Development of Genitalia, Pelvic Parts of the GI & Urinary Tracts & the Internal Iliac Artery

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Variations in Reproductive Anatomy

It is important to note that **internal and external genitalia** exist on a **spectrum** as do **sex and gender**

Some people with variations in reproductive anatomy identify as **intersex**, but the definition of intersex is broad and includes other differences in sex traits

About 1.7% people are born intersex (about the same as identical twins, red hair, green eyes)

Throughout the lecture the terms “male” and ”female” will be used. These represent the **extreme ends of the sex spectrum**. One word to describe these ends is “**endosex,”** which is used for sex characteristics the way “cisgender” is used for gender.

Those who identify in the middle of the spectrum may identify as **intersex**.

https://ktetzlaff.com/intersex/
Intersex Health Care

Studies have shown that **up to 80 percent of intersex patients have changed their care based on discomfort with their medical providers.** Solid policy that takes into consideration the needs of the community is essential to giving intersex patients the care that they deserve. One of my urologic colleagues once said that **no single specialist can provide all the answers when it comes to intersex medical care,** and truer words were never spoken. Quality care of intersex patients **must be truly multidisciplinary,** seeing to the needs of the whole patient and their family. And the key to understanding this whole patient is the provision of peer support.”

—Ilene Wong, M.D.
Intersex Health Care

The main issue raised by members of the intersex community is the continued performance of medically unnecessary genital-"normalizing" surgery on intersex infants before they are old enough to participate in the decision-making process.

Rather than calling for immediate surgical intervention upon the birth of an intersex child, leading practitioners in patient-centered care recommend promptly implementing a long-term management strategy that involves a range of pediatric subspecialists, including intersex-affirming mental health providers, pediatricians, and the parent(s).

Leading medical associations, recognizing that irreversible and deeply life-altering procedures can be safely delayed to both ensure best outcomes and avoid the potential ramifications of anesthesia on the developing brain, are developing policies informed by the patient community to delay harmful, medically unnecessary procedures.

- Intersex Affirming Hospital Guide
Additional Resources

InterACT: Advocates for Intersex Youth
- [https://interactadvocates.org/](https://interactadvocates.org/)
- Affirming Primary Care for Intersex People
- What We Wish Our Doctors Knew

Intersex Justice Project
- [https://www.intersexjusticeproject.org/](https://www.intersexjusticeproject.org/)
  Katja Tetzlaff, Medical Illustrator and Educator
  - [https://ktetzlaff.com/](https://ktetzlaff.com/)
The Embryonic Perineum

The external genitalia of female & male embryos are identical.

The differentiation into the male phenotype is dependent upon the presence of a **Y chromosome & testosterone**.

The female phenotype is a result of the relative absence of testosterone.

* - Perineal body
A - Anus
B - Body
G - Glans
LS - Labioscrotal swelling
UG - Urogenital opening
The labioscrotal swellings do not fuse in the female & become the **labia majora**

As a result, the **labia minora** persist & they surround the vestibule of the vagina that contains the openings of the urethra & vagina

The **body** and the **glans** give rise to the body (not seen) & glans of the **clitoris**
Development of the Male Perineum

The labioscrotal swellings & body fuse in the male forming the **scrotum**, **scrotal raphe** & **body of the penis**

As a result, the **urethra** is incorporated into the body of the penis

The **external urethral orifice** is at the distal end of the glans penis

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**Legend:**
- * - Perineal body
- A - Anus
- B - Body
- G - Glans
- LS - Labioscrotal swelling
- P - Prepuce (foreskin)
- S - Scrotum
- SR - Scrotal raphe
- U - Urethra
- UG - Urogenital opening
Hypospadias

If fusion does not occur properly, the infant may have **hypospadias**

This is a congenital defect where the external urethral orifice is **NOT** at the distal end of the glans penis; (it is one of the most common defects, occurring in ~1 in 250 newborns)

Some individuals born with hypospadias may identify as **intersex**. Surgical intervention is **not medically necessary** unless urine cannot pass through the urethra. Surgery also has the potential for **long term complications**.
Hypospadias

Examples of Hypospadias

Possible Sites of Hypospadias
(these are always on the ventral surface of the penis)
The Prepuce

At the proximal limit of the glans, there is a redundancy of skin that forms in both females & males called the **prepuce**.

The prepuce is also called the **hood** of the clitoris in the female or the **foreskin** in the male.

* - Perineal body
A - Anus
B - Body
G - Glans
LM - Labia majora
Lm - Labia minora
LS - Labioscrotal swelling
P - Prepuce (foreskin)
S - Scrotum
SR - Scrotal raphe
U - Urethra
UG - Urogenital opening
V - Vagina
The Prepuce

The foreskin covers the glans of the flaccid penis at all ages
At birth, the foreskin is fused to the glans but is usually retractable by puberty
The foreskin retracts completely upon erection
The function of the foreskin is controversial, but it believed to enhance sexual pleasure & provide lubrication during intercourse

Circumcision involves surgical removal of the foreskin; this affects both the appearance & sensitivity of the penis; it may protect against acquiring HIV, genital herpes, human papillomavirus (HPV) & genital ulcer disease

* - Perineal body
A - Anus
B - Body
G - Glans
P - Prepuce (foreskin)
S - Scrotum
SR - Scrotal raphe
U - Urethra
Development of the Internal Genitalia
Embryonic Internal Genitalia

In the early female & male embryo:

The developing **internal genitalia** are **identical**

The **gonads** are **identical** & are located on the posterior abdominal wall (retroperitoneal)

There are **two pairs of tubes** running parallel to one another that open into the urogenital space that becomes the bladder & urethra

**Female tubes** (blue; Mullerian/Paramesonephric ducts) develop into:

- Uterus
- Uterine tubes
- Superior half of the vagina

**Male tubes** (red; Wolffian/Mesonephric ducts) develop into:

- Epididymis
- Ductus (vas) deferens
- Seminal glands
- Ejaculatory ducts

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**F** - Female duct  
**G** - Gonad  
**M** - Male duct  
**UG** - Urogenital space
Development of Female Internal Genitalia

Fusion of the inferior part of the female ducts forms the **uterus** and **upper vagina** (green arrow)

The unfused part of the female ducts become the **uterine tubes**

The gonad differentiates into an **ovary**

The gubernaculum becomes the **ovarian ligament & round ligament of the uterus**

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**Anterior View (embryo)**

**Anterior View (adult female)**

F - Female tubes  
G - Gonad  
M - Male tubes  
O - Ovary  
OI - Ovarian ligament  
RI - Round ligament of the uterus  
UG - Urogenital space  
Ut - Uterus  
UT - Uterine tube  
V - Vagina

The male ducts **degenerate** during development of the female

**Remnants** of the male ducts may remain (red arrows); these remnants may become enlarged & cystic
Variations in the Development of Female Internal Genitalia

**Failure of fusion** of the inferior part of the female duct system can result in a uterus with two lumina (bicorneate uterus)

If one of the female ducts does not appear during development (above right), the individual will have only one uterine tube (unicornate uterus)

Women with these anatomical anomalies can still bear children

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**Legend:**
- C - Catheter within vagina
- O - Ovary
- UI - Uterine lumen
- Ut - Uterine wall
- UT - Uterine tube
- VI - Vaginal lumen
Development of Male Internal Genitalia

As the testes descend, the male ducts follow

The superior part of the male ducts adjacent to the gonad gives rise to the **epididymis**

The inferior part of the male ducts gives rise to the **ductus (vas) deferens**

The gonad develops into a **testis**

The **seminal glands** form as outgrowths from the male ducts

The gubernaculum becomes the **scrotal ligament**

The female ducts **degenerate** during development of the male

**Remnants** of the female ducts may remain

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**Anterior View**

*(embryo)*

- B - Bulbourethral gland
- D - Ductus (vas) deferens
- E - Ejaculatory duct
- F - Female tubes
- G - Gonad
- M - Male tubes
- P - Prostate gland
- S - Seminal gland
- SI - Scrotal ligament
- T - Testis
- U - Urethra
- UG - Urogenital space

**Anterior View**

*(adult male)*

- E
- P
- B
- S
- U
- T
- SI
Sexual Differentiation

Y CHROMOSOME → GONAD → TESTIS

The presence of the Y chromosome initiates the differentiation of the gonad into a testis.

In the absence of a Y chromosome, the gonad differentiates into an ovary.
The testis produces testosterone & Mullerian inhibiting substance
Testosterone causes differentiation of the embryonic external genitalia into male external genitalia, as well as the differentiation of the male ducts into male internal genitalia (epididymis, ductus deferens, seminal glands)
Mullerian inhibiting substance causes **degeneration** of the female ducts.
In the absence a Y chromosome, the gonad differentiates into an **ovary**, the embryonic external genitalia differentiate into **female external genitalia**, the female ducts differentiate into **female internal genitalia** (uterus, uterine tubes, superior half of the vagina) & the **male ducts degenerate**
Summary of Sexual Differentiation

Some intersex variations are the result of cells partially responding or not responding to the testosterone produced by testes. Others also involve variations in the Wolffian/Mullerian pathways. Some examples include androgen insensitivity syndrome (partial or complete; indicated by dashed line) and 5-alpha-reductase deficiency.
The Gastrointestinal Tract in the Pelvis & Perineum
The Pelvic & Perineal Parts of the Gastrointestinal Tract

Lateral Views
(female & male pelvis & perineum)

The rectosigmoid junction (green arrows) is at the level of S3 (part of sigmoid colon is in the pelvis)

The upper half of the rectum (above yellow line) is retroperitoneal (its anterior surface is covered with parietal peritoneum [blue line])

The lower half of the rectum (below yellow line) is subperitoneal

The anal canal is within the perineum (below the levator ani)

AC - Anal canal (surrounded by anal sphincters)
B - Bladder
LA - Levator ani
P - Peritoneum
R - Rectum
S - Sigmoid colon
SM - Sigmoid mesocolon
Ut - Uterus
V - Vagina
The Sigmoid Colon & Rectum

The green line indicates the **rectosigmoid junction**

The rectum & sigmoid colon can be distinguished based on their **external** characteristics

Unlike the colon, the rectum does NOT have **omental tags of fat** (appendices epipliocae; green arrow), **teniae coli** (thickened longitudinal strips of smooth muscle) or **haustra**

**Coronal Section**

**AC** – Anal canal (surrounded by anal sphincters)
**LA** – Levator ani
**P** – Peritoneum
**Rr** – Rectum (retroperitoneal)
**Rs** – Rectum (subperitoneal)
**S** – Sigmoid colon
**SM** – Sigmoid mesocolon
**TC** – Teniae coli
The rectum & sigmoid colon can also be distinguished based on their **internal** characteristics.

Internally, the **mucosa** of the sigmoid colon is irregular in appearance & thickness, while that of the rectum is **smooth**; the rectum is characterized by a few incomplete **transverse folds**.

- Anal columns
- AC - Anal canal (surrounded by anal sphincters)
- LA - Levator ani
- R - Rectum
- S - Sigmoid colon
- Tf - Transverse fold
The puborectalis portion of the levator ani encircles the **anorectal junction** forming a **puborectal sling**, that decreases the size of the lumen & keeps the rectum & anal canal at an acute angle to one another.

The puborectalis must **relax** in order for defecation to occur, as must the internal & external anal sphincters.

- Anal columns
- AC - Anal canal (surrounded by anal sphincters)
- Co - Coccyx
- EA - External anal sphincter
- IA - Internal anal sphincter
- LA - Levator ani
- PB - Pubic bone
- PR - Puborectalis
- R - Rectum
- S - Sigmoid colon
- TF - Transverse fold
The anal canal extends from the superior limit of the anal columns (green asterisks) to the anus (black line), the external opening of the termination of the gastrointestinal tract.

The inferior border of the anal columns is the pectinate line (blue line).

Tissue superior to the pectinate line is derived from embryonic endoderm & tissue inferior to the pectinate line is derived from embryonic ectoderm.

The blood & nerve supply differ above & below the pectinate line.

- Anal columns
- EA - External anal sphincter
- IA - Internal anal sphincter
- LA - Levator ani
- Tf - Transverse fold
Blood Supply of the Gastrointestinal Tract in the Pelvis & Perineum

**Inferior Mesenteric** Blood Supply:
- **Sigmoidal** arteries
- **Superior rectal** artery

**Internal Iliac** Blood Supply:
- **Middle rectal** artery
- **Inferior rectal** arteries

Sigmoidal, superior & middle rectal arteries are superior to the pelvic diaphragm (within the abdomen and/or pelvis) while the inferior rectal vessels are inferior to the pelvic diaphragm (within the perineum)

**Key Terms**
- AC - Anal canal
- CI – Common iliac
- EI – External iliac
- IG - Inferior gluteal
- II – Internal iliac
- IR - Inferior rectal
- IT - Ischial tuberosity
- LA - Levator ani

- MR – Middle rectal
- O – Obturator
- OI - Obturator internus
- R – Rectum
- S - Sigmoid colon
- SG - Superior gluteal
- SR - Superior rectal

**Pelvis (posterior view)**

**Note:**
- The detailed anatomical labels and their corresponding blood supplies are shown in the diagram for a comprehensive understanding.
Venous Drainage of the Gastrointestinal Tract

The venous drainage mirrors the arterial supply

Drainage of the sigmoid colon & superior rectum is via the sigmoidal & superior rectal tributaries of the *inferior mesenteric vein* of the portal system

Drainage of the remainder of the rectum & anal canal is via the middle & inferior rectal tributaries of the *internal iliac* venous system

**Hematogenous metastasis** of tumors in the sigmoid colon and superior rectum are likely to metastasize to the liver via the portal vein, while metastases from the lower rectum & anal canal are likely to metastasize to the lungs via the *inferior vena cava*

**AC** - Anal canal  
**CI** – Common iliac  
**EI** – External iliac  
**IG** - Inferior gluteal  
**II** – Internal iliac  
**IVC** - Inferior vena cava  
**IR** - Inferior rectal  
**IT** - Ischial tuberosity  
**LA** - Levator ani  
**MR** – Middle rectal  
**O** – Obturator  
**R** – Rectum  
**S** - Sigmoidal veins  
**SG** - Superior gluteal  
**SR** - Superior rectal
The Urinary Tract in the Pelvis & Perineum
The Ureters

**Superior View**
(female; uterus and rectum partially removed)

**Lateral View**
(male; rectum removed)

The ureters cross the pelvic brim to enter the pelvis near the bifurcation of the common iliac artery into its external and internal branches (the only “NOT Bridge over Water”)

Note that the *uterine arteries* in the female and the *ductus deferens* in the male are both superior to the ureters as they cross it (“Bridge over Water”)

**Key**
- B - Bladder
- CI - Common iliac artery
- D - Ductus (vas) deferens
- EI - External iliac artery
- IC - Inguinal canal
- II - Internal iliac artery
- pg - Prostate gland
- PS - Pubic symphysis
- R - Rectum
- sg - Seminal glands
- Ur - Ureter
- Ut - Uterus
- Utv - Uterine vessels
The **urinary bladder** is **subperitoneal** and covered with parietal peritoneum on its superior surface.

The size of the bladder varies considerably based on its content of urine.

When empty the bladder is posterior to the **pubic bones & pubic symphysis**, however when full the bladder can rise well above the pubic bones as in the image on the right.

Note that the female urethra is **relatively short** as compared to the male urethra.
The bladder is made up of smooth muscle:

**Trigone muscle** - in a triangular area between the ureteral openings & the urethra

**Detrusor muscle** - in the remainder of the bladder wall

During **filling** of the bladder, the detrusor muscle expands & the trigone is contracted

During **micturition** (urination) the detrusor muscle contracts & the trigone relaxes; contraction of the ureters in the wall of the bladder during micturition **prevents** retrograde flow of urine
Blood Supply of the Bladder & Urethra

The bladder & urethra are supplied by multiple branches of the internal iliac artery:

**Superior & inferior vesical arteries** (branches of the umbilical artery & internal iliac, respectively) - both male & female

**Urethral arteries of the penis** (arrow; run within the corpus spongiosum; branches of the internal pudendal artery)

**Pelvis**  
(superior view)

- B - Bladder
- CI – Common iliac
- Do - Dorsal artery of the penis
- EI – External iliac
- II – Internal iliac
- IV – Inferior vesical
- MU – Medial umbilical ligament

- R – Rectum
- SV – Superior vesical
- U – Umbilical
- Ur - Urethra
- Ut – Uterus
- UtA – Uterine artery

**Body of the penis**  
(cross section)
The superior vesical arteries are branches of the umbilical artery that persists into adulthood.

After giving off the superior vesical arteries, the umbilical artery becomes a fibrous cord that runs to the umbilicus (white arrow) on the inner surface of the anterior abdominal wall, the medial umbilical fold.
Anterior Abdominal Wall

Fetal Circulation

The **median umbilical fold** (black asterisks at right & left) is the remnant of the **urachus**, a fetal connection between the bladder & umbilicus.

The **round ligament** (green asterisk) is the obliterated **umbilical vein**.

The **lateral umbilical fold** (red asterisk) is created by the underlying **inferior epigastric arteries**.

**Key Points:**
- B - Bladder
- DV - Ductus venosus
- EI - External iliac vessels
- IE - Inferior epigastric vessels
- IVC - Inferior vena cava
- MU - Medial umbilical fold
- U - Umbilicus
- UA - Umbilical artery
- UC - Umbilical cord
- UV - Umbilical vein
The female urethra is relatively short (~4 cm) & straight as compared to the male urethra.

The proximity of the urethra to the anus probably explains why women are more prone to urinary tract infections.

The urethra passes through the pelvic diaphragm (levator ani) & is surrounded by an external urethral sphincter in the urogenital triangle.

**Note:** The presence of an internal urethral sphincter surrounding the urethra as it exits the bladder is questionable in females; if present, it is not as well developed as in males.
The Female Urethra

The external urethral orifice is within the vestibule of the vagina between the labia minora, posterior to the clitoris & anterior to the vaginal orifice

There is a high level of urinary incontinence in women who have given birth due to weakening of the pelvic diaphragm & the external urethral sphincter
In the female, the **vesicouterine pouch** intervenes between the bladder and the uterus; a uterus in the usual position (anteverted and anteflexed, as shown) rests on the superior surface of the bladder.

The position of the uterus with respect to the bladder can be problematic during pregnancy causing a need for frequent urination.
The male urethra is ~5x longer than the female urethra (~20 cm)

The male urethra is divided into anatomical parts:

- **Intramural part** – where it leaves the bladder & is surrounded by the internal urethral sphincter
- **Prostatic part** – within the prostate gland
- **Intermediate part** – within the perineum where it is surrounded by the external urethral sphincter
- **Spongy part** – within the bulb, corpus spongiosum & glans penis

Note that the urethra is narrowest where it is surrounded by the internal & external urethral sphincters

Note that the urethra is widest within the prostate gland & glans of the penis (navicular fossa)
The Male Urethra

In reality, the male urethra is not in one plane
The urethra makes a 90-degree bend as it goes through the bulb of the penis (red arrow)

The urethra is surrounded by an internal urethral sphincter (gray arrow) as it exits the bladder & by an external urethral sphincter (black arrow) as it passes through the pelvic diaphragm (levator ani)

B - Bladder
Det - Detrusor muscle
G - Glans penis
I - Intermediate part of urethra
IM - Intramural part of urethra
P - Prostatic part of urethra
pg - Prostate gland
PS - Pubic symphysis
R - Rectum
S - Spongy part of urethra
Sg - Seminal glands
T - Trigone
U - Urethra
The Male Urethra

Because the urethra makes a 90-degree bend in the bulb of the penis (red arrows), it appears to end in the bulb in a coronal section such as above.

B - Bladder
Det - Detrusor muscle
G - Glans penis
I - Intermediate part of urethra
IM - Intramural part of urethra
P - Prostatic part of urethra
pg - Prostate gland
PS - Pubic symphysis
R - Rectum
S - Spongy part of urethra
Sg - Seminal glands
T - Trigone
U - Urethra
Catheterization of the Male Urethra

The 90-degree bend in the urethra complicates **catheterization**

The **posterior wall** of the urethra is particularly vulnerable within the bulb of the penis (red arrow)

This can cause **rupture of the urethra** (green arrow) & subsequent pooling of urine within the perineum, scrotum & anterior abdominal wall

B - Bladder  
pg - Prostate gland  
PS - Pubic symphysis  
R - Rectum  
U - Urethra
Branches of the Internal Iliac Artery  Supplying the Body Wall
Body Wall Branches of the Internal Iliac Artery

Some of the branches of the internal iliac artery within the pelvis that supply the body wall:

- **Iliolumbar** - runs superiorly & laterally to the iliac fossa
- **Lateral sacral** - descends along the anterior sacral foramina
- ** Obturator** - goes through the obturator canal with the obturator nerve
- **Internal pudendal** - goes through the greater sciatic foramen to enter the gluteal region & through the lesser sciatic foramen to enter the perineum

**Arteries must be identified based on their route & what they supply!!!**
Body Wall Branches of the Internal Iliac

Some of the branches of the internal iliac artery within the pelvis that supply the body wall:

Iliolumbar - runs superiorly & laterally to the iliac fossa

Lateral sacral - descends along the anterior sacral foramina

Obturator - goes through the obturator canal with the obturator nerve

Internal pudendal - goes through the greater sciatic foramen to enter the gluteal region & through the lesser sciatic foramen to enter the perineum

Arteries must be identified based on their route & what they supply!!!
Body Wall Branches of the Internal Iliac Arter-

--- Greater sciatic foramen
B - Bladder
C - Coccyx
CI - Common iliac artery
Co - Coccygeus
EI - External iliac artery
I - Iliolumbar artery
IG - Inferior gluteal artery
II - Internal iliac artery
IP - Internal pudendal artery
LA - Levator ani
LS - Lateral sacral artery
O - Obturator artery
OI - Obturator internus
P - Piriformis
pg - Prostate gland
PS - Pubic symphysis
R - Rectum
SG - Superior gluteal artery
SV - Superior vesical artery
U - Umbilical artery

These body wall branches go through the **greater sciatic foramen**:

- **Superior gluteal** (usually goes between the lumbosacral trunk & ventral ramus of S1)
- **Inferior gluteal** (goes between ventral rami of S1 & S2 or S2 & S3)
- **Internal pudendal** (is adjacent to the sciatic nerve & does not go between ventral rami)