

THE PELVIS AND THE PERINEUM

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DEVELOPMENT OF THE UROGENITAL REGION

INTERMEDIATE MESODERM: Development of the urogenital system originates from the intermediate mesoderm, one of the three mesodermal layers formed after neurulation.

- There are three mesodermal layers
 - Paraxial Mesoderm: Forms the somites + vertebral column
 - Lateral Plate Mesoderm: Forms the body walls
 - Intermediate Mesoderm: Forms the urogenital system.

UROGENITAL RIDGE: Develops from the intermediate mesoderm. It forms longitudinal columns. This ridge will lead to development of the following:

- **Gonadal Ridge:** Will form the indifferent gonad -----> ovaries / testes
- **Nephrogenic Cord:** Will form the kidney
- **Mesonephric Duct:** Will form the ureter and the male genital ducts, seminal vesicles.
- **Paramesonephric Duct:** Will form the Uterine Tubes
 - **Uterovaginal Primordium:** Formed from the paramesonephric duct. It will form the uterus and part of the vagina.

CLOACA: ENDODERMAL! The distal portion of the GI tube, after foregut / midgut / hindgut. It forms the following structures. It forms the **Urogenital Sinus**, which in turns leads to the following structures.

- **The Urinary Bladder**
- **Urethra, Prostate Gland, Bulbourethral Glands (male)**
 - The prostate is lobulated, coming off the pelvis portion of the UG sinus.
 - The bulbourethral gland also comes off the pelvic portion of the UG sinus.
 - The seminal vesicles **do not come from UG sinus!** -- they come from the mesonephric duct.
- **Urethra, Vaginal Epithelium, Vestibular Glands, Vestibule (female)**

GUBERNACULUM: The primitive **round ligament** and **ovarian ligament** in the female.

- Developmentally, it determines the descent of the gonads in both species.
- It is a long, tenuous cord.
 - The superior end of the cord attaches to the inferior pole of the gonad to pull them down.
 - The inferior pole attaches to the primitive labia (scrotum), or the developing perineal region.
- The shrinking of the gubernaculum pulls the gonad down from the abdominal region (initially it develops as high as T10!)
- **Processus Vaginalis** = invagination in the abdominal wall, near the inferior part of the gubernaculum.
 - It invaginates into the labioscrotal folds.
 - The processus vaginalis is more prominent in the male, due to the descent of the testes through it.
 - **Inguinal Canal** forms by shrinking of the gubernaculum, dragging the processus vaginalis with it. The round ligament (female) or spermatic cord (male) go through the inguinal canal.

- **Congenital Indirect Hernia** results when the processus vaginalis remains patent after birth.
- **DESCENT OF THE TESTES:** Occurs as androgens stimulate the gubernaculum to shrink and become shorter.
 - Occurs within 3 months of development. It brings the testis down to the location of the *deep inguinal ring*. This part is probably due to growth of the caudal region rather than shrinkage of the gubernaculum.
 - 7-9 months of development: The testis complete their descent, going from the deep inguinal ring down to the scrotum. This part is probably due to androgenic shrinking of the gubernaculum.
 - *The vessels, nerve, and lymphatics of the testes all arise from Thoracic vertebrae 10!!* The genital branch of the **genitofemoral nerve**. This is because the testis descend like they do.
- "DESCENT" OF THE OVARIES -- Also due to a growth in the caudal region of the embryo.
 - In absence of androgen, the gubernaculum does not shrink like it does in the male.
 - Instead, the gubernaculum gets stuck on the developing paramesonephric duct and adheres to it.
 - **ROUND LIGAMENT** hence become the distal (inferior) portion of the gubernaculum. It connects the uterus to the labium majus.
 - **PROPER OVARIAN LIGAMENT** comes from the proximal (superior) part of the gubernaculum. It connects the uterus to the gonads.
 - Remember -- the length of the gubernaculum does not change in the female.

MESONEPHRIC DUCT: The Wolffian Duct

- Male structures formed from mesonephric duct:
 - **Ductus Epididymis**
 - **Ductus Deferens**
 - **Ureter**
 - **Pelvis, Calyces and Collecting Tubules of Kidneys**
 - **Ejaculatory Duct**
 - **Seminal Vesicle**
- Female structures formed from the mesonephric duct:
 - **Ureter**
 - **Pelvis, Calyces, and Collecting Tubules of the Kidneys**

PARAMESONEPHRIC DUCT: The Mullerian Duct

- Structures in male: Doesn't form anything we need to know about.
- Structures formed in female:
 - **Uterine Tubes**
 - **Uterus**
 - **Upper portion of vagina**
 - **Vaginal wall**

SPECIFIC DATES TO REMEMBER IN DEVELOPMENT OF UG SYSTEM

- **Eighth Week:** The testis becomes identifiable.
 - The ovaries are not identifiable until the ninth or tenth week.
 - Hence the *sex of the embryo cannot be determined morphologically until week 10.*
- By the **Early Fetal Period**, the 9th week, *all the organ system have already differentiated except the UG System.*
- **Twelfth Week:** The external male genitalia attain distinctive features.
- **Sixteenth Week:** The uterus and vagina are recognizable as such. Hence, you can visible identify a male before a female.

Development of the Vagina:

- Vagina forms a **vaginal plate** and a **lumen**.
- Clinical problems arise when the lumen does not form properly:
 - The lumen may be partially open but have internally closed parts. The problem is not detected until puberty, when menses builds up pressure in the vagina. The problem can easily be fixed surgically.

DEVELOPMENT OF KIDNEYS AND URINARY SYSTEM: There are three systems

- **PRONEPHRIC:** (4 weeks)
 - It gives rise to the **Pronephric Duct**, which in turn gives rise to the **Mesonephric Duct**.
- **MESONEPHRIC:** (4-8 weeks)
 - The distal part of the Mesonephric Duct gives rise to the **Metanephric Diverticulum**, which in turn gives rise to the **collecting system of kidneys**.
- **METANEPHRIC** -- form the definitive kidneys.
 - **Ureteric Buds** sprout from the mesonephric duct, in a cranial to caudal fashion.
 - The buds penetrate the **Metanephric Blastema** and bifurcate, forming the lobules of the kidney.
 - Thereafter, the *ureteric buds and metanephric blastema have reciprocal inductive effects*. This is classical co-induction. Several hours and direct contact are both required for each respective structure to differentiate.
 - The **ureters and collecting system** come from the ureteric buds.
 - The **glomerular capsules and nephrons** (proximal convoluted tubule, Loop of Henle, distal convoluted tubule) all come from the metanephric blastema.

Ascent of the Kidneys:

- As the kidneys ascend they revascularize, taking branches from the dorsal Aorta in the developing embryo.
 - The original *renal artery* in the sacral region disappears.
- **Accessory Renal Arteries:** Extra renal arteries result when one of the embryonic renal arteries fails to regress.
- **Pelvic Kidney:** Complete failure of the kidneys to ascend out of the pelvis.
- **Horseshoe Kidney:** The inferior poles of the metanephroi incorrectly fuse during their ascent. The two kidneys are fused together at the inferior poles.
 - In this case they usually don't rise as high because the inferior mesenteric artery is in the way of complete ascent when the kidneys are fused.

Primitive Urogenital Sinus and development of Bladder: The primitive UG sinus is continuous with the **Allantois** in the anterior part of the cloacal region.

- Primitive sinus is divided into three parts
 - **Superior (Vesicular) Primitive UG Sinus:** Forms the **Bladder**.
 - Some of the proximal part will participate in formation of the prostatic urethra.
 - The distal portions of the mesonephric ducts push themselves into the bladder, forming the primitive **trigone** of the bladder.
 - The middle **constricted pelvic urethra** forms the **membranous (and prostatic in males) urethras**.
 - **Inferior (Phallic) Primitive UG Sinus:** Forms the **Penile urethra** (male) and **Vestibule of vagina** (females)
- Relation between Primitive UG Sinus and the Mesonephric Duct
 - As the bladder grows, the mesonephric duct is incorporated into the posterior wall of the bladder. Initially the **ureteric buds** sprout from the mesonephric duct.
 - The Ureter remains on the upper part of the bladder, while the mesonephric duct transposes itself down to the lower part of the bladder.
 - Since the ureter started at an inferior part, it explains why the *mesonephric duct (presumptive vas deferens) crosses superior to the ureter*.
 - Moral to the story: **the vas deferens crosses superior to the ureters behind the bladder, because of the transposition of ureter and mesonephric duct in the embryo** on the posterior part of the bladder.
 - At the same time, this explains the origins of the trigone on the posterior wall of the bladder.

Formation of the Genital System:

- **Indifferent Gonad Stage:** The genital ridge has formed, but no morphologic sex determination has occurred.
- **Gonadal Ridge** is composed of many different cell derivatives
 - **Coelomic Epithelium**
 - **Intermediate Mesoderm (aka urogenital ridge)**
 - **Underlying Mesenchyme**
 - **Mesonephric-derived cells**

- **Primitive Sex Cords** begin to form along the medial aspect of the genital ridge, before any primary sex determination has occurred.
- **SRY Gene:** On the Y-Chromosome, encodes **Testis-Determining Factor (TDF)**.
 - In the presence of TDF, a male will form.
 - In the absence of TDF, a female will form.
- Differentiation of the male gonads (in presence of TDF)
 - Due to TDF, the primitive sex cords form **Sertoli cells** in the developing male.
 - The *Sertoli Cells* secrete **Anti-Mullerian Hormone (AMH)**, which will cause regression of the paramesonephric (mullerian) ducts in the male.
 - As a result the female structures associated with the paramesonephric duct do not form -- i.e. no uterus, fallopian tubes, and vagina.
 - AMH also seems to make the *medullary stromal cells* differentiate into **Leydig Cells**.
 - The Leydig cells secrete **Testosterone**, which has a positive effect on the development of the mesonephric (Wolffian) duct.

SEX DETERMINATION divided into four phases: Male.

The stages are divided according to the basis by which you can distinguish sex in the embryo.

- **Genetic Sex:** XX or XY.
 - The short arm of the Y-chromosome carries the SRY gene.
- **Gonadal Sex:** Begins once AMH is being secreted by the sertoli cells.
 - Leydig Cells are formed and secrete testosterone, which causes development of the Wolffian duct into the ductus epididymis, ductus deferens, and ejaculatory duct.
- **Ductal Sex:** Begins once the Wolffian duct has differentiated into the primary male-type ducts.
- **Genital Sex:** DHT (di-hydroxy-testosterone) stimulates differentiation of the external genitalia.
 - By now we have reached 8-10 weeks of development for male

SEX DETERMINATION divided into four phases: Female. The stages are divided according to the basis by which you can distinguish sex in the embryo.

- **Genetic Sex:** XX or XY.
 - In the absence of androgen, the mesonephric system undergoes continual regression. It doesn't exist in the mature female.
- **Gonadal Sex:** In the absence of AMH, the cortex of the cords forms the ovarian follicles.
- **Ductal Sex:** Again in absence of AMH, the paramesonephric duct system persists to form the internal female duct-structures (uterine tubes and vagina)
- **Genital Sex:** The **absence of DHT** causes, in effect, no formation of the external genitalia and hence no closure of the urogenital sinus. This results in the vestibule of the vagina.
 - By now we have reached 10-12 weeks of development, for female.

Human Chorionic Gonadotropin (HCG): Hormone produced by placenta that is the identifying hormone in pregnancy tests.

- **Hydatidiform Moles:** Uncontrolled tissue growth, can become cancerous. Similar to pregnancy, but embryonic tissues grow rampantly.
 - These tissues lead to incredible levels of HCG and can thus lead to false positives on a pregnancy test.
- HCG causes the Corpus Luteum to secrete progesterone, and hence inhibit FSH + LH and stop the menstrual cycle from continuing.

Female Ducts and Formation of the Uterus: *The entire vagina and uterus do not arise solely from the paramesonephric duct!*

- **Paramesonephric duct** starts as a tube.
- The caudal parts of the tube are induced by the urogenital sinus to fuse together to form the uterovaginal primordium, and ultimately form part of the uterus.

- At the same time, the *cranial parts of the paramesonephric duct* will drag along with it, ultimately to form the **broad ligament of the uterus**.
 - The Broad Ligament suspends the uterus and helps it maintain its central location in the pelvic cavity.
- The unfused regions form the fallopian tubes.
- Pelvic Area of UG sinus will form the sinovaginal bulb, which in turn gives rise to the *lumen of the vagina*. Remember that the fibromuscular vaginal wall comes from the paramesonephric duct.
- Vagina "follows" the urethra to the perineal region, such that its anterior wall becomes intimately related to the urethra.

Formation of the external genitalia: External genitalia begin as undifferentiated, just as the gonads do.

- The genitalia begin as two swellings: the **cloacal and labial/scrotal swellings**.
- **Genital Tubercle**: The distal end of the urogenital folds. It will form either the penis or clitoris.
- MALE
 - As the swellings grow, the presence/absence of DHT has an impact on the urogenital folds. *The presence of androgen causes the genital folds to seal off and form a urethra, which elongates with the penis.*
 - **Penile Raphe**: Ventral aspect of the penis, where the folds close. It extends distally to the glans penis.
- FEMALE: The folds do not seal off and the phallus does not elongate.
 - Genital tubercle instead forms clitoris, which folds down and is covered by the two labial swellings.
 - The open urogenital sinus becomes the **vestibule** of the vagina.
 - The labial folds become the **labia minora**.
 - The glans of the clitoris become tucked under the labia majora to form the prepuce of the clitoris.

PELVIS OSTEOLOGY AND BORDERS

Primary Bones of Pelvis:

- Sacrum
 - **Ala** wings jutting laterally and articulating with the ilium, at the **sacroiliac joint**.
 - The obturator nerve and lumbosacral trunk enter the pelvis at the sacroiliac joint.
 - **Sacral Promontory** Anterosuperior most aspect, connected to LV5 (final lumbar vertebrae) at the **lumbosacral joint**.
 - **Coccyx Bone** at the posterior tip of the sacrum.
- Two Coxal Bones = the union of ilium, ischium, and pubis, united in the acetabular (thigh joint) region.
 - Ilium
 - ASIS, AIIS, PSIS
 - Tubercle -- on the lateral aspect of the iliac crest.
 - Greater and Lesser Sciatic Notches -- on the posterior internal lips of the iliac crest.
 - **Greater Sciatic Notch** formed by curvature of the inferior part of the ileum.
 - Ischium
 - Ischial Spine
 - Ischial Tuberosity -- Posterior aspect of ischium, where we sit on our ass.
 - **Ischiopubic Rami**
 - Form the lateral boundaries of the pubic arch, or subpubic angle.
 - The location of the urogenital diaphragm.
 - Pubis
 - Pubic Tubercle -- the anteroinferior aspect of the *inguinal ligament* (where it attaches). The other point of attachment is the ASIS.
 - Pubic Crest
 - Pectin Pubis
 - Superior and Inferior Pubic Rami
 - **Obturator Foramen** formed in between them, where the obturator nerve leaves the pelvis and enters the thigh.
 - **Obturator Groove**: The anterior aspect of the obturator foramen, near the pectineal line, where the obturator nerve passes from the pelvis to the thigh.
 - Pubic Body

- **Symphysis Pubis** -- anterior most aspect, connecting two pubic bones, under hormonal control by **relaxin**. It can relax the fibers during childbearing / pregnancy.
- **Sacrospinous Ligament:** Tough ligament between sacrum and ischial tuberosity.
 - Starts on lateral aspect of the posterior surface of the sacrum and extends down to the ischial tuberosity.
- **Greater Sciatic Foramen** is formed from both sacrotuberous and sacrospinous ligaments. The *piriformis muscle* moves along the anterior surface of sacrum, through the greater sciatic foramen, and down onto the femur.
- **Sacrospinous Ligament:** Tough ligament between sacrum and ischial spine.
 - It is *anterior* to the sacrotuberous ligament.
 - It extends posterolaterally to connect to the ischial spine.
- **Lesser Sciatic Foramen:** Also formed from both sacral ligaments.
- *Pathway of Pudendal Canal:* It passes out the Greater Sciatic Foramen, over the Ischial Spine, and back into the lesser sciatic foramen, to travel on the medial aspect of the ischial ramus.

Orientation of the Pelvic Bone: It is tilted forward such that the Anterior Superior Iliac Spine and the Pubic Tubercle are in the same frontal plane.

- It is oriented such that *the urogenital diaphragm*, connected to the ischiopubic rami, *is in a horizontal position*.

Bony Pelvis -- Male -vs- Female

FEATURE	MALE	FEMALE
Shape of Pelvic Inlet	Android (wedge or heart shaped)	Gynecoid (oval shaped)
Diameter	Conjugate diameter (anterior-posterior) is greater than the transverse diameter.	Transverse diameter is greater than the conjugate diameter.
Pubic Arch: Formed anteriorly by the union of the ischiopubic rami	Sharper angle, around 60-70	Broad, obtuse angle for child-bearing... greater than 90

Pelvic Brim: The bony borders of the pelvic diaphragm, separating the false (major) pelvis from the true (minor) pelvis.

- **Linea Terminalis:** Term for the bony line going around the brim.
 - **Promontory of Sacrum** -- anterior most part.
 - **Iliopectineale Line** = the ridge going over the ileum and pecten pubis, defining the medial aspect of the pelvic brim.
- Things that pass over the pelvic brim:
 - The psoas muscle
 - The ureters
 - Gonadal arteries
 - Superior rectal artery

Pelvic Diaphragm: It is the inferior border of the pelvis, separating the pelvis from the perineum. It supports the pelvic organs.

- **Genital Hiatus:** A hole in the pelvic diaphragm, where there is no muscle, just fascia. It overlies the superior part of the urogenital diaphragm. The following structures go through it.
 - Urethra
 - Vagina (female)
- **Levator Ani Muscles:** Attaches to the tendinous arch (arcus tendineus) of the levator ani. It extends all the way from the pubis back to the ileum, and sweeps medially back to the coccyx.
 - **Ileococcygeus Muscle:** The posterolateral part of the levator ani muscle, associated with the ilium.
 - **Pubococcygeus Muscle:** The anteromedial part of the levator ani muscle, associated with the pubis.
 - **Puborectalis Muscle:** The most medial part of the pubococcygeus muscle, going around the rectum. **Puborectal Sling** are the muscle fibers of the puborectalis that swing around the rectum, holding it in place.
 - Pubovaginalis / Puboprostatic: There is also a pubovaginalis part in the female, and less prominent puboprostatic part in the male.

- Obturator Internus Muscle: The muscle underlying the *obturator membrane*, which covers the obturator foramen.
- **Coccygeus Muscles:** Laterally attaches to the ischial spine, and medially attaches to the lateral aspect of the sacrum.
- **Arcus Tendineus:** The line of attachment between the obturator internus muscle and levator ani. Okay, not a line, but rather a sweep of fascia.

FUNCTION OF THE PUBORECTAL SLING: It creates an angle between the rectum and anal canal, which allows you to retain fecal matter. The angle is almost 90, and the anal canal points down and posteriorly.

Urogenital Diaphragm: The part of the pelvic diaphragm that extends medially, between the **ischio pubic rami**.

- Through and through, it is located *inferior to the pelvic diaphragm*.
- Anteriorly, it encloses the sphincter urethrae muscle.
- Posteriorly, it encloses the deep transverse perianal muscle.
- Anteriorly, it encircles the urethra on either side. The anterior recess of the anal fossae becomes smaller and smaller as you move anteriorly.
- It encloses the **Deep Perineal**

Pelvic Roof / Peritoneum: The pelvic roof is defined by the inferior limit of peritoneum, coming down from the abdomen.

- Peritoneum covers the anterior aspect of rectum, then reflect off the uterus (in female), forming the **Rectouterine Pouch (of Douglas)**. That is the inferior most peritoneal recess of the abdomen.
 - Male analogous structure is **rectovesical recess**, reflection between the rectum and seminal vesicles, which are directly posterior to the bladder.
- The peritoneum then covers the uterus and uterine tubes, before going back up the anterior abdominal wall.
- Peritoneum does *not* cover all of the rectum.
- **Central Tendon of the Perineum (Male), or Perineal Body (female):** The junction of most of the musculature of the pelvic diaphragm. *It is the central support for pelvic diaphragm, which in turn supports the pelvis.*
 - *If it is damaged, incontinence results.*
 - It is an attachment point for both the perineum and the pelvis.
 - Point where fibers from pelvis unite with those of external anal sphincter.
 - It is the posterior attachment point of the urogenital diaphragm.
 - Point where external genitalia (corpora) muscles attach.
 - Point where superficial transverse perineal muscles attach.

Endopelvic Fascia: The name of the visceral fascia in the pelvis.

OBGYN STUFF:

- **Pelvic Inlet:** Line from upper part of pubic symphysis back to the sacral promontory.
- **Pelvic Outlet:** Line from the lower part of pubic symphysis back to tip of coccyx.
- **True Conjugate Diameter:** Measured along the pelvic inlet.
- **Diagonal Conjugate Diameter:** Measured from the bottom of the pubic symphysis back to the sacral promontory.
- **Obstetrical Conjugate Diameter:** The smallest opening, from the widest part of the pubic symphysis, back to the sacral promontory.

Perineum: The area inferior to the pelvic and urogenital diaphragms.

- Structures in perineum:
 - External genitalia.
 - Anal canal and anal sphincters
 - Ischiorectal and ischioanal fossa.
- **Urogenital Triangle:** Triangle defining urogenital region of the perineum.
 - Anterior aspect (apex of triangle): pubic symphysis
 - Lateral aspects: Ischial tuberosities
 - Posterior aspect: tip of coccyx bone.

- **Anal Triangle:** Triangle defining the anal region of the perineum.
 - Apex of anal triangle = the tip of the coccyx bone.
 - Sides of anal triangle = the sacrotuberous ligaments and the gluteus maximus.
 - Base of anal triangle = the ischial tuberosities.
- Boundaries between the triangles: A line going from one **ischial tuberosity** to the other one defines the border between the two perineal triangles. The perineal body is in the middle of that line.
 - The line also marks the inferior border of the urogenital diaphragm.
 - **Superficial Transverse Perineal Muscle** goes between the anal and UG triangles, and converges on the perineal body.

RECTUM / ANAL CANAL / ISCHIOANAL FOSSAE

Ischioanal Fossae: The potential spaces surrounding the anal canal, in the anal triangle region, located between the skin of the anal region and the pelvic diaphragm.

- The spaces are triangle-shaped.
- Borders:
 - The apex forms superiorly at the lateral border of the levator ani muscles, where they connect to the obturator membrane.
 - The lateral aspect of the fossae are the obturator internus muscles.
 - The base of each fossa (triangular base) is the perianal skin.
 - The medial aspect of each fossa is the anal canal.
 - The posterior aspect of each fossa is the sacrotuberous ligament and gluteus maximus muscle.
- As you go more anteriorly, the region of the ischioanal fossae becomes thinner, until it converges on the bladder anteriorly. There is very little of the anterior recess left, right next to the pubic symphysis most anteriorly.
- **Anterior Recess of the Ischioanal Fossae** is formed by the reflection of the fossa, anteriorly, with the urogenital diaphragm.
 - This recess is between the pelvic diaphragm (superior border) and UG diaphragm (inferior border).
 - If an abscess were to get into the anterior recess, the fluid would be *superior to the UG diaphragm and inferior to the pelvic diaphragm*.
- **Posterior Recess of the Ischioanal Fossae** is just superior to the sacrotuberous ligament, where it reflects on the posterior part of the pelvic diaphragm.
 - This is inferior to the pelvic diaphragm.
- Contents of Ischioanal Fossae: Fat! -- which allows the expansion of the anal canal and therefore the passage of stored feces.

PUDENDAL CANAL: Contains pudendal artery, pudendal vein, and pudendal nerve.

- It runs along the *lateral wall of the ischioanal fossae*, just medial to the obturator internus muscle.
- It runs along the *medial surface of the ischial tuberosity*.
- It goes out at the greater sciatic foramen, then runs laterally along the ischial spine and sacrospinous ligament, and then comes back in through the lesser sciatic foramen, and then runs along the medial aspect of the ischiopubic ramus.
- **Internal Pudendal Artery and Vein:**
 - A branch of the anterior division of the internal iliac artery / vein.
- **Pudendal Nerve:**
 - *The only nerve innervating the perineal region!*
- Branches of the Pudendal Canal:
 - Inferior Rectal Artery, Vein, and Nerve: Goes to the rectal area.
 - Perineal Artery, Vein, and Nerve: Goes to the Urogenital area.
 - Deep Dorsal Artery, Vein, and Nerve: Goes to the shaft of the penis (clitoris).
 - It travels along the superior aspect of the UG diaphragm.

RECTUM AND ANAL CANAL:

- Rectosigmoid junction is about the level of **S3** -- third sacral segment.
 - **Ampulla:** The distal holding tank for fecal mass, distal part of rectum, before entering the anal canal proper.
 - The *Pelvic Diaphragm* is associated with the ampullary portion of the rectum. That is where the levator ani muscles are!
 - As the ampulla fills up, the **anorectal sling** of the puborectalis muscle holds the anal canal at an angle, and support the ampulla superiorly, to prevent defecation.
 - Defecation occurs when the puborectalis muscle is relaxed and the angle becomes more linear.
 - **Anorectal Flexure:** The transition point between the rectum and anus.
 - Peritoneum: Gradual disappearance of the peritoneum.
 - Upper third of rectum: Both anterior and lateral sides (sigmoid mesocolon)
 - Middle third of rectum: Just anterior side of rectum.
 - Lower third of rectum: No peritoneum!
 - Rectal Folds: Perhaps to hold the shit in place.
 - **Superior Rectal Valve**
 - **Middle Rectal Valve**
 - **Inferior Rectal Valve**
 - Rectal Veins:
 - The **Inferior Rectal Vein:** The **External Rectal Plexus** forms from the inferior rectal vein. This is ectodermal and innervated by somatic efferents (GSE). The external rectal plexus has three sites of drainage:
 - Superior parts dump into the superior rectal vein, then into the IMV. (via anastomoses with portal system.)
 - The middle parts dump into the middle rectal vein and then into the internal iliac.
 - The inferior parts drain into the internal pudendal vein, then into the internal iliac.
 - The **Superior Rectal Vein:** The **Internal Rectal Plexus** forms from the superior rectal vein. This is endodermal and innervated by visceral efferents (GVE).
 - Takes drainage from two vessels: The middle rectal vein and inferior rectal vein.
 - The *anastomoses* between the two -- the **pectinate line** is right at the anorectal flexure, where the inferior rectal vein anastomoses with the superior rectal vein.
 - **Anal Columns:** They are right *above* the pectinate line, at the distal-most part of the rectum.
 - Anal Musculature:
 - **External Anal Sphincter Muscle:** Striated, voluntary muscle, innervated by the *inferior rectal nerves*. These muscles insert on the Central Tendon of the UG diaphragm.
 - External Anal Sphincter comes in three parts:
 - **Subcutaneous External Anal Sphincter** -- circular
 - **Superficial External Anal Sphincter** -- extends longitudinally to either side of the anal canal.
 - **Deep External Anal Sphincter** -- part of pelvic diaphragm that participate in the puborectal sling.
 - External usually maintain a tonic level of contraction to stop from shitting.
 - **Internal Anal Sphincter Muscle:** Smooth, involuntary, innervated by the *pelvic splanchnic nerves*.
 - Parasympathetic reflex.
 - Innervation of Rectum
 - A lot of **pelvic splanchnic nerves** come from the posterior of the rectum and pass around the lateral edges.
 - Relations:
 - The rectum can make an impression on the posterior wall of the vagina. It can invade the posterior wall of the vagina such that the vaginal wall extends down toward the vestibulum.
 - ANTERIOR TO RECTUM: Seminal Vesicles, Prostate, Bladder.
 - POSTERIOR TO RECTUM: All muscles of pelvic diaphragm, bony elements of skeleton, Pelvic splanchnic nerves and pudendal nerve.
 - LATERAL TO RECTUM: Ureters, pelvic splanchnic nerves.
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EXTERNAL GENITALIA

EXTERNAL MALE GENITALIA:

- **Superficial (Dartos) Fascia:** Goes all the way down into the penis.
- **Deep Fascia:** Directly overlies the penis, deepest layer.
- **PENIS CROSS SECTION:**
 - **Corpus Cavernosa:** The two more dorsal bodies of the penile shaft. They fill with blood from the **deep artery** when erect.
 - **Tunica Albuginea:** The very dense fascia that surrounds the corpus cavernosa.
 - **Corpus Spongiosum:** The most ventral of the three erectile tubes.
 - **Urethra:** Travels through the corpus spongiosum.
 - **Glans Penis:** Extension of the corpus spongiosum, and it overlies (caps) the two corpora spongiosa.
- **The Root of the Penis:** The three bodies (corpora spongiosa and cavernosa) converge on the penis. Conversely, the corpus cavernosa divert as you move down the shaft of the penis, toward the ischiopubic rami.
 - When they get down to the bottom, they are then called the **left crus** and **right crus** of the penis.
 - Left and right crura attach to both the ischiopubic rami and the fascia of the UG diaphragm.
 - As you move down the shaft, the corpus spongiosum becomes thicker until it called the **bulb of the penis** at the base. It also attaches to the fascia of the UG diaphragm.
- Communication between Corpora: The corpus bodies do communicate with each other. They are not strictly isolated.
- Penile Stimulation:
 - Afferent fibers are carried back through the **Pudendal Nerve** as GSA somatic fibers.
 - At the same time, *parasympathetic fibers* of the ANS travel along the Pudendal Nerve, specifically the **Pelvic Splanchnic Nerves -- S2, S3, S4.**
 - **PATHWAY OF THE PELVIC SPLANCHNICS INTO THE PENIS:**
 - They travel down through the **prostatic plexus**, which is deep to the UG diaphragm.
 - Then they pass under the **sub-pubic arch.**
 - Then they pass through a hiatus in the **UG Diaphragm**, where they join the fibers of the pudendal nerve.
 - The job of the parasympathetic pelvic splanchnics is to induce *vasodilation*, causing corpus cavernosa to fill with blood from the deep artery.
 - Sympathetic Stimulation *gets rid of* an erection.
- Muscles: Along the root of the penis that aid in erection, by preventing the backflow of blood back out of the shaft.
 - **Investing Fascia (Gallaudet's Fascia)** is the penile fascia that surrounds the muscles.
 - **Bulbospongiosus Muscle:** Penile muscle surrounds the corpus spongiosum and urethra. Aids in the last part of urination and ejaculation.
 - Forms a *herringbone pattern*, V-shape on either side of the urethra. Hence when it contracts it compresses the urethra to aid in expulsion of fluids.
 - It inserts on the central tendon of the perineum.
 - **Ischiocavernosus Muscle:** Penile muscles surround the corpora cavernosa.
 - Upon contraction they restrict the return flow of blood, to maintain erection.
 - They insert on the Ischiopubic Rami bones -- *they do not insert on the Central Tendon of the Perineum.*
- Ejaculation:
 - **Emission:** Peristaltic wave of contractions through the **ductus deferens**, along with contraction of seminal vesicles and prostate gland, causes fluid to move to the Ejaculatory Duct which leads into the **urethra.**
 - Emission is a **sympathetic response.**
 - Seminal Vesicle add fluid to the urethra at the **ejaculatory duct**, most distally. The ejaculatory duct is where the seminal vesicle joins the ductus deferens.
 - Prostate gland adds fluid to the urethra at the **prostatic utricle**, more proximally.
 - **Expulsion:** Spastic contraction of the muscles that overlie the corpora cavernosa. and spongiosa. The same type of muscular contraction (though not spastic) will expel the last bit of urine during urination.
 - Expulsion is a **parasympathetic response.**
- **MALE URETHRA:**
 - **Prostatic Portion of Urethra:** The part that passes through the prostate gland. Directly inferior to the bladder.
 - The prostate sits directly superior to UG diaphragm.
 - **Membranous Portion of Urethra:** The part of the urethra that passes through the urogenital diaphragm.

- **Spongy (Penile) Urethra:** The part of the urethra that goes up the shaft of the penis, starting from the bulb of the penis at its base.
- **Bulbourethral Gland:** Supplies lubrication to the urethra. It is located *in the urogenital diaphragm*.
 - Ducts open into spongy portion of urethra.
 - *Greater Vestibular Gland (Bartholin's Gland)* is homologous structure in female.
- **Ductus Deferens:** Pathway
 - It starts at epididymis, passes *through the inguinal canal*, over the pelvic brim and into the pelvis.
 - It passes **medial to the ureters** on the posterior aspect of the bladder.
 - It joins with the seminal vesicles to form the ejaculatory duct.
- **Seminal Vesicles:** Located posterosuperior to the prostate gland. They go into the prostate gland anteriorly and empty into the ejaculatory duct.

FEMALE EXTERNAL GENITALIA:

- **Mons Pubis:** Overlies the pubic bone.
- **Labium Majus:** Outermost region, covered with hair. Composed of skin and elongated tubes of fat.
 - The distal end of the **ROUND LIGAMENT** of the uterus inserts into the labia majora.
 - **Anterior Labial Commissure:** Just anterior to the prepuce (hood) of the clitoris. The area where the labia majora meet anteriorly. There is no true posterior labial commissure.
- **Pudendal Cleft:** All structures in between the left and right labia majora. It contains the following:
- **Labia Minora:** Fat-free folds between the labia majora. All structures in between the labia minor are contained in the vestibule.
 - The labia minora enclose the vestibule.
 - Anteriorly, the labia minora come together to form the **prepuce of the clitoris**.
 - **Frenulum of Labia Minora:** The posterior junction of the labia minora. This is also known as the **Fourchette**.
- **Vestibule** = the space + all structures located between the labia minora.
 - **Clitoris:** Homologous to the penis in the male.
 - The corpora and crura of the clitoris originate in the labia minora.
 - **Prepuce** = the anterior convergence of the two labia minora.
 - **Frenulum:** The posterior aspect of the clitoris, where the labia minora also converge.
 - **Glans Clitoris:** Distal end. Proximal to it is the **body**, or, **shaft** of the clitoris.
 - **Angle of the Clitoris:** Still more distal to the body.
 - Then the two corpora divert into a left and right crus, that insert into ischiopubic rami, just as in the male.
 - **Suspensory Ligament of Clitoris:** An extension of deep fascia, which attaches at the symphysis pubic. Just anterior to the clitoris.
 - **Vestibular Bulbs:** Homologous to the corpus cavernosa in the male.
 - They are erectile tissue, one on each side.
 - They are not officially part of the clitoris.
 - Development: Unlike the male, the development of the urethra is independent to that of the external genitalia, since the urethra does not travel through the clitoris.
 - **Greater Vestibular (Bartholin's) Gland:** Inferior fascia of the UG diaphragm, just posterolateral to the vaginal wall.
 - Unlike the male counterpart, these glands are superficial to the inferior surface of the UG diaphragm, in the superficial perineal space.
 - Glands empty into the posterolateral wall of the vaginal orifice, providing lubrication.
 - **CLINICAL:** Because of close proximity to outside, vestibular glands are susceptible to infection.

VASCULAR / NERVE SUPPLY TO THE EXTERNAL GENITALIA

- **Deep Dorsal Vein:** It carries most of the blood from the penis / clitoris.
 - It has two pathways:
 - **Primary Pathway:** Passes through the genital hiatus, posterior to the arcuate ligament -----> to **prostatic venous plexus** (only in male) -----> to **Vesicular venous plexus** on the bladder (both sexes) -----> **Internal Iliac Vein**.
 - **Secondary Pathway:** Deep Dorsal Vein -----> Internal Pudendal Vein -----> Internal Iliac
 - **CLINICAL: Prostate Cancer** in the male. If the prostatic venous plexus is removed during removal of the prostate, then very little blood will be able to return from the penis. Result = no erection!

- **Internal Pudendal Vein:** It comes off the Aorta -----> Common Iliac -----> Internal Iliac -----> Anterior Division of Internal Iliac -----> Internal Pudendal.
 - Internal pudendal carries the rest of the blood from the genitalia (the part not carried directly by deep dorsal vein)
 - Has three primary branches:
 - **Deep Dorsal Vein:** Secondary drainage of penis / clitoris
 - **Perineal Vein:** UG diaphragm and UG viscera
 - **Inferior Rectal:** Anal fossa
- **Pelvic Splanchnic Nerves:** Come from the Prostatic Plexus (in the male) and Vesicular Plexus (both sexes) to give autonomic parasympathetic innervation to the penis / clitoris.
 - **Prostatic Plexus** -- ANS plexus from S2, S3, S4.
 - **Vesicular Plexus** -- plexus on bladder from ANS S2, S3, S4.
- **Pudendal Nerve:** Somatic innervation. It originates at the **sacral plexus (S1-S4)**. It enters the perineal region through the lesser sciatic foramen. It has three primary branches.
 - **Inferior Rectal Nerve** -- innervates, um, the rectum.
 - **Perineal Nerve** -- UG viscera
 - **Deep Dorsal Nerve** -- sexual stimulation, man.
- **Ilioinguinal Nerve:** Innervates the anterior labia majora / scrotum.
 - Originates from the **Lumbar Plexus at L1** -- sympathetic innervation. It enters the perineum through the inguinal canal.

BLOCKAGE OF THE PUDENDAL NERVE: The pudendal nerve is the main nerve you need to deaden, to anesthetize the pelvic region... but there are others.

- To find the nerve, *palpate for the ischial spine*, because that is where the nerve exits the pelvis and enters the pudendal canal.
- By anesthetizing right there, you can deaden all the branches in one shot: the inferior rectals, perineals, and deep dorsal.

PERINEUM

TISSUE LAYERS OF THE UROGENITAL TRIANGLE: MALE

- Skin
- Subcutaneous Tissue -- **Camper's Fascia**.
- Superficial Membranous Fascia: Attach to the posterior aspect of the UG diaphragm, just anterior to the central tendon of the perineum.
 - **Scarpa's Fascia:** Abdominal superficial membranous fascia.
 - **Colle's Fascia:** Superficial membranous fascia, continuous with Scarpa's, in the region posterior to the scrotum.
 - **Darto's Fascia:** Superficial membranous fascia of the penis.
- SUPERFICIAL PERINEAL SPACE: All structures between the superficial membranous fascia and the perineal membrane.
 - **Investing Fascia:** Inferior border of the bulbospongiosus muscle. Converges with Buck's fascia at the base of the penis.
 - **Buck's Fascia:** Superior (deep) border of the bulbospongiosus muscle. Converges with investing fascia at the base of the penis.
 - **True Suspensory Ligament of the Penis:** Superior to and continuous with deep fascia, continuous with transversus abdominis fascia of anterior abdominal wall.
 - MUSCLES / CORPORA / VESSELS / NERVES: All are in the superficial perineal space. ALL OF THE MUSCLES ATTACH TO THE PERINEAL BODY
 - Corpus Spongiosum with **Bulbospongiosus Muscle** covering it.
 - Corpus Caverosum with **Ischiocavernosus Muscles** covering it; Crura of the Penis (composed of Corpora Caverosa).
 - **Bulb of the penis** (of the corpus spongiosum)
 - **Superficial Transverse Perineal Muscle:** The posterior border of the UG diaphragm. Attaches to the perineal body and counters the action of the bulbospongiosus muscle.
 - It generally holds the UG structures in place.
 - Perineal Nerves, branches of the pudendal.

- PERINEAL MEMBRANE: Inferior border of the UG diaphragm. It divides the superficial perineal space from the deep perineal space.
- DEEP PERINEAL SPACE
 - Male Muscles of the UG Diaphragm:
 - **Sphincter Urethrae Muscle:** To stop urination.
 - Primary musculature in the male. They are circular fibers which compress the urethra upon contraction, to stop urination.
 - **Deep transverse perineal muscle:** Muscle located in the posterior aspect of the UG diaphragm.
 - Deep dorsal vein/artery of the penis (branch of pudendal vein)
 - Deep dorsal nerve of penis (branch of pudendal nerve)
 - **Bulbourethral (Cowper's) glands** -- in the Deep Perineal Space.
 - Urethra passes through it.
- SUPERIOR MEMBRANE OF THE UROGENITAL DIAPHRAGM

STRADDLE INJURY: Blood investing the superficial perineal space will not get into the deep perineal space. It will be stopped at the following borders:

- Superior Border: Arcuate line in the abdominal wall.
- Lateral Borders: Inguinal Ligaments.
- Deep border: Perineal Membrane.

TISSUE LAYERS OF THE UROGENITAL TRIANGLE: FEMALE

- Skin
- Subcutaneous Tissue -- **Camper's Fascia**.
- Superficial Membranous Fascia: Attach to the posterior aspect of the UG diaphragm, just anterior to the central tendon of the perineum.
 - **Scarpa's Fascia:** Abdominal superficial membranous fascia.
 - **Colle's Fascia:** Superficial membranous fascia, continuous with Scarpa's, in the region posterior to vagina.
- SUPERFICIAL PERINEAL SPACE: All structures between the superficial membranous fascia and the perineal membrane.
 - **Gallaudet's (Deep) Fascia:** Inferior border of the bulbospongiosus muscle.
 - **True Suspensory Ligament of the Clitoris:** Superior to and continuous with deep fascia, continuous with transversus abdominis fascia of anterior abdominal wall.
 - MUSCLES / CORPORA / VESSELS / NERVES: All are in the superficial perineal space. ALL OF THE MUSCLES ATTACH TO THE PERINEAL BODY
 - Two Vestibular Bulbs with **Bulbospongiosus Muscle** covering it.
 - Corpus Cavernosum with **Ischiocavernosus Muscles** covering them; Crura of the clitoris.
 - Urethra / Vagina
 - **Greater Vestibular (Bartholin's) Gland** -- located at the posterior aspect of the vestibular bulb -- in the superficial perineal space.
 - The analogous structure in the male, the Bulbourethral gland, is in the deep perineal space, while the female homolog is in the superficial perineal space. Note difference.
 - **Superficial Transverse Perineal Muscle:** The posterior border of the UG diaphragm. Attaches to the perineal body and counters the action of the bulbospongiosus muscle.
 - It generally holds the UG structures in place.
 - Perineal Nerves, branches of the pudendal nerve.
- PERINEAL MEMBRANE: Inferior border of the UG diaphragm. It divides the superficial perineal space from the deep perineal space.
- DEEP PERINEAL SPACE
 - Female Muscles of the UG Diaphragm:
 - **Compressor Urethrae Muscle** -- passes anterior to the urethra.
 - **Sphincter Urethrae Muscle** -- Passes posterior to the urethra and blends with the compressor urethra.
 - It inserts on the Perineal Body.
 - **Urethrovaginal Sphincter** -- circular, voluntary fibers around the posterior of the urethra. When they contract, both the vagina and the urethra constrict.
 - It inserts on the Perineal Body.
 - **Deep Transverse Perineal Muscle**

- Deep dorsal vein/artery of the clitoris (branch of pudendal vein)
- Deep dorsal nerve of clitoris (branch of pudendal nerve)
- Urethra passes through it.
- SUPERIOR MEMBRANE OF THE UROGENITAL DIAPHRAGM

Genital Hiatus of the UG-Diaphragm:

- Located in between the arcuate ligament and transverse perineal ligament.
- **Arcuate Ligament:** Anterior border of genital hiatus, located just deep to the pubic symphysis.
- **Transverse Perineal Ligament:** Posterior border of the genital hiatus, located just anterior to the muscular part of the UG diaphragm. It is the fusion of the inferior and superior membranes of the UG diaphragm.
- The Deep Dorsal Vein / Nerve of Penis goes below the genital hiatus.
- The **pelvic splanchnic nerves** go through the hiatus to join the dorsal nerve on the other side.

PELVIC VISCERA

URETERS:

- Pathway of the Ureters
 - They are almost always found at the **bifurcation of the iliacs**, where the left and right each bifurcate into left internal/external and right internal/external, respectively.
 - The ureters then pass over the pelvic brim along the posterior wall, briefly follow the internal iliacs, and proceed along the lateral pelvic wall.
 - They are at all times *retroperitoneal* until the peritoneum is lost.
 - Then they sweep onto the rectum (where the peritoneum is lost), and pass anteroinferiorly to enter the posterior surface of the bladder at a diagonal angle.
- MALE: The ureter is related to the *ductus deferens*. The Ductus Deferens is superior and anterior to the ureter.
- FEMALE: The ureter passes *directly inferior to the uterine artery* as it passes over the pelvis to enter the bladder. This is often termed **water under the bridge** (ureter under the uterine artery) and it is critical to any surgery involving the ureters.
- CLINICAL STUFF:
 - Innervation of ureters is T11-L1 -- Sympathetic autonomic. Hence referred pain goes back to the umbilical region!
 - **Ureteric Calculus:** A kidney stone or stone in the ureter.
 - The pain caused by a stone is *colicky pain*... hyperperistalsis in the region superior to the obstruction. This is followed by a dull pain caused by distension of the renal pelvis.
 - The pain is referred to T11-L1
 - May cause obstruction of urinary flow. *Most common sites of obstruction are:*
 - Where the ureter passes over the pelvic brim, at the bifurcation of the iliacs.
 - Where the ureter passes obliquely into the posterior bladder wall.
 - Stone can be removed with endourology: passing a scope up the urethra.

THE BLADDER:

- Parts of Bladder: Most of the bladder has a rough, loosely associated surface, except the trigone.
 - **Fundus** -- the posterior and inferior portion of the bladder.
 - **Neck** -- The part of the bladder that converges down onto the urethra. The inferior third.
 - It forms the **infundibulum** (funnel-like) part of the bladder.
 - **Trigone** -- the triangle on the posterior bladder wall, defined by the two ureters superiorly, and the urethral opening inferiorly.
 - The trigone has a smooth surface and tightly adhered muscle.
 - **Body**
 - **Apex:** The anterior most part of the bladder, posterosuperior to the pubic ramus. The urachus comes off of the apex of the bladder.

- **Uvula:** The raised portion of the bladder near the neck.
 - It is raised due to the impression of the middle lobe of the prostate right inferior to it. **CLINICAL** when the prostate is inflamed it will get raised a lot more and could obstruct the urethral opening.
- **Detrusor Muscle:** The smooth muscle of the bladder, carrying ANS innervation.
- **BED OF THE BLADDER:** Depends on whether it is empty or full.
 - When full, it will push against the rectum (in males) or uterus (in females) posteriorly.
 - Anteriorly, the bladder rests on the symphysis pubis.
 - Anterolaterally, the bladder rests on the obturator internus muscle.
 - Inferiorly, the bladder rests on the pelvic diaphragm in females, and on the prostate gland in males.
- **Vesicular Venous Plexus:** Directly inferior to the bladder (females) or inferior to the prostate (males).
- **MALE Structures:**
 - Seminal Vesicles: On the posterior part of the bladder, near the trigone and fundus of the bladder.
 - Prostate Gland: Associated with the neck of the bladder. The body of the bladder sits on the prostate.
 - Ductus Deferens traverses the superior part of the bladder, joining with the seminal vesicles on the posterior part of the bladder.
 - Rectum is immediately posterior to bladder.
 - **Rectovesical Recess:** The space between the rectum and bladder.
- **FEMALE Structures**
 - Uterus is associated with posterior surface of bladder. As the bladder fills, it pushes the uterus in a posterior (retroflexed) position.
 - The *anterior wall of the uterus is closely related to the posterior wall of the bladder*, due to the common developmental origin of the *sinovaginal bulbs*. This is important clinically.
 - The bladder is anterior to the vagina. Okay?
- **Ligaments:**
 - **MALE:**
 - **Sacrogenital Ligament:** Supporting ligament. Runs from the sacrum, around the rectum, and attaches on the posterior surface of the bladder.
 - **Puboprostatic Ligament:** Attaches the prostate to the pubis.
 - **FEMALE:**
 - **Uterosacral Ligament:** Goes from sacrum, around rectum, and attaches to uterus posterolaterally.
 - **Vesicouterine Ligament:** A continuation of the uterosacral ligament. It attaches the bladder to the uterus.
- The primary support of the bladder is the pelvic diaphragm!
- **Median Umbilical Ligament / Urachus:** A fibrous chord coming off of the apex of the bladder. Directly anterior to the bladder.
 - This is one of the embryonic median umbilical arteries. There are two others going over the bladder.
- **CLINICAL:** Enlargement of prostate will push it into the bladder. This can cause dribbling of urine (incontinence), due to decreased sphincteric action of the sphincter urethrae muscle in the UG diaphragm.
- **Autonomic Control of Micturition:**
 - Voiding of the bladder is an autonomic response through the parasympathetic system, from the *pelvic splanchnic nerves* (S2-S4), specifically the **inferior hypogastric plexus** which goes to the **vesicular plexus** of the bladder.
 - They stimulate the detrusor muscle and inhibit the UG urethral sphincter.
 - Overdistension and pain is carried by pre-ganglionic sympathetics, originating from T11-L2.
 - Somatic voluntary control comes from the **perineal branch** of the pudendal nerve. This can override the parasympathetic voiding reflex -- up to a point.
- **CLINICAL:** Fractures of pubic bone can rupture the bladder.
 - Rupture of bladder superiorly will send urine to the peritoneal cavity.
 - Anterior rupture (rupture of pubic bone) would send urine into the Anterior **Retropubic Space of Retzius**.
 - The *Vesicular Venous Plexus* is located in this space.
- **Blood Supply to the Bladder:**
 - Blood supplied by the **Superior and Inferior Vesicular Arteries**, which are branches of the Anterior Internal Iliacs.
 - Venous drainage is through the **Vesicular Venous Plexus**, which drains into the Internal Iliac Veins.
 - Lymphatics primarily go to external and internal iliac nodes.

PERITONEAL SPACES

- **Vesicorectal Pouch:** Male area between the bladder and rectum. (In the female, there are two such spaces).
- **Vesicouterine Pouch:** Female area between the bladder and uterus.

- **Rectouterine Pouch of DOUGLAS:** The female reflection of peritoneum between the uterus and rectum. It is the *lowest (most dependent) point in the abdominal cavity*, where pathology tends to collect.
- **Pararectal Fossa:** Space created by reflection of peritoneum off of the rectum onto the lateral wall.
 - As feces fills, the fossa deepens.
- **Paravesical Fossa:** Space created by the reflection of peritoneum off of the bladder onto the lateral wall.
 - As the bladder fills, the fossa deepens.
- **Space of Retzius:** Space anterior to the bladder.

FEMALE REPRODUCTIVE ORGANS

Origin of the Ovary:

- The uterus and ovary have a diverse origin. They arise from two different places developmentally.
- When the distal ends of the paramesonephric duct contact the urogenital sinus, they fuse and pull the rest of the paramesonephric duct away from the posterior wall, forming the *broad ligament* of the uterus.

OVARIES:

- It is located more on the posterior aspect of the peritoneum -- posterolateral to the uterus and to the broad ligament.
- **Ovulation:** The ovum is actually released *into the peritoneal cavity* and then picked up by the ovarian tubes.
- **Ovarian Fossa:** The location of the ovaries. A depression in the lateral wall of the pelvis.
- NERVE / BLOOD SUPPLY TO OVARIES -- Once again, they come from back around L2 and L2.
 - Left ovarian vein drains into the left renal. The right ovarian vein drains into the IVC.
 - Left and Right ovarian arteries drain into the abdominal aorta directly.
 - Lymph for the ovaries, therefore, is through the *lumbar aortic nodes*.
 - Parasympathetic supply comes from the *Vagus nerve* rather than the pelvic splanchnic, because of the embryonic origin of the ovaries.
 - Sympathetics are from T10, the *Lesser Thoracic Splanchnics*, via the hypogastric plexus -----> ovarian plexus.

UTERINE TUBES:

- Structures:
 - **Fimbriae:** The finger-like projections going into the peritoneum, which surround each ovary to aid in the deposition of the ovum.
 - **Infundibulum:** The neck of the uterine tube, where it turns, nearest the ovary. Funnel-shaped opening.
 - It has a heavily ciliated lining which produces a current which sweeps the ovum in a distal-proximal direction, toward the uterus.
 - **Ampulla:** The main part of the tube, where fertilization normally takes place.
 - **Isthmus:** The stretch of tube nearest the proper ovarian ligament, close to the uterine junction.
 - **Intramural:** The part of the uterine tube within the myometrium of the uterus.
- CLINICAL:
 - **Ectopic Pregnancy** more common occurs in the uterine tube than in the peritoneum. It is dangerous because the normal cause of pregnancy causes tissues to be digested as the embryo implants in the peritoneal wall somewhere. A tubal pregnancy will eventually cause the tubes to erupt.
 - **Hysterosalpingogram:** An X-Ray given into the endopelvic space to determine whether or not there is an opening in the fallopian tubes.
 - **Peritonitis / Salpingitis:** Infection in the peritoneum can spread to the fallopian tubes, and infection in the fallopian tubes can spread to the peritoneum.
 - When the fallopian tubes are infected (Salpingitis), a *tubal pregnancy* can easily result due to adhesions in the tube.

- BLOOD SUPPLY:
 - It has a **dual blood supply** from the **ovarian artery** and **uterine artery**. The ovarian and uterine arteries anastomose with each other at the fallopian tubes.
 - Veins, nerves, and lymphatics are associated with those of the ovaries.

UTERUS:

- Relations -- Anteriorly related to the bladder and posteriorly related to the rectum. When the bladder is filled, the uterus is more posteriorly located.
- STRUCTURES
 - **Fundus:** The top portion of the uterus, above the level of the uterine tubes.
 - **Body:** Main part, with thick wall.
 - **Isthmic Portion:** The lower one third, which leads down into the cervical canal.
 - **Myometrium:** Muscular wall of the uterus.
 - **Perimetrium:** Outer lining of uterine wall.
 - **Endometrium:** Inner lining of uterine wall.
- POSITIONS
 - **Anteflexed:** Bent anteriorly with respect to the isthmus of the uterus. The cervix may be pointing posteriorly.
 - **Anteverted:** Bent anteriorly at the level of the cervix. The cervix and isthmus point anteriorly.
 - **Retroflexed:** Bent posteriorly with respect to the isthmus.

Ligaments and Peritoneum:

- **Suspensory Ligament of the Ovary:** Connects the ovary to lateral wall. It covers the external iliacs.
 - It *brings the vessels, nerves, and lymph supply* to the ovaries.
 - It is not a true ligament, but rather a condensation of endopelvic fascia.
- **Proper Ovarian Ligament:** Remnant of the gubernaculum. The ligament that connects the ovary to the uterus, running inferior to the uterine tubes.
- **Round Ligament:** Remnant of the gubernaculum. It runs from the fundus of the uterus, inferolaterally to the labia major, joining up with the inguinal ligament about halfway through its course.
 - Carries with it a vascular supply -- the *phrenicular branch of the ovarian artery* or **Samson's Artery**.
- **Broad Ligament:** The sweeping peritoneum that overlies the ovaries and the uterus anteriorly.
- **Mesovarium:** That portion of broad ligament that suspends the ovaries in place. It comes out from the broad ligament, wraps around the ovaries, and goes back to the broad ligament on the posterior wall.
- **Mesometrium:** That portion of broad ligament that is associated with the uterus directly.
- **Mesosalphinx:** That portion of broad ligament that directly overlies the fallopian tubes.
- **Cardinal Ligament:** The ligament connecting to the uterus at the level of the cervix. It provides support to the uterus, but not the primary support -- that comes from the pelvic diaphragm.
 - The *ureters pass right underneath the uterine artery at the location of the cervix -- at the cardinal ligament*.
"Water under the bridge" -- don't cut that ureter!
- VASCULAR / LYMPH SUPPLY
 - Vascular supply is from the **uterine artery** a branch of the anterior internal iliac approaching the uterus at the level of the cervix. The vaginal may branch off it too.
 - Also gets vascular supply from the Ovarian arteries -- from L1 level!
 - Also gets vascular supply from Vaginal artery.
 - LYMPH is on two places too -- Mostly back to the **external iliac nodes**, but a small portion goes back to the *superficial inguinal nodes* because of the presence of the round ligament.
 - Third place -- the lower portion of uterus drains back to the internal iliac nodes, then onto external iliacs.
 - NERVES -- dual nerve supply, divided approx. upper (lumbar plexus) / lower (pelvic splanchnic).
 - Parasympathetic from the pelvic splanchnics.
 - Sympathetic from the hypogastric plexus, from the lumbar.
 - Pain (GVA) afferent receptors go back to T10-L1!
- CLINICAL:
 - Pain from uterine contractions goes back to T10-L1. This means that uterine contraction pain is sympathetic.
 - But for the lower portion of the uterus and upper vagina (the cervix) -- it is parasympathetic back to the pelvic splanchnics.

VAGINA:

- STRUCTURES:
 - **Rugae:** Muscular folds on internal wall -- unlike the stomach which has mucosal rugae folds.
 - **Cervix:**
 - **Supravaginal Portion:** Portion of the cervix above the vagina.
 - **Vaginal Portion:** Portion of the cervix in the vagina.
 - **Urethral (Skene's) Glands:** They lubricate the urethra, have openings into the urethra.
 - **Vestibular Bulbs:** Two of them, analogous to the corpora cavernosa of the penis.
 - **Clitoris:** The clitoris has no corpus spongiosum, because the urethra does not run through the clitoris. There is a crus in the superficial perineal space, on either side of the clitoris and separated by the vagina.
 - PERITONEUM / RECESSES: Only a very small part of the vagina is covered with peritoneum -- the very edge of the *posterior fornix*, just inferior to the rectovaginal pouch of Douglas.
 - MUSCLES:
 - **Urethrovaginal Sphincter:** Helps in the compression of the vagina (and urethra) in an *anteroposterior direction*.
 - **Bulbospongiosus muscles** to either side of the vagina, help in the compression of the vagina along the *lateral axis*.
 - FORNICES: Spaces surrounding the external vaginal wall.
 - **Lateal Fornices:** *The ureters* run along the lateral aspects of the vagina.
 - Since the ureters are there, we know the uterine vessels are also approx at that location -- near the vaginal cervix.
 - **Posterior Fornix:** Covered with peritoneum, it is just inferior to the Pouch of Douglas and hence clinically important. Directly related to the rectum.
 - **Anterior Fornix:** Very thin space, and the anterior vaginal wall (related to bladder) is far thicker than the posterior vaginal wall. This makes it impractical to pierce that wall clinically.
 - CLINICAL
 - **Culdocentesis:** Aspirate fluid out of the rectouterine pouch by passing a needle through the posterior fornix of the vagina.
 - **Culdoscopy:** Pass a fiber-optic scope through the posterior fornix of the vagina to look around.
 - **Rectocele:** With a *weakened pelvic diaphragm*, the anterior wall of the rectum could invade the posterior wall of the vagina, bulging it inward.
 - **Cystocele:** Invasion of the bladder wall, posteriorly, to the anterior vaginal wall.
 - **Enterocele:** Invasion of loops of small intestine into the rectouterine or vesicouterine pouch. This is less common.
 - RELATIONS:
 - The anterior wall of the vagina is intimately related to the posterior wall of the bladder, and the lower part to the urethra.
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MALE DUCTS AND GLANDS

- **Ductus Deferens:** Travel from the testes, pubic symphysis around the superior aspect of the bladder, and they pass *medial to the ureters*, and enter onto the ejaculatory duct.
 - **Ampullary Portion** = the dilated portion near the seminal vesicles as it converges onto the ejaculatory duct.
- **Prostate Gland:** Located immediately inferior and slightly posterior to the bladder. It surrounds the urethra.
 - Has a very dense, true capsule encompassing it.
 - **Anterior Lobe:**
 - **Posterior Lobe:** Assoc with cancer
 - **Middle Lobe:** The important portion of the prostate between the prostatic urethra and the ejaculatory ducts.
- **Seminal Vesicles:** Located immediately posterior to the posterior bladder wall, and *superior to the prostate gland*. It has a bow-tie configuration.
 - It contributes as much as 80% of the volume to seminal fluid.
- **Ejaculatory Ducts:** The union of the ductus deferens and seminal vesicles. The left and right ducts open into the prostatic portion of the urethra.
- **Seminal Colliculus** (aka verumontanum): The name of the point where the ejaculatory ducts enter the prostatic urethra.

- **Bulbourethral (Cowper's) Glands:** Inferior to the prostate, it dumps into the spongy urethra and is located *within the deep perineal space* -- in the urogenital diaphragm.
 - The Female bulbourethral glands (Greater Vestibular Glands) are located in the superficial perineal space, on the superficial surface of the UG Diaphragm.
- CLINICAL:
 - **Benign Prostatic Hypertrophy:** When it affects the middle lobe (hyperplastic middle lobe), it presses up against the bladder, raising the uvula even further and possibly obstructing the urethral opening, making it difficult to urinate or even painful.
 - **Prostate Cancer:** Is usually associated with the *posterior lobe*.

Sacrogenital Ligament: In the male, the condensation of endopelvic fascia going from the sacrum around (similar path as rectal sling) and inserting

Puboprostatic Ligament: Strong, tough ligament going from the back of the pubic bone to the prostate gland in the male. It lends true support to the prostate.

Uterosacral Ligament: Female homology to the sacrogenital ligament.

Vesicouterine Ligament: Female homology to the sacrogenital ligament.

Pubovesical Ligament: Female homology to the puboprostatic ligament, lending support to the bladder anteriorly.

VESSELS

POSTERIOR BRANCH OF THE INTERNAL ILIAC:

- **Iliolumbar Artery** -- goes immediately back superiorly after the anterior-posterior division.
 - **Iliacus Branch** -- supplies iliacus muscle!
 - **Lumbar Branch**
- **Lateral Sacral Artery**
- **Superior Gluteal** -- exits the pelvis through the Greater Sciatic Foramen, passing superior to the Piriformis muscle.
 - This artery is the terminal branch of the posterior division of the internal iliac. You could call the whole posterior division just the Superior Gluteal, really.

ANTERIOR BRANCH OF THE INTERNAL ILIAC

- **Obturator Artery** -- this is first off the anterior branch, or umbilical may be first.\
 - **Accessory Obturator Artery**, if it is there, may anastomose with the *Inferior Epigastric Artery*.
 - If it is there and there is no obturator artery, then it is referred to as a **Abnormal Obturator Artery**.
 - CLINICAL -- in the event of a femoral hernia through the femoral sheath, they must check to see if the pubic branch of the obturator is an accessory or abnormal obturator, so they know whether or not they can cut it. It is abnormal, then they can't -- it's the only blood supply to the area.
- **Umbilical Artery**
 - Can be the first branch off.
 - It often has a **Superior Vesical Artery** as a branch.
 - Identify it because it becomes the **medial umbilical ligament** (obliterated umbilical artery) as it courses.
- **Uterine / Vaginal Arteries:**
 - Uterine Artery courses through the *cardinal ligament*, at the base of the broad ligament near the cervix. It anastomoses with both the vaginal and with ovarian at the top of the uterus.
 - Also forms the **Azygous Plexus** of the Vagina.
 - Water Under the Bridge: Again, the ureters pass right under the uterine artery, at about the level of the cervix.
- **Middle Rectal Artery** -- it passes to the rectum but superior to the pelvic diaphragm.

- **Inferior Vesical Artery** (male only) -- it brings the *primary blood supply to prostate* and to the seminal vesicles.
 - It is usually a branch of the middle rectal, but it can also come off the umbilical.
 - You rarely see this in females, but instead see the uterine artery.
- **Inferior Gluteal Artery:** Exits the pelvis through the Lesser Sciatic Foramen, below the Piriformis muscle. This artery is the terminal branch of the anterior division of the internal iliac.
- **Internal Pudendal Artery** -- all three branches come off after the perineal sweeps back around anteriorly. It can be a trunk with either the Middle Rectal Artery or the Inferior Gluteal Artery.
 - **Inferior Rectal Artery** -- passes to the anal canal, inferior to the pelvic diaphragm.
 - **Perineal Artery** -- supplies the rest of the perineal region -- all the muscles of the perineum.
 - **Deep Dorsal Artery** -- supplies penis / clitoris.

LYMPHATIC DRAINAGE:

- **Right and Left Iliac Nodes:** Almost the whole pelvis *eventually* ends up at the Right and Left Iliac Nodes, then goes onto the chain nodes -----> lumbar nodes -----> lumbar trunk -----> thoracic duct
- **Superficial Inguinal Nodes:** Almost everything in the perineum (inferior to pelvic diaphragm) will drain in part to the superficial inguinal nodes.
 - The Superficial Inguinals drain to the -----> **External Iliac Nodes** -----> Common Iliac Nodes.
- **Uterus:**
 - The UPPER portion of the uterus follows the OVARIES and OVARIAN VESSELS back to the **lumbar chain nodes**.
 - The lower portion of the uterus follows the uterine artery back to the External Iliac Nodes -----> Common Iliac Nodes.
- **External Iliac Nodes:** Generally carries most of the pelvic organs, and drains the superficial inguinal nodes.
- **Ovaries / Testes** -- back to the **Lumbar Chain** nodes. Any questions?
- **PROSTATE:** It breaks the rules!
 - Posterior Surface goes back to the **Internal Iliac Nodes**. This is the lobe most assoc with carcinoma.
 - Anterior Surface follows the bladder to the external iliacs.
 - Inferior Surface follows the pudendal to the internal iliacs.
- **RECTUM** (review)
 - UPPER RECTUM: Follows the pathway of the Superior Rectal Artery: **Pararectal Nodes** -----> **Inferior Mesenteric Nodes** -----> Lumbar Chain Nodes
 - LOWER RECTUM: Follows Middle Rectal Arteries to the Internal Iliacs
 - ANAL CANAL (below PECTINATE line) -- goes back through the Superficial Inguinal Nodes, all the way, dude.

INNERVATION OF THE PELVIS:

- **The Bladder:** An example of where all three nervous systems are acting in concert to control one function.
 - **Voiding Reflex** is Parasympathetic -- from Pelvic Splanchnic Nerves (S-2,3,4).
 - **Pain Sensory** from overdistension is sympathetic.
 - **Voluntary Control** is somatic -- from pudendal.
- **PUDENDAL NERVE:** Carries somatic innervation! If it's somatic, it's pudendal.
 - Voluntary tonic contraction of external anal sphincter -- to stop from taking a dump.
- **GONADS:** Follow the **Lesser Thoracic Splanchnic** back to T10-T11. Developmental origin.
- **EJACULATION:** Mostly a parasympathetic response. Vasodilation of the corpora cavernosa.
 - However, peristalsis of the ductus deferens is sympathetic.
- **UTERUS:** Some of the pain in the uterus is actually carried through the parasympathetic system.