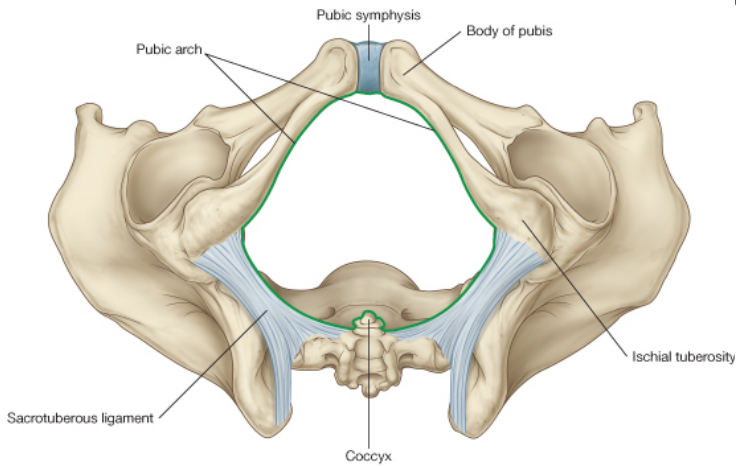
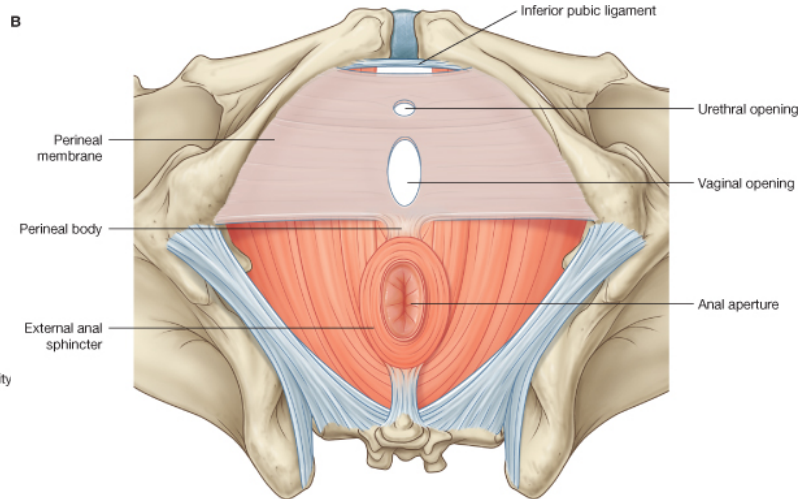


Perineum:

- Region beneath pelvic diaphragm
- Divided into 2 triangles:
 - **Urogenital triangle**
 - **Anal triangle**



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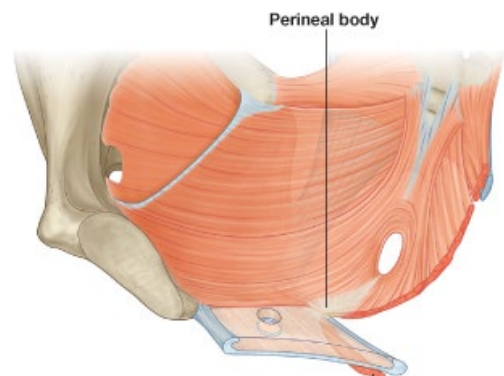
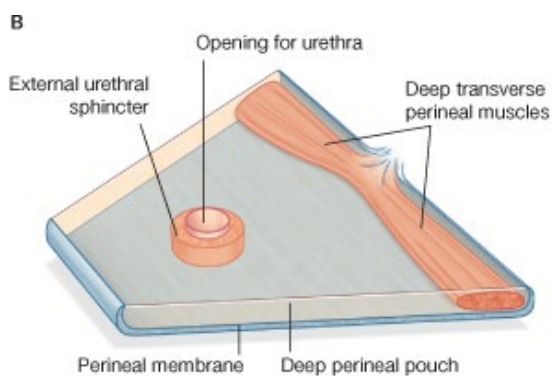
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Urogenital triangle:

- *Apex* = just behind pubic symphysis
- *Lateral walls* = ischiopubic rami + inner surface of obturator internus muscle below level of arcus tendineus.
- *Base* = line between left and right ischial tuberosities

Perineal membrane:

- Flat fibrous sheath
- Triangular
- Runs between lower borders of right and left ischial tuberosities – this forms the long free border at the back.
- Sides run along ischiopubic rami but stop just short of the pubic symphysis
- → Gap exists between perineal membrane and the **arcuate ligament (inferior pubic ligament)**
- Arcuate ligament joins the two pubic bones inferiorly.
- Urogenital hiatus lies over the middle of the perineal membrane
- There is a hole in the perineal membrane which is continuous with the urogenital hiatus – for urethra and vagina to pass through.
- Free margin of perineal membrane is fused to the fibrous **perineal body** of pelvic diaphragm (midline of levator ani).



External sphincter urethrae:

- (note this is different from the internal sphincter)
- Sits between the perineal membrane and the undersurface of the levator ani.
- Arises from inferior pubic ramus and runs behind urethra, encircling it *above the perineal membrane*.
- It is under voluntary control
- Innervated by '**dorsal nerve of penis**' from **pubendal nerve**

MALE PERINEUM:

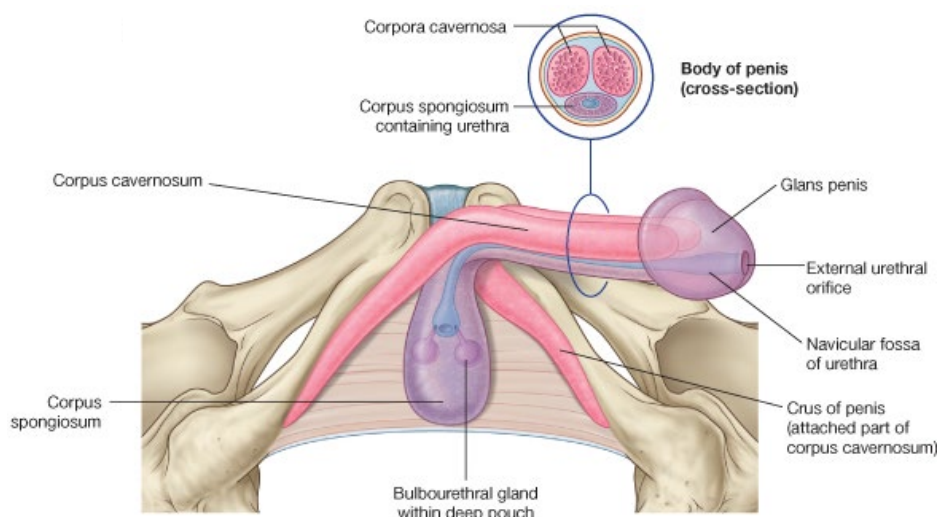
- **Bulbourethral glands** are embedded in **external sphincter urethrae**.
- Bulbourethral ducts pierce perineal membrane before joining urethra.
- **Root of the penis** sits **superficially to the perineal membrane**.
- Root of penis consists of 3 masses of erectile tissue:
 - 2 x corpus cavernosum (crura)
 - 1 x corpus spongiosum (bulb of penis)
- Each mass of connective tissue is covered by a tough fibrous sheath.

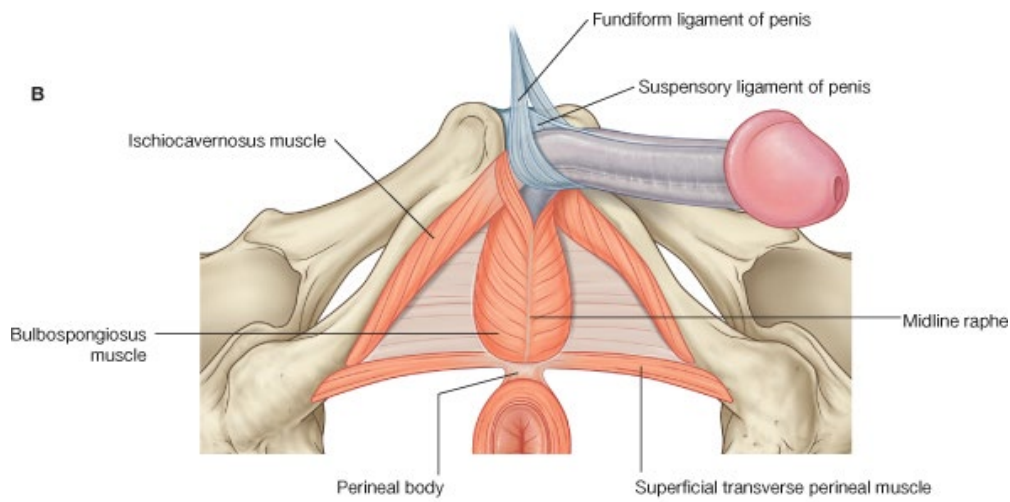
Crura → corpus cavernosum:

- Crura start on inner surface of ischiopubic ramus
- Pass anteriorly to meet at anterior margin of perineal membrane
- Continue into shaft of penis
- In shaft, crura become the corpus cavernosum
- They are separated by fibrous covering, but perforations in fibrous septum allow free communication of blood vessels between the two.
- The **ischiocavernosus muscles** enclose the crura over the ischiopubic rami.

Bulb of penis → corpus spongiosum:

- Bulb of penis lies in midline against undersurface of perineal membrane
- Becomes cylindrical and enters shaft anteriorly to the 2 corpus cavernosum (anatomically, penis is always described as if erect).
- In shaft it is the corpus spongiosum
- Longer, and extends beyond corpus cavernosa → **glans penis**.
- Bulb is covered by **bulbospongiosus muscle**
- Bulbospongiosus muscle has a midline raphe, and can act as a sphincter for ejaculation and urination.
- Ischiocavernosus muscle and bulbospongiosus muscle may contract to help maintain erection.
- Erection is due to 'corkscrew-like' **helicine** arterioles that open onto fibrous saccules.
- Parasympathetic stimulation → relaxation of smooth muscle of these arterioles → arteriole dilation → saccules fill with blood and become taugt.



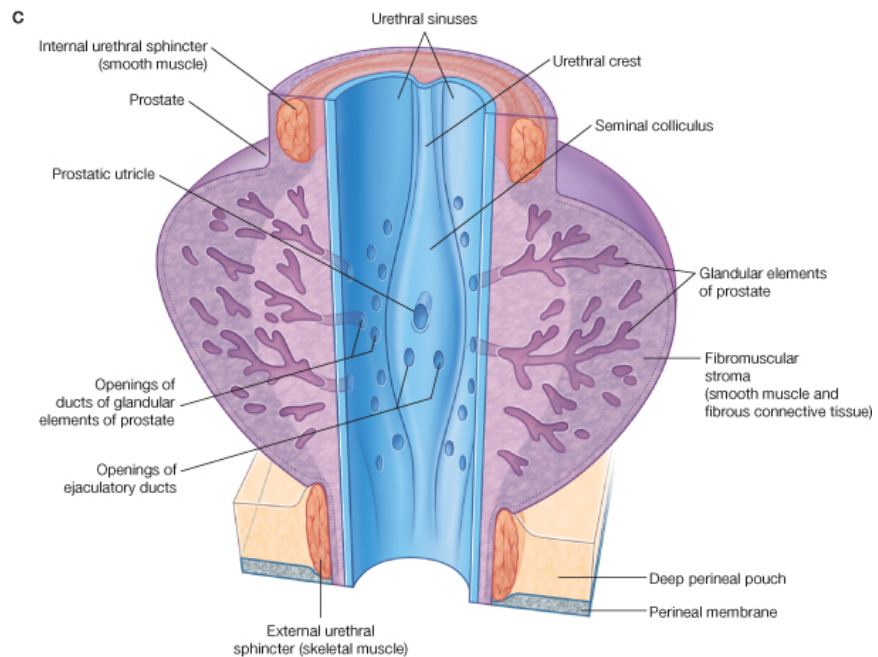


Male urethra:

- Long

Prostatic part:

- Widest & most distensible
- Long ridge on posterior wall – **urethral crest**
- **Prostatic utricle** – pit in the urethral crest
- 2 ejaculatory ducts open either side of the prostatic utricle
- Small openings either side of urethral crest along its length, opening from ducts of prostate gland.
- **Seminal colliculus**



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Membranous part of urethra:

- Surrounded by the external sphincter urethrae
- Called 'membranous' only because it passes through perineal membrane here.

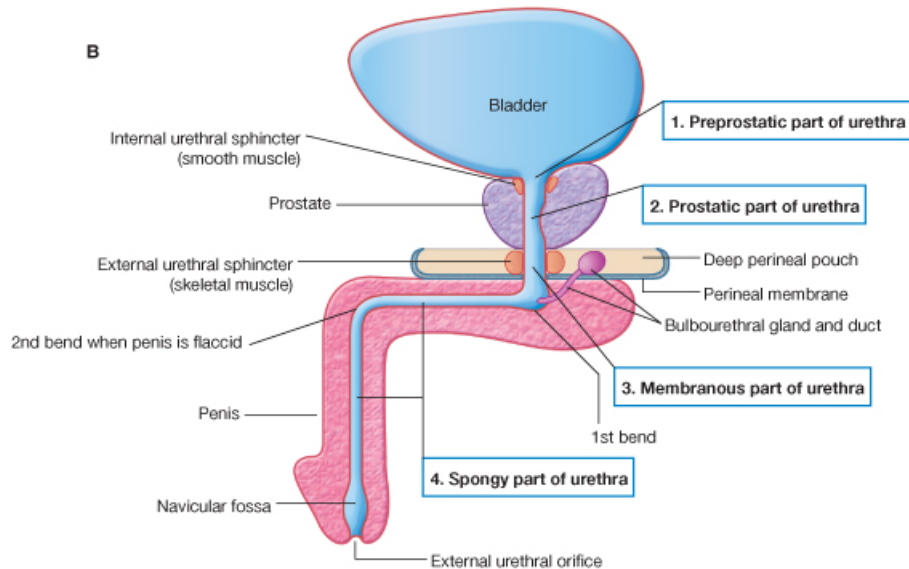
Penile urethra / spongy part of urethra:

- Pierces bulb of penis beneath perineal membrane
- Travels along shaft in corpus spongiosum

External orifice of the urethra:

- Where the urethra opens

- Narrowest part of the urethra.
- There are 2 expanded fossa in urethra:
 - **Navicular fossa** – just distal to external orifice
 - **Intrabulbar fossa** – in the bulb of the penis



DEVELOPMENTAL SIMILARITIES BETWEEN MALE AND FEMALE PERINEUM:

- At the 'indifferent stage' of urogenital development, there are the same components:

Component	Male	Female
Urethral groove in phallus	Enclosed within shaft	Remains open
Urogenital folds	Shaft of penis	Labia minora
Genital swellings	Scrotum	Labia majora

FEMALE PERINEUM:

- 4 erectile components in female:
 - 2 x corpus clitoridis (crura)
 - 2 x bulb of the vestibule

Crura → *corpus clitoridis*:

- **Crura** are attached to ischiopubic ramus
- Smaller than male crura
- Crura fuse anteriorly to form **corpus clitoridis** – forms shaft of clitoris
- Covered, like the males, by the **ischiocavernosus muscle** (smaller than male version)

Bulbs of the vestibule → *glans of the clitoris*:

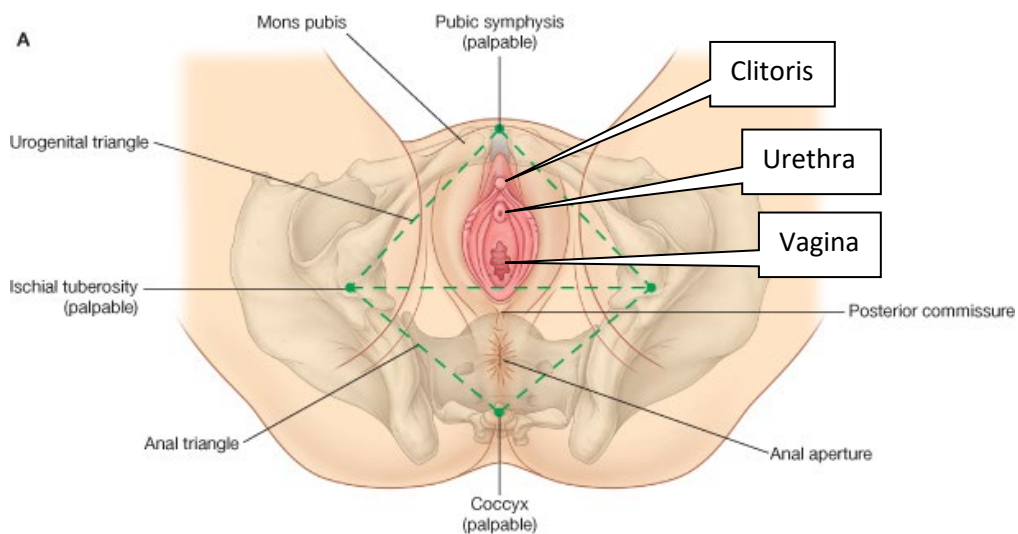
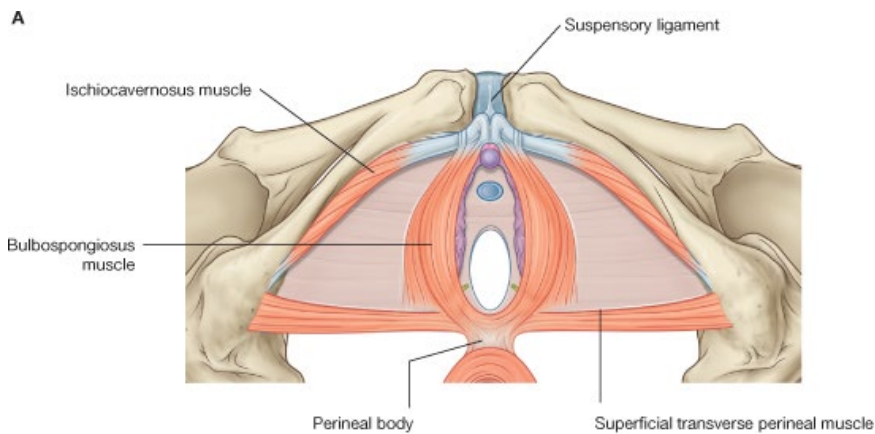
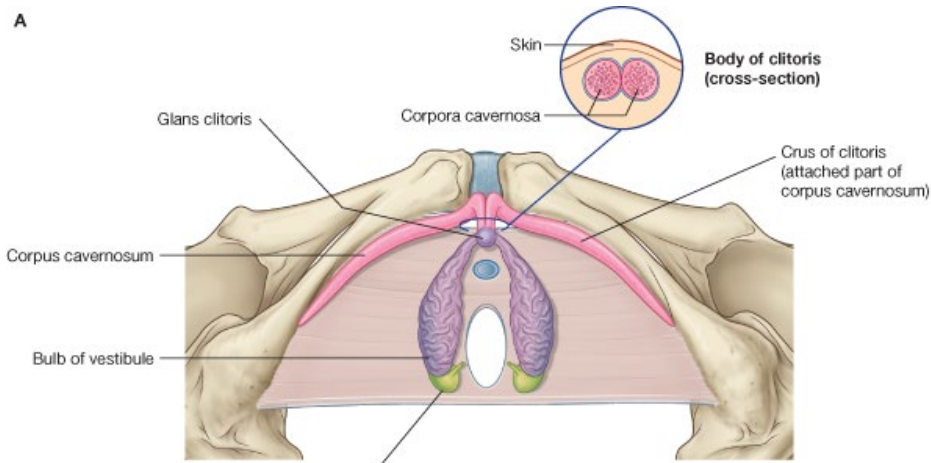
- No single bulb in female (because vagina and urethra open in the midline)
- **Bulb of the vestibule** lies within the labium minus
- The bulbs run anteriorly onto anterior surface of shaft of clitoris
- 2 bulbs fuse with one another at the tip of the clitoris to form the **glans of the clitoris**.
- **Bulbospongiosus muscle** is divided by margin of vagina into left and right. Passes posteriorly over bulb of the vestibule to insert in the fibrous perineal body behind vagina.
- Bulbosongiosus muscle can act as a sphincter for the vagina.

Female urethra:

- Short
- Opens at external urethral orifice in vestibule between the opening of the vagina and the clitoris

Male and female urethral sphincters:

- Both males and females have 2 sphincters:
 - Internal sphincter urethrae – involuntary
 - External sphincter urethrae – voluntary (supplied by pudendal nerve)



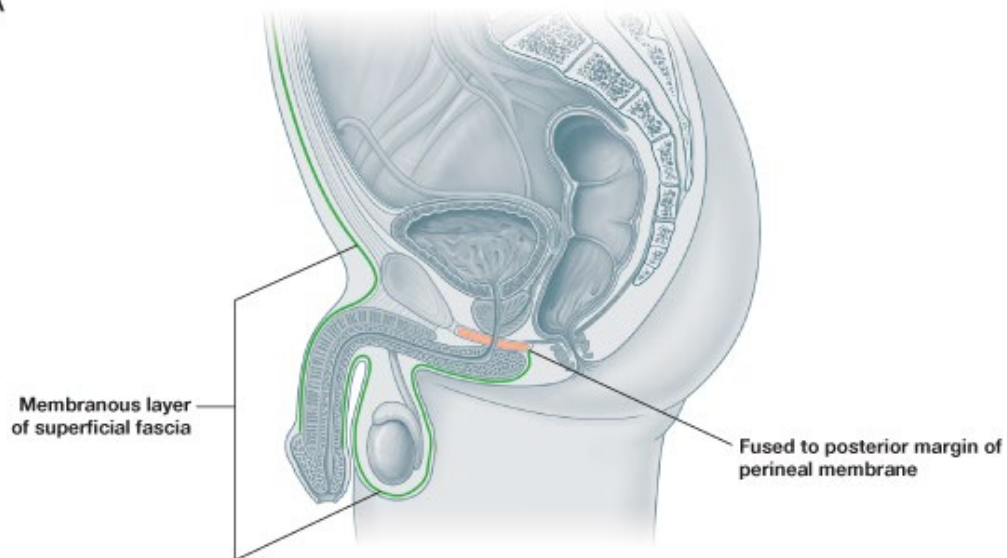
FASCIA COVERING THE UROGENITAL TRIANGLE:

- **Superficial fascia** lies superficial (external) to perineal membrane
- Consists of:
 - Superficial layer – loose CT and fat
 - Deeper membranous layer

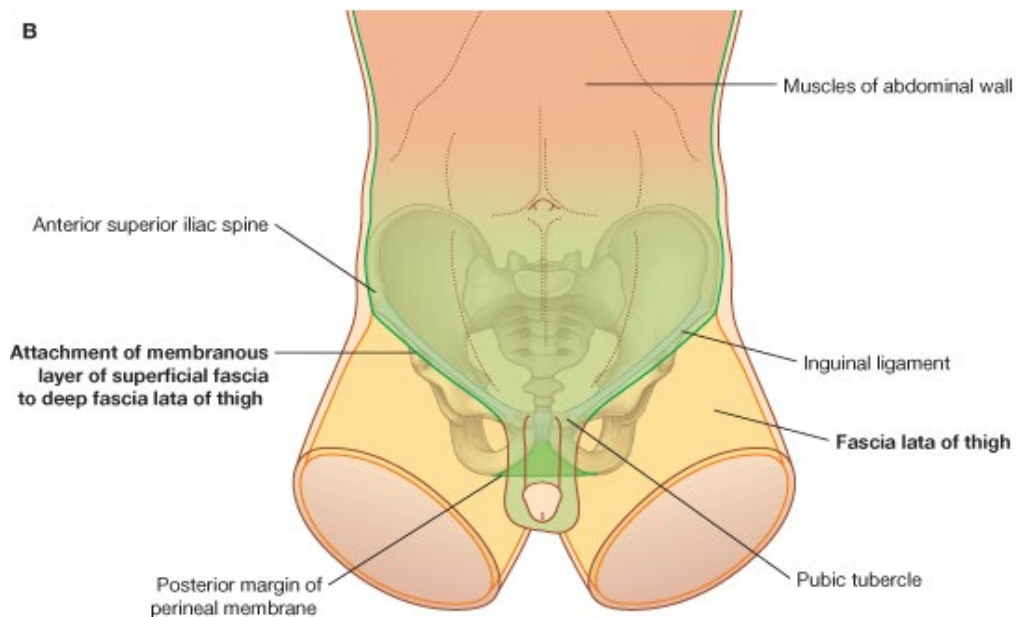
Deeper membranous layer:

- Attaches:
 - Posterior free border of perineal membrane
 - Sides along ischiopubic rami
- Runs up over pubic bones and laterally onto thigh – fuses with **fascia lata** of thigh.
- Runs into skin of scrotum and shaft of penis
- Above it is continuous with the membranous layer of the superficial fascia of the anterior abdominal wall.

A



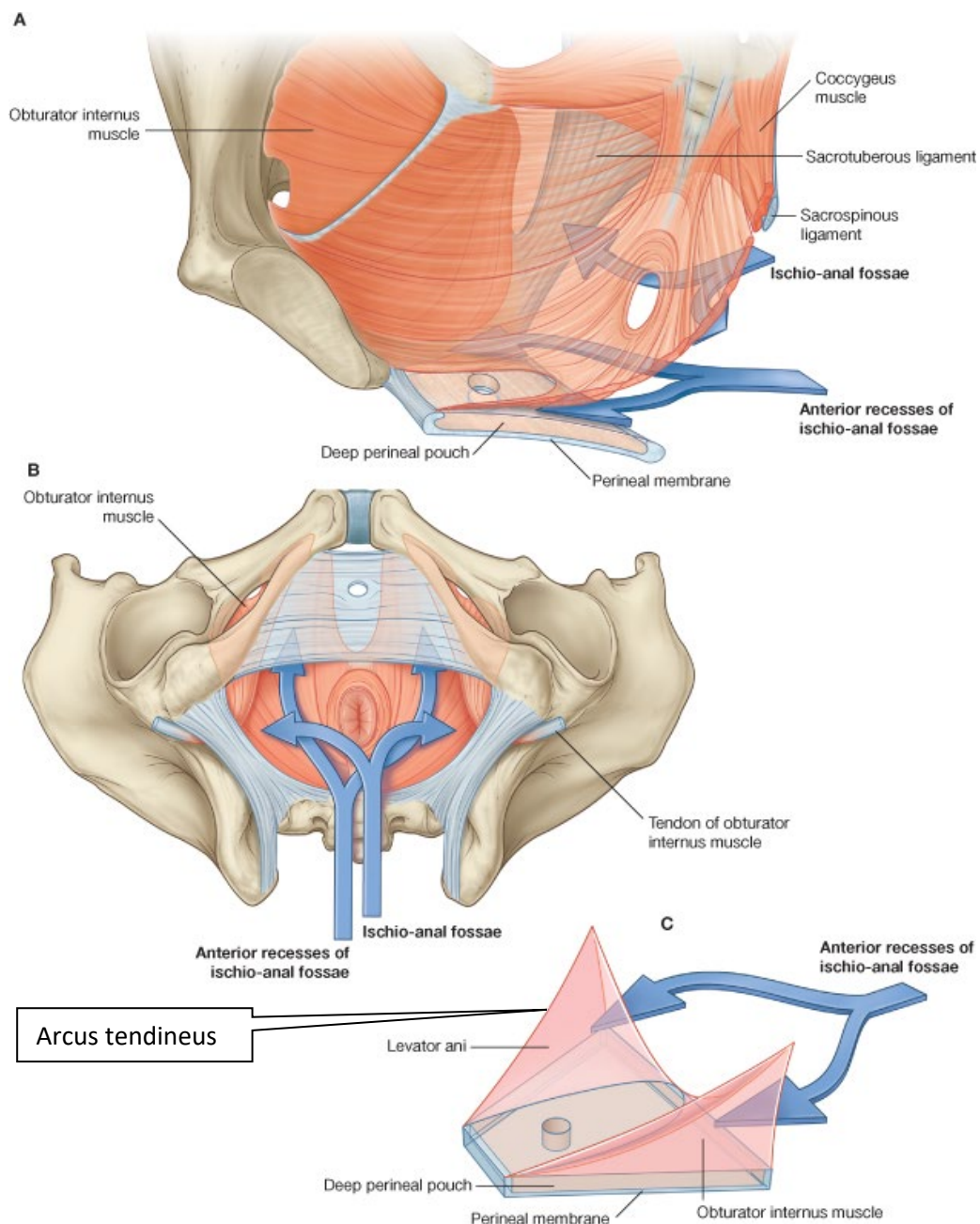
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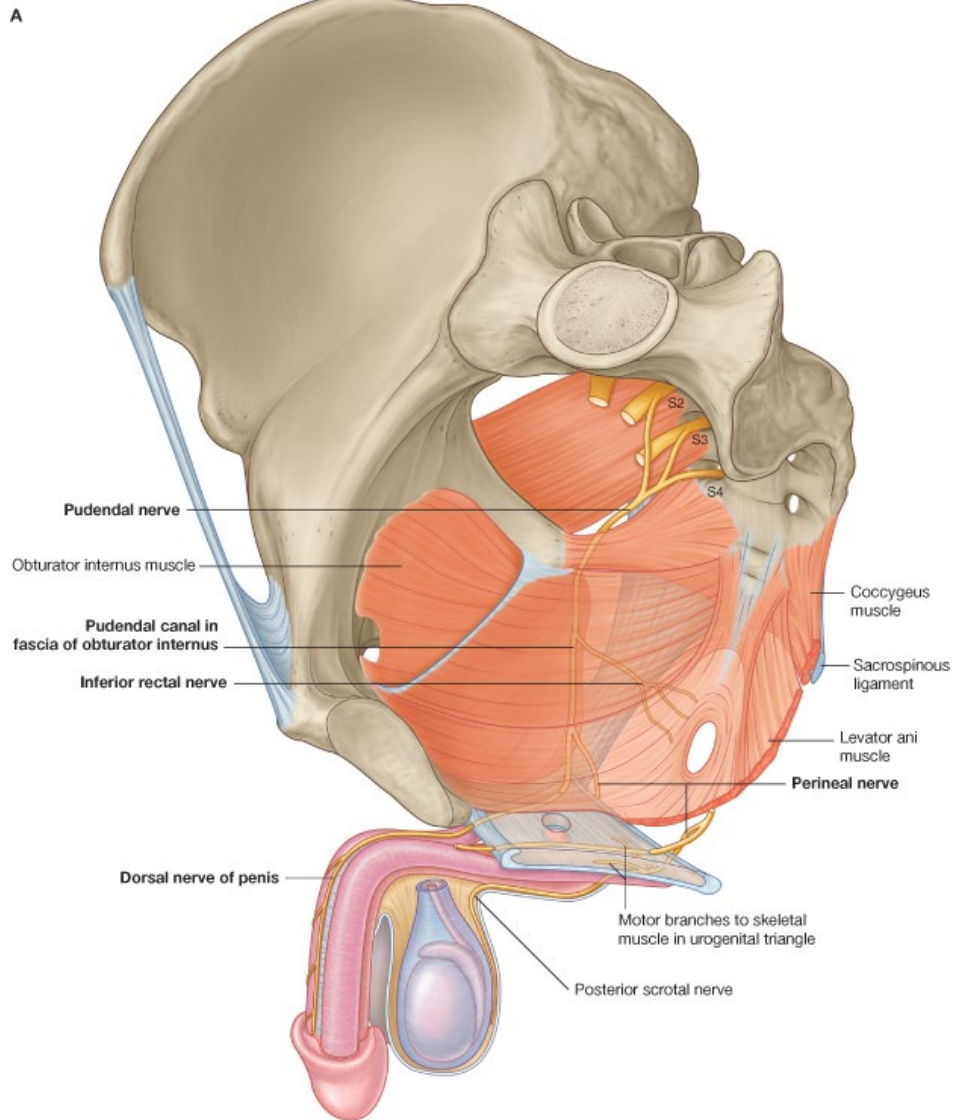
- **Superficial perineal pouch** – between perineal membrane and membranous layer of superficial fascia.
- Blood/urine from ruptured urethra collects in superficial perineal pouch
- Blood/urine cannot pass:
 - Beyond the perineal membrane
 - Backwards into the anal triangle
 - Laterally into thigh
- It *can* track forward into scrotum, shaft of penis and up into anterior abdominal wall.

ANAL TRIANGLE AND ISCHIORECTAL FOSSA:

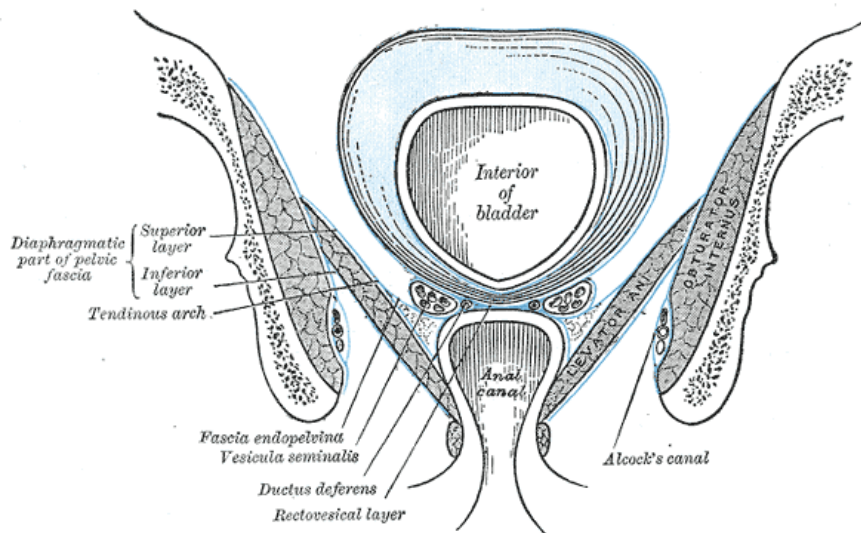
- Anal canal is major structure of anal triangle, and is surrounded by fatty CT
- Space between anal canal and ischiopubic ramus = **ischioanal fossa / ischioanal fossa**
- Ischioanal fossae are continuous with each other around the anus.
- **The ischioanal fossa is filled with loose fatty connective tissue to allow expansion of the vagina / anus**
- Also continuous with the **anterior recess of the ischioanal fossa**
- The anterior recess of the ischioanal fossa is the space between the perineal membrane and the muscles of the pelvic diaphragm above, up to the attachment of the **arcus tendineus** on the obturator internus.



PUDENDAL NERVE:



- **Somatic nerve**
- **S2, S3, S4**
- Main nerve of the **perineum**
- Leaves pelvis through greater sciatic foramen
- Curles around sacrospinous ligament and reenters pelvis through the less sciatic foramen.
- Runs in **pudendal canal (Alcock's canal)** – canal in the fascia covering the inner aspect of obturator internus muscle.

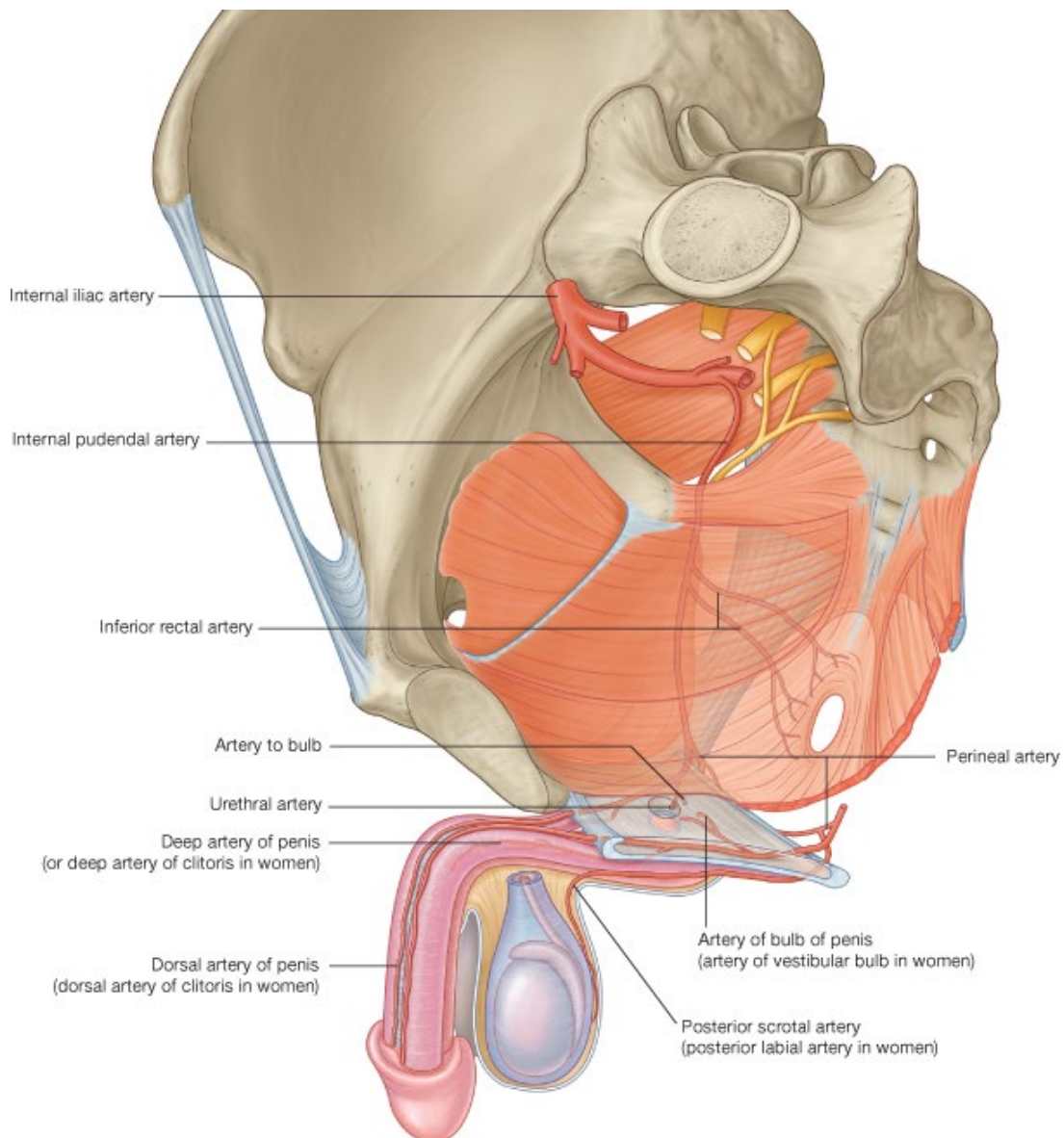


- At point it enters the canal, gives off the **inferior rectal nerve**
- Pudendal nerve continues in pudendal canal
- Bifurcates into 2 terminal branches:
 - **Perineal nerve** – superficial to the perineal membrane
 - **Dorsal nerve of the penis (/dorsal nerve of the clitoris)** – deep to the perineal membrane

Inferior rectal nerve	<ul style="list-style-type: none"> • External anal sphincter (voluntary control) • <i>“S2, 3 and 4, keep the shit off the floor”</i> • Skin around anus (somatosensor)
Perineal nerve (superficial to perineal membrane)	<ul style="list-style-type: none"> • Branches which supply structures which lie on the superficial surface of the perineal membrane. • Skin of perineum • Skin of posterior surface of scrotum
Dorsal nerve of penis (deep to perineal membrane)	<ul style="list-style-type: none"> • External sphincter urethrae (voluntary control) • Innervates the other muscles above the perineal membrane • Runs over posterior surface of penis (clitoris), supplies skin and fascia.

- **Erectile components** of penis supplied not by pudendal nerve (somatic) but by **parasympathetic pelvic splanchnic nerves** from pelvic plexus.

INTERNAL PUDENDAL ARTERY AND VEIN:

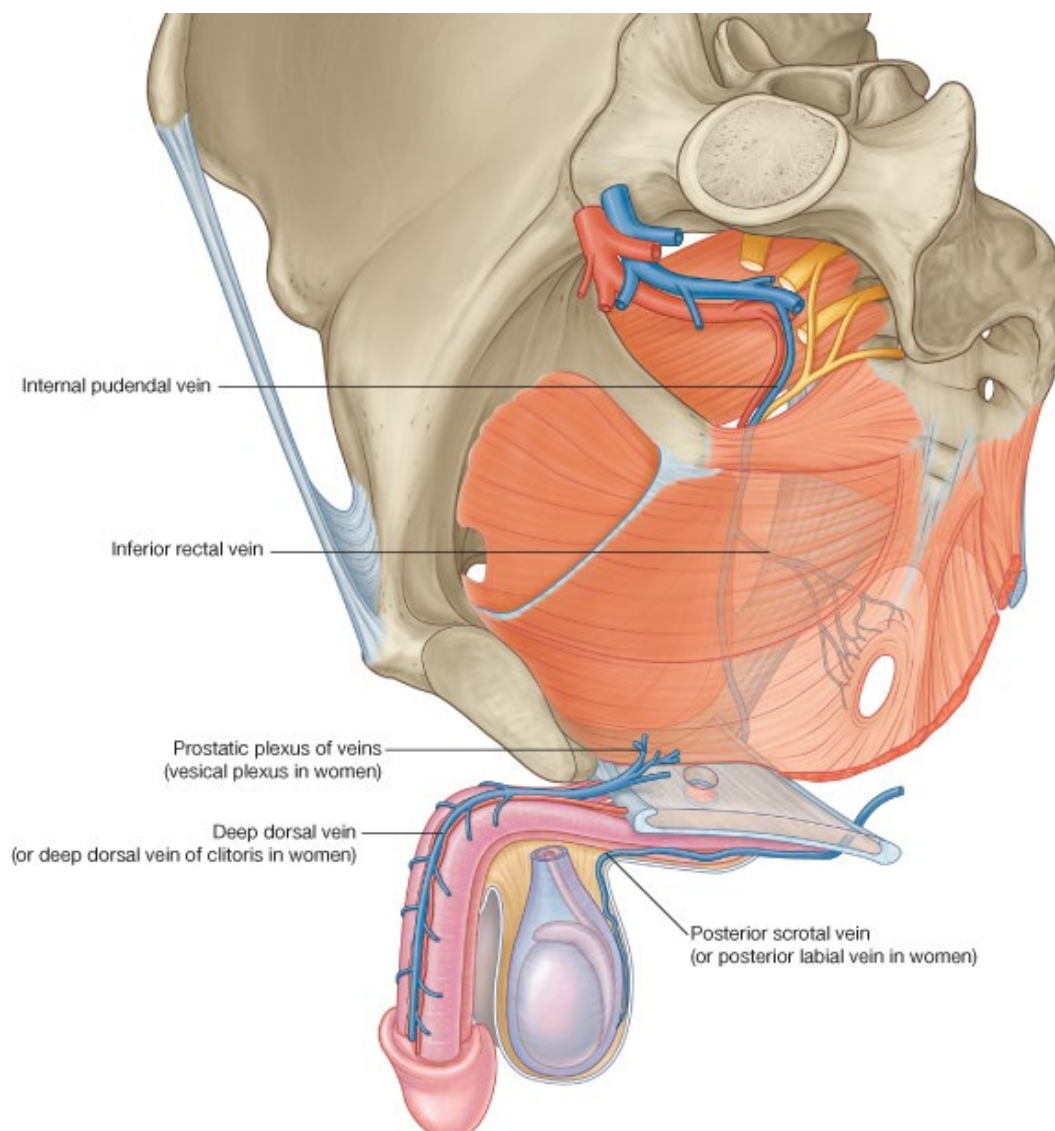


- **Internal pudendal artery** accompanies pudendal nerve (exits pelvis in greater sciatic foramen, then re-enters in lesser sciatic foramen to travel in pudendal canal).
- Runs in pudendal canal just medial to ischiopubic rami.
- Gives off:
 - **Inferior rectal artery**
 - **Perineal artery** (superficial to perineal membrane)
- Gives 3 arteries to the penis :
 - **Dorsal artery of the penis**
 - **Deep artery of the penis**
 - **Artery to the bulb of the penis**

Artery to the bulb of the penis	<ul style="list-style-type: none"> • Pierces perineal membrane • Enters bulb, supplying corpus spongiosum erectile tissue.
Deep artery of the penis	<ul style="list-style-type: none"> • Supplies erectile tissue of corpus cavernosum
Dorsal artery of penis	<ul style="list-style-type: none"> • Runs between deep fascia and fibrous sheath of corpus cavernosum • Supplies skin and superficial layers of penis

VENOUS DRAINAGE OF THE PENIS:

- Tributaries accompany the arteries and drain into the internal pudendal vein
- EXCEPT the single '**deep dorsal vein of the penis**' which drains into the prostatic venous plexus.



SACRAL PLEXUS:

- Consists of:
 - L4 + L5 (ventral rami) – **lumbosacral trunk**
 - S1 + S2 + S3 + S4 (ventral rami – through anterior sacral foramina)
- Sacral plexus is a mixing of these nerves on the surface of the **piriformis muscle**
- Sacral plexus mainly innervates lower limb, but also innervates pelvis and perineum.

Nerves arising from sacral plexus which innervate pelvis / perineum

- Nerves from the sacral plexus innervate **piriformis muscle** (on which the sacral plexus sits)
- **S4** ventral ramis of sacral plexus innervates:
 - **Muscles of pelvic diaphragm; levator ani & coccygeus**
 - **External anal sphincter**
- **Pudendal nerve** is composed from **S2, S3, S4** of sacral plexus
- **Pelvic splanchnic nerves:**
 - **S2, S3, S4** of sacral plexus
 - Parasympathetic supply to:
 - Hindgut
 - Pelvic viscera
 - External genitalia

SACRAL PLEXUS

L4,5,S1,2,3,4,5

Lies on piriformis on posterior wall of pelvis, deep to the vessels & covered by parietal pelvic fascia

6 BRANCHES OFF THE SACRAL ROOTS BEFORE THEY DIVIDE INTO ANTERIOR & POSTERIOR DIVISIONS

They all begin with the letter "P"

1. Posterior femoral cutaneous nerve (S1,2,3)
2. Pudendal nerve (S2,3,4)
(1 & 2 - leave via greater sciatic foramen)
3. Perforating cutaneous nerve (S2,3)
(3 - perforates sacrotuberous ligament)
4. Nerve to piriformis (S1,2)
5. Perineal branch of S4 (to levator ani)
6. Pelvic splanchnics (S2,3,4)
Parasympathetic motor to bladder, hind gut, erection.
Sensory for distension & pain of bladder, lower uterus, lower colon & rectum
(4,5,6 - all remain in pelvis)

FROM ANTERIOR DIVISIONS

- Nerve to quadratus femoris (L4,5,S1)
- Nerve to obturator internus (L5,S1,2)
- Tibial portion of sciatic nerve (L4,5,S1,2,3)
(see sciatic nerve in leg section)

FROM POSTERIOR DIVISIONS

- Superior gluteal (L4,5,S1)
- Inferior gluteal (L5,S1,2)
- Common fibular portion of sciatic nerve (L4,5,S1,2)
(see sciatic nerve in leg section)

For more details & illustrations, please see page 132 in the book - Instant Anatomy, by R H Whitaker & N R Borley. 4th edition. Wiley-Blackwell 2010

Nerves which don't supply the pelvis:

Nerve	Innervation
Sciatic nerve	Leaves through greater sciatic foramen. Composed of: <ul style="list-style-type: none">• Anterior tibial part• Posterior 'common peroneal' part
Superior and inferior gluteal nerves	Gluteal region
Posterior femoral cutaneous nerve	Skin on back of thigh

SUMMARY OF AUTONOMIC NERVES IN ABDOMEN AND PELVIS:

Overview of parasympathetic NS

- Parasympathetic leave CNS from:
 - Cranial nerves (vagus nerves from brain, III, VII, IX, X)
 - Sacral segments S2, S3, S4 (the pelvic splanchnic nerves)

Overview of sympathetic NS

- Sympathetic leave the CNS from:
 - T1-L2 (thoracolumbar)
- Leave CNS and enter sympathetic trunks
- Sympathetic trunks run from base of skull → pelvis (i.e. further than T1-L2, allowing sympathetic nerves to reach areas of body above / below T1/L2)
- 2 sympathetic trunks unite over coccyx to form **ganglion impar**

Sympathetic NS in abdomen and pelvis:

- Preganglionic sympathetic fibres to abdominal/pelvic viscera all come from **T5-L2**
- These preganglionic sympathetic fibres are **splanchnic sympathetic nerves** (Note; they are preganglionic and pass through the sympathetic trunk without synapsing):
 - T5-T9 **greater thoracic splanchnic nerve**
 - T10-T11 **lesser thoracic splanchnic nerve**
 - T12 **least thoracic splanchnic nerve**
 - T12-L2 **lumbar sympathetic splanchnic nerves**
- These preganglionic sympathetic splanchnic nerves synapse in ganglia that lie along **anterior surface of abdominal aorta** – **preaortic ganglia**.

Preaortic ganglia

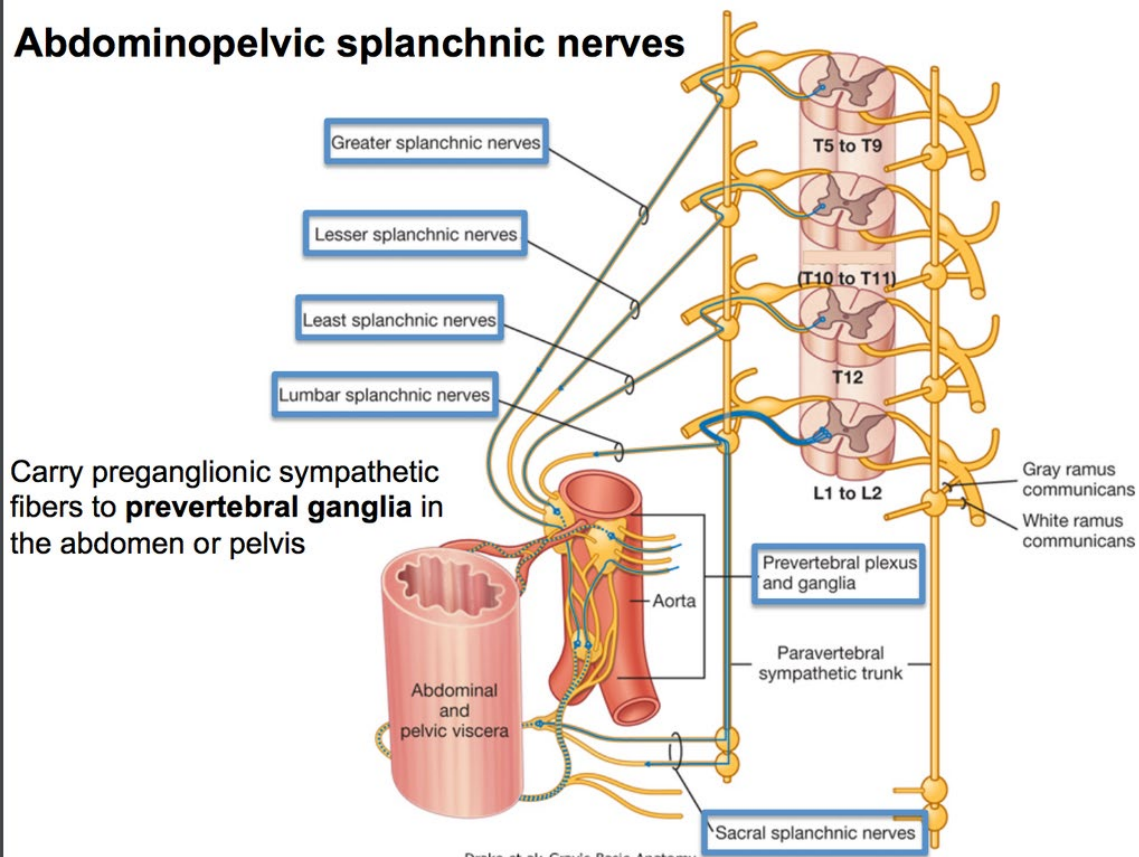
- **Coeliac ganglia** (foregut)
- **Superior mesenteric ganglia** (midgut)
- **Inferior mesenteric ganglia** (hindgut)

Pelvic autonomic ganglia

- **Superior hypogastric ganglia:**
 - Ganglia on front of aorta below inferior mesenteric ganglia, as low down as 2nd sacral segment
- **Inferior hypogastric ganglia:**
 - Either side of the rectum
- **Pelvic sympathetic ganglia**

- Postganglionic sympathetic fibres emerging from the **preaortic ganglia** travel with the associated blood vessels, to innervate the organs supplied by these vessels.
- Postganglionic sympathetic fibres emerging from the **superior/inferior hypogastric plexuses** travel directly to the pelvic organs.
- Fibres from sympathetic trunk in the pelvis:
 - Travel with sacral and coccygeal nerves to limbs and skin
 - Enter **inferior hypogastric plexuses** to innervate pelvic viscera.

Abdominopelvic splanchnic nerves



Parasympathetic NS in abdomen and pelvis:

- Preganglionic parasympathetic fibres to foregut and midgut:
 - **Vagus nerve (X)**
- The ganglia for these preganglionic parasympathetic fibres are found in wall of gut / within target organ (ENS)
- The preganglionic parasympathetic vagal fibres join with the sympathetic fibres in the preaortic, and hypogastric ganglia.
- **The sympathetic ganglia, to which preganglionic parasympathetic fibres now mix, are known as plexuses.**
 - Coeliac plexus
 - Superior mesenteric plexus
 - Inferior mesenteric plexus
- Preganglionic parasympathetic fibres to the hindgut and pelvic organs:
 - **Pelvic parasympathetic splanchnic nerves**
- These mix with the superior and inferior hypogastric ganglia to give:
 - Superior hypogastric plexus
 - Inferior hypogastric plexus
- Again, the ganglia for these preganglionic parasympathetic fibres are found in wall of hindgut / within pelvic viscera

- HOWEVER, there are some exceptions where the preganglionic parasympathetic fibres will synapse in tiny ganglia in the hypogastric plexuses:
 - Nerves supplying erectile tissue of penis and clitoris; synapse in hypogastric plexuses and postganglionic parasympathetic fibres run pierce pelvic diaphragm and perineal membrane to innervate crura and bulb of penis/clitoris.

SUMMARY:

Plexus	Preganglionic sympathetic input	Preganglionic parasympathetic input
Preaortic plexuses	<ul style="list-style-type: none"> • Preganglionic sympathetic splanchnic nerves from T5-L2 pass through sympathetic trunks without synapsing and then enter the preaortic plexuses, where they synapse and travel with blood vessels to target organs. 	<ul style="list-style-type: none"> • Preganglionic parasympathetic nerves join the preaortic plexus from the: <ul style="list-style-type: none"> ○ Vagus nerves above ○ Pelvic parasympathetic splanchnic nerves below (S2, S3, S4) which ascend from the hypogastric plexuses. Distribute from the prearotic plexuses with the postganglionic sympathetic fibres.
Superior and inferior hypogastric plexuses	<ul style="list-style-type: none"> • From: <ul style="list-style-type: none"> ○ Sympathetic trunks in pelvis ○ Preaortic plexuses Postganglionic sympathetic fibres from the S&I hypogastric plexuses travel directly to the viscera. 	<ul style="list-style-type: none"> • Parasympathetic pelvic splanchnic nerves (S3, S4, S5)

VISCERAL PAIN IN THE ABDOMEN AND PELVIS:

- Sensory information travels back to the CNS (spinal cord) in **visceral afferent fibres**
- **These afferent fibres travel to the CNS in efferent autonomic nerves** – along exactly the same nerves as the motor sympathetic / parasympathetic pathways described above.
- The visceral afferent fibres are identical to other sensory neurons; one neuron with cell body in dorsal root ganglion.

Sensations other than pain from foregut and midgut:

- Travel in afferents in vagus nerve along with efferent parasympathetic fibres.

Sensation of pain in abdominal viscera:

- Travels back to spinal cord in afferents which accompany sympathetic pathways.

Sensation of pain in pelvis and perineum:

- Travels back to spinal cord in afferents which accompany pelvic parasympathetic pathways.

Concept of pain referral:

- Afferents return to dorsal root ganglia at segmental origin of sympathetic/parasympathetic efferents which supply the particular viscera.
- **Pain is then referred to the furthest point from the spinal cord along that somatic dermatome.**

Stomach:

- Origin of efferent innervation → T7 & T8 (with sympathetic nerves in greater splanchnic)
- Referred pain → dermatome T6 & T7, **just below sternum**

Gonads:

- Origin of efferent innervation → T10 & T11
- Referred pain → dermatome T10, the **umbilicus**

Appendix:

Early:

- Origin of efferent innervation → T10 & T11
- Referred pain → dermatome T10, the **umbilicus**

Late:

- Peritoneum over appendix in R. Iliac is irritated
- Parietal peritoneum supplied by somatosensory neurones – v. sensitive (esp to stretch)
- → late pain is localised to appendix.
- **Rebound tenderness** (recoiling of peritoneum after pressing it) is v. painful.

Ureters:

- Origin of efferent innervation → T12 & L1
- Referred pain → dermatomes T12 & L1 (in back between ribs and iliac crest, radiating down to inguinal canal and scrotum) – i.e. **loin and groin**
- Stones in ureters

Uterine cervix:

- Origin of efferent innervation → S3 & S4
- Referred pain → dermatomes S3 & S4 (**back of sacrum**)

Uterine body:

- Origin of efferent innervation → T11, T12 & L1
- Referred pain → dermatomes T11, T12 & L1 (**lower abdominal wall**)

FEW NOTES ON THE ANAL CANAL:

- Junction between anus and rectum is the point at which it passes through the pelvic diaphragm.
- Distal anal canal gets its blood supply from the inferior rectal arteries of internal pudendal artery
- Puborectalis (component of levator ani) is the most important anal sphincter.

LYMPH NODES OF THE PELVIS & PERINEUM:

- Main lymphatic drainage of pelvis and perineum are along main arteries:
 - Internal iliac lymph node
 - External iliac lymph nodes
 - Common iliac lymph nodes.

NOTE: SECONDARY CARTILAGINOUS JOINTS LIE IN THE MIDLINE

