بسم الله الرحمـٰن الرحيم

{مِن نُّطْفَةٍ خَلَقَهُ فَقَدَّرَهُ}

Embryology | FINAL 2 + 3 – v1

Development of The Midgut & Hindgut

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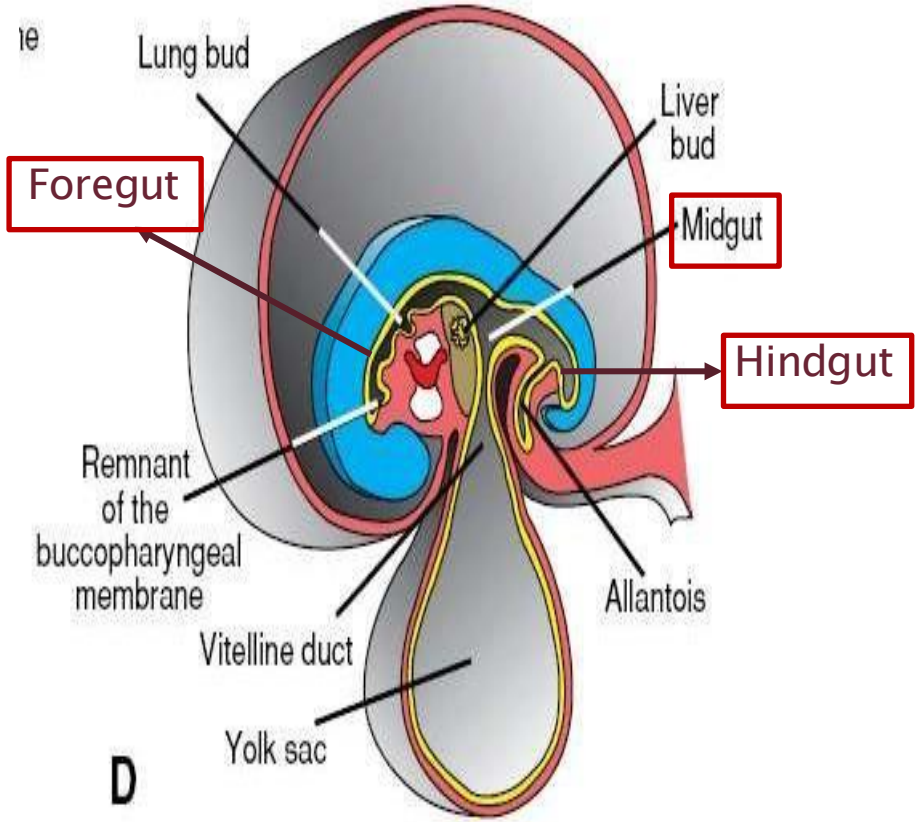
GIT Embryology 3

Midgut: slides 3-20

Hindgut: slides 21-28

This file includes everything that was mentioned about midgut and hindgut in the embryo lectures 2+3 ☺

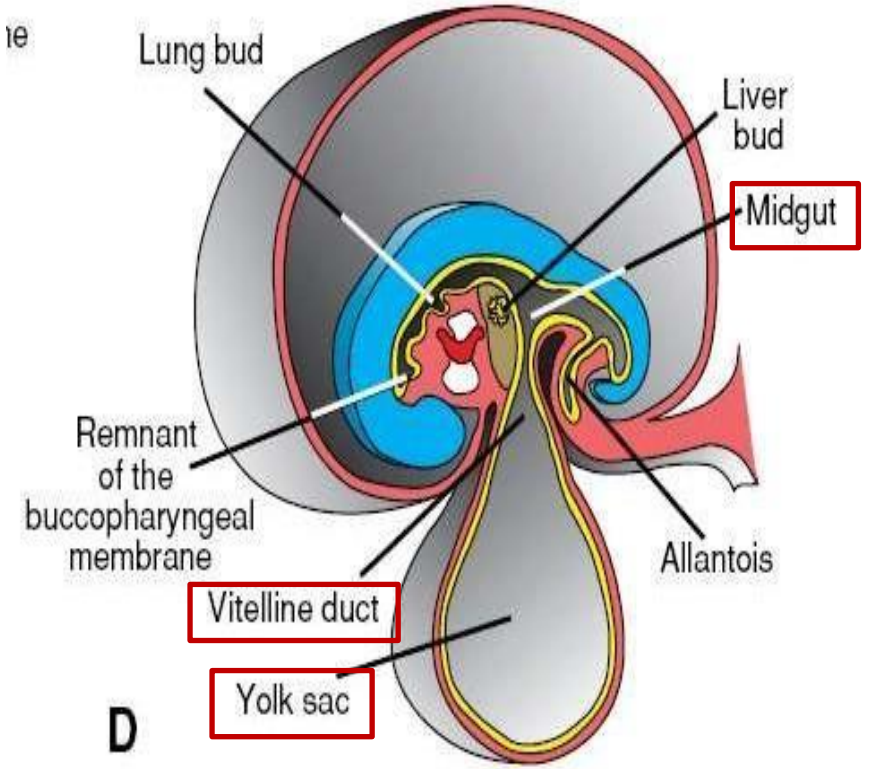


1- Midgut Extension and Blood Supply

- ✓ The midgut starts after the **liver bud** and includes:
  - **Lower half** of the **duodenum**, **jejunum**, **ileum**
  - Parts of the **large intestine** including: **cecum**, **appendix**, **ascending colon** and **proximal (medial) 2/3 of transverse colon.**

- ✓ **The vitelline duct** connects the **yolk sac** with the **midgut** specifically the **ileum** in the embryo, and it is obliterated after delivery, if not → meckel's diverticulum.

- ✓ Over its entire length the midgut is supplied by the **superior mesenteric artery.**

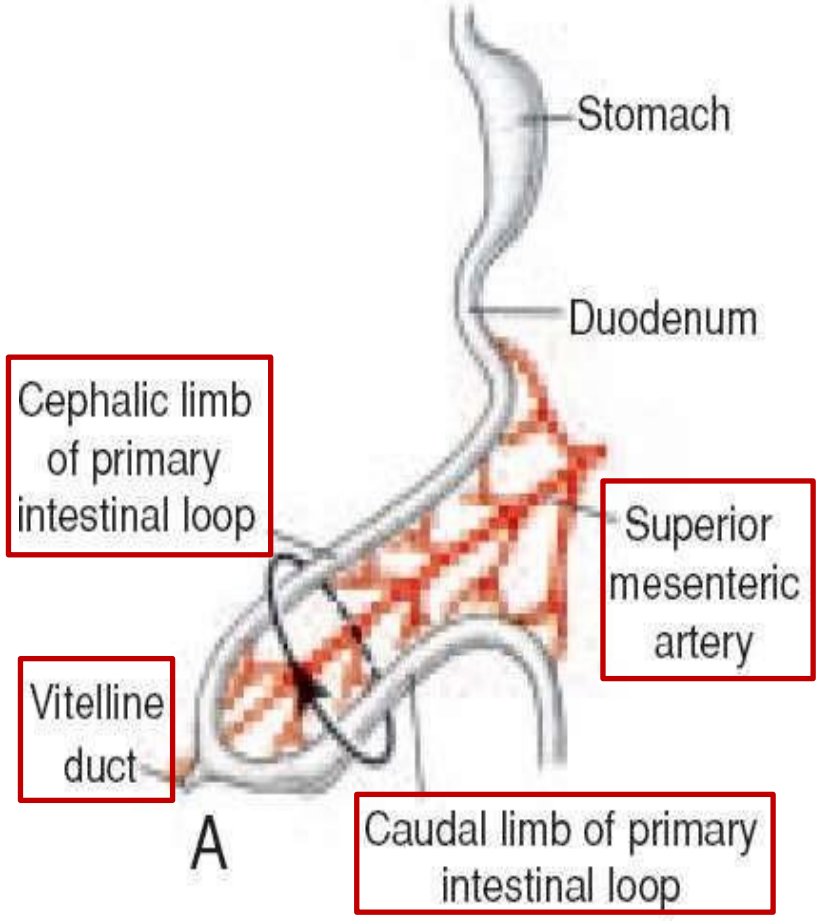


2- Midgut Development Axis

- ✓ Development of the midgut is characterized by **rapid elongation** of the gut and its mesentery, resulting in formation of the **Primary Intestinal Loop**. *Next slide*

- ✓ **At its apex**, the loop remains in **open** connection with the **yolk sac** by way of the narrow **vitelline duct.**

- ✓ The axis in development is the superior mesenteric artery, we have two parts:
  1 Above the **S.M.A** called: **Cephalic** limb of **primary intestinal loop.**
  2 Below the **S.M.A** called: **Caudal** limb of **primary intestinal loop.**



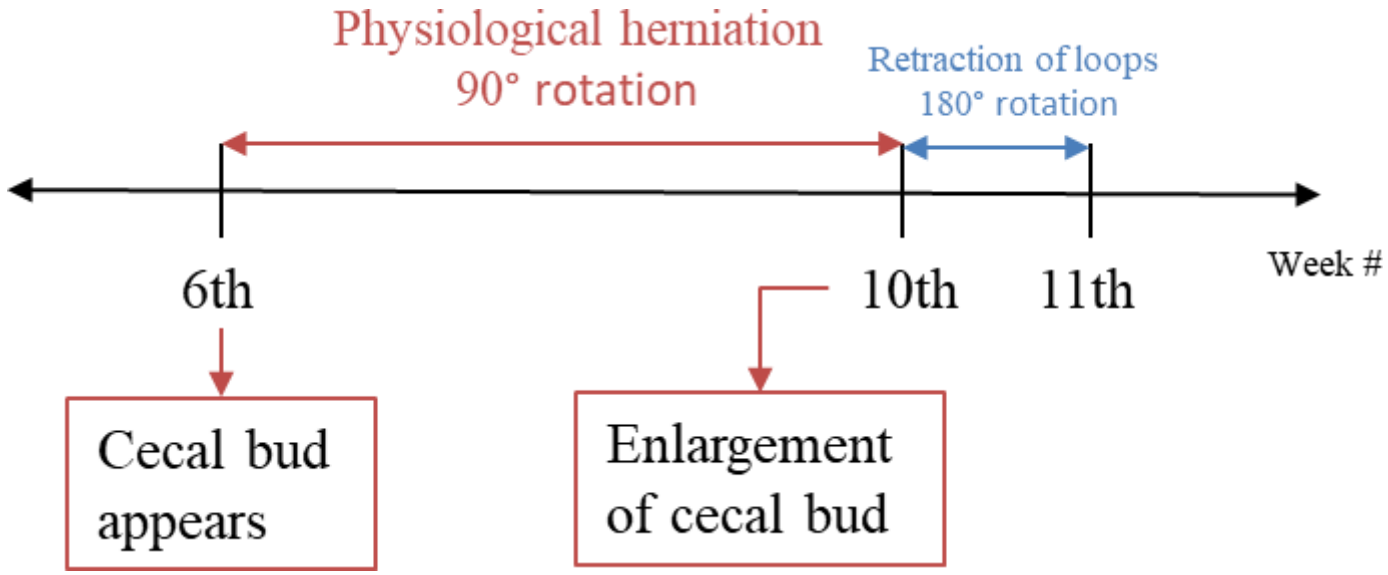
2- Midgut Development Axis

Limb	Develops Into	Growth Rate	Reason
Cephalic limb	- Distal part of the duodenum - Jejunum - Part of the ileum	**Faster** elongation	Becomes the small intestine, which is about 6 meters long
Caudal limb	- Lower portion of the ileum - Cecum - Appendix - Ascending colon - Proximal 2/3 of the transverse colon	**Slower** elongation	Becomes part of the large intestine, which is about 1.5–2.5 meters

3- Development Of Intestinal Loops

✓ The **development** of the **intestinal loop** consists of **two processes:**

A. Physiological herniation
B. Rotation around the intestinal loop



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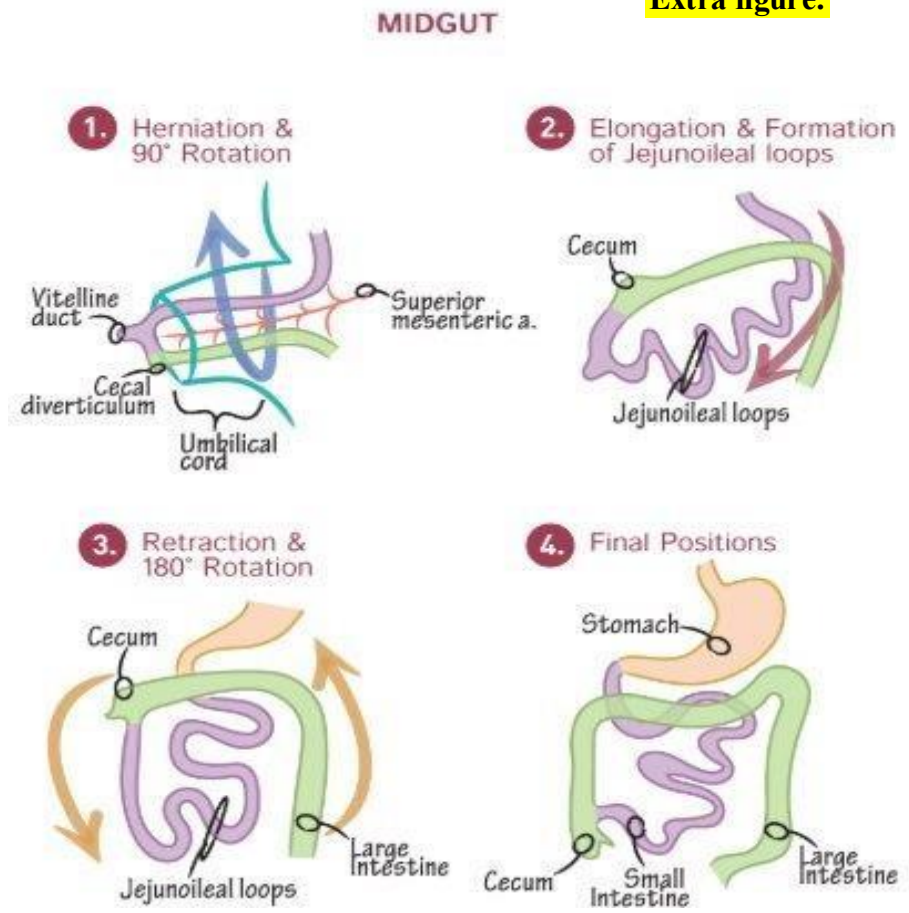


We recommend watching this animation to better imagine the process!

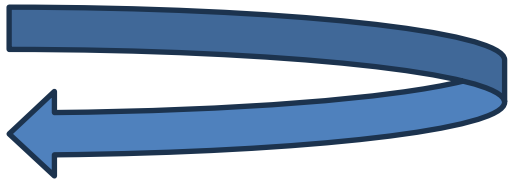
3- Physiological Herniation

- During the **6th week** and **ends** in the **10th week.**

✓ In this process, the intestinal loops, **enter** the extraembryonic cavity in the **umbilical cord** around the superior mesenteric artery and they will **elongate** and **rotate** there.

✓ This happens due to:

1. The **rapid elongation** of the **proximal** part of the small intestine (mainly the **cephalic** limb) , also the **Slow elongation** of the **distal** part (The **caudal** limb) this will lead to
2. The **engorgement** of the **abdominal cavity** due to:



- The **expansion** of the **liver**.
- The **descent** of the **diaphragm**.

→ As a result, the **abdominal cavity** temporarily becomes too **small** to contain all the intestinal loops, and **they enter the umbilical cord.**

3- Physiological Herniation

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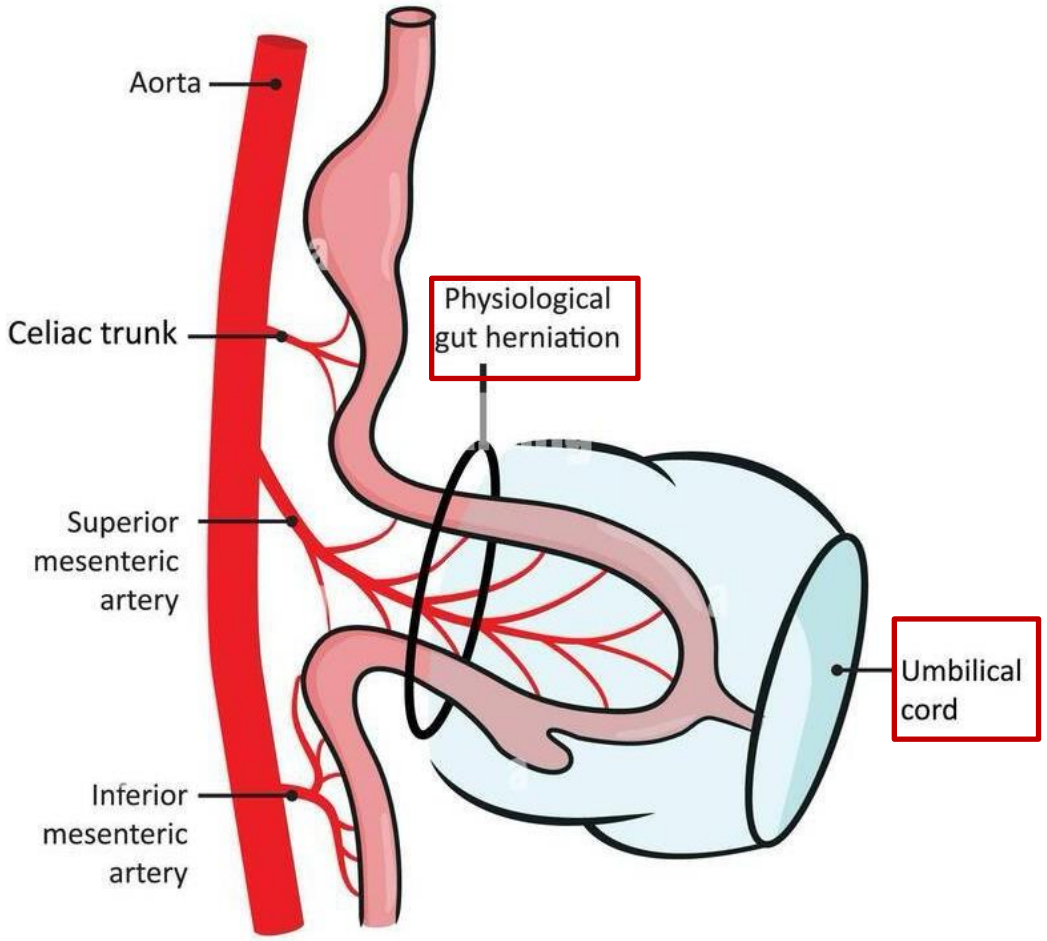

- ✓ By the **10th week**, the **midgut** returns to the abdominal cavity, which has now **enlarged** enough to accommodate **it.**

3. Rotation Of The Midgut

- Coincident with growth in length, the primary intestinal loop rotates around an axis formed by the **superior mesenteric artery**

- When viewed from the front, this rotation is **counterclockwise**, and it amounts to approximately 270◦ when it is complete, and it's divided into:
  - Rotation during **herniation** (about 90◦)
  - Rotation during **return of the intestinal loops into the abdominal cavity** (remaining 180◦), which happens in *the **end** of the **10th week** beginning of **11th week***

We'll double-check this sentence with the doctor

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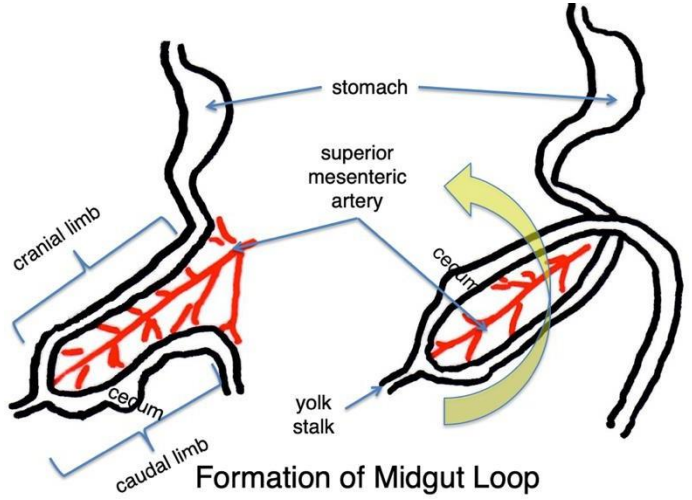


Formation of Midgut Loop

✓ The differences between **stomach** and **midgut**:

- Stomach:90° clockwise
- Midgut:270° counterclockwise

4- Retraction of Herniated Loops

- ✓ During the **10th week**, herniated intestinal loops begin to **return** to the **abdominal cavity** and end at **11th week** due to:

1. **Regression** of the **mesonephric kidney.**
2. **Reduced upward** growth of the **liver**.
3. **Expansion** of the **abdominal cavity**.

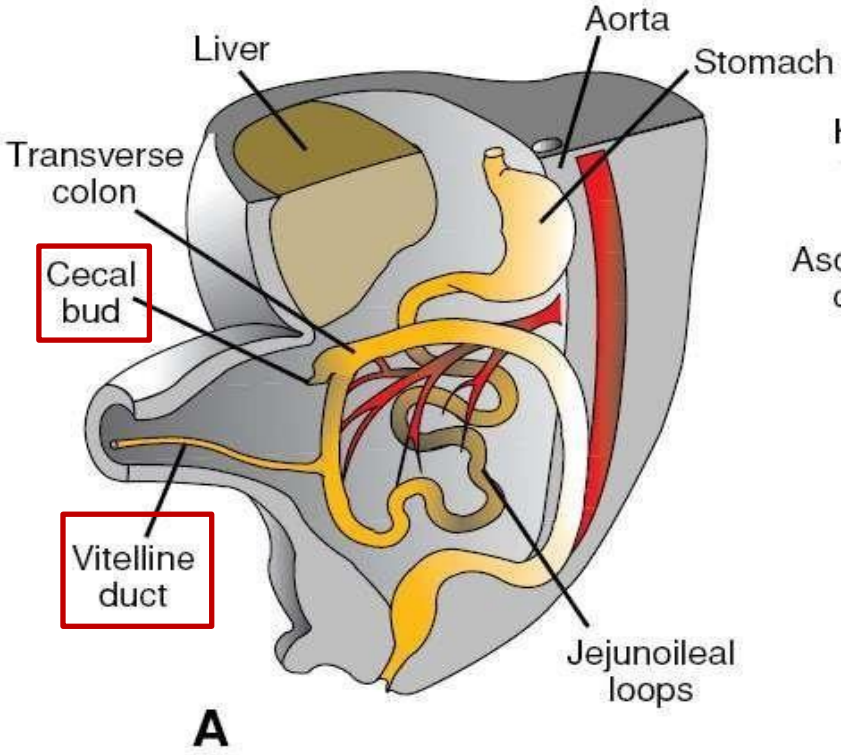
➢ Order and Direction of Return:

- ✓ **The first part** to re-enter the abdominal cavity is the **proximal** portion of the **jejunum**, , which goes **upwards** and **left** to the **upper left quadrant** and the **ileum** goes to the **lower part** of the **abdomen**.
- ✓ The later returning loops gradually settle more and more to the right.
- ✓ **The last part** to return is the **cecum** and **appendix** (**as the cecal bud**) in **right upper quadrant below liver.**

5- Cecal Bud

- ✓ **The cecal bud** appears at the **6th week**, and at the **10th week** it **enlarges** and forms:
  - **The cecum**
  - **Appendicular diverticulum** → from it forms the **appendicular bud** (from the wall of cecum) → eventually forming the **appendix**
  - On the **left side** it forms **transverse colon**

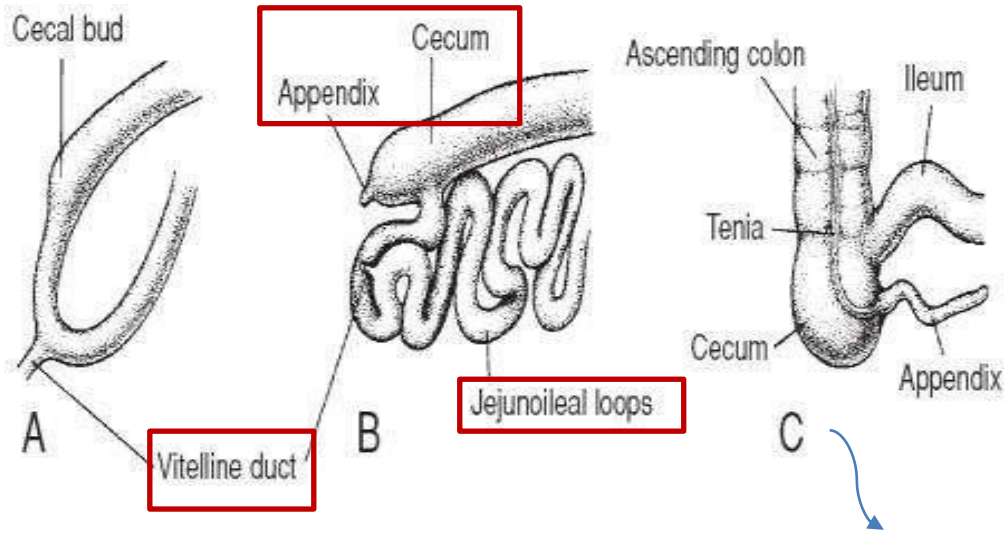
Note: The doctor had explained that the transverse colon develops from the cecal bud. The elongation of the cecal bud extends in 2 directions: to the left to form the transverse colon, and downwards to form the ascending colon and appendix. However, most external resources didn't mention that the transverse colon develops from the cecal bud.

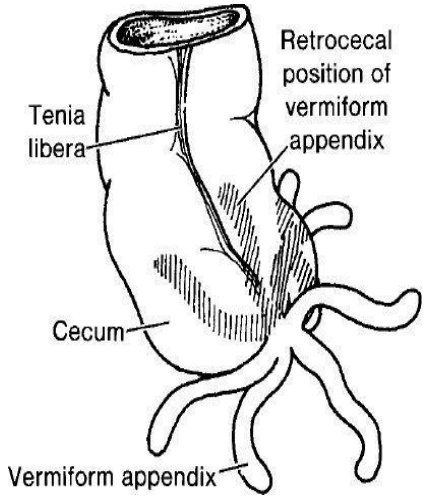


- ✓ Temporarily it lies in the **right upper quadrant** directly **below** the **right lobe of the liver.**

5- Cecal Bud

- ✓ From here it descends into the **right iliac fossa**, placing the **ascending colon** and **hepatic flexure** on the **right side of the abdominal cavity**
- ✓ During this process, **the distal end** of the **cecal bud** forms a **narrow diverticulum**, the **appendix.**
- ✓ Since the appendix develops during **descent of the colon**, its final position frequently is **posterior** to the **cecum** or **colon** on the **right side.**
- ✓ These positions of the appendix are called **retrocecal (common position) or retrocolic, respectively**





The final presentation is found on the right side

6- Mesenteries of Intestinal Loops

➢ Recall that mesentery is formed from:

✓ **Dorsal Mesogastrium**

Gives rise to:

- Greater momentum
- Mesentery of small intestine
- Mesentery of transverse colon
- Mesentery of sigmoid colon
- Ligaments of the spleen

✓ **Ventral Mesogastrium**

Gives rise to:

- Lesser omentum
- Ligaments of liver except ligamentum teres

➢ Organs According to Presence of Mesentery

✓ **Organs that have mesentery**

- Jejunum
- Ileum
- Transverse mesocolon
- Sigmoid mesocolon

6- Mesenteries of Intestinal Loops

✓ **Retroperitoneal organs**

- Duodenum
- Pancreas
- Ascending colon
- Descending colon

✓ In these organs, the mesentery becomes **fixed to the lateral and anterior walls (absent posteriorly).**

➢ Development of Mesentery

At the beginning of development, the mesentery originates from the posterior abdominal wall and is initially very short.

The midgut is **suspended** from **the dorsal abdominal wall** by a **short mesentery**.

With elongation of the small intestine, especially the jejunum and ileum, the mesentery also elongates forming **the mesentery proper** of the jejunum and ileum.

During intestinal rotation, the mesentery undergoes folding and twisting as a consequence of the rotation process.

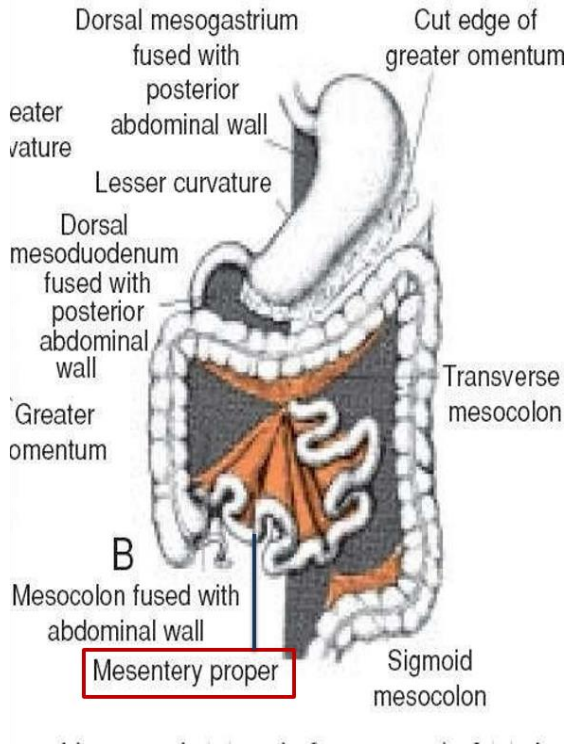
The rotation occurs around the superior mesenteric artery (SMA), which

Arises from the posterior abdominal wall

Supplies the jejunum and ileum

Acts as the axis of rotation

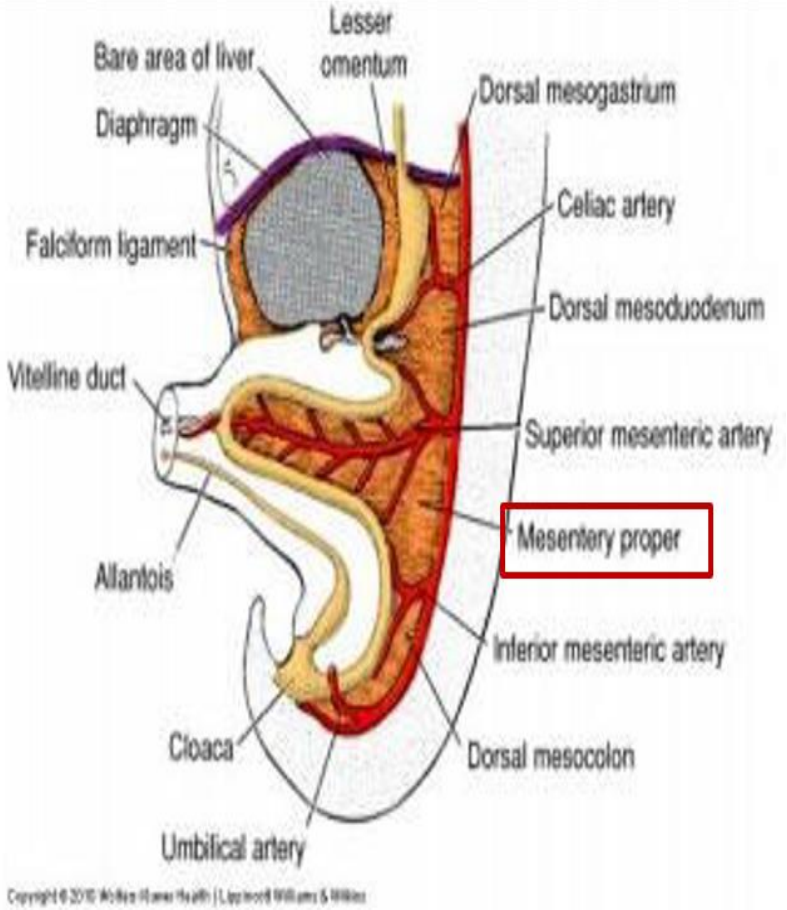
Therefore, the mesentery twists around the SMA during rotation.



6- Mesenteries of Intestinal Loops

- **The mesentery proper elongates** toward the posterior abdominal wall and **attaches** to it.
- ✓ **The mesentery of the jejunum and ileum:**
- **Remains intraperitoneal**
- **Retains its mesentery,** which is:
  - **fan-shaped**
  - **Contains branches of the superior mesenteric artery (that supplied it)**

✓ Its length is approximately **15 cm (6 inches).**



6- Mesenteries of Intestinal Loops

➢ Relation Between Mesenteries

Initially, the mesentery of the **jejunoileal loops** is **continuous** with that of the **ascending colon.**
Later, when the **ascending(mesocolon)** and **descending** portions of the colon obtain their definitive positions:
Their mesenteries press against the peritoneum of the **posterior abdominal wall**
Their mesenteries fuse with the posterior abdominal wall
They become fixed there and they become secondarily **retroperitoneal**
As a result:
The transverse colon remains **intraperitoneal** because it retains its mesentery
The ascending and descending colon become retroperitoneal due to disappearance and fusion of their mesenteries with the posterior abdominal wall
Therefore, **the peritoneum covers only their anterior and lateral surfaces.**

✓ Transverse Mesocolon

The transverse colon has its own mesentery called **the transverse mesocolon.**
Embryologically:
It is derived from the greater momentum
✓ The greater momentum descends as two layers

6- Mesenteries of Intestinal Loops

✓ The transverse mesocolon eventually attaches to **the anterior border of the pancreas.**

❖ **Some embryology textbooks describe the transverse mesocolon as extending from the posterior abdominal wall to the transverse colon.**

➢ Sigmoid Mesocolon

The sigmoid colon possesses a mesentery called **the sigmoid mesocolon**, which is formed as a result of **elongation**.

➢ Mesoappendix

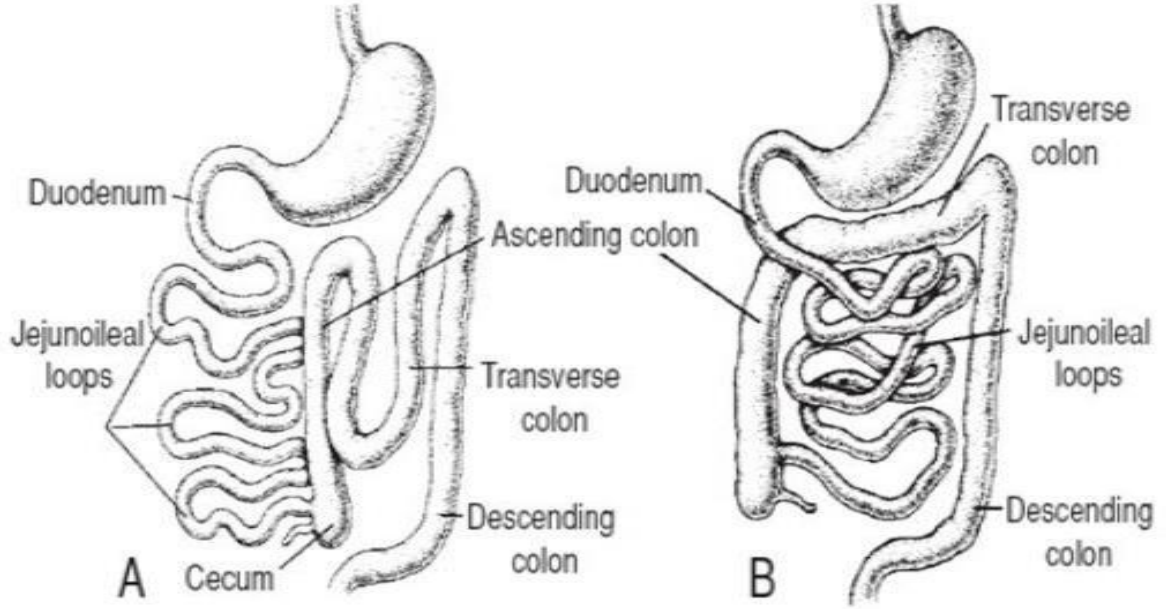
The appendix has its own mesentery called **the mesoappendix**, making it an intraperitoneal organ.

➢ Positions of the Appendix

Retrocecal → about **70%** (**most common**)
Pelvic → about **21%**
Pre-ileal or post-ileal → about **1%** each.

7- Midgut Abnormalities

A. **Gut rotation defects**
   1. Volvulus
   2. Partial rotation
   3. Reverse rotation
   4. Duplications and cycsts
B. **Gut atresia and stenosis**
C. **Body wall defects**
   1. Omphalocele
   2. Gastroschisis



A. Represents partial/ abnormal rotation: left-sided colon.
B. Represents reversed rotation: appendix on left.

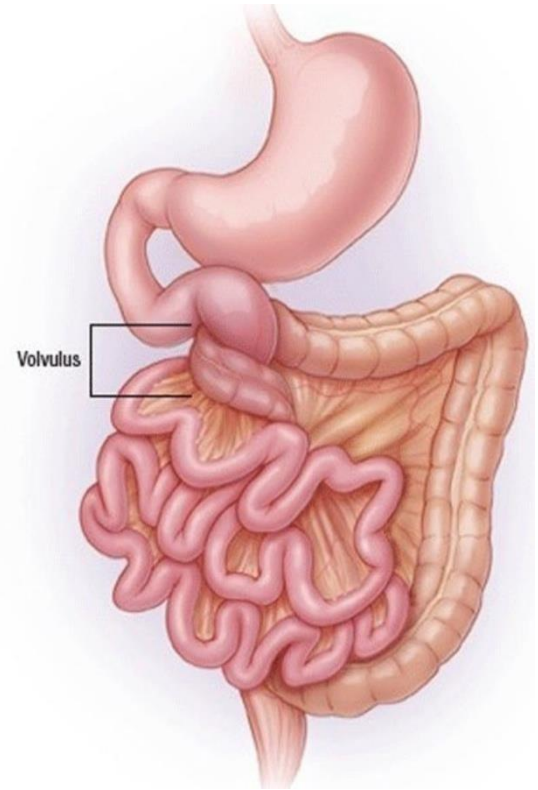
7- Gut Rotation Defects

- **Abnormal rotation** of the intestinal loop may result in **twisting** of the intestine and a **compromise of the blood supply.**

➢ Volvulus

✓ **twisting** mainly of **small intestines** (jejunum and ileum) due to their **length 6m,** it's like a long balloon that is twisted , results in:

- **Cut of blood supply → degeneration** of the twisted part (**gangrene**)



✓ Some movements & rotations may unwind this volvulus.

✓ **Treatment**: by **surgical intervention**; they **cut** the **degenerated part** & **ligate** the rest

7- Gut Rotation Defects

➢ Partial rotation

- ✓ Results in **left-sided colon.**
- ✓ Normally the primary intestinal loop rotates **270◦ counterclockwise.**

- ✓ Occasionally, rotation is only **90◦**, In this case, the **colon** and **cecum return first** from the **umbilical cord** and **settle** on the **left side** of the **abdominal cavity**
- ✓ The other **intestinal loops return later** and **settle more to the right**.

➢ Reversed rotation

- ✓ occurs when the **primary loop** rotates **90◦ clockwise** rather than **counterclockwise**, The transverse colon goes to the back posterior to superior mesentric artery and the duodenum.

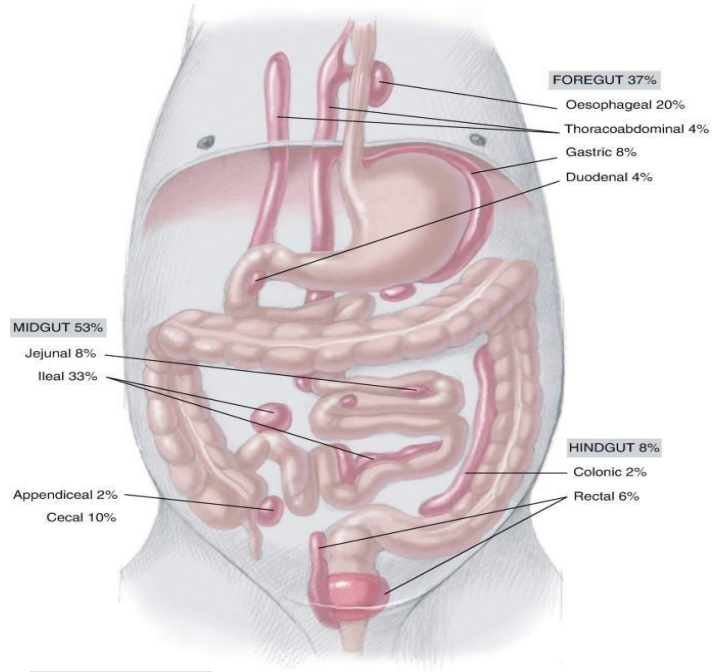
7- Gut Rotation Defects

➢ Duplications and Cysts

✓ may occur anywhere along the length of the gut tube (it happens mainly in the jejunum & ileum)

- **Clinical note:**

✓ **Appendix** or **ascending** colon may be found on the **left** side instead of the right, due to **malrotation**.



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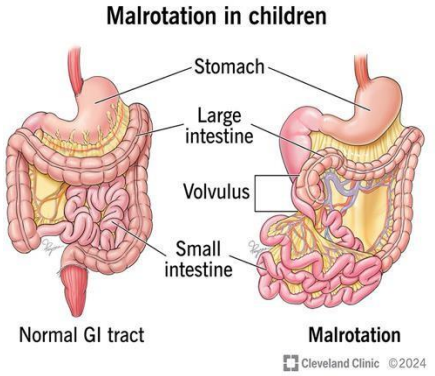

7- Gut Atresia and Stenosis

- ✓ **Atresia** and **stenosis** may occur anywhere along the intestine.
- ✓ Most occur in the **duodenum** (1/1500 births).
- ✓ Atresia in the **upper duodenum** is probably due to a lack of **recanalization** .
- ✓ Normally the duodenum is **filled** with cells, then **recanalization** occurs.

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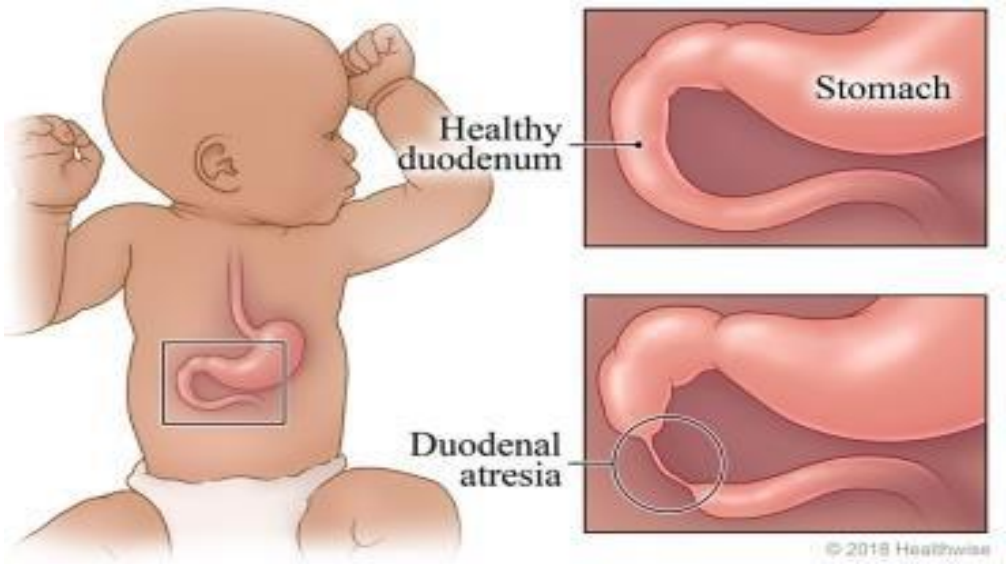


7- Body Wall Defects - Omphalocele

- ✓ **Omphalocele** involves herniation of abdominal viscera through an **enlarged umbilical ring** which is the beginning of umbilical cord in the abdominal wall.
- ✓ The viscera are covered by **amnion** (amniotic fluid).

- ✓ The defect originates from a **failure of the bowel to return** to the body cavity from its physiological herniation which should happen in the **10th week** , rather it stays in the umbilical cord.

7- Body Wall Defects - Omphalocele

✓ **Omphalocele** occurs in **2.5/10,000** births (**rare**) and is associated with :

- **high rate of mortality (25%)**
- **severe malformations**, such as cardiac anomalies **(50%)**
- **neural tube defects (40%).**
- **Chromosomal abnormalities** in live-born infants

➢ **Treatment**:

✓ **Evaluate the small intestine**:

- If **healthy → return it into the abdomen**.
- If **gangrenous → remove the affected part** and **ligate the ends.**

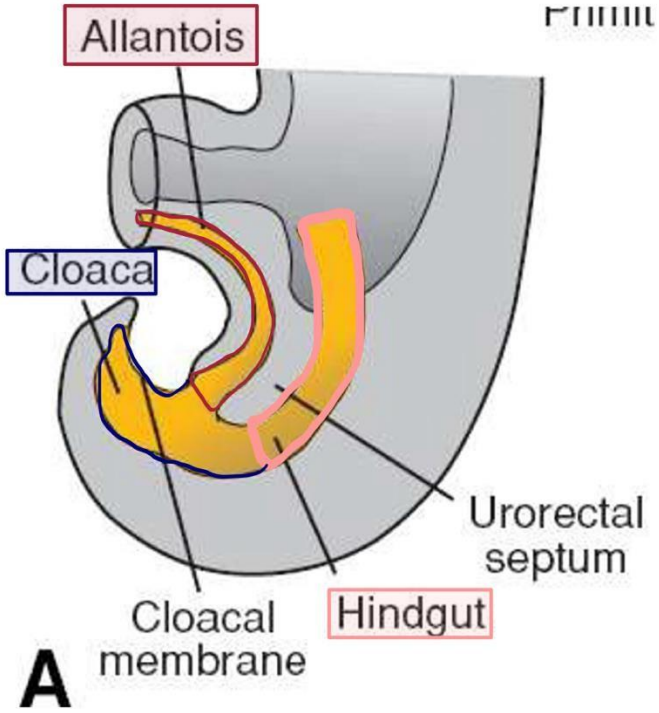
7- Body wall defects - Gastroschisis

- ✓ **Gastroschisis** is a **herniation** of abdominal contents through the body wall directly into the **amniotic cavity.**

- ✓ It occurs **lateral to the umbilicus** usually on the **right** (it does **not** herniate through the umbilicus)

8- Hindgut Extension & Blood Supply

- ✓ **The hindgut** gives rise to the **distal third** of the **transverse colon**, the **descending colon,** the **sigmoid**, the **rectum**, and the **upper part** (half) of the anal canal
- ✓ **Blood supply**: **inferior mesenteric artery**
- ✓ Hind gut is **endodermal except lower half of anal canal ectodermal.**
- ✓ **Allantois**: Between **urinary bladder** & **umbilicus** (must be obliterated),after obliteration it is called **urachus.**



9- Cloaca

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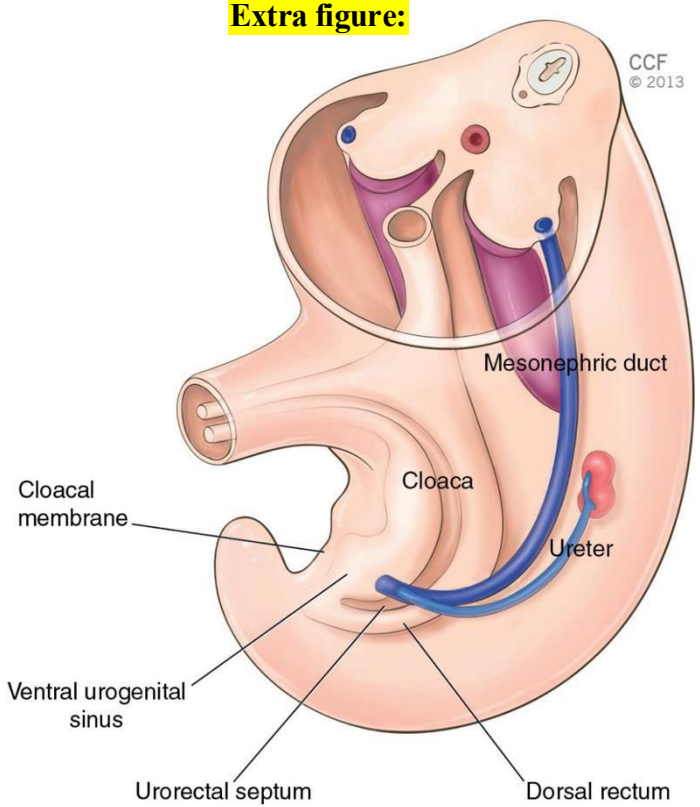


➢ Definition:

- ✓ a **pelvic** cavity present during embryonic development.
- ✓ Connected to the **hindgut** & **allantois**

➢ Divisions and Contributions

- **Posterior (upper) part:**
- ✓ Receives the **terminal portion** of the **hindgut.**
- ✓ Forms the **primitive anorectal canal** → contributes to the **hindgut**.
- **Anterior (lower) part:**
- ✓ Receives the **allantois**.
- ✓ Forms the **primitive urogenital sinus** → contributes to **the urogenital system.**

9- Cloaca

➢ Embryological Origin

✓ The cloaca:

- Lined by **endoderm** → therefore, endodermal in origin.
- Its **ventral boundary** (**outer** surface) is covered by **ectoderm**.

✓ The cloacal membrane:

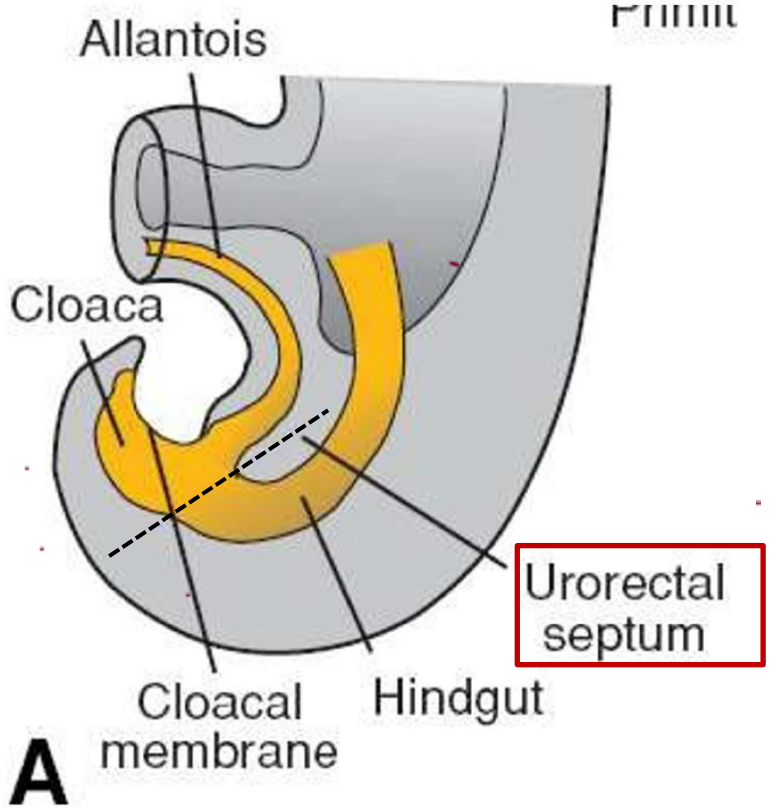
- Its **outer** surface is called the **proctodeum** (**ectodermal** in origin).
- The proctodeum gives rise to the **lower half of the anal canal.**
- Must **rupture** so that the **upper** (**endodermal**) and **lower** (**ectodermal**) **halves of the anal canal can join** together.

10- Urorectal septum

- A layer of mesoderm (mesenchymal structure) **lies** between the **allantois** (urogenital system) and **hindgut**, In other words, it splits the cloaca into two parts.

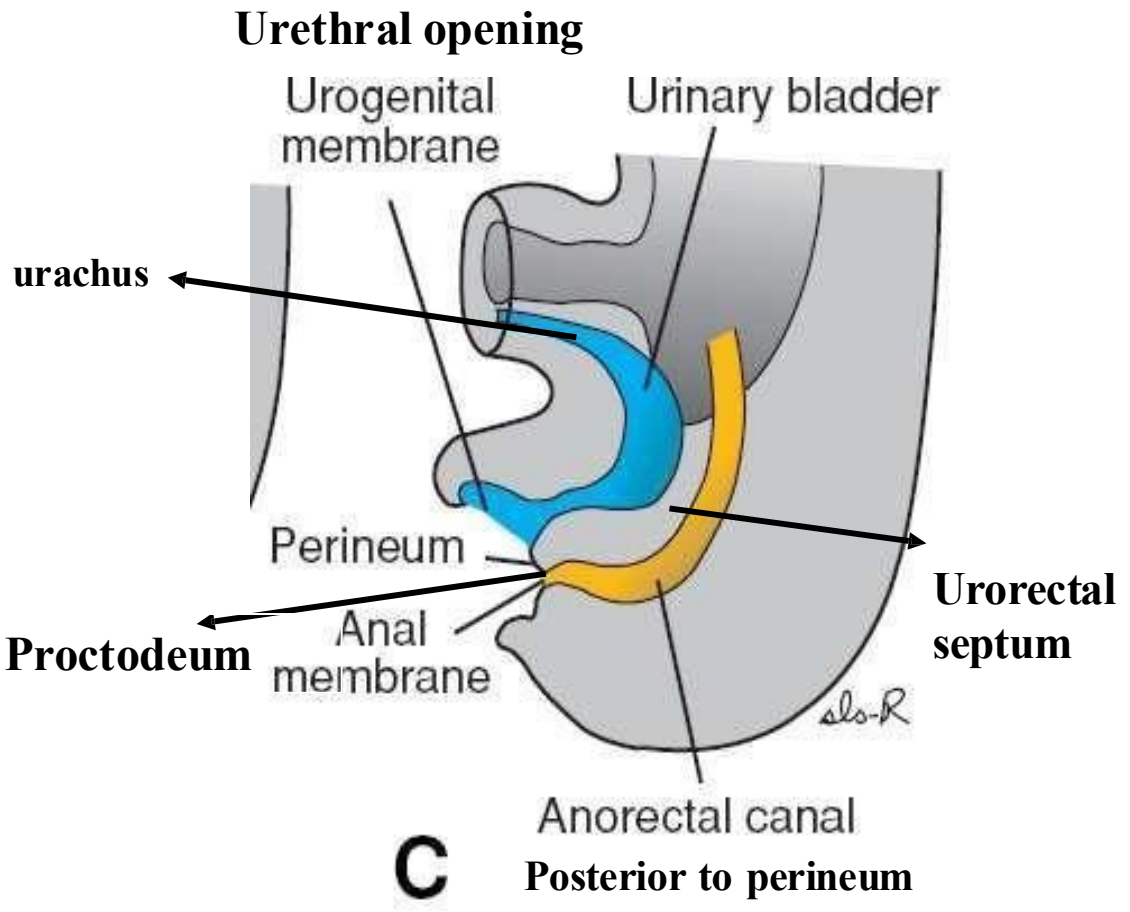
- The tip of it makes the **perineal body** which **separates** the **anal canal** and the **urinary bladder** and **urethra**.

✓ Urorectal septum participates in the formation of the **anal canal** & the **UGS- specifically the urinary bladder.**



11- Caudal part of Anal Canal

Feature	Details
Proctodeum	Formed by proliferation of **ectoderm** at the **caudal** end of the **anal canal**
Function of Proctodeum	Continuation of the anal canal **externally**
Recanalization	Occurs during the **ninth week**
Origin of caudal anal canal	**Ectodermal**
Blood supply (caudal anal canal)	**Inferior rectal arteries** (branches of internal pudendal arteries)
Membrane rupture	Both **anal** and **urogenital membranes** rupture to create openings



12- Pectinate Line

- The junction between the endodermal and ectodermal regions of the anal canal is delineated by the **pectinate line, just below the anal columns**

- At this line, the epithelium changes from **simple columnar** to **stratified squamous non keratinized** for upper 1cm & **keratinized epithelium** for the lower 1 cm.

Anal canal epithelium

Upper 2cm		Simple columnar
Lower 2cm	Upper 1cm	Stratified squamous non-keratinized
	Lower 1cm	Stratified squamous keratinized

13- Anorectal Malformations

- ✓ **The junctions between different embryonic origins -transitional zones - always suffer from malformations.**
- ✓ Anorectal malformations are birth defects in which the **anus** and **rectum** (the lower end of the digestive tract) **don't develop properly.**
- ✓ They occur in an estimated 1 in 4,000 newborns and can range from mild to complex.
- ✓ Anorectal malformations include several different abnormalities, including:
  - **The anal passage** may be **narrow** .
  - A **membrane** may be **present over the anal opening.**
  - The rectum **may not connect to the anus** (**imperforate anus**).
  - The **rectum** may **connect to a part of the urinary tract or the reproductive system through an abnormal passage called a fistula.**
  - **Absence** of the **lower half of the anal canal**
  - **Abnormal position**

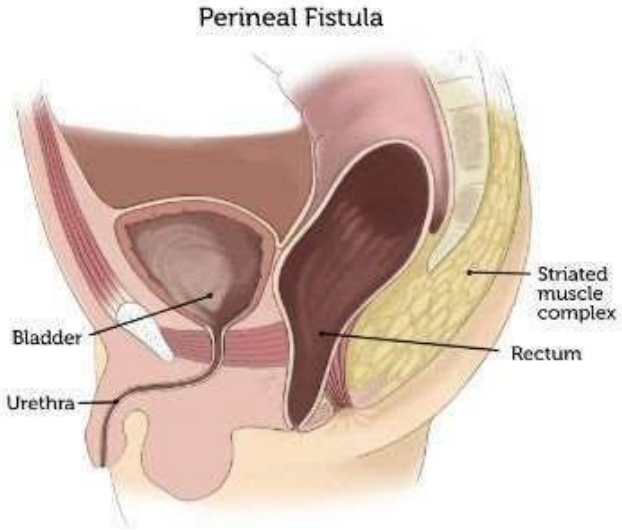
13- Anorectal Malformations

✓ Anorectal malformations, including imperforate anus, can affect male and female babies in different ways:

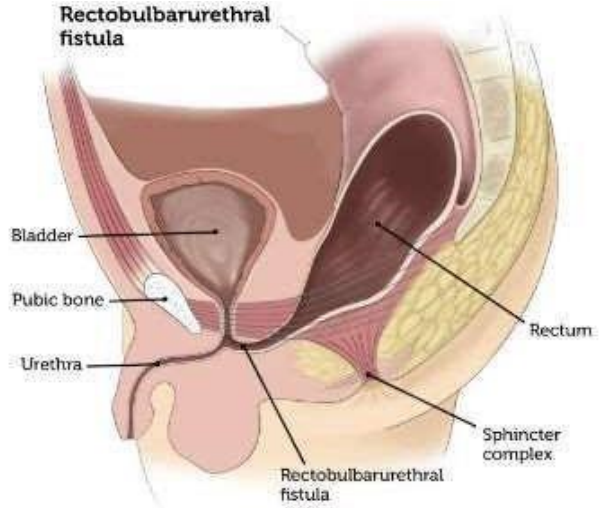
Sex	Common Anorectal Malformations
Male	- Perineal fistula - Rectobulbar urethral fistula - Rectoprostatic fistula - Rectobladder neck fistula
Female	- Rectoperineal fistula - Rectovestibular fistula - Cloaca - Rectovaginal fistula (more common in females)

Note: The urethra has 4 parts: membranous, bulbar, prostatic, and penile, Malformations may affect any of these parts.

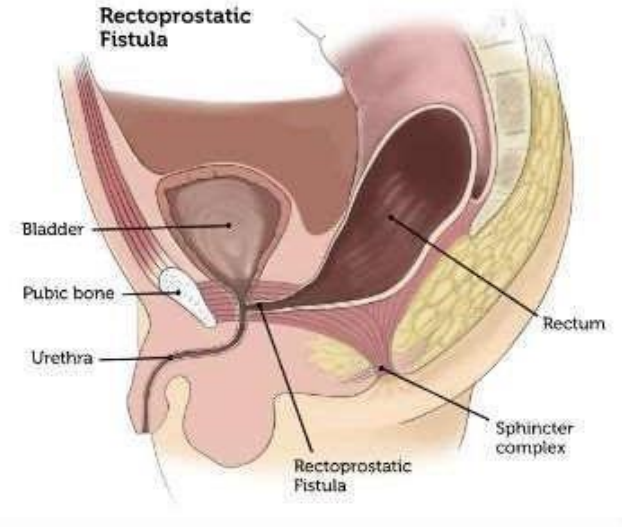
13- Anorectal Malformations



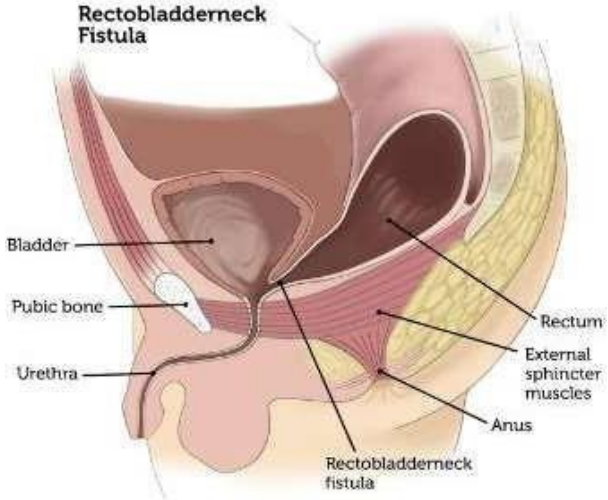
Perineal fistula:
Rectum opened into perineum



Rectobulbarurethral fistula:
Rectum opened into urethral &bulbar membrane



Rectoprostatic fistula :
Rectum opened into prostate



Rectobladderneck fistula:
Rectum opened into urinary bladder neck

Additional Resources:

رسالة من الفريق العلمي:

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1	Slide 20	**Reversed rotation** the appendix becomes on the **left** side instead of the right.	**Reversed rotation** The transverse colon goes to the back posterior to superior mesentric artery and the duodenum.
V1 → V2			