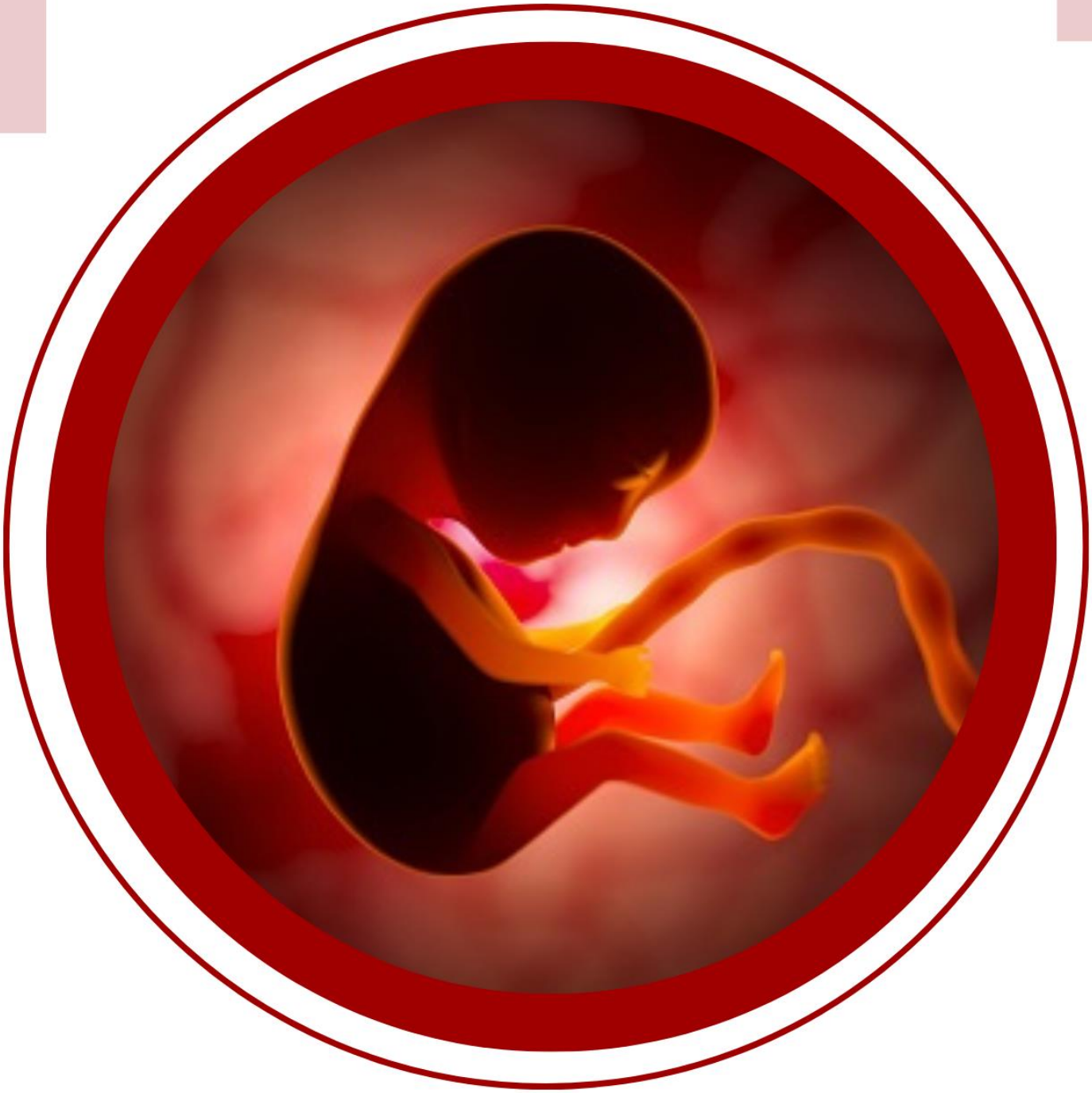
GI
EMBRYOLOGY

 # 3



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Before we start, here are some notes regarding this sheet :

***The last 2 pages contain new content, only mentioned in 2023 lectures.**

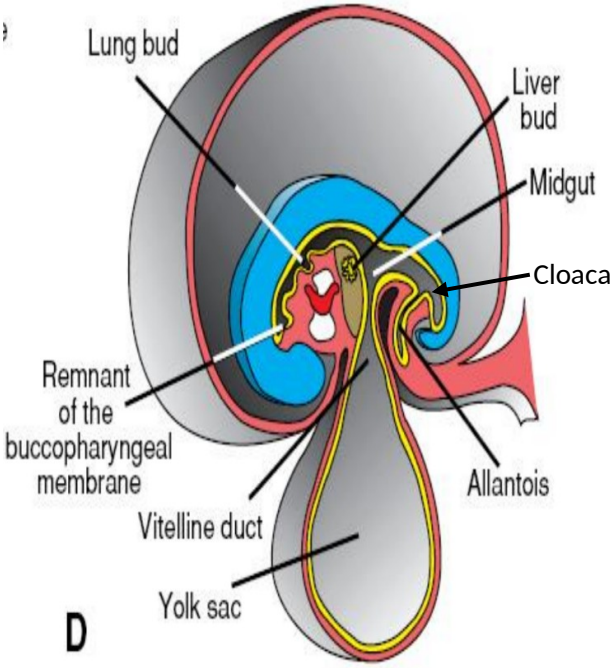
*Any photo within a blue border is an extra photo to make things clear.

We talked in the last lecture about the foregut (pharynx, esophagus, stomach, liver, pancreas and upper half of the duodenum) while the lower half of duodenum follow the midgut.

Midgut

- The midgut is suspended from the dorsal abdominal wall by a short mesentery and communicates with the yolk sac by way of the **vitelline duct or yolk stalk.**

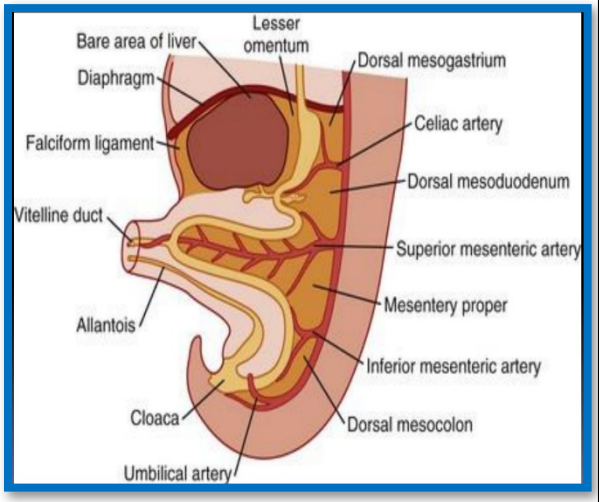
*Cloaca and Allantois, which are found in hindgut will in develop and make urinary bladder and umbilicus.



- We said before that foregut the blood supply is celiac trunk while the midgut supplied by the **superior mesenteric artery** and the hindgut supplied by inferior mesenteric artery

- Development of the midgut is characterized by rapid elongation of the gut and its mesentery (rapid elongation for the small intestine to reach 6 m length unlike the large intestine that is less rapidity), resulting in formation of **the primary intestinal loop**

*Intestinal loop (jejunum and ilium) are formed around superior mesenteric artery and will be connected with vitelline duct.



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

- The Midgut include (lower half of the duodenum, jejunum, ilium, cecum, appendix, ascending colon, proximal 2 third of the transverse colon while distal third follow the hindgut)

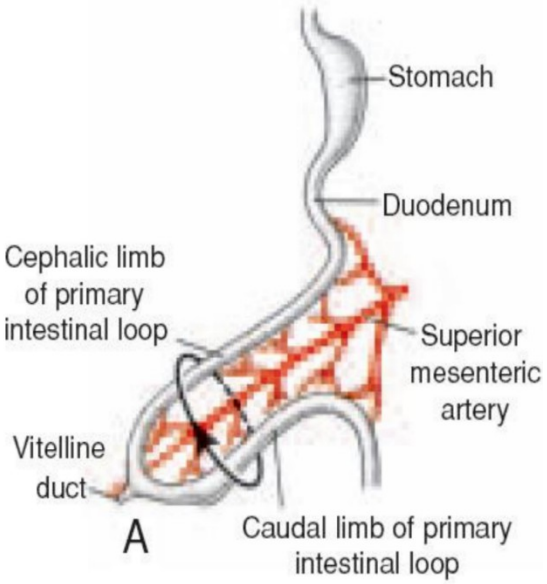
- In the adult the midgut begins immediately distal to the entrance of the bile duct into the duodenum terminates at the junction of the proximal two-thirds of the transverse colon with the distal

third.

- The Midgut is divided into: 1.Cephalic limb. 2.Caudal limb.
- The **cephalic limb** of the loop develops into the distal part of the duodenum, the jejunum, and proximal part of the ileum.

- The **caudal limb** becomes the distal part of the ileum, the cecum, the appendix, the ascending colon, and the proximal two-thirds of the transverse colon.

- The apex of the cephalic and caudal limb is called vitelline duct (That's connect the apex with umbilicus)



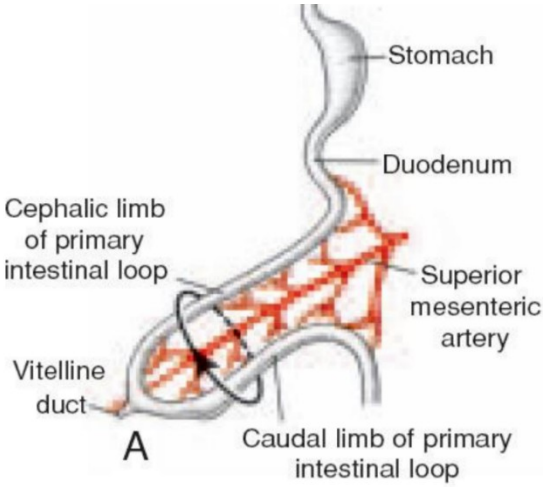
Physiological Herniaton

- Development of the primary intestinal loop is characterized by rapid elongation, particularly of the cephalic limb.
- In the development of midgut, as a result of the rapid growth and expansion and enlargement of the liver and heart the abdominal cavity temporarily becomes too small to contain all the intestinal loops, and they enter the extraembryonic cavity in the umbilical cord through the umbilical ring **during the sixth week** of development (physiological umbilical herniation).

*It happens when the loops of small intestine enter umbilical cord around superior mesenteric artery within vitelline duct.

Rotation of the midgut :

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

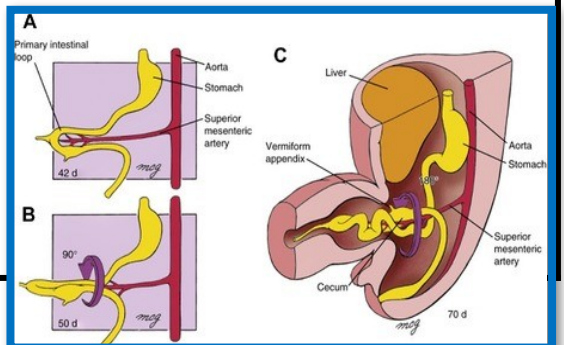


*Remember: In small intestine there will be elongation and coiling but in large intestine there will be elongation without coiling.

*Also during Herniation there will be rotation and its direct is counter clockwise (anti clockwise) around superior mesenteric artery.

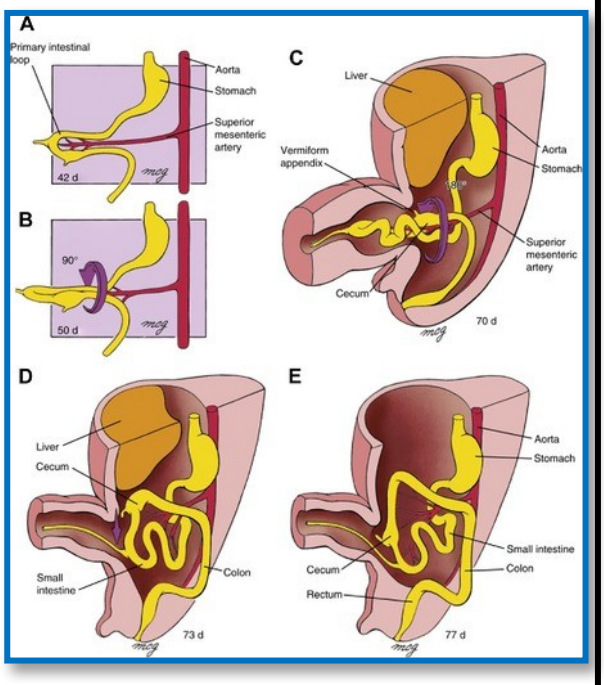
- When viewed from the front, this rotation counter clockwise, and its amounts to approximately 270° when it is completed

* During Herniation the rotation will be 90° (during 6th week)



* During 10th and 11th weeks, there will be another 180° to return intestine (hernia) into the abdominal cavity.

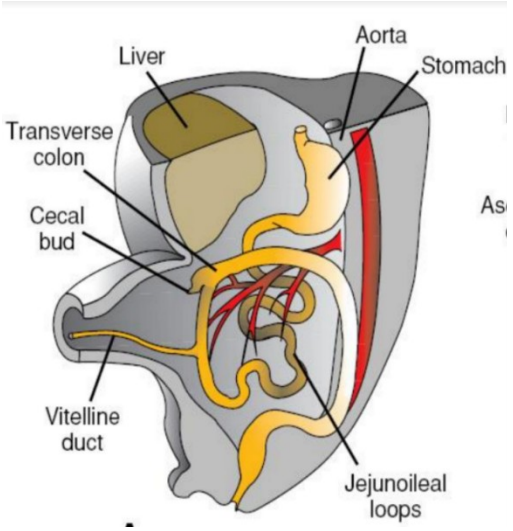
* The summation of rotation is degrees 270°



- Even during rotation, elongation of the small intestinal loop continues, and the jejunum and ileum form a number of coiled loops (elongation to become 6 m)
- The large intestine likewise lengthens considerably but does not participate in the coiling phenomenon.

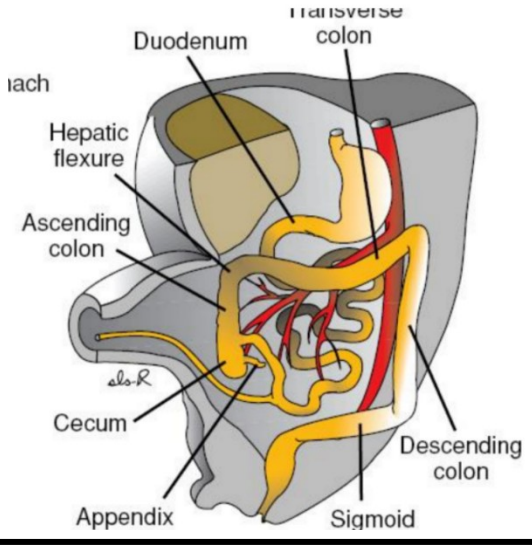
Retraction of herniated loops:

- During the 10th week, herniated intestinal loops begin to return to the abdominal cavity.
- Is thought that regression of the mesonephric kidney, reduced growth of the liver, and expansion of the abdominal cavity play important roles of retraction of the hernia .
- During the retraction the proximal portion of the jejunum, the first part to reenter the abdominal cavity, comes to lie on the left upper side of the abdominal cavity .
- The later returning loops (like the cecum) gradually settle more and more to the right.



*When the intestines return, the first part returns is jejunum to the upper left side of the abdomen, then duodenum and so on. The last part returns is cecum and it will develop a cecal bud upwards below the liver then it descends downward and gives hepatic flexure and ascending colon, when it settle in the right iliac fossa, also gives appendicular diverticulum which forms the appendix.

- **The cecal bud**, which appears at about the sixth week as a small conical dilation of the caudal limb of the primary intestinal loop, is the last part of the gut to reenter the abdominal cavity.
- Temporarily it lies in the right upper quadrant directly below the right lobe of the liver
- From here it descends into the right iliac fossa, placing the **ascending colon** (and give bud called appendicular bud forms the appendix) and **hepatic flexure on the right side of the abdominal cavity**



- **For more clarification :**

A. Cecal bud that's form below the liver and we can see the vitelline duct.

B. Small intestines form a coiling and we see the cecal bud and appendicular diverticulum

C. Then it descends downward in the right iliac fossa and forms the appendix, cecum and ascending colon. During this process the distal end of the cecal bud forms a narrow diverticulum, the **appendix .**

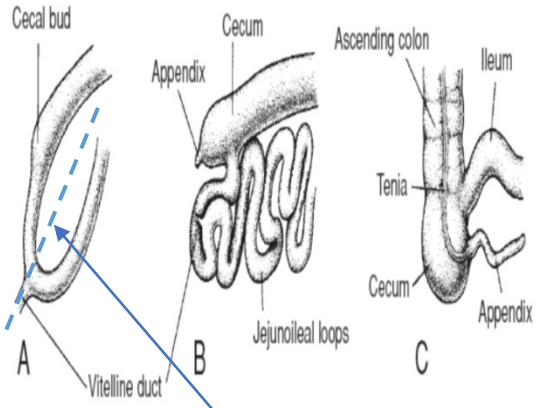


Figure 13.28 Successive stages in development of the cecum and appendix. **A.** 7 weeks. **B.** 8 weeks. **C.** Newborn.

Don't forget that we have the superior mesenteric artery here

- Since the appendix develops during descent of the colon, its final position frequently is posterior to the cecum or colon.
- **These positions of the appendix are called retrocecal or retrocolic, respectively.**

Mesenteries of the intestinal loops :

*Small intestine has mesentery (fan in shape) and it attached to posterior abdominal wall

*Transverse colon has mesocolon attached to anterior border of the pancreas.

*Greater omentum has 2 layer descends and 2 layers ascends which surrounds transverse colon.

*Lesser omentum from mesogastrium and goes toward the liver.

*sigmoid colon has mesentery, but the ascending and descending colon and duodenum fixed in the posterior abdominal wall .

- The mesentery of the primary intestinal loop, **the mesentery proper**, undergoes profound changes with rotation and coiling of the bowel.
- When the caudal limb of the loop moves to the right side of the abdominal cavity, the dorsal mesentery twists around the origin of the **superior mesenteric artery**.
- Later, when the ascending and descending portions of the colon obtain their definitive positions, their mesenteries press against the peritoneum of the posterior abdominal wall

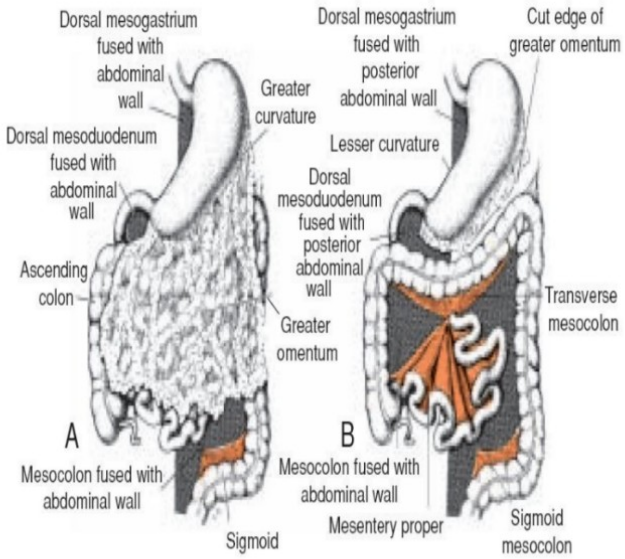
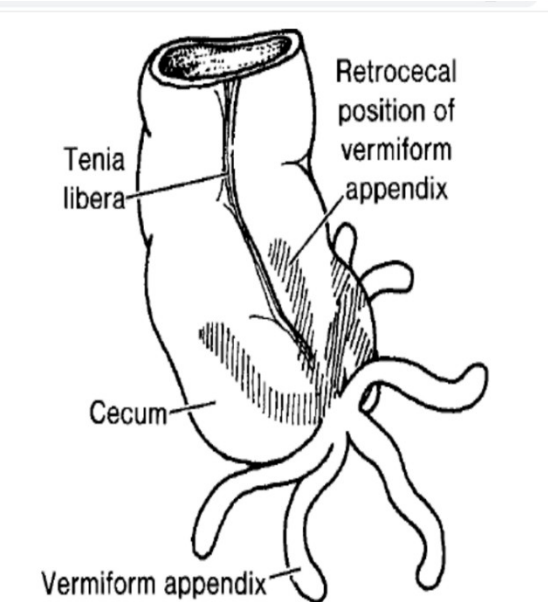


Figure 13.30 Frontal view of the intestinal loops with (**A**) and after removal of (**B**) the greater omentum. *Gray areas*, parts of the dorsal mesentery that fuse with the posterior abdominal wall. Note the line of attachment of the mesentery proper.

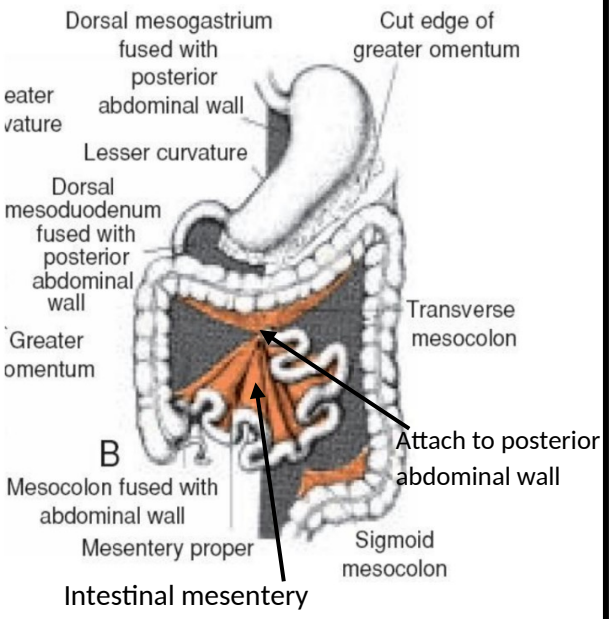
- After fusion of these layers, the ascending and descending colons are permanently anchored in a retroperitoneal position.
- The appendix, lower end of the cecum, and sigmoid colon, however, retain their free mesenteries.



*Appendix around cecum usually called Retrocecum (the reason of that, when the cecum descends down supposed to settle and be fixed in the right iliac fossa and surrounded by peritoneum, but some times the peritoneum become looser so behind it a fossa will be formed and this fossa is called Retrocecal fossa and the appendix enters it).

- The fate of the transverse mesocolon is different. It fuses with the posterior wall of the greater omentum but maintains its mobility.
- Its line of attachment finally extends from the hepatic flexure of the ascending colon to the splenic flexure of the descending colon

- The mesentery of the jejunoileal loops is at first continuous with that of the ascending colon
- When the mesentery of the ascending mesocolon fuses with the posterior abdominal wall, the mesentery of the jejunoileal loops obtains a new line of attachment that extends from the area where the duodenum becomes intraperitoneal to the ileocecal junction



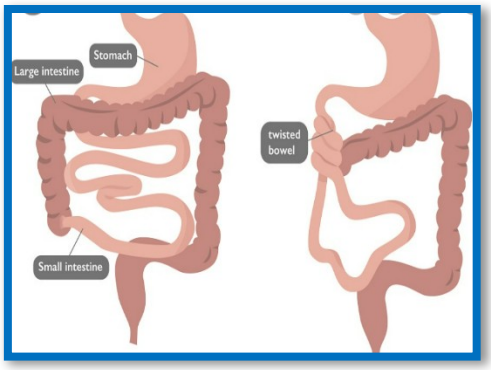
- The mesentery extends from the duodenojejunal junction on the left side at the level of the L2 and to the right side in front of sacroiliac joint in the right iliac fossa.

Gut Rotation Defects:

*Remember that the intestine loops rotate 270° counter clockwise and any defect can happen during this rotation, and the easiest defect is that the rotation becomes clockwise instead of counter clockwise. As a result of that we will find the appendix in the left iliac fossa instead of right iliac fossa, also the ascending colon instead of descending colon and so on.

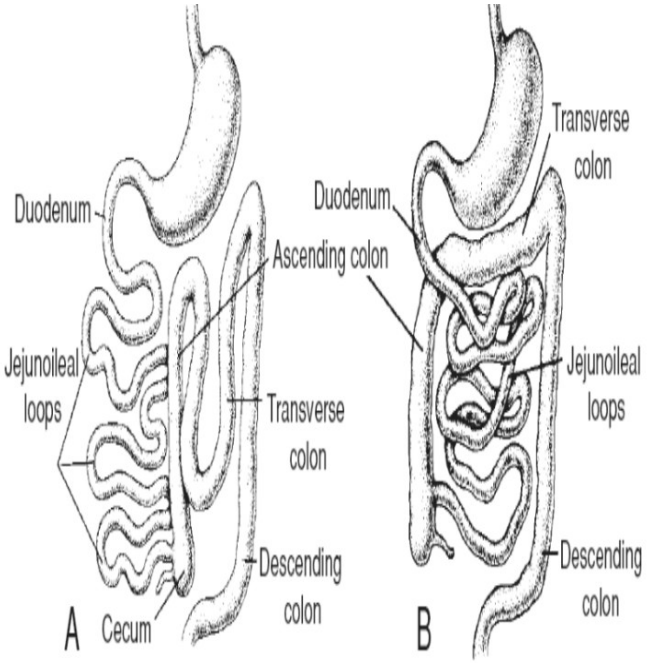
*According to these defects we can explain any abnormalities, like Volvulus and finding the left side organs become in the right and vice versa.

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

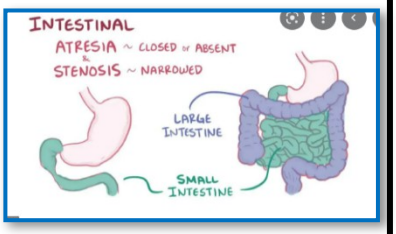


*Volvulus: It happens when a small part small intestine and its mesentery rotate clockwise instead of anticlockwise as a result of that it twists on itself and causes cut of blood supply, obstruction and degeneration of a small part of intestine.

- Normally the primary intestinal loop rotates 270◦ counterclockwise. Occasionally, however, rotation amounts to 90◦ only that's causing the volvulus.
- When this occurs, the colon and cecum are the first portions of the gut to return from the umbilical cord, and they settle on the left side of the abdominal cavity,
- The later returning loops then move more and more to the right, resulting in left- sided colon.
- Reversed rotation of the intestinal loop occurs when the primary loop rotates 90◦ clockwise In this abnormality the transverse colon passes behind the duodenum and lies behind the superior mesenteric artery. (but if it rotates completely it become in the opposite side)



- Duplications of intestinal loops and cysts may occur anywhere along the length of the gut tube
- They are most frequently found in the region of the ileum, where they may vary from a long segment to a small diverticulum.
- Symptoms usually occur early in life, and 33% are associated with other defects, such as intestinal atresias, imperforate anus, gastroschisis, and omphalocele



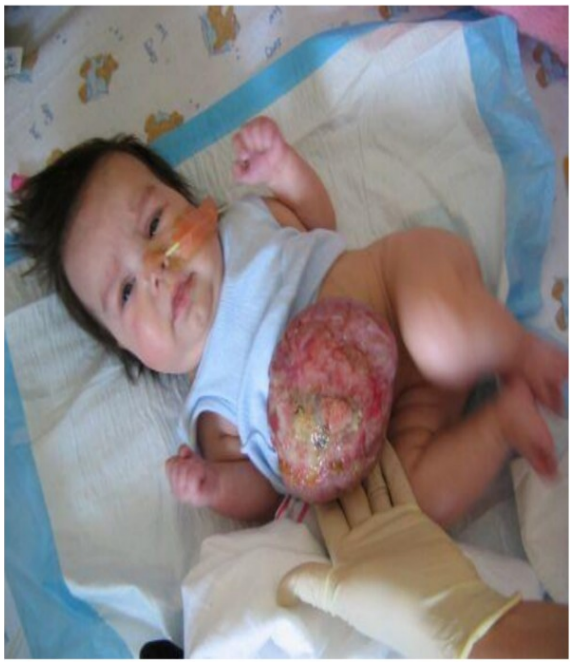
Gut Atresia and Stenosis :

- Atresia and stenoses may occur anywhere along the intestine.
- Most occur in the duodenum, fewest occur in the colon, and equal numbers occur in the jejunum and ileum (1/1500 births), which is a small percentage.
- Atresia in the upper duodenum are probably due to a lack of recanalization.

*Atresia is a blockade may occur anywhere along the intestine and causes obstruction.

* Stenosis refers to a partial obstruction that results in a narrowing of the opening (lumen) of the intestine.

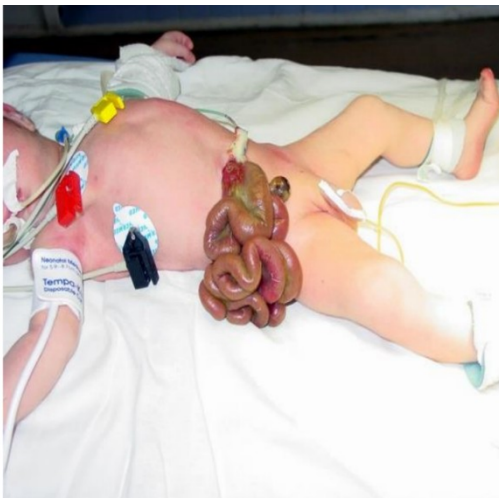
Body Wall Defects :



1. Omphalocele

- **Omphalocele** involves herniation of abdominal viscera through an enlarged **umbilical ring**.
- The origin of the defect is a failure of the bowel to return to the body cavity from its physiological herniation (remain in the umbilical cord outside the umbilical ring)
- It characterized by the viscera are **covered by amnion** (amniotic fluid) also it has a sac surround it.
- Omphalocele occurs in 2.5/10,000 births and is associated with a high rate of mortality (25%) and severe malformations, such as cardiac anomalies (50%) and neural tube defects (40%).
- Approximately half of live-born infants with omphalocele have chromosomal abnormalities.

2. Gastroschisis



- **Gastroschisis** is a herniation of abdominal contents through the body wall directly into the amniotic cavity (without amniotic fluid)
- It occurs lateral to the umbilicus usually on the right not in the umbilical cord

*It occurs in the abdominal wall in the lateral right side mostly.

*It doesn't have an amniotic fluid and a sac that surrounds it.

** Be aware about the differences and characteristics.

Hindgut

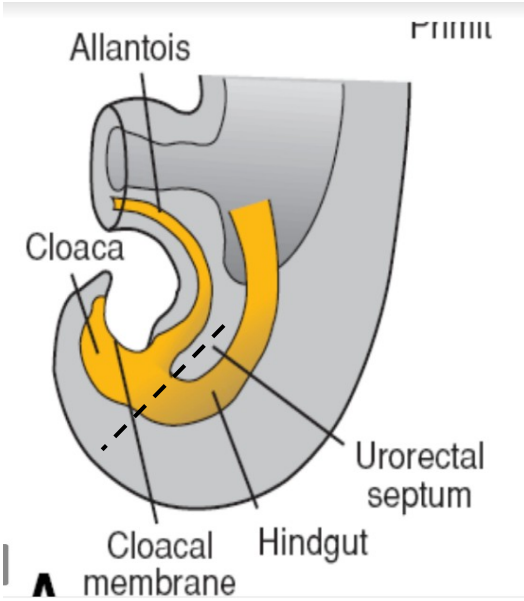
- The hindgut gives rise to the distal third of the transverse colon, the descending colon, the sigmoid, the rectum, and the upper part of the anal canal.

*Remember that the upper part of the anal canal arises from endoderm and the lower half of it arises from ectodermal, and they are separated by pectinate line.

*The Cloacal membrane separates upper and lower half of anal canal

- The endoderm of the hindgut also forms the internal lining of the bladder and urethra (that are anteriorly)

*We see hindgut that's connected with them cloaca (lower end of the GI tract it's endodermal sac connected anteriorly with the yolk sac and allantois). Allantois connected with the umbilicus and must obliterate to avoid the connection between urinary bladder and umbilicus and the urine get out through the umbilicus.



*We see **Urorectal septum** (which is a mesodermal part) when it grows, it will separates hindgut with the posterior part of cloaca and makes anal canal.

*The anterior part is called Urogenital sinus (anterior to cloaca) which will make urinary bladder and urethera.

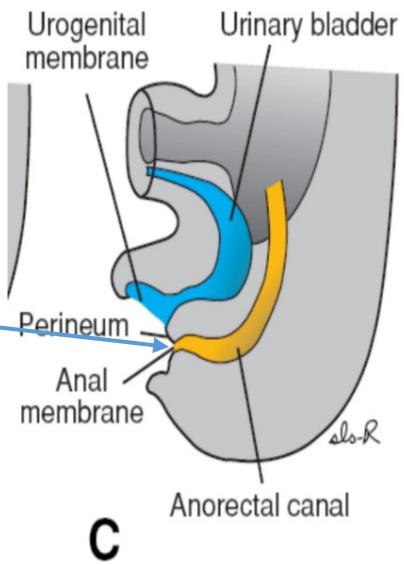
- The terminal portion of the hindgut enters into the posterior region of the cloaca, the primitive anorectal canal; the allantois enters into the anterior portion, the primitive urogenital sinus.
- So the cloaca is attached anteriorly by yolk sac / allantois/urogenital sinus (that's form the urinary bladder and urethra) and posteriorly the hindgut
- The cloaca itself is an endoderm- lined cavity covered at its ventral boundary by surface ectoderm. (called proctodeum that's important because it forms the lower half of anal canal
- This boundary between the endoderm and the ectoderm forms the **cloacal membrane**
- A layer of mesoderm**, the urorectal septum, separates** the region between the allantois and hindgut.
- This septum is derived from the merging of mesoderm covering the yolk sac and surrounding the allantois.

After separation:

*After separation by Urorectal septum, we have hindgut and anal canal posteriorly and anteriorly we have urinary bladder and urogenital membrane.

*At the end of Urorectal septum, it will make the perineum.

- At the end of the seventh week, the cloacal membrane ruptures, creating the anal opening for the hindgut and a ventral opening for the urogenital sinus.
- Between the two, the tip of the urorectal septum forms the perineal body
- proliferation of ectoderm closes the caudal most region of the anal canal.



*after rapture of the anal membrane the ectoderm make closure of the septum and separation between the ectodermal part and the endodermal parts), which will make pectinate line.

- During the ninth week, this region recanalizes.
- Thus, the caudal part (lower half) of the anal canal originates in the ectoderm (proctodeum) and it is supplied by the inferior rectal arteries, branches of the internal pudendal arteries while the upper half supplied by the superior rectal artery)

* proctodeum is an ectodermal part anteriorly to the perineum membrane which makes the lower part of anal canal

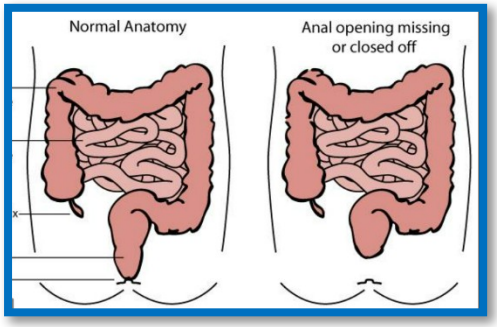
The junction between the endodermal and ectodermal regions of the anal canal is delineated by the pectinate line, just below the anal columns

- At this line, the epithelium changes from columnar to stratified squamous epithelium.

Abnormalities in the hindgut :

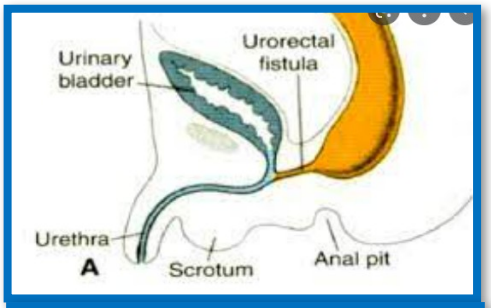
1. Imperforated anus

*At the beginning the cloacal membrane ruptured and a connection between proctodeum and upper half of anal canal happened so there will be a canalization and opening so the anal canal will be formed, if this thing doesn't happen, there will an imperforated anus.



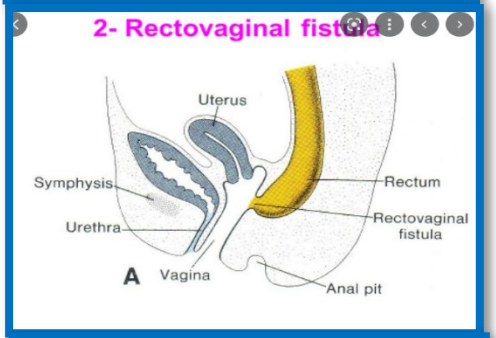
2. Urorectal fistula

*Usually there is a connection between upper half of anal canal and urinary bladder, in this condition instead of opening in the anal canal, it opens in the urinary bladder.



3. Rectovaginal in female

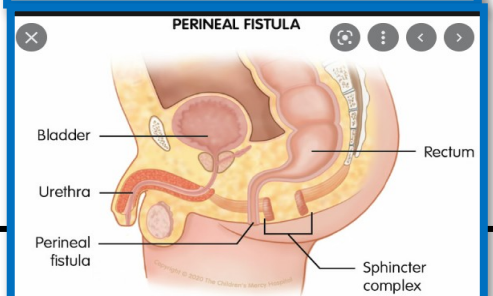
*In this condition, instead of opening in the perineum (anal orifice) and lower half of anal canal, it opens with vagina.



4. Rectoperineal fistula

*The doctor didn't mention it in 2022 lectures.

*for explanation: it is a small tunnel that develops between the end of the bowel and the skin near the anus.



IMPORTANT !!

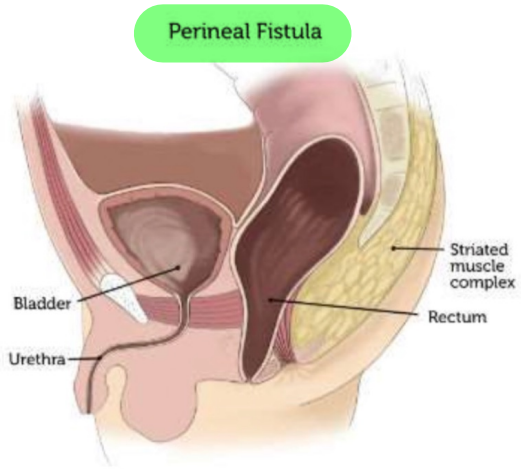
WHAT ARE ANORECTAL MALFORMATION?

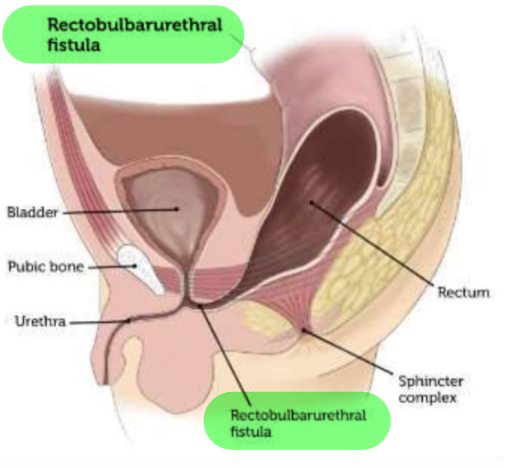
• Anorectal malformations are birth defects in which the anus and rectum (the lower end of the digestive tract) don't develop properly. They occur in an estimated 1 in 4,000 newborns and can range from mild to complex.
• Anorectal malformations include several different abnormalities, including:
- The 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.

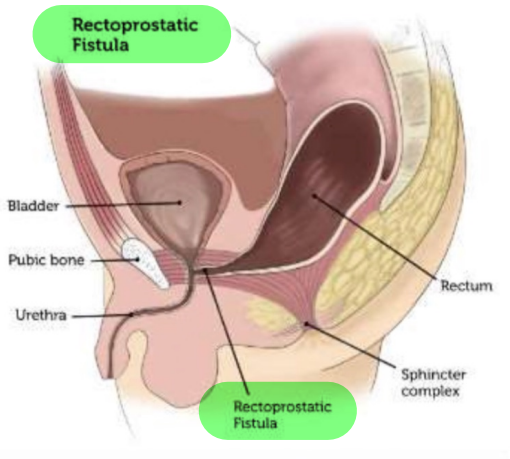
❖Types of anorectal malformations:

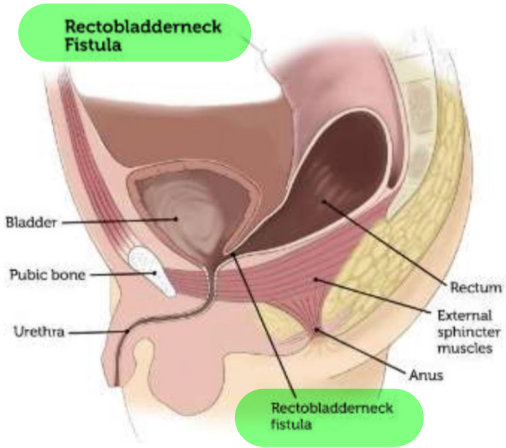
• Anorectal malformations, including imperforate anus, can affect male and female babies in different ways.
• In boys, the main anorectal malformations are perineal fistula, rectobulbarurethral fistula, rectoprostatic fistula and rectobladderneck fistula.
• In girls, the main anorectal malformations are rectoperineal fistula, rectovestibular fistula and cloaca.
• A type of anorectal malformation called imperforate anus can occur in both boys and girls.

Types of anorectal malformations



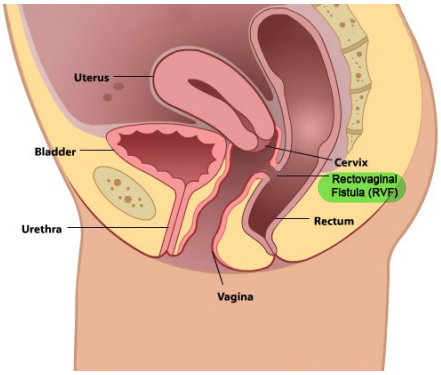






***Another type mentioned by the doctor:**

-Retrovaginal fistula.



****We'll take the development of testis in urogenital system.**

Good luck ;)