ANATOMY - GUS 11

Development of Placental Circulation

- The nourishment of the zygote initially comes from the zygote itself, as it contains a large amount of cytoplasm.
- As the zygote continues to divide, it begins to take in more nutrients not from itself, but from the surrounding fluid in the fallopian tube.
- Eventually, this fluid is no longer sufficient, so the zygote draws nutrients from the endometrium during implantation.
- Implantation occurs during the first week of development.
- At this stage, it receives nourishment from the blood vessels and glands of the endometrium.
- As the zygote embeds deeper into the functional layer of the endometrium, it starts to move away from these glands and blood vessels.
- Consequently, placental circulation begins to form during the second week to provide sustained nutrient and oxygen supply.
- Placental circulation first forms as spaces called lacunae within the syncytiotrophoblast.
- Fluids begin to leak into these lacunae, where they start to collect.
- These spaces eventually establish connections with the maternal spiral arteries.
- Maternal blood begins to flow into these lacunae, forming the early uteroplacental circulation.
- These blood-filled lacunae are located near the amniotic and yolk sacs, where the embryo is developing.
- The lacunae gradually start to connect with each other to form a network of lacunae, also known as **intervillous spaces**, which are established around day 12 (while lacunae themselves begin forming by day 9).
- These networks are externally linked to the maternal spiral arteries, which drain blood into the lacunae.
- All of these lacunae are located within the syncytiotrophoblast.
- However, this lacunar network alone is not sufficient for later stages of development.
- As the embryo progresses from the bilaminar to the trilaminar disc stage, it requires more efficient filtration and nutrient exchange.
- This need drives the development of more complex circulatory structures that deliver blood and nutrients through the amniotic and yolk sacs to support the growing embryo.
- After the development of the amniotic sac, yolk sac, and the trilaminar disc (composed of ectoderm, endoderm, and intraembryonic mesoderm), another layer called the extraembryonic mesoderm forms.
- The extraembryonic mesoderm is a mesenchymal tissue that separates the cytotrophoblast from the two vesicles (the amnion and yolk sac).
- This extraembryonic mesoderm later differentiates into two layers: the somatic extraembryonic mesoderm and the splanchnic extraembryonic mesoderm.
- The first blood vessels in the embryo develop from the splanchnic extraembryonic mesoderm.
- These vessels then spread into the extraembryonic mesoderm and the intraembryonic mesoderm, establishing circulation within and outside the embryo.

Summary:

- The yolk sac, amniotic sac, and developing embryo are separated from the cytotrophoblast by the extraembryonic mesoderm.
- The extraembryonic mesoderm gradually forms cavities that split it into two layers:

a. The **splanchnic mesoderm**, which surrounds the yolk sac.

b. The **somatic mesoderm**, which surrounds the amniotic sac and lines the inner surface of the cytotrophoblast.

- These layers contribute to the formation of the **chorionic membrane**, which is composed of:
  a. The somatic extraembryonic mesoderm
  b. The cytotrophoblast
  c. The syncytiotrophoblast
- The **chorionic cavity** (also known as the **extraembryonic coelom**) forms between the amniotic/yolk sacs and the chorion.
- As development proceeds, the amniotic cavity, yolk sac, and the embryo itself move further away from the chorion.
- Despite this increasing distance, a connection to the developing embryo is maintained via the **connecting stalk**, which later becomes the umbilical cord.
- These changes occur during the **3rd to 4th week** of development, a period when the **embryonic heart also starts to function**.

Development of the Chorionic Sac and Villi:

- The cytotrophoblast is a single-layered population of cells that lies underneath and is surrounded by the multinucleated syncytiotrophoblast.
- As development progresses, the cytotrophoblast begins to proliferate, forming solid cellular projections that extend into the syncytiotrophoblast without blending into it.
- These projections are called **primary chorionic villi** — columns of cytotrophoblast cells pushing toward the syncytiotrophoblast.
- At this stage, they do not participate in maternal-fetal exchange yet; they are structural and non-functional in terms of nutrient or gas exchange.
- Eventually, these villi will be invaded by extraembryonic mesoderm, transforming them into **secondary chorionic villi**, which mark the next stage in villous development.
- In the secondary stage, the cytotrophoblast cell columns become solid masses that are invaded by the **somatic extraembryonic mesoderm**, which fills the interior of the primary villi structure.
- This results in a central core of somatic mesoderm surrounded by cytotrophoblast cells, projecting toward the syncytiotrophoblast.
- These secondary villi still do not function in exchange processes.
- Once **blood vessels** begin to form inside the core of the somatic mesoderm, they invade these secondary villi — transforming them into **tertiary chorionic villi**, which are now capable of participating in maternal-fetal exchange.

Summary:

- Primary villi = just cytotrophoblast cell column.
- Secondary villi = primary + mesoderm invasion.
- Tertiary villi = secondary + blood vessels inside.

The tertiary villi that we make are now in close proximity to the lacunae network or the intervillous space, as previously explained.

They move toward the syncytiotrophoblast, where the lacunae network also resides. These spaces are located between the villi, and this is why they are called **intervillous spaces**.

The villi keep growing, and the lacunae network stays nestled between them until it fully integrates, forming the mature intervillous spaces.

Once they become intervillous spaces, they facilitate more efficient blood filtration between the maternal and fetal sides.

The tips of the cytotrophoblast also continue growing outward, forming the **cytotrophoblastic shell** above the intervillous spaces and surrounding the villi.

The **trophoblastic shell** acts as a cellular barrier separating maternal tissue from fetal tissue.

That concludes the discussion of placental circulation.

The placenta

- The embryo is implanted inside the endometrium.
- Until the end of the embryonic period, the entire embryo with all its membranes remains within the endometrium.
- As development continues, the chorionic membrane grows larger and begins pressing against the endometrium, eventually bulging toward the uterine cavity.
- The villi we discussed earlier served the small embryo, but as it grows, it requires a more substantial source of nourishment — leading to the formation of the placenta.
- The placenta is essentially the same structure, renamed to reflect its expanded role. The villi we referred to earlier are now considered part of the placenta. To this, we add the chorionic membrane — specifically called the *chorion frondosum* — along with the *decidua basalis* from the maternal side. Together, they form the placenta.
- As the embryo bulges toward the uterine cavity, it moves away from the maternal blood supply (villi and sinuses).
- With this bulging, the embryo stretches these villi, restricting them only to the area where it connects with the uterine wall.
- The villi facing the uterine cavity eventually disappear since they no longer serve a purpose there.
- The placenta consists of two parts — a fetal part and a maternal part.
- The fetal part is the villous (fetal) chorion.
- The maternal part is the decidua basalis.
- By the way, decidua means the functional part of the endometrium that sheds after pregnancy. In Arabic, it's called مشيشمة.
- The chorionic villi become restricted and attached only to the uterine wall, as the embryo develops and bulges into the uterine cavity.
- The amniotic sac surrounds the entire embryo as it grows, while the yolk sac disappears or degenerates, becoming part of the umbilical cord.
- The amniotic cavity grows so fast that it eventually fills and overtakes the entire chorionic cavity, causing the chorionic cavity to disappear.

The decidua is the functional part of the endometrium.

It consists of three parts:

- **Decidua basalis** — located beneath the chorionic villi.
- **Decidua capsularis** — the part of the endometrium that bulges toward the uterine cavity with the embryo.
- **Decidua parietalis** — the remaining part of the endometrium lining the uterus that doesn't surround the embryo.

The embryo keeps growing until the decidua capsularis and decidua parietalis fuse into a single layer.

As we said also, the amnion grows fast and eventually fills the chorionic cavity.

Together, they form the amniochorionic membrane = which is the amniotic sac + the chorionic cavity.

The amniochorionic membrane connects with the **Decidua parietalis.**

The cytotrophoblastic shell connects with the **Decidua basalis**.

The chorionic plate with separate the amniotic cavity and developing embryo from the **Decidua**.

The chorionic plate connects with the umbilical cords and it has the intense blood vessels that conduct it between the mother and the fetus

The tertiary villi would branch even more to reach the end to be called the stem villi that branches off heavily, which increases the surface area for the exchange of blood between the villi and the intervillus spaces and so the embryo it self

Exchange happen through the placental membrane, which consists from:

• **Syncytiotrophoblast cytoplasma**

• **Cytotrophoblast**

• **Connective tissue (extra-embryonic mesoderm)**

• **Capillaries endothelium**

Cytotrophoplastic cells and mesodermal layer begin to disappear and then capillaries endothelium come in direct contact with syncytiotrophoblast

The blood that fills the intervillus space from the:

spiral artery ← straight artery ← radial artery

spiral vein → straight vein → radial vein

The area that is between the cytotrophoblastic shell and the endometrium is NOT smooth, due to the septae that the endometrium sends toward the developing villi, so interdigitation will be formed between the cytotrophoblastic shell and the endometrium, all of this will result in the septation of the endometrium (Decidua) into what is called ***Cotyledon***

Amnion and yolk sac

amnion **=** amniotic membrane, a thin cell layer surrounding the **+** amniotic cavity.
The amniotic cavity lies directly next to the dorsal side of the developing embryo—whether it's a bilaminar or trilaminar disk, or during embryo folding.

Inside the amniotic cavity is amniotic fluid, which nourishes the early embryo mainly by water filtration.

As the embryo grows and folds, the amniotic cavity expands to surround the entire embryo, staying with it until birth.

In short, the embryo develops inside the amniotic sac, filled with protective amniotic fluid.

As we said again, the amnion grows fast and eventually fills the chorionic cavity.

Together, they form the amniochorionic membrane = which is the amniotic sac + the chorionic cavity.

The sources of the fluids of the amniotic cavity:

1. Early by the filtration of the F. tubule and endometrium (**mother**)

2. Then by the fluids that are filtrated through the inter-lacunar villi (**mother**)
3. Then by the blood vessels of the developing embryo (**mother**)
4. Then by the filtration of skin of the embryo during keratinization (**embryo**)
5. Then by the urinary system after the renal system develop enough to produce urine by urination, and it is also by the GI, respiratory tract, breathing the amniotic fluid contains so many molecules and amino acids that help the maturity of the lungs (**embryo**)

These fluids are also filtered and circulated again back to the fetus

Function of the amniotic fluid:

1. Mechanical shock protection
2. Chemical protection and nourishment where it protects the developing internal structures and skin
3. Temperature regulation for the embryo
4. Aids in the symmetry of limbs of the embryo and for the free development o limbs, where if there is dehydration or oligioammionitic fluid will causes abnormalities

The yolk sac:

Ventrally located, where it goes through stages:
Primary then it pinches off where it turns into secondary yolk sac where it goes and connect with the umbilical cord fold where it is functional there
It has fluid but then decreases, making the amniotic one is the major part for the nourishment

Covered by the splanchnic part of the extra-embryonic mesoderm while the amniotic cavity covered by the somatic part of the extra-embryonic mesoderm along with the chornionic membrane (also recalling that this membrane got the developing blood vessels)

Functions of the yolk sac:

1. Blood vessels build
2. Germ cells for the developing gonads during the 6th week
3. Connects with the midgut where it helps for the development of GIT
4. Nourishment of embryo in early stages