Human Vascular Development

• Overview
• Aortic Arch Development
• Arterial Vascular Development
• Venous System Development
• Lymphatic Development
• Transition from Fetal to Post-Natal Circulation
Development of the Arterial and Venous Systems

Veins
- Cardinal system
- Portal system
- R. umbilical v.
- Vitelline veins
- Posterior cardinal veins develop (28 days)
- Subcardinal veins develop
- Supracardinal veins develop
- Ductus venosus
- Portal v.
- Superior mesenteric v.
- L. umbilical v.
- Inferior mesenteric v.
- SVC
- Azygos v.
- Hemiazygos v.
- IVC

Arteries
- Blood islands form in yolk sac (day 17)
- First hepatic colonization with hematopoietic stem cells (23 days)
- Aortic arches form (days 24 to 29), vitelline network is present (day 26)
- Second hepatic colonization with hematopoietic stem cells (30 days)
- Upper limb: 41 days
- Upper limb: 46 days
- Lower limb: 49 days
- Lower limb: 60 days
- Definitive arteries to the gut, viscera and body wall differentiate
- Bone marrow colonization by definitive hematopoietic stem cells (10.5 weeks)

Days
- 21
- 28
- 35
- 42
- 49
- 56
- 63
- 70
- 77
- 84

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Cranial Ends of the Dorsal Aortae Form a Dorsoventral Loop: The First Aortic Arch
Aortic Arches Arise in a Craniocaudal Sequence Surrounding the Pharynx
Aortic Arches Give Rise to Important Head, Neck, and Upper Thorax Vessels
Aortic Arch Development in the Chick Embryo
Fgf8 is Required for Pharyngeal Arch Development in Mouse

Cardiovascular and Thymic Defects in \textit{Tbx1} Hypomorphemic Mutant Neonates

Aortic Arch Development

Dorsal aorta

1
2
3
4
5
6
7 iseg

Ventral aorta

Harsh Thaker
Aortic Arch Development

Dorsal aorta

Ventral aorta

1 2 3 4 5 6 7 iseg

Heart

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Aortic Arch and Derivatives

Aortic sac

Truncus arteriosus

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Aortic Arch and Derivatives

Harsh Thaker
Aortic Arch and Derivatives

Harsh Thaker
Recurrent Laryngeal Nerves

Harsh Thaker
Defects in Normal Regression of the Arterial System Lead to Vascular Anomalies

- **Double Aortic Arch**
  - Failure of the right dorsal aorta to regress

- **Aberrant Right Subclavian Artery**
  - Regression of the right fourth arch
  - 1% of the general population
  - 40% of patients with Trisomy 21 and CHD

- **Right Aortic Arch**
  - Retention of the right dorsal aorta segment
  - 13-35% of patients with TOF
  - 8% of patients with TGA
Failure of Regression of the Right Dorsal Aorta Leads to a Double Aortic Arch
Double Aortic Arch

Dorsal aorta

Ventral aorta

7 iseg

Harsh Thaker
Regression of the Right Fourth Arch Results in an Aberrant Right Subclavian Artery

Abnormal obliteration of the right 4th aortic arch
R. 7th intersegmental a. (precursor of r. subclavian a.)

Abnormal retention of this segment of the r. dorsal aorta

Abnormal r. subclavian a. crosses posterior to esophagus
L. subclavian a.
L. common carotid a.
R. common carotid a.

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Aberrant Right Subclavian Artery

Dorsal aorta

Ventral aorta

7 iseg
Aberrant Right Subclavian Artery
Retention of the Right Dorsal Aortic Segment Yields a Right Aortic Arch
Right Aortic Arch: Mirror Image Branching versus Aberrant Left Subclavian Artery
Vascular Rings May Cause Compression of the Trachea and the Esophagus

- **Double Aortic Arch**
  - Failure of the right dorsal aorta to regress

- **Right Aortic Arch**
  - Ductus arteriosus is directed towards the right
  - If the ductus, or later, the ligamentum arteriosum, passes behind the esophagus, constriction may occur
Double Aortic Arch Presenting with Dysphagia in a 31-Year-Old Woman
Aortic Arch Anomalies Can Cause Significant Clinically Compromise in the Neonatal Period

- **Interrupted Aortic Arch**
  - Obliteration of the right and left fourth aortic arches

- **Coarctation of the Aorta**
  - Constriction of the aorta in the region of the ductus arteriosus
  - 0.3% of live births
  - Most common cardiac anomaly in Turner’s Syndrome
Obliteration of the Right and Left Fourth Aortic Arches Leads to Interruption of the Aorta

Schoenwolf et al: Larsen's Human Embryology, 4th Edition. Copyright © 2008 by Churchill Livingstone, an imprint of Elsevier, Inc. All rights reserved.
Constriction of the Aorta in the Region of the Ductus Arteriosus Produces Coarctation
Post-ductal Coarctation of the Aorta Utilizes Collateral Circulation to Supply Blood to the Lower Body
Post-ductal Coarctation of the Aorta Utilizes Collateral Circulation to Supply Blood to the Lower Body
Vitelline Arteries Give Rise to the Arterial Supply of the Gastrointestinal Tract
Lateral Branches of the Descending Aorta Highlight Developmental Histories of Each Organ
The Developing Venous System

- Vitelline
- Umbilical
- Cardinal
Vitelline Veins Form a Portal System to Drain Blood from the Foregut, Midgut, and Part of the Anorectal Canal
The Developing Venous System

- Vitelline
- Umbilical
- Cardinal
- Subcardinal
- Supra cardinal
- Supra-Subcardinal Anastomosis

Harsh Thaker
The Systemic Venous System Develops from Four Bilaterally Symmetric Cardinal Veins
Following Remodeling of the Subcardinal System, the Supracardinal Veins Sprout
Remodeling of Abdominal Venous System Occurs through Obliteration of the Left Supracardinal Vein
Failure of Left Cardinal Veins to Undergo Normal Regression Leads to Venous Anomalies

- LSVC occurs in 0.3% to 0.5% of the normal population
- In 65% of cases, left brachiocephalic vein is also missing
- 4% of patients with CHD have an LSVC
- Usually drains to the coronary sinus
Lymph Sacs and Ducts Form by Lymphangiogenesis to Drain Fluid from Tissue Spaces Throughout the Body
Cystic Hygromas Develop in Turner’s Syndrome Patients Secondary to Blockage of Lymphatic Ducts
Fetal Circulation Bypasses the Developing Pulmonary Circulation
Pulmonary Vascular Resistance Drops Precipitously and Initiates the Transition to Post-Natal Circulation
Normal Closure of the Ductus Arteriosus Occurs during the Transition to Neonatal Circulation in Series

- Prostaglandins maintain a patent ductus arteriosus
- Indomethacin is used to induce ductal closure
- Physiologic closure occurs by 2 days in 82% of patients