Lectures of Human Embryology

"Body Cavities & GIT"

By

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Development of Body Cavities

- A single U-shaped cavity called **intraembryonic coelom** develops in the lateral plate mesoderm and infront of the prochordal plate.
- It divides the mesoderm into 2 layers:
  1. Dorsal layer called **somatic (parietal) layer**. It gives rise to the parietal layer of the serous membranes (pleura, pericrdium and peritoneum).
  2. Ventral layer called **splanchnic (visceral) layer**. It gives rise to the visceral layer of the serous membranes (pleura, pericrdium and peritoneum).

- **Fate of IEC:**
  During the 2\textsuperscript{nd} month the IEC is divided as follows:
  1. The cranial transverse part (infront of prochordal plate) gives rise to the **pericardium**.
  2. The cranial parts of the 2 lonitudinal limbs gives rise to **pleura** on each side.
  3. The caudal parts of the 2 lonitudinal limbs gives rise to **peritonium**.
Development of Peritoneum

1. The peritoneum develops from the caudal parts of the 2 vertical limbs.

2. As a result of folding of the embryo, the caudal parts of the 2 vertical limbs become close together, surrounding the gut.

3. Therefore, the gut becomes connected to the ventral wall of the embryo by ventral mesentery and to the dorsal wall by dorsal mesentery.

4. Most of the ventral mesentery degenerates and disappears to from a single "peritoneal" cavity, except a small cranial part persists forming ventral mesogastrium.

5. On the other hand, most of the dorsal mesentery persists, except that of duodenum, ascending colon and descending colon. The dorsal mesentery forms mesogastrium of stomach, mesentery proper of small intestine and dorsal mesocolon (at both transverse and sigmoid colons).

Separation of the pericardium from the pleural cavities:

1. Separation begins through appearance of a membrane, called pleura-pericardial membrane that arises one on each side from mesenchyme of body wall and extends inwards.

2. At the same time, the developing lung bud on each side invaginate the medial wall of primitive pleural cavity.
3. As the lungs grow, the membrane extend ventrally around the heart through splitting the mesenchyme of body wall. Thus, it separates the pleura from the pericardium. Then, the membrane forms the fibrous pericardium.

4. The pleural sacs approach each other and fuse with root of lungs.

![Separation of the pericardium from the pleural cavities](image)

**Separation of the peritonium from the pleural cavities**

"Development of Diaphragm":

1. Separation begins through appearance of a crescent-shaped fold, called pleuroperitoneal membrane that arises dorso-laterally from the body wall, one on each side at the caudal ends of pleural cavities.

2. The membrane extends ventro-medially to join the septum transversum and dorsal mesentery of oesophagus, separating the peritoneum from the 2 pleural sacs.

3. The peripheral muscular rim of the diaphragm, supplied by intercostals nerves is derived by extension of body wall mesoderm.

![Development of Diaphragm](image)
N.B.: The septum transversum is formed in the neck region by fusion of the cervical myotomes (3rd, 4th and 5th). Then as a result of cranial folding of the embryo, it descends cranially, pulling its nerve supply from phrenic nerve (C3,4,5).

**GIT Development**

**Introduction**
- As a result of folding of the embryo during the 4th week, the secondary yolk sac is divided into 2 parts;
  1. Part enclosed inside the body of embryo, called **primitive gut**, that is lined by endoderm.
  2. Part lying outside the body of embryo, called **definitive yolk sac**.

  The 2 parts are temporally connected together by a duct, called **vitelline duct**, passing through the primitive umbilical ring.

N.B.: As the primitive umbilical ring becomes narrower, the vitelline duct becomes constricted to form the **yolk stalk** by the 5th week. Then, it becomes divided to separate the gut from the definitive yolk sac.

- The **primitive gut** forms 3 parts:
  1. Middle portion, connected by vitelline duct to definitive yolk sac is called **midgut**.
  2. Cranial portion, cranial to midgut is called **foregut**.
  3. Caudal portion, caudal to midgut is called **hindgut**.
- Cranially, the foregut (lined by endoderm) is separated from the stomatodeum (lined by ectoderm) by oral (buccopharyngeal) membrane.
- Caudally, the hindgut (lined by endoderm) is separated from the proctodeum (lined by ectoderm) by cloacal membrane.
- Later on, these membranes rupture leading to communication of the gut with the exterior at its 2 ends; cranial end forming mouth and caudal end forming the anus.

**Derivatives of the Gut**

The primitive gut extends from the oral membrane to the cloacal membrane.

**Parts:**

1. **Foregut:**
   - It extends from the oral membrane to the origin of the hepatic diverticulum.
   - It is divided by the respiratory diverticulum into:
     1. **Cranial portion:** gives rise to:
        - Part of the mouth,
        - Pharynx and pharyngeal arches and its derivatives e.g. auditory tube, middle ear, tonsils).
        - Trachea and Bronchial tree.
        +
        - Teeth,
        - Tongue,
        - Thyroid gland,
        - Salivary glands.
     2. **Caudal portion,** caudal to respiratory diverticulum. It gives rise to:
        - Esophagus,
        - Stomach,
        - Upper part of duodenum,
        +
        - Liver, gall bladder and biliary passages,
        - Pancreas.
II. **Midgut:**

It begins from the hepatic diverticulum to the junction between the right two-thirds and the left one third of the transverse colon.

It gives rise to:
- *Parts of small intestine:*
  - Duodenum (lower part),
  - Jejunum,
  - Ileum.
- *Parts of large intestine:*
  - Caecum and appendix,
  - Ascending colon,
  - Transverse colon (right two-thirds).

III. **Hindgut:**

It begins from the junction between the right two-thirds and the left one third of the transverse colon to the cloacal membrane.

It is divided by the allantois into:

1. **Cranial portion:** gives rise to:
   - Transverse colon (left one-third),
   - Descending colon,
   - Sigmoid colon.

2. **Caudal portion:** gives rise to:
   - Rectum,
   - Upper part of anal canal,
   + Some uro-genital organs.
Development of Mouth

- It arises from 2 sources, separated by oral membrane:
  1. Ectodermal-lined part is derived from the stomatodeum (a depression lying between the forebrain bulge and cardiac bulge).
  2. Endodermal-lined part is derived from the cranial part of the foregut.
- The oral membrane ruptures at the 4th week, so that the mouth is continuous with the pharynx.

Development of Esophagus

- It arises from foregut, caudal to the respiratory bud.
- At first, it is short, but its length increases as the heart descends.
- Its musculature arises from the surrounding mesoderm.
Development of Stomach

- It arises from foregut, caudal to the respiratory bud.
- At first, it appears as a fusiform dilatation in the foregut. It is attached to the ventral body wall by ventral mesogastrium and to the dorsal body wall by dorsal mesogastrium.
- Unequal growth of borders occurs, resulting in the following:
  1. The dorsal border elongates more than the ventral border, forming the greater curvature of stomach, while the ventral border forms the lesser curvature of stomach.
  2. The cranial part of greater curvature bulges upwards to form the fundus.
- Stage of rotation: The stomach rotates to the right side for 90º, resulting in:
  1. The left surface becomes anterior and the left vagus becomes anterior gastric nerve. At same time, the right surface becomes posterior and its right vagus becomes posterior gastric nerve.
  2. The dorsal mesogastrium is pulled to the left, creating a pouch behind the stomach, called omental bursa (or lesser peritoneal sac).

Development of the Intestine (Gut)

- It passes into 4 stages, as follows:
  1. **Pre-herniation:**
     - The intestine is derived from the following parts:
       - Caudal part of foregut,
       - Mid-gut,
       - Hindgut.
At this stage, the midgut elongates to form a U-shaped loop, convex ventrally. Its summit is connected at its summit to definitive yolk sac by the vitelline duct.

2. Herniation:
   - The developing intestine herniates outside the body cavity through the extra-embryonic coelom (EEC) "into the umbilical cord". This occurs at the 6th week, as a result of faster development of the intestine more than the abdominal cavity.
   - While in EEC, the intestinal loop undergoes rotation for 90° to the right side, so that its cranial limb becomes right in position and the caudal limb becomes left.
   - The cranial (right) limb grows more rapid than the caudal limb forming series of convolutions, occupying mainly the right side. At the same time, the caudal limb shows a conical swelling near its apex, forming the coecum (and the appendix).
     N.B.: This conical part differentiates between the small and large intestine i.e. the part proximal to it forms the small intestine, while the other part forms the large intestine.

3. Reduction of Herniation:
   - The intestinal loop returned again to the abdominal cavity. This occurs by about the 10th week of fetal life, as a result of increase size of the abdominal cavity.
   - The original cranial limb (forming the small intestine) returns before the other limb so that it occupies the dorsal and lower part of abdominal cavity and the caudal limb occupies the ventral and upper part of the cavity.
     N.B.: The conical swelling of coecum impeding this return may be the cause for lateness of return the caudal limb.
   - As it returns, it undergoes another 180° rotation (to complete 270°) so that the coecum (with appendix) comes lie close to the liver in the upper right quadrant of abdomen. Also the caudal limb (forming the transverse colon) passes in-front of the duodenum.
   - Then, the coecum descends to lie in the right iliac fossa, forming the ascending colon.
4. **Fixation**
   - The dorsal mesentery of some parts of the GIT disappears, fixing these parts to the posterior abdominal wall. These parts are duodenum, ascending colon and descending colon.
   - N.B.: The dorsal mesentery persists in the following parts:
     - Jejunum and ileum forming mesentery proper.
     - Transverse colon forming transverse mesocolon.
     - Sigmoid colon forming sigmoid mesocolon.

![Development of Intestine](image)

**Clinical Application**

**Congenital Esophageal Anomalies**

1. **Esophageal atresia**
   Cause: Posterior deviation of the trachea-esophageal septum. Manifestations: Failure of normal swallowing of amniotic fluid by the embryo. This results in a condition called **polyhydramnios** (accumulation of excess amniotic fluid).

2. **Esophageal stenosis**
   It usually occurs in the lower third of esophagus and results in difficulty in swallowing. Cause: It may result from incomplete recanalization or vascular abnormalities that affect the bloodflow.

3. **Trachea-esophageal fistula**
   Cause: Failure of complete separation between the esophagus and trachea.

4. **Congenital Hiatal Hernia**
   Cause: Failure of descent of esophagus, resulting in a short esophagus that leads to upward traction of stomach to be herniated through the esophageal hiatus of the diaphragm.
Clinical manifestations: This leads to regurgitation of the acidic juice of the stomach into the oesophagus, leading to heartburn and then irritation and ulceration of the oesophagus. Persistent reflux leads to fibrosis and stricture of the oesophagus.

![Figure showing: Hiatal Hernia](image)

**Congenital Stomach Anomalies**

1. **Pyloric stenosis**
   Cause: Congenital hypertrophy of the circular and to a lesser extent the longitudinal muscles of the pylorus.
   Clinical manifestations: Obstruction of the passage of food. This results in severe vomiting.

2. **Hour-glass stomach:**
   The stomach shows a congenital constriction separating it into 2 dilated portions.

3. **Transposition of stomach:**
   It may be a part of situs inversus.

**Congenital Intestine Anomalies**

1. **Abnormalities of mesenteries**
   1. **Mobile coecum:**
      Cause: It may result from failure of degeneration of a portion of ascending mesocolon.
   2. **Abnormal long mesentery:**
      Cause: It may result from failure of fusion of the mesentery with the posterior abdominal wall.
      Clinical manifestations: Abnormal movements of gut or even volvulus (twisting of the intestine).
   3. **Retro-colic hernia:**
      Entrapment of portion of small intestine behind the mesocolon.
Cause: It may result from failure of fusion of the mesentery with the posterior abdominal wall. This leads to creation of retro-colic pockets especially behind the ascending colon.

II. Abnormalities of vitelline duct

1. Meckel's diverticulum:
   Cause: Failure of obliteration of the proximal portion of vitelline duct.
   This case is characterized by:
   - Incidence: about 2% of population.
   - Site: about 2 feet from the ileo-coecal junction.
   - Length: about 2 inches.
   - Manifestations: The case is usually asymptomatic. However, its inflammation may present with the clinical picture of acute appendicitis.
   *N.B.: To remind it, remember number "2"

2. Vitelline sinus:
   Cause: Failure of obliteration of the distal "outer" portion of vitelline duct.
   It may lead to discharge of mucous.

3. Vitelline cyst:
   Cause: Failure of obliteration of a middle portion of vitelline duct.
   It may lead to intestinal strangulation and volvulus.

4. Vitelline fistula:
   Cause: Failure of obliteration of the vitelline duct.
   It may lead to discharge of faeces at the umbilicus.

5. Vitelline band:
   Cause: The duct is obliterated but fails to disappear and it persists as a fibrous band, connecting the umbilicus with intestine.
   It may lead to intestinal strangulation and volvulus.

Anomalies of vitelline duct
III. Abnormalities due to imperfect reduction and rotation
1. Congenital umbilical hernia (Omphalocele):
   Cause: Failure of reduction of the intestinal loop after its physiological herniation during the 6\textsuperscript{th} to the 10\textsuperscript{th}.

2. Congenital volvulus:
   Cause: Rotation occurs more than 270°.
   It is a condition in which the intestine twists on itself, causing intestinal obstruction, manifested by abdominal pain, distension and vomiting.

3. Left sided caecum and appendix:
   Cause: Rotation occurs less than 270° (for only 90°).

4. Posterior transverse colon, passing behind the duodenum:
   Cause: Rotation occurs in a reversed direction.

IV. Other Abnormalities
1. Undescended caecum and appendix
   They lie below the liver.

2. Atresia of the gut:
   The lumen is occluded due to failure of recanalization.

3. Stenosis of the gut:
   The lumen is narrowed due to incomplete recanalization.