluteus maximus and minimus have been removed to expose the sciatic nerve and underlying anatomical structures.

The sciatic nerve is derived from the **lumbosacral plexus**. It leaves the pelvis and enters the gluteal reigon via greater sciatic foramen.

The nerve leaves the greater sciatic foramen inferior to the **piriformis** muscle, then descends in the plane between the superficial and deep groups of gluteal muscles:

- **Posteriorly** to the deep gluteal muscles (obturator internus, gemmelus inferior and superior and quadriceps femoris)
- **Anteriorly** to gluteus maximus and the superficial group of gluteal muscles

The sciatic nerve continues down the posterior thigh, giving rise to motor branches for the hamstring muscles. When the sciatic nerve reaches the apex of the **popliteal fossa**, it terminates by bifurcating into the tibial and common fibular nerves.

In reality, the sciatic nerve is two individual nerves bundled together in the same connective tissue sheath; the tibial nerve and the common fibular nerve. These usually separate at the apex of the popliteal fossa, however in 12% of people they separate as they leave the pelvis.

3- Motor Functions

Despite passing through the **gluteal** region, the sciatic nerve does not innervate any muscles there. The nerve does, however, directly innervate the muscles in the posterior compartment of the thigh, and the hamstring portion of the **adductor magnus**.

The sciatic nerve also indirectly innervates many other muscles, via its two terminal branches:

- **Tibial Nerve –** the muscles of the posterior leg (calf muscles), and some of the intrinsic muscles of the foot
- **Common Fibular Nerve** – the muscles of the anterior leg, lateral leg, and the remaining intrinsic foot muscles.

In total, the sciatic nerve is responsible for the motor innervation of the posterior thigh, all of the leg and all of the foot.

4- Sensory Functions

The sciatic nerve does not have an direct cutaneous function. However it does an indirect sensory innervation, via its terminal branches:

- **Tibial Nerve –** Innervates the postero-lateral and antero-lateral sides of the leg, and the plantar surface of the foot (the sole).
- **Comon Fibular Nerve -** Innervates the lateral leg and the dorsal surface of the foot.

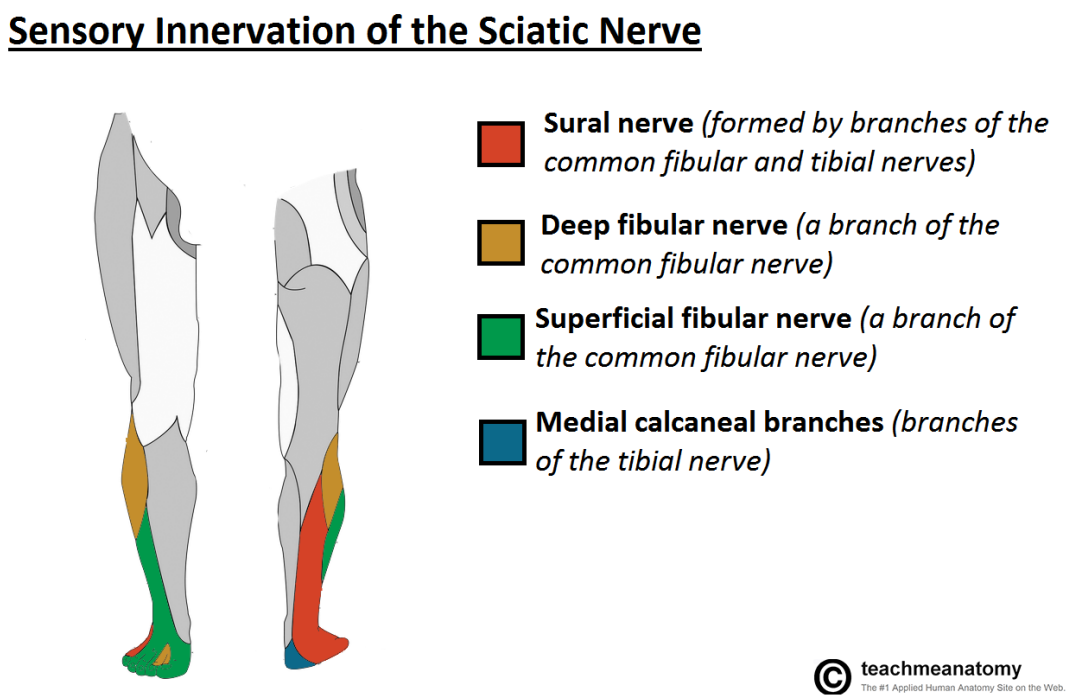

Fig 1.1 – The cutaneous innervation of the terminal branches of the sciatic nerve.

Clinical Relevance: Intramuscular injections

The sciatic nerve passes through the **gluteal** region, thus a clinician must take into account its anatomical course when administering **intramuscular** injections into the gluteal region.

The gluteal region can be divided into quadrants using 2 lines, marked by bony landmarks:

- One line descends vertically from the highest point on the iliac crest.
- The other horizontal line passes through the vertical line half way between the highest point on the iliac crest and ischial tuberosity.

The sciatic nerve passes through the lower medial quadrant. To avoid damaging the sciatic nerve therefore, intramuscular injections are given only in the upper lateral quadrant of the gluteal region.

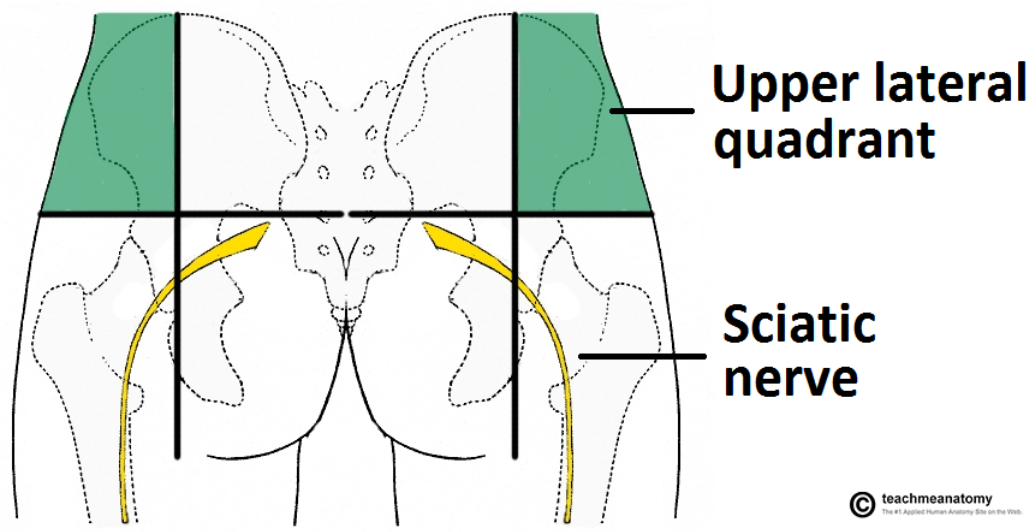

Fig 1.1 – Safe intramuscular injections into the gluteal region.

The Femoral Nerve

Contents

The femoral nerve is one of the major nerves supplying the lower limb. In this article, we shall look at the anatomical course of the nerve, its motor and sensory functions, and any clinical relevance.

Once you have finished reading this article, try out our quick quiz at the bottom of the page to see how much you've learnt!.

1- Overview

- **Nerve Roots:** L2-L4
- **Motor**: Innervates the **anterior thigh muscles** that flex the hip joint (pectineus, iliacus, sartorius) and extend the knee (quadriceps femoris: rectus femoris, vastus lateralis, vastus medialis and vastus intermedius)
- **Sensory:** cutaneous branches to the **anteromedial thigh** (anterior cutaneous branches of the femoral nerve) and a terminal cutaneous branch supplies the **medial side of the leg and foot** (saphenous nerve)

2- Anatomical Course

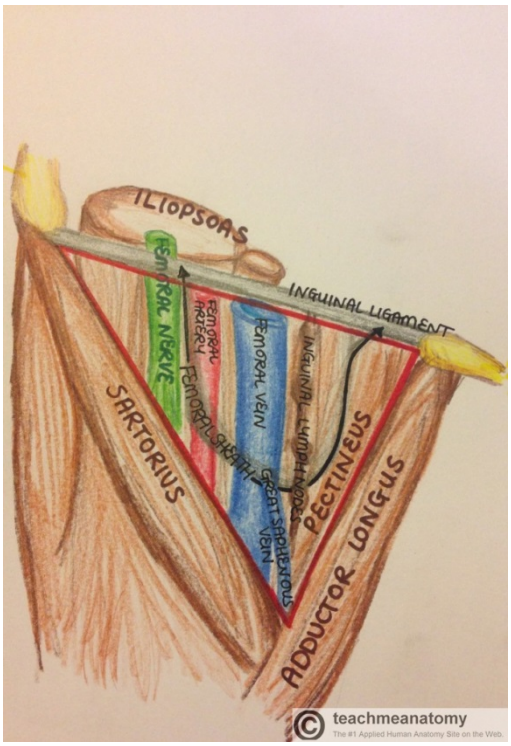

Fig 1.0 – Course of the of the Femoral Nerve through the Femoral Triangle (In Red)

The femoral nerve is the **largest branch of the lumbar plexus**. The nerve roots of the femoral nerve are **L2/L4**.

The nerves descend from the lumbar plexus **in the abdomen** through the **psoas major muscle**. The nerve then travels through the pelvis to approximately the mid point of the inguinal ligament. It then traverses **behind the inguinal ligament** into the thigh and splits into an **anterior and posterior division**.

It passes through the **femoral triangle** lateral to the femoral vessels (enclosed within the femoral sheath) and gives off **articular branches** to the hip and knee joints.

The **terminal cutaneous** branch of the femoral nerve is the **saphenous nerve** which continues, with the femoral artery and vein, through the adductor canal.

Clinical Relevance: Arterial or Venous Sampling from the Femoral Vessels

If arterial or venous sampling is required from the femoral artery or vein respectively, it is essential to be aware of the order in which the structures lie.

Remembering 'NAVY' gives a reminder of the structures from LATERAL to MEDIAL

Lateral - Femoral NERVE - Femoral ARTERY - Femoral VEIN - Medial

3- Motor Functions

The Femoral Nerve supplies some of the muscles of the **anterior thigh**

Hip Flexors:

- Pectineus. Actions: adducts and flexes the thigh, assists with medial rotation of the thigh
- Iliacus. Actions: acts with psoas major and psoas minor (forming iliopsoas) to flex the thigh at the hip joint and stabilise the hip joint
- Sartorius. Actions: flexes, abducts and laterally rotates the thigh at the hip joint. Flexes the leg at the knee joint

Knee Extensors:

- Quadriceps Femoris: Rectus Femoris, Vastus Lateralis, Vastus Intermedius. Actions: extend the leg at the knee joint. Rectus femoris also steadies the hip joint and assists iliopsoas in flexing the thigh

4- Sensory Functions

The first cutaneous branches of the femoral nerve are the **anterior cutaneous branches** that arise in the femoral triangle. They supply the skin on the **anteromedial thigh**.

The last cutaneous branch of the femoral nerve is the **saphenous nerve** which supplies the skin on the **medial side of the leg and the foot**.

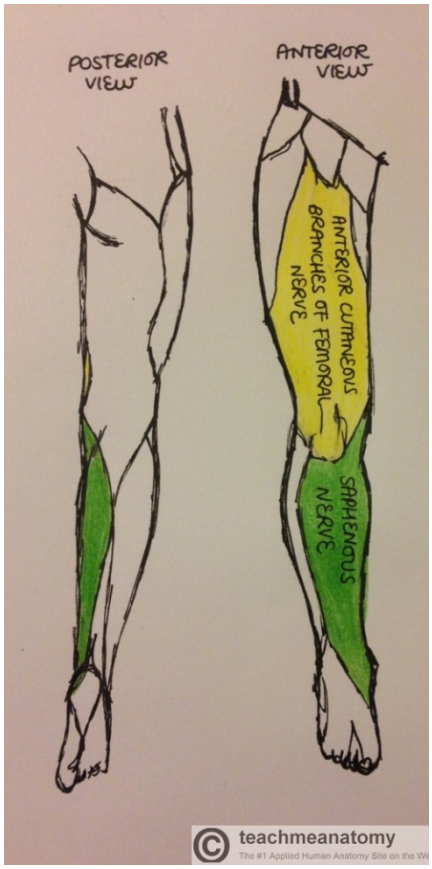

Fig 1.2 – Cutaneous branches of the Femoral Nerve

5- Clinical Relevance: Disorders of the Femoral Nerve

Stripping of the Saphenous Vein

The saphenous vein is often stripped in individuals with problematic varicose veins. The **long saphenous vein** is accompanied in it's course by the **saphenous nerve**. Damage to the **saphenous nerve** during this procedure can lead to pain, paraesthesia or complete loss of sensation the medial side of the lower leg (please see Fig. 2 above for distribution)

Femoral Nerve Block

Femoral nerve block (in combination with a **sciatic** nerve block) may be indicated in patients requiring lower limb surgery who cannot tolerate a **general anaesthetic**. A femoral nerve block can also be used as peri and post operative **analgesia** for patients with a fractured neck of femur who cannot tolerate particular analgesics.

Cutaneous Innervation of the Lower Limb

Contents

Cutaneous innervation is defined as an area of **skin** supplied by a specific nerve. In this article we shall look at the major peripheral nerves that contribute towards the sensory innervation of the lower limbs.

Cutaneous branches arise from mixed nerves and travel into the **subcutaneous tissue** of the limb, to innervate the overlying skin.

In the lower limb, the majority of the mixed nerves arise from the **lumbar** and **sacral** plexuses.

1- Nerve Plexuses in the Lower Limb

The vast majority of lower limb nerves arise from two nerve 'networks', known as the **lumbar** and **sacral** plexuses.

Cutaneous nerves can arise from two places:

- **Directly** from the lumbar or sacral plexuses. For example, the Ilioinguinal nerve arises directly from the lumbar plexus.
- As cutaneous branches of the **mixed nerves** that arise from the lumbar or sacral plexuses. For example, the saphenous nerve arises from the femoral nerve.

The **lumbar plexus** is located anterior to the transverse processes of the lumbar spine. It consists of the spinals roots from **L1** to **L4**. There is also some contribution from the T12 root.

In general, the nerves arising from the lumbar plexus supply the anterior and medial **thigh**. Major nerves that arise from the lumbar plexus are the **femoral nerve** (L2-L4), and the **obturator nerve** (L2-L4)

The **sacral plexus** is made up of the spinal roots **L5-S4**. It gives rise to nerves which supply the posterior thigh, leg and foot. The main branch of the sacral plexus is the **sciatic nerve.**

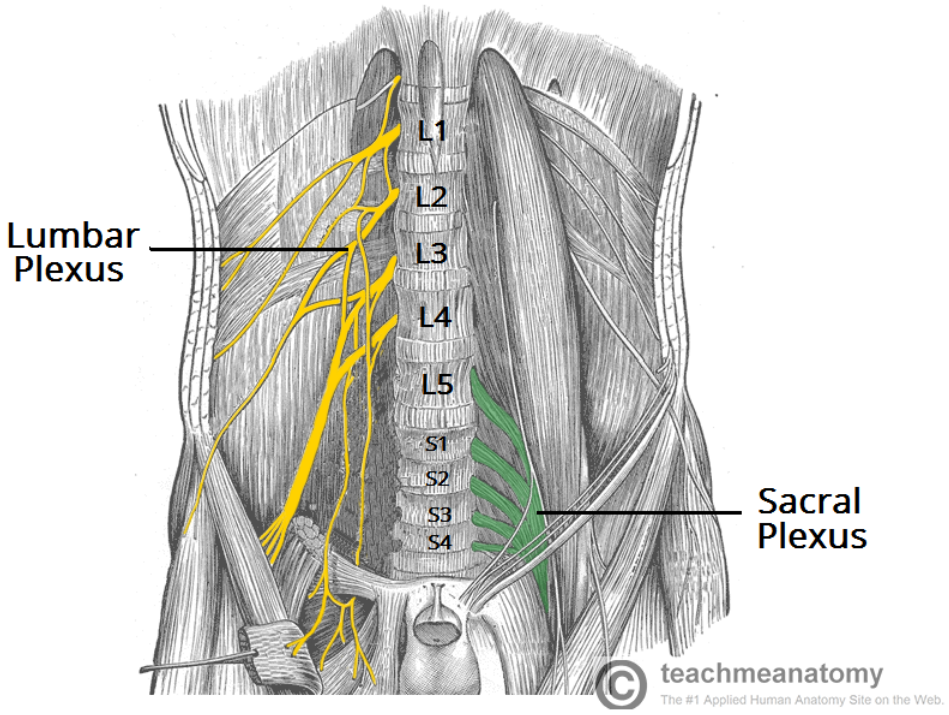

Fig 1.0 – The right lumbar plexus, and the left sacral plexus.

2- The Major Cutaneous Nerves

The **femoral**, **tibial** and **common fibular** nerves are the major nerves of the lower limb. They all give rise to cutaneous branches. Here, we shall look at the anatomical course, and sensory spread of these branches.

The Femoral Nerve

Responsible for the cutaneous innervation of anteromedial thigh, and the medial leg and foot.

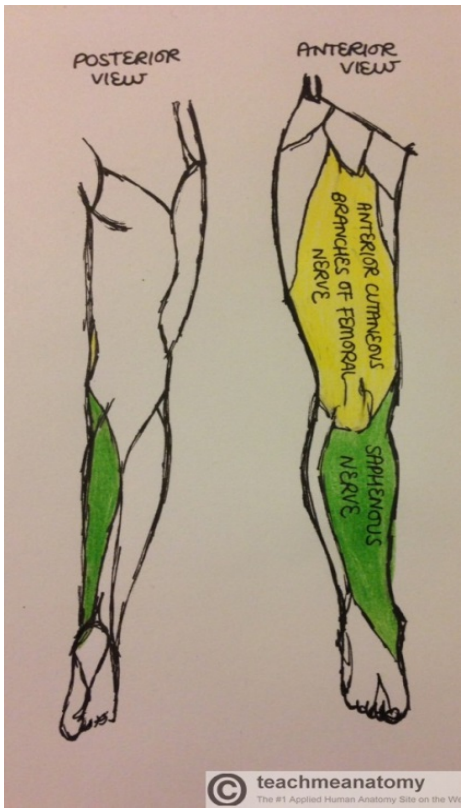

Fig 1.2 – Cutaneous branches of the Femoral Nerve

The femoral nerve (L2-L4) is a mixed nerve (i.e. contains sensory and motor fibres), that arises from the **lumbar plexus.** It descends through the psoas major muscle, and enters the lower limb on the anterior aspect of the thigh.

Two cutaneous nerves arise from the femoral nerve; the **anterior cutaneous branches**, and the **saphenous nerve**.

The **saphenous nerve** arises in the femoral triangle and descends down the thigh, via the adductor canal. It exits the canal just before the adductor hiatus, crossing the medial aspect of the knee and passing deep to the **sartorius** tendon. This sensory nerve supplies the skin on the **medial** side of the leg and foot.

The **anterior cutaneous branches** also arise in the femoral triangle. These nerves innervate the skin of the anterior and medial aspects of the thigh.

The Tibial Nerve

Responsible for the cutaneous innervation of the posterolateral leg, the sole and the heel.

The tibial nerve is one of the terminal branches of the **sciatic nerve**. It arises at the apex of the popliteal fossa, and descends down the posterior compartment of the leg.

It has several cutaneous branches:

- **Sural nerve** - Is formed by branches of the tibial and common fibular nerves. It supplies the skin of the posterolateral leg and the lateral margin of the foot.
- **Medial plantar nerve** – Supplies the skin of the medial sole of the foot, and the plantar aspect, nails and sides of the medial three and a half toes.
- **Lateral plantar nerve** – Supplies the skin of the lateral sole, and the plantar aspect, nails and sides of the lateral one and a half toes.
- **Calcaneal nerves** – Supplies the skin of the heel.

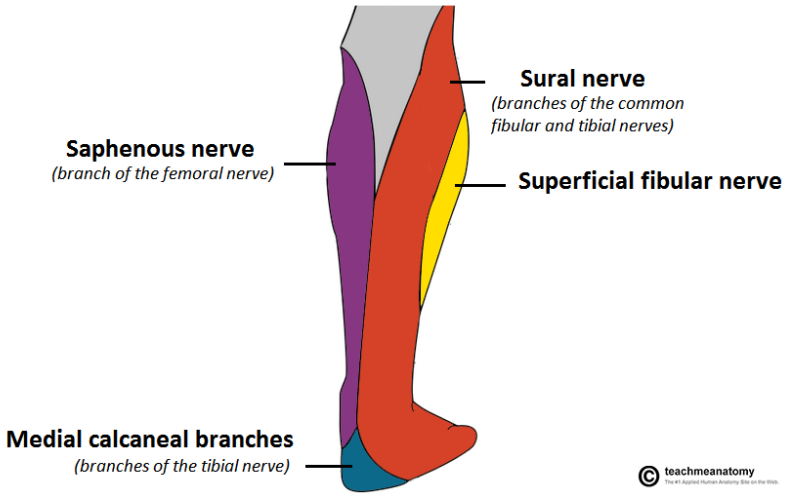

Fig 1.1 – Cutaneous innervation to the posterior leg. Tibial nerve contributes via the sural nerve and calcaneal branches

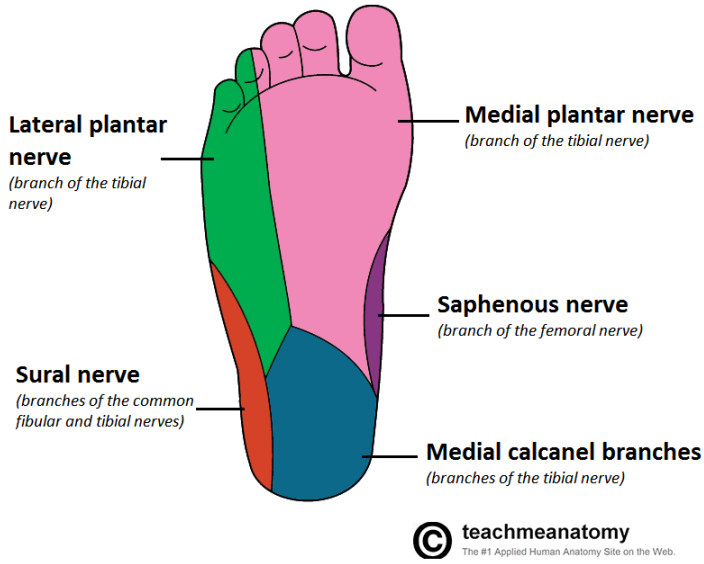

Fig 1.2 – Cutaneous innervation to the sole of the foot.

The Common Fibular Nerve

Responsible for the cutaneous innervation of the anterolateral leg, posterolateral leg, and the dorsal surface of the foot.

The tibial nerve is one of the terminal branches of the **sciatic nerve**. It arises at the apex of the popliteal fossa, and enters the lateral compartment

The cutaneous branches of the common fibular nerve are:

- **Superficial fibular nerve** (a mixed nerve) – Moves through the lateral compartment of the leg and perforates the deep fascia of the leg. It innervates the skin of the anterolateral leg and dorsum of the foot (apart from the skin between the big and 2nd toes).
- **Deep fibular nerve** (a mixed nerve) – Supplies the web of skin between the big and 2nd toes.
- **Sural nerve** – Formed by branches of the tibial and common fibular nerves. It supplies the skin of the posterolateral leg and the lateral margin of the foot.
- **Lateral Sural Nerve -** Supplies part of the anterolateral leg.

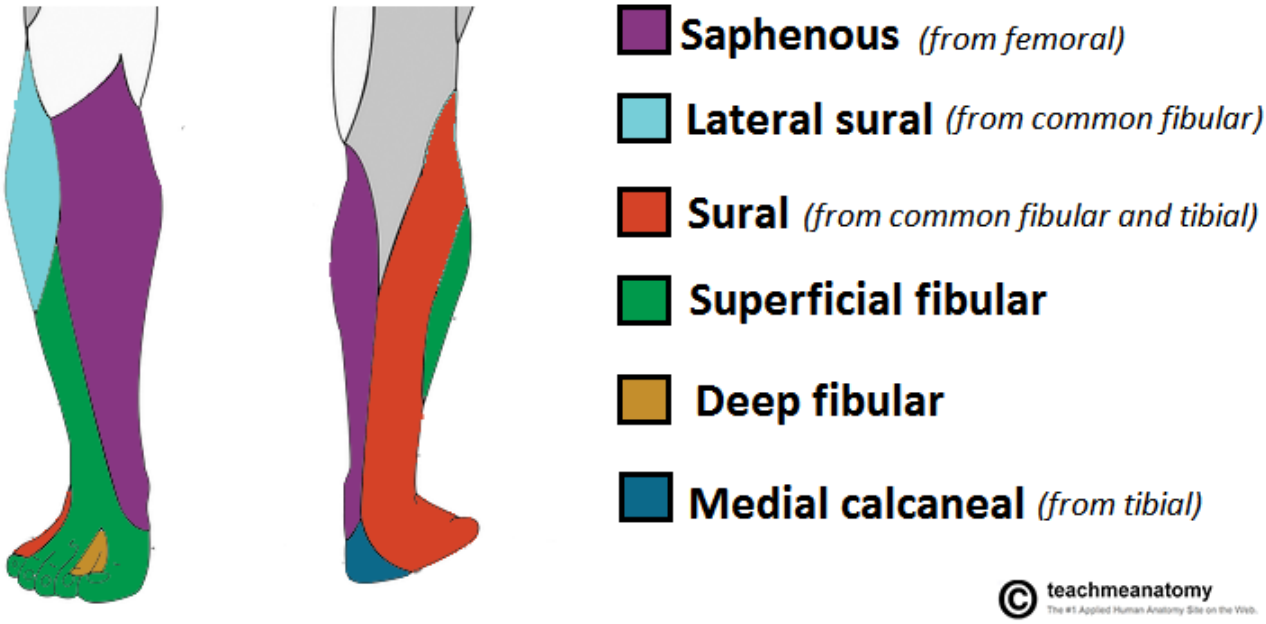

Fig 1.3 – The sensory innervation of the legs and feet.

3- Other Cutaneous Nerves

In addition to the major cutaneous nerves, smaller areas of skin are supplied by minor nerves. These tend to arise directly from the lumbar or sacral plexi.

Lumbar plexus:

- **Iliohypogastric** – Parallels iliac crest, generally divides into anterior and lateral branches.
- **Ilioinguinal** – Moves through the inguinal canal.
- **Genitofemoral** – Moves down anterior surface of psoas major where it divides into genital and femoral branches.
- **Lateral cutaneous nerve of thigh** – Passes 2-3cm medial to anterior superior iliac spine (deep to inguinal ligament).
- **Cutaneous branch of obturator nerve** (via Obturator nerve) – Descends between adductors longus and brevis and splits into branches.

Sacral plexus:

- **Posterior cutaneous nerve of thigh** – Enters gluteal region via greater sciatic foramen then passes deep to fascia lata.

The Abdominal Wall

Contents

The abdominal wall encloses the abdominal cavity, which holds the bulk of the gastrointestinal viscera.

In this article, we shall look at the layers of this wall, its surface anatomy and common surgical incisions that can be made to access the abdominal cavity.

1-Functions of the Abdominal Wall

Before we consider the anatomy of the abdominal wall, it is useful to have an overview of its functions. We can then consider the relationship of structure and function.

The main roles of the abdominal wall:

- Forms a firm, flexible wall which keeps the **abdominal viscera** in the abdominal cavity
- **Protects** the abdominal viscera from injury
- Maintains the **anatomical position** of abdominal viscera against gravity
- Assists in **forceful expiratio**n by pushing the andominal viscera upwards
- Involved in any action (coughing, vomiting) that **increases intra-abdominal** pressure

2-Layers of the Abdominal Wall

The layers of the abdominal wall consist of (external to internal):

1. Skin
2. Superficial fascia (or subcutaneous tissue)
3. Muscles and associated fascia
4. Parietal peritoneum

We shall now look at these individual layers in more detail.

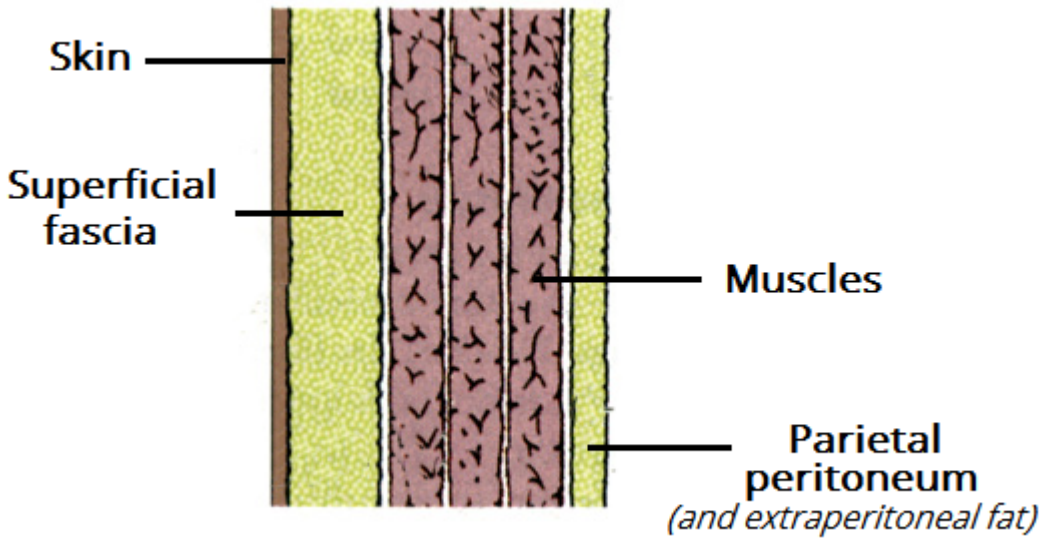

Fig 1.0 – The layers of the abdomen.

3-The Superficial Fascia

The superficial fascia consists of fatty **connective tissue**. The composition of this layer depends on its location:

- **Above the umbilicus:** A single sheet of connective tissue. This continuous with the superficial fascia in other regions of the body.
- **Below the umbilicus:** It is divided into two layers; the fatty superficial layer (Camper's fascia) and the membranous deep layer (Scarpa's fascia). Superficial vessels and nerves run between these two layers of fascia.

4-Muscles of the Abdominal Wall

There are five muscles in the abdominal wall. They can be divided into two groups:

- **Vertical muscles** – There are two vertical muscles, situated near the mid-line of the body.
- **Flat muscles** – There are three flat muscles, situated laterally.

The Flat Muscles

There are three flat muscles; the **external oblique**, **internal oblique** and **transversus abdominis**. They are located **laterally** in the abdominal wall, stacked upon one another.

These muscles act to flex, laterally flex and rotate the trunk. Their fibres run in differing directions and **cross** each other – strengthening the abdominal wall and decreasing the risk of herniation.

External Oblique

The largest and most **superficial** flat muscle in the abdominal wall. Its fibres run **inferomedially**. As the fibres approach the mid-line, they form an **aponeurosis** (a broad flat tendon).

In the mid-line, the aponeuroses of all the flat muscles become entwined, forming the **linea alba**. This is a fibrous structure that extends from the xiphoid process of the sternum to the pubic symphysis.

Internal Oblique

This muscle lies deep to the external oblique. It is smaller and thinner in structure, with its fibres running **superiormedially** (perpendicular to the fibres of the external oblique). Near the midline it forms aponeurotic fibres which contribute to the linea alba.

Transversus Abdominis

The deepest of the flat muscles, with **transversely** running fibres. Like the other flat muscles, it contributes aponeurotic fibres to the linea alba. Deep to this muscle is a well formed layer of fascia, called the **transversalis fascia**.

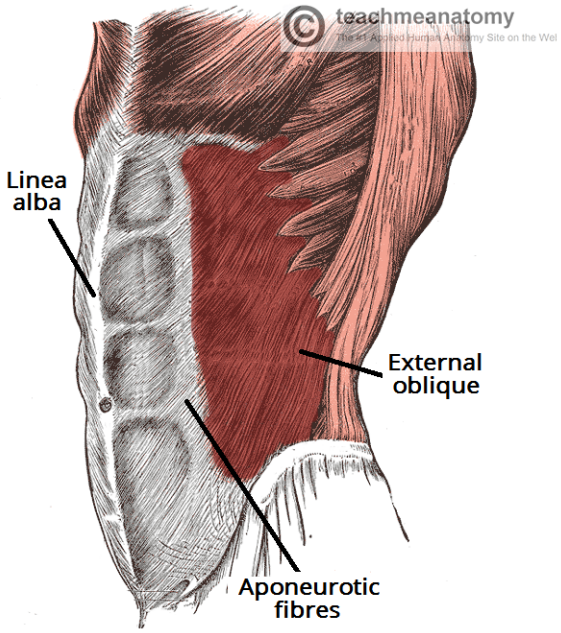

Fig 1.1 – Lateral view of the abdominal wall. The external oblique and its aponeurotic fibres are visible.

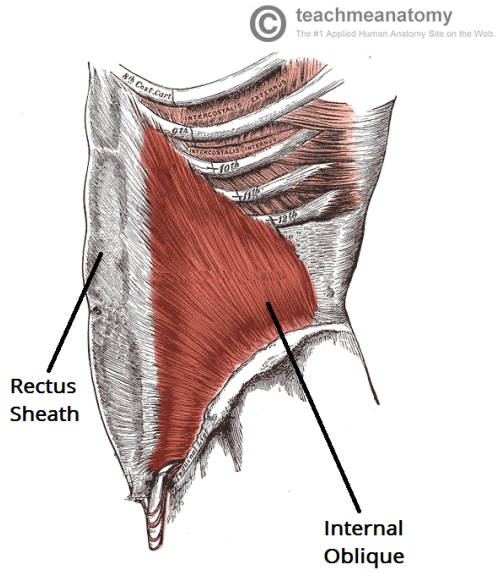

Fig 1.2 – Lateral view of the abdominal wall. The internal oblique is visible – note that its fibres are perpendicular to those of the external oblique.

The Vertical Muscles

Rectus Abdominis

This is a long, paired muscle, found either side of the midline in the abdominal wall. It is split into two by the **linea alba**. The lateral border of the two muscles create a surface marking called the **linea sumilunaris**.

At several places, the muscle is intersected by fibrous strips, known as **tendinous intersections.** The tendinous intersections and the linea alba give rise to the 'six pack' seen in individuals with low body fat.

As well as assisting the flat muscles in compressing the abdominal viscera, the rectus abdominus also stabilises the pelvis during walking, and depresses the ribs.

Pyramidalis

This is a small triangle shaped muscle, found superficially to the rectus abdominus. It is located inferiorly, with its base on the **pubis bone**, and the apex of the triangle attached to the linea alba. It acts to tense the **linea alba**.

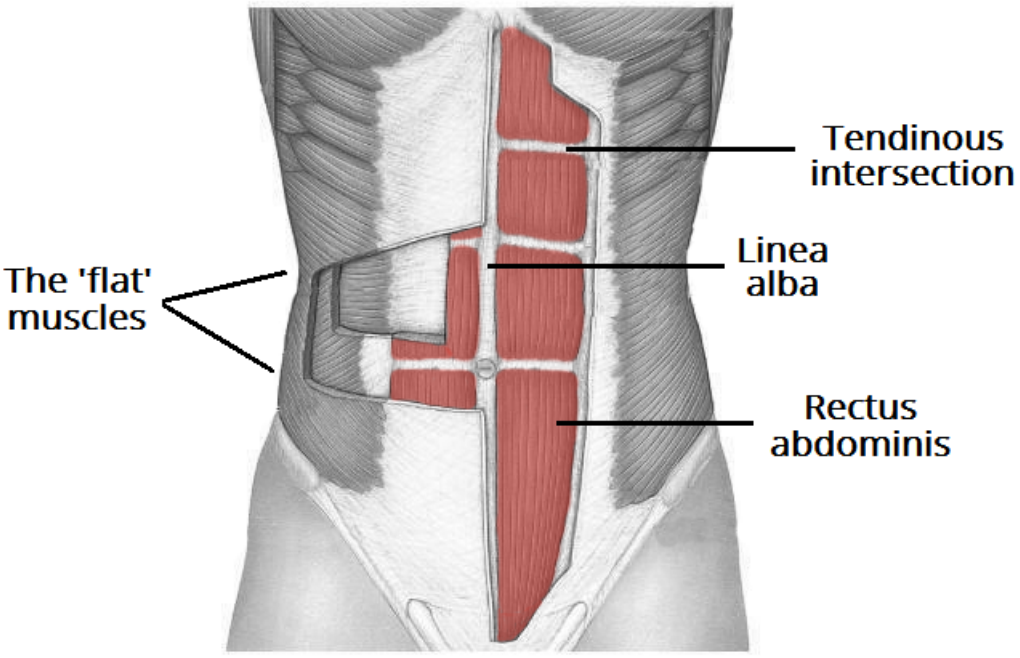

Fig 1.3 – Anterior view of the abdominal cavity. The pyrimidalis muscle is **not** visible.

The Rectus Sheath

The rectus sheath is formed by the **aponeuroses** of the three flat muscles, and encloses the rectus abdominus and pyramidalis muscles. It has an anterior and posterior wall for most of its length:

- The **anterior wall** is formed by the aponeuroses of the external oblique, and of half of the internal oblique.
- The **posterior wall** is formed by the aponeuroses of half the internal oblique and of the transversus abdominus.

Approximately midway between the umbilicus and the pubic symphysis, all of the aponeuroses move to the anterior wall of the **rectus sheath**. At this point, there is no posterior wall to the sheath; the rectus abdominus is in direct contact with the **transversalis fascia**.

The area of transition between having a posterior wall, and no posterior wall is known as the **arcuate line**.

5-Clinical Relevance: Surgical Incisions

There are various incisions used to gain access to abdominal cavity. In assessing which incision is best, the surgeon must consider:

- Direction of muscle fibres (you want to split the muscle fibres rather than cut them)
- Location of nerves
- Ease of access to the desired viscera

Vertical Incisions

Median.

An incision that is made through the linea alba. It can be extended the whole length of the abdomen, by curving around the umbilicus. The linea alba is poorly vascularised, so blood loss is minimal, and major nerves are avoided. All can be used in any procedure that requires access to the abdominal cavity.

Paramedian.

Similar to the median incision, but is performed laterally to the linea alba, providing access to more lateral structures (kidney, spleen and adrenals). This method ligates the blood and nerve supply to muscles medial to the incision, resulting in their atrophy.

Transverse Incisions

Transverse

This incision is made just inferior and laterally to the umbilicus. This is a commonly used procedure, as it causes least damage to the nerve supply to the abdominal muscles, and heals well. The incised rectus abdominus heals producing a new tendinous intersection. It is used in operations on the colon, duodenum and pancreas.

Suprapubic (Pfannenstiel)

Suprapubic incisions are made 5cm superior to the pubis symphysis. They are used when access to the pelvic organs is needed. When performing this incision, care must be taken not the perforate the bladder (especially if it is not catherised), as the fascia thins around the bladder area.

Subcostal

This incision starts inferior to the xiphoid process, and extends inferior parallel to the costal margin. It is mainly used on the right side to operate on the gall bladder, and on the left to operate on the spleen.

McBurney

This is a 'grid iron' incision, because it consists of two perpendicular lines, splitting the fibres of the muscles without cutting them – this allows for excellent healing. McBurney incision is performed at McBurney's point (1/3 of the distance between the ASIS and the umbilicus). It is mostly used in appendectomies.

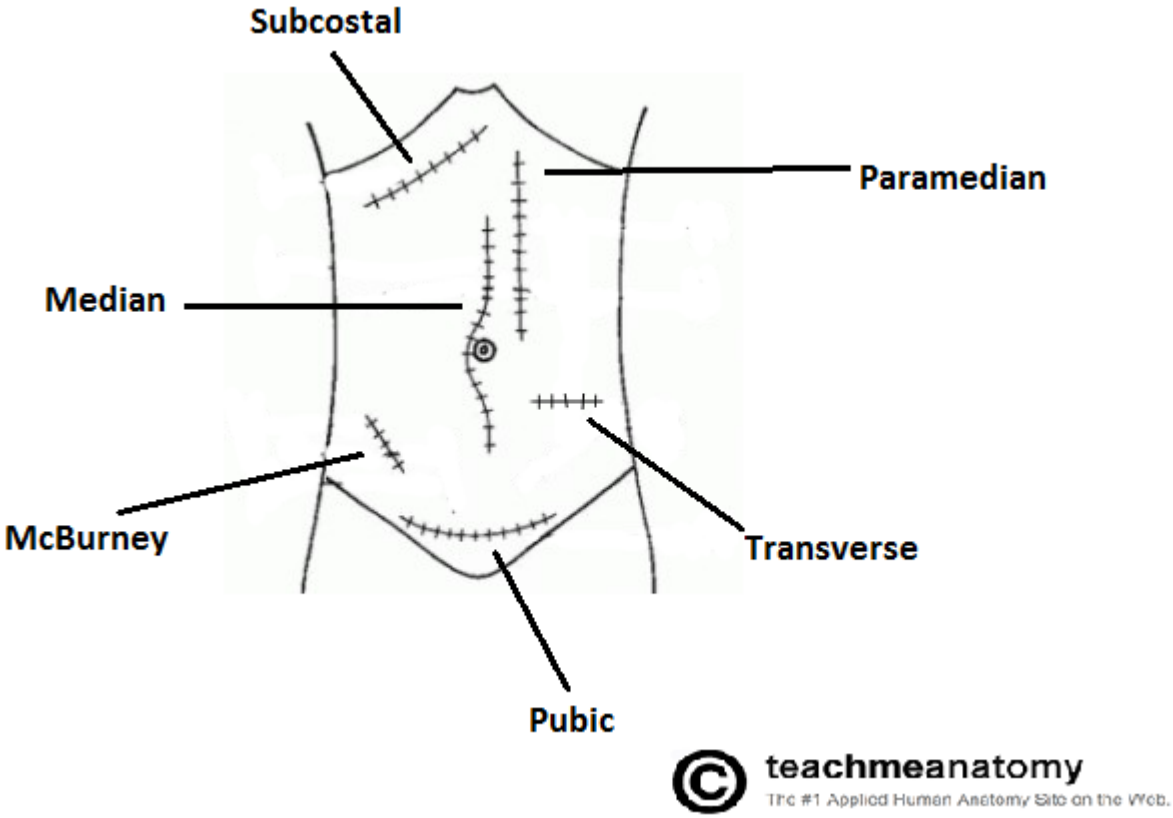

Fig 1.5 – Common surgical incisions into the abdominal wall.

6- Surface Anatomy of the Abdominal Wall

The abdominal cavity contains many organs, many of which can be palpated directly, or their position can be visualised by surface markings.

The **umbilicus** is the most visible structure of the abdominal wall, and is the scar of the site of attachment of the umbilical cord. It is usually midway between the xiphoid process and the pubis symphysis.

The rectus abdominus gives rise to some abdominal markings. The lateral border of this muscle is indicated by the **linea semilunaris**, a curved line running from the 9th rib to the pubic tubercle. The **linea alba** is a fibrous line that splits the rectus abdominus into two. It is visible as a vertical groove extending inferiorly from the xiphoid process.

The abdomen is a large area, and so it split into **nine regions** – these are useful clinically for describing the location of pain, location of viscera and describing surgical procedures. The nine regions are formed by two horizontal planes, and two vertical planes.

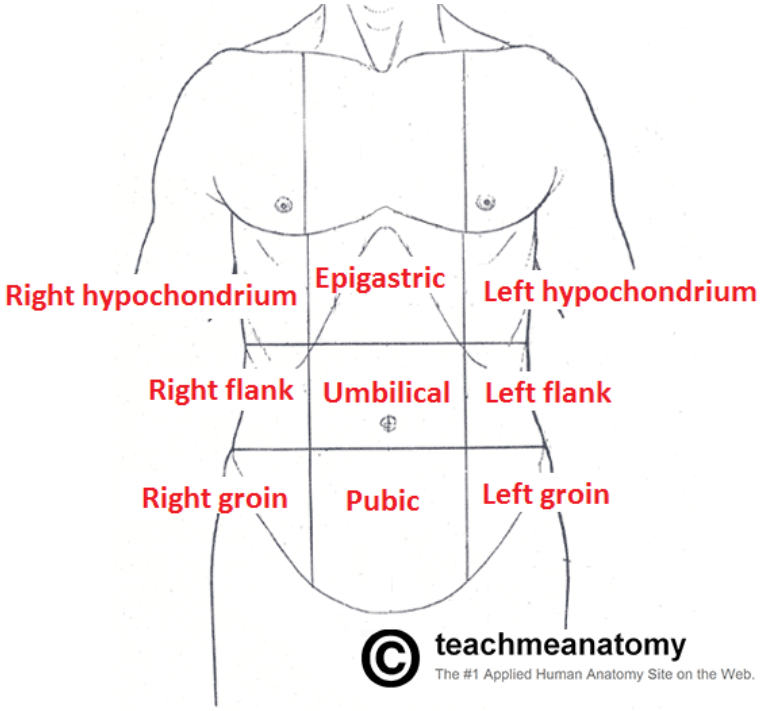

Fig 1.6 – The nine areas of the abdomen.

There are two horizontal planes:

- **Transpyloric plane:** Horizontal line halfway between the xiphoid process and the umbilicus, passing through the pylorus of the stomach.
- **Intertubercular plane:** Horizontal line that joins the iliac crests.

The two vertical planes run from the middle of the clavicle to the mid-inguinal point (halfway between the anterior superior iliac spine of the pelvis and the pubic symphysis). These planes are called **mid-clavicular lines**.

The Peritoneal Cavity

Contents

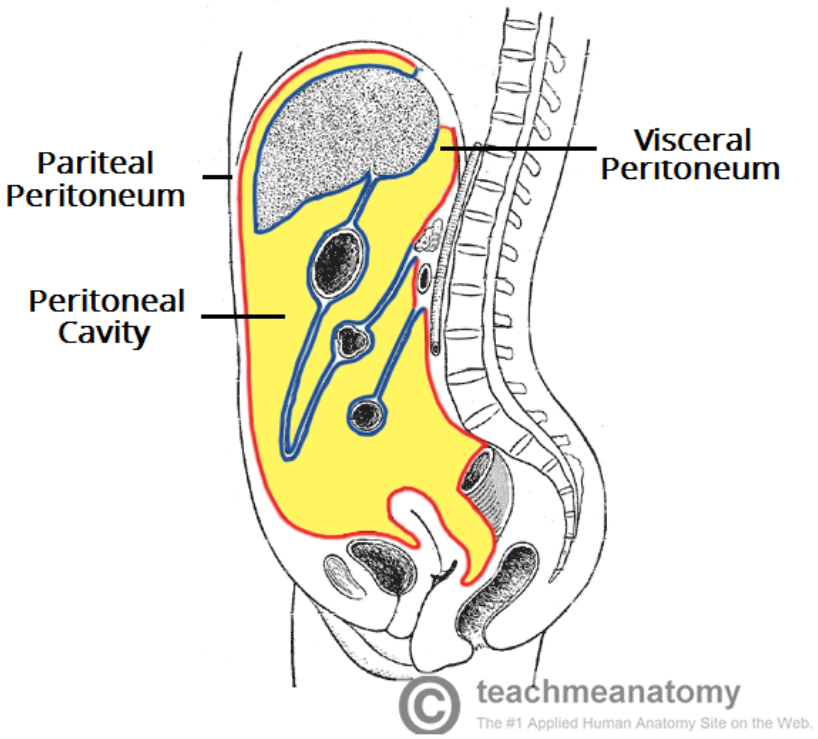

Fig 1.0 – The structure of the peritoneum and the peritoneal cavity. Note how the visceral layer invaginates to cover the organs.

The peritoneal cavity is a **potential space** between the **parietal** and **visceral** **peritoneum**.

It contains only a thin film of **peritoneal fluid**, which consists of water, electrolytes, leukocytes and antibodies.

The fluid serves two main functions:

- It acts as a lubricant, enabling free movement of the abdominal viscera.
- The antibodies fight infection.

Ordinarily, the peritoneal cavity is only of capillary thinness; however, it is referred to as a potential space because excess fluid can accumulate in the peritoneal cavity resulting in the clinical condition of **ascites** (see clinical applications).

1- Subdivisions of the Peritoneal Cavity

The peritoneal cavity can be divided into the **greater** and **lesser peritoneal sacs**. The greater sac is constitutes the majority of the peritoneal cavity. The lesser sac (also known as the **omental bursa**) is smaller and lies posterior to the stomach and lesser omentum.

The Greater Sac

The greater sac is the larger portion of the peritoneal cavity. It is further divided into two compartments by the mesentery of the **transverse colon** (known as the transverse mesocolon):

- The **supracolic compartment** lies above the transverse mesocolon and contains the stomach, liver and spleen**.**
- The **infracolic compartment** lies below the transverse mesocolon and contains the small intestine, ascending and descending colon. The infracolic compartment is further divided into **left and right infracolic spaces** by the mesentery of the small intestine**.**

The supracolic and infracolic compartments are connected by the **paracolic gutters** which lie between the posterolateral abdominal wall and the lateral aspect of the ascending or descending colon.

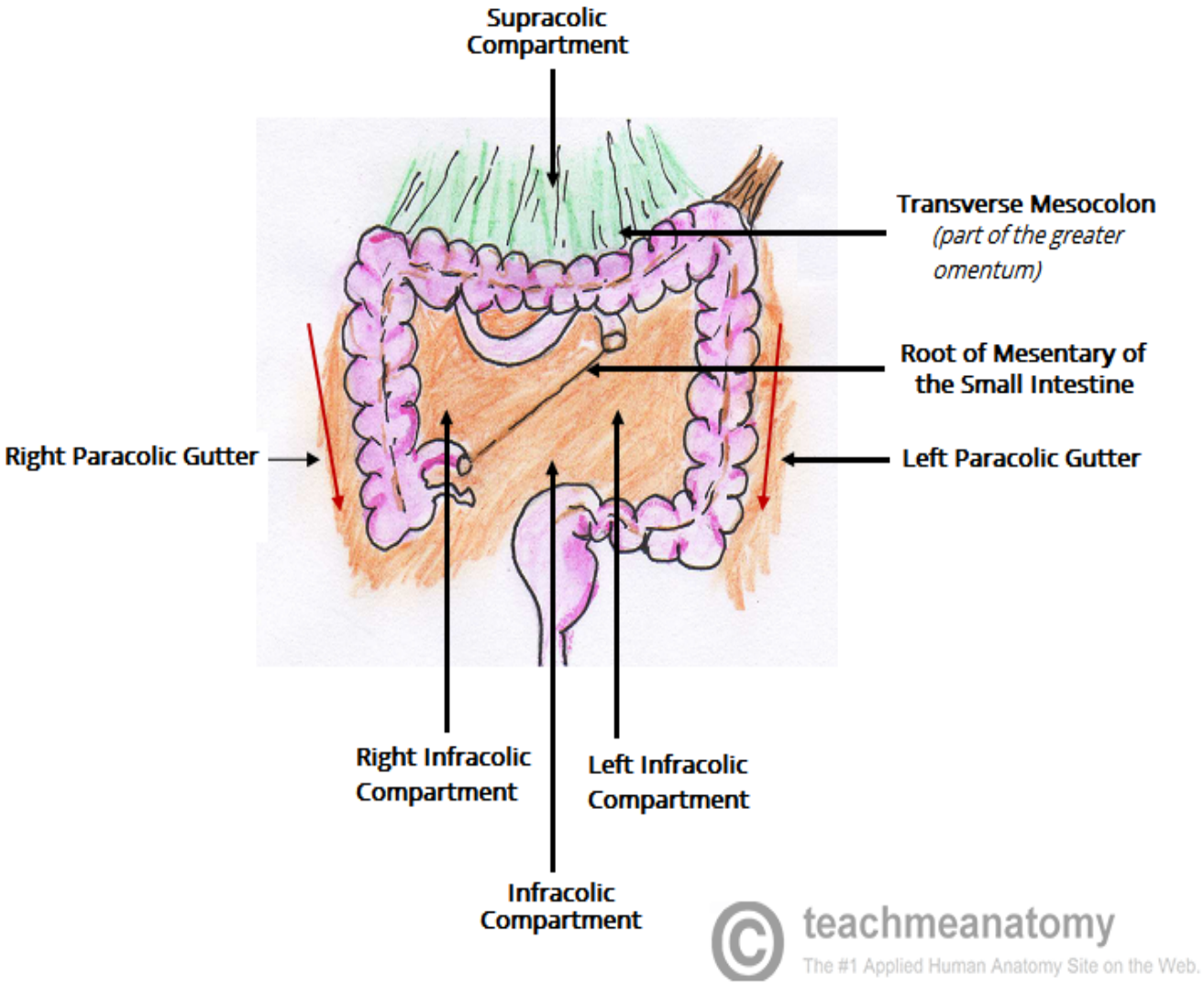

Fig 1.1 – The greater sac

Clinical Relevance: Subphrenic Abscesses

The subphrenic spaces are recesses in the **greater sac** of the peritoneal cavity between the anteriosuperior diaphragmatic surface of the liver and the diaphragm. They are separated into **right** and **left** subphrenic spaces by the **falciform ligament** of the liver.

Subphrenic abscesses generally occur as a result of the accumulation of **pus** in the **left or right subphrenic space** as a consequence of **peritonitis.** They are more common on the **right** side due to the increased frequency of appendicitis and ruptured duodenal ulcers.

Lesser Sac (Omental Bursa)

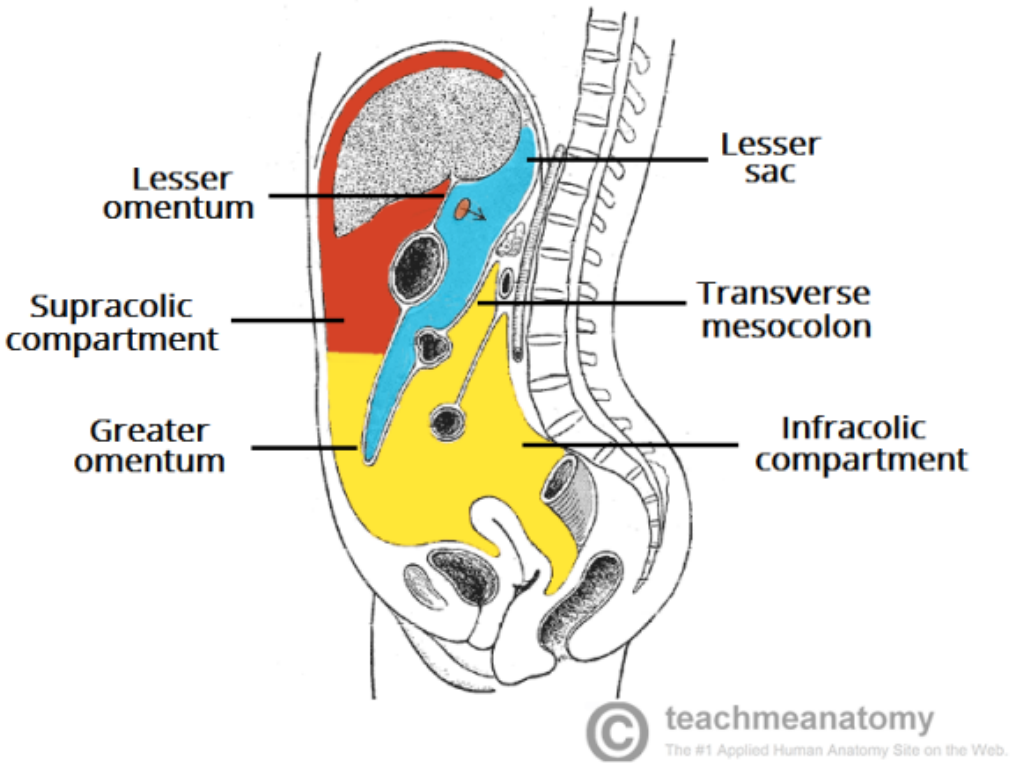

Fig 1.2 – The subdivisions of the peritoneal cavity

The omental bursa lies posterior to the stomach and lesser omentum. It allows the stomach to move freely against the structures posterior and inferior to it.

The omental bursa is connected with the greater sac through an opening in in the omental bursa, the **epiploic foramen.**

The epiploic foramen is situated posterior to the free edge of the lesser omentum (the hepatoduodenal ligament).

2- Structure of the Peritoneal Cavity in the Pelvis

Due to the different **pelvic organs**, the peritoneal cavity differs in structure between the sexes. This is the most **distal** portion of the cavity, and so any infected fluid is likely to collect here. Thus, it is clinically important to be aware of the differences between males and females.

Male

In the male, the **rectovesical pouch** is a double folding of peritoneum between the rectum and the bladder. The peritoneal cavity is completely closed in males.

Females

In females, the **rectouterine pouch (pouch of Douglas)** is a double folded extension of the peritoneum between the **rectum** and the posterior wall of the **uterus**. The **vesicouterine pouch** is a double fold of peritoneum between the anterior surface of the uterus and the bladder.

The peritoneal cavity is **not completely closed** in females. The abdominal ostia of the **uterine tubes** opens into the peritoneal cavity providing a potential pathway between the female genital tract and the peritoneum.

Clinically, this means that infections of the vagina, uterus and uterine tubes may result in infection and inflammation of the peritoneum (peritonitis). This is, however, rare due to the presence of a **mucous plug** in the external os (opening) of the uterus which prevents the passage of pathogens but allows sperm to enter the uterus.

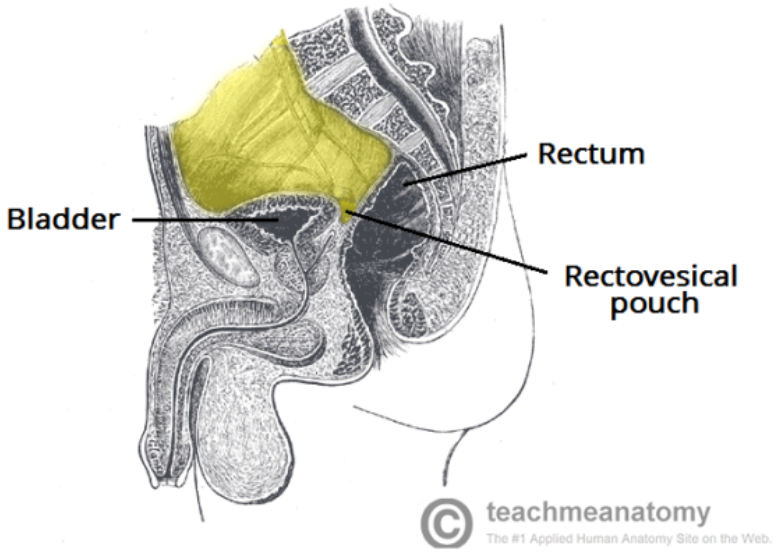

Fig 1.3 – The rectovesical pouch

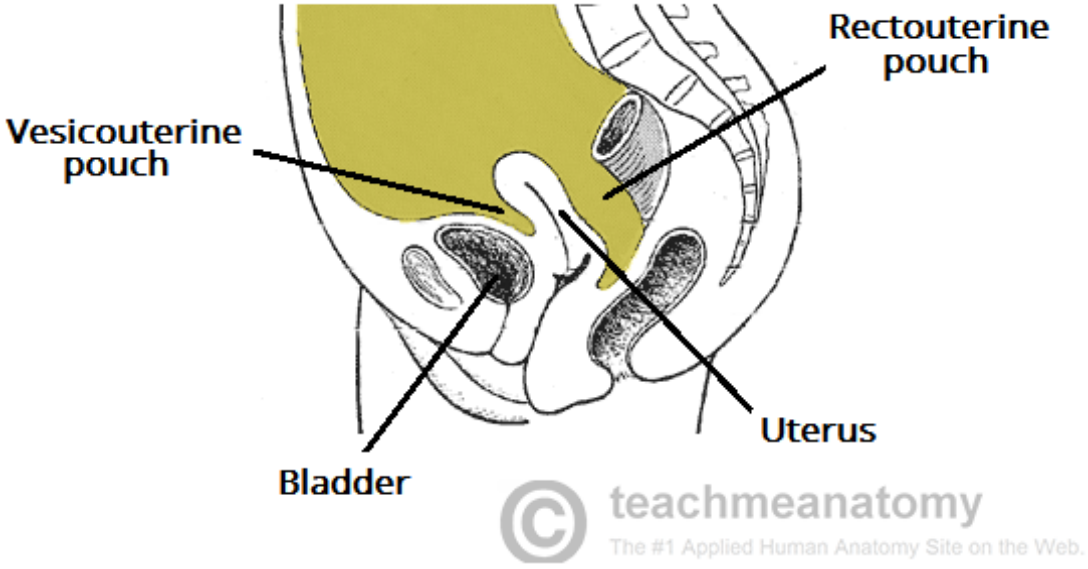

Fig 1.4 – The vesicouterine and rectouterine pouches

3- Clinical Relevance: Sampling of Peritoneal Fluid

Culdocentesis

Culdocentesis involves the extraction of fluid from the **rectouterine pouch** (pouch of Douglas) through a needle inserted through the **posterior fornix of the vagina.** It can be used to extract fluid from the peritoneal cavity or to drain a **pelvic abscess** in the rectouterine pouch.

Paracentesis

Paracentesis is a procedure used to drain fluid from the peritoneal cavity. A needle is inserted through the **anterolateral** abdominal wall into the peritoneal cavity. The needle must be inserted superior to the urinary bladder and the clinician must take care to avoid the **inferior epigastric artery**.

It is used to drain ascitic fluid, diagnose the cause of ascites and to check for certain types of cancer which may metastasise via the peritoneum, e.g. liver cancer.

4- Clinical Relevance: Disorders of the Peritoneal Cavity

Ascites

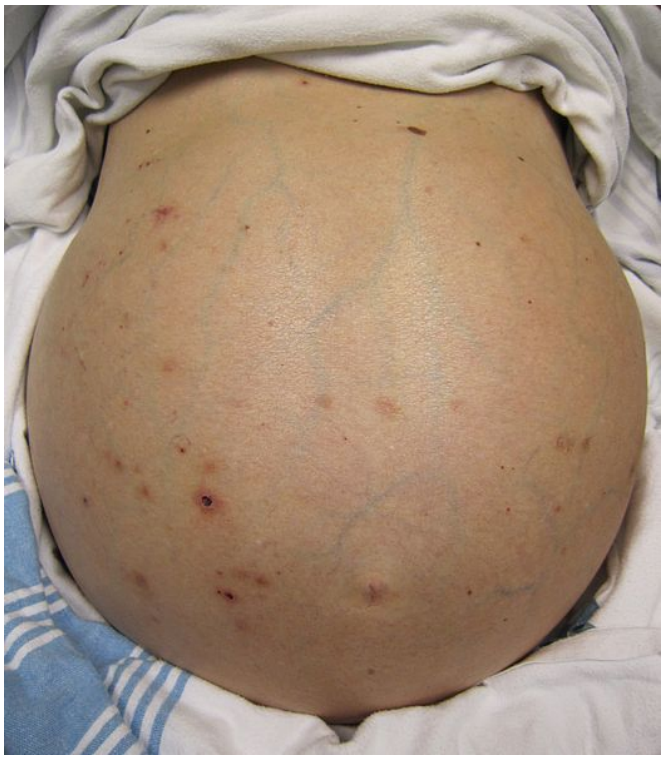

Fig 1.5 – Ascites.

Ascites refers to an accumulation of **excess fluid in the peritoneal cavity**. It can occur in conjunction with infection and peritonitis, however it is more commonly caused by **portal hypertension** secondary to cirrhosis of the liver.

Other causes include; malignancies of the GI tract, malnutrition, heart failure, and mechanical injuries which result in internal bleeding. Patients present with a distended abdomen, discomfort, nausea, and dyspnoea.

The **paracolic gutters** provide a route for the flow ascitic fluid, and for the spread of intraperitoneal infections and cancer metastases. Patients with peritonitis are often positioned in a sitting position (at least a 45° angle) to encourage the flow of ascitic fluid into the pelvis where toxins are absorbed more slowly.

Peritonitis

Peritonitis refers to infection and inflammation of the peritoneum. It can occur as a result of **bacterial contamination** during a **laparotomy** (open surgical incision of the peritoneum) or it can occur secondary to an **infection** elsewhere in the GI tract, for example a burst appendix, acute pancreatitis or a gastric ulcer eroding through the wall of the stomach. Exudation of fluid into the peritoneal cavity occurs.

The patient experiences pain and tenderness of the overlying skin and the anterolateral abdominal muscles contract to protect the viscera (known as **guarding**). Other symptoms include; fever, nausea, vomiting, and constipation. Patients may lie with their knees flexed in an effort to relax the anterolateral abdominal wall muscles. Generalised peritonitis (when peritonitis is widespread in the abdominal cavity) can result in **sepsis** and thus must be treated as an emergency or it can be fatal.

The Peritoneum

Contents

The peritoneum is a continuous transparent membrane which lines the abdominal cavity and covers the abdominal organs (or viscera).

It acts to support the viscera, and provides a pathway for blood vessels and lymph. In this article, we shall look at the structure of the peritoneum, the organs that are covered by it, and its clinical correlations.

1- Structure of the Peritoneum

The peritoneum consists of two layers which are **continuous** with each other; the **parietal peritoneum** and the **visceral peritoneum**. They both consist of a layer of simple squamous epithelial cells, called **mesothelium**.

Parietal Peritoneum

The parietal peritoneum lines the internal surface of the abdominopelvic wall.

It is derived from **somatic mesoderm** in the embryo.

It receives the same somatic nerve supply as the region of the abdominal wall that it lines, therefore pain from the parietal peritoneum is **well localised** and it is sensitive to pressure, pain, laceration and temperature.

Visceral Peritoneum

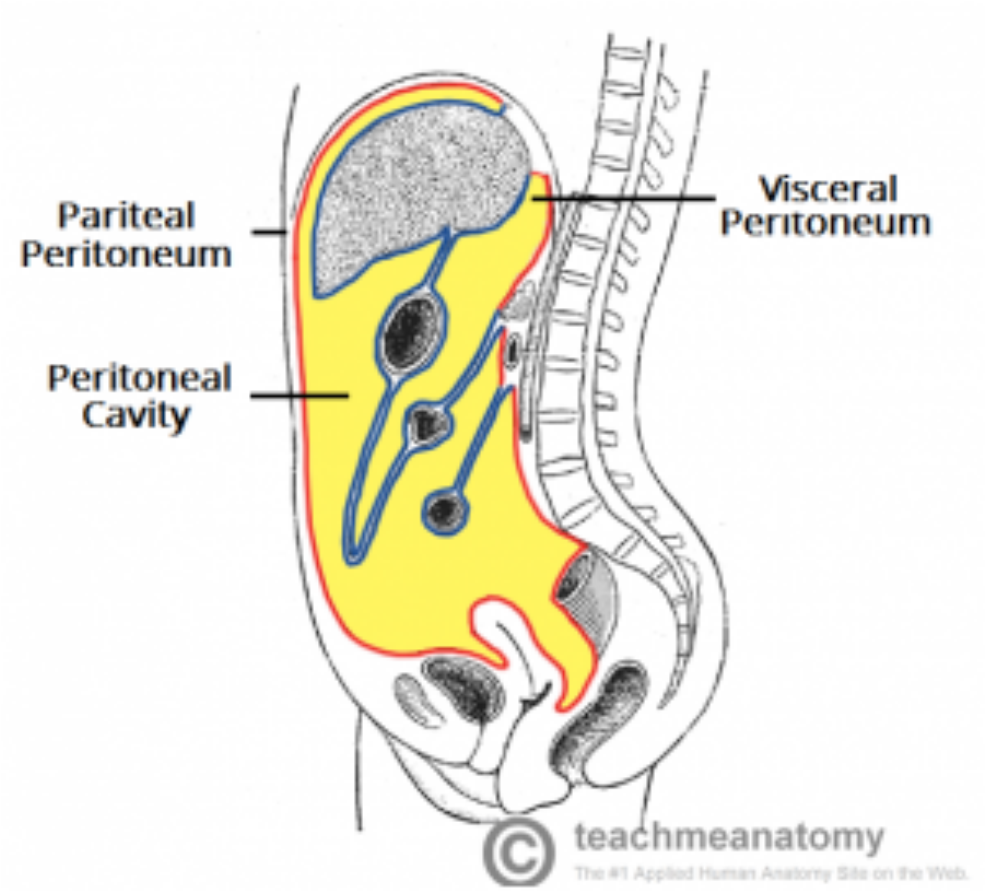

Fig 1.0 – The structure of the peritoneum and the peritoneal cavity. Note how the visceral layer invaginates to cover the organs.

The visceral peritoneum invaginates to cover the majority of the abdominal viscera.

It is derived from **splanchnic mesoderm** in the embryo.

The visceral peritoneum has the same nerve supply as the viscera it invests. Unlike the parietal peritoneum, pain from the visceral peritoneum is **poorly localised** and is only sensitive to stretch and chemical irritation.

Pain from the visceral peritoneum is referred to areas of skin (dermatomes) which are supplied by the same sensory ganglia and spinal cord segments as the nerve fibres innervating the viscera.

Peritoneal Cavity

The peritoneal cavity is a **potential space** between the parietal and visceral peritoneum. It contains a small amount of lubricating fluid.

2- Intraperitoneal & Retroperitoneal Organs

The abdominal viscera can be divided anatomically by their relationship with the peritoneum. There are two main groups, **intraperitoneal** and **retroperitoneal** organs.

Intraperitoneal Organs

Intraperitoneal organs are completely covered in visceral peritoneum, anteriorly and posteriorly. Examples include the stomach, liver and spleen.

Retroperitoneal Organs

These organs are only covered in peritoneum on their anterior surface. They can be subdivided into two groups:

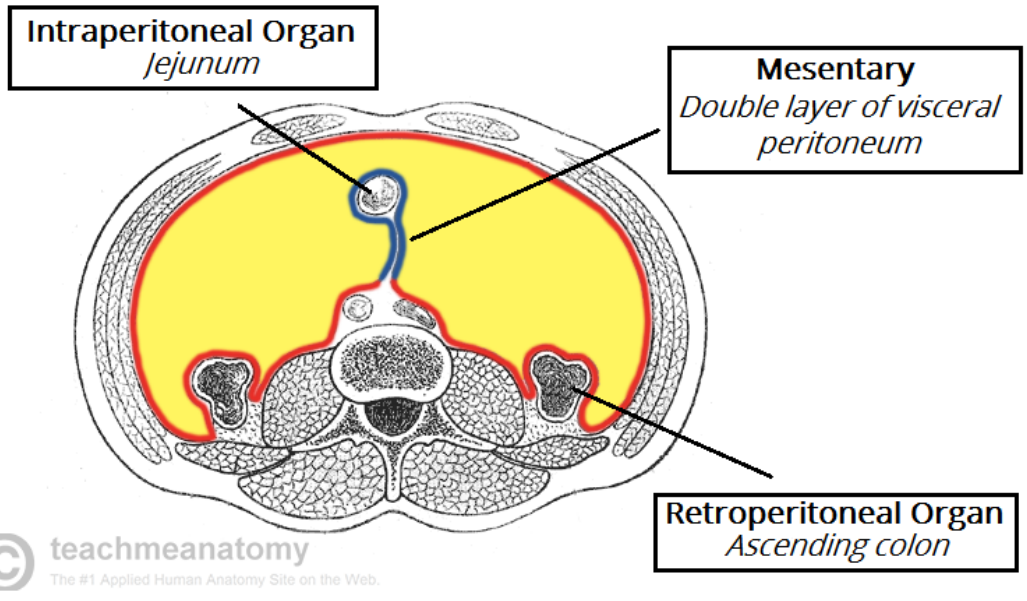

Fig 1.1 – Intraperitoneal and retroperitoneal organs

Primarily retroperitoneal organs develop and remain outside of the parietal peritoneum. The oesophagus, rectum and kidneys are all primarily retroperitoneal

- **Secondarily retroperitoneal** organs were initially intraperitoneal, suspended by mesentary. Through the course of embryogenesis they became retroperitoneal, with their mesentery fusing with the posterior abdominal wall. Thus, peritoneum only covers the anterior surface. Examples of secondarily retroperitoneal organs include is the ascending and descending colon.

A useful mnemonic to help in recalling which abdominal viscera are retroperitoneal is:-

SAD PUCKER

- **S** = Suprarenal (adrenal) Glands
- **A** = Aorta/IVC
- **D** =Duodenum (except the duodenal cap- first 2cm)
- **P** = Pancreas (except the tail)
- **U** = Ureters
- **C** = Colon (ascending and descending parts)
- **K** = Kidneys
- **E** = (O)esophagus
- **R** = Rectum

3- Peritoneal Reflections

The peritoneum covers a multitude of viscera within the gut and conveys neurovascular structures from the body wall to the viscera. In order to adequately fulfil its functions, the peritoneum develops into a highly folded, complex structure and a number of terms are used to describe the folds and spaces that are part of the peritoneum.

Mesentery

A mesentery is double layer of visceral peritoneum. It connects an intraperitoneal organ to the (usually) posterior abdominal wall. It provides a pathway for nerves, blood vessels and lymphatics from the body wall to the viscera.

The mesentery of the **small intestine** is simply called **'the mesentery'**. Mesentery related to other parts of the gastrointestinal system is named according to the viscera it connects to, for example the transverse and sigmoid mesocolons, the mesoappendix.

Omentum

The omentum is a double layer of peritoneum that extends from the **stomach and proximal part of the duodenum** to other abdominal organs.

Greater Omentum

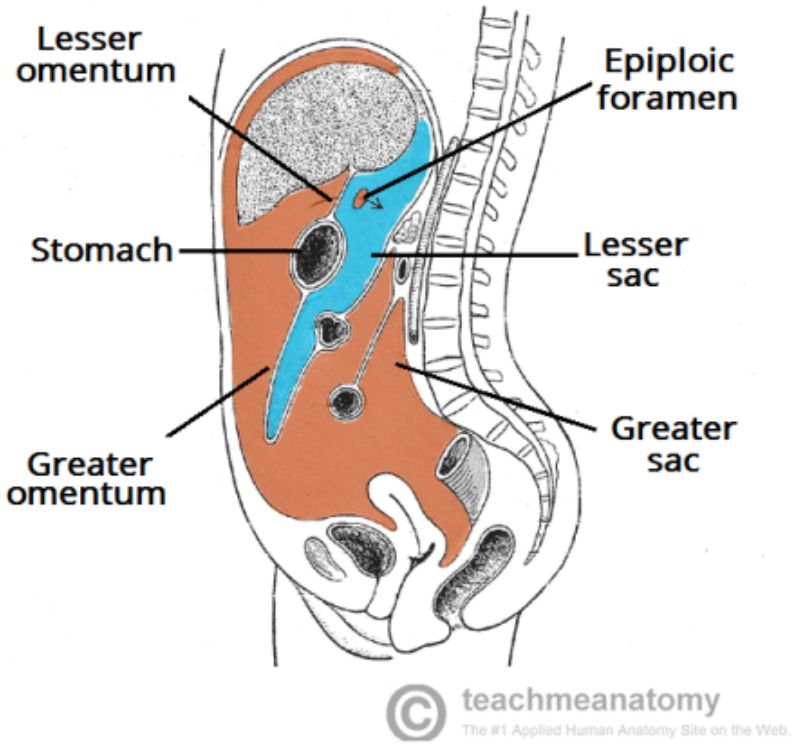

Fig 1.2 – The greater and lesser omenta.

The greater omentum consists of four layers of peritoneum. It descends from the **greater curvature of the stomach and proximal part of the duodenum**, then folds back up and attaches to the **anterior surface of the transverse colon**.

It has a role in immunity and is sometimes referred to as the 'abdominal policeman' because it can migrate to infected viscera.

Lesser Omentum

The lesser omentum is considerably smaller and attaches from the **lesser curvature of the stomach and the proximal part of the duodenum** to the **liver**. It consists of two parts: the **hepatogastric ligament** and the **hepatoduodenal ligament.**

Peritoneal Ligaments

A peritoneal ligament is a double fold of peritoneum that connects viscera together or connects viscera to the abdominal wall, for example the hepatogastric ligament which connects the liver to the stomach.

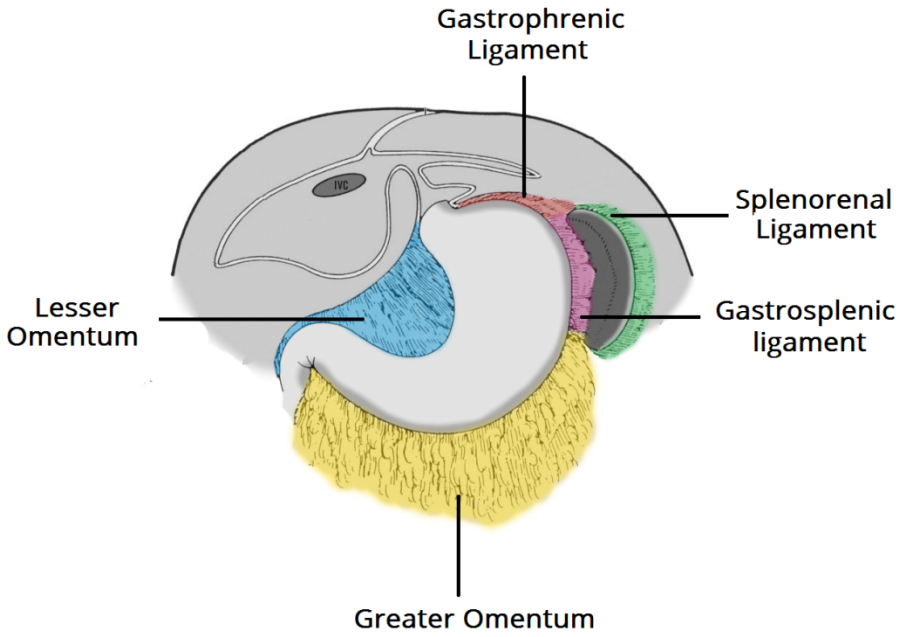

Fig 1.3 – Omenta and peritoneal ligaments.

4- Clinical Applications

Referred Pain

Pain from the **viscera** is **poorly localised**. As described earlier, it is referred to areas of skin (dermatomes) which are supplied by the same sensory ganglia and spinal cord segments as the nerve fibres innervating the viscera.

Pain is referred according to the **embryological origin** of the organ; thus pain from **foregut** structures are referred to the **epigastric** region, **midgut** structures are to the **umbilical** region and **hindgut** structures to the **pubic** region of the abdomen.

- The **foregut** includes the **oesophagus, stomach, pancreas, liver, gallbladder and the duodenum** (proximal to the entrance of the common bile duct).
- The **midgut** extends from the **duodenum** (distal to the entrance of the common bile duct) to the junction of the **proximal two thirds of the transverse colon** with the distal third.
- The **hindgut** extends from the **distal one third of the transverse colon** to the upper part of the **anal canal**.

Pain in **retroperitoneal** organs (e.g. kidney, pancreas) may present as **back pain.**

Irritation of the **diaphragm** (e.g. as a result of inflammation of the liver, gallbladder or duodenum) may result in **shoulder tip pain**.

Referred Pain in Appendicitis

Initially pain from the appendix (midgut structure) and visceral peritoneum is referred to the **umbilical region**. As the appendix becomes inflamed and irritates the parietal peritoneum the pain becomes localised to the **right lower quadrant**.

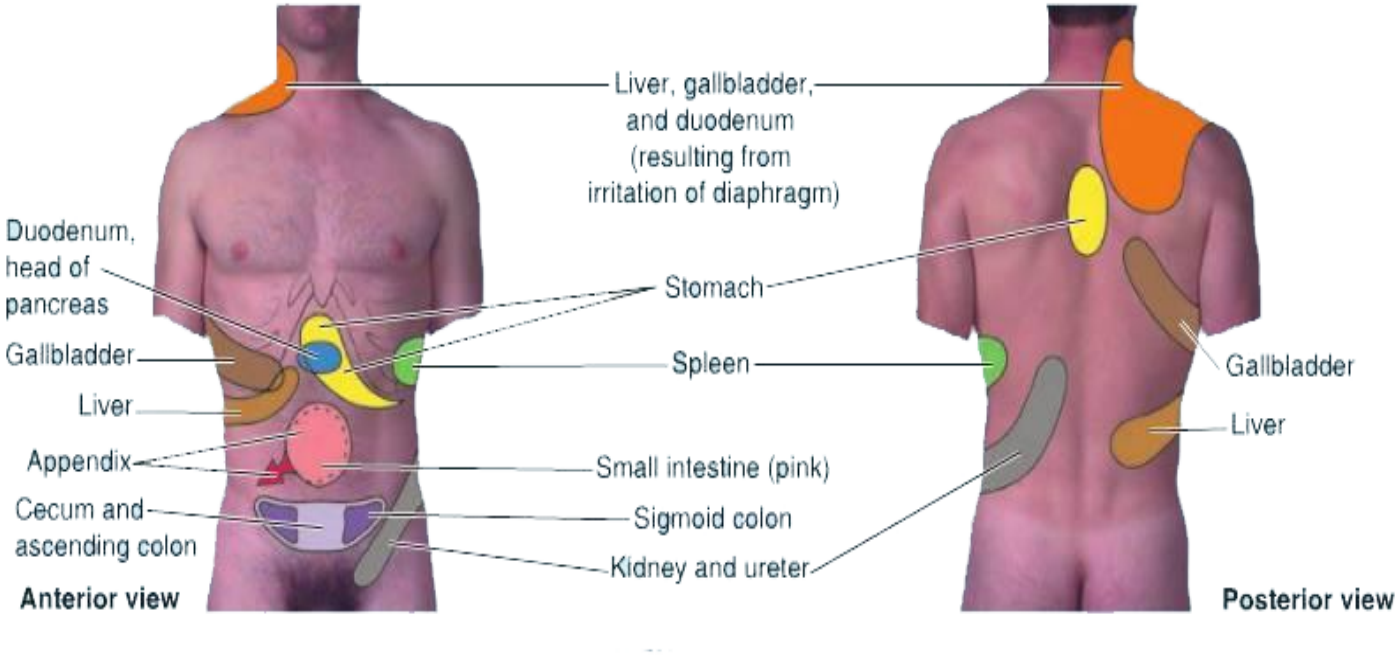

Fig 1.4 – Diagram of abdominal referred pain.

Peritoneal Adhesions

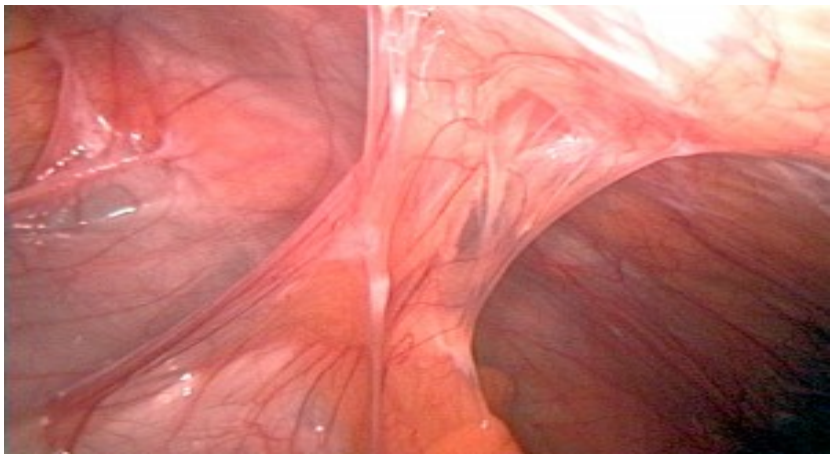

Fig 1.5 – Peritoneal adhesions

Damage to the peritoneum can occur as a result of infection, surgery or injury.

The resulting inflammation and repair may cause the formation of **fibrous scar tissue**. This can result in **abnormal attachments** between the visceral peritoneum of adjacent organs or between visceral and parietal peritoneum.

Such adhesions can result in pain and complications such as **volvulus**, when the intestine becomes twisted around an adhesion resulting in a bowel obstruction.

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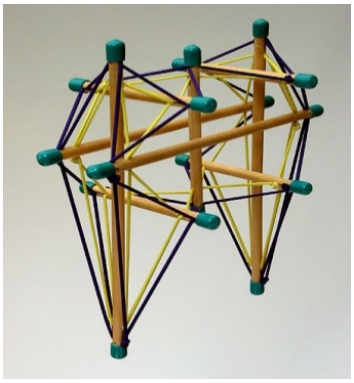


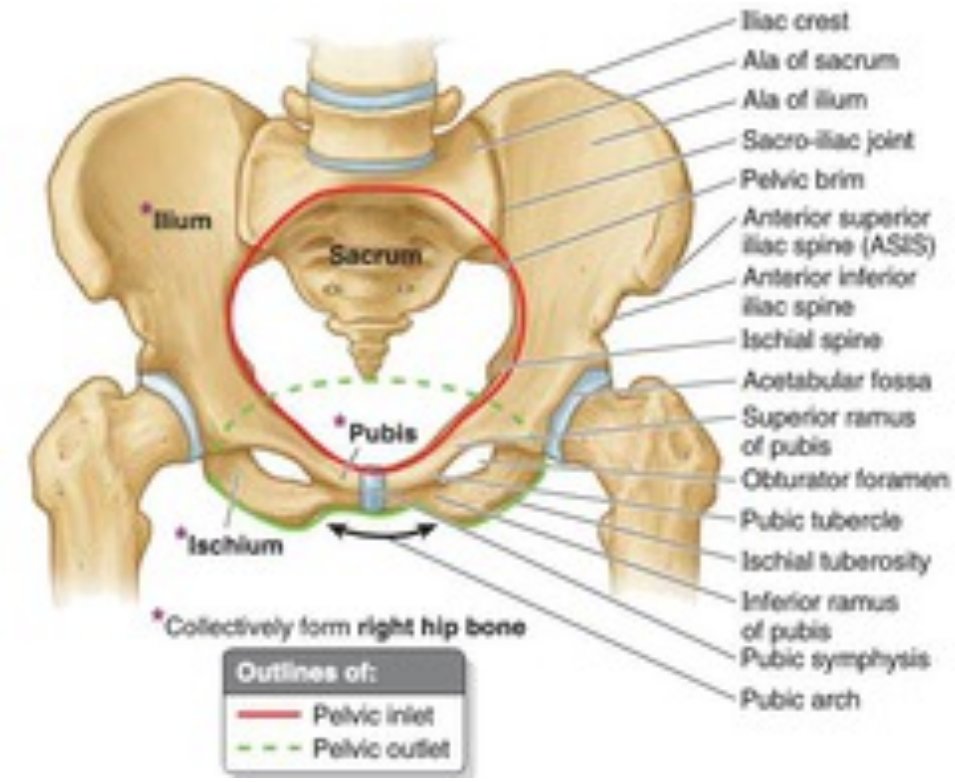
Pelvilogy Program

PELVIS 1 QUIZ

By Guy VOYER DO

SEMINAR 1

PELVIC QUIZ



What is the pelvic brim? Which bones of the pelvis contribute to it?

The superior boundary of the true pelvis.

The ilium, sacrum, and pubis all contribute to the pelvic brim.

In the attached image, it is outlined in red.

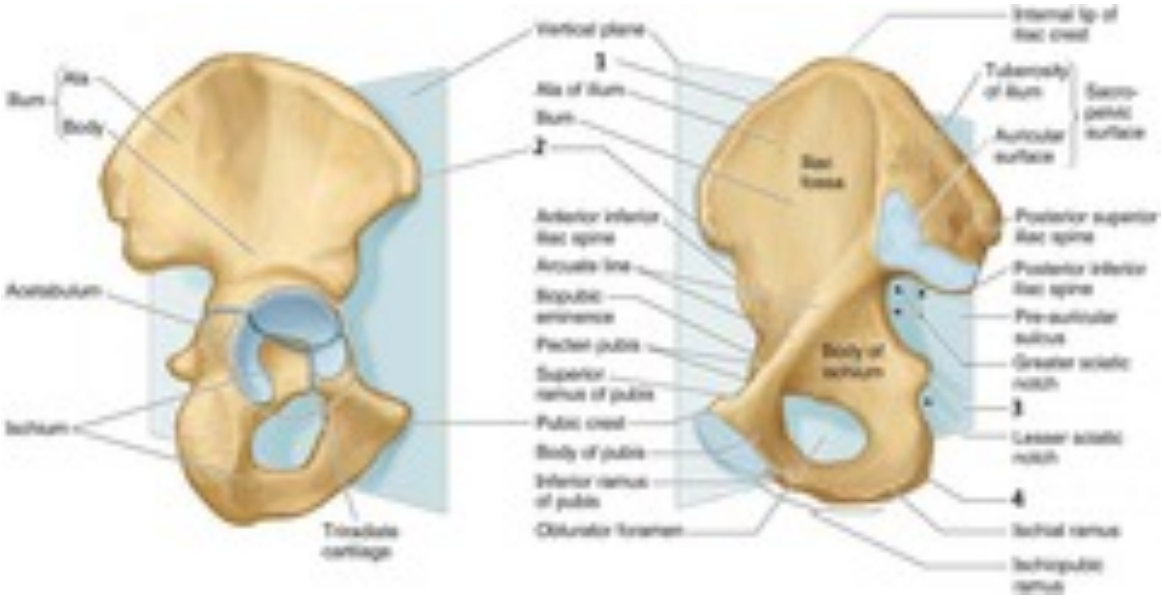
Label the following image.

1. Iliac Crest

2. Anterior Superior Iliac Spine

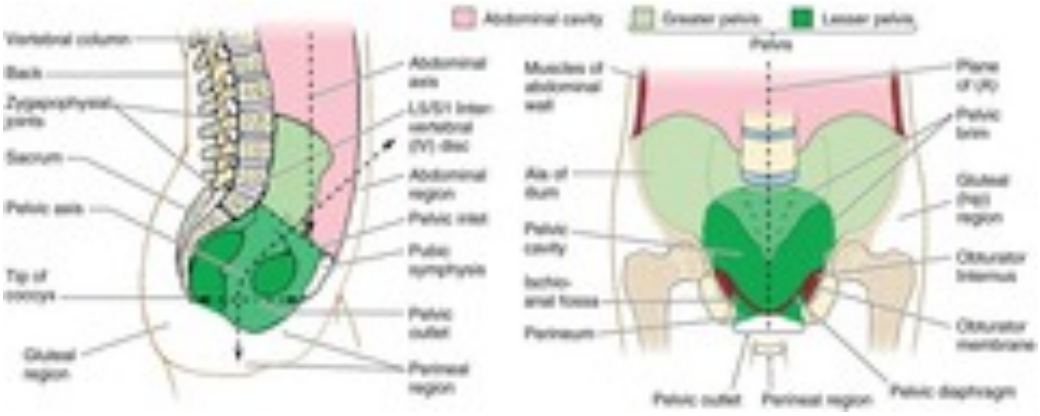
3. Ischial Spine

4. Ischial Tuberosity



What four landmarks define the true pelvic cavity?

The pelvic brim (or pelvic inlet)



1. The muscular pelvic diaphragm
2. The lower half of the Ilium, Ischium, and Pubis
3. The sacrum and coccyx

What forms the superior border of the true pelvic cavity?

The pelvic brim or pelvic inlet.

What forms the inferior border of the true pelvic cavity?

The muscular pelvic diaphragm.

What forms the anterior border of the true pelvic cavity?

The lower half of the Ilium, Ischium, and Pubis.

What forms the posterior border of the true pelvic cavity?

The sacrum and coccyx.

What is the false pelvis? What occupies the space contained within the false pelvis?

The false pelvis is the area superior to the true pelvis. It is defined laterally and superiorly by the wings of the Ilium.

Abdominal viscera occupies the space of the false pelvis.

In the attached image, the false pelvis is the area shaded in light green.

What pelvic bone predominantly bears the weight of the abdomen?

The pubic bone.

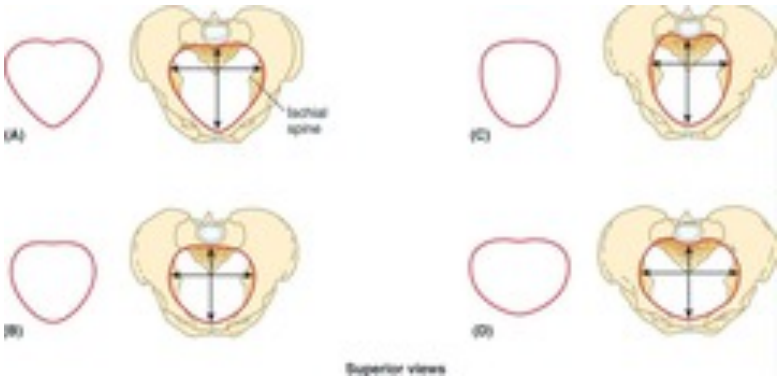
What is a good "rule of thumb" that generally allows you to distinguish between a male and female pelvis?

Male – the "V" shape made between your index and middle fingers should, when placed over the pubic symphysis, approximate the pubic width of the male pelvis. See attached image.

Female – the "V" shape made between your thumb and index finger should, when placed over the pubic symphysis, approximate the pubic width of the female pelvis. See attached image.

What forms the lateral border of the true pelvic cavity?

The lower half of the Ilium, Ischium, and Pubis.



Label the following pelvic variations.

Possible answers are: Android, Anthropoid, Gynecoid, and Platypelloid.

Which are most common in males? Which are most common in females?

A. Android

B. Gynecoid

C. Anthropoid

D. Platypelloid

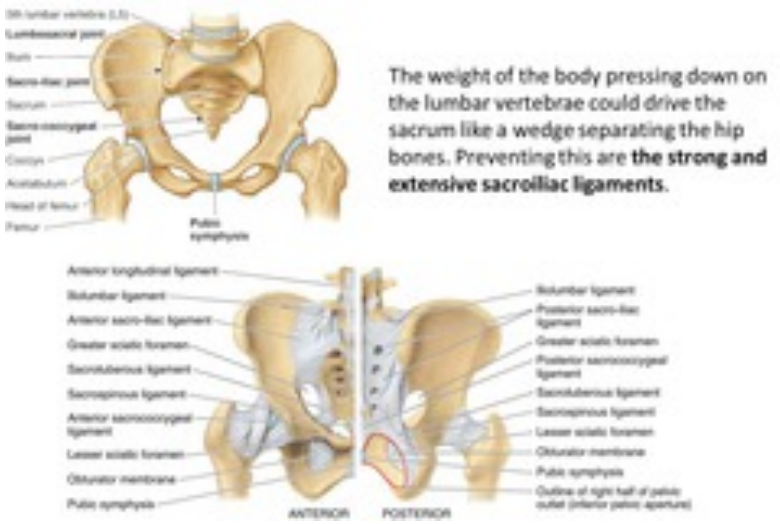
A and C are most common in males. A and B are most common in white females and B and D are most common in black females. Overall, B is the most common type in females.

Of the following pelvic variations, which is best for child bearing?

Android, Anthropoid, Gynecoid, and Platypelloid.

Gynecoid.

Dr. Kramer explained that although Platypelloid looks like the best option (the most wide), in discussions with gynecologists, they agree that babies' heads engage the gynecoid pelvis better than the Platypelloid pelvis.



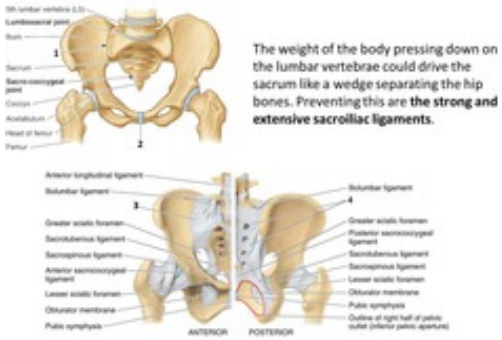
What ligaments stabilize the sacro-iliac joint?

The anterior and posterior sacro-iliac ligaments.

True or false: Just like the joints between the Ilium, Ischium, and Pubis, the joint between the Ilium and the Sacrum is fused.

False.

The sacro-iliac joint is NOT a fusion. For this reason, there are very strong ligaments that hold this joint together, preventing the weight of the body from driving the sacrum (like a wedge) between the bones of the hip.



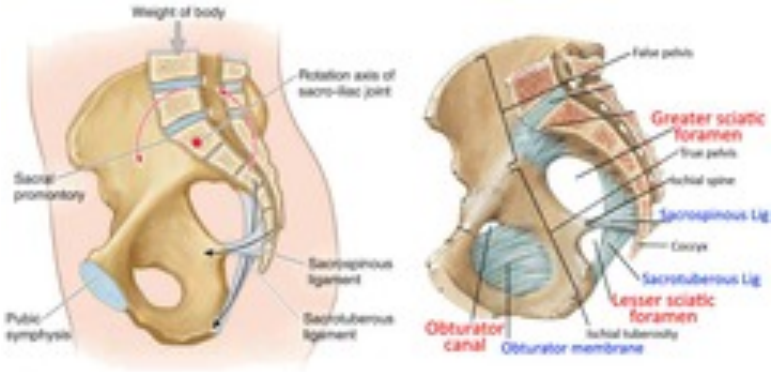
Label the following image.

1. Sacro-iliac joint

2. Pubic Symphysis

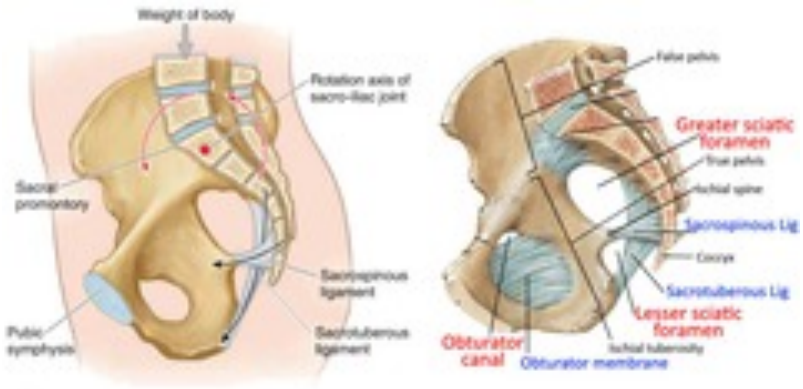
3. Anterior Sacro-iliac Ligament

4. Posterior Sacro-iliac Ligament



The weight of the body on the pelvis should cause it to rotate. What two ligaments prevent the pelvis from rotating?

The sacrospinous and sacrotuberous ligaments.



Unlike many anatomical structures, the pelvis lies at an angle (with the true pelvis facing anteriorly). In a standing person, describe the direction of the sacrotuberous and sacrospinous ligaments relative to the ground.

Sacrotuberous - the sacrotuberous ligament runs roughly perpendicular to the ground in a person who is standing. In other words, it runs roughly parallel to the plane of the standing person's body.

Sacrospinous - the sacrospinous ligament runs roughly parallel to the ground in a person who is standing.

Basically, the sacrotuberous and sacrospinous ligaments are roughly perpendicular to each other, with the sacrospinous ligament running roughly parallel to the ground.

The greater pelvis is defined as the area bounded:

A. superiorly by the pelvic brim

B. inferiorly by the pelvic diaphragm

C. anteriorly by the hip bones

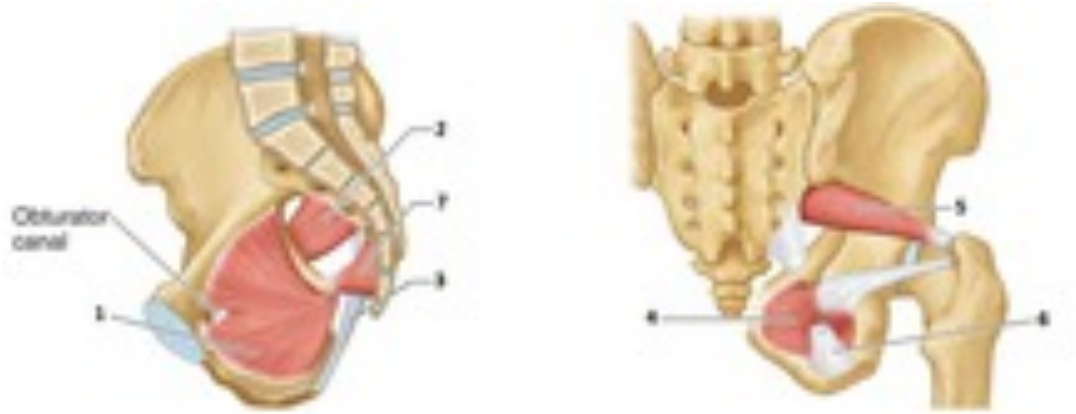
D. posteriorly by the coccyx

E. laterally by the illium

E.

The greater pelvis is synonymous with the false pelvis. It is bound by the ala or wing of the ilium. The ilium runs posteriorly and laterally of the false pelvis area, making E the correct answer.

Most of the answers refer to the boundaries of the true pelvis.



Label the following image.

1.Obturator Internus

2. Piriformis

3. Sacrotuberous Ligament

4. Obturator Internus

5. Piriformis

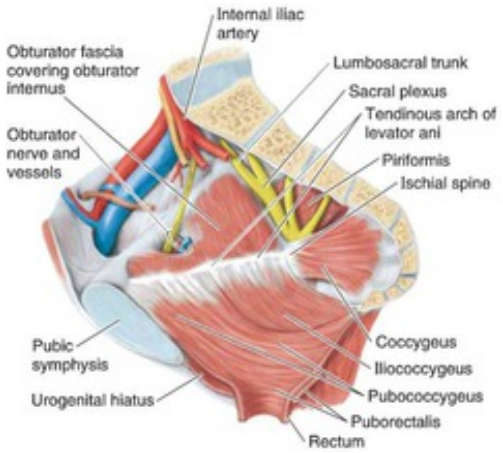
6. Sacrotuberous Ligament (cut)

7. Coccygeus

True or false: Because humans quit moving their "tails" (most likely) millions of years ago, the coccygeus will probably not have much of a muscle belly.

True.

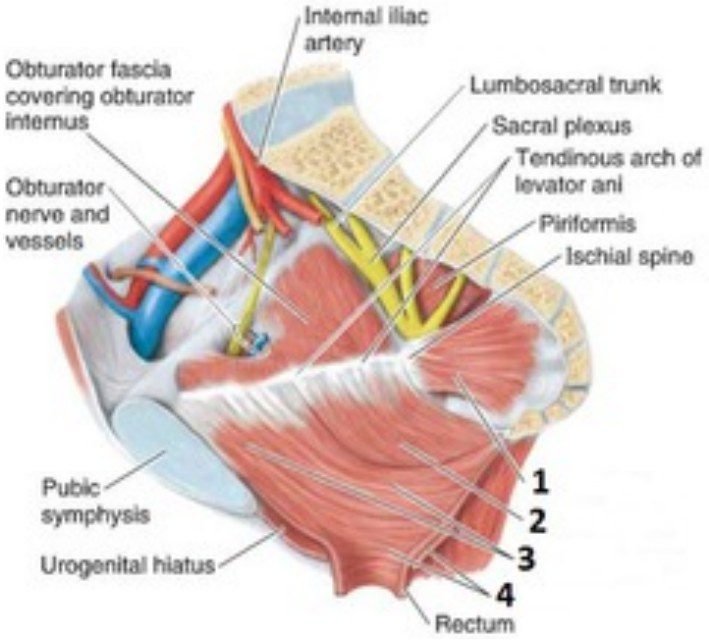
The coccygeus will probably just look like faschia - - it is unlikely to have much of a muscle belly



. What collection of muscles (three muscles that are collectively called by one name) cover the obturator internus?

The levator ani.

The levator ani is composed of the following three muscles: Iliococcygeus, Puborectalis, and Pubococcygeus.



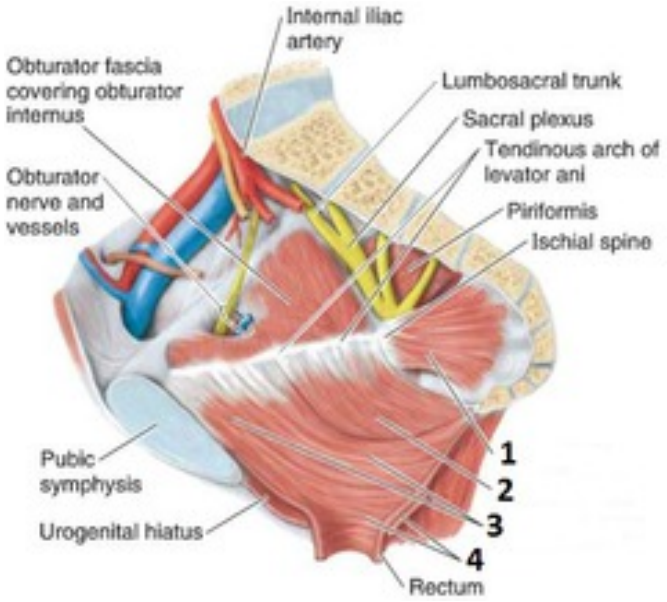
Label the following muscles of the pelvic diaphragm.

1. Coccygeus

2. Iliococcygeus

3. Pubococcygeus

4. Puborectalis



The tendonous arch of the levator ani is the thickening of obturator faschia that stretches between two important landmarks. What are these landmarks?

1. The Pubic Symphysis.

2. The Ischial Spine.

What four muscles comprise the inferior border of the lesser pelvis? Collectively, what are they called?

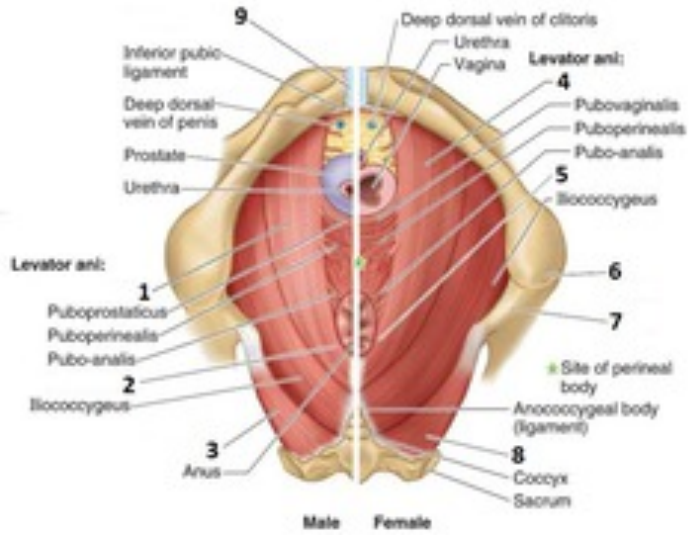
1. The coccygeus

2. The pubococcygeus

3. The iliococcygeus

4. The puborectalis

Collectively, these are called the pelvic diaphragm – – they form the inferior border of the lesser pelvis.



Label the following image. What is the specific name for this anatomical "view?"

1. Pubococcygeus
2. .Puborectalis
3. Coccygeus
4. Pubococcygeus
5. Puborectalis
6. Ischial Tuberosity
7. Ischial Spine
8. Coccygeus
9. Pubic Symphysis

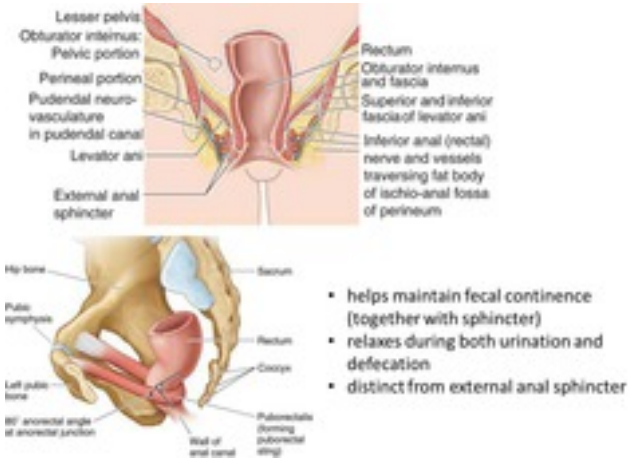
Dr. Kramer specifically said not to worry about the series of very specific muscles named between 1 and 2, 4 and 5.

This position is called the lithotomy (I think that's what he called it) position.

True or false: the coccygeus is one of the levator ani muscles.

False.

The coccygeus is not one of the levator ani muscles; however, the coccygeus, combined with the three levator ani muscles, are collectively called the pelvic diaphragm.

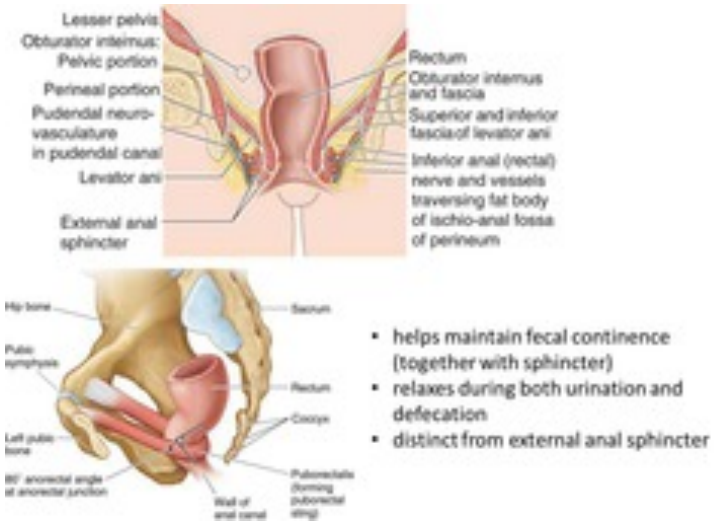


What important function is executed by the levator ani muscles, particularly the puborectalis?

It helps to maintain the anorectal angle. This is the angle that the rectum forms with the anus.

If the angle is affected, a person can become fecally incontinent.

All of the levator ani muscles participate in maintaining the anorectal angle; however the puborectalis is most important.

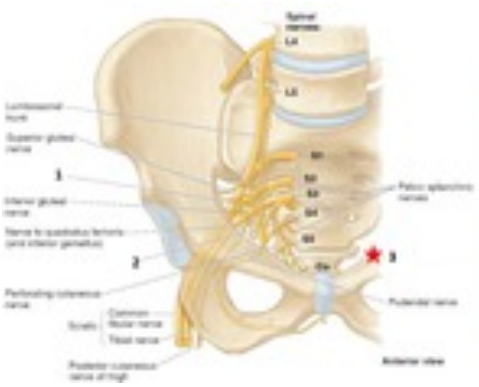


Describe the importance of the anorectal angle.

The anorectal angle prevents the anus and rectum from lining up as one contiguous tube. This "kink" in the rectum/anus is called the anorectal angle.

The anorectal angle is important in maintaining fecal continence. The levator ani, particularly the puborectalis, relax during defecation and urination, allowing feces to pass through the rectum and anus.

See the attached images and text for more information.



Boundary	Muscle	Innervation
Lateral wall	Obturator internus	Nerve to obturator internus (L5, S1, S2)
Posterior superior wall	Piriformis	Anterior rami of S1 and S2
Floor	Coccygeus (ischiococcygeus)	Branches of S4 and S5 spinal nerves
	Levator ani (pubococcygeus, puborectalis, iliococcygeus, and ischiococcygeus)	Nerve to levator ani (branches of S4), inferior anal (rectal) nerve, and coccygeal plexus

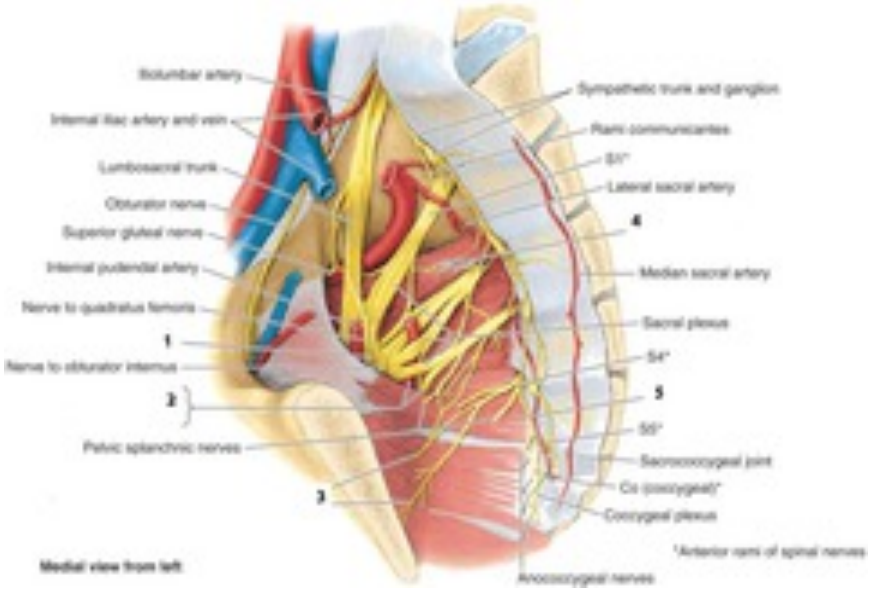
Label the following image. Also, consider that attached table.

1. Nerve to the Piriformis

2. Nerve to the Obturator Internus

3. Nerve to Levator Ani

These are all so close to the spinal nerves that they take direct branches from the spinal nerves.



Label the following image.

1. Sciatic Nerve

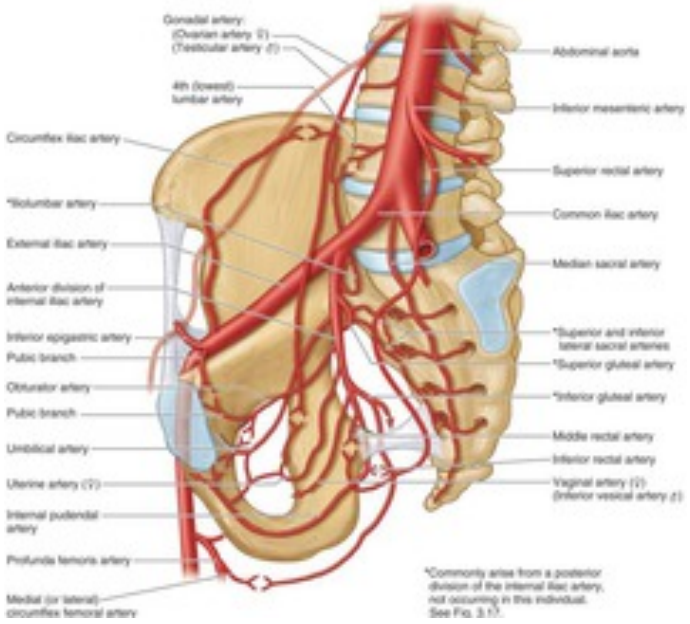
2. Pudendal Nerve and Inferior Gluteal Artery

3. Nerve to Levator Ani and Coccygeus

4. Nerves to Piriformis

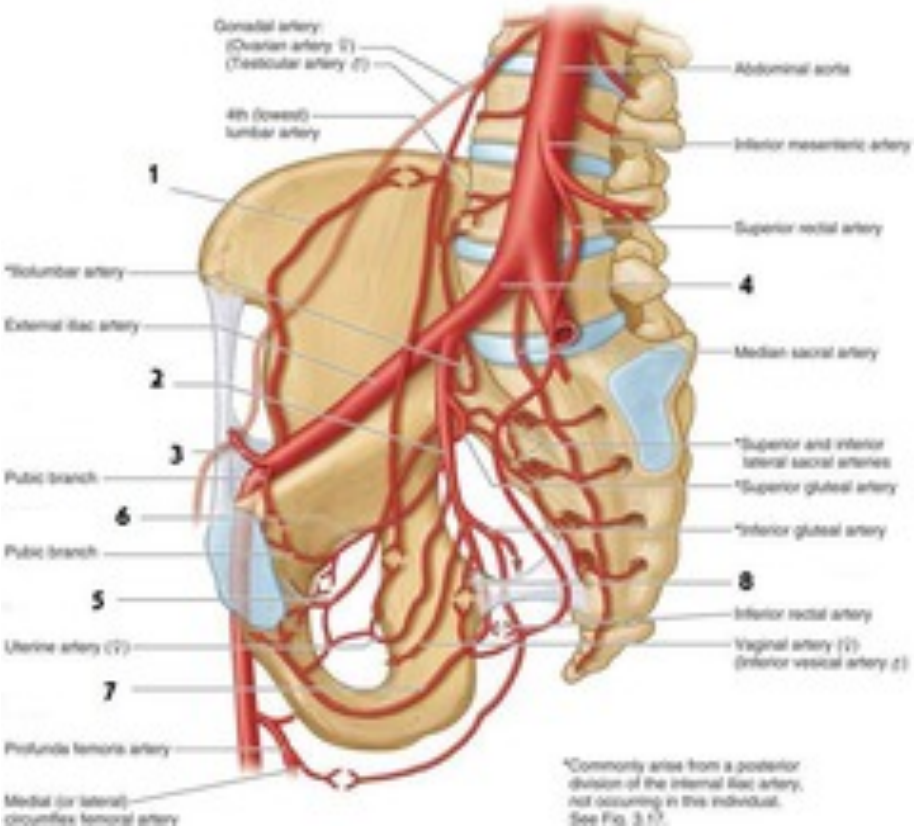
5. Coccygeus

6. Nerve to Obturator Internus



What important blood vessel division occurs at/near the level of the sacro-iliac joint?

The division of the common iliac artery into internal and external branches (the internal and external iliac arteries).



Label the following image.

1. Circumflex Iliac Artery
2. Internal Iliac Artery
3. Inferior Epigastric Artery
4. Common Iliac Artery
5. Umbilical Artery
6. Obturator Artery
7. Internal Pudendal Artery
8. Middle Rectal Artery

What artery travels from the true pelvis into the false pelvis (Dr. Kramer described it as the "only one" that does this)?

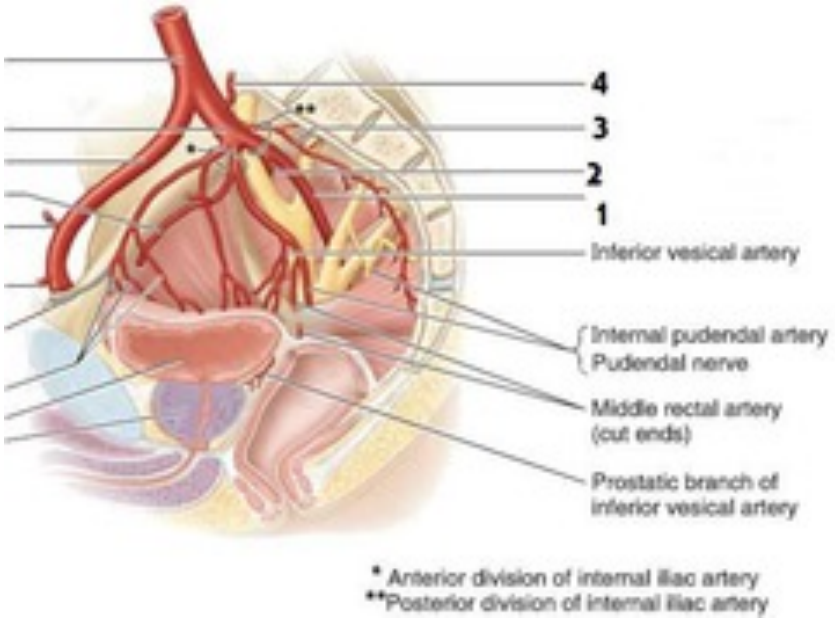
The Iliolumbar Artery.

True or false: the umbilical artery is completely obliterated in adults. It no longer exists as a blood vessel.

False.

While much of the umbilical artery obliterated, there is still a blood vessel there.

The umbilical artery gives rise to the superior vesicular artery, which supplies the bladder.



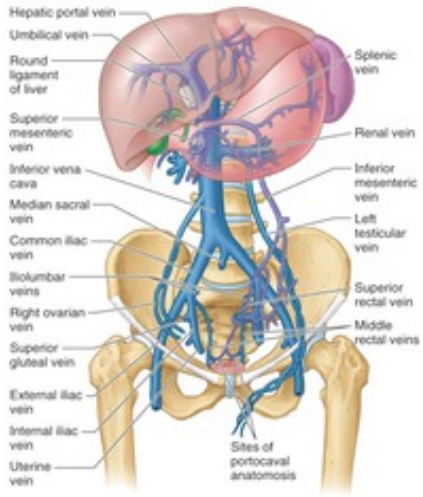
Label the following image.

1. Inferior Gluteal Artery

2. Superior Gluteal Artery

3. Lateral Sacral Artery

4. Iliolumbar Artery



There is only one anastamosis of the portal and systemic venous systems that occurs within the pelvis. Where does it occur?

Near the anal canal.

What do we mean by the term "caval?"

"Caval" is synonymous with "systemic."

In the case of anastamoses between the portal system and the systemic venous circulation, only one is found in the pelvis. It is commonly called the portocaval anastamosis.

A 29 year-old woman is admitted to a hospital because the birth of her child is several days overdue. During childbirth, her pelvic diaphragm is torn. Paralysis in which muscle will result?

A. Piriformis

B. Rectus abdominis

C. Obturator internus

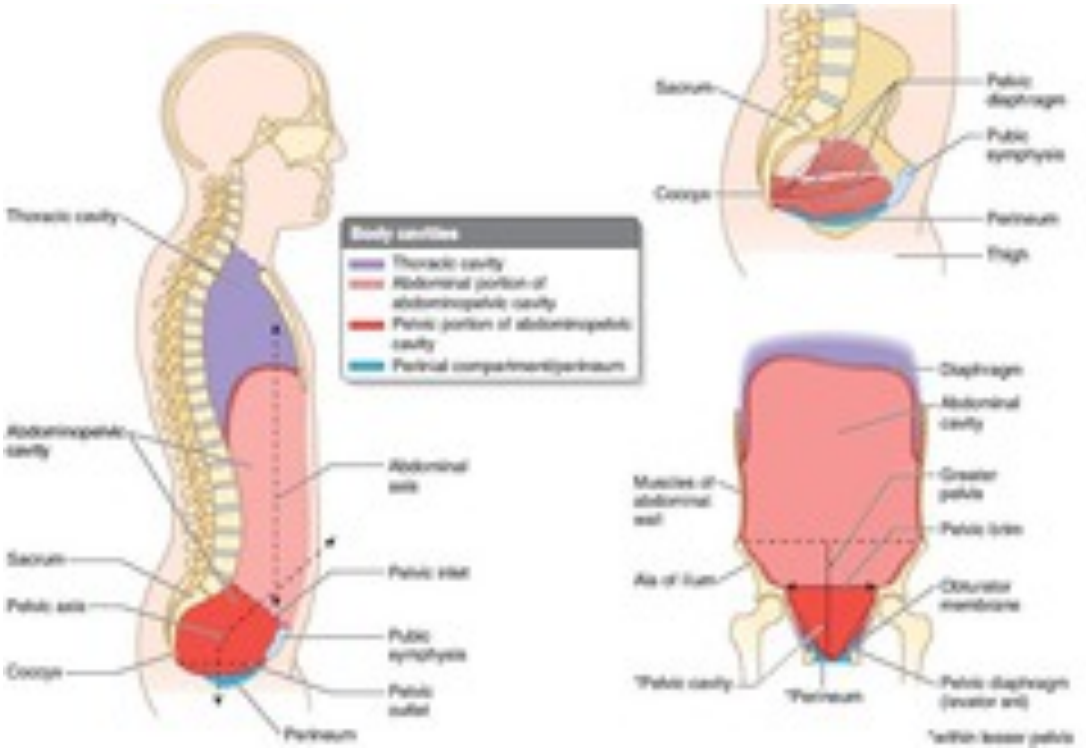
D. Levator ani

E. Coccygeus

D. Levator Ani.

The only muscles in this list that are part of the pelvic diaphragm are the levator ani and the coccygeus.

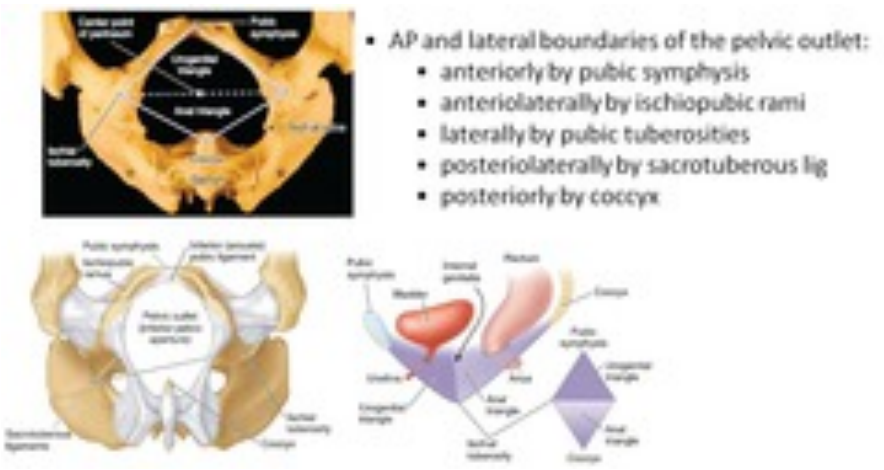
Because the levator ani is closer to the vagina (which is presumably where the tearing occurred) we would expect levator ani to be more correct than coccygeus.


Thoracic cavity
Abdominopelvic cavity
Sacrum
Pelvic axis
Coccyx
Abdominal axis
Pelvic inlet
Pubic symphysis
Pelvic outlet
Perineum
Body cavities
Thoracic cavity
Abdominal portion of abdominopelvic cavity
Pelvic portion of abdominopelvic cavity
Pelvic compartment/perineum
Sacrum
Coccyx
Pelvic diaphragm
Pubic symphysis
Perineum
Thigh
Diaphragm
Abdominal cavity
Muscles of abdominal wall
Greater pelvis
Pelvis brim
Ala of ilium
Obturator membrane
*Pelvic cavity
*Perineum
Pelvis diaphragm (levator ani)
*within lesser pelvis

Describe the position of the perineum relative to the pelvic diaphragm.

The perineum is defined to the be the space inferior to the pelvic diaphragm that is also positioned between the legs.

In the attached image, the perineum is shaded in blue.



Anatomically, the shape of the perineum is a diamond composed of two triangles. What are the lateral borders of the diamond? What is the anterior border of the diamond? What is the posterior border of the diamond? What are the names of the two triangles?

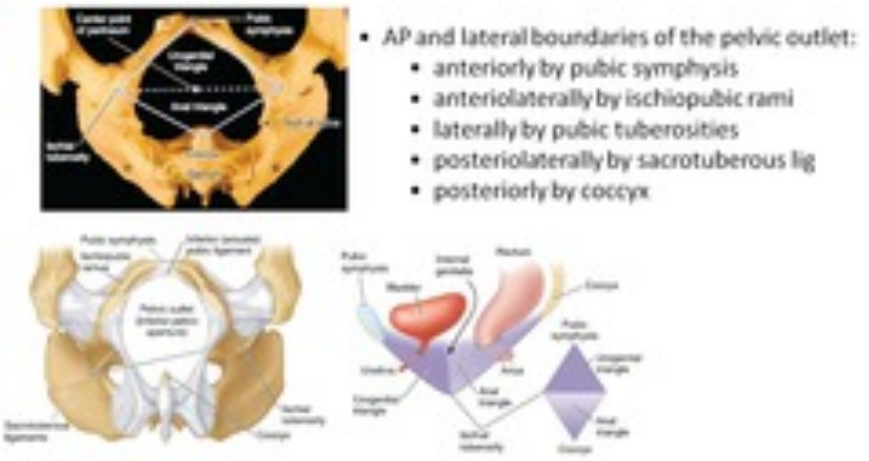
Lateral Border – the pubic tuberosities

Anterior Border – the pubic symphysis

Posterior Border – the coccyx

Anterior Triangle – Urogenital Triangle

Posterior Triangle – Anal Triangle



True or false: While the perineum does follow the contours of the tissue between the coccyx and pubic symphysys, it is basically flat.

False.

The perineum is a diamond that is "hinged" at the juncture of the urogenital and anal triangles.

In other words, it slopes (90 degree angle) toward both the coccyx and pubic symphysis.

See the attached image for a graphical illustration.

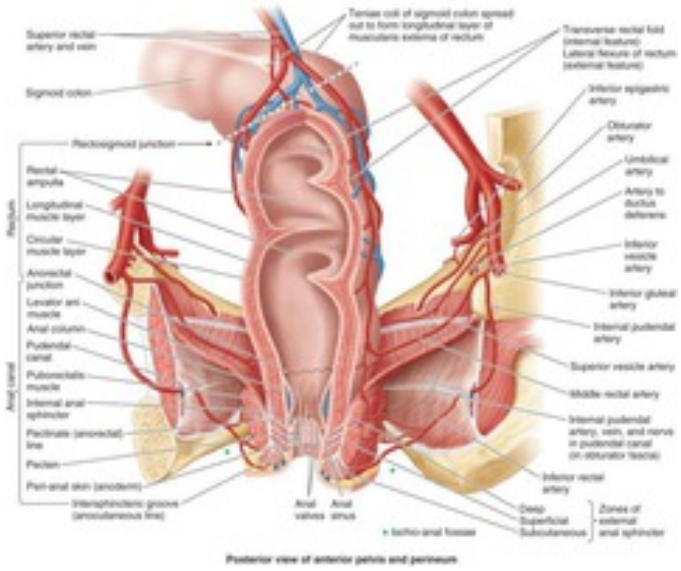
What is the perineal body?

The perineal body is a fibromuscular mass that lies at the central point of the perineum.

Several muscles come together at the perineal body.

Who's perineum is larger, the average male or the average female? Why?

The average female has a larger perineum.The lateral boundaries of the perineum are the pubic tuberosities. Because, as discussed earlier in Dr. Kramer's lecture, the female pelvis has a wider gap between the pubic tuberosities, it makes sense that a female perineum would be larger (in area) than a male perineum.



What do we mean when we say that the rectum perforates the levator ani muscles?

The rectum doesn't pierce these muscles. These muscles wrap around the anus (particularly the puborectalis).

What structures mark the end of the rectum and the beginning of the anus?

The levator ani muscles.

The rectum ends where it perforates these muscles.

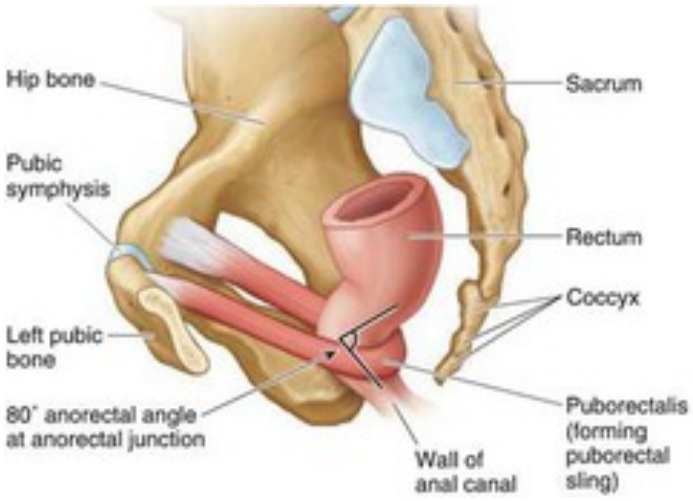
True or false: the pectinate line and anorectal junction are two different names for the same structure.

False.

The pectinate line and the anorectal junction are two different structures.

The pectinate line is about 2/3 of the way down the anus, closer to the superficial area/perineum.

The anorectal junction, on the other hand marks the junction between the rectum and anus. It is the line between them and is marked by the anorectal angle.



Where, in the anorectal area, would you find the pectinate line? Where would you find the anorectal junction?

Pectinate Line – the pectinate line is found about 2/3 of the way down the anus (down meaning closer to the anal opening). The pectinate line does not mark the boundary between the anus and rectum.

Anorectal Junction – the anorectal junction marks the boundary between the anus and rectum. It is found at the anorectal angle, the point at which the puborectalis wraps around the rectum/anus, forming a sling.

Of the following anal sphinctors, which are under voluntary control? What nerve innervates the voluntary sphinctors?

Sphinctor Ani Externus; Sphinctor Ani Internus; Corrugator Cutis Ani.

Sphinctor Ani Externus.

This sphinctor contains three parts: deep, superficial, and subcutaneous.

Branches of the pudendal nerve innervate these sphinctors.

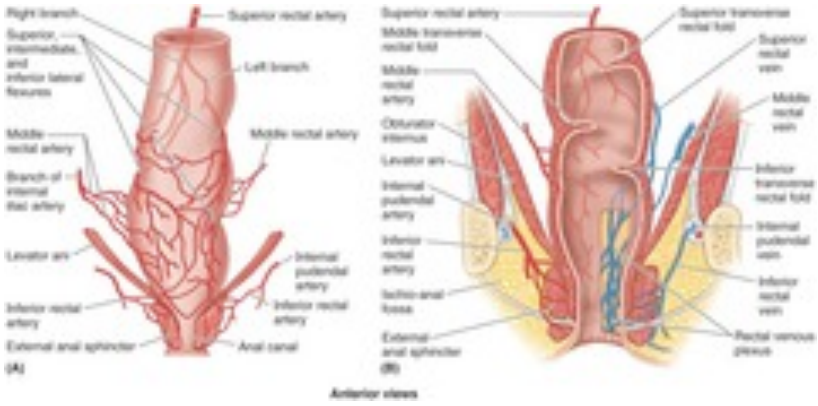
Of the following anal sphinctors, which are under involuntary control? What nerve innervates the involuntary sphinctors?

Sphinctor Ani Externus; Sphinctor Ani Internus; Corrugator Cutis Ani.

Sphinctor Ani Internus and Corrugator Cutis Ani.

Both of these sphinctors are smooth muscle sphinctors that are under autonomic control.

These sphinctors are innervated by pelvic autonmic plexi.



What nerve and artery supply and drain the rectum?

The superior rectal artery and vein.

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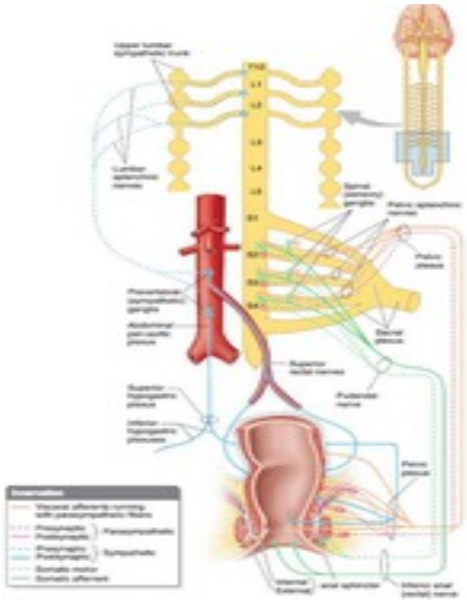
What important anastamosis occurs near the rectum?

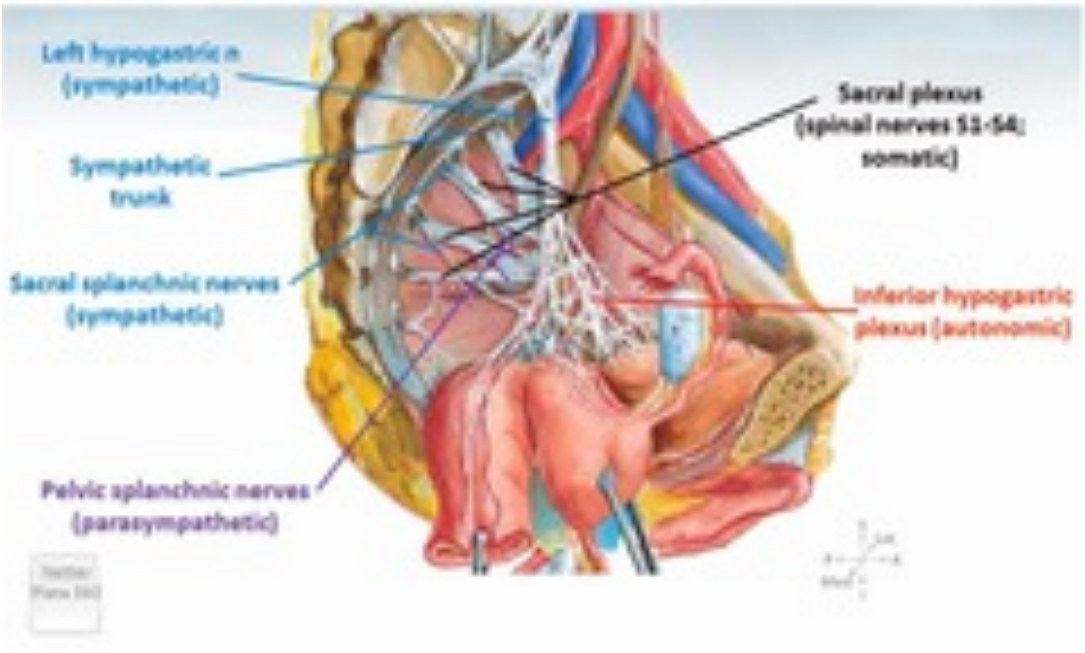
The portalcaval anastamosis.

This is where the arteries and veins of the rectum combine, forming an anastamosis between the portal system and systemic circulation.



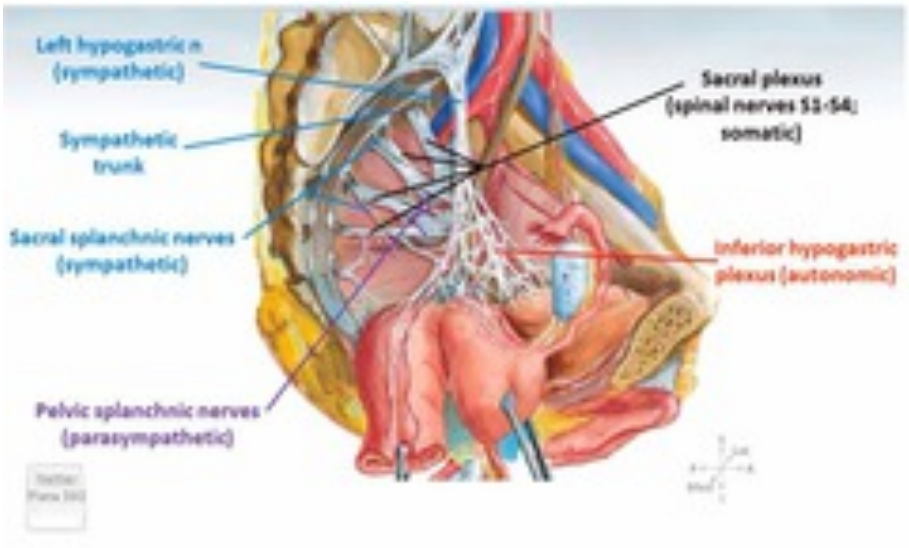
What spinal nerves supply both the autonomic and somatic nerves of the rectum?

S 2, 3, and 4. Keeps the poo off the floor


Left hypogastric n (sympathetic)
Sympathetic trunk
Sacral splanchnic nerves (sympathetic)
Pelvic splanchnic nerves (parasympathetic)
Sacral plexus (spinal nerves S1-S4; somatic)
Inferior hypogastric plexus (autonomic)

What four spinal nerves form the sacral plexus? What are the two main nerves formed by this plexus?

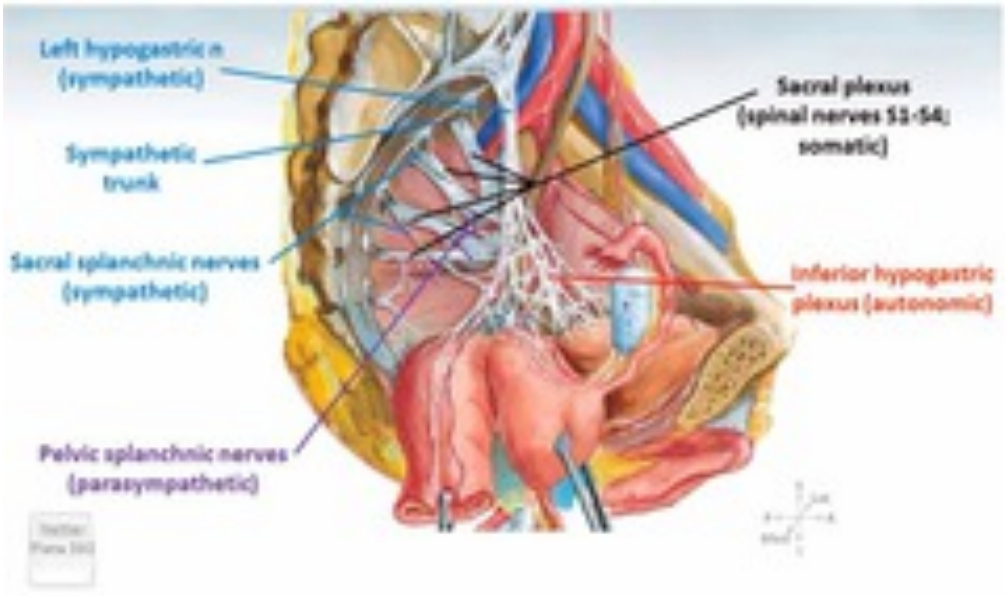
S1, 2, 3, and 4.This plexus forms the sacral nerve and the pudendal nerve. According to Dr. Kramer, these are the two main nerves of the sacral plexus.



Does the inferior hypogastric plexus carry autonomic or somatic nerves?

Autonomic nerves.

The inferior hypogastric plexus carries sympathetic and parasympathetic nerves ONLY. There are no somatic nerves involved.


Left hypogastric n
(sympathetic)
Sympathetic
trunk
Sacral splanchnic nerves
(sympathetic)
Pelvic splanchnic nerves
(parasympathetic)
Sacral plexus
(spinal nerves S1-S4;
somatic)
Inferior hypogastric
plexus (autonomic)

Are sacral splanchnic nerves sympathetic or parasympathetic nerves? How about pelvic splanchnic nerves?

Sacral Splanchnic Nerves – Sympathetic

Pelvic Splanchnic Nerves – Parasympathetic

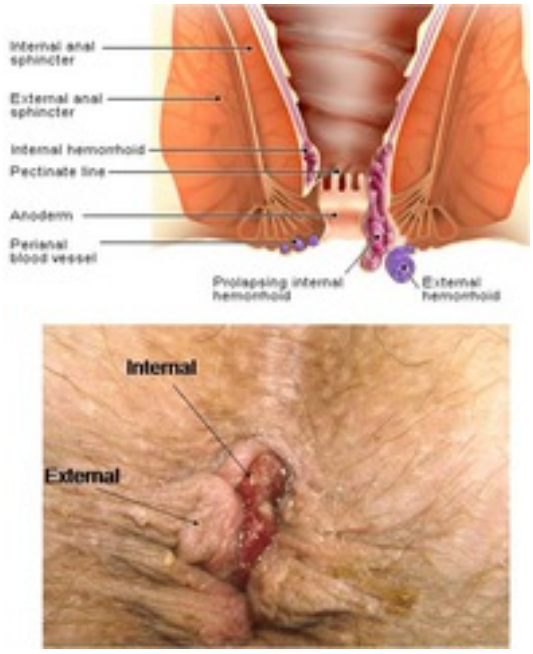
What is the significance of the pectinate line (anal/rectal)?

The pectinate line separates the embryological endoderm from embryological ectoderm.

The pectinate line also marks the division between visceral innervation and somatic innervation.

Additionally, different arteries feed the tissues on each side of the pectinate line.

See the table in the attached image for more details.



Why are external hemorrhoids more painful than internal hemorrhoids?

The pectinate line divides the tissues around the rectum and anus into two groups. The groups have different innervation, vascularization, and correspond to different embryological structures (endoderm and ectoderm).

The innervation of the two segments cause the difference in hemorrhoid pain.

Internal hemorrhoids lie in tissue that is innervated by visceral nerves. These do not sense pain as acutely as the somatic innervation present in the tissues where external hemorrhoids arise.

The pectinate line is essential to understanding the differences between internal and external hemorrhoids.

A 22-year old victim of an automobile accident has damaged structures that from the boundary of the perineum. Which structure is spared?

A. sacrospinous ligament

B. sacrotuberous ligament

C. ischial tuberosities

D. tip of the coccyx

E. pubic tuberosities

A : The sacrospinous ligament

The sacrospinous ligament is higher in the pelvis and is not part of the perineum