Development of Body Cavities

In the ranking of most popular study subjects among students, embryology is often near the bottom. In exams, the (admittedly) rare questions on the field can allow the student to shine by knowing only a limited number of facts, and, on a normal day in the clinic, symptoms, and malformations stemming from this developmental period are hardly uncommon so it is indeed worthwhile looking into the details of this field, and not just for aspiring pediatricians. This article explains the most important facts about the development of the body cavities and the relevant symptoms.

Human Body Cavities

The pericardial and pleural cavities (cavitas pericardialis and pleuralis), which house the heart and lungs respectively, and the larger peritoneal cavity (cavitas peritonealis) containing the majority of the abdominal organs, are known as the human body cavities. The body cavities are covered with a serous membrane (tunica serosa).

The body cavities of a growing child develop in the embryonic period, during the 4th to 8th weeks of development (early development, 1st-3rd; embryonic period, 4th-8th; and fetal period, 9th-38th week of development).
Before the 3rd week of pregnancy, the **trifoliate germinal disc** is covered with the 3 blastodermic layers (ectoderm, mesoderm, and endoderm) as a **smooth embryonic disc**, with already developed extraembryonic cavities (**amniotic cavity** and **yolk-sac**). At the **end of the embryonic period**, the embryonic tissue is separated from the extraembryonic tissue. At the end of the 8th week, the shape of the body is already recognizable with nearly all organs located in their proper place.

The following details are important to understand the clinical symptoms and appreciate the **relevant clinical studies**.

**Development of the Trunk Wall**

In the 4th week of development, 2 crucial developmental events lead to the formation of the thoracic and abdominal wall and thus the body form of the embryo: the **lateral folding** (rolling) and the **craniocaudal folding**. Both events are triggered by the significant growth of the **neural plate** and the formation of the **neural tube**.

For example, the C-shaped growth of the embryo results in a mushroom shape, with the edges of the mushroom hood rolling inward and growing medially, until the right and left sections merge into a sort of sphere.

Simultaneously, the enclosures for the heart (**heart plate**) and the **septum transversum** (the eventual diaphragm) move into the sagittal plane, the middle of the embryo. The initially cohesive body cavity forms for the 1st time: the **intraembryonic coelom** (Gr. *koilom* = hollow space). The coalescence leads to the formation of hollow spaces in the intraembryonic mesoderm and eventually result in body cavities.

A portion of the intraembryonic, **lateral plate mesoderm cells** is in contact with the ectoderm and is called the **somatopleura**. The cell layer bordering the enteroderm is
known as the splanchnopleura. The septum transversum (the eventual diaphragm) forms at the intersection of the 2 layers.

**Separation of Thoracic and Abdominal Cavities and Development of the Diaphragm**

The diaphragm forms in the 6th to 8th weeks of development via coalescence of the septum transversum and the plicae pleuraperitoneales.

The septum transversum grows ventrally between the heart and the liver enclosures and into the body cavity, i.e. into the intraembryonic coelom. The pleuropericardial folds (plicae pleuraperitoneales) grow against it from the anterior, lateral trunk wall. Toward the end of the 8th week of development, these sections coalesce to form the diaphragm, separating the thorax and abdomen spatially.

The muscles of the diaphragm develop 1st during the 4th month of pregnancy carrying the precursor muscle cells from the anterior, lateral trunk wall. The innervation of the diaphragm by the n. phrenicus occurs during the embryonic period, as the diaphragm moves in a caudal direction. During this descent, it is innervated by the ventral branches of the cervical nerves CE - C5.

**Congenital Diaphragmatic Hernias**
Congenital diaphragmatic hernias appear in 1 out of every 10,000 births on average. By definition, they result in the displacement of abdominal organs (stomach and intestine) into the chest cavity via gaps in the diaphragm.

The most common congenital hernia is the Bochdalek hernia (95%). Its hernial orifice is located almost always around the left trigonum lumbocostale. However, this weak point may also appear on the right, although it is effectively ‘sealed’ by the liver on top of it.

The far less common Morgagni hernia (5%) appears in the right trigonum sternocostale.

Intestinal loops that migrate into the thorax (referred to as an enterothorax) lead to displacement and compression of the heart and lungs, depending on the size. The affected children exhibit respiratory failure, leading to asymmetric curvature of the chest cavity, and the stomach may be partially shrunken due to missing ‘contents’. Any peristaltic sounds may be auscultated via the thorax, and air-filled intestinal loops (white) may be visible above the diaphragm in X-ray images.

Diaphragmatic hernia visible during pregnancy via ultrasound is a neonatal emergency. Large hernias may result in insufficient space in the chest cavity, leading to underdevelopment (hypoplasia) of the lungs and its supplying vessels.

Formation of Pericardial and Pleural Cavity

The 1st, primitive pericardial cavity forms from fissures in the mesenchyme during the 5th week of development. Initially, it is still connected to the peritoneal cavity via canales pericardioperitoneales, as the diaphragm is not yet sealed.

Simultaneously, the respiratory buds grow in a dorsomedial direction from the root of the lung to the left and right into these 2 cavities, and their edges form the primitive pleural cavity. The primitive pleural cavity is lined by the aforementioned splanchnopleura (pleura parietalis), and the somatopleura (pleura visceralis) surrounds the developing
The 2 cavities are ultimately separated by the protruding *plicae pleuropericardialis*, which finally coalesce into the *membrana pleuropericardialis*, which, in turn, merges with the root of the lung at the end of the embryonic period (8th week).

### Formation of Abdominal Cavity

The **abdominal cavity** also forms during the aforementioned embryonic development. Through the craniocaudal folding of the embryo, a small part of the adjacent *yolk-sac* emerges in an intraembryonic position and is sealed into a tube, initiating intestinal development.

The developing intestine lying in the simple body cavity (*intraembryonic coelom*) is stretched by the enormous growth in length, leading to the formation of **anterior and posterior intestinal portals**, carrying a connection to the yolk-sac located externally: the omphalomesenteric duct (*ductus omphaloentericus, ductus vitellinus*).

It plays a role in the physiological umbilical hernia and formation of the umbilical cord. In addition, it may rarely persist in adults, as a so-called **Meckel’s diverticulum** on the small intestine.

**Note:** The intestinal tube is formed by intraembryonic segments of the yolk-sac.

The growing intestine is divided into **foregut**, **midgut**, and **hindgut**. The foregut later forms the stomatodaeum, i.e., the beginning of our gastrointestinal system, and is sealed by the **buccopharyngeal membrane**. At the anterior intestinal portal/the hindgut, the **cloacal membrane** forms the border with the amniotic cavity.

### Physiological umbilical hernia – a crucial developmental step

The rapid growth of the midgut leads to a lack of space in the situs of the embryo. Therefore, a hernial sac with intestinal loops and vessels (the eventual **a. mesenterica superior**) moves into the **extraembryonic coelom** (also umbilical coelom) during the 8th to 11th weeks of development. The intestinal segments continue to grow within this structure, and eventually turn on the axis of the vessels (once at 270° counter-clockwise).

The individual intestinal segments are now located together in their proper position. Subsequently, they are relocated into the body cavity following the longitudinal growth of the embryo. Clinical symptoms of an **omphalocele** (see below) appear in the absence of this step.

At this point, the aforementioned connection between the U-shaped midgut and yolk-sac still exists: the **ductus omphaloentericus** (also ductus vitellinus or omphalomesenteric duct), which virtually ‘pulls’ the intestinal loops out, and, upon further development, becomes narrow and sealed. After the intestine has returned to the situs, this duct becomes a structural component during umbilical cord formation.

The omphalomesenteric duct is also important for adults: a **Meckel’s diverticulum** may remain in the event of poor regression. If the intestine is not completely withdrawn into the body during the physiological umbilical hernia, clinical symptoms of an **omphalocele** appear, and intestinal loops may be found outside the body during birth (see below).
Development of mesenteries and division of the peritoneal cavity

The intestine located within the body are also fixed to the abdomen by the mesenteries. The midgut initially carries two mesenteries on its upper segments (mesenterium ventrale and dorsale), which connect the intestinal tube with the anterior and posterior walls of the peritoneal cavity.

The upper segment of the peritoneal cavity is divided into right and left sections by these mesenteries during development. The caudal part of the esophagus, the stomach and the upper duodenum form from this upper part of the midgut.

The lower section of the intestine is merely held in place by mesenterium dorsale, which results in a single cavity in the lower portion of the peritoneal cavity into which the dorsal intestinal tube extends.

Abnormal Body Cavities
Omphalocele

When the intestinal loops fail to return to the developing body after the physiological umbilical hernia, a portion of the abdominal viscera may remain in the hernial sac of the umbilical cord. This defect is referred to as omphalocele or umbilical cord hernia.

In most cases, they are parts of the small intestine or the liver. A persistent umbilical hernia can be diagnosed during pregnancy via sonography. Due to the high risk of infection, the affected children require surgical treatment immediately after birth.

In the event of an umbilical cord hernia, other malformations occur in 40% of cases, often leading to right lateral laparoschisis (abdominal wall defect) in which abdominal organs protrude from the right side of the body, uncovered and usually infected, warranting careful surgery.

Image: Laparoschisis sagittal view. By X.Compagnion, Licence: CC BY-SA 2.5

In the case of gastroschisis, the abdominal organs protrude from the midline due to unknown causes. The hernial sac may burst during the physiological umbilical hernia resulting in a suspension of the abdominal organs in the amniotic fluid.

If a large portion of the intestine is located outside the abdominal cavity, or if the child carries a tiny abdomen, it is possible to 1st tend to the intestinal loops with a sterile plastic bag. The bag is then placed above the child’s stomach so that the intestinal loops fall back into the abdomen under gravity. The gap in the abdominal wall is then surgically sealed.

Meckel’s diverticulum
The protrusion of the small intestinal wall may remain in the individual as a remnant of the **omphalomesenteric duct**. It occurs in 1–2% of the population, and more frequently involves men.

Due to the early embryonic formation of omphalomesenteric duct, the **Meckel's diverticulum** (as its remnant) not only receives intestinal mucous but in over 50% of cases, may involve gastric mucous cells, cells from the large intestine and cells from the pancreas.

Generally, a Meckel's diverticulum is located 50–75 cm (19.6–29.5 in) proximal to the ileocecal junction (ICJ). In most cases, such a diverticulum remains asymptomatic. In the event of inflammation, however, it may result in **gastrointestinal bleeding** and **peritonitis**, and the patients exhibit colicky pain and symptoms similar to **inflammation** of the appendix (**appendicitis**).

Meckel's diverticulum is **removed surgically**. If there is any suspicion of appendicitis, and no intraoperative indication of inflammation of the **appendix**, the surgeon must always inspect the **ileum** for a Meckel’s diverticulum.

**Tip**: Most terms in embryology are Greek or Latin in origin. Google the translation to better understand the terminology.

You can learn more about embryology in the [Lecturio course on general and special embryology](https://lecturio.com) from Dr. Steffen-Boris Wirth, M.D. or on the page [embryology.ch](http://embryology.ch) of the Universities of Fribourg, Lausanne, and Bern.

**References**


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