

Embryology - GIT - Lecture 2

Last time we talked about embryology of the GIT. We said that the development of the stomach is accompanied with the development of the duodenum and the pancreas.

Also we talked about the rotation of the stomach, this rotation is clockwise which means 90 degree, and this is due to the enlargement of the liver.

the enlargement of the liver make a push on the right side so the stomach will make a rotation 90 degrees clockwise.

the duodenum will be accompanied in this rotation and from one part, after this rotation it becomes four parts. we have always to imagine that the duodenum is retroperitoneal. the same thing happens with the pancreas. there is a pancreatic bud, ventral and dorsal, and both with the rotation will become the ducts of the pancreas (the ventral is below the dorsal).

You have to know that the dorsal mesentery is always larger than the ventral and with the rotation the ventral mesentery became below the dorsal mesentery.

Development of the liver and the bile ducts :

the liver has a bud which begins from the middle part of the duodenum.

Remember : the duodenum is divided in two parts, the upper half supplied by the foregut and the lower half supplied by the midgut .

so the hepatic bud which begin from the middle part of the duodenum will proliferate and give two hepatic buds, one right and one left, which go to the right and left lobes . then a gall bladder bud will appears in the right side which will make the gall bladder .

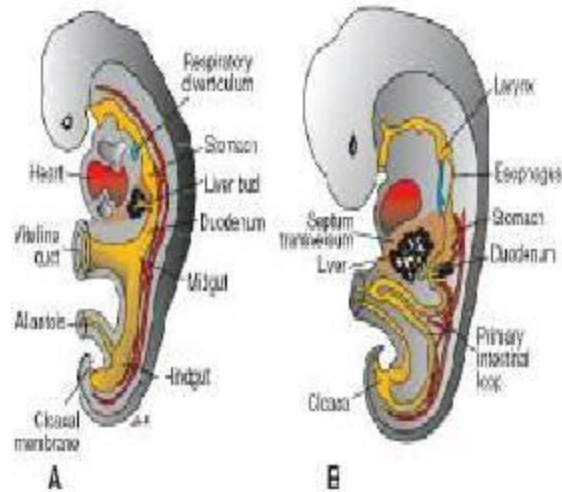


Figure 13.14 A. A 3-mm embryo (approximately 25 days) showing the primitive gastrointestinal tract and formation of the liver bud. The bud is formed by endoderm lining the foregut. B. A 5-mm embryo (approximately 32 days). Epithelial liver cords penetrate the mesenchyme of the septum transversum.

So the gall bladder will begin by :

1- Proliferation of the cells , THEN

2- Canalization

3- The gall bladder, with its fundus and body , and after that formation of the cystic duct.

so gall bladder development begins by a gall bladder bud which is endodermal proliferation of cells .

same thing for the liver : the liver rises from the distal end of the foregut(as a solid bud) which is endoderm in origin.

The hepatic bud grows anteriorly and in origin it's a masses of splanchnic mesoderm named septum transversum . so septum transversum is mesenchymal in origin.

*Septum transversum : it comes between thorax and the abdomen and it participate in the development of the diaphragm, the heart and the liver.

the liver vascularization is from the mesoderm and the origin of this vascularization is from broken off vitelline and umbilical veins, that make the sinusoids. These sinusoids inside the mesenchyme will cut . There is a breakdown of these vascular veins which are the vitelline and the umbilical veins which are in the septum transversum.

The columns of endodermal cells will make the liver cords(or cells).

The hepatic bud will divide to right and left (terminal),then canalization will take place which means formation of ducts.

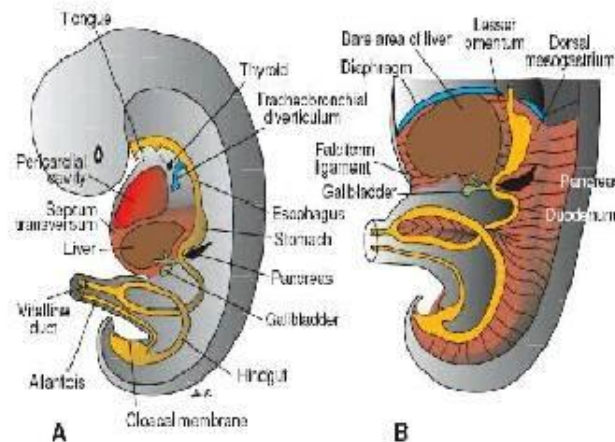


Figure 13.15 **A.** A 9 mm embryo (approximately 36 days). The liver expands caudally into the abdominal cavity. Note condensation of mesenchyme in the area between the liver and the pericardial cavity, foreshadowing formation of the diaphragm from part of the septum transversum. **B.** A slightly older embryo. Note the falciform ligament extending between the liver and the anterior abdominal wall and the lesser omentum extending between the liver and the foregut (stomach and duodenum). The liver is entirely surrounded by peritoneum except in its contact area with the diaphragm. This is the bare area of the liver.

Formation of gallbladder and cystic duct:

Gallbladder and cystic duct are in the ventral mesentery and any ligament formed will be also from the ventral mesentery(related to the liver).

So the gallbladder is from the hepatic bud: from an outgrowth or proliferation; then canalization occurs to form the cystic duct. The fundus and the body are the end of the gallbladder bud.

Abnormalities of the gallbladder:

-Double gallbladder (from two buds) with may have one cystic duct for the two gallbladders or two cystic ducts.

-Atresia of bile duct: bile duct with obliteration (blind end) causing a dilatation of the hepatic duct.

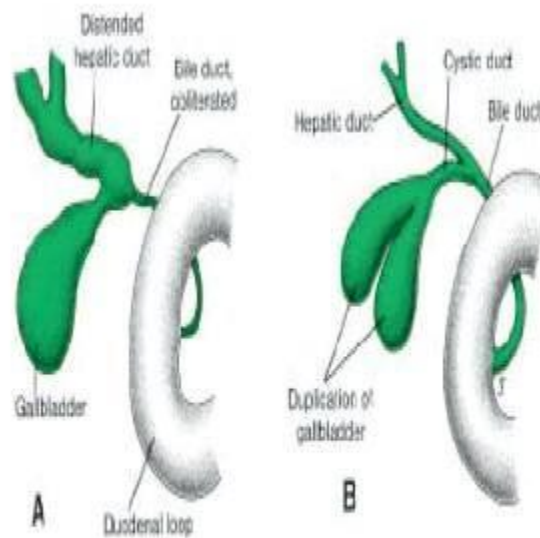


Figure 13.20 A. Obliteration of the bile duct resulting in distention of the gallbladder and hepatic ducts distal to the obliteration. B. Duplication of the gallbladder.

These abnormalities are important because when we use ERCP, we have to know that there is an abnormality before making this procedure.

Duodenum

we said that duodenum's development follows the rotation of the stomach and this rotation forms the parts of the duodenum.

we said also that ventral bud of the pancreas rotate and become below the dorsal bud, forming the head and the uncinat process of the pancreas .

so the head and the uncinete process are from the ventral bud (specially the lower part of the head is from the ventral bud) but the upper part of the head, the body and the neck are from the dorsal pancreatic bud.

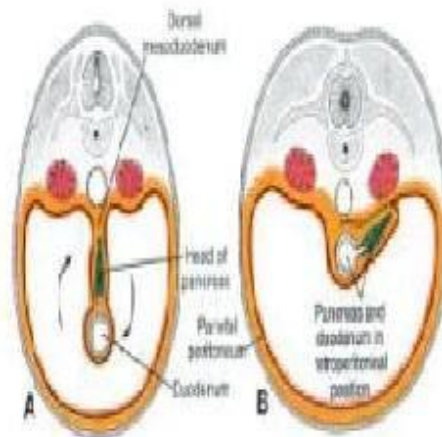


Figure 11.17 Transverse sections through the region of the duodenum at various stages of development. At first the duodenum and head of the pancreas are located in the median plane (A), but later they swing to the right and acquire a retroperitoneal position (B).

the duodenum has a caudal and a cephalic part , the small part of the ventral mesentery attach to the ventral border of the first part of the duodenum (so will be intraperitoneal) but the second, third and fourth part are adherent to the posterior abdominal wall (so they are retroperitoneal except the last part which is the beginning of the jejunum).

Ligament Of Treitz :

Some smooth muscles and fibrous tissues belong to the dorsal mesentery remains as suspensory ligaments of the duodenum (ligament of Treitz) which make a fixation of the terminal part of the duodenum and go to the right crus of the diaphragm.

The function of the ligament of treitz is to prevent movement inferiorly.

Pancreas :

Remember : pancreas developed from dorsal and ventral bud which are endodermal in origin.

it will be a fusion of the pancreatic ducts. The main pancreatic duct derived from ventral pancreatic duct and distal part of the dorsal pancreatic duct .

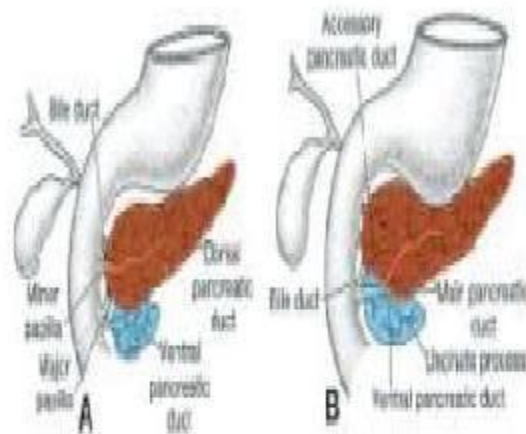


Figure 13.22 A, Pancreas during the sixth week of development. The ventral pancreatic bud is in close contact with the dorsal pancreatic bud. B, Fusion of the pancreatic ducts. The main pancreatic duct enters the duodenum in combination with the bile duct at the major papilla. The accessory pancreatic duct (when present) enters the duodenum at the minor papilla.

Important : in the pancreas , there is an outgrowth of the cells which make a duct (canalization of a pancreatic duct).

Islets of langherans are a group of cells which are from peripheral ducts.

The pancreatic cells (islet) will disconnect from the duct forming patches of cells.

The secretion of insulin and glucagon begins in the 5th month of pregnancy (so islets becomes completely developed).

The exocrine part of the pancreas :

The ventral part of the pancreatic bud forms the head of the pancreas (the inferior part) and an uncinus process.

The upper part of the head, the neck and the body are from the dorsal pancreatic bud.

Abnormalities of the pancreas :

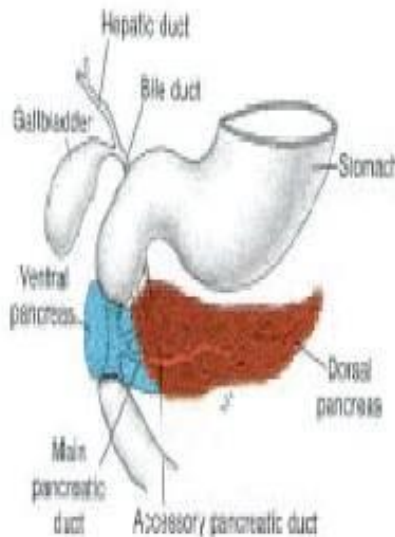


Figure 13.23 Annular pancreas. The ventral pancreas splits and forms a ring around the duodenum, occasionally resulting in duodenal stenosis.

Most important abnormality : **Annular pancreas**

there will be contraction or constriction of the duodenum because the ventral part stays ventrally and the dorsal part stays dorsally and when there is approximation, the two parts make narrowing or obstruction of the duodenum (duodenal stenosis) that's why the annular pancreas is dangerous and it needs surgery.

Development of Midgut and Hindgut :

Remember : midgut take its blood supply from the superior mesenteric artery .

midgut begins from the lower half of the duodenum and end in the lateral third of the transverse colon (so intestine and large intestine).

The apex of the midgut is the vitelline duct or the umbilical cord (because the vitelline duct is in the umbilical cord).

So the superior mesenteric artery will develop from the abdominal aorta in the posterior abdominal wall . This development is by growing in the dorsal mesentery in the direction of the apex (umbilicus/ umbilical cord) and it will rotate around the vitelline duct.

This will constitute an axis of rotation and umbilical cord because the small intestine and the midgut will rotate like the rotation of the stomach but it's a different rotation.

Development of the Cecum :

it begins by a dilatation in the place of the cecum , followed by a rotation. The cecum will ascend below the liver. After birth it will descend to the iliac fossa and complete its development and the development of the appendix. so the development of the cecum and the appendix complete after birth.

Physiological Hernia :

Due to the enlargement of the liver , the abdominal cavity becomes small . In the development of small intestine and large intestine , the abdominal cavity becomes too small to contain the intestine which go to the umbilical cord.

The movement of small intestine through the umbilical cord is called : physiological umbilical herniation , and it occurs during the 6th week of development. Physiological umbilical herniation will be followed by regurgitation after that during the 10th or 11th week.

So the physiological umbilical herniation will return to the abdominal cavity during the 10th or 11th week.

DEVELOPMENT OF CECUM AND APPENDIX :

After Birth , the cecum and the appendix go downwards to the right iliac fossa.

Rotation of the Midgut :

First :The rotation is 90 degree anticlockwise.

The axis of rotation is the umbilical cord which contains the superior mesenteric vessels and the vitelline duct.

After rotation 90 degree anticlockwise the cecal bud which constitute the cecum becomes upwards, below the liver.

After that, there's another rotation: 180 degrees anticlockwise. So, the total rotation is 270 degrees. After this rotation; cecum, appendix, ascending colon, transverse colon, descending colon and sigmoid colon will be formed. all these are located in the peripheral side, but after rotation for ex. Descending colon move to left side , ascending colon to right side . If rotation occurs in opposite direction, cecum and appendix will be in the left side instead of right side.

So the total rotation is 270degrees: 1st 90 then 180, anticlockwise rotation.

As a result of rotation; transverse colon lies in front of the superior mesenteric artery (in front of 2nd part of duodenum, too), 3rd part of duodenum lies behind superior mesenteric (which is anterior to 3rd part of duodenum "horizontal part"). Cecum and appendix into contact to right lobe of the liver, after delivery they descend downward to right iliac fossa. Laterally, we find the whole large intestine in the lateral side, inside is the small intestine.

Primitive mesentery gives duodenum, ascending colon and descending colon, remember; they are retroperitoneal; they are attached to posterior abdominal wall, their posterior peritoneal will disappear but the parietal of posterior abdominal wall remain. so disappearance occurs to the one that comes from dorsal mesentery.

While the other organs; jejunum, ileum and transverse persist as mesentery of small intestine, transverse has mesocolon and sigmoid has a mesocolon.

At the end, cecum and appendix will be in the right iliac fossa.

As midgut return to the abdominal cavity- at 11th week it'll completely be returned to abdominal cavity- the vitelline duct will be obliterated and separated from the midgut; sometimes a diverticulum remains, named "**Meckel's Diverticulum**".

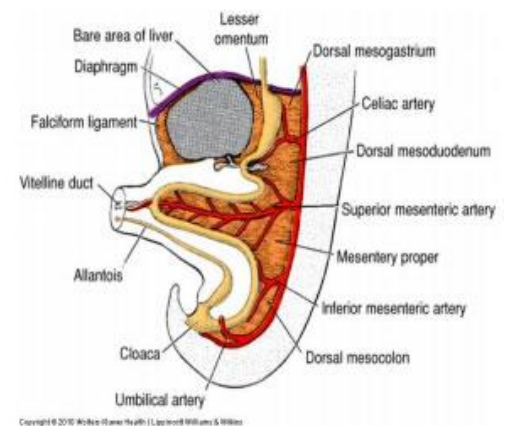
The end of development of midgut.

Hindgut:

As we see in the pic, abdominal aorta gives celiac trunk: to foregut, superior mesenteric: to midgut, inferior mesenteric: to hindgut.

Hindgut Starts from lateral 3rd of transverse colon, descending colon, sigmoid colon, rectum and the upper half of anal canal. Upper half of anal canal is endodermal while the lower half is ectodermal.

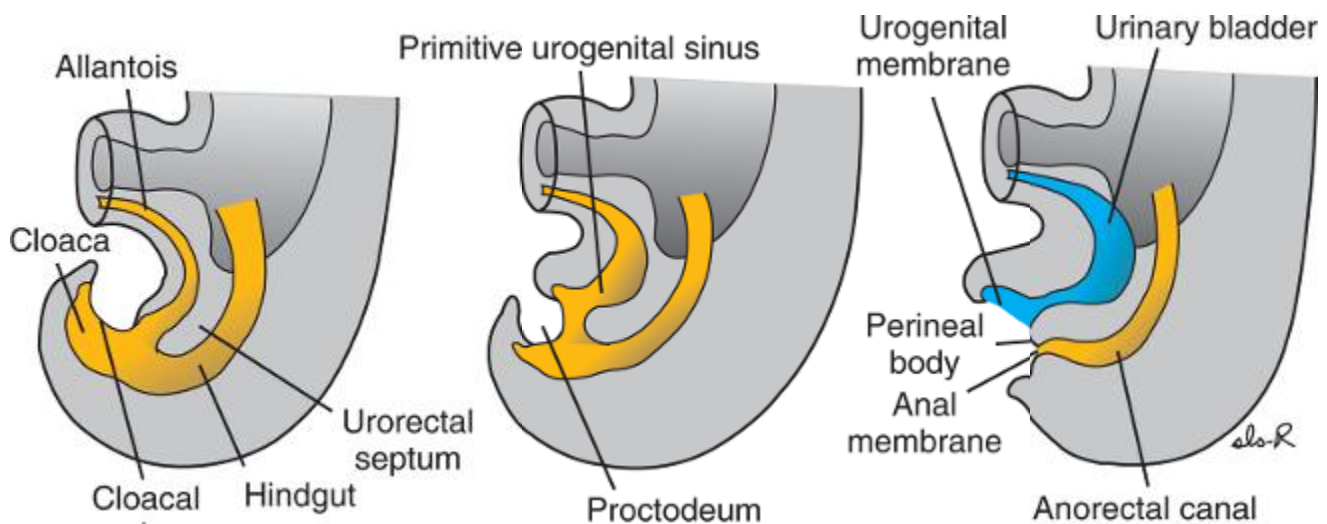
*Cloaca is endodermal.



* Allantois; connection between hindgut and the umbilicus, but later between urinary bladder and umbilicus. The anterior part of cloaca form urinary bladder while the posterior part from anal canal, so there will be separation, how? By mesenchymal wedge "urorectal septum" uro:urinary, rectal:rectum.

This septum –which is mesenchymal in origin-will grow >> separate the cloaca into anterior part and posterior part .anterior to the cloaca is cloacal membrane, this membrane separates the cloaca (which is endodermal) from *proctodeum* (which is ectodermal),so there are 3 germinal structures in front of cloaca . cloaca itself is endodermal , cloacal membrane in the middle, proctodeum(ectodermal) is the most anterior.

So the urorectal septum will separate cloaca into anterior part: urinary(or urogenital : forming urinary bladder and genital organs),posterior part: anal canal and rectum.



In the last stage,there will be complete separation between urinary and rectum by urorectal septum- which is mesodermal- the perineal body lies anteriorly to the rectum, so perineal body lies between urinary and anal (between anus -which is the end of anal canal- and anteriorly urethra or urinary bladder).perineal body is formed at the end of septum , in front of it proctodeum(ectodermal).

So the terminal portion of the hindgut is cloaca-primitive anorectal canal- ,allantios lies between umbilicus and cloaca(endodermal structure)covered ventrally by ectoderm(proctoduem) ,cloacal membrane lies between endoderm and ectoderm; this cloacal membrane will rupture and replaced by *ectoderm*. Proliferation of ectoderm closes the most caudal region of the anal canal; this means the lower half of anal canal is ectoderm. At 9th week ,the ectodermal region recanalized after growth forming the anal canal. The junction between endodermal part and ectodermal part of the anal canal is pectinate line-at the lower part of anal column "anal valve"- so this line lies between the two parts of anal canal (ectoderm and endoderm). Columnar cells in the upper half and stratified squamous cells in the lower half. Simple columnar in the upper half because it's endodermal; while the lower part is stratified because it's ectodermal .

Abnormalities in the hindgut :

1-urorectal fistula: fistula between the rectum and urinary bladder; so fecal material and urine have one passage.

Treatment: "surgery" to close the fistula and open the anal canal.

"fistula means tract between two cavities".

2-rectovaginal fistula- abnormality in females-: opening in the posterior wall of the vagina "fistula between the rectum and posterior wall".

3-imperforated anus : no rupture of the anal membrane "failure of anal membrane breakdown" .

treatment:

simple surgery , they make an opening to let feces pass through it.

4- in males, rectoperineal fistula: opening in the perineum.

Treatment: it should be closed , and they make a tract to the anal pit.

*Gut rotation defects :

as we said, clockwise rotation might occur instead of anticlockwise rotation, so appendix and cecum will be in the left side , and left side colon.

*Gut atresia and stenosis might occur; especially in the duodenum as a result of annular pancreas

Body wall defects :

1- omphalocele: hernia in the umbilical cord. So, umbilical hernia through umbilical ring is physiological hernia , it remains after delivery "it won't return to abdominal cavity". This amphalocele is covered by amnion, it occurs in 2.5/10.000 birth, high mortality rate, 50% cardiac anomalies (interseptal defect between 2 ventricles or 2 atria),50% chromosomal anomalies.

2-Gastroschisis: hernia through the region of the right umbilical vein; which is usually obliterated. Gastroschisis is congenital abdominal hernia –in the abdominal wall with umbilicus-.

Testis and ovaries :

Regarding to testis, maldescending or abnormal site of descending of testis .

testis are formed in the posterior abdominal wall at the level of L1. gubernaculum along with processus vaginalis ;both are the guideline of testis to descend downward to reach the scrotum at the 8th month of fetal life

– in the uterus- .Also, ovaries are formed at the level of L1 , and they descend by gubernaculum and processus vaginalis –it comes from abdominal peritoneum- .

after descending ,processus vaginalis should be obliterated ,and gubernaculum disappears,too . we only see it's remnants " remnant of gubenaculum"

But as we said there're abnormalities; maldescending , abnormal site of testis .

in cases of undescended testis >>the treatment should be as soon as possible. In the past they used to perform the surgery when the kid can tolerate the surgery , usually at the age of 7 -before developing into cancer and then there will be no development of testosterone and sperms-.

Nowadays, we make the surgery as soon as the undescended testis is diagnosed.