Digestive System

University of Jordan

Faculty of Medicine

Batch of 2013-2019

Medical Committee
The University of Jordan

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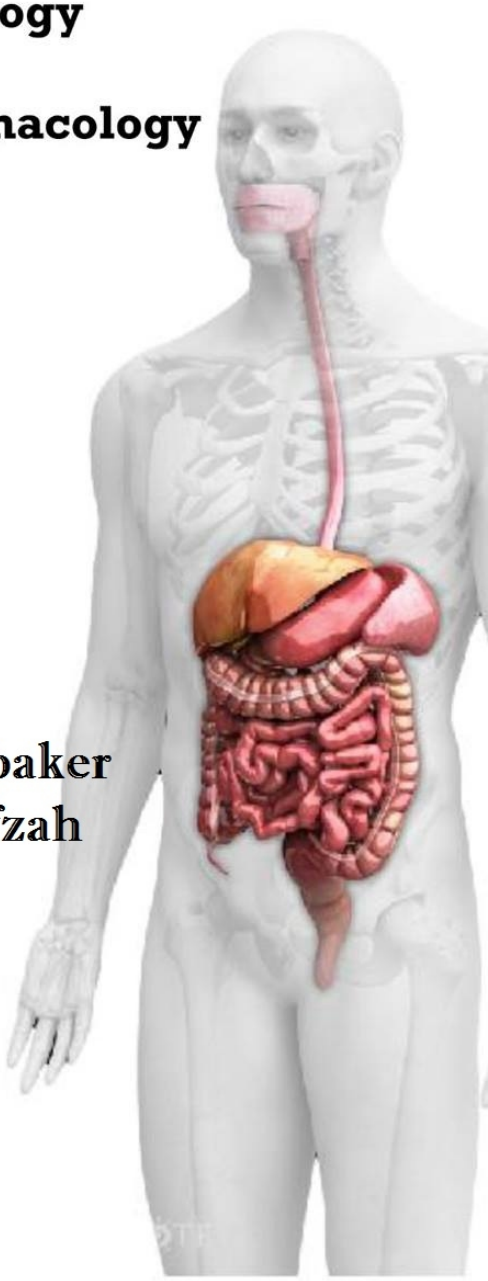

Sheet #: 1

Done by: Mohammad Abubaker
& Hamzah Mahafzah

Date:

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DESIGNED BY: TAMER ALTAMIMI "SMILE"

GIT Embryology Lecture #1

**This sheet is written according to the records of both sections

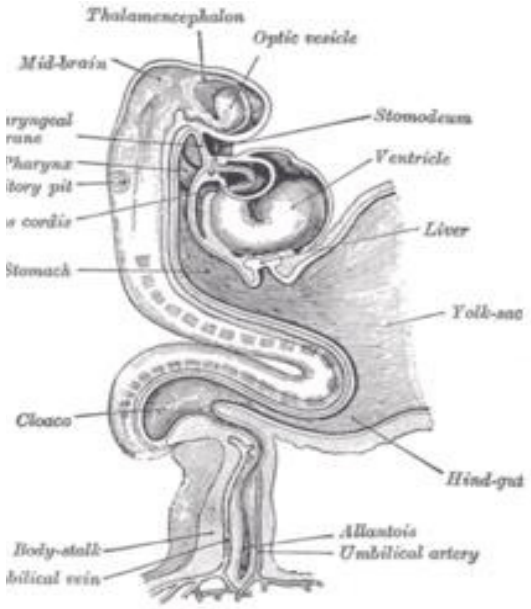
Gastrointestinal tract embryology will be covered within 2 lectures. We will discuss the development of the oral cavity, the glands, the tongue, the pharynx, the esophagus, the stomach, the foregut (liver, gallbladder, pancreas and duodenum), the midgut (Until the lateral third of the transverse colon) and the hindgut (lateral third of the transverse colon, descending colon, sigmoid colon, rectum and anal canal).

To understand embryology you should *always put in mind the final picture of the organ*; like when we say the development of the mouth, you should relate the development to the final picture, another example is the stomach; once we say the development of the stomach you should keep in your mind the final picture of the stomach (two openings, two surfaces, lesser curvature, lesser omentum, greater curvature and greater omentum).

In development we pay attention to the origin (ectoderm, mesoderm or endoderm), and from last year embryology if you could remember; *The Trilaminar Germ Disk* consists of Ectoderm, Mesoderm and Endoderm.

1. Development of the Oral Cavity

This is an image for an embryo; you can notice the cephalic head and caudal end. The caudal end has the ***Cloaca***; which is the end of the hindgut in the embryo and the onset of formation of



the Urinary Bladder and anal canal. The cephalic head has the ***Stomodeum***; which is located in the oral cavity between the anterior and posterior parts.

The Oral Cavity originates from two sources:

1. Depression in the Stomodeum and it's lined with *Ectoderm* which means it's ectodermal in origin
2. Cephalic end of the foregut; It's *endodermal* in origin (cephalic means the most upper part)

Foregut: Start behind the stomodeum and it contains part of the oral cavity, the pharynx, the esophagus, and the stomach until the upper half of the duodenum

Ampulla of Vater, or the Common Bile Duct and pancreatic duct opening separates the duodenum into upper half and lower half; the upper half is related to the foregut and the lower half is related to the midgut

These two points are separated by the *Buccopharyngeal membrane;* this membrane gets ruptured at the 3rd week of development (three weeks after fertilization)

If the Buccopharyngeal membrane persists, we get an *imaginary line*; this imaginary line divides the oral cavity into **anterior-superior** and **posterior-inferior** parts

This Imaginary line extends *obliquely* from body of sphenoid, through the soft palate and the inferior part of the mandible (which is related to incisor teeth)

The anterior-superior structures (that lie above this line) are ***ectodermal in origin***; like hard palate, sides of the mouth, lips and enamel of the teeth (مينا الاسنان)

The posteroinferior structures to this line are ***endodermal in origin;*** like tongue, soft palate, palatoglossal and palatopharyngeal folds and floor of the mouth

Oral cavity... Two origins:

1. Ectodermal→ depression of the stomodeum → anterior-Superior to the imaginary line.

2. Endodermal→ cephalic part of the foregut → posterior-inferior to the imaginary line.

2. Development of Salivary Glands

The Salivary glands are Exocrine glands

Both exocrine and endocrine glands *develop* from the epithelial surface, for example; the lining epithelium of the oral cavity is stratified squamous non-keratinized

Development is **proliferation of epithelial cells through the mesenchymal layer below the epithelium (connective tissue layer),** and this proliferation (growth of cells) will construct *rods* of cells and at the end of these rods we will have the *acini* which are secretory cells that could be exocrine or endocrine

If these acini were endocrine, the rod of cells will disappear, and only secretory aciniwill remain. These secretory acini have numerous blood vessels and the secretion goes through the blood (Endocrine Gland)

If it was exocrine, there would be **canalization** of the rod of cells and it will become a duct and at the end of the ducts we have secretory acini

In the Parotid gland we have acini and parotid duct that opens in the oral cavity

And now we repeat again, the glands during the 7th week of development arise as solid outgrowth of cells from the lining epithelium of developing mouth, and these cells will grow into the underlying mesenchyme (connective tissue layer), after that the epithelial buds will go through repeated branching to form solid ducts then canalization to these solid ducts occurs, at the end, secretory acini will be formed

Difference between Exocrine and Endocrine glands development:

Disappearance of the solid buds → Endocrine

Canalization of the solid buds → Exocrine

The surrounding mesenchyme will condense and form capsule, and this capsule will give the septa (connective tissue) which divide the gland into lobes and lobules

The Parotid gland is derived from Ectoderm, while the Submandibular and Sublingual are derived from Endoderm

Glands:

-Exocrine: epithelial cells proliferation →rod of cells with acini atits end → the rod forms a duct by canalization.

-Endocrine: epithelial cells proliferation→ rod of cells with acini attheend→ the rod disappears and the acini remain →a dense bloodsupply develops.

-Salivary glands are exocrine; (parotid→ ectoderm),

(Submandibular & sublingual → endoderm).

3. Development of the Tongue

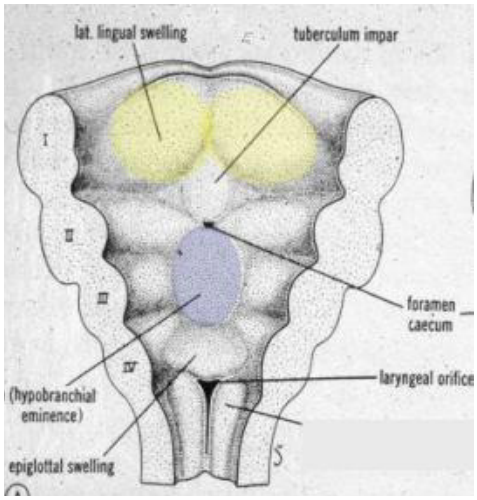
The tongue is divided into anterior two-thirds and posterior one-third

The anterior two-thirds are derived from the first pharyngeal arch, and innervated by the lingual nerve which is a branch of the mandibular (general sensation), and chorda tympani a branch from the facial nerve (for tasting).

The posterior one-third is derived from the third pharyngeal arch, and innervated by the glossopharyngeal nerve, for both sensory and taste. (Taste for circumvallate papillae since they are originated from the posterior third)

The Cranial nerves follow the Pharyngeal arches

What separates between the anterior two-thirds and posterior one-third is the *sulcus terminalis* and *foramen cecum*



The tongue develops in embryoat the *fourth* week from the first pharyngeal arch, in the form of **two lateral lingual swellings** and **tuberculum impar**(which lies in the midline). These three swellings originate from the first pharyngeal arch and they grow towards the midline and when they meet in the midline they form the anterior two thirds of the tongue.

The **copula** is found in the midline and it's at the level of the third pharyngeal arch, and then it continues with the **hypo-pharyngeal eminence** which comes from the third pharyngeal arch and sometimes the fourth pharyngeal arch contributes in its development

with the third arch. They grow towards the midline, towards the copula which will disappear eventually.

So what actually forms the posterior one-third of the tongue is the third pharyngeal arch growth from the lateral side to the midline, but the copula determines the onset of the growth (land mark of the arch growth).

The circumvallate papilla comes from the third pharyngeal arch (posterior part), afterwards it slides anteriorly but its nerve supply remains glossopharyngeal nerve.

Sulcus terminalis and foramen cecum are between the anterior two thirds and the posterior one third, so we can conclude that they are originated between the development from the first arch and the development from the third arch.

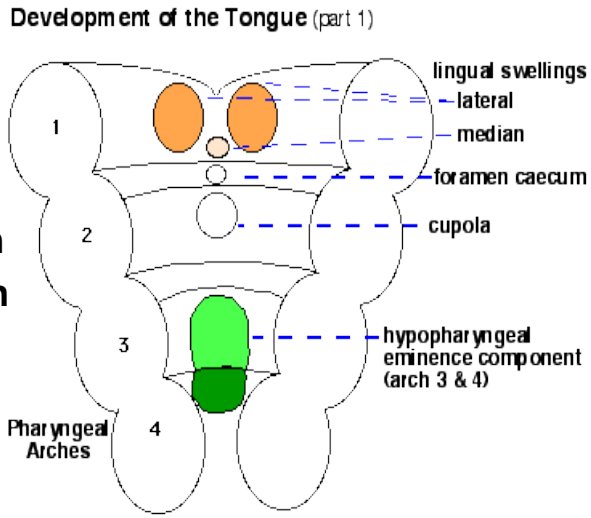
The figure at the next page shows the floor of the pharynx which is found in the cephalic part of the foregut. It is composed of **six pharyngeal arches, the upper four are very important in the development of the pharynx and the tongue.
**Each arch of the pharyngeal arches contains all the three germ layers; they are composed of mesodermal components in the middle, endodermal components inside (pharyngeal clefts), and ectodermal components outside (pharyngeal pouches).
The **muscles** of the tongue mainly originate from the **occipital somites** and are innervated by the hypoglossal nerve.

Tongue:

- Ant. 2/3 → from the 1st pharyngeal arch (particularly from the lateral lingual swellings and the tuberculum impar) → innervated mainly by the lingual N.
- Post. 1/3 → 3rd pharyngeal arch (Copula and hypo-pharyngeal eminence) → innervated totally by the glossopharyngeal N.
- Circumvallate papillae are related to the posterior one third of the tongue and originated from the third pharyngeal arch.
- Muscles of the tongue are originated from occipital somites, and innervated by hypoglossal nerve.

4. Development of the Pharynx

The pharynx is the most cephalic part of the foregut, and it is located posterior to the oral cavity.



Pharynx develops from the pharyngeal arches (Upper 4 arches), specifically from the **pharyngeal clefts (endoderm from inside)**.

The pharynx develops in the neck from the endoderm of the foregut (the cephalic part of the foregut).

The endoderm is separated from the surface ectoderm by mesenchyme. Each arch contains mesoderm in the middle, ectoderm outside (pharyngeal pouches), and endoderm inside (pharyngeal clefts).

Each arch forms a swelling on the surface of the walls of the foregut. As a result of these swellings a series of clefts (pharyngeal clefts) are seen from inside. And similar grooves are found outside (pharyngeal pouches).

The pharynx → the upper 4 pharyngeal arches → the endodermal portion of them (The pharyngeal clefts).

5. Development of the Anterior Abdominal Wall

The wall of the gut in the embryo is endodermal from inside

The **visceral mesoderm** surrounding the wall of the gut from outside forms the visceral peritoneum (it surrounds the *endoderm* of the gut)→**splanchnopleuric** mesoderm.

The **parietal mesoderm** lining the *ectoderm* from inside is called somatic layer forms the parietal peritoneum →**somatopleuric** mesoderm.

The peritoneal cavity is the space between the splanchnic (visceral) and somatic (parietal) mesoderm

The anterior abdominal wall is derived from the **somatoplueric mesoderm**. The somatoplueric mesoderm forms the external oblique, Internal oblique and transversus abdominus muscles, and all of them insert into linea Alba.

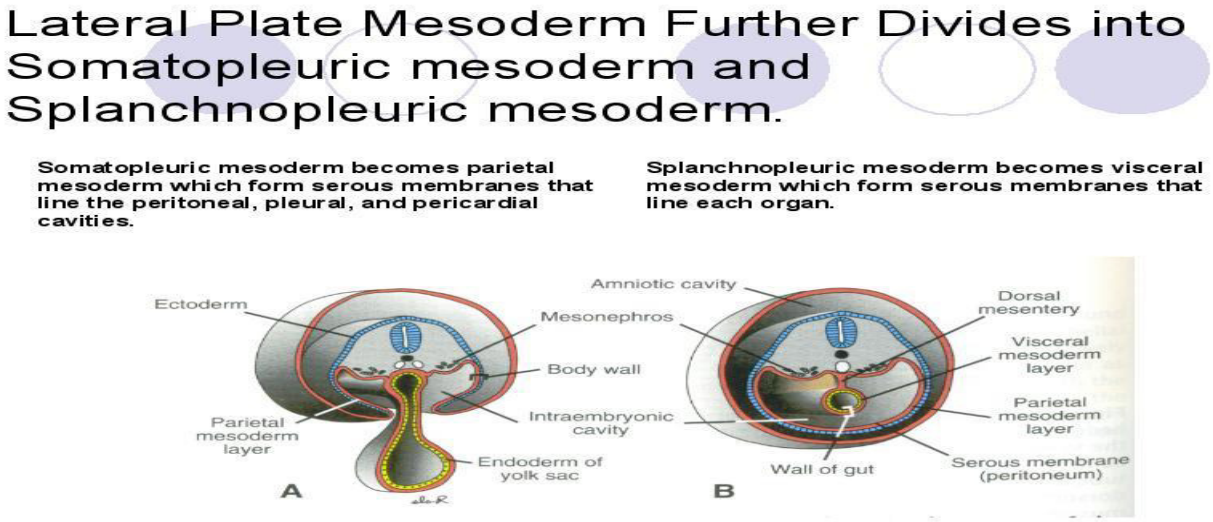
So, the lateral plate mesoderm in the embryo will undergo segmentation. It will divide into somatic and splanchnic layers. They line the ectoderm primarily, but after that the splanchnic layer will cover the gut to form the visceral peritoneum. The somatic layer will remain lining the ectoderm forming the parietal peritoneum and then continues to form the external oblique, internal oblique, and transverses abdominus muscles.

Finally the abdominal Wall; right and left sides of mesenchyme fuse together at **three** months into the midline to form the linea Alba.

The rectus abdominus muscle originates from the somite of the embryo (myotome) or the somatic myotome, so it has tendenous intersections which are adherent to the anterior wall of the rectus sheath. (they are formed inside the rectus sheath which is formed by

the aponeurosis of the three abdominal muscles (external oblique, Internal oblique and transversus abdominus)).

As shown in the figure below, the embryo is composed of three layers: ectoderm (in blue), mesoderm (in red), and endoderm (in yellow "which is called the Yolk sac").



The peritoneum:

- Visceral → splanchnic layer of mesoderm lining the gut from outside. (inside the gut we have endoderm).
- Parietal → somatic layer of mesoderm lining the ectoderm from inside.

Peritoneal cavity → the potential space between somatic and splanchnic layers of mesoderm.

Anterior Abdominal Wall → ectoderm and parietal (somatic) mesoderm.

Abdominal muscles:

- External oblique, internal oblique, transversus abdominus→somatic layer of mesoderm from thetwo sides → then they fuse to form the linea alba and the rectus sheath.
- Rectus abdominal→Myotomes of the somites→ inside the rectus sheath → it has tendenous intersections.

6. Development of the Umbilicus and Umbilical Cord

The umbilical cord connects the placenta with the umbilicus of the fetus. It originates from the placenta in endometrium of the mother and ends in the umbilicus of the fetus.

The umbilical cord contains:

1. Two arteries and a vein (In the beginning it had two veins but the right vein gets obliterated)

The two arteries carry deoxygenated blood from the fetus to the placenta. The two veins carry oxygenated blood from the placenta to the fetus (the right one gets obliterated and disappears)

2. Remains of yolk sac
3. Vitelline Duct

Vitello-intestinal duct, between the midgut and umbilicus, must be obliterated. Otherwise;

A) If a pouch remains, it could cause **Mickelle's Diverticulum**which is a 2 inches-long pouch in the ileum, 2 feet away from the ileocecal junction, and found in 2% of people., but when it contains heterotopic pancreatic tissue or gastric mucosa, it may cause ulceration, bleeding, intestinal obstruction (when the intestines wind on the vitelline duct) or even perforation (peritonitis).

B)Vitelline Duct abnormalities (no obliteration/ no fibrosis) and if it persists and remains open, it may cause **fecal fistula** (discharge of contents of the ileum through the umbilicus).

C)Sometimes, instead of complete closure and obliteration of the vitello-intestinal duct, a cyst occurs in the middle and causes no complications.

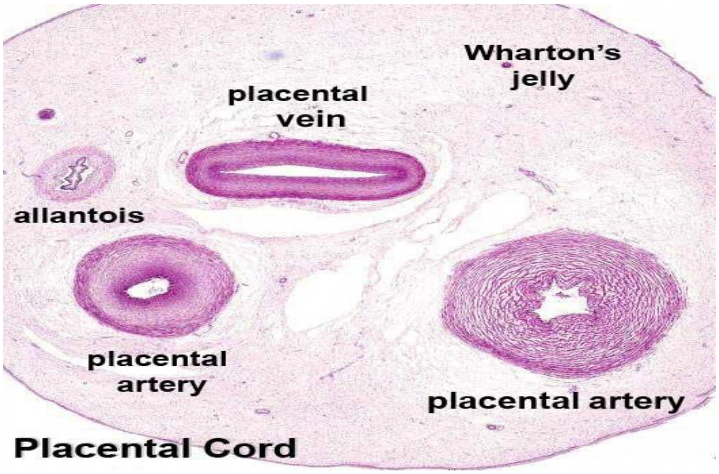
4. Big amount of Wharton's jelly (umbilical connective tissue)

Nowadays, *Wharton's jelly* and its contents are very important. In developed countries, once a baby is born, they take a sample from Wharton's jelly in the umbilical cord because it contains *stem cells*. And these stem cells are being freezed and used once needed

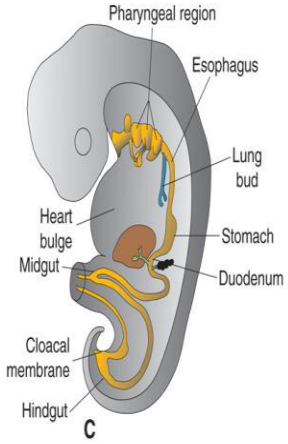
Wharton's Jelly is Umbilical connective tissue

The umbilical cord contains: placental blood vessels, Wharton's jelly, Allantois, remains of theYolk sac and the vitelline duct.

- Umbilical bloodvessels→ 2 arteries carry de-oxygenated blood from the fetus to the placenta. The leftvein carries oxygenated blood in the opposite way.
- Wharton's jelly → loose connective tissue → contains stem cells.
- Allantois → a duct between urinary bladder and the umbilicus → obliterated normally to become the median umbilical ligament → if it persists, urine will pass through the umbilicus.
- Vitelline duct → between midgut and the umbilicus → normally obliterated → if it persists, Meckel's diverticulum or fecal fistula could occur.



7. Development of the Esophagus



Esophagus is caudal to pharynx and descends to reach the stomach, and it's a part of the foregut.

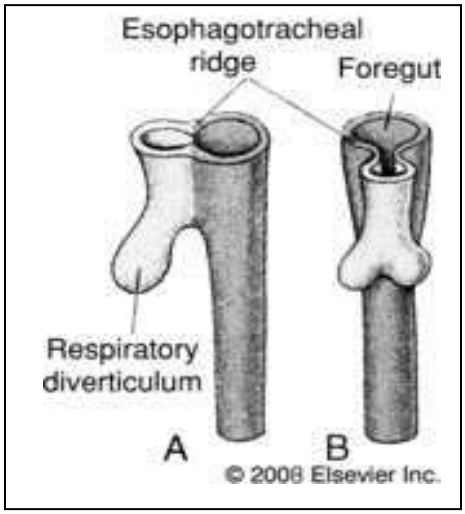
The lung bud is situated anterior to the foregut.

Approximately at the 4th week, the respiratory diverticulum (lung bud) appears as an outgrowth from the ventral wall (anterior wall) of the foregut.

Formation of the respiratory tract starts when lung buds are formed.

Anterior wall of the foregut → Lung buds (respiratory tract)

Posterior wall of the foregut → Esophagus



The trachea lies anterior to the esophagus.

Initially the lung bud is in open communication with the foregut (esophagus), so there must be development of **ridges** from right to left side and which will make and separation between the respiratory tract and the foregut (esophagus).

These ridges on the right and left sides fuse towards the midline to form a constriction called esophago-tracheal ridges, which separates between the foregut and the respiratory tract (i.e. separates between the trachea and the esophagus). This separation is important, the esophagus will form on the posterior wall of the

foregut, while the lung buds develop from the anterior wall of the foregut and the then they will form the trachea.

The epithelium lining the internal of the larynx, trachea and bronchi is **endodermal** in origin, whereas, the cartilage and muscles originate from the connective tissue.

The respiratory tract (larynx) maintains its communication (connection) with the esophagus (foregut) through the *laryngeal orifice (epiglottic orifice),* which is controlled by the epiglottis (i.e. inlet of the larynx).

Important complications between the respiratory passage and esophagus**:**

1) Esophageal Atresia and Fistula, which need urgent medical intervention, and if done so babies will live normal lives

*In the figure, notice the following:

A→Proximal esophageal atresia (blinded ended), and distal fistula (abnormal connection between the distal part of the esophagus and the trachea).

B→Proximal and distal atresia without fistula.

C→common fistula/communication between esophagus and trachea.

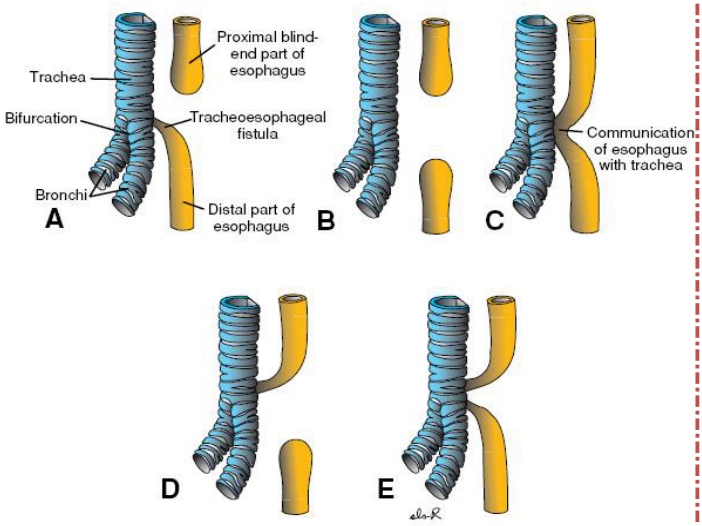


Figure 13.7 Variations of esophageal atresia and/or tracheoesophageal fistula in order of their frequency of appearance: **A,** 90%; **B,** 4%; **C,** 4%; **D,** 1%; and **E,** 1%.

D→Distal esophageal atresia and proximal fistula (abnormal connection between the

proximal part of the esophagus and the trachea).

In its *most common form*→proximal esophageal atresia and distal fistula/ tacheo-esophageal fistula (A), it contributes to 90% of esophageal abnormalities. (the proximal part of the esophagus ends as a blind sac and the distal part is connected to the trachea by a narrow canal just above the bifurcation), it occurs in 1 of 3000 births.

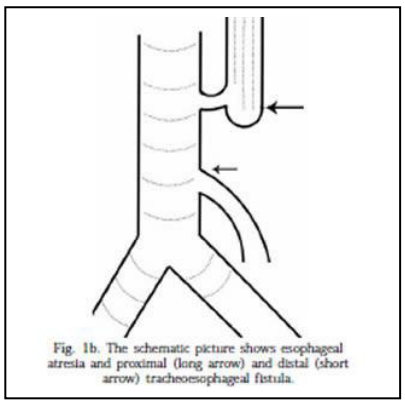


Fig. 1b. The schematic picture shows esophageal atresia and proximal (long arrow) and distal (short arrow) tracheoesophageal fistula.

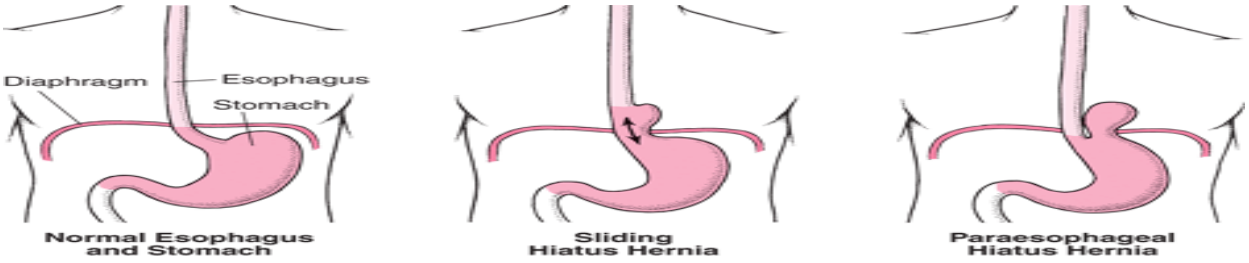
Complications:

1. During fetal life, before birth, **Polyhydramnios** is realized by the doctor. Which is increased/ excess amniotic fluid around the fetus because ofprevention of normal passage of amniotic fluid into the intestinal tract (Normally, the amniotic fluid has a certain circulation (absorption & excretion)). [note: the fluid is very important in the development of the respiratory system and lungs,oligohydramnioswhich is opposite topolyhydramniosmay cause respiratory defects and lung atresia].
2. Esophageal abnormalities may associate with cardiac abnormalities such as; inter-atrial septal defect or inter-ventricular septal defect, which is the presence of opening between the two atrium and two ventricles, respectively.
3. Regurgitation of the feeding (vomiting), this is the first sign after birth.
4. Infection in respiratory tract (pneumonia) due to the presence of the fistula.

5. Air could go from the respiratory tract to the stomach, so when the baby cries, there will be bulging in the abdomen, which indicates the presence of air in the stomach.
6. Renal agenesis. (the kidney has not been formed).

2)The lumen of the esophagus may narrow, producing **esophageal stenosis,** usually in the lower third(treated by dilatation).

3)**Congenital hiatal hernia**: which is resulted from the mal-descending of the esophagus (it normally descends as a result of the growth of the heart & liver), and the stomach is then pulled up into the esophageal hiatus through the diaphragm.



The esophagus → posterior of the wall of the foregut
Lung buds → anterior of the wall of the foregut

- They must be separated by esophageo-tracheal ridges. If not:
  1. Fistula: abnormal connection (proximal or distal).
  2. Atresia: blinded end (proximal or distal).
  3. Esophageal stenosis: narrowing in the lumen.
  4. Congenital hiatal hernia: mal-descending→ part of stomach through the esophageal hiatus.
- 1 birth per 3000 births will have proximate Atresia with distal fistula → results: *vomiting after milking, **polyhydramnios,***cardiac problems,****renal agenesis,*****pneumonia,******bulged stomach while crying.

8. Development of the Stomach

The Stomach has two openings (Cardiac orifice and pyloric orifice), lesser curvature attached to it the lesser omentum, greater curvature attached to it the greater omentum, and two surfaces anterior and posterior

The stomach appears as a *fusiform dilation* (spindle in shape) of the foregut with an upper and lower opening at the fourth week of development

Regarding development we should notice it **along two axes**

- Longitudinal axis; where rotation of stomach occurs 90 degrees clockwise so, the left side along with the left vagus become anterior and the right side along with the right vagus become posterior.
  The left side grows rapidly and because of this rapid growth the greater curvature is formed.
- Antero-posterior axis; from the upper opening until the lower opening. During development the upper opening (cardia) moves downwards to the left and the pyloric opening moves to the right and upwards.
  There is **approximation** between the two openings around this axis.
  The cardia lies one inch to the left (of the midline) at the level of T10 and the pyloric one inch to the right at the level of L1

We have two mesenteries:

1. *Dorsal Mesentery* (Dorsal Mesogastrium) (On the posterior surface of the stomach); when it rotates with *the greater curvature* it forms the *greater omentum*.

2. *Ventral Mesentery* (Ventral Mesogastrium) (On the anterior wall of the stomach); when it rotates with *the lesser curvature* it forms the *lesser omentum*.

Rotation around the longitudinal axis pulls the dorsal mesogastrium to the left, creating a space behind the stomach called the *omental bursa (lesser peritoneal sac)*.

The Ventral mesentery forms the lesser omentum and ligaments of the liver (falciform, coronary, and triangular ligaments). [Slow development]
The Dorsal mesentery forms the greater omentum, mesocolon, mesentery of the small intestine, sigmoid mesocolon, lieno-renal ligament and gastro splenic ligament (all the ligaments that are attached posteriorly). It then attaches to the posterior abdominal wall. [Rapid development]

Some complications occur during the development, such as:

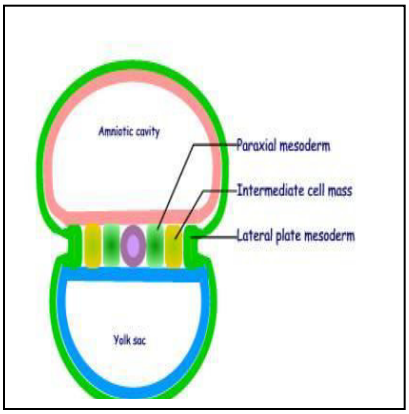
Pyloric Stenosis: is thickening of the inner circular smooth muscle of the pyloric sphincter(sometimes the longitudinal also involve) → hypertrophy of the sphincter → low passage of the contents to the duodenum. → The baby will have a **projectile vomiting** (vomiting with force) after feeding, meaning that the vomit will not merely appear around the baby's mouth, rather it will pass forward, maybe to reach the face of his mother.

The stomach:

- Longitudinal axis → rotation, clockwise, 90 degrees→left structures will be anterior & right will be posterior.
- Anterior-posterior axis → approximation of the openings → cardia down and left, pylorus up and right.
- Dorsal mesentery → Greater omentum & splenic ligaments (& other posterior ligaments).
- Ventral mesentery → Lesser omentum & liver ligaments
- The space left by the stomach because of the rotation → lesser sac.
- Pyloric stenosis → inner circular muscles hypertrophy → projectile vomiting

This is the *Trilaminar Germ Disk*.

The mesoderm is divided into lateral plate, paraxial and intermediate mesoderm.



When intercellular clefts appear in the *lateral mesoderm*,the plates are divided into two layers: the **somatic mesoderm layer** and the **splanchnic mesoderm layer.**

Reminder: The peritoneal cavity lies between the somatic and splanchnic layers

The splanchnic layer overlies the gut (the endodermal). The somatic layer overlies the abdominal wall (the ectodermal)

*A7la t7yyeh la **yousef toubah**, **Rakan Radi**, **Tariq Bushnaq**, o la kol el shabaab <33*

Hamzah Mahafza

*Dedicated to **Mohammed Sultan AbuOrabiAlAdwan**, and Doctor 2013 members*

MohammeddAbubaker

Corrected by: BushraMaaqbeh