الجهاز الهضمي

علم الأجنّة

رقم المحاضرة : الثالثة و الأخيرة

الكُتّاب: باسل صلاح

المدقق: باسل صلاح

الدكتور: د. محمد هشام المحتسب

Don’t panic, this file may contain a lot of slides, but it also contains a lot of summaries & recaps! Also the slides themselves are not filled nor overcrowded with information & explanatory boxes (except for few ones ☺).

The topics of this lecture are quite interesting & the lecture itself is easy to digest, so have fun!

The color code for the following modified slides:
Black text: the professor’s slides.
<u>Underlined Black text: what the professor has read from the slides.</u>
Red text: what the professor has mentioned & explained during the lecture.
Blue text: extra information that may be useful.
Purple text: information thought to be of greater importance.
I also used the purple color to emphasize on medical & significant & essential terms regarding the context.

Gi Embryology 3

Remember:

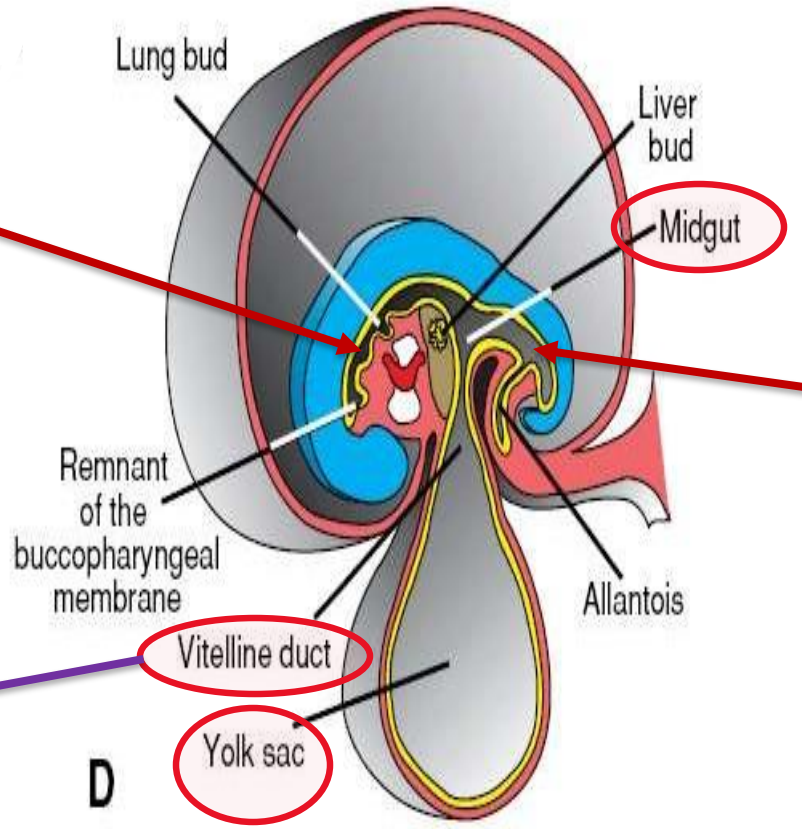
The primitive gut consists of 3 parts:

1) **The foregut**
2) **The midgut**
3) **The hindgut**

In the previous lectures we discussed the development of the foregut.

In todays lecture, we are going to discuss the development of the midgut & the hindgut & the embryopathological conditions concerning them.

Foregut



Hindgut

The vitelline duct is a channel which connects the yolk sac with the midgut (the ileum of the midgut more specifically).

❑ About the midgut:

➔ It begins (caudal to/ distal to/ after) the liver bud.

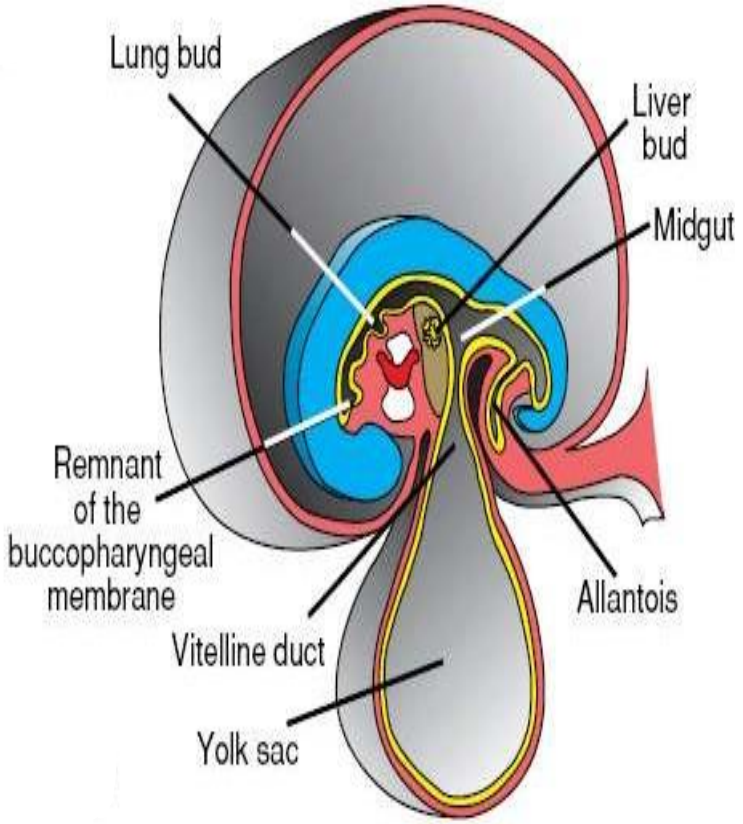
➔ Regarding the small intestine, the midgut develops to form: the jejunum, ileum & the distal part of the duodenum.

➔ Regarding the large intestine, the midgut develops to form: the caecum, appendix, ascending colon & the (proximal/ right) 2 thirds of the transverse colon.

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.**

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

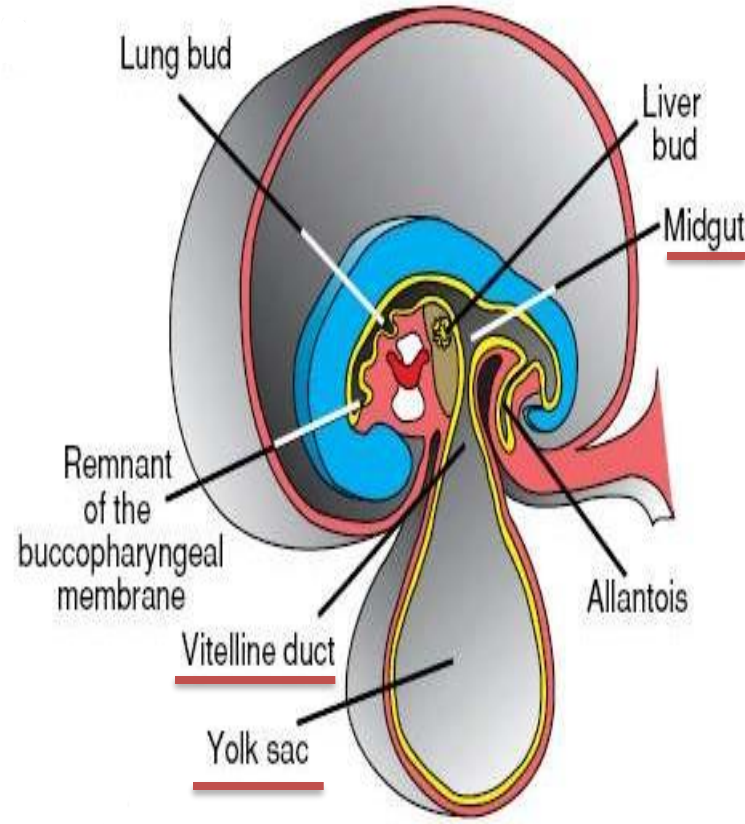


Midgut

- Development of the midgut is characterized by rapid elongation of the gut and its mesentery, resulting in formation of the **primary intestinal loop.**

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

The parts of the midgut which form the jejunum & the ileum are the parts which undergo very rapid elongation relative to the slower parts of the midgut which form the large intestine.
And that's why the jejunum & ileum collectively are longer than the large intestine (the length of the small intestine in a full grown adult is roughly 6 meters, while the length of the large intestine is about 2 meters).



❑ About the primary intestinal loop:

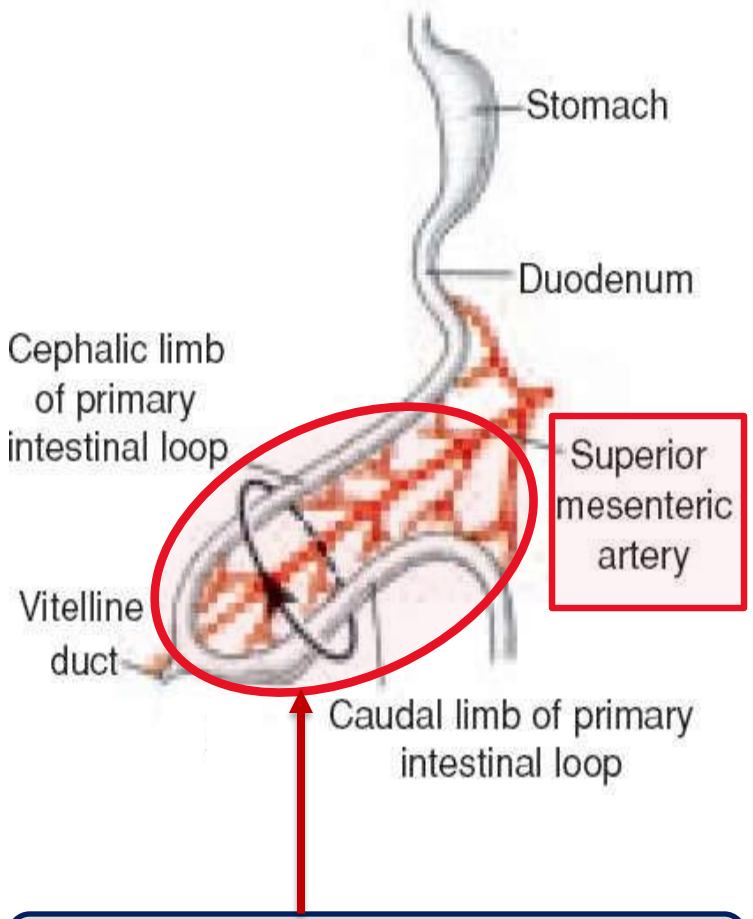
➔ It is an extension of the midgut towards the yolk sac formed by the rapid elongation of the midgut.

➔ The superior mesenteric artery is located inside the primary intestinal loop (as illustrated in the image).

➔ At some point, the primary intestinal loop is going to rotate around the superior mesenteric artery.

➔ So the superior mesenteric artery is considered the axis of rotation of the primary intestinal loop.

➔ Note: the last two points are just for better understanding right now but they are going to be discussed further in the following topics.



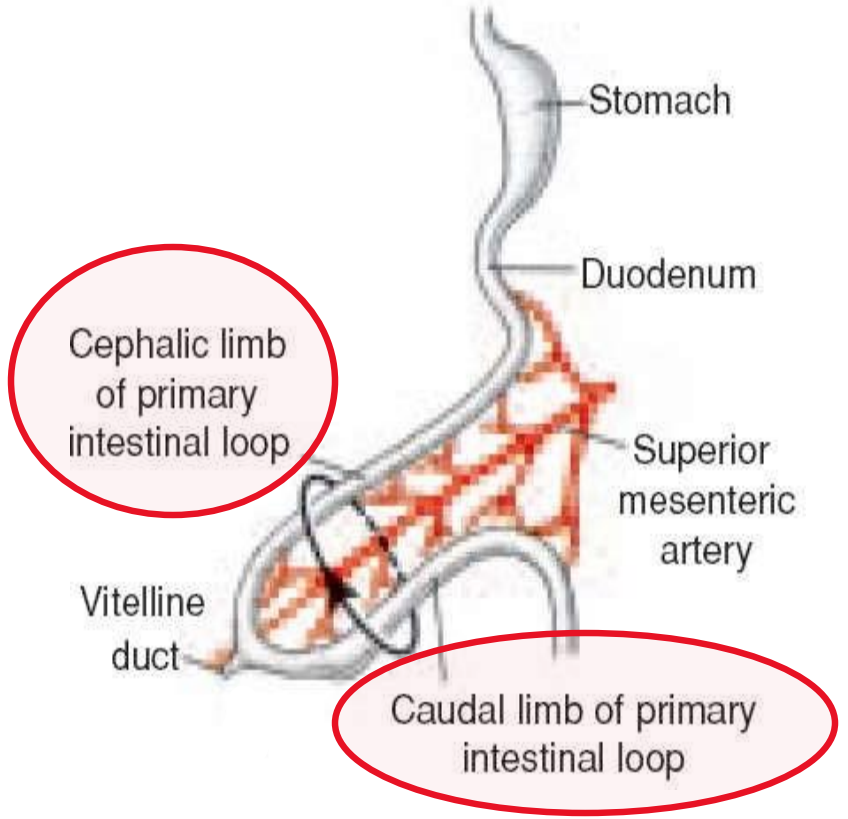
The primary intestinal loop

❑ **About the primary intestinal loop:**

➔ **The primary intestinal loop is divided into 2 limbs (parts) according to its relation to the superior mesenteric artery:**

1) **The limb above the superior mesenteric artery: the cephalic limb of the primary intestinal loop (named so because it lies closer to the head of the fetus).**

2) **The limb below the superior mesenteric artery: the caudal limb of the primary intestinal loop (named so because it lies closer to the tail of the fetus).**

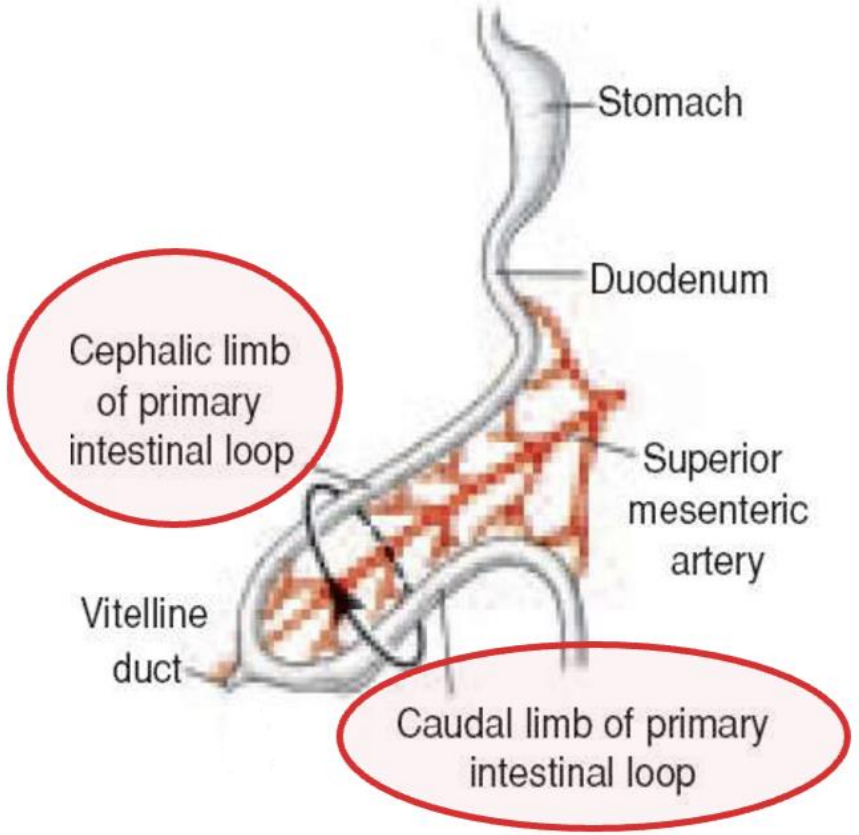


❑ About the primary intestinal loop:

➔ The cephalic limb is going to undergo elongation more rapidly than the caudal limb.

➔ So, we can infer that:

1) the cephalic limb is going to form most of the "small intestine" part of the midgut.
2) While the caudal limb is going to form the "large intestine" part of the midgut.



❑ More explanation regarding the previous slide:

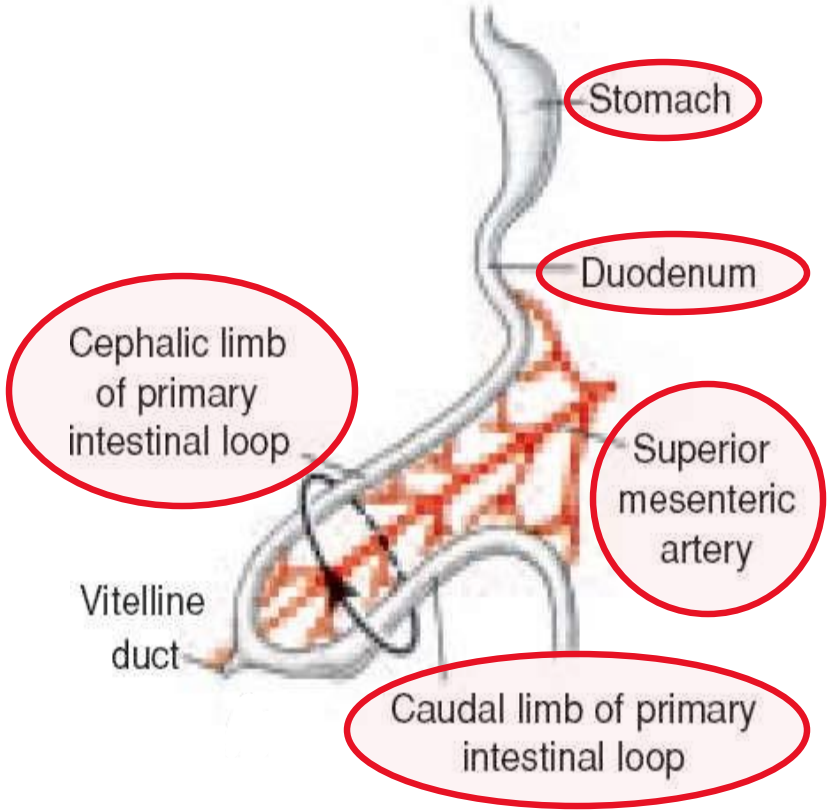
➔ It was mentioned earlier that the part of the midgut that is going to form the jejunum & ileum is going to undergo more rapid elongation than the part of the midgut that is going to form the caecum, appendix, ascending colon & the proximal 2 thirds of the transverse colon.

➔ And since we mentioned that the cephalic limb of the primary intestinal loop of the midgut is going to undergo more rapid elongation than the caudal limb ➔ We can conclude that:

- The cephalic limb is going to form most of the "small intestine" part of the midgut; as it is the part which undergoes rapid elongation.
- The caudal limb is going to form the "large intestine" part of the midgut; as it is the part which undergoes slower elongation.

Remember (regarding the duodenum):
The proximal duodenum is formed by the foregut, while the distal duodenum is formed by the midgut.

- In the adult, the midgut begins immediately distal to the entrance of the bile duct into the duodenum.
- The midgut terminates at the junction of the proximal two-thirds of the transverse colon with the distal third.
- The cephalic limb of the loop develops into the distal part of the duodenum, the jejunum, and part of the ileum.
- The caudal limb becomes the lower portion of the ileum, the cecum, the appendix, the ascending colon, and the proximal two-thirds of the transverse colon.



- **The development of the primary intestinal loop includes 2 processes:**

1) **Physiological herniation**
2) **Rotation of the primary intestinal loop**

❑ **About the physiological herniation:**

➔ Remember: the term herniation is used when part of the viscera bulges or protrudes through an opening or area of weakness of the tissue which contains & covers it.

➔ All of the cases of herniation we discussed in previous lectures & topics were abnormal & pathological.

➔ However, in this current topic "physiological herniation", it can be inferred from its name that it is a normal (physiological) process which occurs in the fetal life.

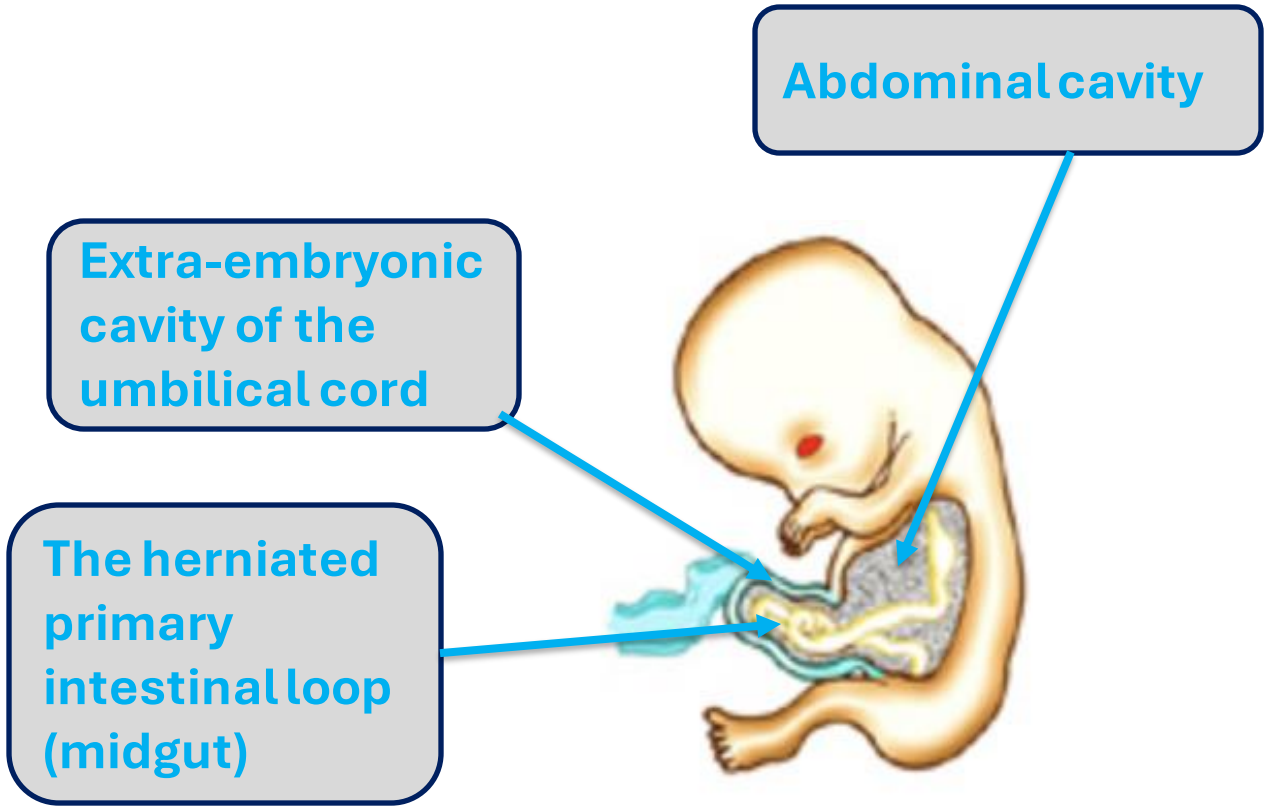
➔ In this process, the primary intestinal loop (midgut) herniates & protrudes into the umbilical cord outside the abdomen.

➔ This occurs because of the rapid elongation of the primary intestinal loop, rapid enlargement of the liver & the downward descending movement of the diaphragm ➔ which makes the abdominal cavity temporarily small & unable to contain the rapidly growing intestinal loop (midgut) ➔ which in turn results in its bulging into the umbilical cord.

1- PHYSIOLOGICAL HERNIATION

- Development of the primary intestinal loop is characterized by rapid elongation, particularly of the cephalic limb.

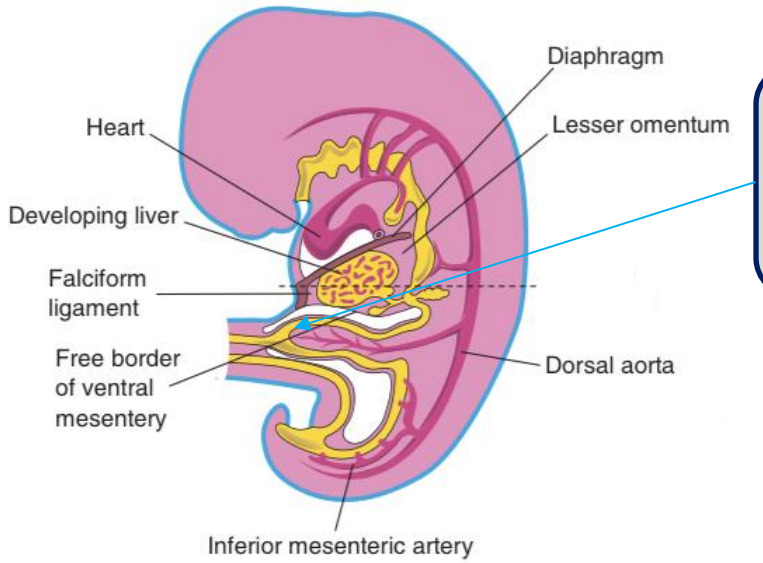
- As a result of the rapid growth and expansion of the liver , **downward descending movement of the diaphragm & the rapid elongation of the cephalic limb of the primary intestinal loop**, the abdominal cavity temporarily becomes too small to contain all the intestinal loops, and they enter the extraembryonic cavity in the umbilical cord during the sixth week of development (**physiological umbilical herniation).**



Extra image demonstrating physiological herniation of the intestinal loop for better understanding

Extra images from “BEFORE WE ARE BORN” embryology textbook (don’t focus on the extra details)

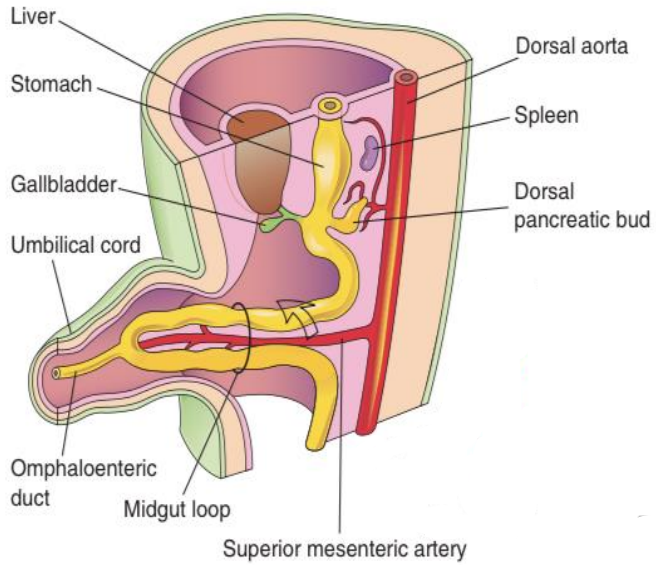
Sagittal section of a 5-week embryo



Primary Intestinal loop

Notice that the intestinal loop (midgut) is still in the abdominal cavity but is about to herniate into the umbilical cord.

3D view (mostly side view) of an embryo at the beginning of the 6th week



Notice how the intestinal loop (midgut) is herniating into the umbilical cord, outside the abdominal cavity.

❑ About the physiological herniation:

➔ Because this herniation is physiological, the primary intestinal loop is going to return to the abdominal cavity eventually. and we call this returning process "retraction of the herniated loops".

➔ Physiological herniation:

- Begins at the 6th week of development, and ends at the 10th week of development where the midgut returns to the abdominal cavity.

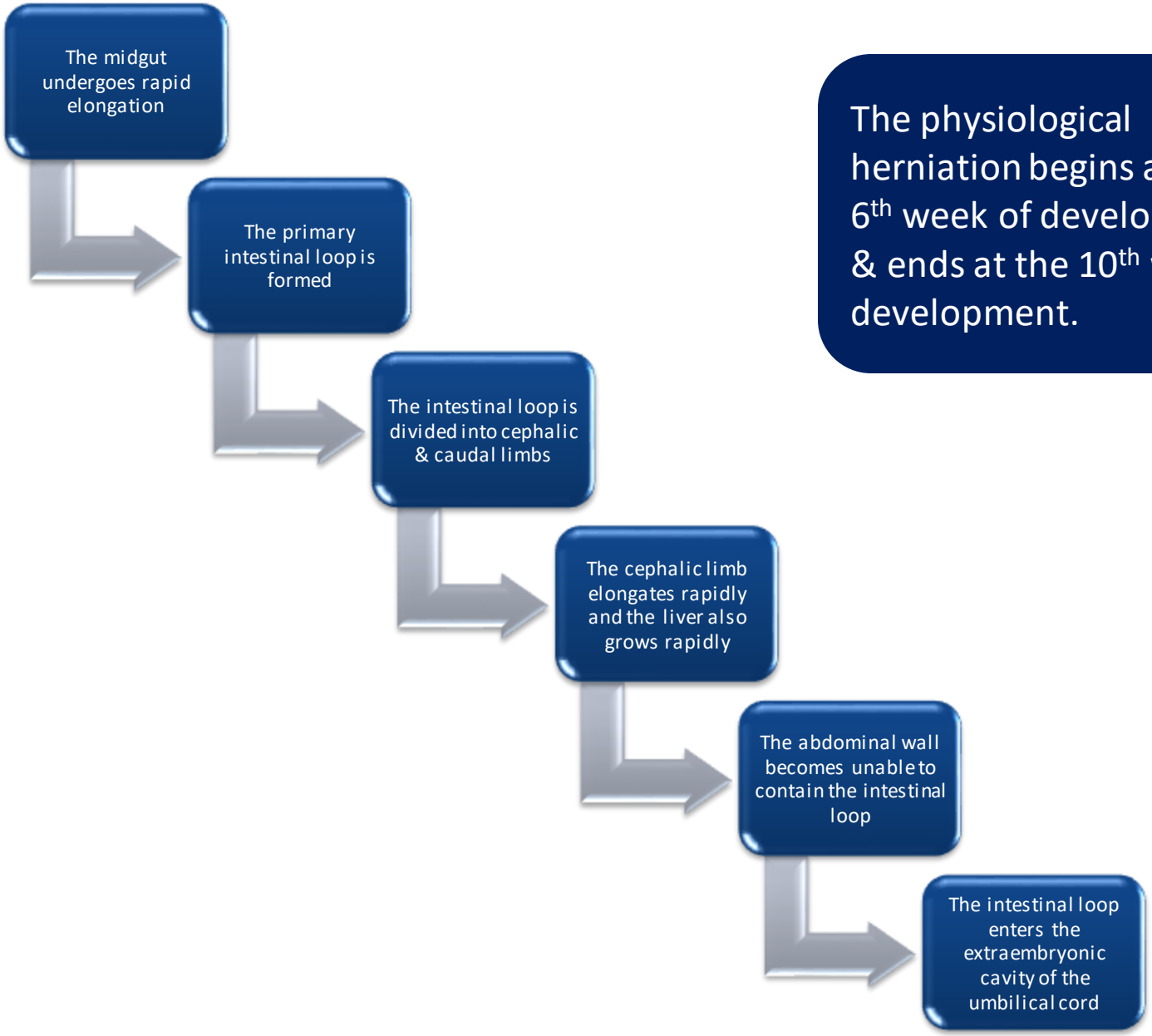
➔ Why does the primary intestinal loop retract & return to the abdominal cavity?

- Because the abdominal cavity enlarges enough to contain the intestinal loop again.

During herniation ➔ The second process of development of the primary intestinal loop occurs, which is the rotation of the intestinal loop. However, rotation does not occur only during the physiological herniation, it also occurs during the process of retraction of the midgut to the abdominal cavity.

We are going to discuss the rotation of the intestinal loop and the retraction of the herniated loops in further details in the following slides.

Quick summary of the physiological herniation:

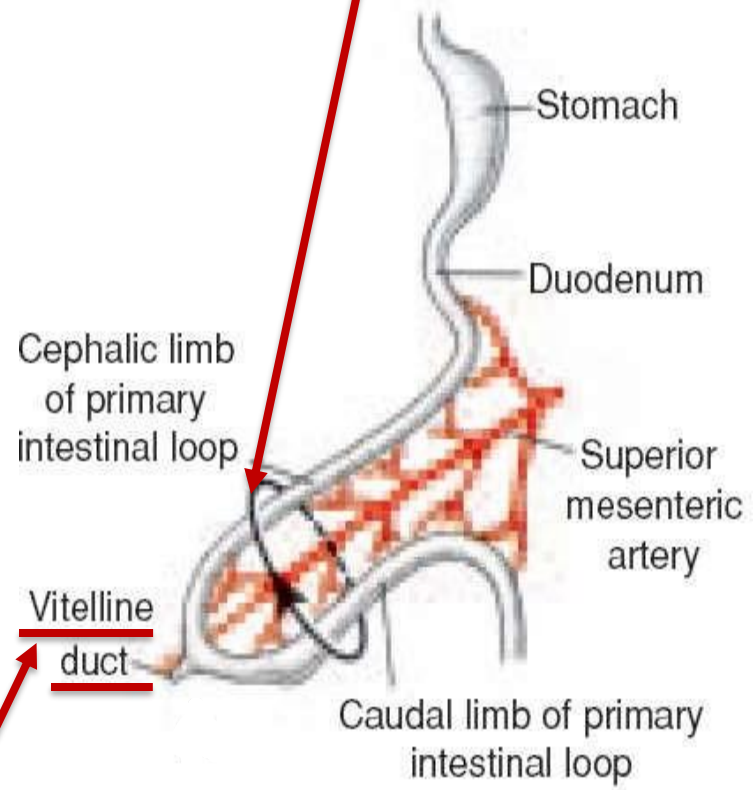


The physiological herniation begins at the 6th week of development & ends at the 10th week of development.

2- 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.

Notice the circular arrow around the intestinal loop indicating that it rotates around the superior mesenteric artery.



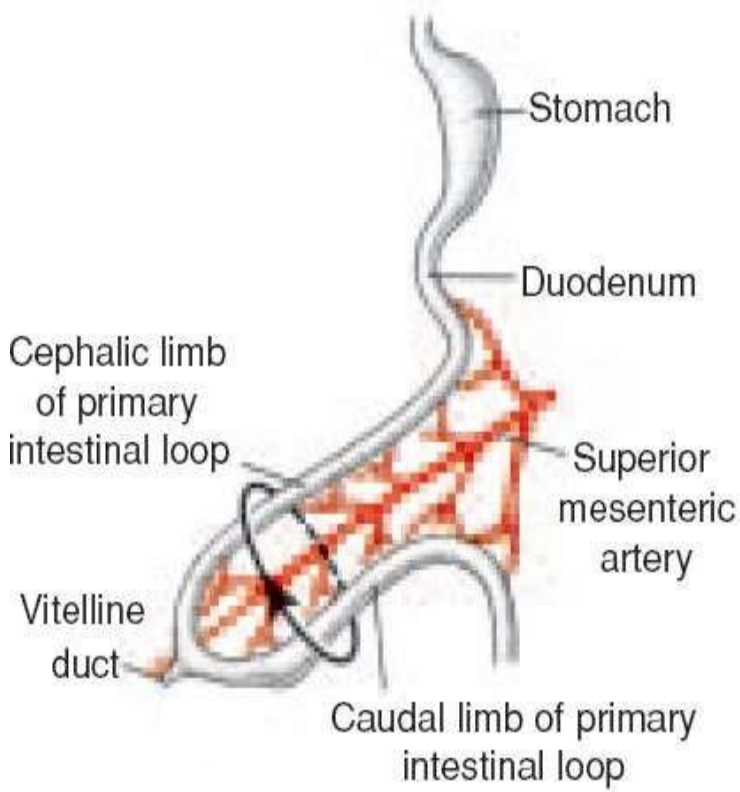
Notice how the vitelline duct is present at the apex of the loop.

- Even during rotation, elongation of the small intestinal loop continues, and the jejunum and ileum form a number of coiled loops.
- The large intestine likewise lengthens considerably but does not participate in the coiling phenomenon.
- Rotation occurs during herniation (about 90◦) as well as during return of the intestinal loops into the abdominal cavity (remaining 180◦).

➔ **The primary intestinal loop rotates in total about 270° counterclockwise from the frontal view, and it occurs at 2 different stages:**

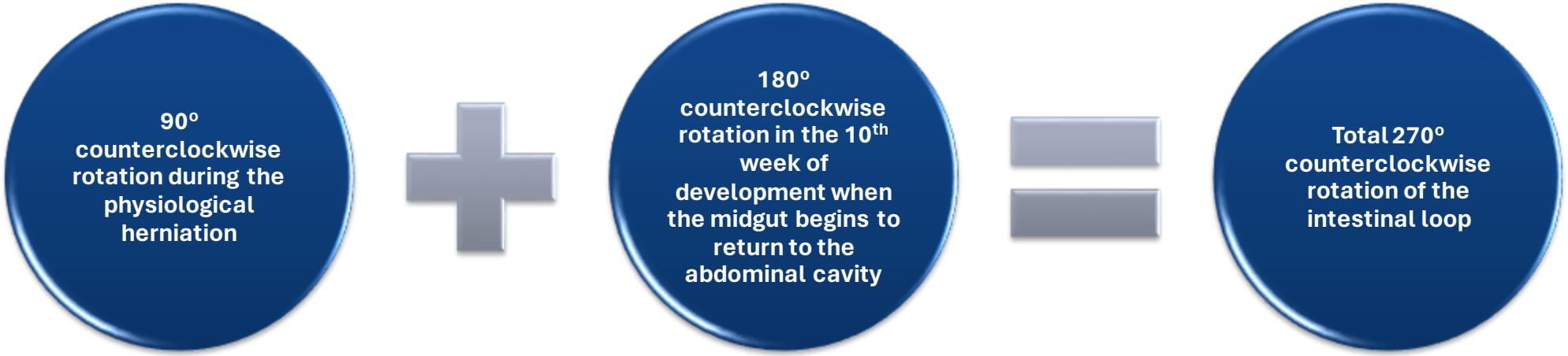
➔ **90° rotation counterclockwise from the frontal view, which occurs during the physiological herniation process.**

➔ **180° rotation counterclockwise from the frontal view, which occurs in the 10th week of fetal development when the midgut begins to return to the abdominal cavity.**



Rotation of the midgut in simple words:

Rotation occurs around the the superior mesenteric artery.



Remember:
When "counterclockwise rotation" is mentioned; it means "counterclockwise rotation of the loop when it is viewed from the front".

- Extra videos for better understanding & visualization of the rotation process of the midgut:

1) 1 minute video: https://youtu.be/qtsTwRffkaQ?si=Nn5UeCR9245kjzDl

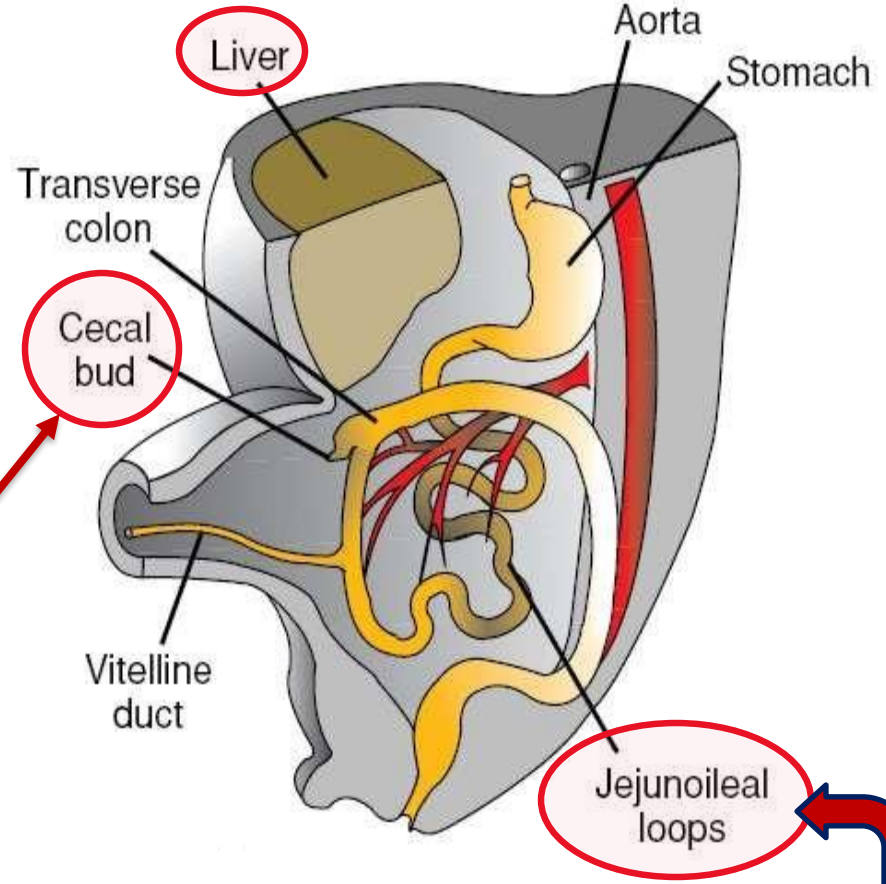
2) 2 minutes video: https://youtu.be/vJA1A0v6Aa4?si=DdmvECErIRww3XlQ

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 **in the retraction of the herniated loops to the abdominal cavity**.
- The proximal portion of the jejunum, the first part to re-enter the abdominal cavity, comes to lie on the left side **upwards.**
- The later returning loops gradually settle more and more to the right.

Also the liver grows upwards providing more space in the abdominal cavity.

The caecal bud is the precursor of the caecum & the appendix.

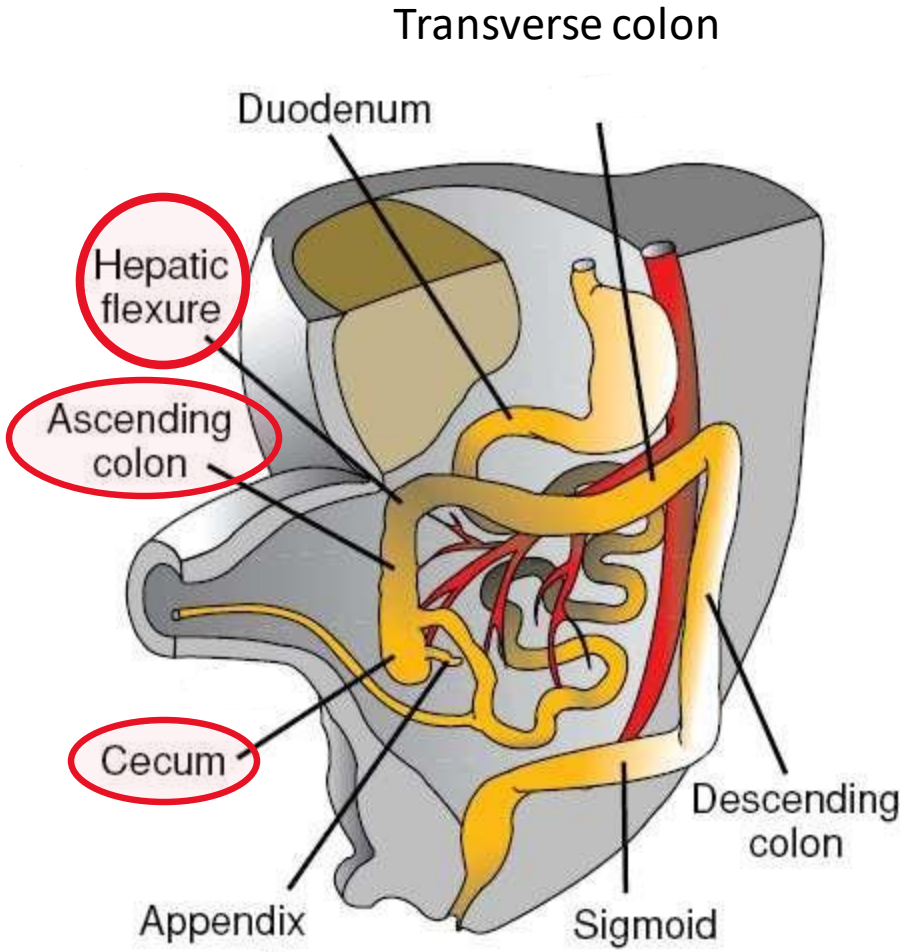


Notice how they are located on the left side of the abdominal cavity.

- 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 re-enter 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 hepatic flexure on the right side of the abdominal** cavity.

Further explanation is in the next slide…

Notice the caecum, appendix, ascending colon & the hepatic flexure lying on the right side of the abdominal cavity.



➔ The first part of the midgut to re-enter the abdominal cavity is the proximal jejunum.

➔ The last part of the midgut to re-enter the abdominal cavity is the caecal bud, which later forms the caecum & the appendix.

❑ About the caecal bud:

➔ It appears at the 6th week of fetal development.

➔ It re-enters the abdominal cavity in the 10th week to lie in the right side below the liver (in the right upper quadrant).

➔ When it re-enters the abdominal cavity, it enlarges to form the caecum & the appendicular diverticulum.

➔ Then, the caecum & the appendicular diverticulum descend downwards into the right iliac fossa.

➔ When they descend downwards, they form the ascending colon.

➔ Also, when they descend downwards, they place the ascending colon & the hepatic flexure in 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.
- These positions of the appendix are called **retrocecal or retrocolic, respectively.**

The common position of the appendix is the retrocaecal position.

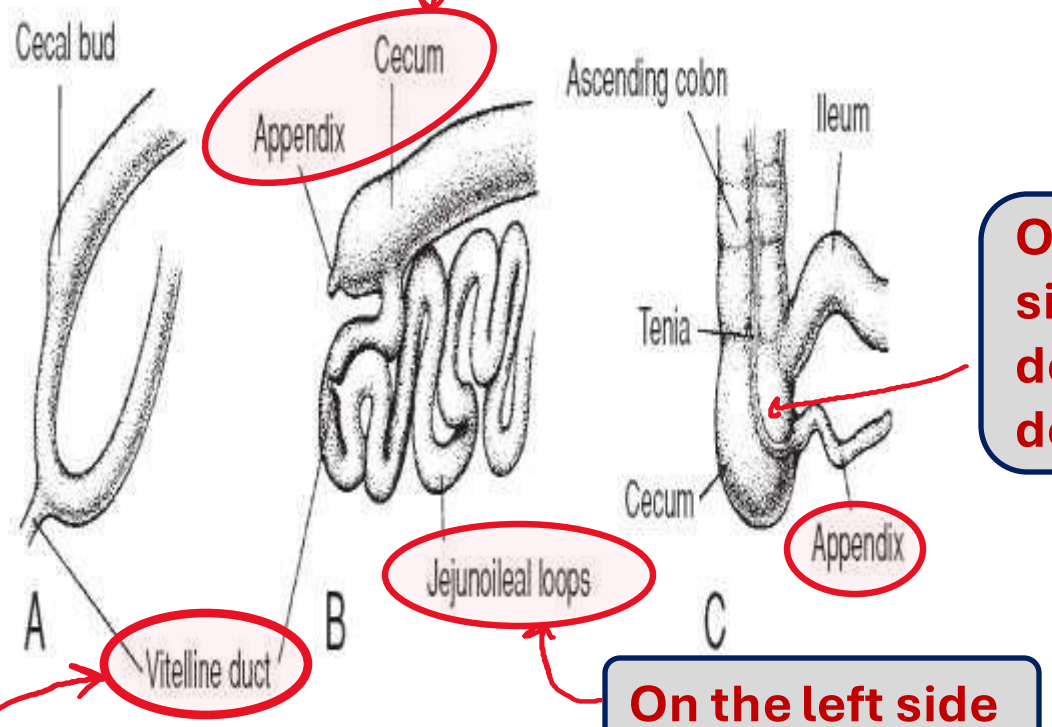


Figure 13.28 Successive stages in development of the cecum and appendix. **A.** 7 weeks. **B.** 8 weeks. **C.** Newborn.

On the right side below the liver

On the right side after descending downwards

On the left side

Notice how the vitelline duct is present at the apex of the intestinal loop.

Quick summary of the retraction process of the herniated midgut

The retraction of the herniated intestinal loop (midgut) to the abdominal cavity:

- ➔ Begins at the 10th week of development.
- ➔ Occurs because of the expansion of the space of the abdominal cavity.

The proximal portion of the jejunum

- The first part of the midgut to re-enter the abdominal cavity.
- After it re-enters the abdominal cavity, it is going to lie in the upper left side of the abdominal cavity.

The caecal bud

- The last part of the midgut to re-enter the abdominal cavity.
- After it re-enters the abdominal cavity, it is going to lie in the right upper quadrant below the right lobe of the liver.
- It is going to enlarge to form the ceacum & the appendicular diverticulum.
- Then, it is going to descend downwards into the right iliac fossa; placing the ascending colon & the hepatic flexure on the right side of the abdominal wall.
- The appendix forms as the colon is descending; that's why most frequently it acquires a retrocaecal/ retrocolic position.

Quick summary in order to understand the big picture!

➔ The midgut communicates with the yolk sac via the vitelline duct.

➔ The part of the midgut which is going to form the jejunum & the ileum undergoes very rapid elongation relative to the part of the midgut that is going to form the large intestine; which leads to the formation of the primary intestinal loop.

➔ The primary intestinal loop is still in contact with the yolk sac via narrow vitelline duct.

➔ The primary intestinal loop is divided into two parts (limbs):

1) The cephalic limb: which lies above the superior mesenteric artery and forms most of the "small intestine" part of the midgut.
2) The caudal limb: which lies below the superior mesenteric artery and forms the "large intestine" part of the midgut.

➔ The cephalic limb of the intestinal loop undergoes more rapid elongation than the caudal limb.

- The rapid elongation of the intestinal loop, together with the rapid growth of the liver, makes the abdominal cavity unable to contain the intestinal loop; which leads to its bulging into the extraembryonic cavity of the umbilical cord, a process called “physiologic herniation”.

- Physiologic herniation begins at the 6th week of fetal development & ends at the 10th week.

- During the physiologic herniation of the intestinal loop (midgut). The intestinal loop rotates about 90^{o} counterclockwise –-from the frontal view— around the superior mesenteric artery.

- At the 10th week of fetal development, the mesonephric kidney regresses, the liver growth undergoes reduction & the abdominal cavity expands; all of which play a significant role in the retraction of the herniated primary intestinal loop (midgut) into the abdominal cavity.

- In the process of retraction of the herniated intestinal loop, the intestinal loop itself undergoes rotation of about 180^{o} counterclockwise —when viewed frontally— around the superior mesenteric artery.

- In total, the primary intestinal loop has undergone rotation of about 270^{o} counterclockwise —when viewed frontally— around the superior mesenteric artery.

- During the retraction process of the herniated intestinal loop, the first part of the intestinal loop (midgut) to re-enter to the abdominal cavity is the proximal portion of the jejunum.
- After the proximal portion of the jejunum re-enters the abdominal cavity, it is going to lie in the upper left side of the abdominal cavity.
- The last part of the intestinal loop (midgut) to re-enter the abdominal cavity is the caecal bud.
- After the caecal bud re-enters the abdominal cavity, it is going to lie in the right upper quadrant of the abdominal cavity just below the right lobe of the liver. Furthermore, it is going to enlarge to form the caecum & the appendicular diverticulum.
- Then, it is going to descend downwards into the right iliac fossa placing the ascending colon & the hepatic flexure in the right side of the abdominal cavity.
- The appendix forms as the colon is descending. So, most of the time it acquires a retrocaecal/retrocolic position.

Now, we are going to discuss the mesenteries of the intestinal loops…

- Mesentery is a double layer of visceral peritoneum.
- The mesentery connects intraperitoneal visceral organs to the internal layer of the posterior abdominal wall (the parietal layer of peritoneum).

- Some abdominal organs have mesentery & they are called "intraperitoneal" organs, for example: jejunum, ileum, transverse colon, sigmoid colon, etc..
- Other abdominal organs don't have mesentery & they are fixed to the posterior abdominal wall & they are called "retroperitoneal" organs, for example: the ascending colon, the descending colon, etc…

- The mesentery of the intraperitoneal organs is attached to the posterior abdominal wall.

MESENTERIES OF THE INTESTINAL LOOPS

- 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**

The mesentery of the primary intestinal loop is called "the mesentery proper", and it undergoes elongation.

The mesentery proper is derived from the dorsal mesentery of the embryo.

The direction of elongation of the mesentery proper is towards the posterior abdominal wall as it is attached to it.

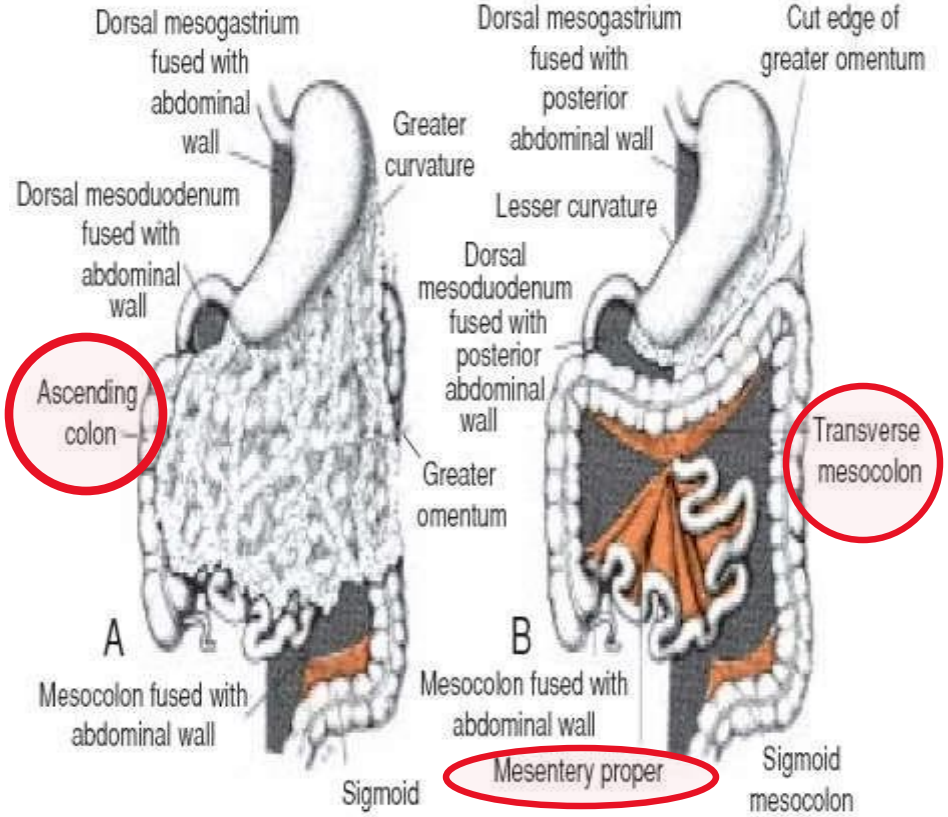


Figure 13.30 Frontal view of the intestinal loops with (**A**) and after removal of (**B**) the greater omentum. *Gray areas*, parts of the dorsal mesentery that fuse with the posterior abdominal wall. Note the line of attachment of the mesentery proper.

- 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.

➔ **The mesentery of the ascending & the descending parts of the colon (which are retroperitoneal organs) posteriorly disappear, and the ascending & descending parts of the colon become fixed by their lateral wall to the posterior abdominal wall, as the peritoneum surrounds them anteriorly & on both sides.**

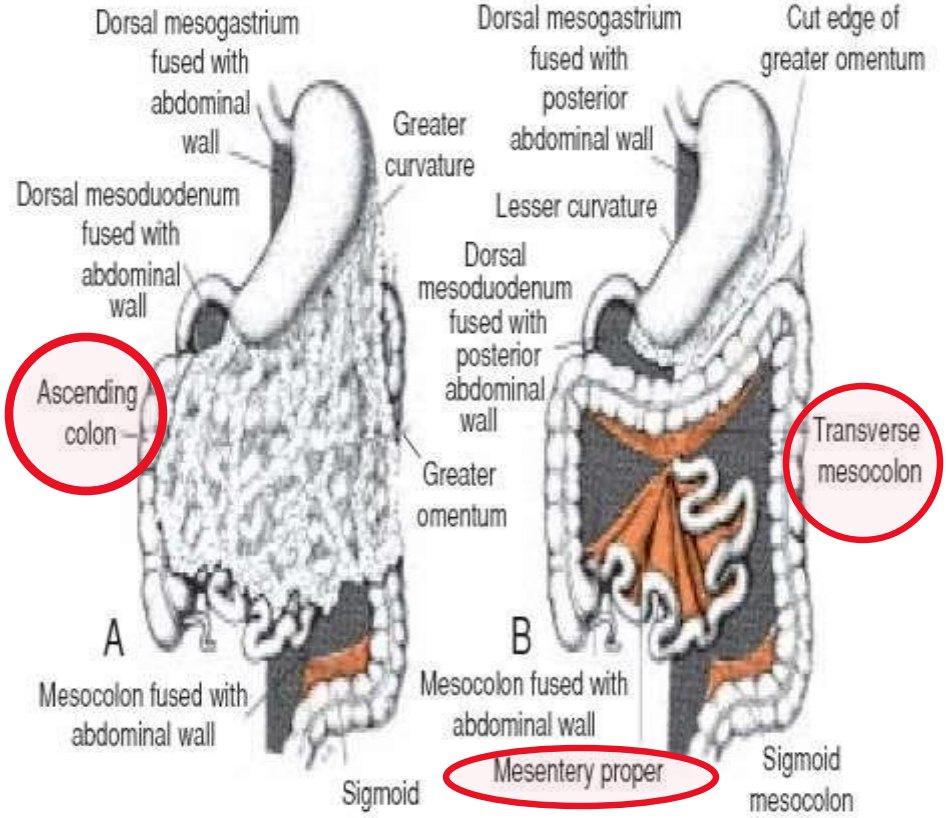
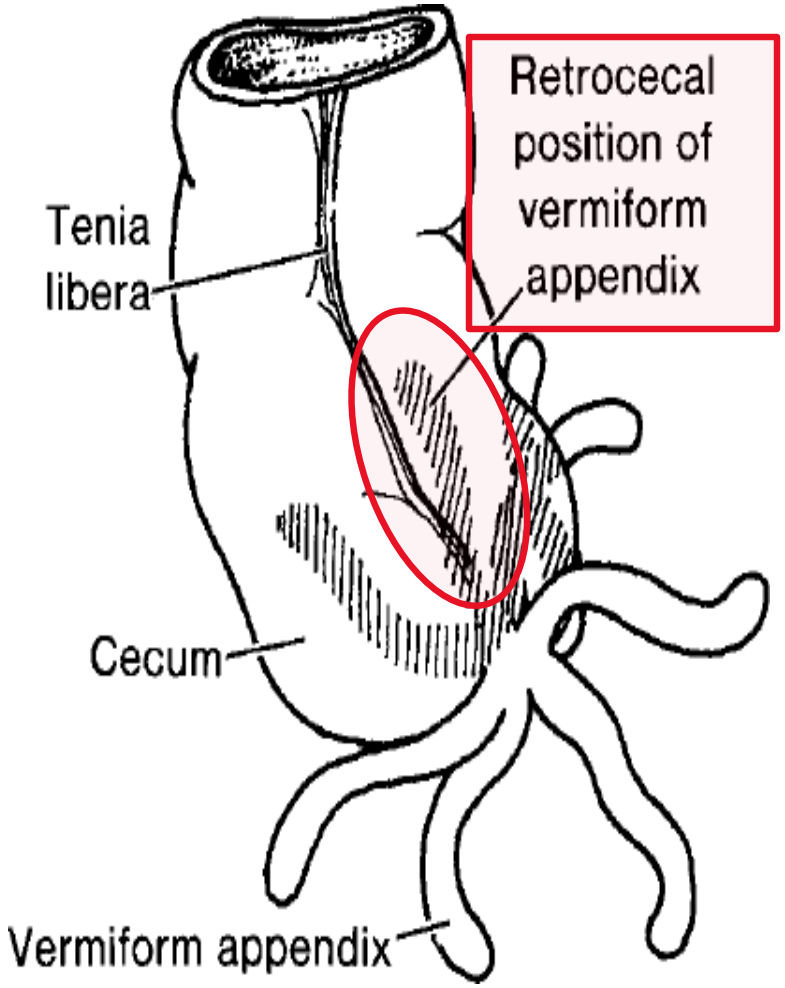


Figure 13.30 Frontal view of the intestinal loops with (**A**) and after removal of (**B**) the greater omentum. *Gray areas*, parts of the dorsal mesentery that fuse with the posterior abdominal wall. Note the line of attachment of the mesentery proper.

- After fusion of these layers, the ascending and descending colons are permanently anchored in a retroperitoneal position.

- The appendix, lower end of the caecum, and sigmoid colon, however, retain their free mesenteries.

So, the appendix is intraperitoneal in position, & its mesentery is called mesoappendix.



- 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 transverse colon has mesentery called transverse mesocolon which is derived from the dorsal mesentery.

➔ **In the peritoneum lecture, we said that 2 layered-sheet of the greater omentum descends downwards & ascends upwards and it surrounds the transverse colon & extends as the transverse mesocolon towards the anterior border of pancreas. But this is medically inaccurate regarding the formation of the transverse mesocolon.**

➔ **Whats embryologically & medically correct is that the dorsal mesentery extends from the internal layer of the posterior abdominal wall as two layers & surrounds the transverse colon & then it assembles & fuses with part of the ascending sheet of the greater omentum (which is also composed of 2 layers) during fetal development.**

➔ **So, the transverse colon is attached to a 4-layered transverse mesocolon (mesentery), which is formed by 2 layers of dorsal mesentery & other 2 layers of the ascending sheet of the greater omentum.**

Which is formed by parietal peritoneum.

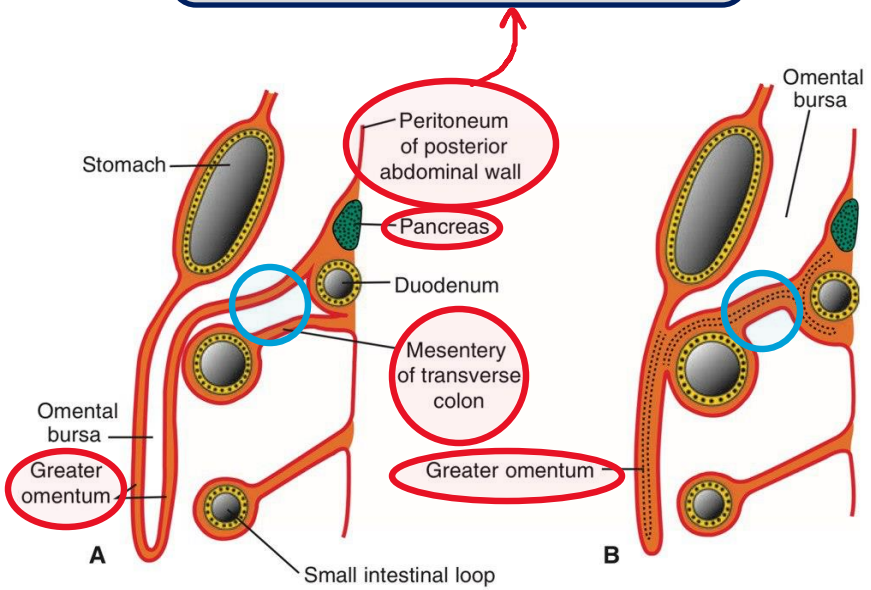


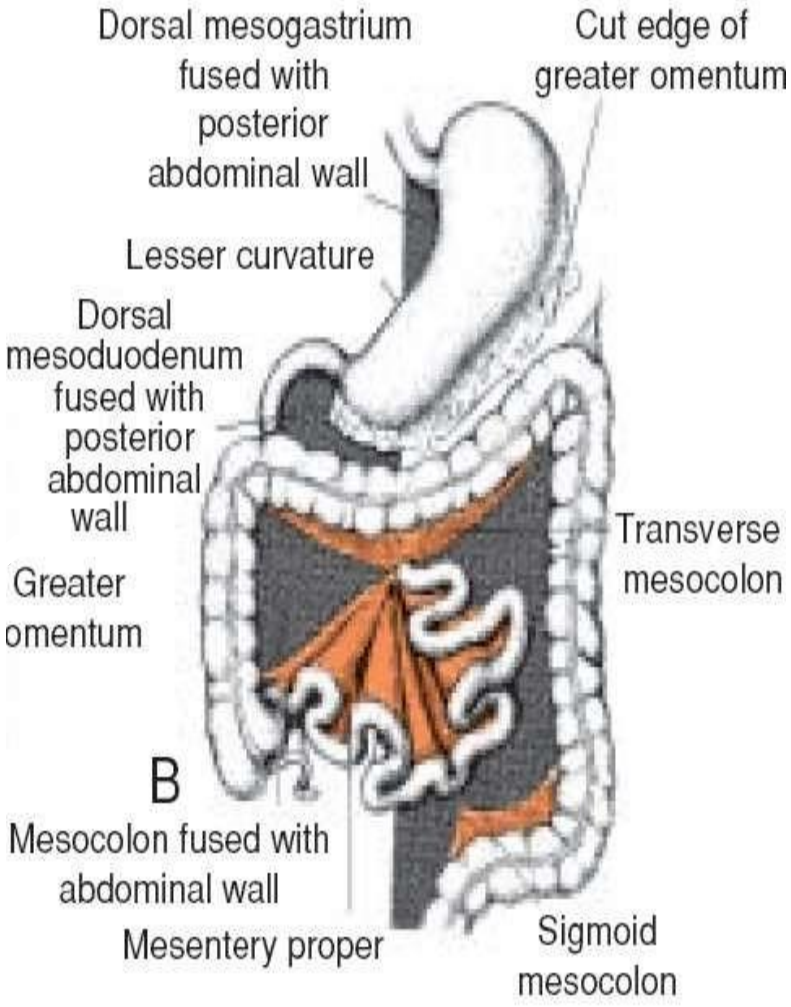
Figure 15.13 **A.** Sagittal section showing the relation of the greater omentum, stomach, transverse colon, and small intestinal loops at 4 months. The pancreas and duodenum have already acquired a retroperitoneal position. **B.** Similar section as in **A** in the newborn. The leaves of the greater omentum have fused with each other and with the transverse mesocolon. The transverse mesocolon covers the duodenum, which fuses with the posterior body wall to assume a retroperitoneal position.

Extra image from Langman's medical embryology

Notice how the ascending & descending parts of the greater omentum fuse together during embryological development. Also, notice how the transverse mesocolon is originally formed by the dorsal mesentery, but then it fuses with part of the ascending sheet of the greater omentum, forming a 4-layered transverse mesocolon.

- The mesentery of the jejunoileal loops is at first continuous with that of the ascending colon.

- When the mesentery of the ascending colon fuses with the posterior abdominal wall **(when the mesentery disappears & the ascending colon becomes fixed to 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.



Quick summary of the mesenteries of the intestinal loops

Ascending & Descending Colon

They initially have mesenteries, but then their mesenteries press against the posterior abdominal wall & they become retroperitoneal.

Transverse Colon

It is intraperitoneal, & its mesentery (transverse mesocolon) is formed initially by the dorsal mesentery.

Then, it fuses with part of the 2-layered ascending sheet of the greater omentum, forming a 4-layered transverse mesocolon.

Jejunum & Ileum

They are intraperitoneal organs & their mesentery is called “mesentery proper”.

The mesentery proper is derived from the dorsal mesentery, and it undergoes elongation.

The mesentery proper is originally continuous with the mesentery of the ascending colon, but after the ascending colon becomes retroperitoneal, the mesentery proper acquires a new line of attachment; which begins from the distal inch of the duodenum & extends to the ileocaecal junction.

Remember that the midgut normally rotates 270° counterclockwise.

Gut Rotation Defects

We are going to discuss 3 pathological conditions regarding abnormal gut rotation in the fetal life.

1) Incomplete rotation of the intestinal loop (midgut):

- Normally the primary intestinal loop rotates 270◦ counterclockwise. Occasionally, however, rotation amounts to 90◦ only.

So, the intestinal loop rotates about 90° counterclockwise only instead of the complete 270° counterclockwise rotation.

- 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.**

Although the caecal bud is supposed to be the last portion to re-enter the abdominal cavity.

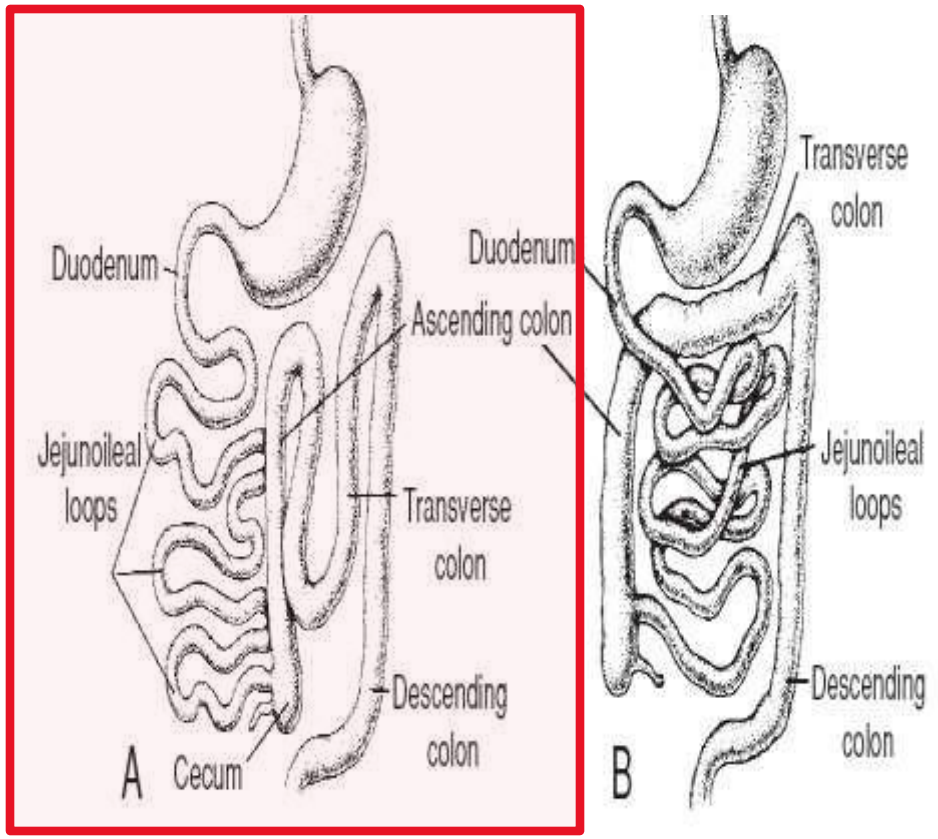


Figure 13.33 A. Abnormal rotation of the primary intestinal loop. The colon is on the left side of the abdomen, and the small intestinal loops are on the right. The ileum enters the cecum from the right. **B.** The primary intestinal loop is rotated 90° clockwise (reversed rotation). The transverse colon passes behind the duodenum.

2) **Reversed rotation of the intestinal loop, which 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.

3) **Duplications of intestinal loops and cysts, which 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.

Here, the intestinal loop rotates in the opposite direction (pay attention that it rotates 90° clockwise not counterclockwise).

Could also occur in the jejunum.

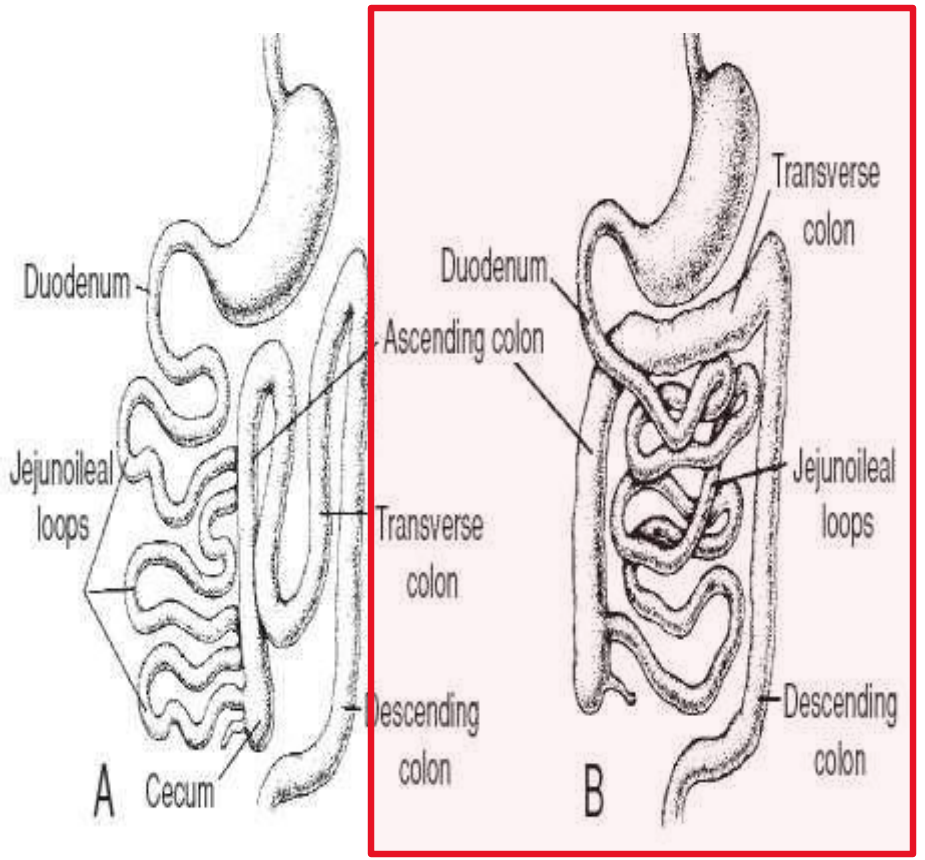


Figure 13.33 A. Abnormal rotation of the primary intestinal loop. The colon is on the left side of the abdomen, and the small intestinal loops are on the right. The ileum enters the cecum from the right. **B.** The primary intestinal loop is rotated 90° clockwise (reversed rotation). The transverse colon passes behind the duodenum.

Gut Rotation Defects

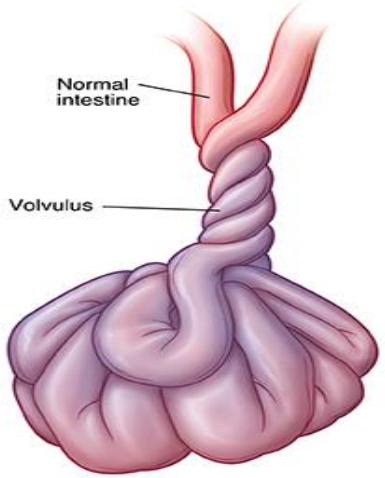
- Symptoms usually occur early in life, and 33% are associated with other defects, such as intestinal atresias, imperforate anus, gastroschisis, and omphalocele.

We are going to discuss most of these conditions in the following slides.

Extra note from Langman's medical embryology:
The origin of the gut rotation defects is unknown, although they may result from abnormal proliferations of gut parenchyma.

Gut Rotation Defects

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



Extra image of volvulvus

- ➔ The volvulus leads to compromised blood supply to the abnormally twisted part of the intestine.
- ➔ Which eventually leads to its degeneration.
- ➔ Volvulus mainly occurs in the ileum & jejunum.
- ➔ Volvulus is treated by surgically cutting the abnormally twisted part and stitching (anastomosing) the normal (healthy) parts of the intestine together.

Quick summary of the gut rotation defects

Gut rotation defects

Which can lead to volvulus, ischemia & tissue degeneration.

Incomplete rotation

- ➔ The midgut rotates only 90° counterclockwise.
- ➔ Results in left-sided colon.

Inverted rotation

- ➔ The midgut rotates 90° clockwise.
- ➔ Results in the transverse colon lying behind the duodenum & the superior mesenteric artery.

Duplications of intestinal loops & cysts

- ➔ Most commonly occur in the ileum.
- ➔ Vary from long segments to small diverticulum.

Gut Atresias and Stenosis

- **Atresias and stenosis may occur anywhere along the intestine.**

- Mostly occur in the duodenum, fewest occur in the colon, and equal numbers occur in the jejunum and ileum (1/1500 births).

- Atresias in the upper duodenum are probably due to a lack of recanalization.

Recanalization: the process in which a solid material is transformed into a tube.
In the embryo, the duodenum is normally filled with cells until it undergoes recanalization to become tubular.

Body Wall Defects

Which involve 2 conditions:
1) **Omphalocele**
2) **Gastroschisis**

1) **Omphalocele** involves herniation of abdominal viscera through an enlarged umbilical ring.

- The viscera, are covered by amnion.
- The origin of the defect is a failure of the bowel to return to the body cavity from its physiological herniation **after the 10th week of development.**
- Omphalocele occurs in 2.5/10,000 births **(rare/uncommon)** 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.

Omphalocele is simply an unreturned (or unretracted) physiological hernia.

The amnion is a membrane which separates the herniated loop from the amniotic cavity (which contains the amniotic fluid).

Put in mind that omphalocele may be associated with chromosomal abnormalities!

In some cases, the omphalocele can be treatable!

Firstly, they investigate the status of the tissue of the herniated intestine.

- ➔ **If the tissue is degenerated/ necrotic/ gangrenous, then it should be surgically cut, & the normal healthy parts of the intestine can be stitched together.**

- ➔ **If the tissue is still viable & healthy, the doctor can place it back inside the abdomen and it could be treated without surgical interventions.**

2) **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.

In omphalocele, the hernia is inside the umbilical cord.
While in gastroschisis, the hernia is in the amniotic cavity outside the umbilical cord (mostly at the right side of the umbilical cord).

Like omphalocele, we investigate the status of the herniated tissue, and if it is still viable & healthy, it can be placed back into the abdominal cavity without any resection.

❑ **Extra notes regarding gastroschisis from Langman's medical embryology 14th edition:**

➔ **Gastroschisis is most likely due to abnormal closure of the body wall around the connecting stalk.**

➔ **in omphalocele, the hernia is usually covered by the amnion. While in gastroschisis, the hernia is located in the amniotic cavity without being covered by the amnion or peritoneum, which leads to its exposure to the amniotic fluid; which in turn could damage the bowel.**

➔ **Both omphalocele & gastroschisis can be diagnosed by CT (Computed Tomography) scan later in pregnancy.**

➔ **Gastroschisis cases are increasing in frequency especially among young pregnant women (below 20 years old).**

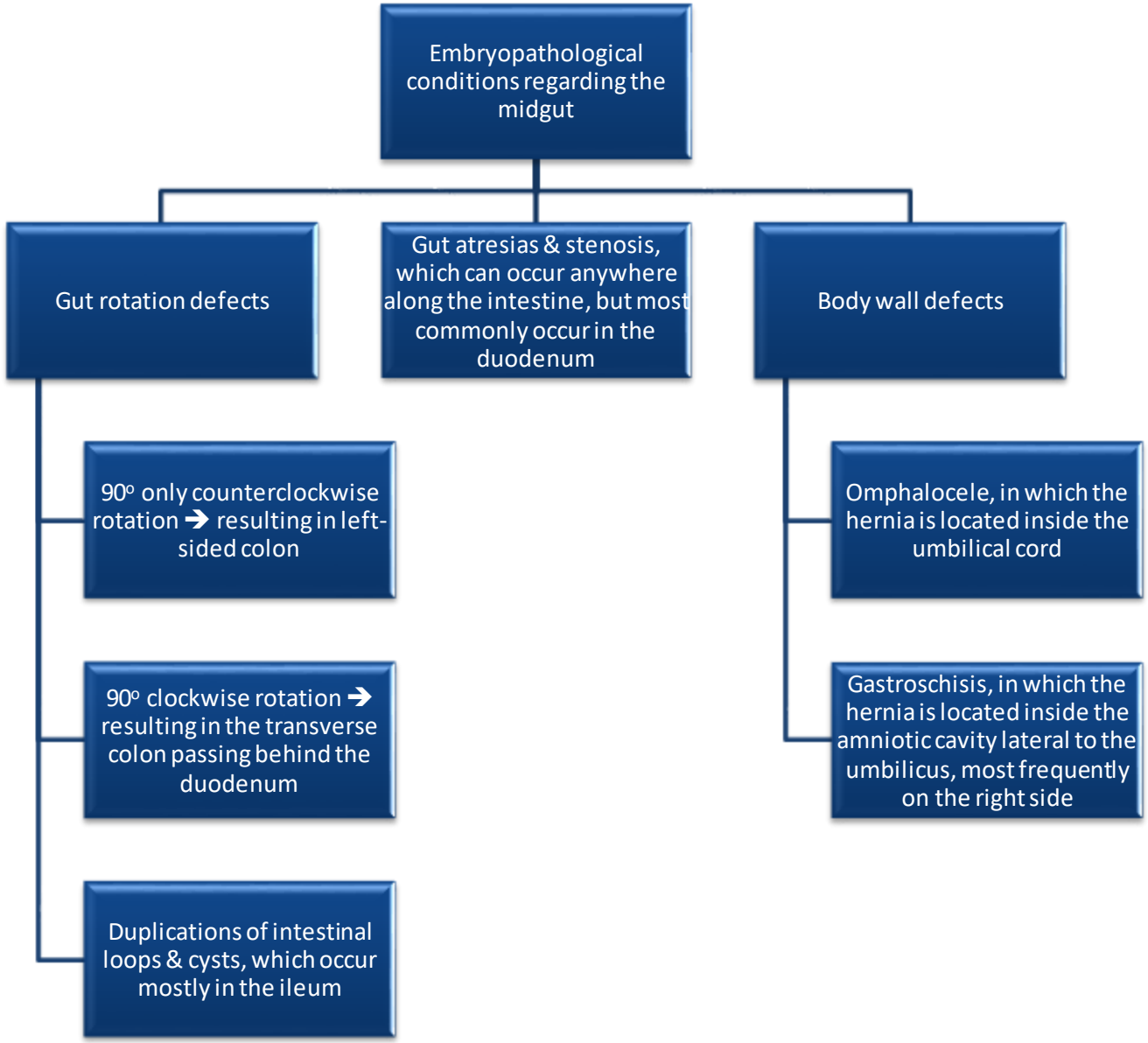
➔ **Unlike omphalocele, gastroschisis is not associated with chromosomal abnormalities or other severe defects, so its survival rate is excellent.**

➔ **Volvulus may occur leading to compromised blood supply & degeneration of large regions of the intestine leading to fetal death.**

Quick comparison between the omphalocele & the gastroschisis

	Omphalocele	Gastroschisis
Location of the hernia	In the umbilical cord as a result of unreturned physiological hernia.	In the amniotic cavity lateral to the umbilical cord (mostly on the right side).
The covering of the herniated viscera	It is covered by the amnion & the peritoneum.	It is not covered by the amnion neither by the peritoneum; which makes it exposed to the amniotic fluid.
Association with other defects	Associated with severe malformations, such as cardiac anomalies & neural tube defects.	No association with other defects.
Association with chromosomal abnormalities	50% of the cases showed so.	No association with chromosomal abnormalities.
Treatment	Could be treated without surgical interventions if the herniated tissue is still healthy & normal.	Could be treated without surgical interventions if the herniated tissue is still healthy & normal.

Quick revision



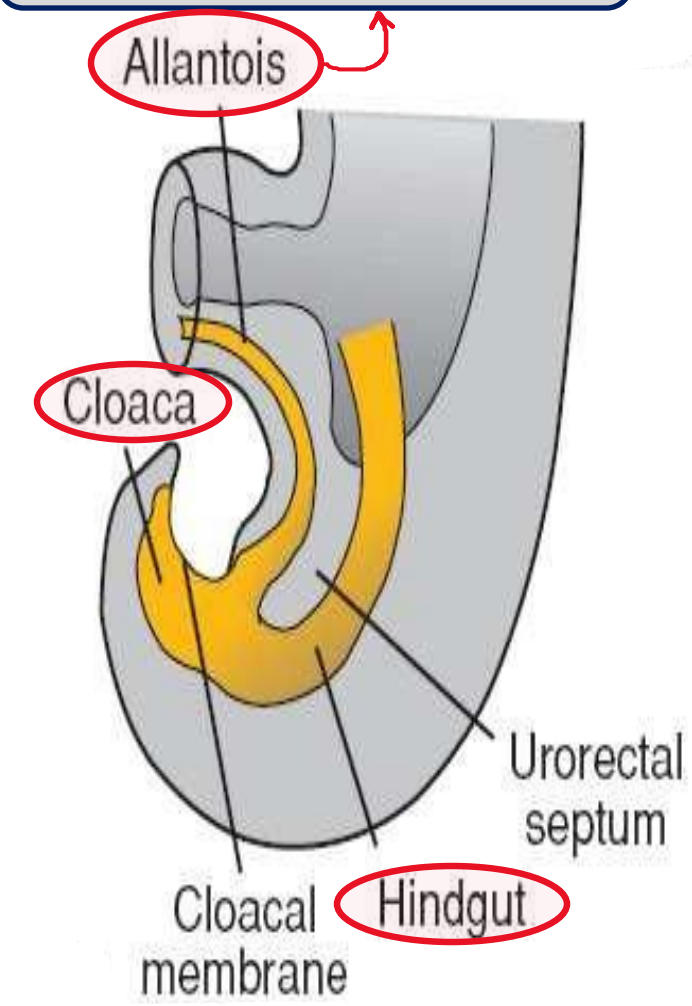
Hindgut

- 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.
- The endoderm of the hindgut also forms the internal lining of the bladder and urethra.
- The terminal portion of the hindgut enters into the posterior region of the cloaca, **forming** the primitive **anorectal canal.**
- **The allantois enters into the anterior** portion, **forming** the primitive **urogenital sinus.**

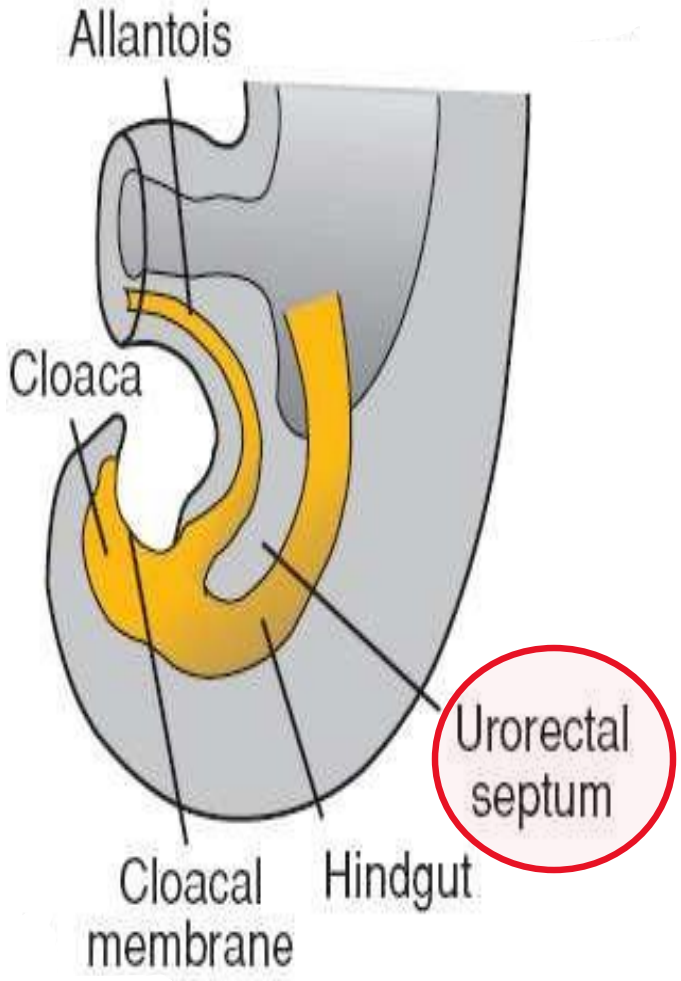
Cloaca is a pelvic structure, and in the embryo, it is attached to the allantois anteriorly & the hindgut posteriorly.

The posterior part of the cloaca grows & participates in the formation of the hindgut, While the anterior part of the cloaca participates in the formation of the urogenital system.

Located between the cloaca & the umbilicus



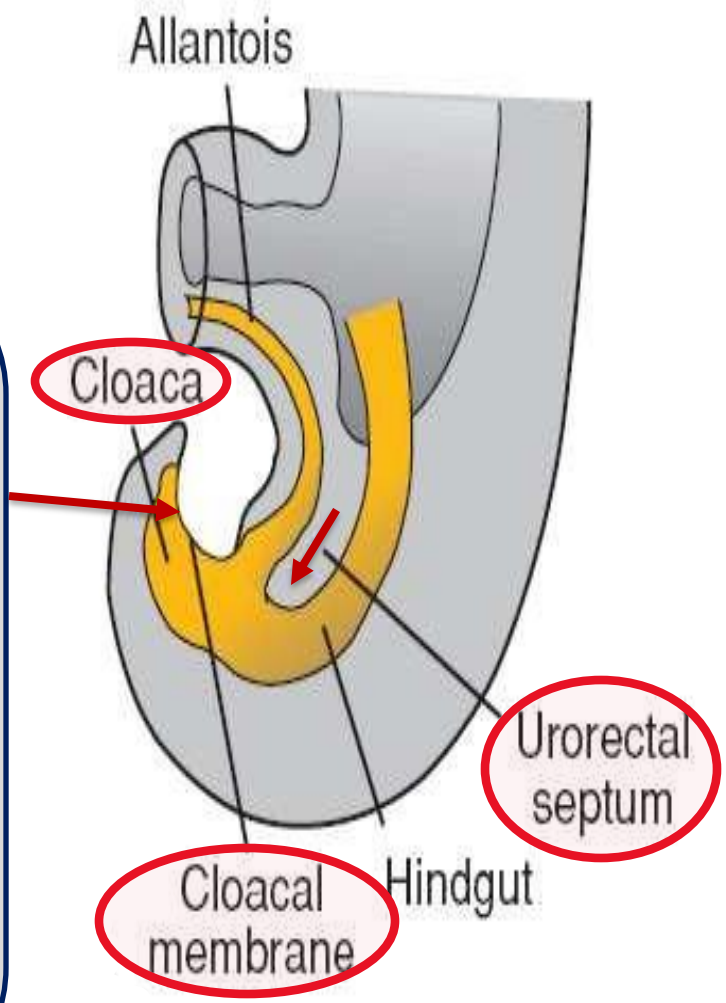
- Between the allantois (anterior) & the hindgut (posterior), there is a layer of mesoderm separating them both from each other. This layer is called “the urorectal septum”.
- The urorectal septum plays a significant role in the formation of the anal canal & the urogenital system (especially the urinary bladder) & separates them both from each other.
- Keep in mind that the urorectal septum is a mesenchymal structure.
- The urorectal septum grows into the cloaca, and at the end of its course, it forms the perineal body.



- The cloaca itself is an endoderm-lined cavity covered at its ventral boundary by surface ectoderm.
- 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.

Cloaca is endodermal in origin. While at the ventral outer surface is covered by ectoderm.

- **About the cloacal membrane:**
  - ➔ **ventral covering of the cloaca.**
  - ➔ **The space (or pit) anterior to it is called "proctodeum".**
  - ➔ **The ectodermal proctodeum is responsible of continuing the formation of the lower half of anal canal.**



❑ **Always remember!**

➔ **The upper half of the anal canal is formed by the endoderm of the hindgut.**

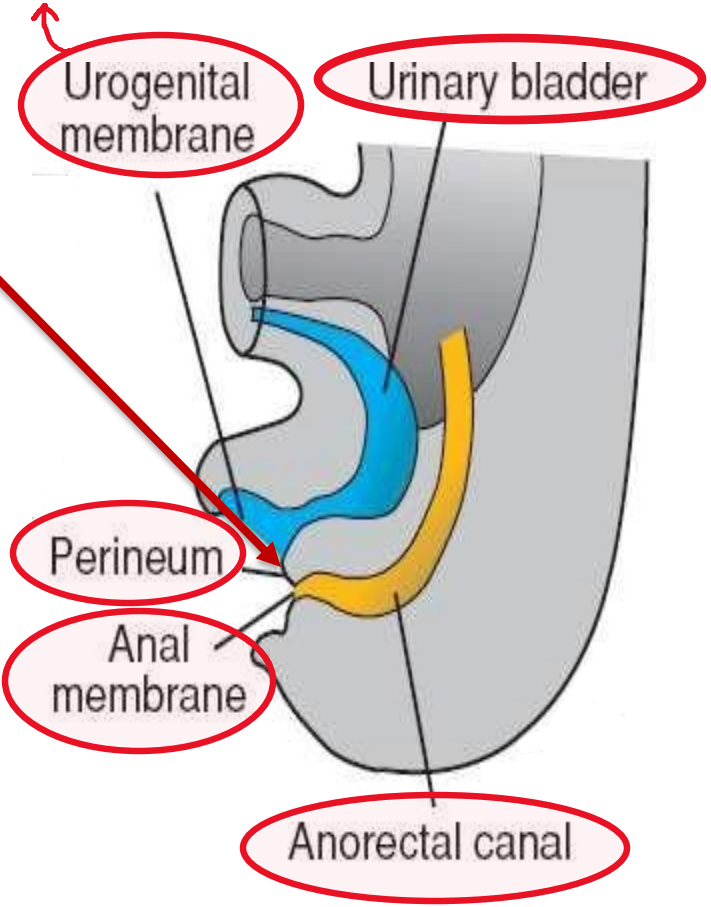
➔ **The lower half of the anal canal is formed by the ectoderm of proctodeum.**

Because the upper & lower halves of the anal canal are different in origin; they are also different in innervation, sensation, lymphatic drainage, venous drainage & blood supply.

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

➔ **The urorectal septum eventually forming the perineal body (perineum).**
➔ **Posterior to it, there is the anal canal, & its lower half is going to be formed by the ectoderm of proctodeum.**
➔ **Anterior to it, there is the allantois which forms the fetal urinary bladder.**

Which eventually ruptures to form the urethra.



The internal pudendal artery is a branch of the internal iliac artery.

While the upper half is supplied by the superior rectal artery, a branch of the inferior mesenteric artery.

- The junction between the **—originally—** endodermal **(upper half)** and **—originally—** ectodermal **(lower half)** regions of the anal canal is delineated by the **pectinate line, just below the anal columns.**

Anal columns are vertical folds formed by the infolding of the mucosa & some of the muscular tissue in the upper half of the anal canal.

- At this line, the epithelium changes from **simple** columnar **in the upper half** to stratified squamous **non-keratinized** epithelium **in the lower half.**

While the lower 1 cm of the anal canal becomes keratinized.

Quick summary of the important topics of the hindgut

The Cloaca

- It is endodermal in origin.
- It is attached to the hindgut posteriorly; participating in the formation of the anorectal canal. Also, it is attached to the allantois anteriorly; participating in the formation of the urogenital sinus.

The Urorectal Septum

- It is a layer of mesoderm separating the allantois from the hindgut; & it has a significant role in the formation of the anorectal canal & the urogenital system.
- At the end of its course, the urorectal septum forms the perineal body.

The Anal Canal

- The upper half of the anal canal is formed by the endoderm of the hindgut, while the lower half is formed by the ectoderm of the proctodeum.
- Thus the upper & lower halves of the hindgut have different blood supply, lymphatic drainage & innervation.

The Pectinate Line

- Present at the junction between the upper & lower halves of the anal canal, just below the anal columns.
- The type of epithelium above the pectinate line is simple columnar, and the type of epithelium below the pectinate line is stratified squamous.

Now, what are anorectal 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:

1) The anal passage may be narrow.
2) A membrane may be present over the anal opening.
3) The rectum may not connect to the anus (imperforate anus).
4) The rectum may connect to a part of the urinary tract **instead of opening in the anus, forming a fistula.**
5) The rectum may connect to a part of the reproductive system through an abnormal passage called a fistula.

This membrane was supposed to rupture but didn't!

Put in mind that the organs or regions that have parts with different embryological origins (example: the anal canal which has an endodermal upper part & ectodermal lower part) are prone to abnormalities & malformations. So, the malformations occur due to improper junctioning of the endodermal & ectodermal parts of the anal canal, which can lead to fistulas, imperforate anus, absence of the lower half or acquiring an abnormal position.

- **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**, rectovaginal fistula** and cloaca.

- <u>A type of anorectal malformation called imperforate anus can occur in both boys and girls.</u>

Note that:

➔ **Imperforate anus can affect both males & females.**

➔ **However, other types of malformations (fistulas for example) have different frequencies between both sexes, or occur in one sex without the other.**

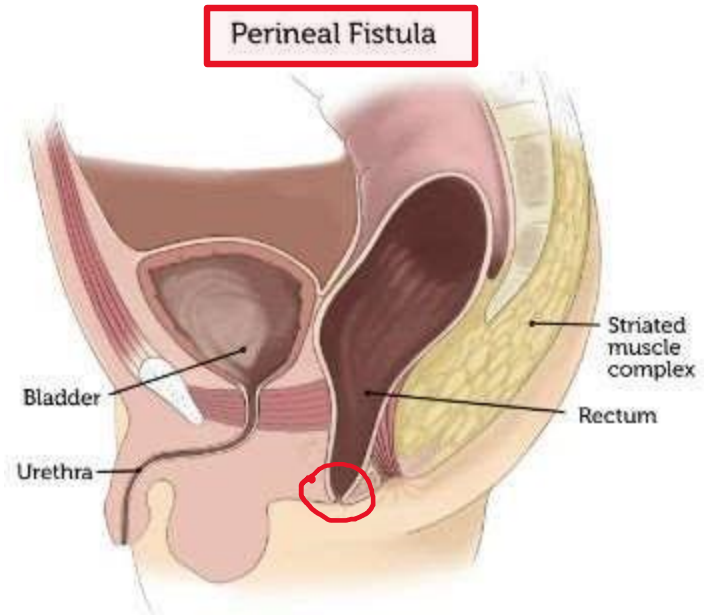
➔ **In females for example, rectovaginal fistulas are common.**

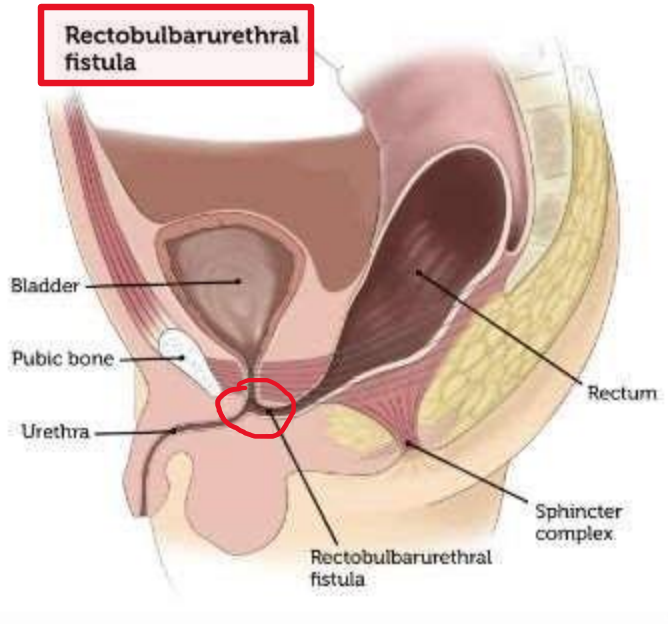
➔ **While in males, rectoprostatic fistulas are common.**

Types of anorectal malformations

Notice that in all cases, the rectum doesn't open in the anus.

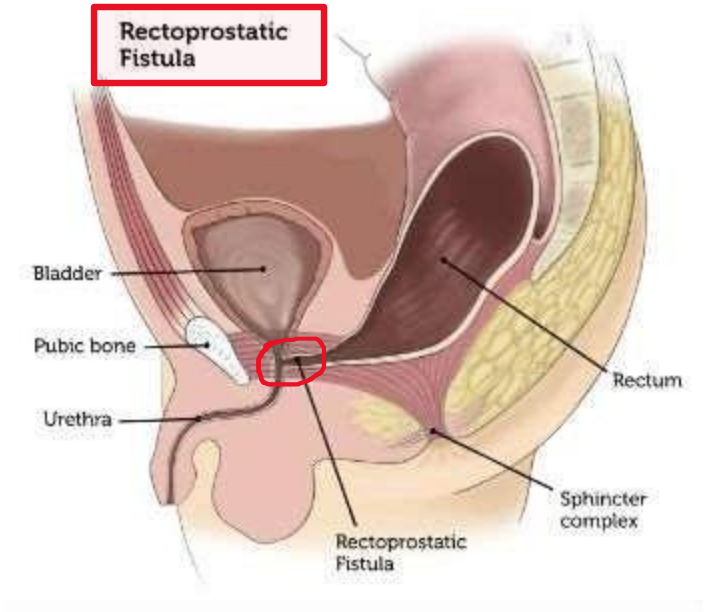
Notice that the rectum opens in the perineum.

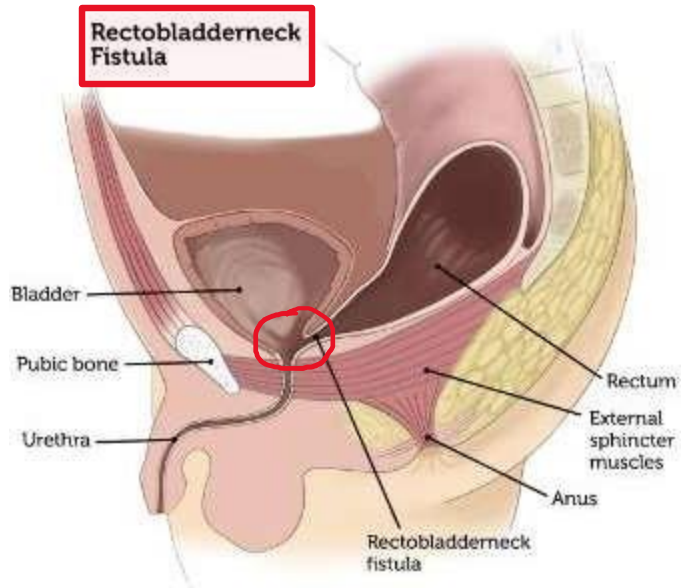




Notice that the rectum opens in the urethra & bulbar membrane.

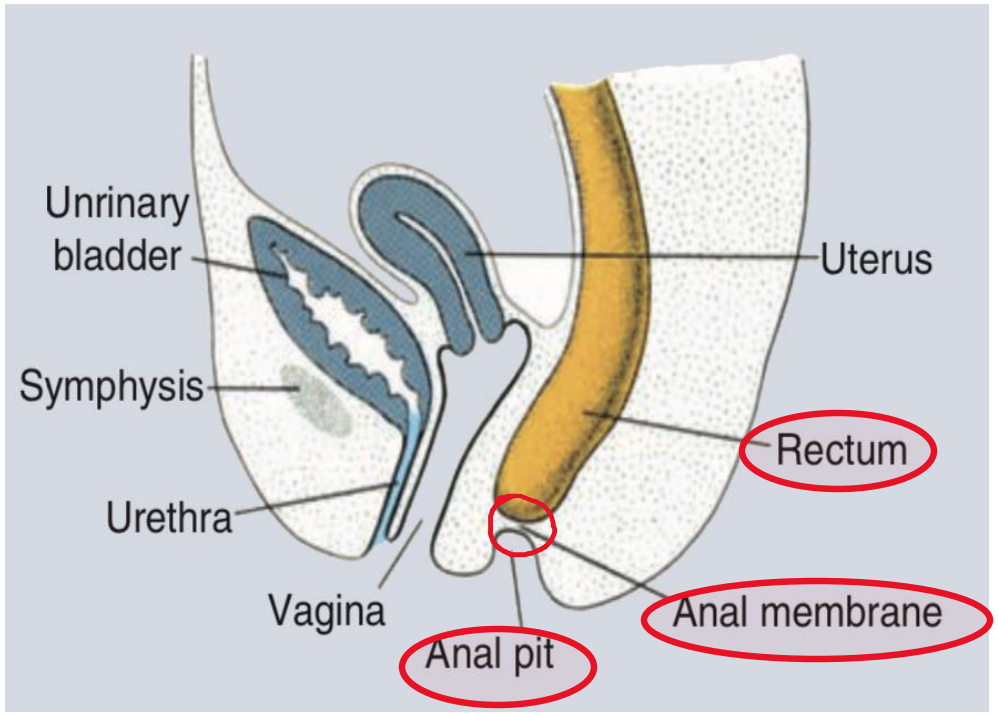
Notice that the rectum opens in the prostate.



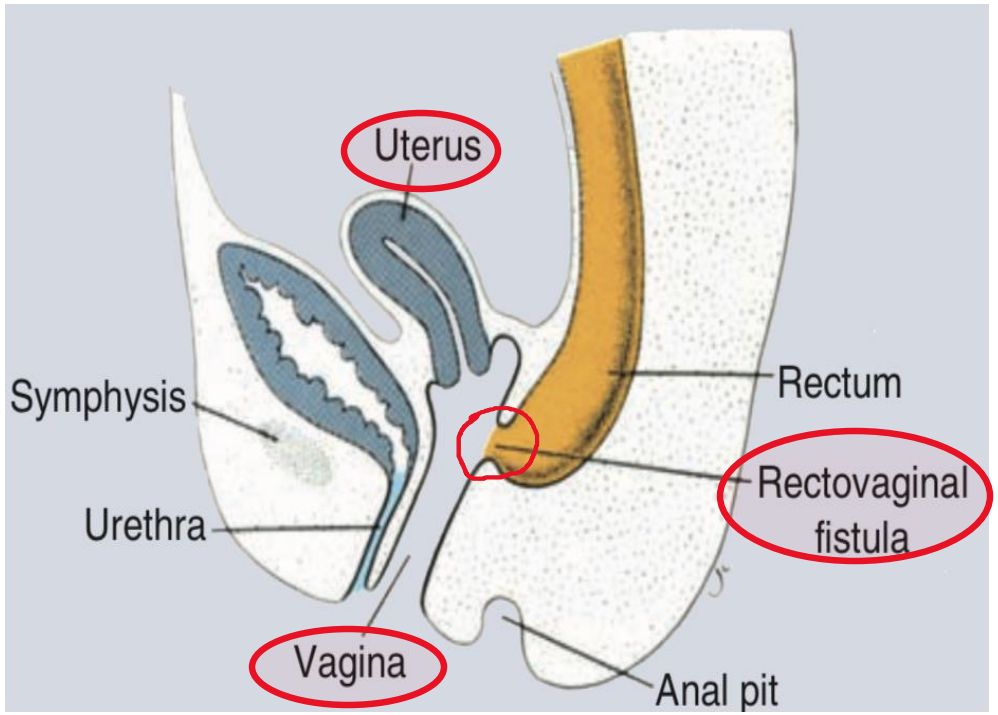


Notice that the rectum opens in the neck of the urinary bladder.

Extra images from Langman's medical embryology for better understanding

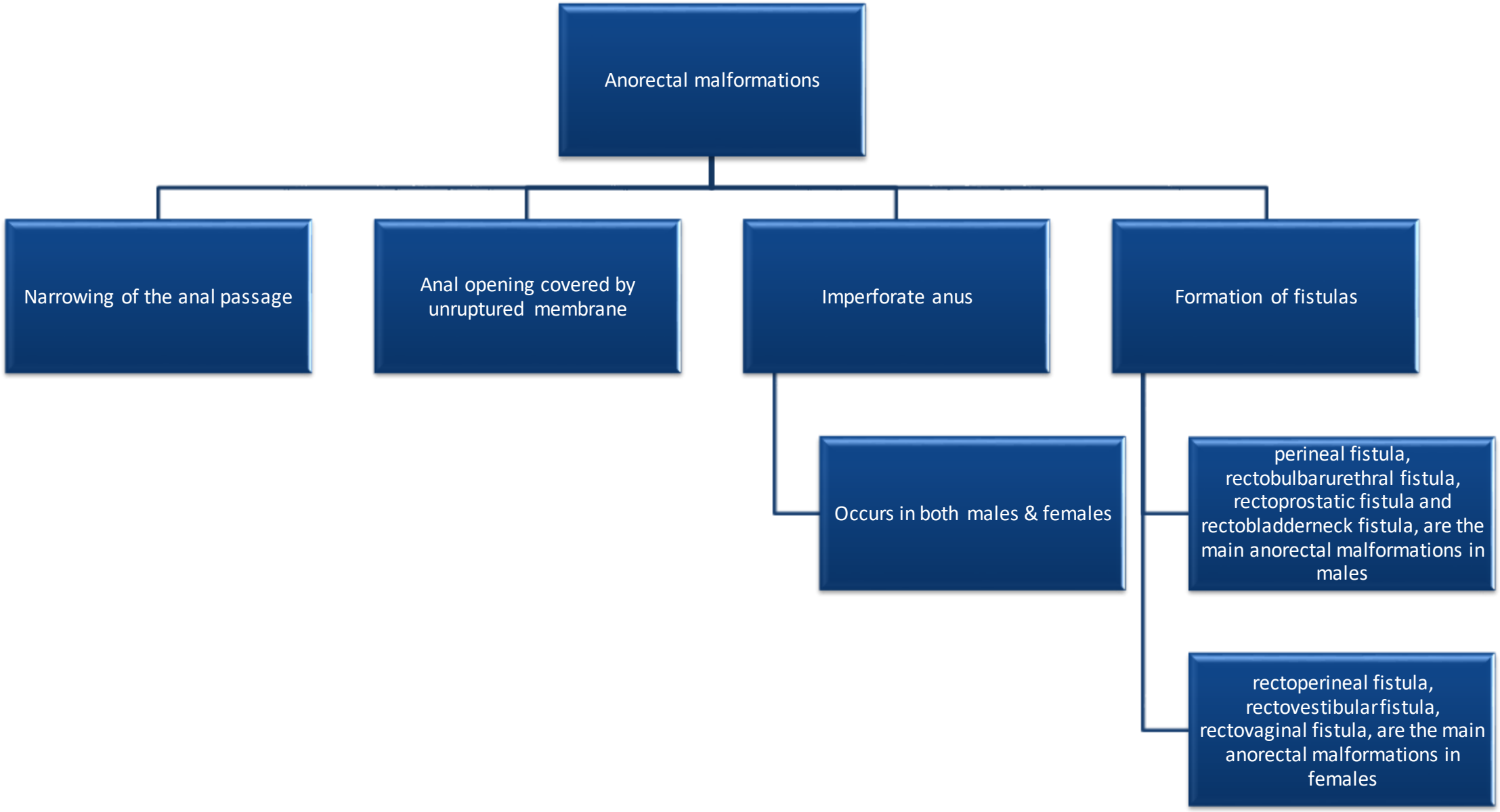


Imperforate anus



Rectovaginal fistula

Quick revision of the important topics of the anorectal malformations



Good luck

اللهم انصر إخواننا المجاهدين في غزّة يا ذا الجلال و العزّة، اللهم إنّهم عبادك في أرضك و تحت سمائك، و لا نملك لهم إلّا سؤالك و أنت خير من يجيب، اللهم احفظهم و احرسهم بعينك التي لا تنام و اكنفهم بكنفك الذي لا يُرام، اللهم بردًا و سلامًا على عبادك المستضعفين في غزّة و فلسطين.