Lectures of Human Embryology

By

DR. ABDEL-MONEM AWAD HEGAZY

M.B. with honor 1983,
Dipl."Gynecology and Obstetrics "1989,
Master "Anatomy and Embryology" 1994,
M.D. "Anatomy and Embryology" 1999

Associate Professor of Anatomy and Embryology

Faculty of Medicine, Zagazig University (Egypt) &
College of Medicine, Majmaah University (Saudi Arabia)
Development of Amnion

Amnion is a thin, tough, transparent membrane, containing the amniotic fluid. It is the inner membrane, lining the chorion, and covering the umbilical cord and the foetal surface of placenta.

Development of Amnion:

1. It first appears as a small cavity between the trophoblast and the ectoderm of the embryonic disc.
2. The cavity is floored by the ectoderm and roofed by the amnioblastic layer, probably derived from the covering cytotrophoblast.
3. As a result of folding that begins at the 3rd week and completed by the 4th week of foetal life, the amnion completely surrounds the embryo.
4. With further growth, it obliterates the extraembryonic coelom (EEC).
5. At the same time, it approximates the connecting stalk and vitelline duct to form the umbilical cord. So the cord acquires a covering from the amnion.
Site of Implantation in Endometrial lining of Uterine body

Stage of bilaminar embryonic disc

Development of amniotic cavity, secondary yolk sac, exocoelomic cyst and chorionic villi

Folding of embryo
Origin of Amniotic Fluid

1. Maternal blood: Early in pregnancy, the amniotic fluid is derived from the maternal plasma. It passes through the fetal membranes by osmotic and hydrostatic forces.
2. Amnioblastic cells: It is probably derived from the amniotic epithelium.
3. Later on with further growth, the foetus contributes to the amniotic fluid e.g. by urination.

Functions of Amniotic Fluid

Its functions include, it:

1. **Permits** movements of the foetus, allowing muscle-skeletal movements.
2. **Prevents** adhesions of the foetus to amnion.
3. **Protects** the foetus from external trauma.
4. **Provides** a source of nutrition for the foetus, as it contains glucose.
5. ,, a medium for excretion.
6. ,, a constant temperature, as it is bad conductor for heat.
7. At the beginning of labour, the amniotic sac **protrudes** through the cervical canal, helping its dilatation.
8. During labour, the amniotic sac ruptures and the fluid **passes** down the female genital tract acting as a lubricant and disinfectant agent (natural antiseptic fluid).

Characters of Amniotic Fluid

1. **Volume**: It increases gradually to reach 800 to 1000 ml at full term, then declines by approximately 150 ml every week if delivery is delayed.
2. **Composition**: About 99% of amniotic fluid is water and the other 1% is formed of cells and organic and inorganic constituents. Cells in the amniotic fluid include cells that are shed primarily from the skin, fetal bladder, GIT and amnion.

Clinical Applications of Amniotic Fluid

1. Abnormalities of volume may indicate some congenital defects in the foetus (as shown below…..).
2. Examination of the amniotic fluid may be indicated in the following conditions:
i. Genetic diagnostic tests (or Karyotyping), by examination of the cells in amniotic fluid to check for hereditary or genetic diseases—such as Down syndrome, especially in old pregnant women (more than 35 years old).

ii. Foetal maturity estimation, e.g.
- Concentration of lecithin and sphingomyelin reflects the state of maturity of lungs.
- Concentration of creatinine reflects the maturity of kidneys.
- Concentration of bilirubin reflects the maturity of liver.

iii. Check for presence of infection in the amniotic fluid that might require treatment during intrauterine life.

3. Recently, human amniotic fluid has been shown to contain stem cells. These cells have the potential to differentiate into any of the three germ layers. Therefore, this finding is a good promising research field for specific cell-based therapies.

N.B.: Amniocentesis
It is a procedure in which specimen of amniotic fluid is withdrawn and examined. A needle is inserted into the amniotic sac through the abdominal wall under ultrasound guide. Then, about 20-30 ml of amniotic fluid is withdrawn. The procedure is common done at 15th -18th week. It is done after the 14 weeks’ gestation to not endanger the foetus.

Abnormalities of Amniotic Fluid

Amniotic fluid is normally swallowed by the foetus and absorbed by GI tract.

1. Polyhydramnios (or Hydramnios)
   It is an excessive increase in amount of amniotic fluid (volume 1.5-2 liters).
   Causes:
   A. Foetal causes: These are the congenital defects in embryo that prevent or decrease the amniotic fluid swallowing. These cases include:
      - Congenital atresia of the esophagus, duodenum and upper part of jejunum.
      - Congenital anomalies of CNS, e.g. anencephaly and hydrocephalus.
   B. Maternal diseases, e.g. diabetes mellitus.

2. Oligohydramnios
   It is a marked decrease in amount of amniotic fluid (volume is less than 0.5 liter).
   Causes:
Oligohydramnios occurs in congenital anomalies of urinary system that result in inability of foetus to urinate in the amniotic fluid, e.g. - renal agenesis (absence of kidney) or - urethral obstruction. This condition results in other foetal defects due to adhesions resulting from decreased amniotic fluid.

**Yolk Sac**

Yolk sac contains no yolk as its name indicates, so it does not store nourishment, but transfers it for the embryo. Throughout the development, it gradually decreases in size. It passes through the following stages:

1. **Primary yolk sac:** arises from the blastocoele.
2. **Secondary yolk sac:** arises from the primary yolk sac as a result of appearance of endodermal layer so that it is completely surrounded by endoderm.
3. **Definitive yolk sac:** occurs after folding of the embryo. Part of secondary yolk sac is enclosed within the folded embryo to form the gut. The other part remains outside the body of embryo to form the definitive yolk sac, connected to the gut by vitelline duct. The definitive yolk sac becomes small in size and separates to form a small cyst at the placental end of umbilical cord.
4. **Allantois (urachus):** arises as a diverticulum from the caudal part of gut. After embryo folding, it becomes incorporated into the umbilical cord. Blood vessels in its wall enlarge and become the umbilical vessels. After birth, it is changed to fibrous cord called "median umbilical ligament" that connects the umbilicus to the apex of urinary bladder.

**Functions of yolk sac:** (T.G.E.B.)

1. **Transfer of nutrients** in the early stages of development: It plays a role in nutrient transfer from the trophoblast to the embryo during the 2nd and 3rd intrauterine life.
2. **Germ cells:** Its wall is the source of primordial germ cells, that migrate towards the developing gonads where they form the spermatogonia or oogonia.
3. **Endoderm of the gut:** It gives rise the endoderm of the gut, that form the digestive and respiratory tracts.
4. **Blood formation (haemopiosis)** in the early stages of development (from the 3rd to the 6th week) where the haemopiotic function is taken by the liver.
Umbilical Cord

It is a band of mesoderm, containing umbilical vessels and covered by amnion. It connects the foetus with the placenta.

Development

It passes through the following stages:

1. Primitive umbilical cord:
   - After folding of the embryonic disc, the connecting stalk comes to lie on its ventral surface. At the same time and as a result of expansion of the amniotic cavity, the connecting stalk, vitelline duct and allantois are enclosed together forming primitive umbilical cord.
   - Then structures passing through the umbilical ring, forming primitive umbilical cord are:
     i. Connecting stalk.
     ii. Vitelline duct and vitelline vessels.
     iii. Allantois and umbilical vessels.
     iv. Loops of intestine (physiological hernia), passing around the vitelline duct.

2. Definitive umbilical cord:
   It is formed only from one umbilical vein and two umbilical arteries in Wharton's jelly. This occurs as a result of the following changes:
   i. Loops of intestine returns again to the abdominal cavity.
   ii. Allantois is obliterated and right umbilical vessel disappears.
   iii. Vitelline duct is obliterated and vitelline vessels disappear.
   iv. Mesoderm of connecting stalk is changed into a loose connective tissue called "Wharton's jelly".

3. Changes in intra-abdominal part after birth:
   The cord is ligated and cut after birth. Later on, the following changes occur:
   i. The allantois (urachus) is obliterated and fibrosed to form the median umbilical ligament.
   ii. The 2 umbilical arteries are obliterated and fibrosed to form the lateral umbilical ligament.
   iii. The umbilical vein is obliterated and fibrosed to form the ligamentum teres.
Gross Anatomy of Umbilical Cord:
- Length: about 50-60 cm.
- Thickness: about 1-2 cm.
- Surface: smooth as it is covered by amnion.
- Shape: spirally twisted, as the umbilical vein is shorter than the arteries. The twists reach about 40 turns.

Abnormalities of Umbilical Cord:

I. Abnormalities in the cord itself:
   A. Length:
      1. **Long umbilical cord** (> 60 cm):
         Dangers:
         - Prolapsed cord through the cervical canal, leading to difficulty of labour.
         - Winding around the foetal neck or limb---leading to foetal asphyxia.
         - True knots---leading to foetal asphyxia.
      2. **Short umbilical cord** (< 30 cm):
         Dangers:
         - Ruptured cord.
         - Premature separation of placenta (with danger of foetal death).
         - Inversion of uterus.
   B. Shape:
1. **False knots** (localized thickening) of umbilical cord. They are localized collection of Wharton's jelly and of no significance.

2. **True knots**: This may result from too long cord that may be tighten and cause foetal death.

II. **Abnormalities in the cord attachment to the embryo**:
   1. **Congenital umbilical hernia** (omphalocele).
   2. **Vitelline fistula** (may result in discharge of faeces at umbilicus).
   3. **Urachal fistula** (may result in discharge of urine at umbilicus).

III. **Abnormalities in the cord attachment to the placenta**:
   1. **Eccentric attachment**: The cord is attached away from the center of placenta.
   2. **Marginal attachment of the cord**: The cord is attached to the margin of placenta.
   3. **Membranous insertion of the cord** "velamentous": The cord is attached to the membranes connected to placenta.