Paediatrics Cardiology

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CARDIAC EMBRYOLOGY

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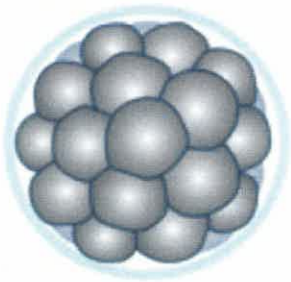
Introduction 00:00:19

Overview

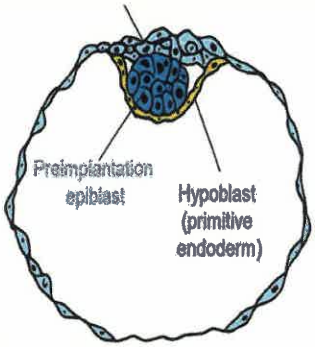
- Heart : First functional organ to develop in embryo.
- Timeline :
  - Starts : 3rd week of gestation.
  - Completes : 8th week of gestation.
- Nutritional requirement at 3rd week cannot be satisfied only with diffusion.
- Developement : Mesoderm (Cardiogenic plate).

Timeline :

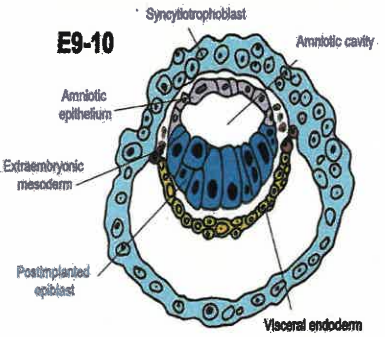
Timeline	Features
Day 15-16	Cardiogenic cells migrate from primary heart field
Day 18-19	Endocardial tube form
Day 20-21	Tube fuse to create the primitive chambers
Day 22	Heart (Primitive heart tube) begins to beat
Day 22-28	Cardiac looping starts and completed by day 28
Week 4-8	Atrial, ventricular separation and outflow tract formation takes place
8 weeks	Major cardiac development is complete



Morula



Blastocyst

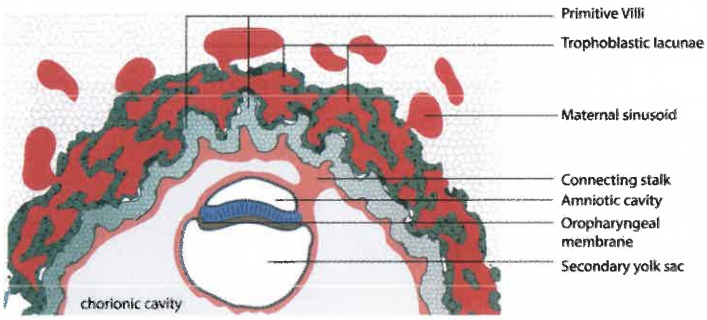


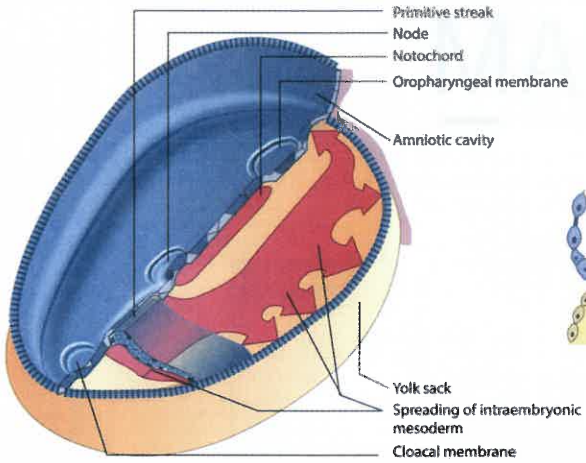
9-day blastocyst

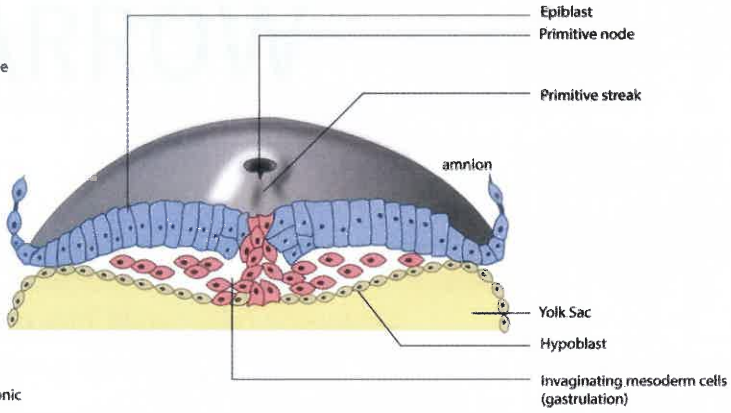
- Morula : 16 cell stage.
- Outer cell mass (Trophoblast) :
  - Cytotrophoblast : Cuboidal cells, mononuclear cells.
  - Syncytiotrophoblast : Multinucleated cell lining.
- Inner cell mass (Embryoblast) :
  - Tall columnar epiblastic layer : Cavity is formed (Amniotic cavity and cells surrounding are amnioblast).
  - Cuboidal hypoblast layer.

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Development of heart

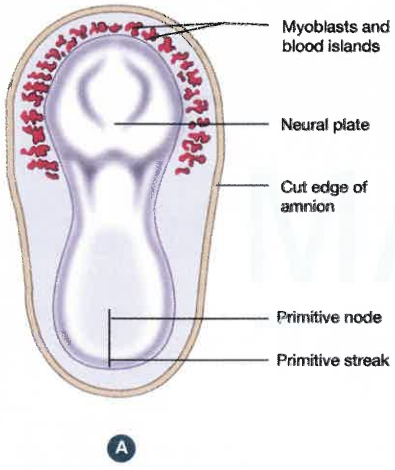


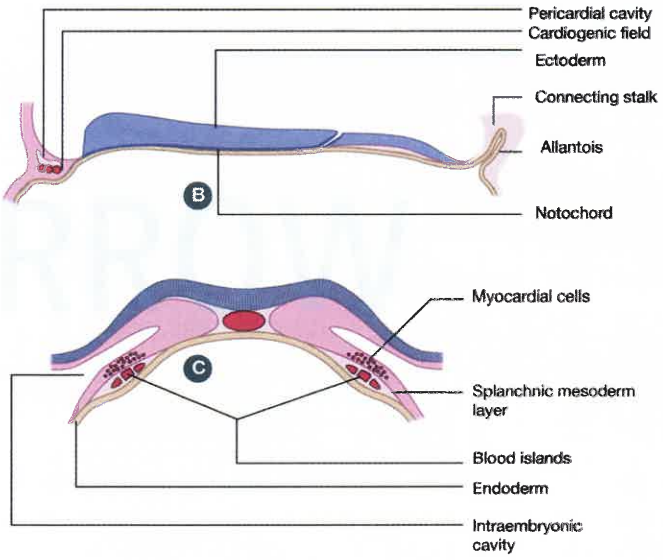




- Trophoblast layer : Undergoes vaculisation.
- Syncytiotrophoblast : Invades endometrium eroding capillary system of maternal endometrium leading to blood islands (Helps in increasing in diffusion of oxygen from maternal side to fetal side).
- Extraembryonic mesoderm : Forms chorionic cavity.

Embryonic development of heart





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- Cells from epiblast layer enters space between hypoblast and epiblast through primitive streak (Happens during gastrulation).
- Gastrulation : Formation of 3 germ layers (Ectoderm, endoderm and mesoderm).
- Mesoderm divides into paraxial, lateral plate and intermediate mesoderm.
- Lateral plate mesoderm divides into splanchnopleuric and somatopleuric mesoderm.

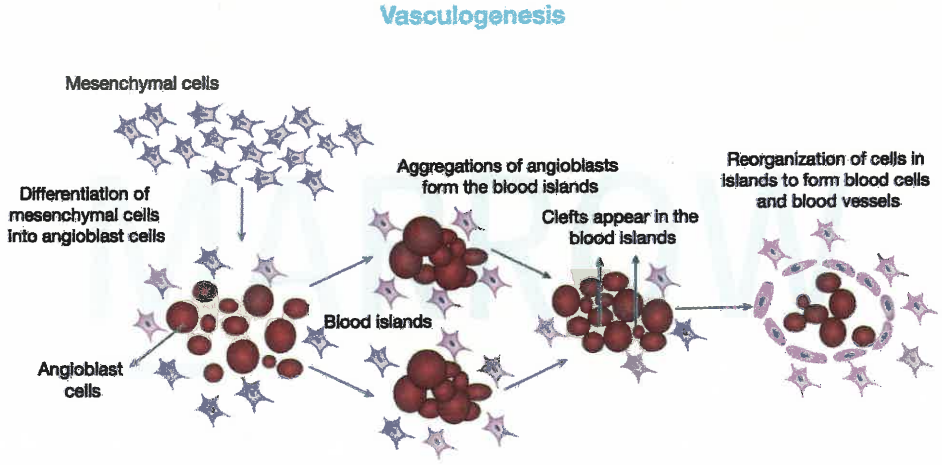
Establishment of cardiogenic field 00:08:46

Overview :

- Cardiogenic progenitor cells lie in the epiblast.
- Epiblast cells migrate through the primitive streak cranially to lie in splanchnopleuric layer of mesoderm.
- Splanchnopleuric layer of lateral plate mesoderm is induced by the underlying pharyngeal endoderm to form cardiac angioblasts.
- Blood islands appear in this mesoderm forming blood cells and vessels.
- Form a horseshoe shaped primary heart field along the cranial end of the embryonic disc in front of buccopharyngeal membrane and neural folds.

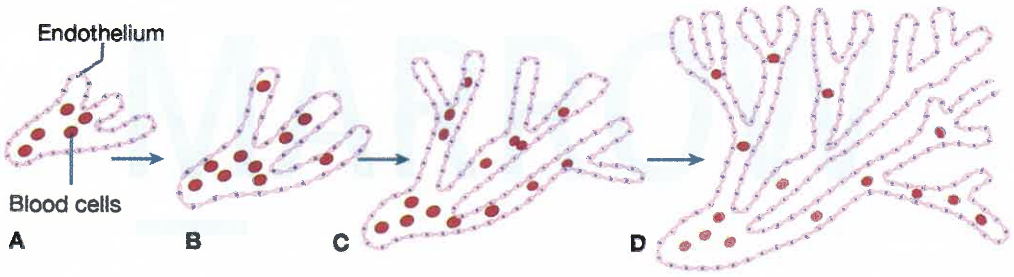
Primary and secondary heart field :

- 2 distinct populations of mesodermal progenitor cells.
- Primary heart fields : mesodermal cells located in cardiogenic field.
  - Differentiate early and contribute to primary heart tube, which later loops and develops into different chambers.
  - Develops into atria, LV and part of RV.
- Secondary heart field : Appears by 21st day in the splanchnopleuric mesoderm ventral to pharynx.
  - Part of right ventricles and outflow tracts of heart.



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Vasculogenesis



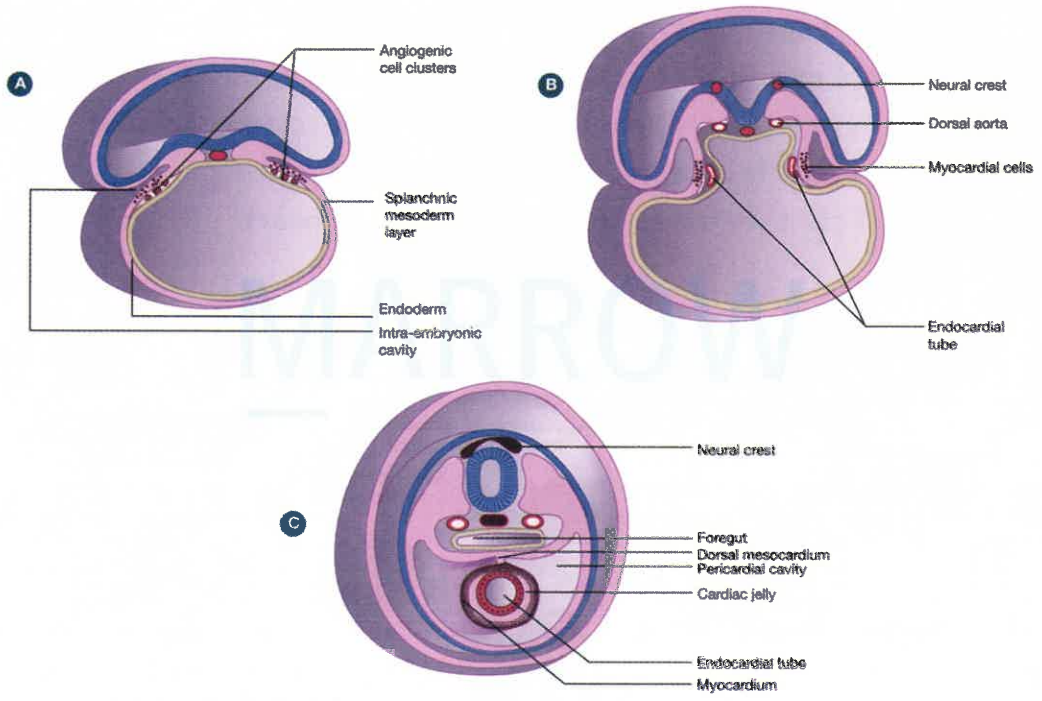
- Molecular regularization of vasculogenesis : FGF2 and VEGF.
- Angiogenesis : VEGF, PDGF and TGF-beta.

Vasculogenesis and angiogenesis :

- Ist blood cells : Formed by induction of mesodermal cells to hemangioblasts (Common precursor for blood cells and vessels).
- Later : Definitive hemopoietic stem cells develop in bone marrow.
- Blood vessels develop by 2 processes : vasculogenesis and angiogenesis.
- Vasculogenesis : Process of differentiation of angioblasts into endothelial cells and formation of primitive vascular network.
- Angiogenesis : Process of sprouting of new vessels from existing ones.

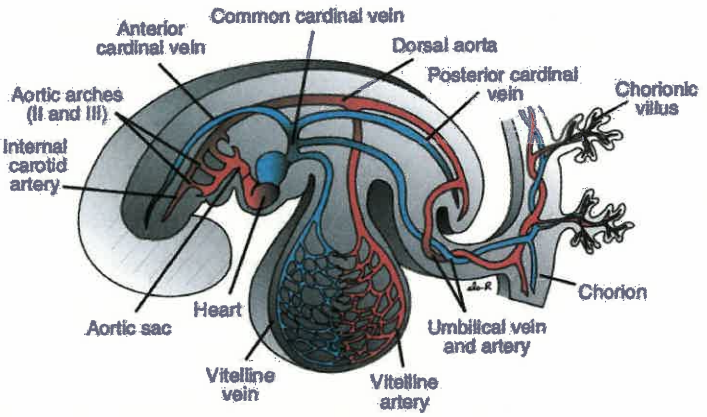
Formation of extraembryonic blood vascular system :

Development of heart



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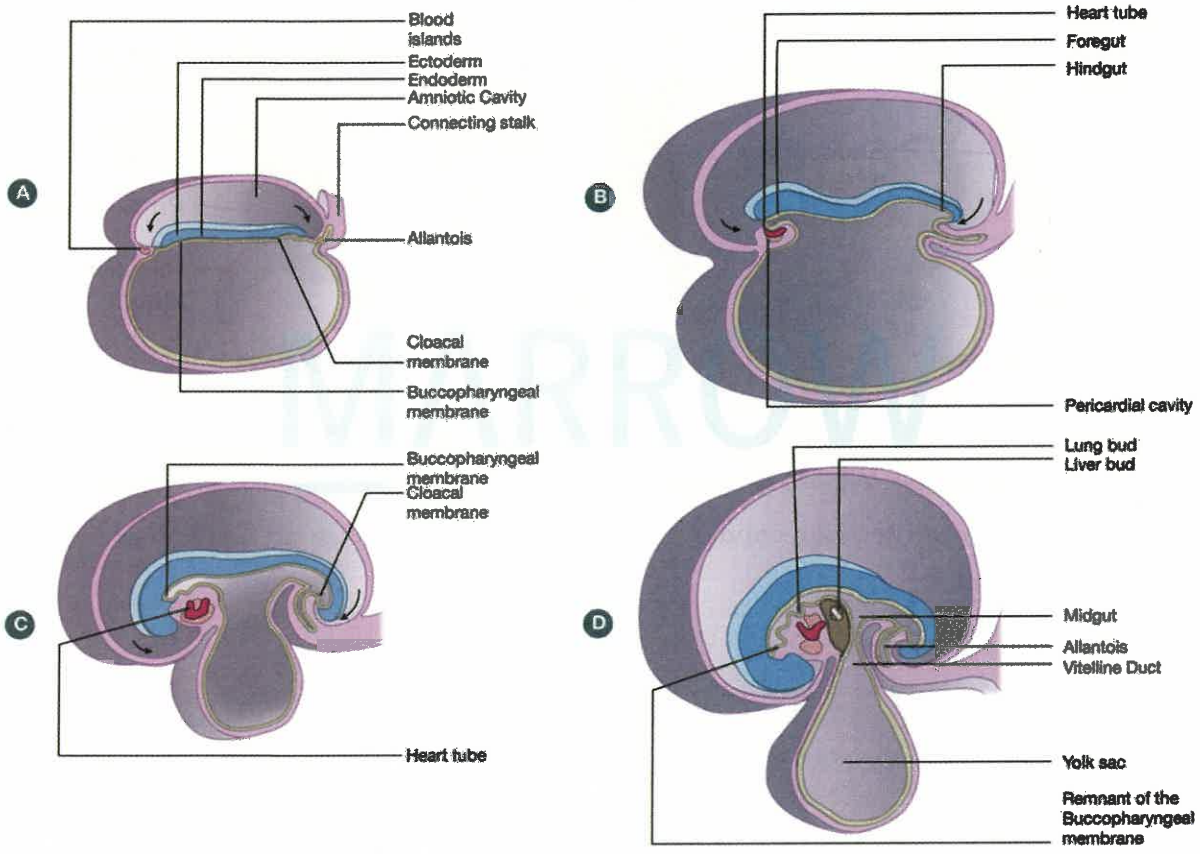
- Primitive heart tubes develops in the cardiogenic area.
- 2 longitudinal vessels (Dorsal aortae) develop on either side of notochord & along the dorsal wall of yolk sac.
- Other blood islands appear bilaterally, parallel & close to the midline of the embryo.
  - Cardinal vessels develop in the body wall of the embryo.
- Early part of 3rd week :
  - Wall of yolk sac : Vitelline vessels.
  - Connecting stalk & chorion : Umbilical vessels.
- Cranially : Dorsal aortae invade the cardiogenic area and join the primitive heart tubes at cephalic end of embryonic disc.
- Caudal end : Dorsal aortae extends into connecting stalk as umbilical arteries.



Extraembryonic circulating system

Folding :

Development of heart



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Cephalocaudal folding of embryo :

Splanchnopleuric mesoderm and developing heart come to lie ventral to the foregut.

Lateral folding of embryo :

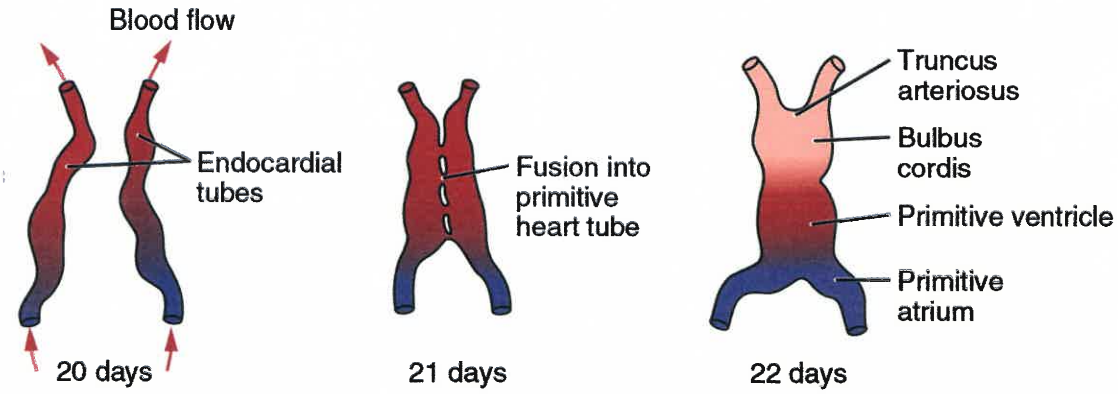
- Somatopleuric mesoderm : Forms the outer layer of (Parietal) pericardium.
- Splanchnopleuric mesoderm : Forms the inner layer of (Visceral) pericardium.
- Tube lies dorsal to the pericardial cavity & ventral to foregut.
- intraembryonic cavity over CF develops into the pericardial cavity.
- Splanchnopleuric mesoderm lining the dorsal side of the pericardial cavity proliferates to give rise to myocardium and visceral pericardium.
- Parietal layer of pericardium : Derived from somatopleuric mesoderm.

Formation of primitive heart tube

00:19:48

Formation :

- Day 20-21 : Tube fuse to create the primitive heart tube with primitive chambers.
- Day 22 : Heart (Primitive heart tube) begins to beat.

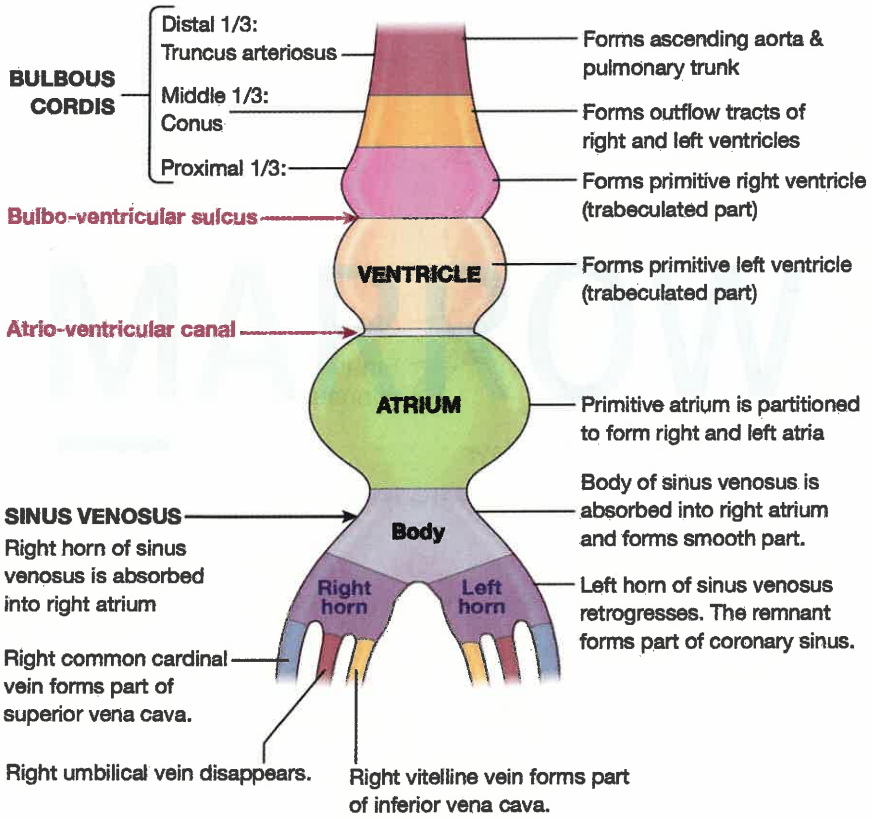


Formation of primitive heart tube

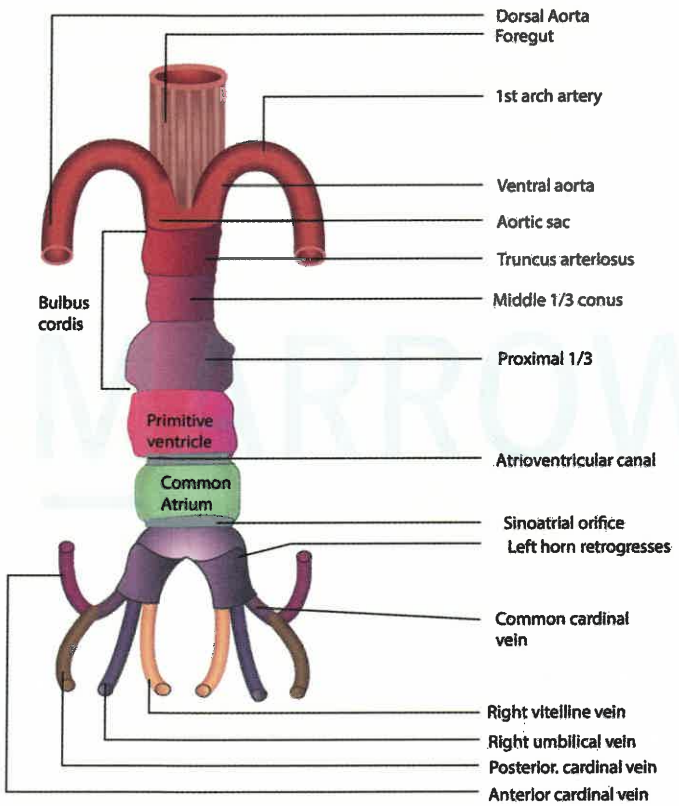
- Sinoatrial orifice : Orifice between sinus venosus and primitive atrium.
- Atrio-ventricular canal : Junction between primitive atrium and primitive ventricle.

Heart tubes at final stage of development

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Subdivisions of fused heart tube

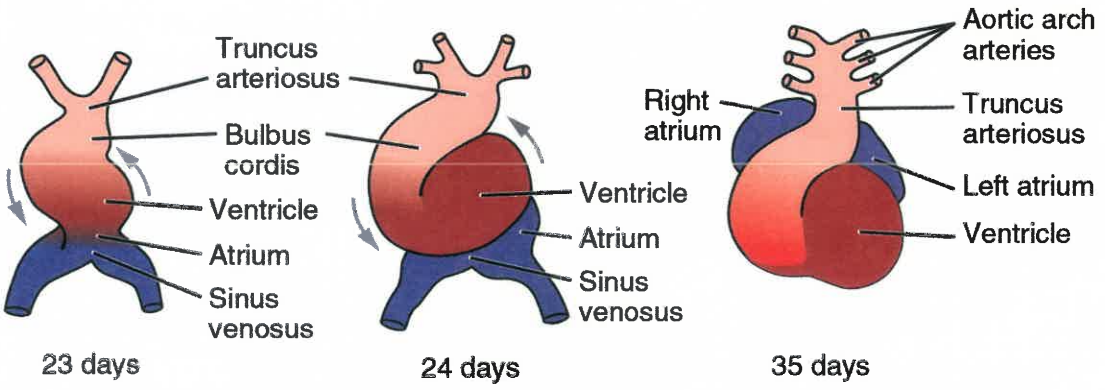


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Looping of the heart tube

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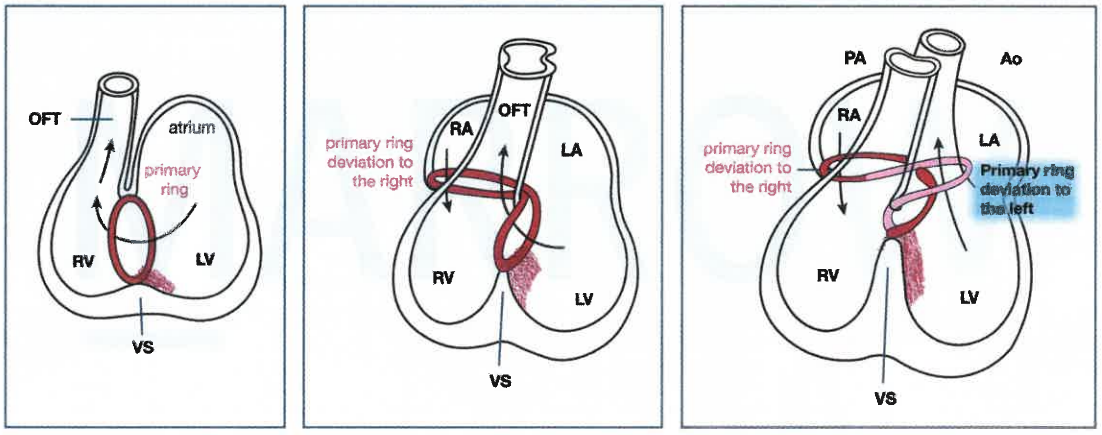
Features :



Looping of the heart tube

- Day 23 : Cardiac looping starts.
- Heart tube elongates and bends into an S-shape.
- Dextral looping (D-looping) occurs, positioning the atria postero-superiorly and ventricles antero-inferiorly.
- Cardiac looping is complete by day 28.
- Errors in looping : Lead to congenital defects such as dextrocardia, heterotaxy syndrome.
- Cephalic portion : Bends ventrally, caudally and to the right.
- Caudal portion : Shifts dorsocranially and to the left.
  - DILV : Double inlet left ventricle.
  - DORV : Double inlet right ventricle.

Spiralling of aorticopulmonary septum

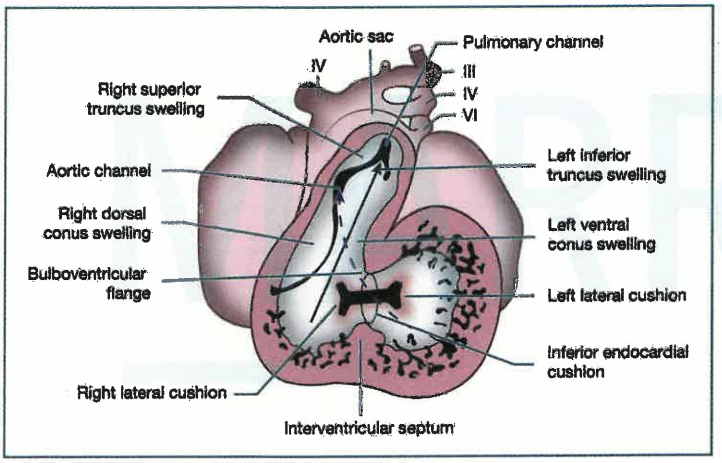


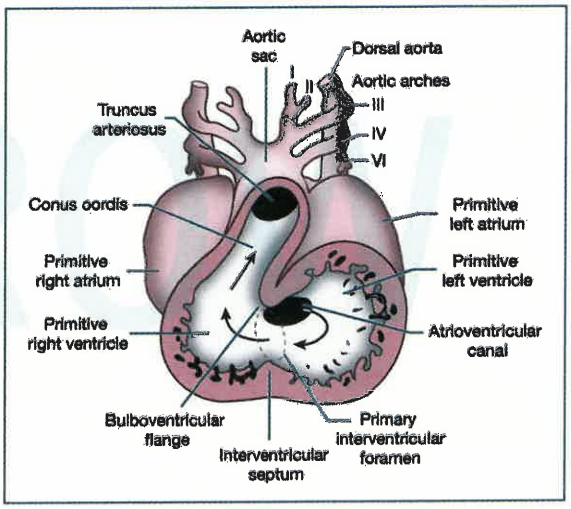
For a normal heart formation :

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- AV canal has to expand.
- Outflow tract will migrates leftward.

Anatomy of embryology of heart





Development of systemic and pulmonary veins :

Retrogression of the left horn of sinus venosus

