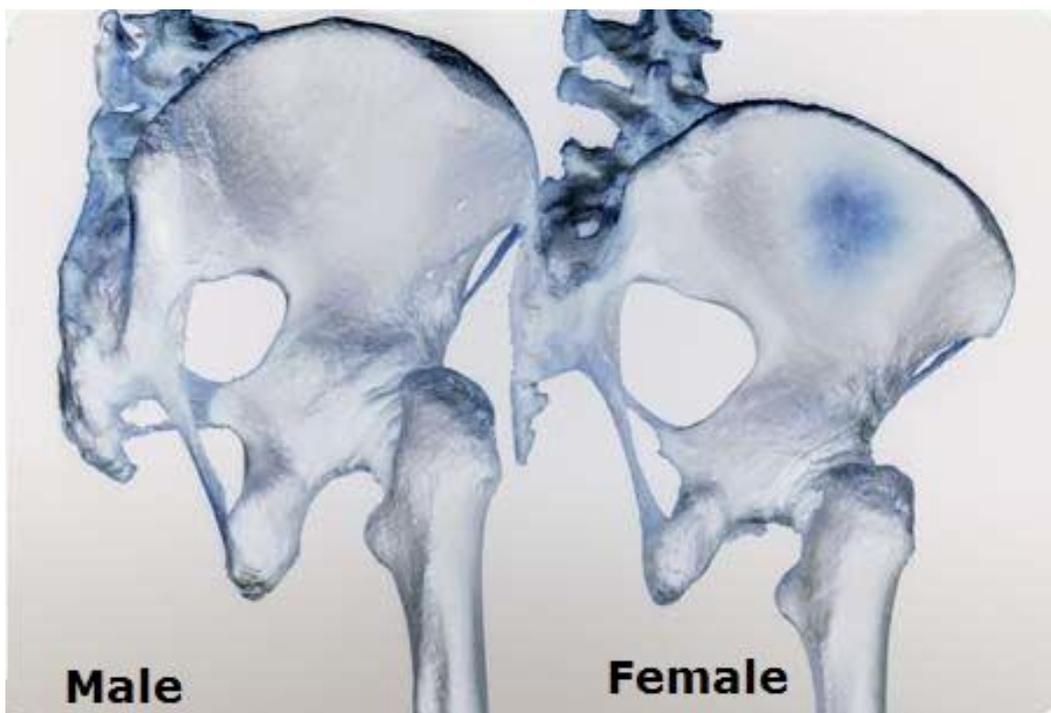


The Pelvis



Contents

The Pelvis.....	i
The Pelvis.....	1
The Pelvic Cavity.....	2
Sex differences.....	2
Biiliac width.....	4
Ligaments of pelvis.....	5
Mechanism of the Pelvis.....	7
The Pelvic Floor.....	12
Pelvic Floor Structure.....	13
The Uterine Ligaments.....	17
Ligaments Associated with the Ovary.....	19
Ligaments Associated with the Uterus.....	20
Blood vessels of pelvis.....	23
.....	24
Nerves of pelvis.....	24
The sacral plexus.....	24
The coccygeal plexus.....	25
Obturator nerve.....	25
The Urinary System.....	27
The Urethra.....	30
The Prostate.....	31
The Uterus.....	33
Vasculature.....	34
The Perineum.....	35
The Anal Triangle.....	36
Urogenital triangle.....	37
Disorders of the Pelvis.....	40
Pelvic diaphragm failure.....	40
Pelvic Inflammatory Disease.....	41
Diastasis Symphysis Pubis.....	44
Avulsion fractures.....	44
Pathological fractures.....	45
Fracture iliac wing.....	46
Cysts.....	46
Osteosarcoma.....	47
Chondrosarcoma, enchondroma and osteochondroma.....	47
Ewing sarcoma and lymphoma.....	48
Pelvic Fractures.....	49

Figure 1 Bones of the pelvis	1
Figure 2 Pelvis viewed from the side	1
Figure 3 Diagram showing pelvic brim	2
Figure 4 Diagram showing pelvic inlet and outlet	2
Figure 5 Diagram showing main difference between male and female pelvis	2
Figure 6 Differences between male and female pelvis, here from the side	3
Figure 7 Side view of male and female pelvis with pelvic contents	3
Figure 8 Diagram showing different types of pelvis	4
Figure 9 Model showing anterior view of female pelvis with ligaments	5
Figure 10 Diagram showing view of posterior pelvis and ligaments	5
Figure 11 Diagram showing sagittal section of female pelvis, showing ligaments	6
Figure 12 Transmission of forces through pelvis.....	7
Figure 13 Diagram showing approximate line separating anterior and posterior arches of pelvis	7
Figure 14 The femorosacral arch	7
Figure 15 The Ischiosacral Arch.....	8
Figure 16 Components of force on the sacrum.....	8
Figure 17 Diagram showing weight through sacrum forcing ilia apart.....	9
Figure 18 Diagram showing transverse sections of the sacroiliac joint at its three levels, showing planes of movement	9
Figure 19 Nutation of sacrum (ilia bones move posterior; forward rotation of sacrum).....	10
Figure 20 Counternutation of sacrum (ilia bone move anterior; posterior rotation of sacrum)	10
Figure 21 Weisl's lines of reference in pelvis	10
Figure 22 Different positions used by Weisl in his radiographic examination.....	11
Figure 23 An overview of the pelvic cavity and its walls. Note the funnel shape of the pelvic floor...	12
Figure 24 Obturator Internus and piriformis.....	13
Figure 25 Diagram of pelvic diaphragm muscles of male and female	14
Figure 26 Diagram of the pelvic floor muscles from above.....	15
Figure 27 Schematic of external pelvic diaphragm muscles.....	15
Figure 28 External view of pelvic diaphragm muscles.....	16
Figure 29 Diagrams showing the prostate and cervix as being central to the deep pelvic diaphragm	16
Figure 30 Diagrams showing the prostate (above) and cervix (below) from their superior aspect ...	17
Figure 31 Contents of the female pelvic bowl.....	17
Figure 32 Diagram of the posterior uterus, showing the broad and round ligaments	18
Figure 33 Schematic of three parts of the broad ligament	19
Figure 34 Major ligaments of the ovary	19
Figure 35 Overview of the uterus and fallopian tubes with associated ligaments	20
Figure 36 Schematics of the major ligaments of the cervix	21
Figure 37 Diagram showing the round ligament (here from the front of the uterus) and the broad ligament (here from the back of the uterus) demonstrating their function of support during pregnancy	21
Figure 38 An episiotomy – a deliberate cut to the perineum	22
Figure 39 Diagram of vessels of pelvic bowl	24
Figure 40 Schematic of somatic nerves of pelvis	25
Figure 41 Schematic of Autonomic nerves of pelvis	26
Figure 42 Diagram of Urinary System	27
Figure 43 Diagrams of male and female urinary bladders	27
Figure 44 Diagram of peritoneal folds around bladder	28
Figure 45 Diagrams showing support ligaments of bladder in male and female	28
Figure 46 Diagram of ligaments of bladder	29
Figure 47 Trigone of bladder.....	29
Figure 48 Urethra of male and female	30

Figure 49 The prostate	31
Figure 50 views of prostate lobes from side and above.....	31
Figure 51 Digital examination of prostate.....	32
Figure 52 Benign prostatic hyperplasia	32
Figure 53 Prostatic Cancer	32
Figure 54 Diagram showing regions of uterus.....	33
Figure 55 The uterus and its various positions.....	33
Figure 56 Secondary fascial supports for the uterus	34
Figure 57 Uterine ligamentous support, viewed from the side and above	34
Figure 58 Round ligament	35
Figure 59 Perineum - from exterior	35
Figure 60 Perineum.....	35
Figure 61 Anal canal.....	36
Figure 62 Ischiorectal fossa.....	37
Figure 63 The Perineal Pouches	37
Figure 64 Superficial Perineal Pouch.....	39
Figure 65 Male external genitalia	40
Figure 66 Prolapse of pelvic organs	41
Figure 67 Pelvic Inflammatory Disease	41
Figure 68 Paget's Distribution.....	42
Figure 69 X-Rays of pelvis with Paget's disease.	43
Figure 70 Pubic Diastasis.....	44
Figure 71 Avulsion fractures of anterior inferior iliac spine	45
Figure 72 Pathological fracture of pelvis.....	45
Figure 73 MRI showing fracture of right iliac wing.....	46
Figure 74 X-ray showing bony cysts	46
Figure 75 Osteosarcoma of right pelvic wing	47
Figure 76 Osteochondroma of pelvis	48
Figure 77 X-ray and MRI of Ewing Sarcoma.....	48
Figure 78 Fracture of the acetabulum	49
Figure 79 Fracture through both superior and inferior pubic rami	49

The Pelvis

The Pelvis, or pelvic girdle, is an irregular bony structure at the base (caudal end) of the spine. In the adult, it is formed by a ring of bones formed by the sacrum (with the coccyx) and the innominate bones (made up of three bones fused together: the ilium, the ischium and the pubis. These three constituent parts of the innominate formed separately and did not fuse together until puberty.

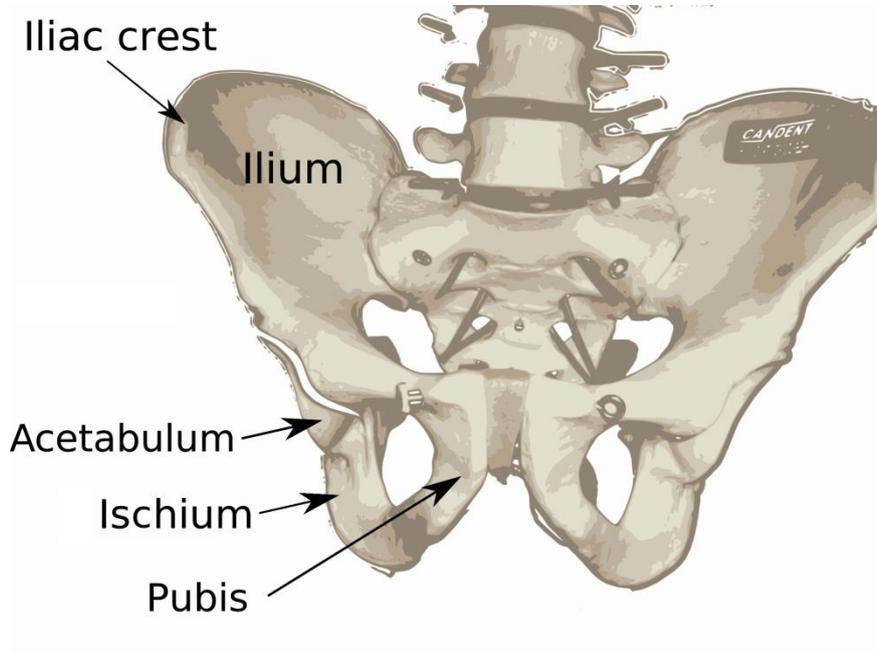


Figure 1 Bones of the pelvis

The ilium is the largest and uppermost part of the pelvis, the ischium is the posterior-inferior (the part you sit on) and the pubis is the anterior part. The two innominates are joined anteriorly at the pubis symphysis and posteriorly to the sacrum. The three bones that constitutes the innominate come together in the acetabulum; the concavity forming the socket of the hip joint.

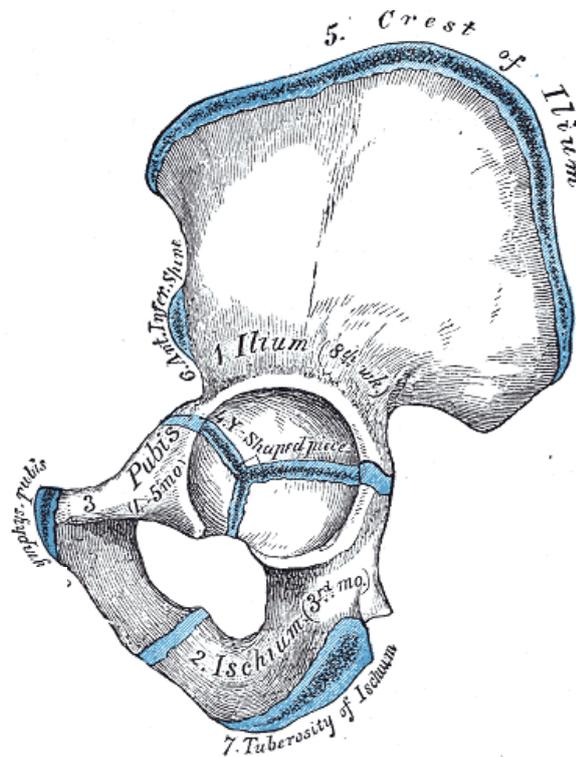


Figure 2 Pelvis viewed from the side

The Pelvic Cavity

The pelvic cavity is a body cavity that is bounded by the bones of the pelvis and which primarily contains the reproductive organs, bladder and rectum.

The lesser pelvis (or true pelvis) only includes structures inferior to the pelvic brim, or inlet. Its inferior margin is the pelvic outlet.

The greater pelvis, or false pelvis, is the expended portion of the cavity situated above and in front of the pelvic inlet (also known the pelvic brim)



Figure 3 Diagram showing pelvic brim

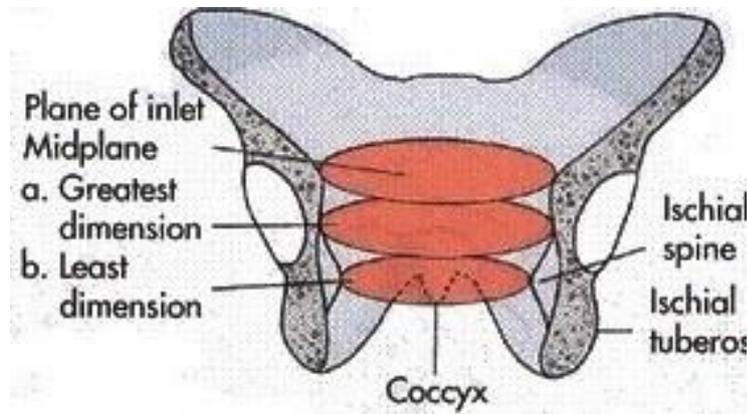
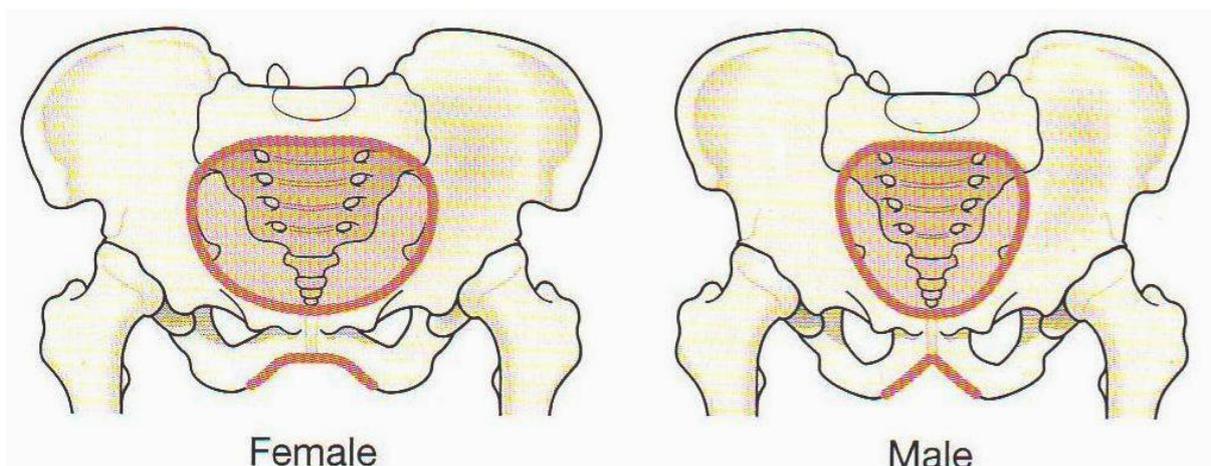


Figure 4 Diagram showing pelvic inlet and outlet

Sex differences

Figure 5 Diagram showing main difference between male and female pelvis



- The infrapubic pubic angle is greater than 90° in females
- The female pelvis is shorter in height, but broader than the male
- The pelvis inlet is more heart shaped in males; in females it is more round or oval
- The greater sciatic notch is narrower in males
- The acetabulum
 - In males faces more laterally
 - In females it faces more anteriorly
- The sacrum is more triangular is shorter in females

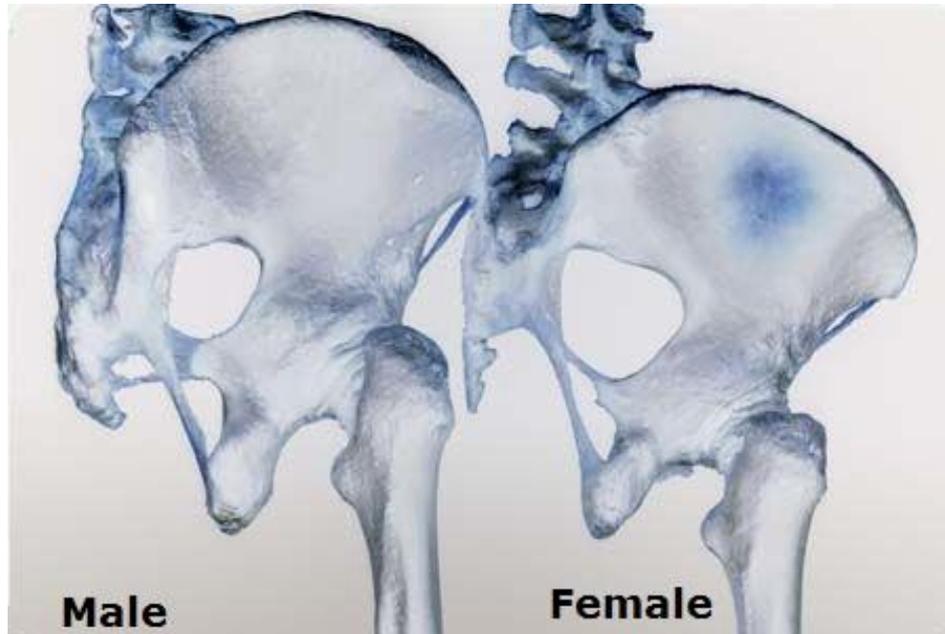


Figure 6 Differences between male and female pelvis, here from the side

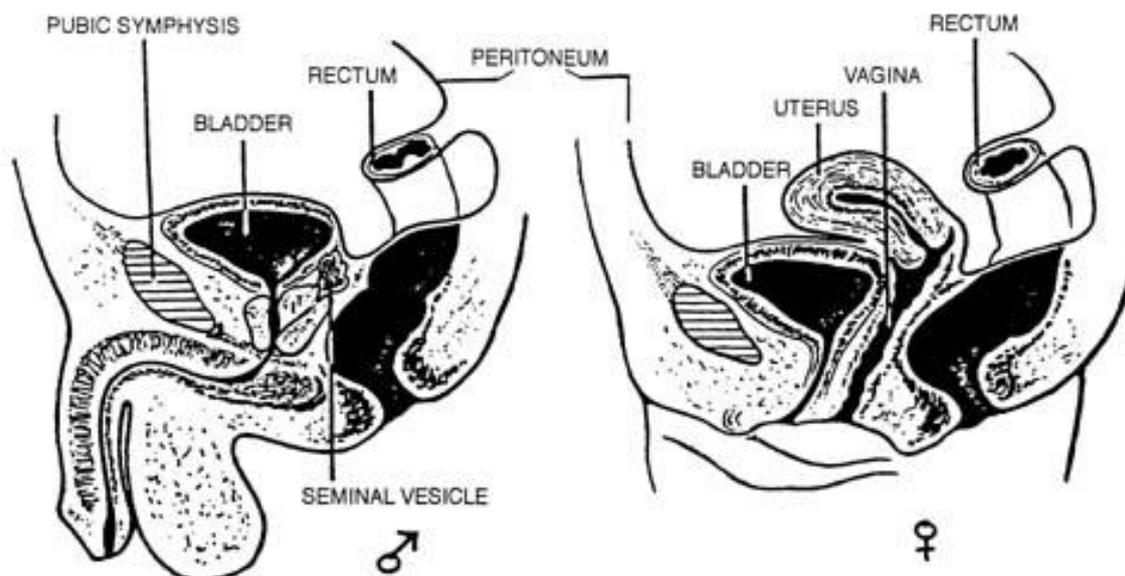


Figure 7 Side view of male and female pelvis with pelvic contents

There are 4 types of pelvis:

- **Gynaecoid** - normal female pelvis, round with enlarged transverse diameter
- **Android** - Normal male pelvis, heart shaped
- **Anthropoid** - Long anterior/posterior diameter
- **Platypeloid** - long transverse diameter

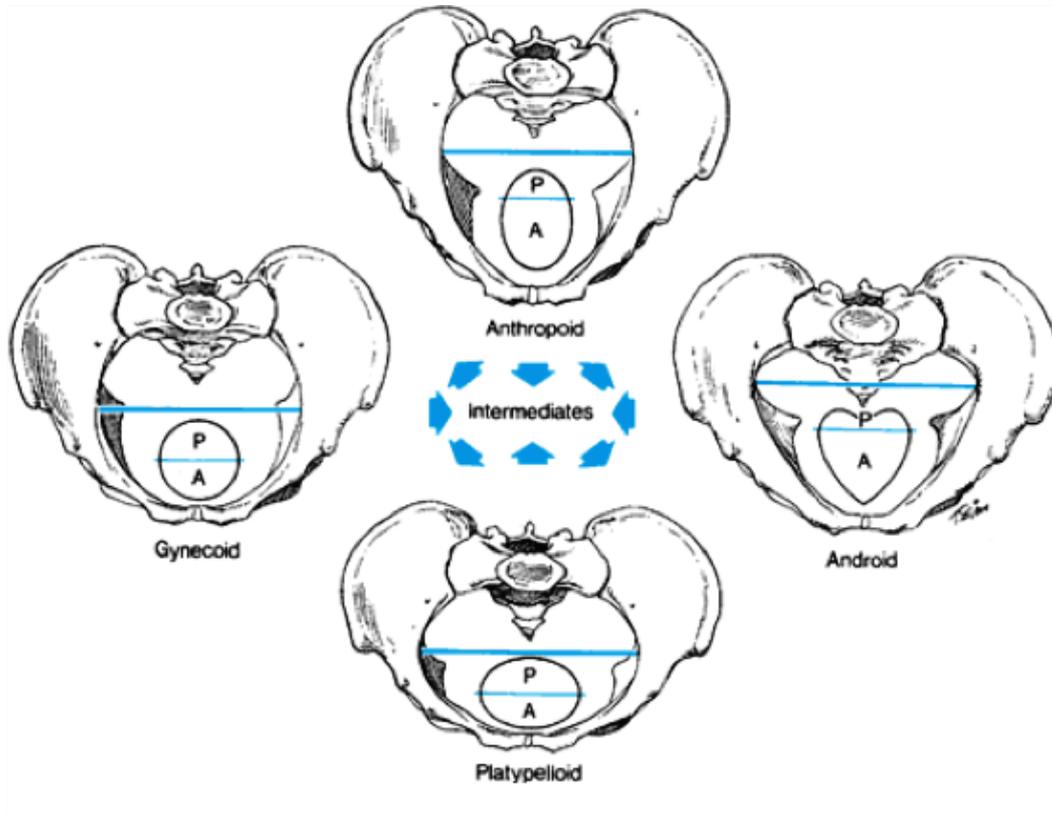


Figure 8 Diagram showing different types of pelvis

Race differences

African women tend to have a smaller pelvic floor area than European women

Biliac width

In humans, biliac width is an anatomical term referring to the widest measure of the pelvis between the out edges of the upper iliac bones.

Biliac width has synonyms: pelvic bone width, biliac breadth, intercrystal breadth/width, bi-iliac breadth/width and bilocrystal breath/width.

In the average adult female, it measure 28cm (11in). it is best measured by anthropometric callipers (an anthropometer designed for such measurement is called a pelvimeter). Attempting to measure biliac width with a tape measure along a curved surface is inaccurate

The biliac width measure is helpful in obstetrics because a pelvis that is significantly too small or too large can have obstetrical complications. For example, a large baby and/or a small pelvis often necessitates a caesarean section.

It is also used by anthropologists to estimate body mass.

Ligaments of pelvis

The pelvis is a ring of three bones and three joints and hence needs to be extremely stable.

Figure 9 Model showing anterior view of female pelvis with ligaments

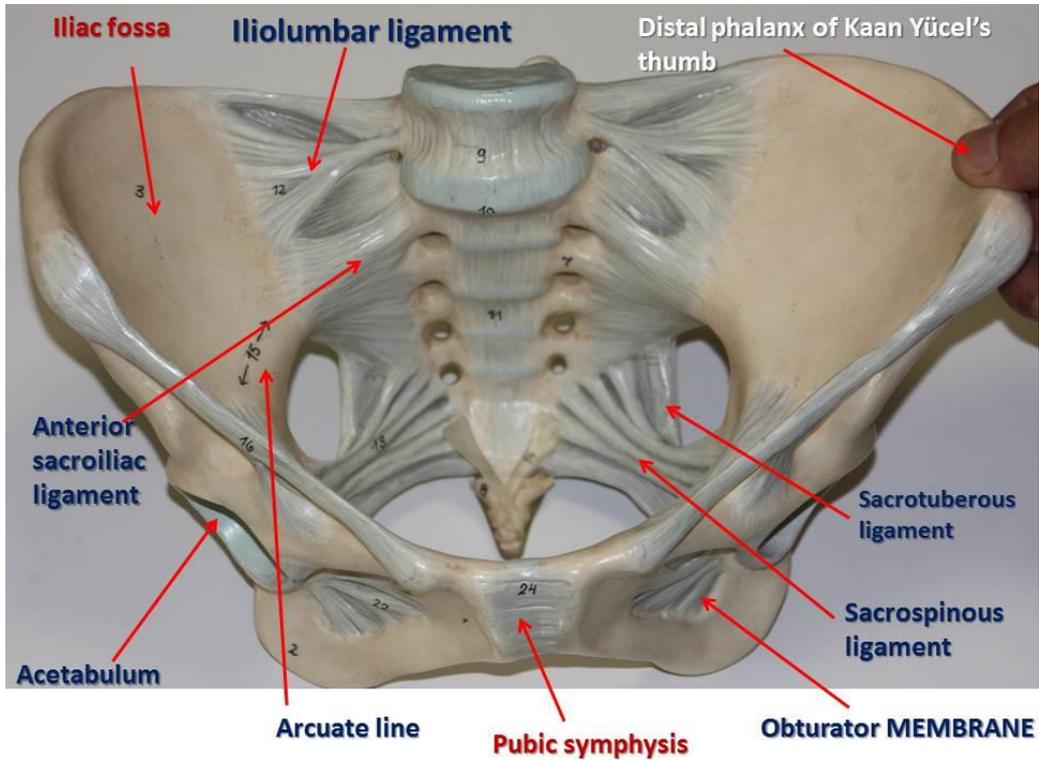
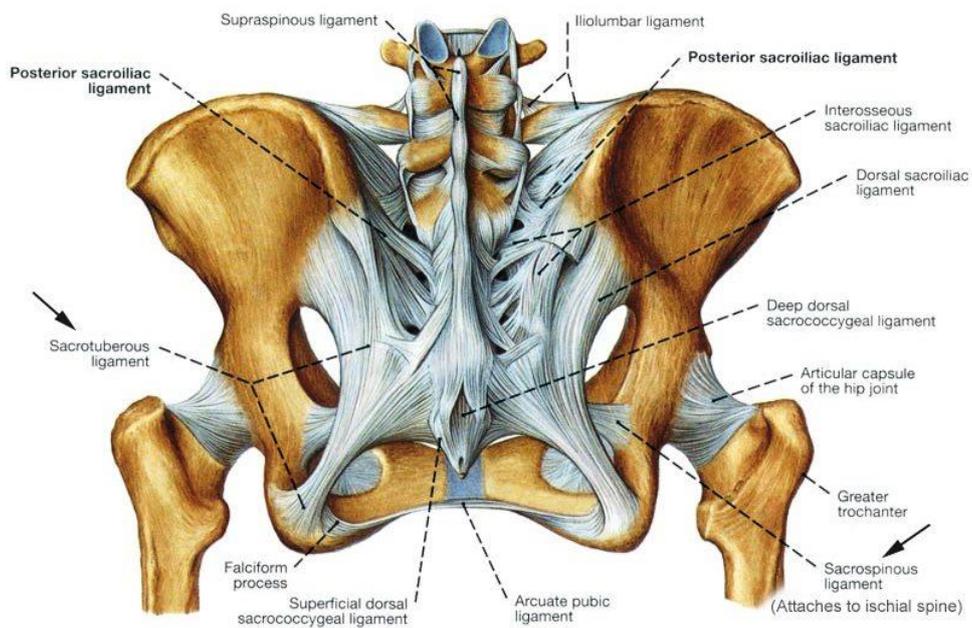


Figure 10 Diagram showing view of posterior pelvis and ligaments



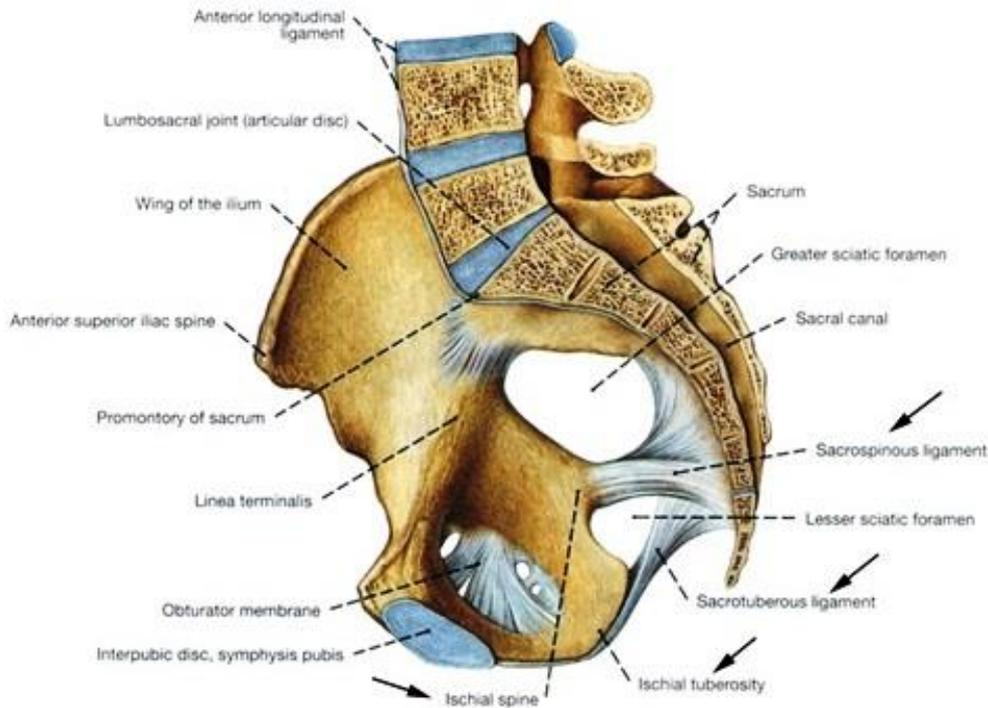


Figure 11 Diagram showing sagittal section of female pelvis, showing ligaments

The primary ligaments of the pelvis girdle are

- **The Sacroiliac ligaments** (anterior and posterior)
 - Stabilise the sacroiliac joints
- **The Suprapubic and infrapubic ligaments**
 - Stabilise the pubic symphysis

In addition to these are two other very important ligaments:

- **The Sacrotuberous ligaments**
 - These pass from the sacrum down to the ischial tuberosity
- **The Sacrospinous ligaments**
 - These pass from the sacrum anterior to the ischial spine

The weight of the body expresses itself on the top of the sacrum, anterior to the sacroiliac joints, and the sacral promontory; this will act to rotate the sacrum anteriorly. Together, these two ligaments create a necessary counterforce and stabilise the sacrum from rotating anteriorly.

Another spinal ligament that must be included here is:

- **The Iliolumbar ligament**
 - These pass from the transverse processes of L4 and L5 to the iliac crest

In addition to these, there is a membrane that covers the majority of the obturator foramen

- **The Obturator Membrane**

It has no stabilising function, per se, but acts as an origin for two of the deep lateral rotator of the hip, the obturator muscles: internus and externus

Mechanism of the Pelvis

One function of the pelvis is the protection of the contents of the pelvic bowl. It also affords attachment attachments to muscles of the trunk and lower limbs. Its most important function is to transmit forces:

- The weight of the trunk and upper limbs to the lower extremity
- The forces of the lower extremity into the pelvis

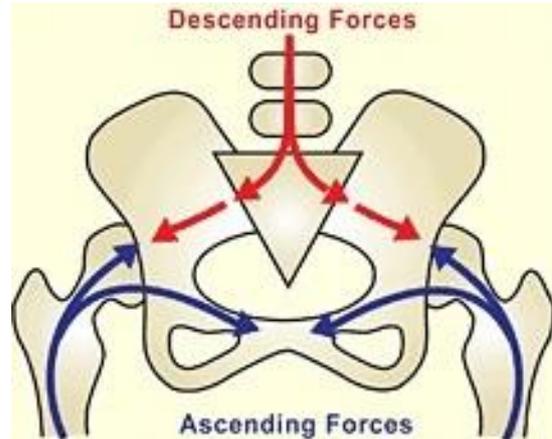
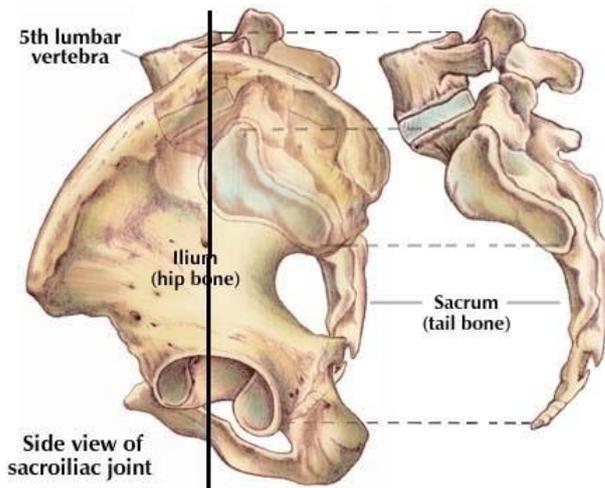


Figure 12 Transmission of forces through pelvis



The primary weight bearing joint in the pelvis is the sacroiliac joint. The joint is a real diarthrosis, i.e., a mobile joint with a joint cavity between two bony surfaces. It extends between S1 and S3 and articulates with the iliac bone.

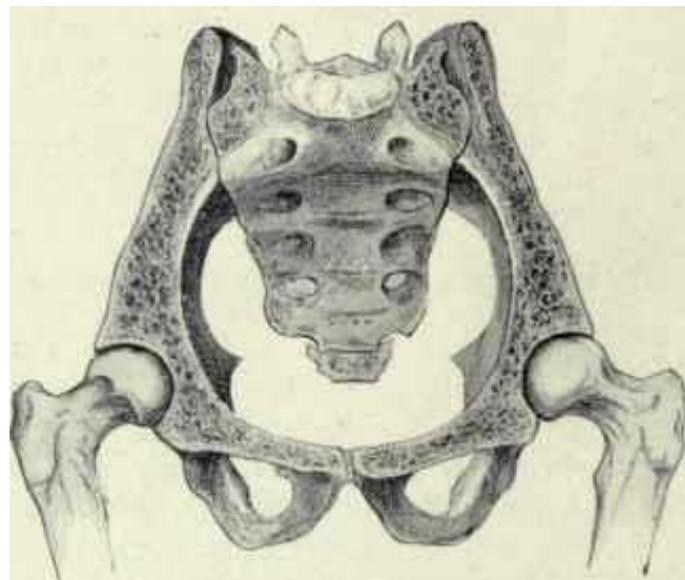
Figure 13 Diagram showing approximate line separating anterior and posterior arches of pelvis

The pelvis may be divided into two arches divided by a line

passing through the acetabulum. The posterior of these two arches (shown here) is the one concerned chiefly with transmitting the weight.

Figure 14 The femorosacral arch

The essential parts of the **femorosacral** (posterior) **arch** are the three upper sacral vertebrae and the strong pillar of bone running from the sacroiliac joint to the acetabular cavity. This arch extends from the acetabula on the sides to the sacrum in the middle, which is its keystone. The weight of the body is transmitted downward through the spine to the sacrum, and then through the two sides of the femorosacral arch to the heads of the femurs.



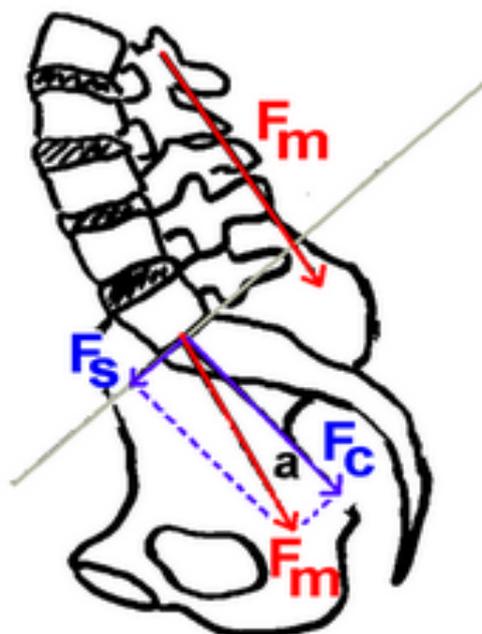
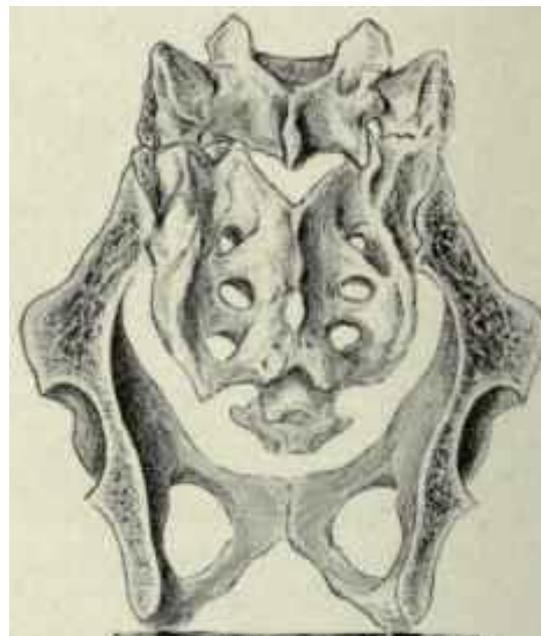
For an arch to be effective its two extremities must be firmly anchored, so that they do not separate when pressure is made on it. In artificial arches, as used in bridges, this separation is guarded against by a rod running from one extremity to the other,

forming a chord of the arc. In the pelvis this mechanism is impossible, because this "tie-rod" would infringe on the cavity of the pelvis, and it is to obviate this that a counter arch is introduced.

In addition to this for the reception and diffusion of weight, the acetabular cavity is strengthened by two other bars of bone. This secondary arch is formed by the rami and bodies of the pubic bones, and passes anteriorly from one acetabulum to the other on the opposite side. It is much weaker than the primary arch

The ischiosacral arch. The main arch passes upward from one tuberosity of the ischium through the sacrum down to the opposite tuberosity; the subsidiary arch passes forward from one tuberosity of the ischium through the pubes and back to the opposite tuberosity.

Figure 15 The Ischiosacral Arch



In order to lessen the concussion of rapid changes of distribution of the weight, joints (the sacroiliac joints) are interposed between the sacrum and the iliac bones, the pubic symphysis exists in the middle of the anterior arch.

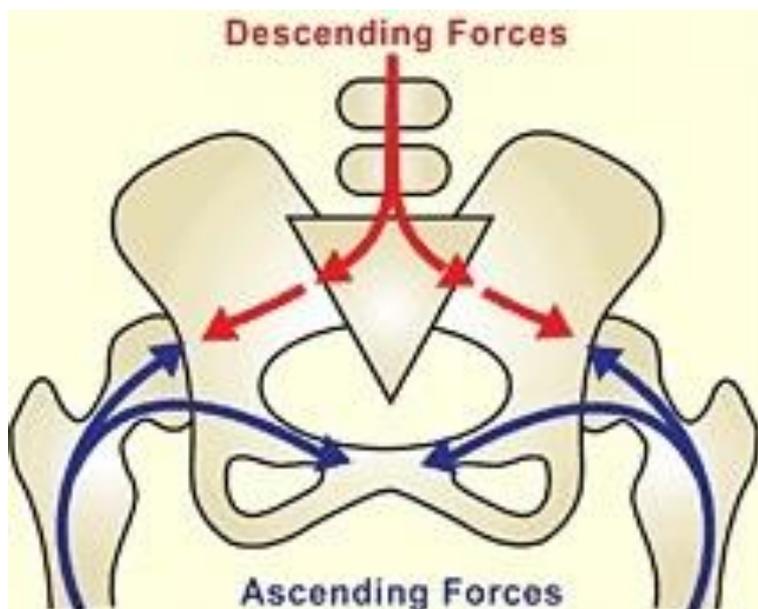
The sacrum forms the summit of the posterior arch. The weight falls on it at the lumbosacral joint and, theoretically, has a component in two directions.

1. Directs the sacrum down and backwards between the two iliac bones
2. Thrusts the upper end of the sacrum down and forwards towards the pubic cavity

Figure 16 Components of force on the sacrum

From Hippocrates (460-377 B.C.) until Vesalius (1514-1564), it has been suggested that the sacro-iliac joint is mobile during pregnancy only.

Analysing the movements of the pelvis is not a simple matter as a point of reference needs to be established. The sacroiliac joint is between the sacrum and the iliac bone, so to analyse the movement of one, the other has to 'stay still'. Another way of seeing it is that the two complementary bones will have reciprocal movements.

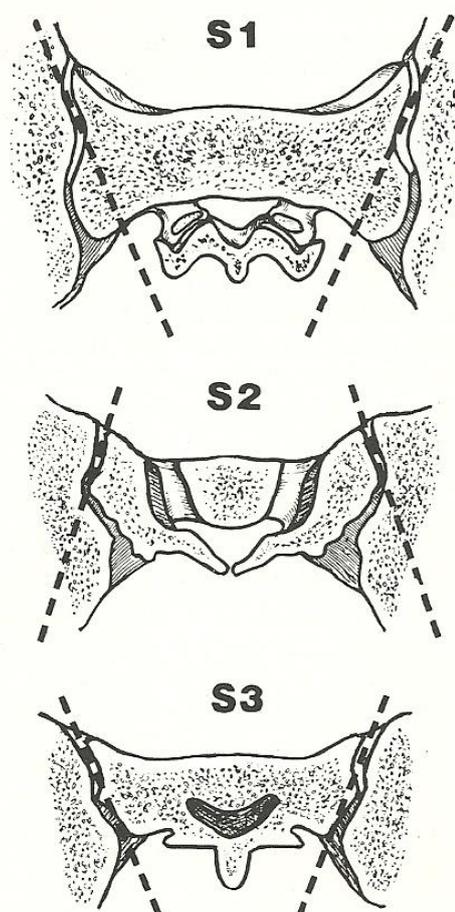


The movements of the sacrum between the ilia are regulated by its shape. Viewed as a whole, it presents the shape of a wedge with its base upwards and forwards. The first component of the force is therefore acting against the resistance of the wedge.

Figure 17 Diagram showing weight through sacrum forcing ilia apart

Here the tendency is to separate the two iliac bones, a movement that is resisted by the sacroiliac and iliolumbar ligaments as well as the ligaments of the pubic symphysis (not shown here).

Figure 18 Diagram showing transverse sections of the sacroiliac joint at its three levels, showing planes of movement



Broadly speaking, the articular shape allows movement in the sacroiliac joint with the innominate moving anterior and lateral, though the range of movement will be very small due to the stabilising action of the strong ligaments of the region.

With reference to the sacrum within the pelvic wings, the movement is referred to as **nutation** and **counternutation**

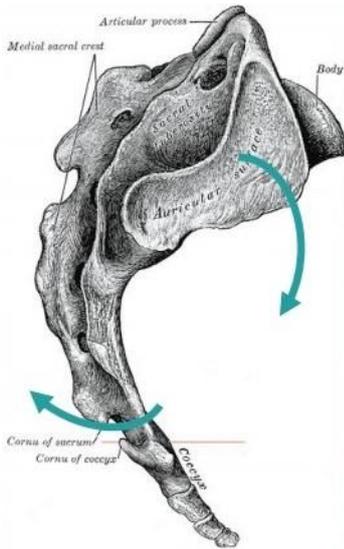


Figure 19 Nutation of sacrum (iliac bones move posterior; forward rotation of sacrum)

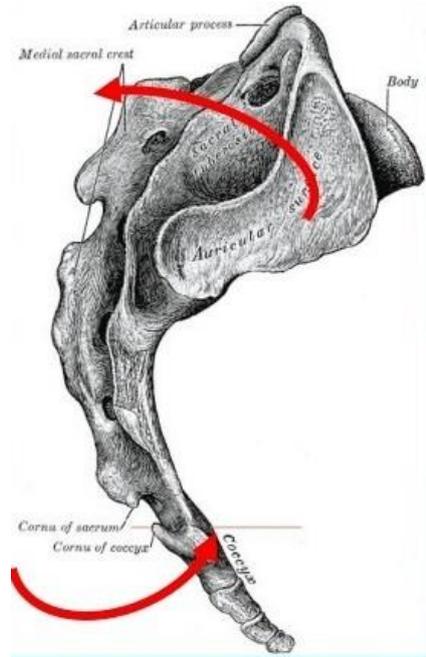


Figure 20 Counter-nutation of sacrum (iliac bone move anterior; posterior rotation of sacrum)

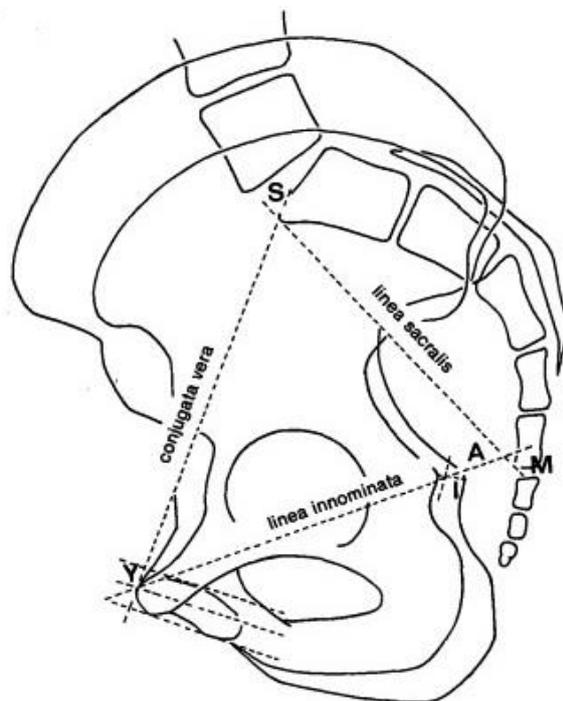
Hence with:

- **Nutation**, the iliac bones move posterior and medial, with the ASIS separation decreasing
- **Counter-nutation**, the iliac bones move anterior and lateral, with the ASIS separation increasing

Weisl (1955) researched the movements of the sacrum between the iliac bones. At the time that Weisl started his research, it was already known that a decrease of the pelvic inlet (conjugata vera) leads to an increase of the pelvic outlet (linea innominata). This was taken to imply nutation of the sacrum in the sacro-iliac joint.

Figure 21 Weisl's lines of reference in pelvis

In the supine position, 26 men and 30 women were radiographically examined, after which different positions had to be reached. A similar procedure was used, starting from the prone position (27 men, 28 women), and from the upright position (12 men, 10 women). Comparisons were made between two different positions.



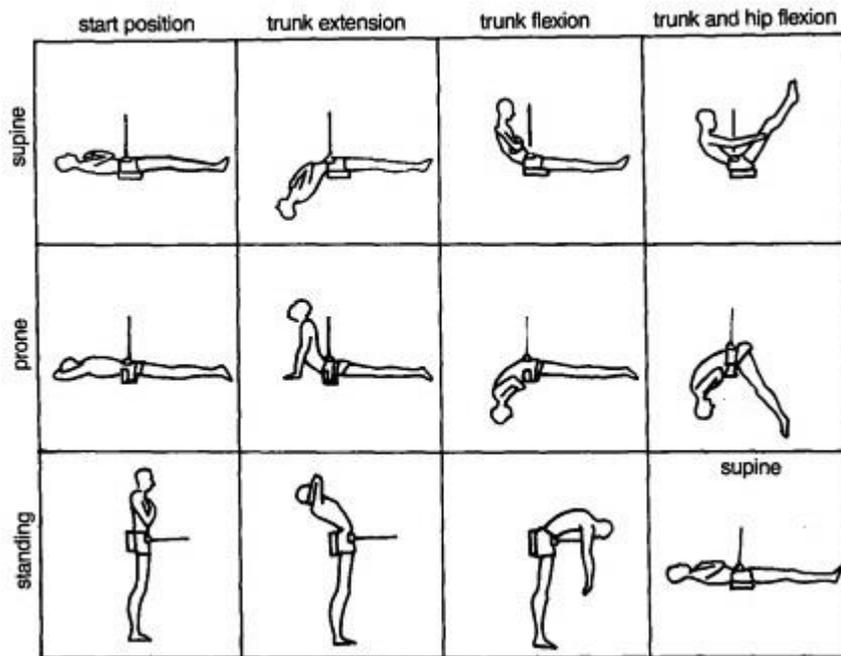


Figure 22 Different positions used by Weisl in his radiographic examination

Using these techniques and the triangle of reference (figure 21), two triangles can be compared and any change can be interpreted as sacroiliac movement. The most important sacro-iliac

change that Weisl found was related to the transition from a supine to the upright position. In 90% of the test persons, there was a pronounced displacement of the promontory towards ventral, whereas in 77% of the test persons, the conjugata vera became smaller. Weisl found promontory displacement towards dorsal in 5% of the test persons, and in 5% no displacement at all. In other movements less displacement took place.

There was a pronounced difference between male and nulliparous female sacro-iliac mobility on the one hand and multiparous female mobility on the other. Furthermore, Weisl reported a conspicuous difference between sacral movements during the transition from the supine position to trunk extension and those during the transition from the standing position to trunk extension. Only in the upright position trunk extension enlarges the conjugata vera, displacing the promontory somewhat towards dorsal.

Weisl demonstrated through X-Ray studies that:

- In the upright position, the sacrum is displaced towards ventral, that is to say, it is in nutation.
- In the lying position, however, it is in contranutation. Hence, it is difficult for the sacrum to (further) contranutate in the lying position.
- For trunk flexion the opposite was observed. Especially in trunk flexion from a lying position-the more so if in combination with hip flexion-the conjugata vera becomes smaller, implying nutation of the sacrum.
- Tilt of pelvic constellation is the same as that during labour, implying enlargement of the pelvic outlet due to the nutation of the sacrum

This and other studies shows sacroiliac mobility, but it depends upon the distribution of the load, and Lavignolle observed that hip flexion in a supine position leads to relatively large sacro-iliac movements.

The Pelvic Floor

The majority of muscles crossing the pelvis are muscles moving the spine and hip joint. The muscles inherent within the pelvis are those of the pelvic diaphragm, or pelvic floor. Their function is to support the contents of the pelvic bowl.

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.

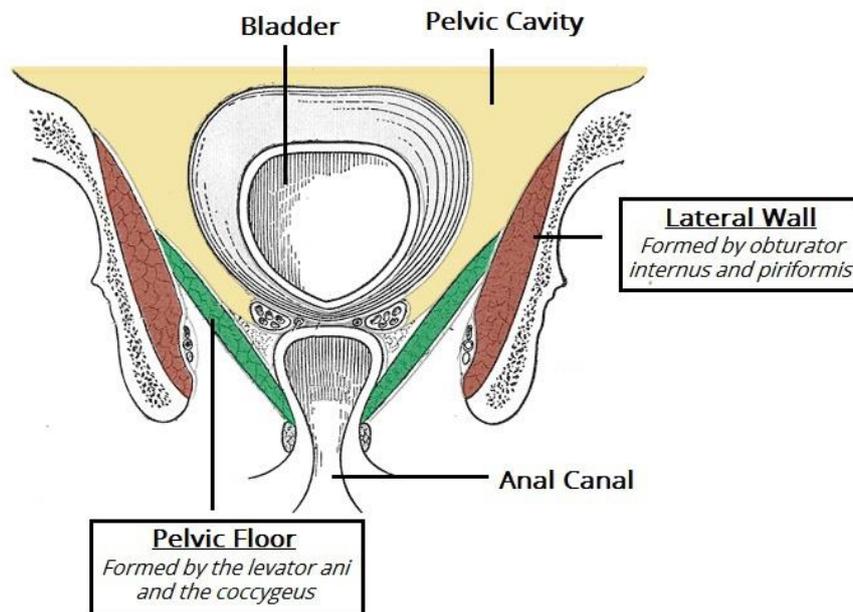


Figure 23 An overview of the pelvic cavity and its walls. Note the funnel shape of the pelvic floor

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

Other muscles here are really of the hip, but also contribute to the pelvic diaphragm:

- **Obturator internus**
 - Passes from the inner surface of the obturator membrane, out to the top of the femur at the intertrochanteric crest
- **Piriformis**
 - Passes from the anterior surface of the sacrum to the intertrochanteric crest

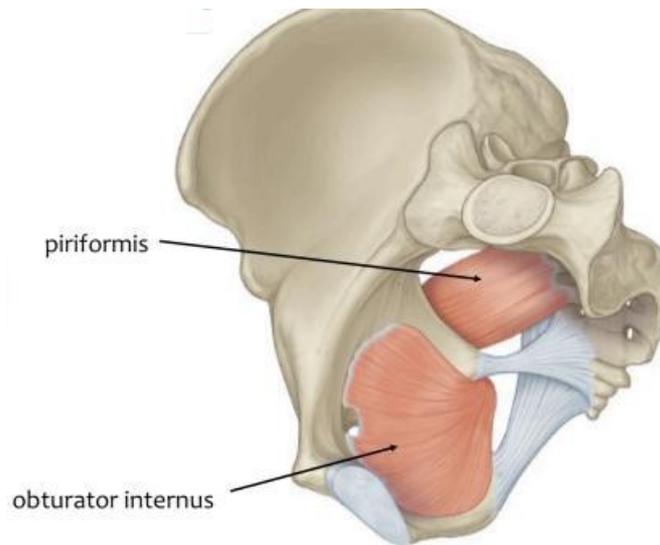


Figure 24 Obturator Internus and piriformis

Pelvic Floor Structure

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 urogenital 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 (its function is described in the perineum article).

Functions

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 faecal continence. The muscle fibres have a sphincter action on the rectum and urethra. They relax to allow urination and defecation.

Muscles

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. There is a similarity of the pelvis diaphragm muscles of both the male and female, except for the presence of the vagina, just posterior to the urethra.

There are three main muscles of this group:

- **Pubococcygeus**
 - Passes from the pubis back to the coccyx
- **Iliococcygeus**
 - Passes from the ischial tuberosities, back to the coccyx
- **Coccygeus**
 - Passes from the ischium and sacrospinous ligament, back to the coccyx

It may be noted that the pubococcygeus and iliococcygeus both pass back and also meet in the midline, creating a loop, or lasso, wrapping around the rectum, just superior to the anus and act to consciously elevate and pull the rectum forwards into a kink, whilst tightening the pelvic floor.

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

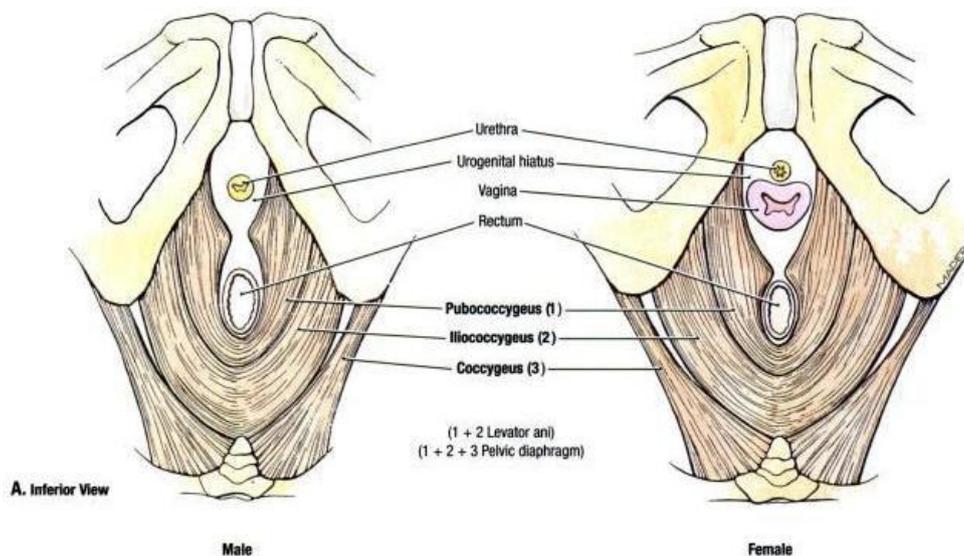


Figure 25 Diagram of pelvic diaphragm muscles of male and female

At the centre of the perineum is the perineal body (fig 28)

The diagram below shows these muscles from above.

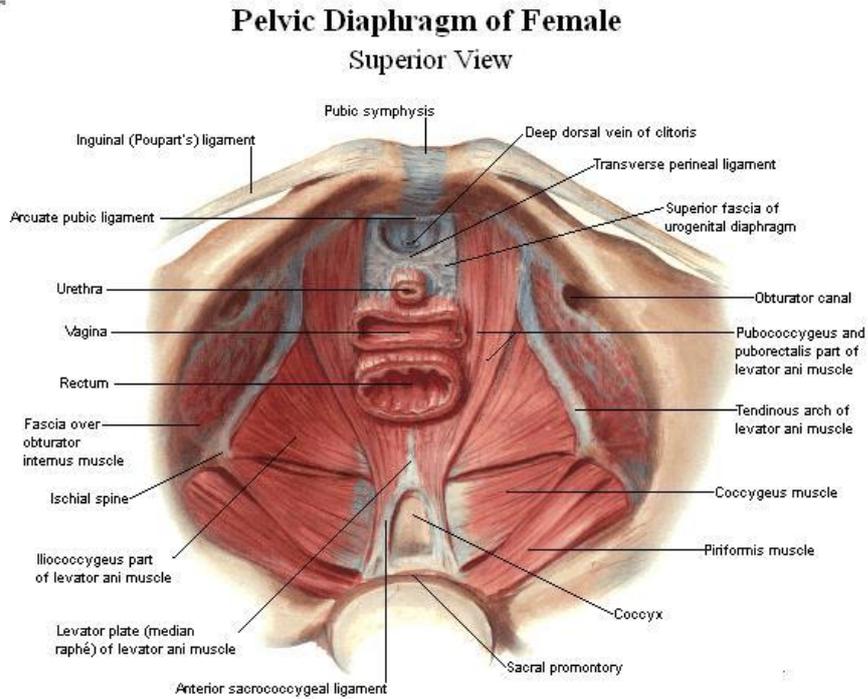


Figure 26 Diagram of the pelvic floor muscles from above

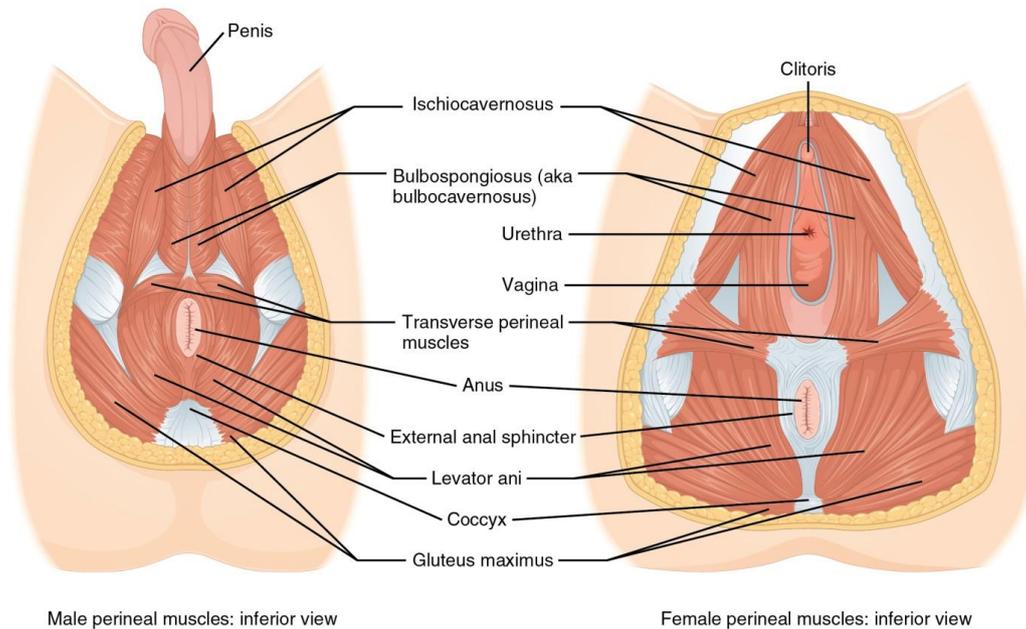


Figure 27 Schematic of external pelvic diaphragm muscles

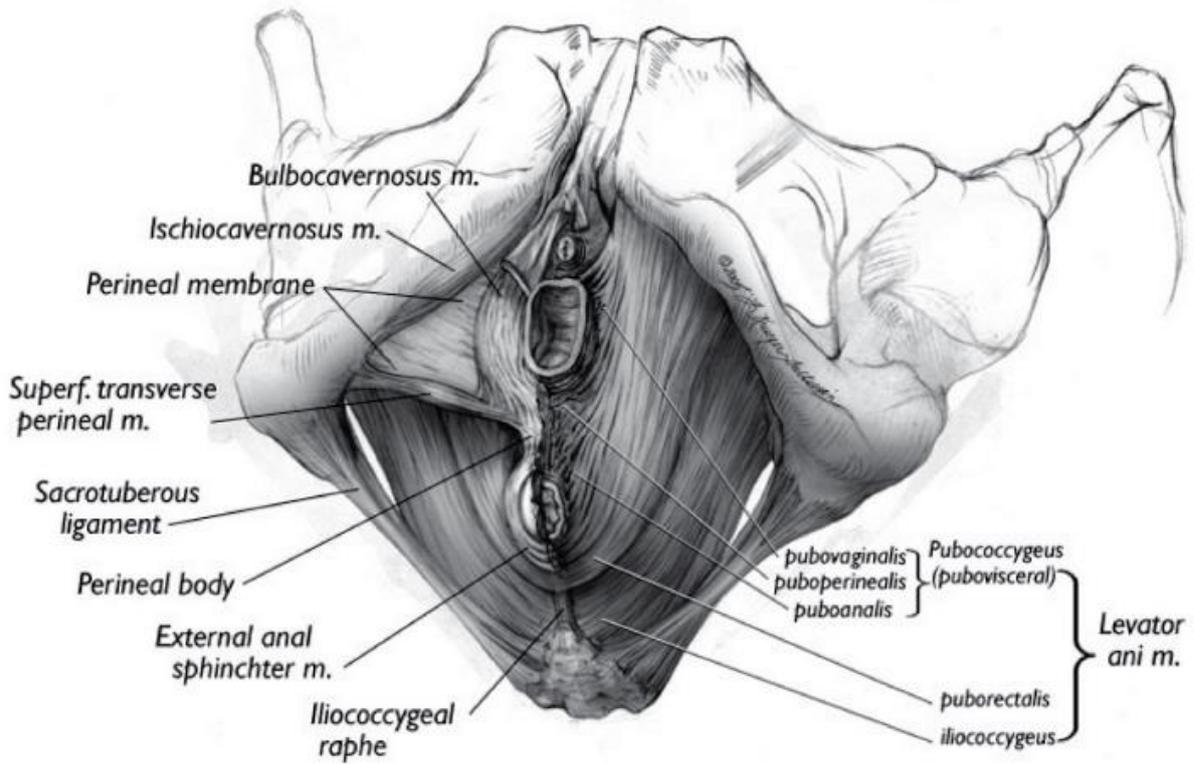
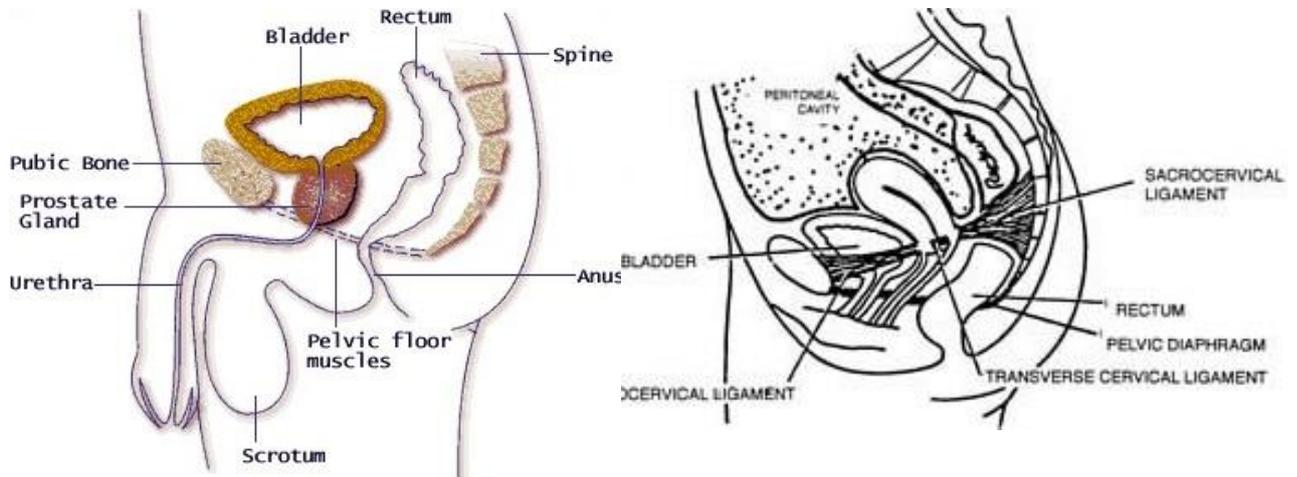


Figure 28 External view of pelvic diaphragm muscles

These muscles constitute the pelvic diaphragm and is the outermost layer of muscles. Deep to these are fibrous ligamentous structures that support the organs contained within the pelvic bowl; the centre of these being the prostate (male) and the cervix (female).

Figure 29 Diagrams showing the prostate and cervix as being central to the deep pelvic diaphragm



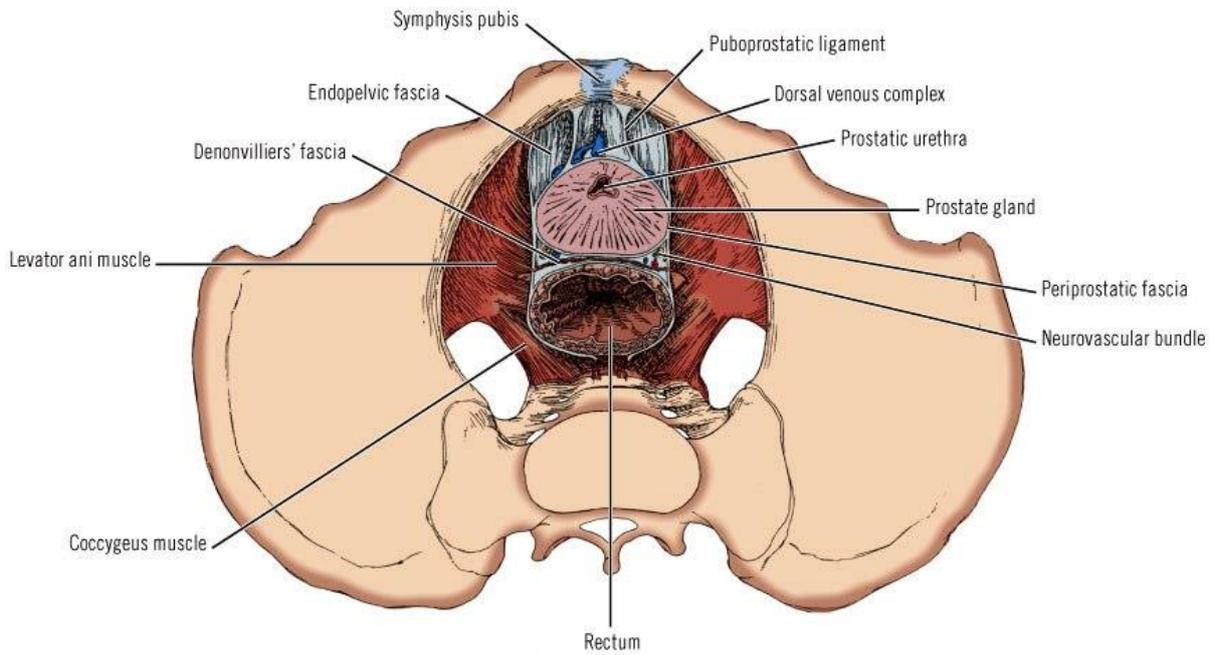


Figure 30 Diagrams showing the prostate (above) and cervix (below) from their superior aspect

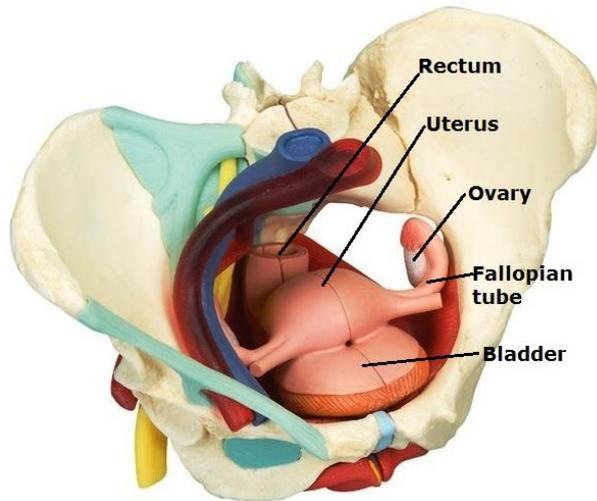


Figure 31 Contents of the female pelvic bowl

The Uterine Ligaments

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.

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

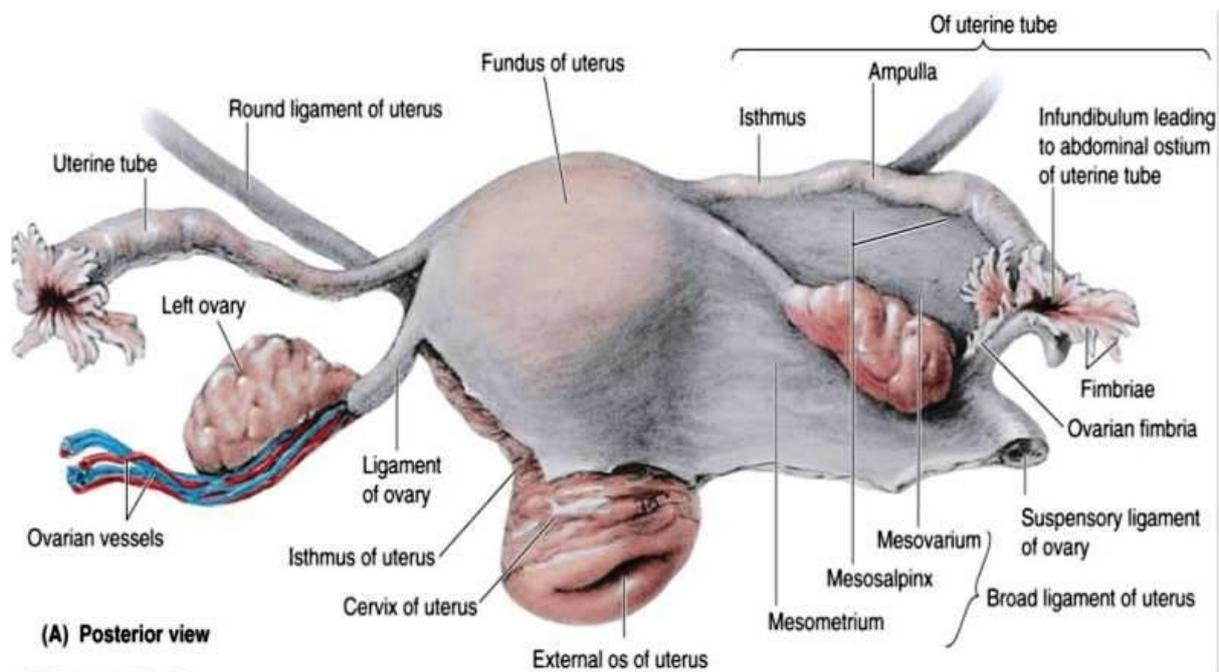


Figure 32 Diagram of the posterior uterus, showing the broad and round ligaments

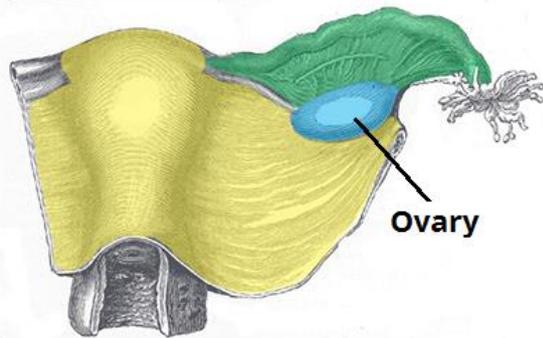
Subdivisions of the broad ligament

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
- **Mesosalphinx** – Originates superiorly to the mesovarium, enclosing the fallopian tubes

Seeing these schematically:

Coronal Plane:



Sagittal Plane:

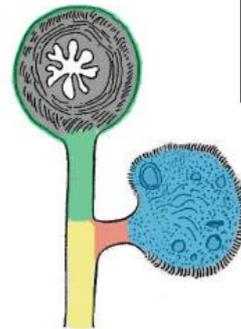


Figure 33 Schematic of three parts of the broad ligament

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)

Ligaments Associated with the Ovary

There are two main ligaments that attach to the ovary:

• **The Ovarian Ligament**

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).

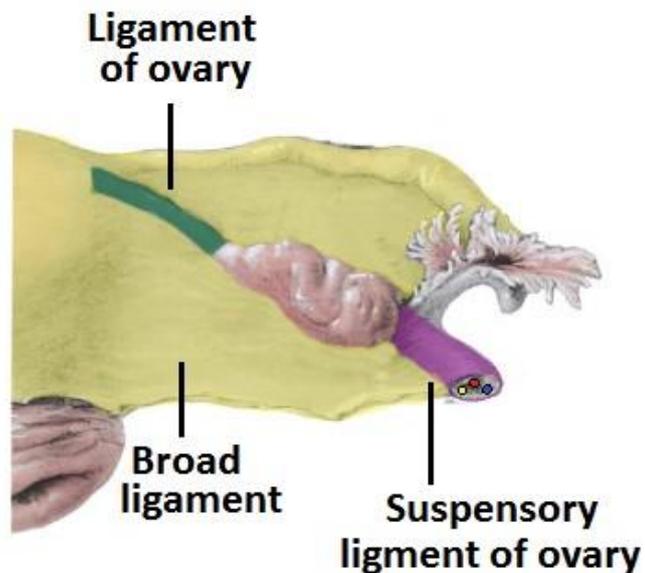


Figure 34 Major ligaments of the ovary

Ligaments Associated with the Uterus

There are 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.

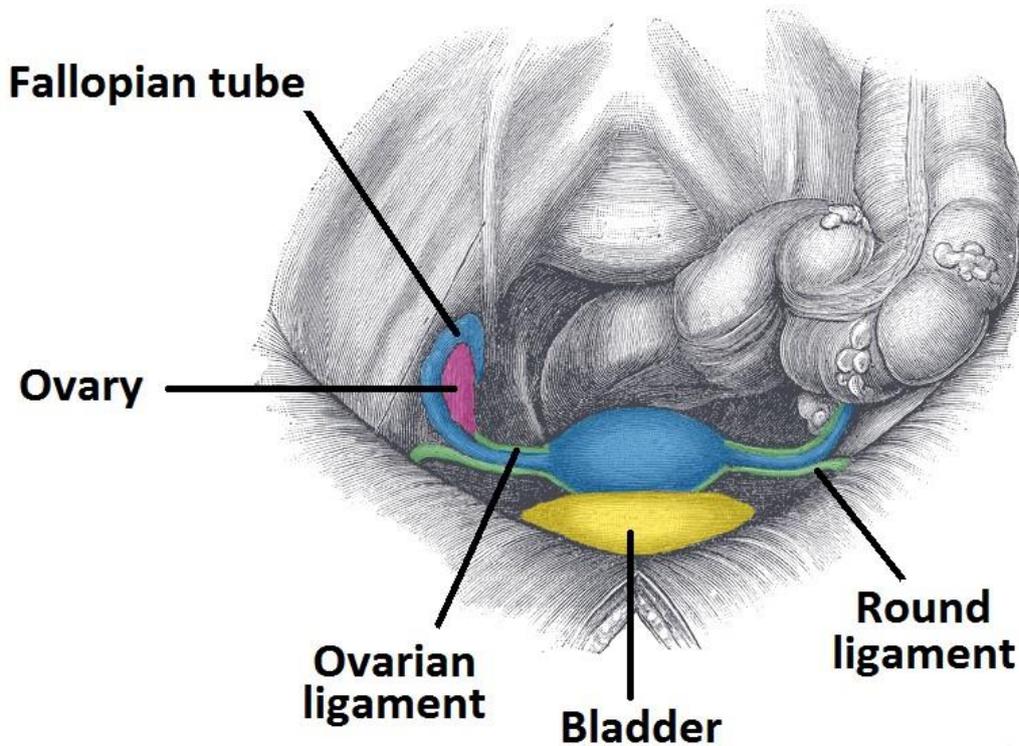


Figure 35 Overview of the uterus and fallopian tubes with associated ligaments

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), passes through the inguinal canal, and attaches to the labia majora

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.

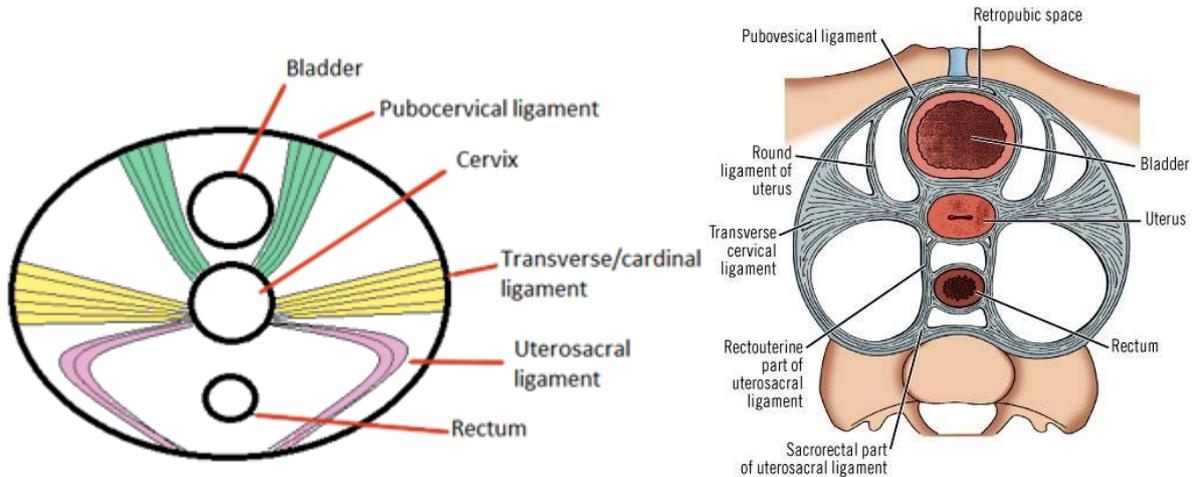


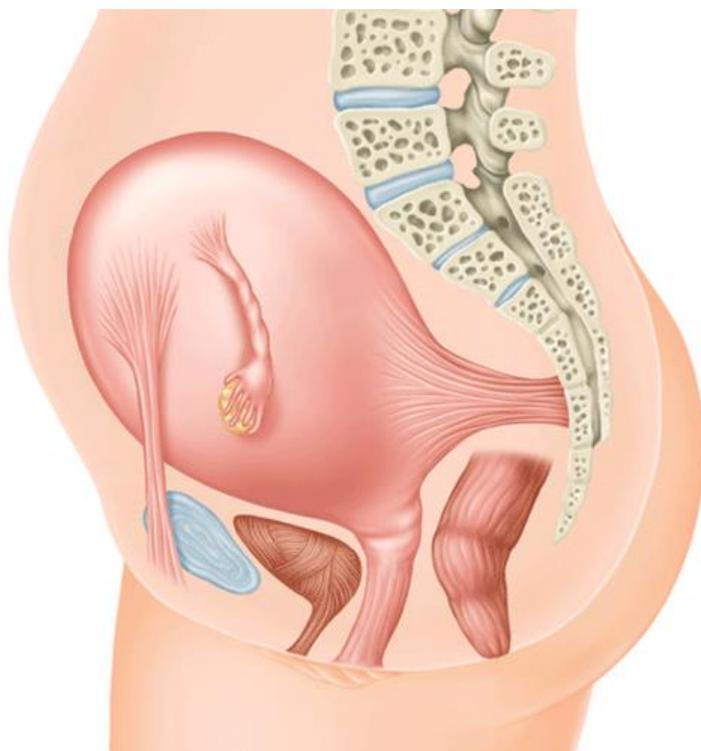
Figure 36 Schematics of the major ligaments of the cervix

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.



These ligaments collectively help maintain the position of the uterus during pregnancy

Figure 37 Diagram showing the round ligament (here from the front of the uterus) and the broad ligament (here from the back of the uterus) demonstrating their function of support during pregnancy

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.

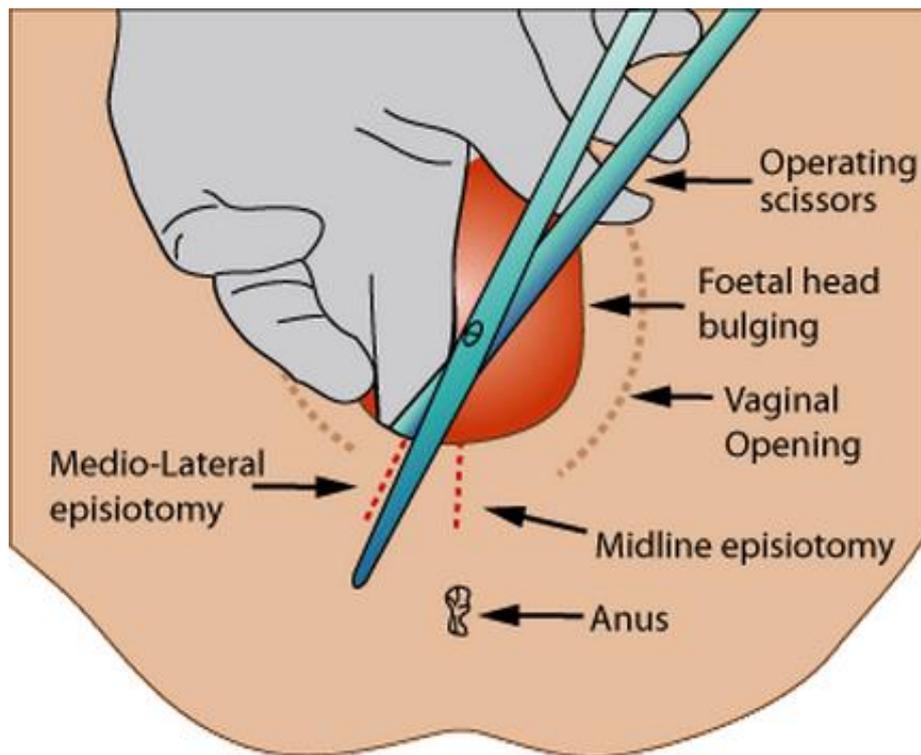


Figure 38 An episiotomy – a deliberate cut to the perineum

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).

Blood vessels of pelvis

Arteries of the pelvis are all branches of the internal iliac artery

- Iliolumbar
 - Psoas Major
 - Quadratus lumborum
 - Iliacus
- Lateral sacral
 - Anterior sacral foraminae
- Obturator
 - Obturator canal
- Superior and Inferior Gluteal
 - Greater sciatic foramen - skin
- Internal pudendal
 - Greater sciatic foramen
- Superior vesicle
 - Fundus of bladder
 - Ductus deferens
- Inferior vesicle (vaginal in female)
 - Fundus of bladder
 - Prostate
 - Seminal vesicles
 - Vagina
- Middle rectal
 - Rectum

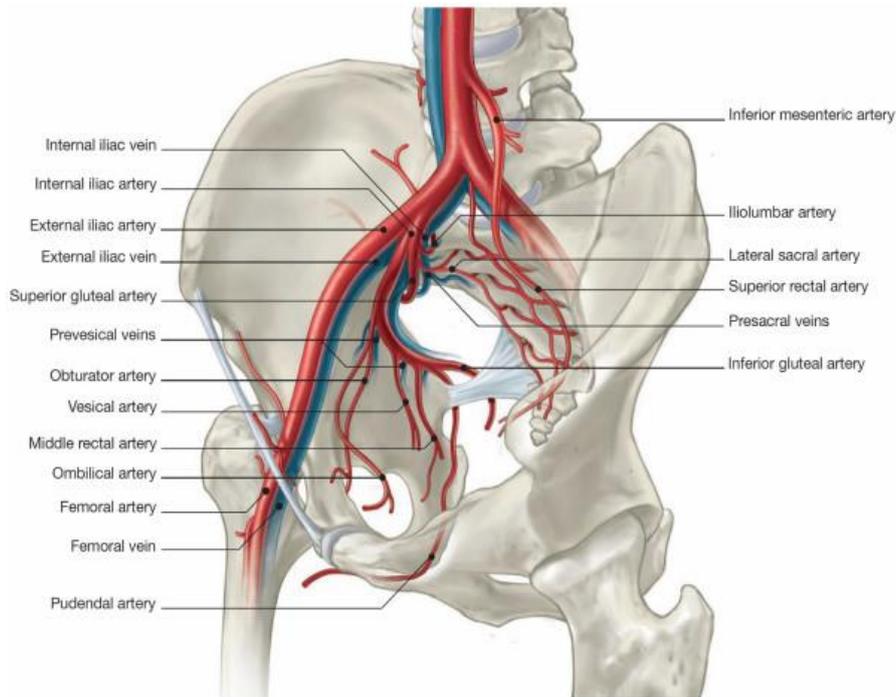


Figure 39 Diagram of vessels of pelvic bowl

Nerves of pelvis

This can be divided into somatic, going to the musculature, and the autonomies.

The sacral plexus

The 4th and 5th lumbar spinal nerves form the lumbosacral trunk. The lumbosacral trunk goes on to join the 1st through 4th sacral nerves as they exit the sacrum to form the sacral plexus. The sacral plexus runs down on the posterior pelvic wall anterior to the piriformis muscle.

The nerves that stem from the sacral plexus include the following:

Sciatic nerve: This nerve is formed by the 4th lumbar through 3rd sacral spinal nerves. It's the largest nerve in the body. It leaves the pelvis through the greater sciatic foramen to enter the gluteal area. It supplies the hamstrings and everything below the knee

Pudendal nerve: This nerve is formed from the 2nd through 4th spinal sacral nerves. It exits the pelvis through the greater sciatic foramen and enters the perineum through the lesser sciatic foramen to innervate the muscles and skin of the perineum.

Superior gluteal nerve: Formed by the 4th lumbar through the 1st sacral spinal nerves, this nerve leaves the greater sciatic foramen to innervate gluteal muscles.

Inferior gluteal nerve: This nerve's formed by the 5th lumbar through 2nd sacral spinal nerves. Like the superior gluteal nerve, it runs through the greater sciatic foramen to innervate gluteal muscles.

Nerve to the quadratus femoris muscle: This nerve is formed from the 4th lumbar through the 1st sacral spinal nerves. It leaves the greater sciatic foramen to innervate hip muscles.

Nerve to the obturator internus muscle: This nerve is formed by fibres from the 5th lumbar through the 2nd sacral spinal nerves. It also leaves the greater sciatic foramen to innervate hip muscles.

Nerve to the piriformis muscle: Stemming from the 1st and 2nd sacral spinal nerves, this nerve innervates the piriformis muscle.

Perforating cutaneous nerve: This nerve is formed from the 2nd and 3rd sacral spinal nerves and innervates the skin over the lower and medial portion of the buttock.

Posterior femoral cutaneous nerve: This nerve's formed from the 2nd and 3rd sacral spinal nerves and innervates the skin of the perineum and the back surface of the thigh and leg.

Pelvic splanchnic nerves: Stemming from the 2nd through 4th sacral spinal nerves, these nerves provide the parasympathetic innervation to the pelvic organs.

The coccygeal plexus

The coccygeal plexus of nerve fibres is formed by the 4th and 5th sacral spinal nerves and the coccygeal nerves. It supplies the coccygeus and levator ani muscles and the sacrococcygeal joint. Anococcygeal nerves innervate the skin between the coccyx and anus.

Obturator nerve

The obturator nerve arises from the lumbar plexus and doesn't innervate anything in the pelvis, but it runs through the pelvis to the medial thigh. It supplies the adductors group of muscles

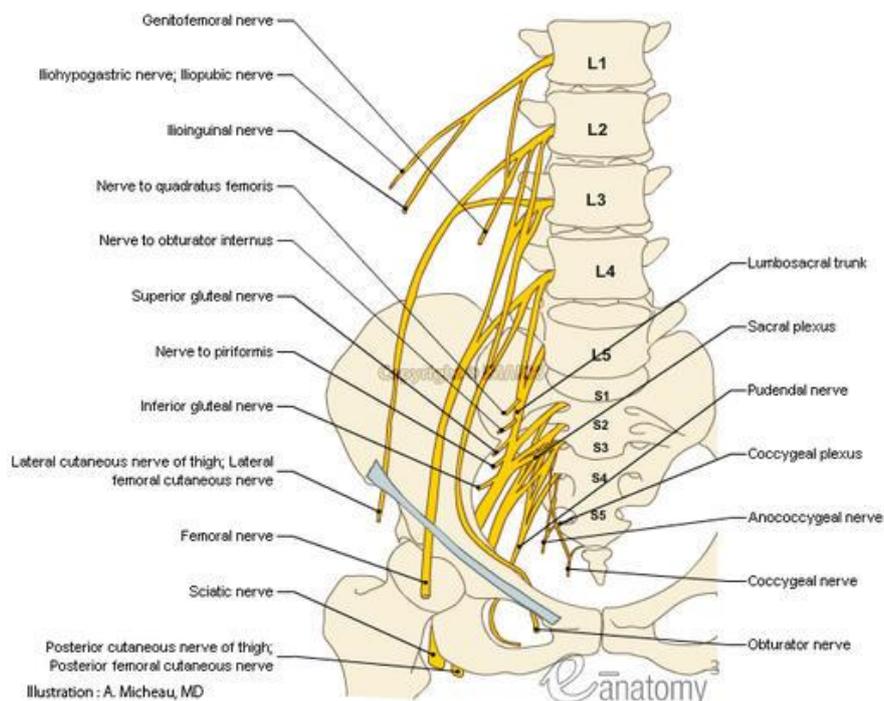
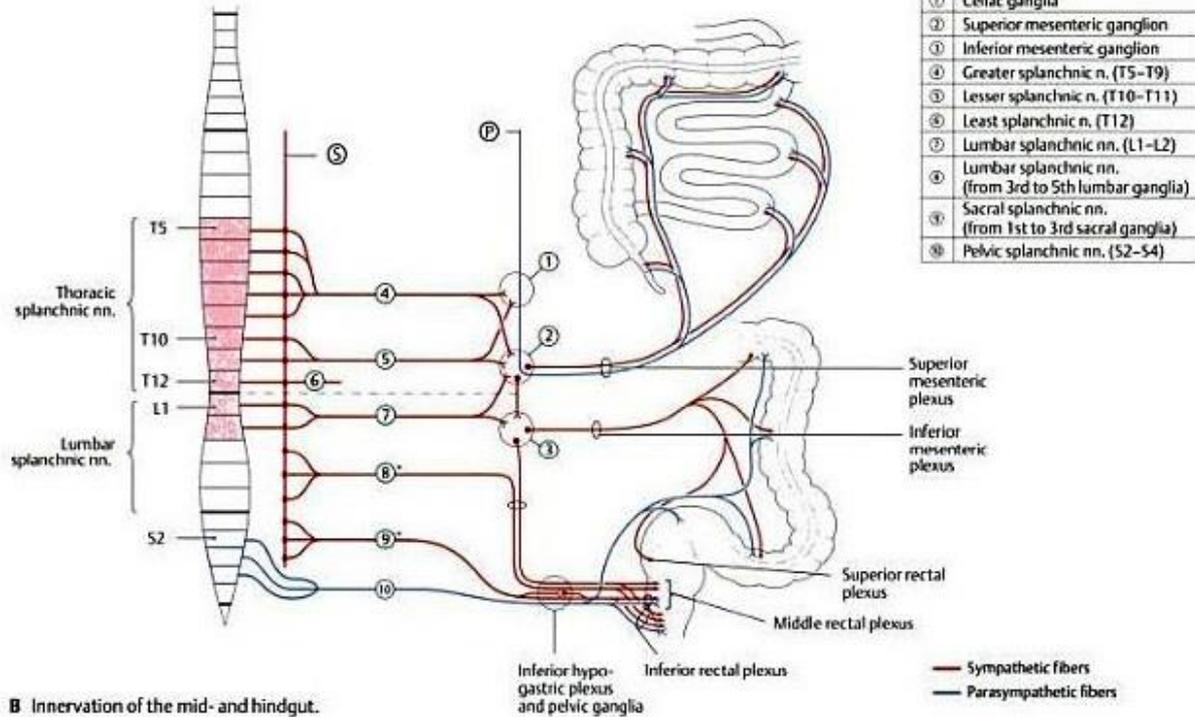


Figure 40 Schematic of somatic nerves of pelvis

The Autonomics

A Innervation of the foregut. As the left and right vagus nerves descend along the esophagus, they become the anterior and posterior vagal trunks, respectively. Each trunk produces a celiac, pyloric, and hepatic branch, and a gastric plexus.



B Innervation of the mid- and hindgut.

*Synapse in the lumbar sympathetic ganglia.

Figure 41 Schematic of Autonomic nerves of pelvis

The sympathetic chain is a continuation of the lumbar chain. The inferior hypogastric plexus, the hub of all autonomic control within the pelvis, is more of a meshwork of nerves than nerve trunks. It starts in the abdomen at the origin of the inferior mesenteric artery and passes along the aorta to the presacral area where it splits into a left and right branch and lays behind the rectum

The parasympathetic chain arises from S2, S3 and S4. It supplies the pelvic structures as well as the left colic flexure, descending and sigmoid colon.

The Urinary System The Ureters

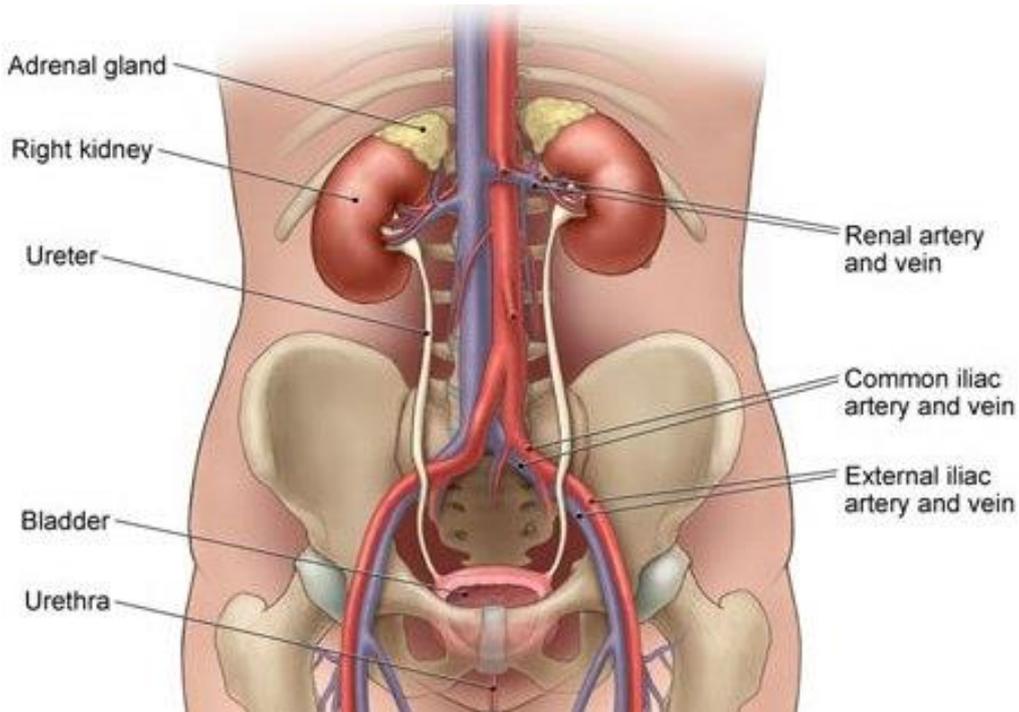
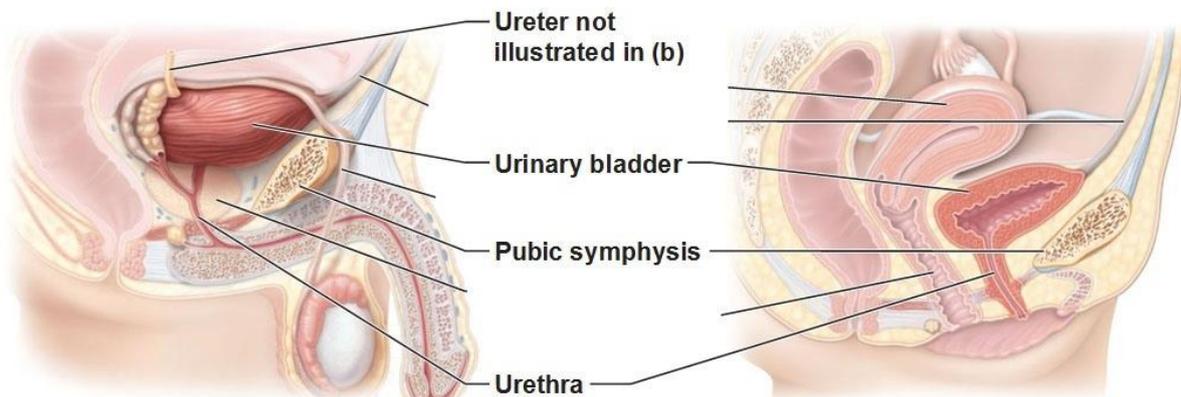


Figure 42 Diagram of Urinary System

The ureter is a very important structure on the posterior abdominal wall. It passes down and remains retroperitoneal until it approaches the bladder from its posterolateral side.

The Urinary Bladder



(a) Sagittal section through male pelvis, urinary bladder shown in lateral view

(b) Sagittal section through female pelvis

Figure 43 Diagrams of male and female urinary bladders

The urinary bladder is just behind the pubic bone.

Its peritoneal reflections:

Vesicouterine pouch (female) between the bladder and the uterus

Rectovesicular pouch (male) between the bladder and the rectum

Its wall is the detrusor muscle and it is lined with transitional epithelium

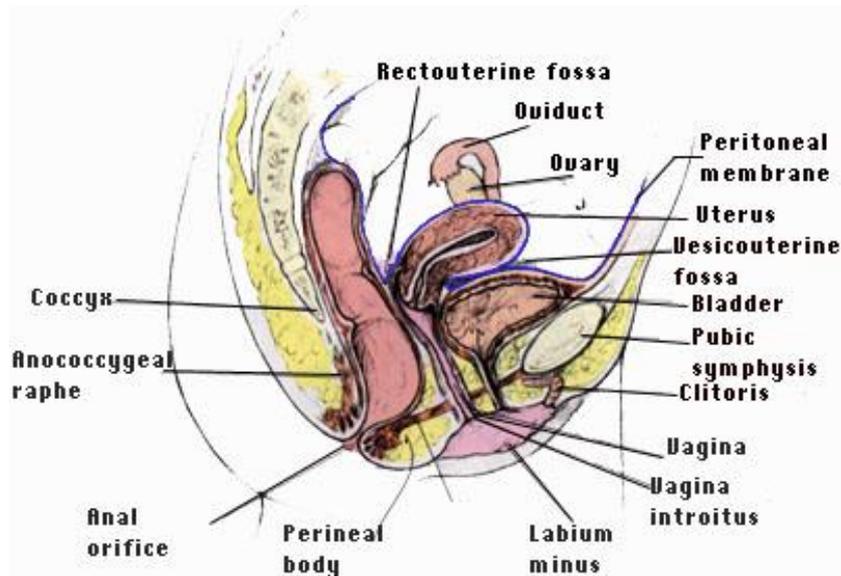
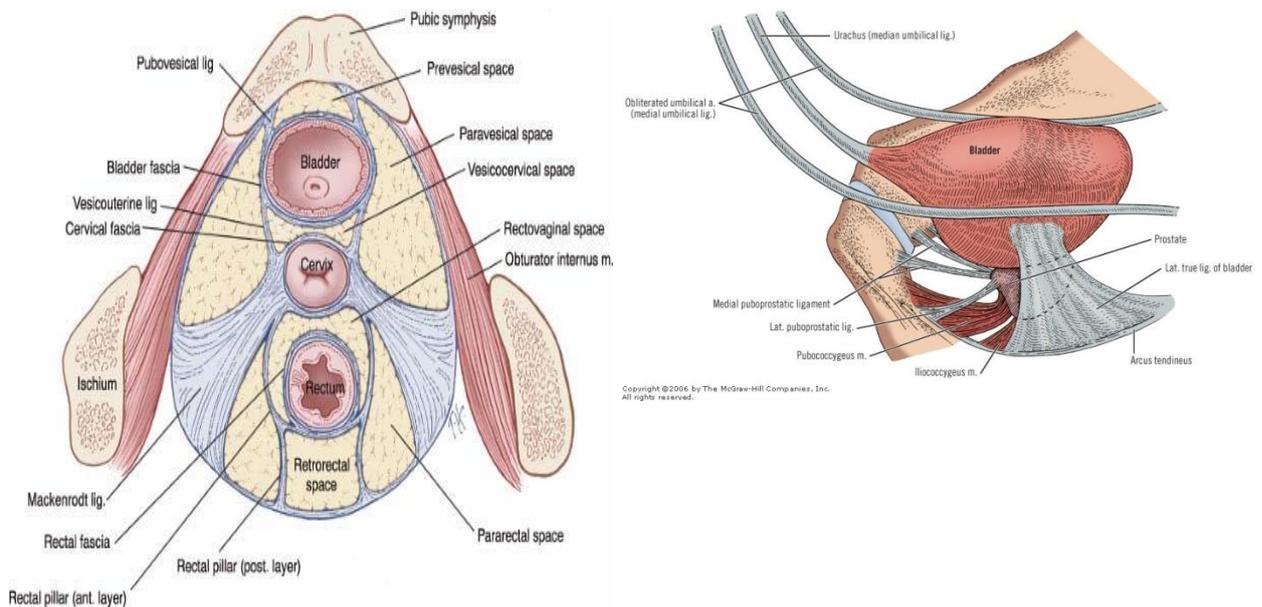


Figure 44 Diagram of peritoneal folds around bladder

The neck is just inferior to the trigone of the bladder and is called the **sphincter vesicae**. It is supplied by the autonomic and is fixed by the **pubovesical ligament** (female) and the **puboprostatic ligament** (male).

Figure 45 Diagrams showing support ligaments of bladder in male and female



More support is proffered by:

- **Urogenital diaphragm**
- **Pelvis fascia**
- **Medial Umbilical ligament** (obliterated umbilical artery)
- **Median Umbilical Ligament** (Urachus)

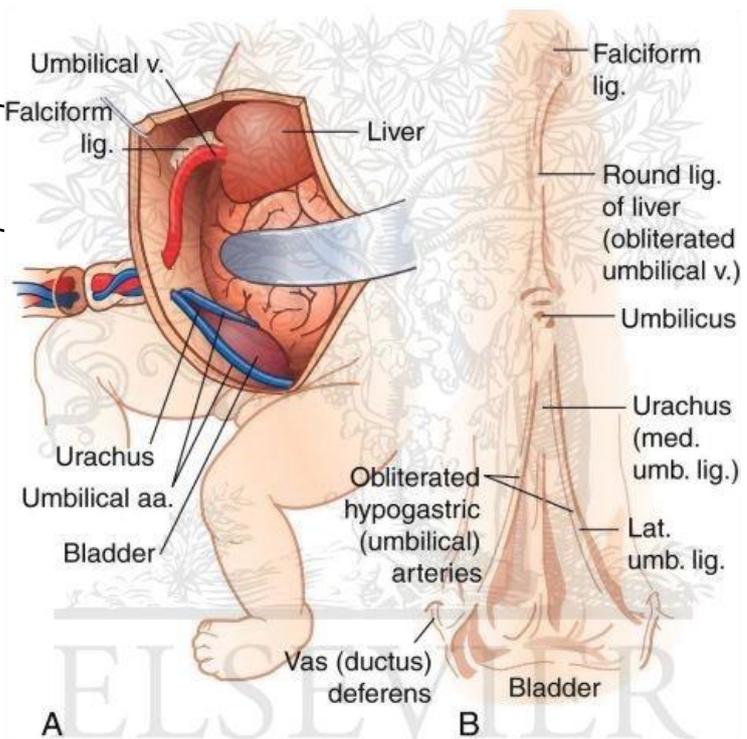


Figure 46 Diagram of ligaments of bladder

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Trigone

The trigone is a triangular area at the base of the bladder, at its exit. It is a region that is very sensitive to pain and pressure (of the bladder filling). It is supplied by the inferior hypogastric nerve.

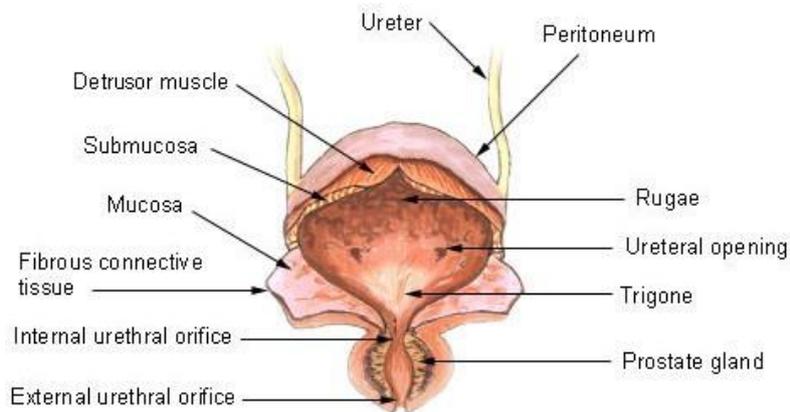


Figure 47 Trigone of bladder

The Urethra

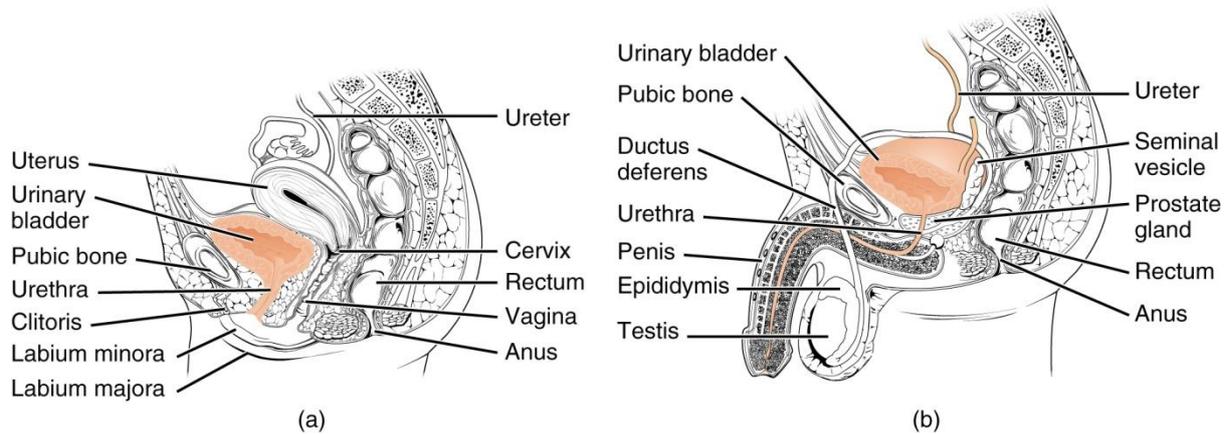


Figure 48 Urethra of male and female

<p>Female 4cm length Sphincter urethrae is incomplete Damage to urogenital diaphragm can be common during childbirth and can lead to urinary incontinence</p>	<p>Male 20cm length Has 3 segments:</p> <ol style="list-style-type: none"> 1. Prostatic urethra <ul style="list-style-type: none"> • Most dilatable, contains opening of ejaculatory duct 2. Membranous urethra <ul style="list-style-type: none"> • Urogenital diaphragm, sphincter urethrae and is fixed and narrow and has opening for bulbourethral glands which secrete mucus to expel urine during ejaculation 3. Spongy (penile) urethra <ul style="list-style-type: none"> • Longest section. Contains lacunae (openings to urethral glands). They are commonly infected in venereal disease, leading to a stricture and results in a burning sensation in urination
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Prostatic utricle - occurs near the opening of the vas deferens into the urethra

Seminal vesicles - produce part of semen

The Prostate

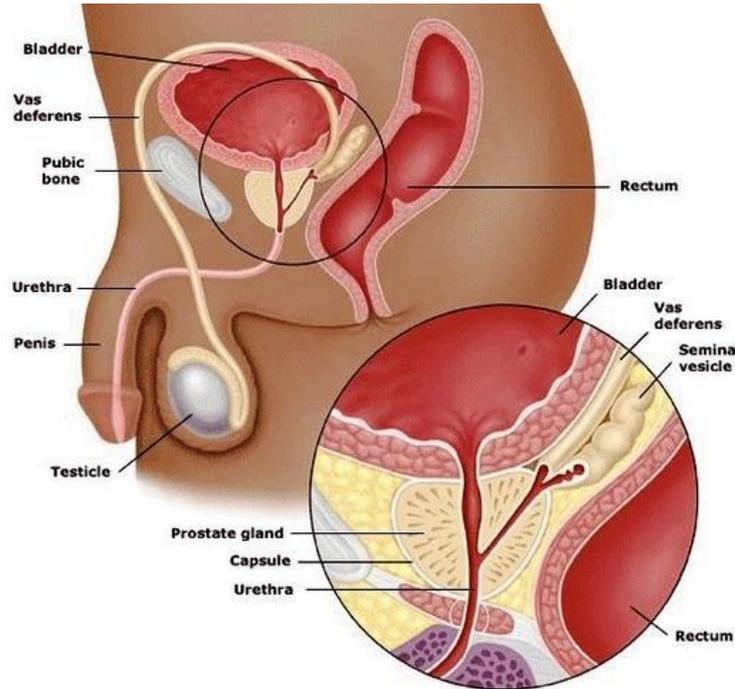


Figure 49 The prostate

The prostate consists of fibromuscular connective tissue and its size is 4x3x2cm.

It is divided into 5 lobes:

- 2 lateral
- Anterior
- Posterior
- Median

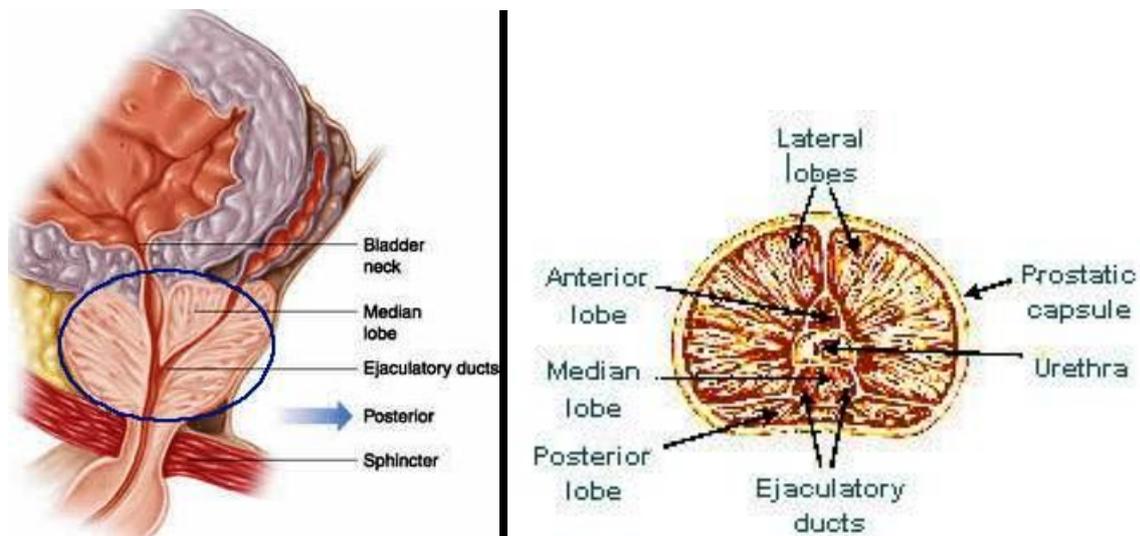


Figure 50 views of prostate lobes from side and above

The ejaculatory duct inserts between the posterior and median lobes

Prostatic secretions contain citric acid and alkaline phosphatase. Of these elevated phosphatase levels can be a sign of prostate cancer

Vasculature:

- Inferior and middle vesicle arteries and prostatic plexus

Lymphatics

- Internal iliac nodes

Nerve supply

- Inferior hypogastric plexus

Clinical correlations

A digital rectal examination can be carried out to assess the prostate as to whether it is enlarged

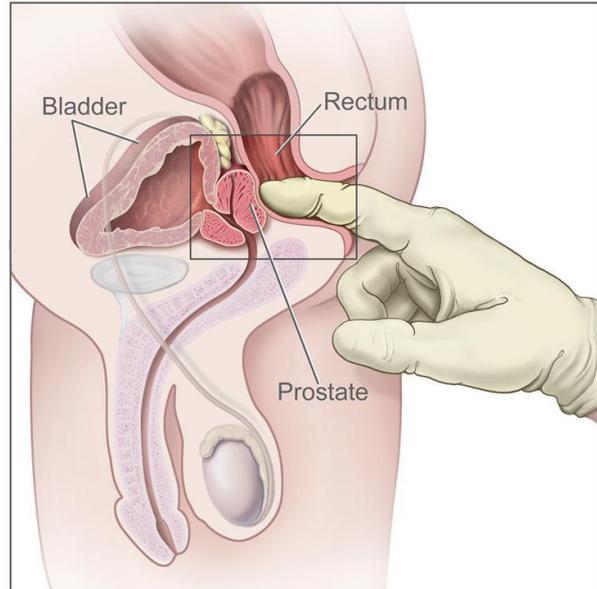
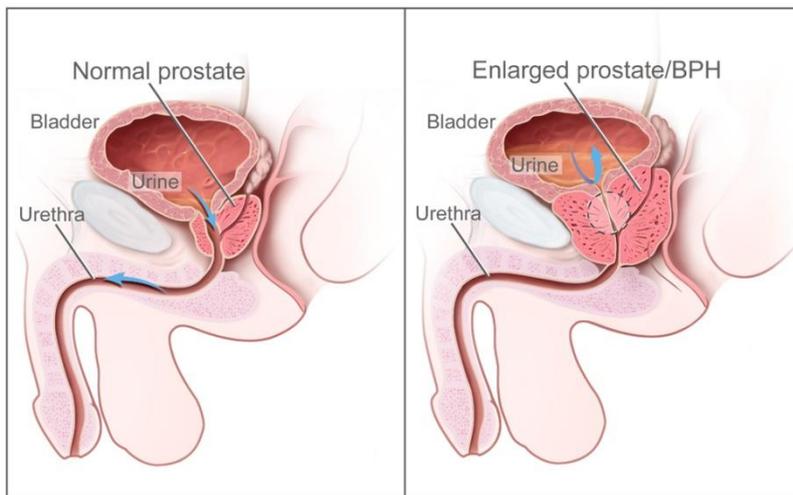


Figure 51 Digital examination of prostate



The median lobe is highly glandular and is prone to benign prostatic hyperplasia (>40yoa) leading to obstruction of urine flow.

Figure 52 Benign prostatic hyperplasia

The posterior lobe is more prone to carcinoma. This cancer can spread from the prostatic plexus to the vertebral plexus and into the CNS. This can cause back pain.

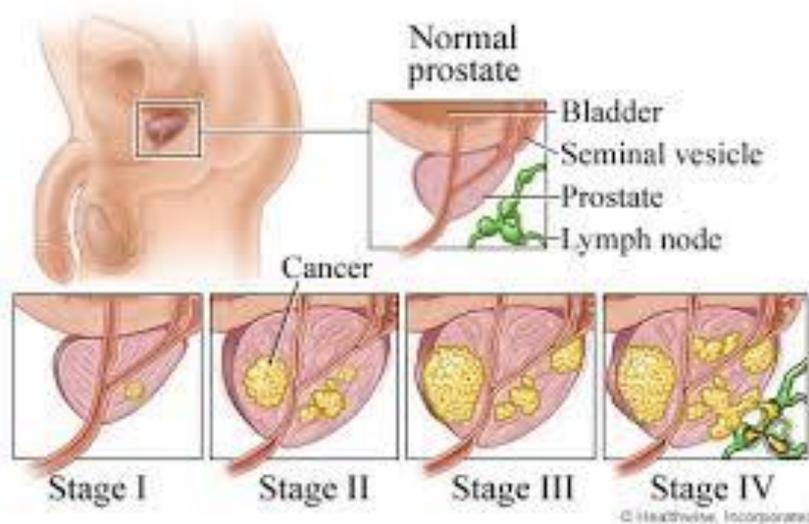


Figure 53 Prostatic Cancer

The Uterus

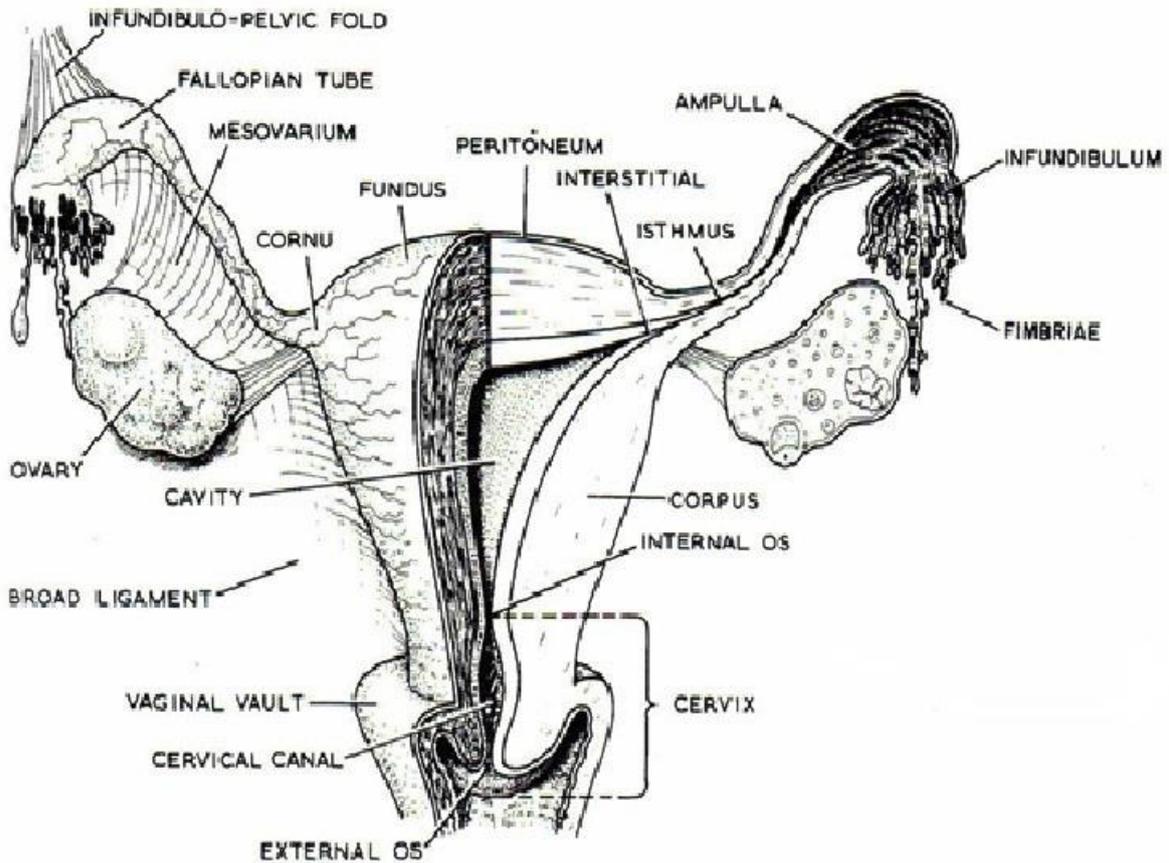


Figure 54 Diagram showing regions of uterus

The uterus has four parts:

- Fundus
- Cornu
- Body (corpus)
- Cervix

The muscular wall of the uterus is the myometrium

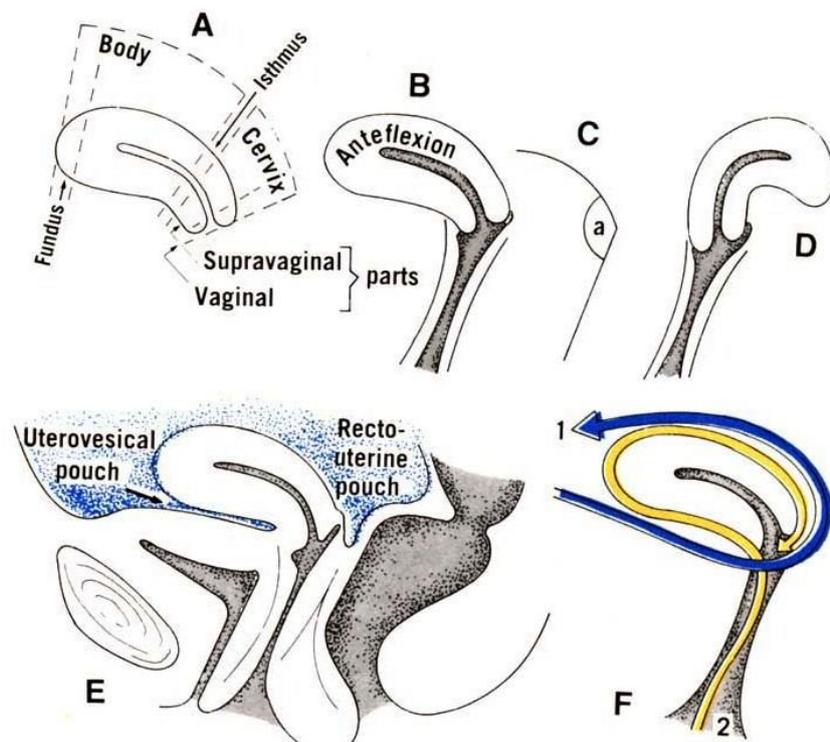


Figure 55 The uterus and its various positions

- A - Shows the parts of the organ.
- B - Shows the normal position of ante flexion and anteversion.
- C - Shows the angle (a) of anteversion.
- D - Represents a retroverted uterus.
- E - Shows the uterovesical and recto-uterine pouches.
- F - Demonstrates the principle of (1) abdominal and (2) vaginal hysterectomy (arrows).

The primary support of the uterus is the pelvic and urogenital diaphragms (see earlier)

Secondary support to the uterus are 3 fascial condensations:

- a. Transverse cervical ligaments (cardinal ligaments)
- b. Uterosacral ligament
- c. Pubocervical ligament

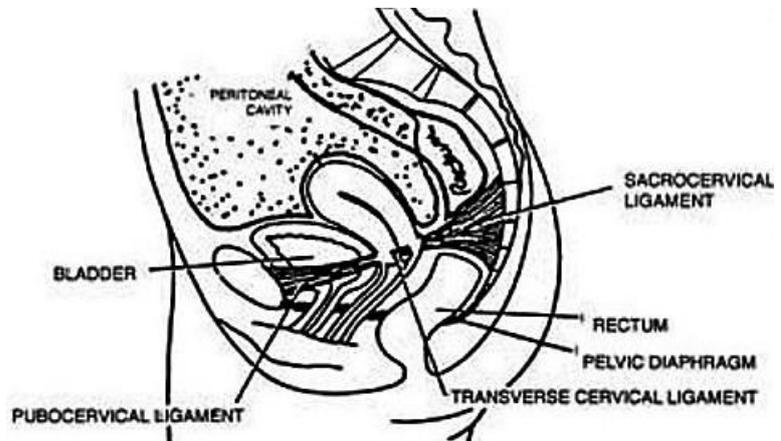
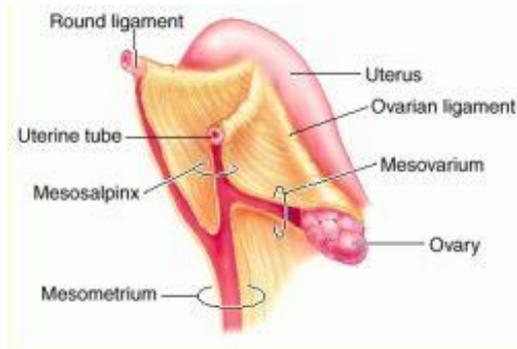


Figure 56 Secondary fascial supports for the uterus



Also:

- The peritoneum, via the broad ligament
- Rectouterine pouch (pouch of Douglas)

Figure 57 Uterine ligamentous support, viewed from the side and above

Vasculature

- Uterine artery
- Uterine venous plexus
- Internal iliac vein

Lymphatics

- External and internal iliac nodes
- Sacral node

Nerve supply

- Inferior hypogastric plexus

The ovary is suspended from the pelvic wall by the **suspensory ligament** (fig 50), and the blood vessels to the ovary also lie in that ligament.

The ovarian ligament continues to the uterus as the **round ligament**; a structure that passes forward, out through the inguinal canal and merges with the labia majora.

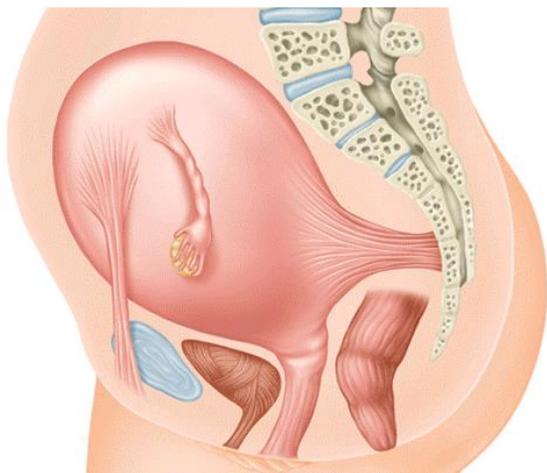


Figure 58 Round ligament

The ovarian ligament and round ligament are remnants of the cords that pulled down the ovaries from their original abdominal wall position. The natural growth of the uterus halts this progression. If no uterus develops, the ovaries will continue to descend similar to the testes in the male.

The Perineum

The perineum is a diamond shaped area inferior to the pelvic diaphragm; it includes the anus and the external genitalia.

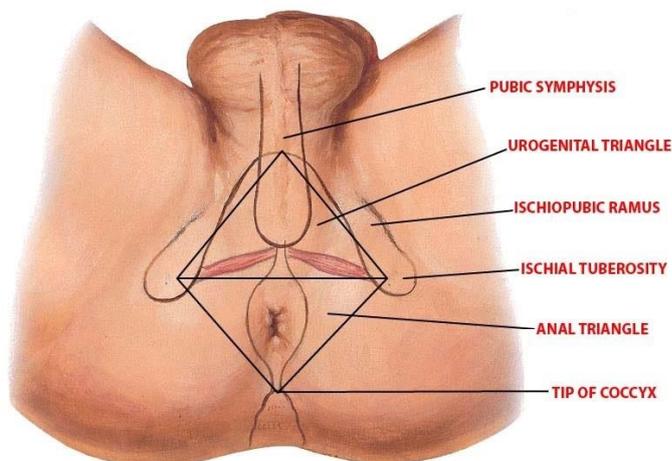


Figure 59 Perineum - from exterior

Boundaries:

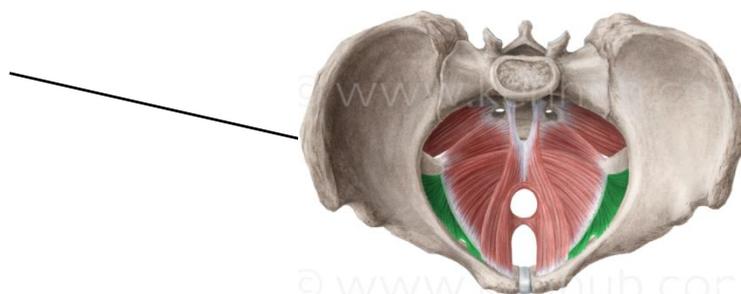
Above:

- Pelvic diaphragm

Lateral:

- Medial surface of pubic and ischial rami
- Obturator internus, below attachment of levator ani

Figure 60 Perineum



The perineum is divided into two triangles (Fig 59) by a transverse line between the two ischial tuberosities.

The posterior (anal) triangle

This includes the anus, the anal canal and urogenital fossae (fat filled spaces on either side of the anus)

The anterior (urogenital) triangle

This includes pouches, external genitalia and urethra

The **perineal body** is the central tendon of the perineum and appears as a thickened, midline condensation of fibrous tissue.

The **Coccygeal body** is a midline condensation of fascia between the anus and coccyx

The Anal Triangle

The anal canal is about 4cm long, is directed posterior and downwards and begins at the end of levator ani

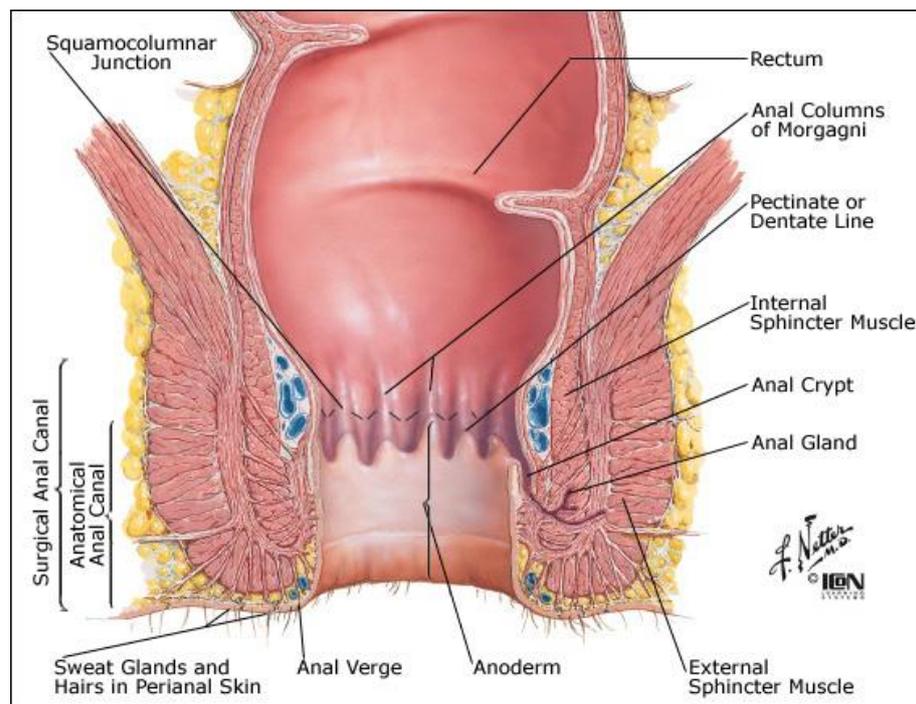


Figure 61 Anal canal

There are three regions to the anal canal:

Superior;

- Anal valves and columns (6-10 folds)
- Anal sinus (pockets of space formed by valves)
- Anal glands (produce mucous secretion to aid passage of faeces)

Transitional

- Pectinate line (smooth, hairless, about 2cm wide). It marks the transition between:
 - Ectodermal and endodermal mucosal epithelia
 - Inferior and superior blood supply, venous and lymphatic drainage

Cutaneous

- Pigmented skin, hairs, glands

Ischiorectal fossa

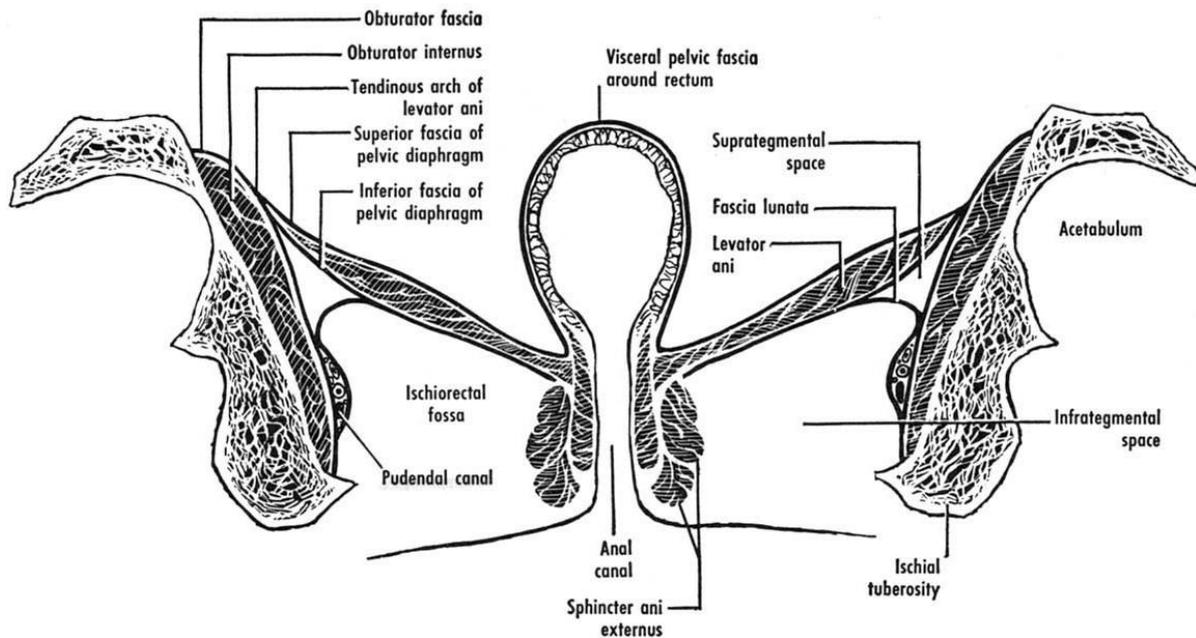


Figure 62 Ischiorectal fossa

These are wedge shaped spaces just lateral to the anal canal. The lateral walls are formed by obturator internus and is filled with adipose and fibrous tissue. It permits distension of the anal canal. The pudendal canal (Adcock's canal) is found on the lateral walls of the fossa, containing the pudendal nerve and internal pudendal vessels. It extends from the lesser sciatic notch to the posterior tip of the urogenital diaphragm. It has not lymphatic drainage and infections here can be dangerous.

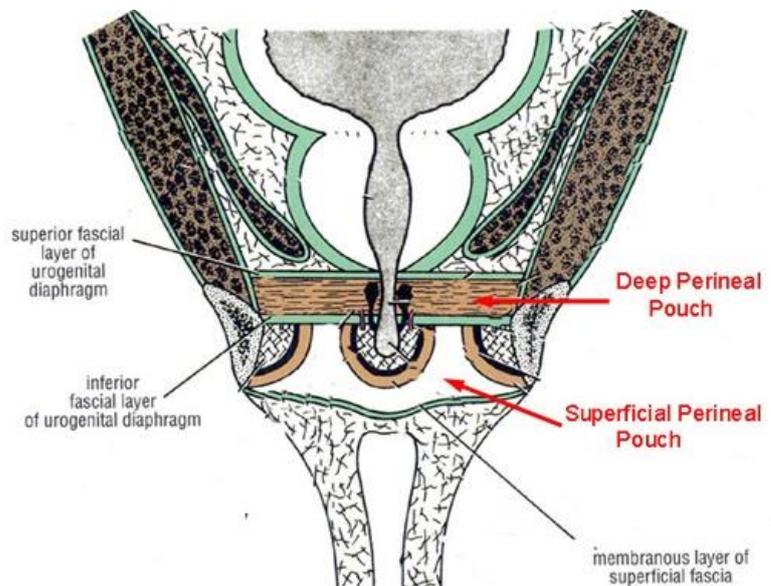
Urogenital triangle

The urogenital triangle is divided into two pouches, superficial and deep. Sandwiched between these are three fascial layers, which fuse posteriorly and merge with the perineal body.

Deep perineal pouch

Figure 63 The Perineal Pouches

The deep perineal pouch consists of transverse sheets of muscles spanning the triangular space between the ischiopubic rami. It is covered above and below by the superior and inferior fascia of the urogenital diaphragm, which fuse around the anterior free edge to form the transverse perineal ligament.



The pouch is completely closed; it does not communicate with other perineal or pelvic spaces.

Its muscular components completely fill the pouch

- Deep transverse perineal muscle
- Urethrovaginal sphincter (in females) medial fibres encircle vagina and urethra
- Sphincter urethrae (in males) medial fibres encircle membranous urethra

Other contents:

- Branches of pudendal nerve and internal pudendal vessels both run along its lateral walls
- In females, it is pierced by the vagina and urethra
- In males, it contains the bulbourethral glands (Cowper's glands)
- In males it is pierced by the membranous urethra

The perineal membrane (the inferior fascia of the urogenital diaphragm) provides attachment for the external genitalia.

The Superficial Perineal Pouch (see Fig 63)

The superficial perineal pouch is the space enclosed between the perineal membrane and the perineal fascia

- It is continuous anterosuperiorly with the superficial abdominal wall
- It is limited laterally by the superficial perineal fascia to the ischiopubic rami
- It is limited posteriorly by the posterior margin of the urogenital diaphragm
- In males, it surrounds the penis and scrotum
- In females, it is split by the vestibule (opening) of the vagina and confined to each side of the labia majora

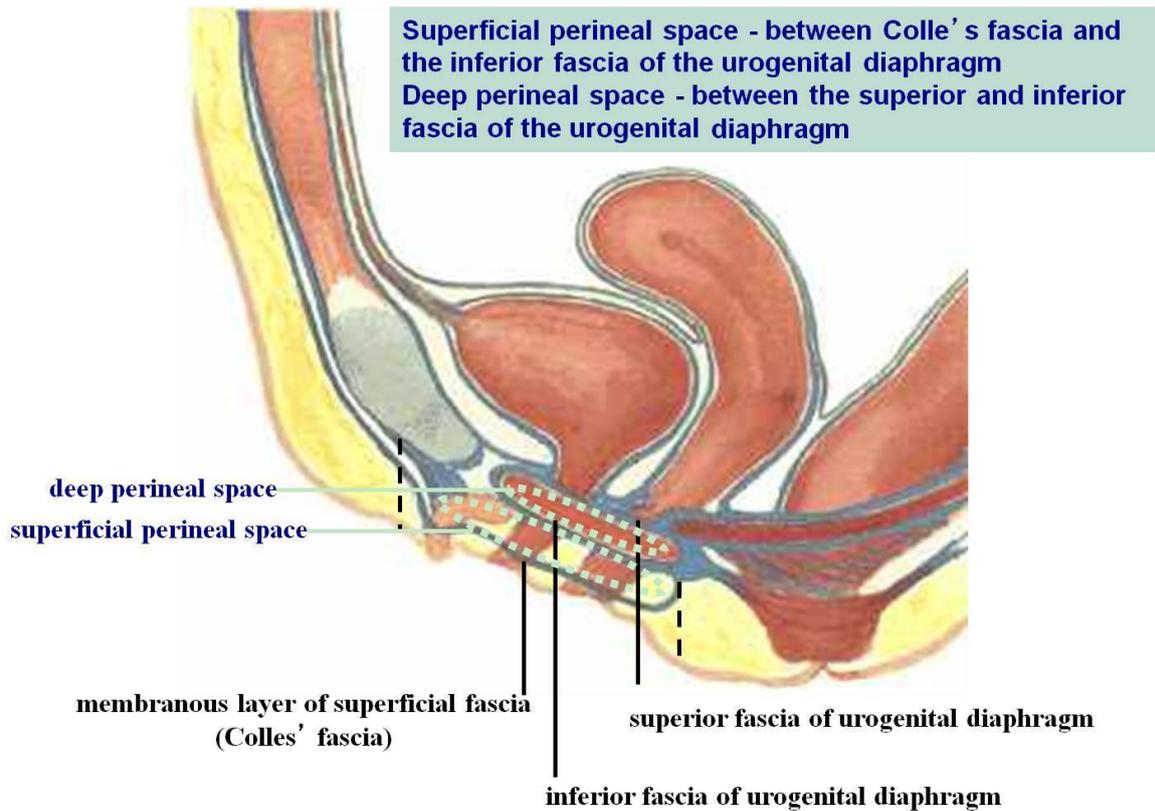


Figure 64 Superficial Perineal Pouch

It is divided into two compartments by the deep perineal fascia (Buck's Fascia) and the superficial compartment is continuous with the tissue space of the anterior abdominal wall while the deep space is closed anterosuperiorly.

Contents:

- Erectile cavernous masses
- Corpus spongiosum
- Corpus cavernosa
- Superficial perineal muscles:
 - Superficial transverse perineal; extending from the ischial tuberosity to the perineal body, and anterior to the anus
 - Bulbospongiosus
 - Ischiocavernosus

Branches of the pudendal nerve and the internal pudendal vessels supply the genitalia

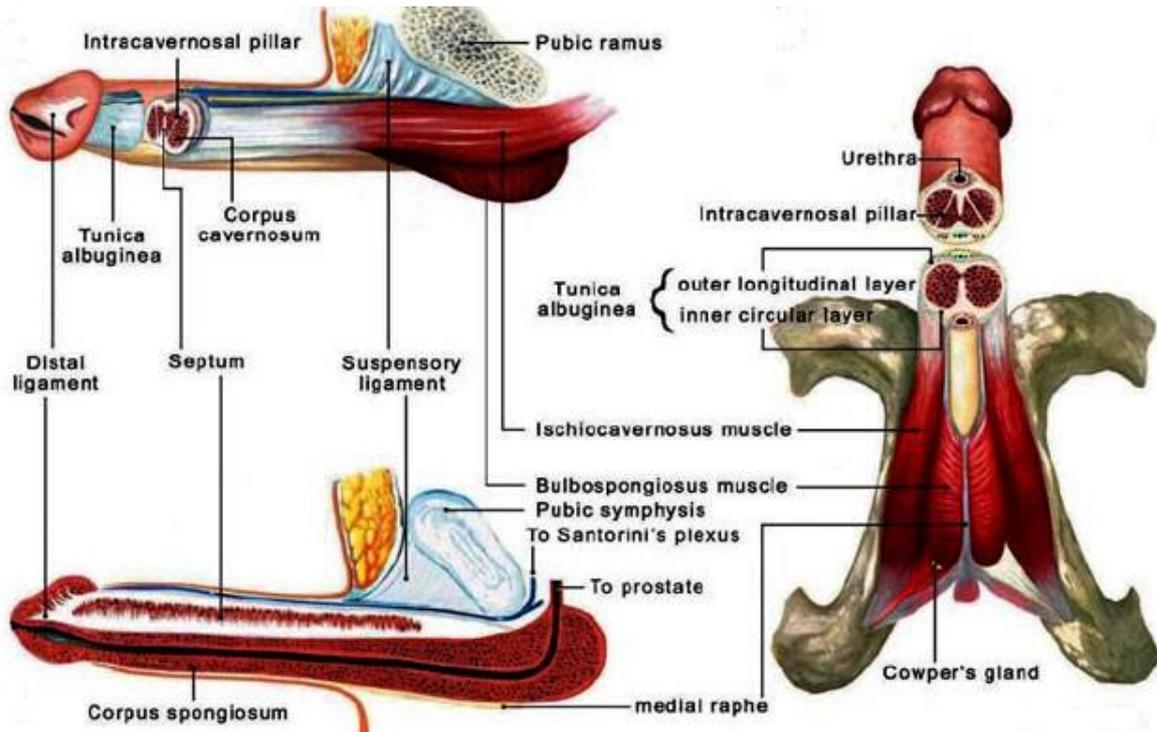


Figure 65 Male external genitalia

Disorders of the Pelvis

Pelvic diaphragm failure

If the pelvic diaphragm fails in the female, then the contents of the pelvic bowl may 'slip' down and even prolapse. Examples of these are:

Bladder prolapse/Cystocele of uterus

Rectocele

Prolapse

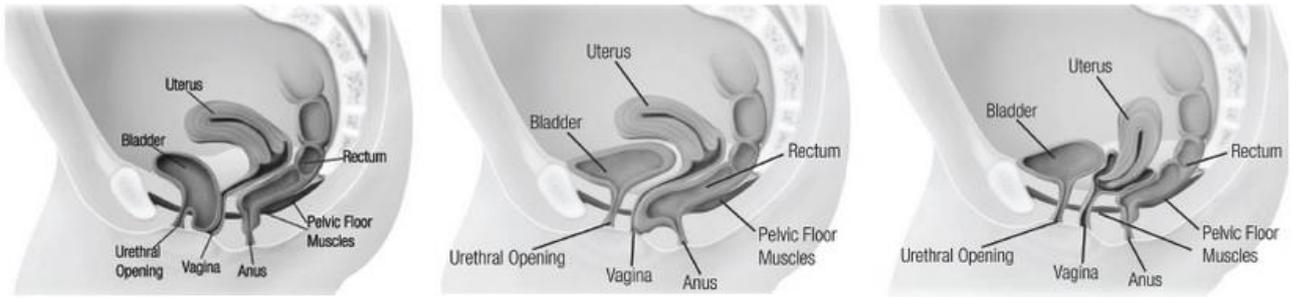


Figure 66 Prolapse of pelvic organs

If these become serious, they may need surgical repair

Pelvic Inflammatory Disease

Pelvic inflammatory disease (PID), general acute inflammation of the pelvic cavity in women, caused by bacterial infection of the cervix, uterus, ovaries, or fallopian tubes. The disease is most often transmitted by sexual intercourse and is usually the result of infection with gonorrhoea or chlamydia. PID typically occurs in women who are under age 25 and are sexually active, who have multiple sexual partners, who have unprotected sex, or who have a history of sexually transmitted disease.

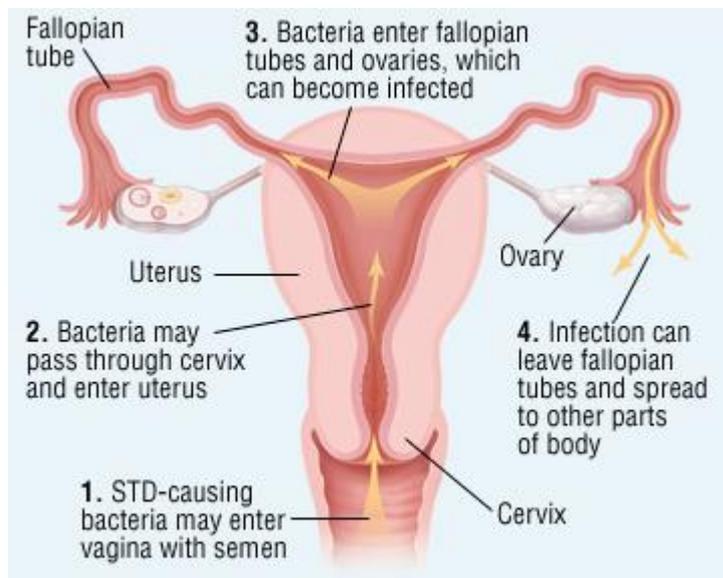


Figure 67 Pelvic Inflammatory Disease

The symptoms of PID are similar to and may be mistaken for those of gonorrhoea. They include pain in the abdomen and lower pelvis, chills, nausea, fever, and a thick and peculiarly odorous vaginal discharge. The major complication of PID is scarring of the fallopian tubes,

with infertility often a consequence. The incidence of ectopic pregnancies (i.e., those in which the fertilized egg becomes embedded outside the uterus) is much higher in women with a history of PID. Some women develop chronic pelvic pain. Other complications include the development of abscesses on the fallopian tubes or ovaries, which can result in potentially dangerous infections.

The treatment of PID consists of antibiotic therapy to fight the infection. The diagnosis and treatment of male sexual partners of women with PID is also called for, since failure to do so exposes the women to further infections.

Paget's Disease (osteitis deformans)

Normal bone undergoes a continual process of remodelling. This involves **osteoclast** activity, breaking down bone, and **osteoblast** activity, forming new bone. Paget's disease causes a malfunction in this process, with the new bone that is laid down being soft and porous. Soft bones can be weak and bend easily, leading to a shortening of the affected part of the body. The bone replacement takes place very quickly and an excess may be formed. This may cause the bone to get large, painful and may break easily. The bone affected by Paget's tends to have more blood vessels, resulting in the area feeling warmer than usual.

Paget's can affect any bone, but most commonly:

- Spine
- Pelvis
- Femur
- Tibia

Figure 68 Paget's Distribution

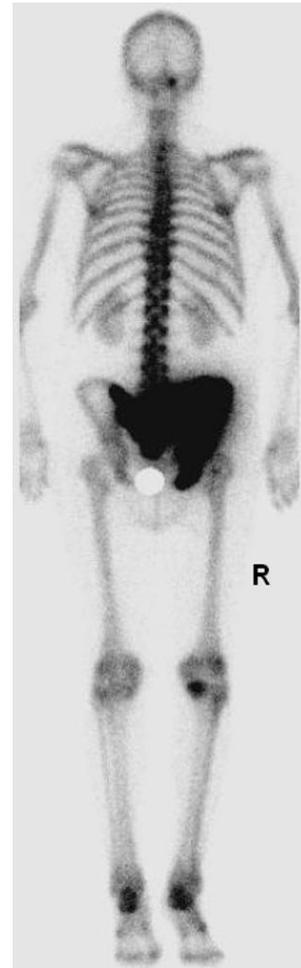
Paget's can also predispose to other conditions, such as O/A, kidney stones and heart disease

Paget's:

- Affects more men than women
- Usually people over 40 yoa
- No apparent cause
- 30% sufferers have other family members with it
- It is a worldwide condition, but more prevalent in Europe and Australia; sufferers more likely to have an Anglo-Saxon descent, hence it may have a genetic factor
- The symptoms may be so mild that the person has no symptoms at all
- It may manifest as cutaneous rash in genital area
- No known cure

Warning Signs

- As it has a very slow onset, many people do not know they have it
- The fist symptom may be pain in or over a bone
- The affected area may feel warm
- Tiredness
- If it affects the leg, it may change its shape such that is bows outwards
- Usually only affect one or two bones



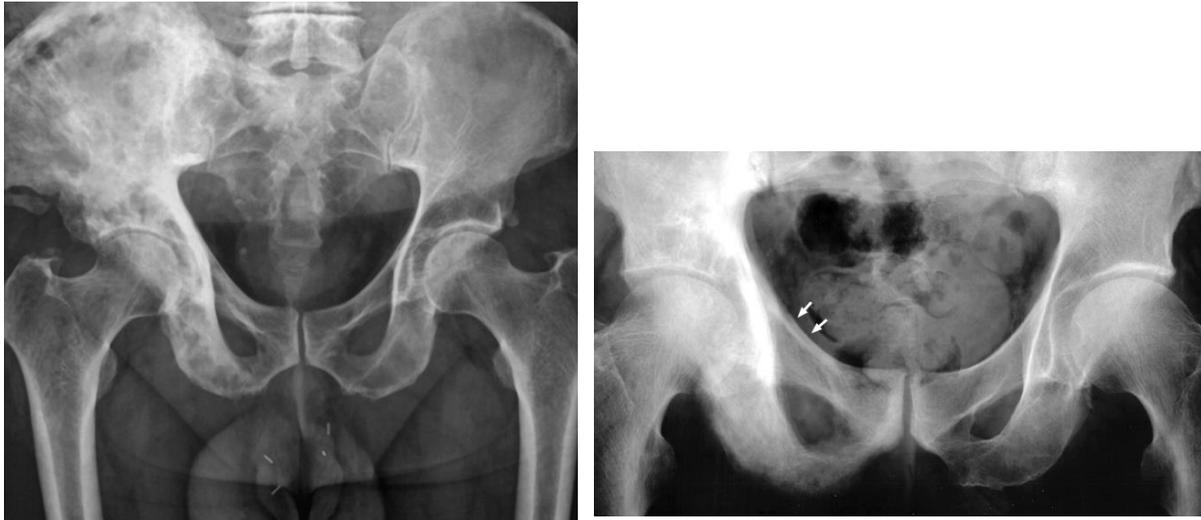


Figure 69 X-Rays of pelvis with Paget's disease.

Note in Fig. 69, that there is thickening of the bone, with thickening of the iliopectineal line in the X-Ray on the right.

Medicines Prescribed

- Bisphosphonates
 - These have been shown to be helpful in rebuilding bone, in reversing bone loss and causing the body to produce normal bone
- Calcitonin
 - This hormone decreases blood calcium and increases bone density. It reduced bone destruction and can also reduce pain. Often Calcitonin from eels and salmon are used; it is many times more powerful than the human form
- Calcium supplements are recommended
 - Milk, cheese, yoghurt, salmon, sardines, dark green leafy vegetables, almonds and broccoli

Exercises

- The pain and swelling of Paget's can make the joints stiff. Not using it will cause them to become weak; exercise will help reduce the stiffness and keep the joint moving
- The wrong type of exercise can make the condition worse; some may even cause the bones to break

Hot and cold can give temporary relief symptoms

- Heat helps to reduce pain and stiffness via increasing circulation
- Cold helps numb the area via reducing blood flow; it can help reduce inflammation

Advice

- After heavy or repetitive activity; **rest**
- Use the back and limbs wisely to avoid putting stress on them (e.g. use a trolley for shopping)
- Maintain an ideal body weight to minimise the strain on the bones

Paget's disease occurs anywhere in the skeleton, but the pelvic bones and proximal femur are among the preferential sites. Although Paget's disease is not a neoplastic condition, it may be confused with tumours or tumour-like lesions. Diffuse metastatic disease is the most important diagnosis to rule out. The lytic phase may mimic an osteolytic tumour, but especially the mixed lytic and blastic phases may be confused with metastases from prostate cancer, or the regional metastases from tumours arising from the urogenital system.

Diastasis Symphysis Pubis

Diastasis symphysis pubis is the separation of normally joined pubic bones, as in the dislocation of the bones, without the incident of a fracture. An X-ray film will show a marked gap between the pubic bones, normally there is a 4–5 mm gap but in pregnancy, hormonal influences cause relaxation of the connecting ligaments and the bones separate up to 9 mm. To demonstrate instability of the joint the patient is required to stand in the "flamingo" position, (standing with weight on one leg and the other bent). A vertical displacement of more than 1 cm is an indicator of symphysis pubis instability. A displacement of more than 2 cm usually indicates involvement of the sacroiliac joints.



Figure 70 Pubic Diastasis

External forces such as falling from a horse or a car accident can result in this type of injury to the symphysis pubis. In Fig. 70 the instability was discovered clinically and was stabilized by a pelvic brace.

Avulsion fractures

Avulsion fractures occur at specific sites in the adolescent patient. The most important ones are the anterior superior iliac spine (Sartorius and tensor fascia latae), anterior inferior iliac spine (rectus femoris), and ischial tuberosity (hamstrings). Post-traumatic hematoma, reactive tissue and immature callus may

mimic a tumour on MR and radiographs in the acute and subacute phase. In the remodelling phase of healing the distorted anatomy may be mistaken for an osseous tumour on radiographs.

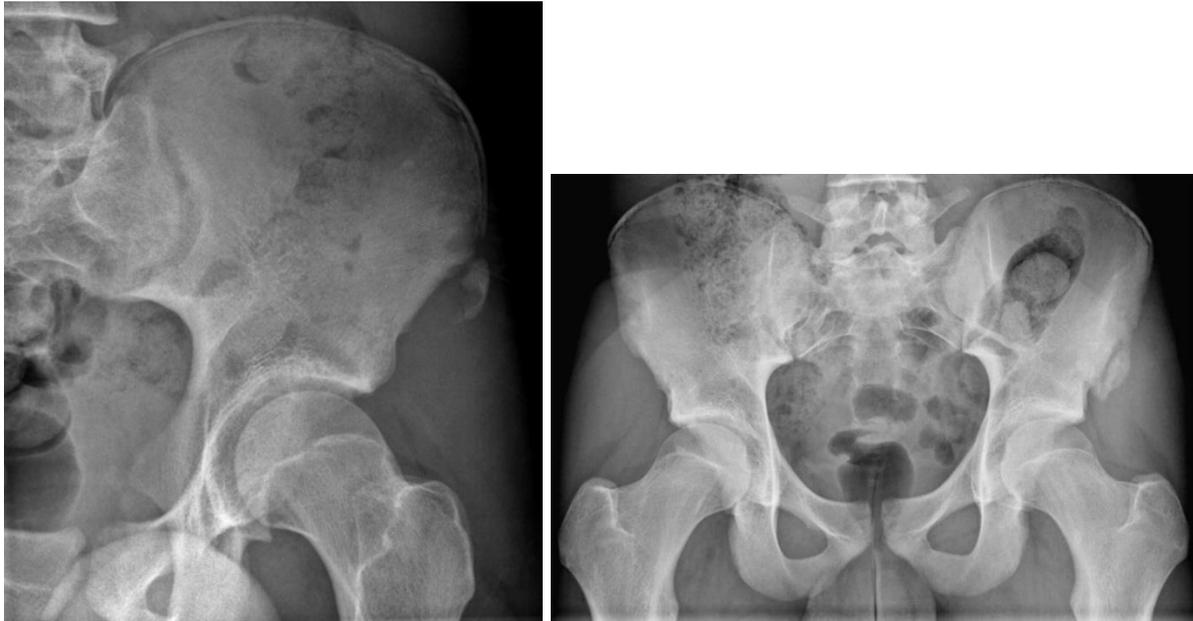


Figure 71 Avulsion fractures of anterior inferior iliac spine

Fig. 71 show an avulsion fracture of the left anterior superior iliac spine in a 16 years old boy after sport related trauma. The one on the left was taken immediately after injury and the one on the right was two months after trauma, showing there is progressive consolidation.

Pathological fractures

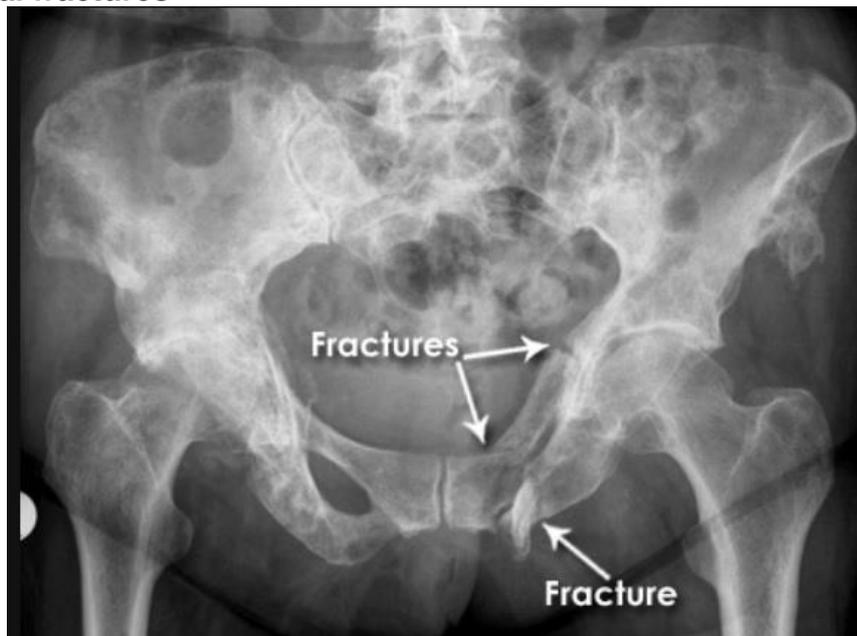


Figure 72 Pathological fracture of pelvis

Pathological fractures can result from bony insufficiency, secondary to osteopenia or osteoporosis. In this case it was secondary to multiple bony lesions secondary to breast cancer. As the pelvis is a ring of bones, fractures always occur in two places.

Fracture iliac wing

On the other site of the age spectrum (in the elderly) insufficiency fractures secondary to osteoporosis or radiation therapy induced osteonecrosis may mimic a tumour, especially metastases. The clue here is the location, most characteristically the sacrum. Many of these fractures occur bilaterally and at multiple sites. MRI may be confusing, but the typical features of fracture on CT or the so called “Honda sign” on bone scintigraphy allow a confident diagnosis to be made. Osteoporotic insufficiency fractures can occur at many locations including acetabulum, ischial bones, pubic bones and proximal femur. Stress fractures in healthy active adolescents occur mainly medially in the proximal femur.



Figure 73 MRI showing fracture of right iliac wing

Fig. 73 shows a coronal T1 weighted image shows a pathologic fracture at the left iliac wing in a 50-year-old woman who suffers from metastatic disease from breast cancer.

Cysts

Large subchondral cysts or geodes occurring primary or secondary to osteoarthritis or rheumatologic disease may raise suspicion of a neoplasm on conventional radiographs. The hip is a tight-joint, therefore synovial disease may cause marked osseous destruction in femur and acetabulum. The herniation pit or fibrocystic changes may be large occasionally but is easily identified because of its typical location at the femoral head-neck junction.



Figure 74 X-ray showing bony cysts

Fig. 74 shows a poly-ostotic fibrous dysplasia in a 48 years old woman. There are lesions in the right proximal femur and pelvis with mixed lysis and sclerosis in combination with a shepherd's crook deformity of the femur.

Osteosarcoma

Osteosarcoma, especially the conventional type, occurs not infrequently in the proximal femur (5%) and iliac bone (3%). Other types are rare in the pelvic region. Osteosarcoma is very rare in sacrum, pubic, and ischial bones (<1%). Radiographic features are similar to that of osteosarcoma in the extremities. Its hallmark is osteoid formation, which is seen in association with asymmetric destruction of bone, and asymmetric soft tissue extension. Tumours are larger than those in the extremity and more often contain large cartilaginous components (conventional or chondroblastic type of osteosarcoma depending on the fraction of tumour consisting of cartilage). The cartilaginous components are identified when ring and arc type of enhancement is seen on Gd-chelate enhanced MR. Most important differential considerations are chondrosarcoma, especially when there is a large cartilaginous component, and Ewing sarcoma. Ewing sarcoma has a more symmetric destruction and soft tissue extension.



Figure 75 Osteosarcoma of right pelvic wing

Fig. 75 shows a 27 years old woman with an osteosarcoma of the right iliac wing. (a) Large lytic lesion is seen on the conventional radiograph.

Chondrosarcoma, enchondroma and osteochondroma

For peripheral chondrosarcoma the frequency distribution is: iliac bone (14%), pubic bone (11%), and proximal femur (7%). Chondrosarcoma is the osseous tumour in the pelvis causing the vast majority of the clinical problems. The main reason is that chondrosarcomas are usually large when detected. Furthermore, the tumours are very fragile and break easily during surgical manipulation, leading to tumour spill in the surgical bed. This often results in multiple soft tissue recurrences. Diagnosis is straightforward because of the characteristic cartilaginous popcorn calcifications seen on radiographs, and the ring and arc enhancement pattern on MRI.



Figure 76 Osteochondroma of pelvis

Fig. 76 shows recurrent multifocal chondrosarcoma with the typical ring and arc enhancement at the level of the right iliac wing.

Ewing sarcoma and lymphoma

Ewing sarcoma is relatively common in the iliac bone (14%), proximal femur (9%), and less common in ischial (3%), and pubic bones (3%). Although the radiographic features are the same as in extremity locations, reactive sclerosis is often more prominent in the iliac bone than in the extremities. Most important differential diagnosis is osteosarcoma. In contrast to osteosarcoma, Ewing sarcoma easily penetrates cortical bone without gross destruction, and extends in a concentric fashion. When located in the iliac bone it extends easily both in the gluteal and iliac muscle compartments.



Figure 77 X-ray and MRI of Ewing Sarcoma

Fig. 77 shows a Ewing sarcoma of the right iliac wing in a 35 years old man. The left is an X-ray showing increased density projecting over iliac wing secondary to soft tissue mass, and a sclerotic area with cortical irregularity superiorly. The right image shows a coronal MRI, T2 fat saturated.

Pelvic Fractures

As was stated above, as the pelvis is a ring of bones, if a fracture occurs, it will always occur in two places. There are a number of classifications of such fractures and they can include just the bony pelvis, the pubis and/or the sacroiliac joint as well.

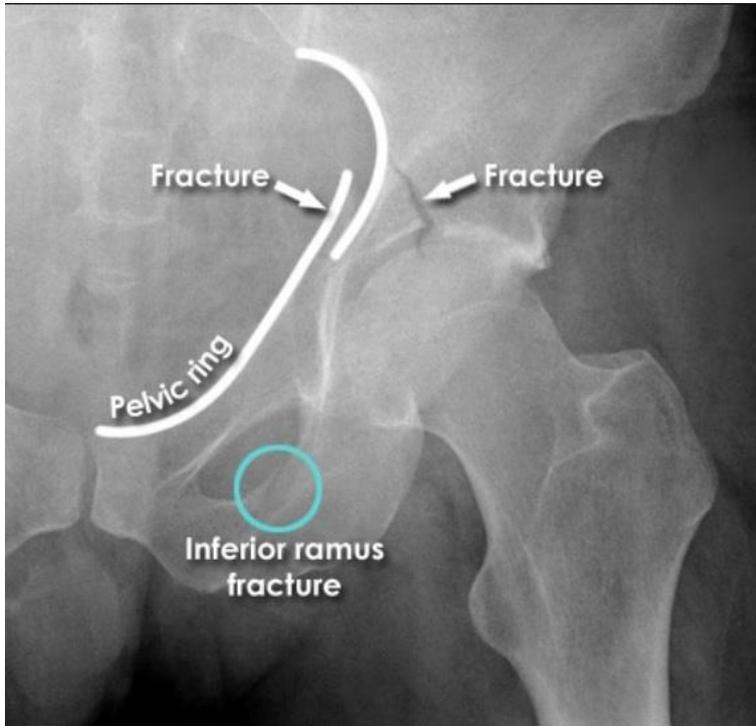


Figure 78 Fracture of the acetabulum

This shows fractures to the pelvic ring, the inferior ramus and through the articular surface of the acetabulum.

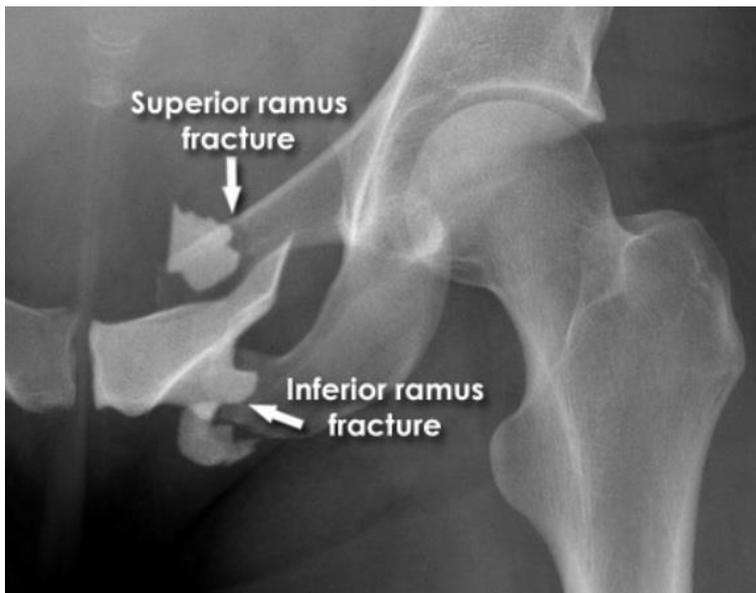


Figure 79 Fracture through both superior and inferior pubic rami

This shows fractures (highlighted) of the superior and inferior pubic rami with comminution.