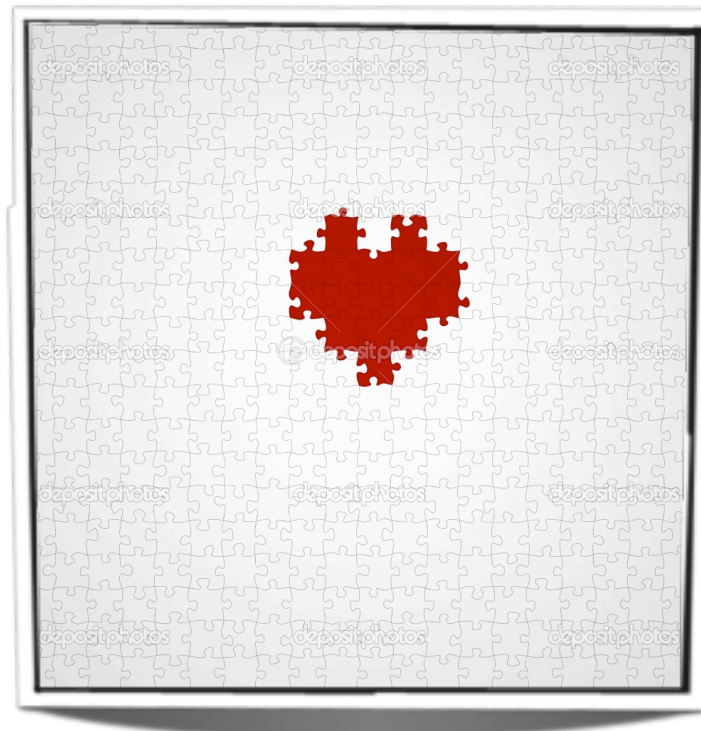

Embryology

Development of the Heart

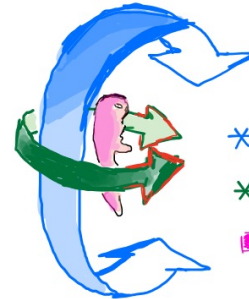
Embryology team:

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FORMATION OF THE HEART TUBE

- * The heart is the first functional organ to develop.
- * At the 18th day (before cranial-transverse-fold) angioplastic cords (forming islets of angioplastic cells) canalize to form the two heart tubes. Cranial to the mouth cavity and nervous system, ventral to the developing pericardial sac.
- * After cranial fold, the developing heart tubes lie in the ventral aspect of the embryo dorsal to the developing pericardial sac.
- * After lateral folding of the embryo, the two heart tubes fuse together in craniocaudal direction in the pericardial cavity forming a single endocardial heart tube.
- * The heart begins to beat at 22 to 23 days. Blood flow begins at the 4TH week . Can be visualized by Ultrasound Doppler.



- * Transverse folding
- * Lateral folding
- Imaginary embryo

FATE OF THE HEART TUBE

- * The rate of its development is faster than the pericardial sac. Due to this it shows five alternate dilations separated by constrictions. The endocardial heart tube has 2 ends:
 - * Sinus Venosus (most caudal).
 - * Truncus Arteriosus (most cranial).
 - * Bulbus Cordis.
 - * Common Ventricle.
 - * Common Atrium.

U-SHAPED HEART TUBE

- * Bulbus cordis and ventricle grow faster than other regions causing the heart tube bends upon itself, forming the U-shaped heart tube.
- * A part of bulbus cordis and ventricle unite together and form the bulboventricular loop (while the other part of bulbus cordis forms aortic vestibule & infundibulum).

LOOP FORMATION OR S-SHAPED HEART TUBE

- As the heart tube develops, it bends upon itself. The atrium and sinus venosus become dorsal to the truncus arteriosus, bulbus cordis, and ventricle. (S-shaped)

VEINS ASSOCIATED WITH HEART DEVELOPMENT

- * By this stage the sinus venosus has developed two lateral expansions (two horns). Right and left horns and the body.
- * Each horn of the sinus venosus receives three veins:
 1. **Common cardinal vein**: from the fetal body.
 2. **Vitelline vein**: from the yolk sac.
 3. **Umbilical vein**: from the placenta or umbilical cord.

FATE OF SINUS VENOSUS

- Due to shift of circulation from left to right, the right horn of the sinus venosus will enlarge. The **left horn** and **body** will **atrophy**.
 - * **The right horn**: forms the smooth posterior wall of the right atrium.
 - * **The left horn and body**: form the coronary sinus.
 - * **The left common cardinal vein**: forms the oblique vein of the left atrium.

RIGHT ATRIUM

- * **Rough trabeculated anterior part** of the right atrium is derived from the **primordial common atrium**.
- * **Crista terminalis** (internally) and **sulcus terminalis** (externally) is a demarcation that separates the anterior rough wall and posterior smooth wall.

LEFT ATRIUM

SMOOTH PART:

- * Most of the left atrial surface is smooth.
- * The four pulmonary veins open into the left atrium and form the smooth part.
- * The smooth part: derived from the absorbed Pulmonary veins.

ROUGH PART:

- * The rough part is restricted only to left auricle.
- * **Rough trabeculated part (left auricle)**: derived from the common primordial atrium.

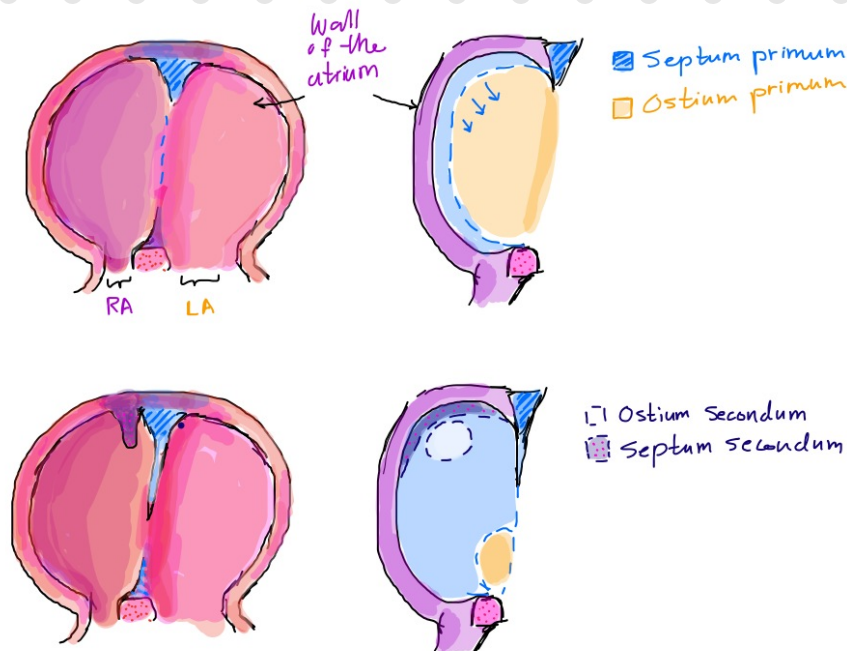
PARTITIONING OF PRIMORDIAL HEART

- Partitioning begins by the middle of 4th week and is completed by the end of 5th week.

1-Partitioning of the atrioventricular canal (Separating the common atrium from the ventricle, forming AV orifices):

*2 endocardial cushions form on the dorsal and ventral walls of the AV canal. They grow and fuse forming the **septum intermedium** which divides the AV canal into right and left canals.

*These canals partially separate the primordial atrium from the ventricle.



2-Partition of the common atrium (Into left and right atrium):

*Septum Primum

*It is a sickle-shaped septum. Grows from the roof of the common atrium towards the septum intermedium.

*Its anterior and posterior ends reach the endocardial cushions before its central part forming a gap between the right and left atrium. This gap is called **ostium primum**.

*It serves as a shunt, enabling the oxygenated blood to pass from right to left atrium.

*The ostium primum shrinks and disappears as the septum primum fuses completely with the endocardial cushions to form the **interatrial septum**.

*Septum secundum.

*The upper part of septum primum shows gradual resorption as it is pulled downward forming 4 openings that fuse together into a foramen called **ostium secundum**.

*Another septum descends on the right side of the septum primum called **septum secundum**. The blood can still escape to the LA by moving below the septum secundum from the ostium secundum.

*It forms an incomplete partition between the two atria.

Consequently a valve-like foramen forms, (**foramen ovale**).

Fate Of Foramen Ovale

Before birth: Blood moves from RA -high pressure- through the foramen ovale to LA -low pressure- (due to lack of blood in the lungs).

At birth: As the lung starts working, the four pulmonary veins will drain blood into the left atrium. The pressure in LA increases and exceeds that of RA.

- *The two septae oppose each other and clap shut.
- *Its site is represented by the **Fossa ovalis**.
- *The **septum primum** forms the **floor** of the fossa ovalis.
- *The **septum secundum** forms the **margin -limbus (anulus) ovalis**.

3-Partitioning of Primordial Ventricle (Into right and left ventricles):

*Muscular part of the interventricular septum:

*Division of the primordial ventricle is first indicated by a median muscular ridge, ascending from the floor, the primordial interventricular septum.

*It is a thick crescentic fold which has a concave upper free edge.

*This septum bounds a temporary connection between the two ventricles called **interventricular foramen**.

*The muscular part of the IV septum is derived from:

- 1.A tissue extension from the right side of the endocardial cushion.
- 2.Aorticopulmonary (spiral) septum.
- 3.Thick muscular part of the IV septum.

*Spiral aorticopulmonary septum

*A spiral septum develops within the **truncus arteriosus** dividing it into **aorta** and **pulmonary trunk**.

*The pulmonary artery joins the right ventricle while the aorta joins the left ventricle.

4-BULBUS CORDIS (Into the infundibulum and the aortic vestibule)

The bulbus cordis forms the smooth upper part of the two ventricles.

Right Ventricle: **Conus Arteriosus or Infundibulum** of the right ventricle which leads to the **pulmonary trunk**.

Left Ventricle: **Aortic Vestibule** of left ventricle which leading to **ascending aorta**.

MAJOR CARDIAC ANOMALIES

Atrial Anomalies:

1- Atrial Septal Defects (ASD):

*Absence of septum primum and septum secundum(or septum secundum only) leads to **common atrium**.

2- Excessive resorption of septum primum (ASD):

*There is no septum primum, so the fossa ovalis won't be closed.

3- Patent foramen ovale:

*An opening between the two atria.

Ventricular Anomalies:

1- Ventricular septal defect (VSD) (Roger's disease):

*Absence of the membranous part of interventricular septum.

*Usually accompanied by other cardiac defects.

2- Tetralogy of Fallot (once the baby cries, he will be bluish):

A.VSD: the two ventricles are opened into each other.

B.Pulmonary stenosis (constriction).

C.Overriding of the aorta: the aorta receives blood from the right and left ventricles.

D.Right ventricular hypertrophy: due to the excess pushing of blood.

3- Transposition of great arteries (vessels) or TGA:

*TGA is due to abnormal rotation or malformation of the aorticopulmonary septum. The right ventricle joins the aorta, while the left ventricle joins the pulmonary artery.

*One of the *most common causes* of **cyanotic heart disease** in newborn.

*It is *often* associated with ASD or VSD.

4- Persistent Truncus Arteriosus:

*It is due to failure of the development of the aorticopulmonary (spiral) septum.

*It is usually accompanied with VSD.

The Organ	The Origin
Heart	Splanchnic mesoderm in the wall of yolk sac (cardiogenic area)
Heart primordium (2 heart tubes)	Angioplasic cords
Single endocardial heart tube	Fusion of 2 heart tubes
Smooth posterior wall of right atrium	Right horn of the sinus venosus
Smooth part of left atrium	Absorbed pulmonary veins
Coronary sinus	Atrophy of left horn & body of the sinus venosus
Oblique vein of the left atrium	Left common cardinal vein
Rough trabeculated anterior part of the right atrium (musculi pectinati)	Primordial common atrium
Rough trabeculated part of the left atrium; left auricle	
Ostium primum	Fusion of anterior & posterior ends of septum primum
Ostium secundum	Resorption of upper part of septum primum
Foramen ovale	Septum secundum
Interatrial septum	Fusion of septum primum with septum intermedium & disappearance of ostium primum
Fossa ovalis	Foramen ovale
Floor of fossa ovalis	septum primum
Limbus (annulus) ovalis	septum secundum
Interventricular septum: A) Muscular part.	A) Median thick crescentic fold.
Membranous part.	A) 1- Tissue extension from Rt side of septum intermedium. 2- Aorticopulmonary septum. 3- Thick muscular part of IV septum.
Aorta & pulmonary trunk	Truncus arteriosus
Smooth upper part of 2 ventricles (infundibulum & aortic vestibule)	Bulbus cordis

Thank you

