Cardiovascular system Embryology

2009

Blood and blood vessels

- Blood islands – vasculogenesis:
- Mesoderm (mesenchyme)
- FGF2 + VEGF induce differentiation to haemangioblasts (haematopoetic stem cells) and angioblasts (endothelium)

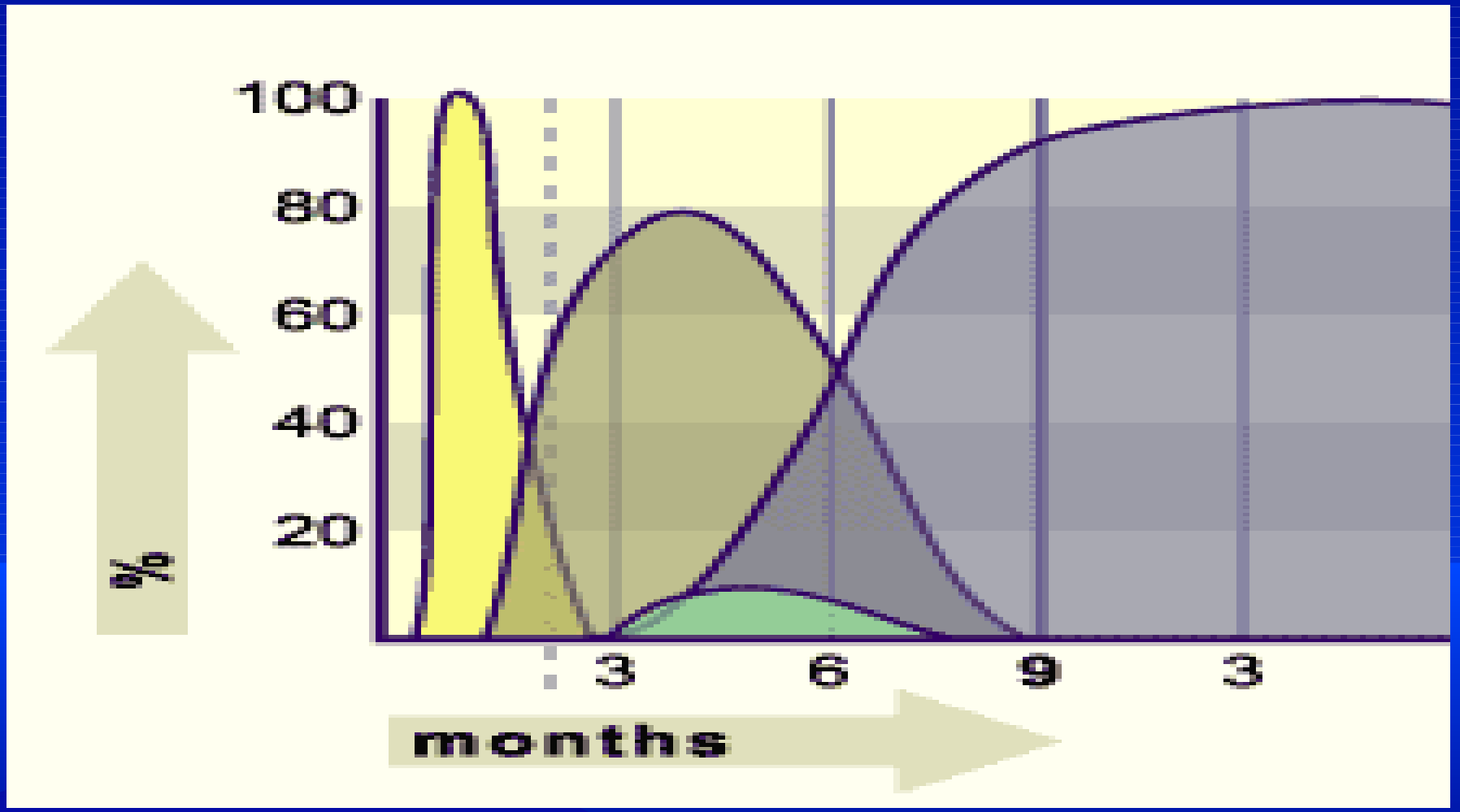
Angiogenesis

- Primary vascular bed is established by vasculogenesis
- Existing vessels sprout up = angiogenesis (mediated VEGF)
- First blood islands appear in the wall of yolk sac at the 3rd week of development, and later in mesoderm in other regions.

Haematopoesis

- First generation – blood islands - transitory
- Second generation of stem cells arise from intraembryonic mesoderm – aorta-gonad-mesonephros region. Stem cells colonize liver and spleen: hepato-lienal period
- Later, stem cells colonize bone marrow – definitive blood forming tissue

Haemopoesis



Formation of heart tube

- Cardiogenic area – in mesoderm in front of buccopharyngeal membrane and future brain
- Folding of embryonic body – pericardial cavity and heart move to cervical region and later to thorax

Heart

- Pair of cardiac primordia fuse except for the most caudal reagion
- Longitudinal growth – heart tube bulges into the pericardial cavity, it is attached to the body wall by dorsal mesocardium(that disappears later forming transverse pericardial sinus)
- Heart is fixed to septum transversum and to the pharyngeal arches (aortal arches)

Cardiac loop

- Truncus arteriosus
- Conus cordis
- Bulbus cordis
- Ventricle
- Atrioventricular canal
- Common atrium
- Sinus venosus

Development of heart tube

- Common atrium = atrium
- Bulbus cordis= trabecular part of right ventricle
- Conus cordis = outflow tract of both ventricles
- Bulboventricular sulcus= primary inter-ventricular foramen
- Ventricle = left ventricle

Septum formation in common atrium

- Timing: development starts at the end of 4th week
- Septum primum extend toward endocardial cushions of atrioventricular canal – ostium primum
- Closure of ostium primum + formation of ostium secundum (cell death).
- Septum secundum – overlap ostium secundum
- The opening left by septum secundum – oval foramen
- Remaining lower part of septum primum = valve of the oval foramen

Septum formation in the atrioventricular canal

- Atrioventricular endocardial cushions
- Superior and inferion endocardial cushions fuse – complete division (5^{th} week)
- Orifice are surrounded by mesenchymal tissue - valve

Septum formation in the truncus and conus

- Truncus swellings or cushions – twist around each other – aorticopulmonary septum – septum spirale – dividing truncus into aortic and pulmonary channel
- Swelling in conus fuse together and with truncal
- Neural crest cells (hindbrain)- contribution to the formation of the septum – abnormal migration = malformation

Formation of interventricular septum

- Muscular interventricular septum – muscular wall of ventricles
- Interventricular foramen
- Conus septum, inferior endocardial cushion and top of interventricular septum fuse forming membranous part of the interventricular septum

Development of the arterial system

- Ventral aorta
- Dorsal aorta
- Aortic arches
- Vitelline arteries
- Umbilical arteries

Aortic arches

- I. Terminal part of maxillary artery
- II (Stapedial artery)
- III. Common carotid artery
- IV. Arch of aorta and right subclavian artery
- VI. Pulmonary artery and ductus arteriosus

Vitelline and umbilical arteries

- Arteries supplying yolk sac (number of paired arteries) – vitelline arteries
- They develop in vascular supply of gut – celiac, superior mesenteric, and inferior mesenteric artery
- Umbilical arteries – paired branches of dorsal aorta – to placenta (allantois) in embryonic stalk or later in umbilical cord
- It persist as internal iliac and superior vesical arteries (medial umbilical ligaments)

Venous system

- Vitelline veins
- Umbilical veins
- Common cardinals veins

Vitelline veins

- Vitelline veins form plexus surrounding duodenum – pass septum transversum - sinusoids in liver
- Reduction of left sinus horn – blood flow enter right side of heart – right hepatocardiac channel – hepatocardiac portion of the inferior vena cava
- Network around duodenum – portal vein
- Left vitelline vein except for hepatic part disappears
- Right vitteline vein – superior mesenteric vein

Umbilical veins

- Initially pass along liver, then enter liver participating on sinusoids formation
- Proximal part of both and right left umbilical vein disappear
- Peripheral part of left umbilical vein - in umbilical cord
- Anastomosis with vena cava (right hepatocardial duct) – ductus venosus
- After birth- ligamentum teres hepatis (from artery) and ligamentum venosum (from duct)

Cardinal veins

- Anterior cardinal veins – drain cephalic part of embryo
- Posterior cardinal veins - drain the rest of embryo
- Common cardinal veins enter sinus horns

Anterior cardinal veins

- Anastomosis between anterior cardinal veins – left brachiocephalic vein – blood from the left side is moved to right
- Superior vena cava is formed from right common cardinal vein and proximal part of the right anterior cardinal vein
- Inferior vena cava develops from many different regions and venous systems