Embryology of the CNS Vasculature
Posterior Circulation Anatomy

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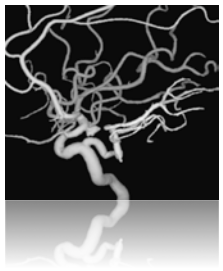
Learning Objectives

- Understand the key aspects of embryological development of the cerebral circulation, and how variations in anatomy relate to these complex events
- Appreciate normal vascular anatomy of the vertebrobasilar circulation and common variants, with an emphasis on clinical and therapeutic aspects
- Apply knowledge of cerebrovascular anatomy to specific clinical scenarios

Disclosures: None

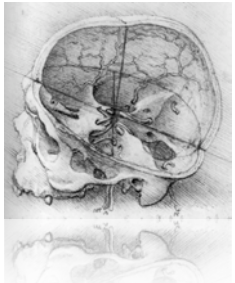
Introduction

- Mastery of anatomy is essential for physicians involved in the management of patients with vascular diseases of the nervous system.
- Classical anatomy and its variations cannot be understood without an appreciation of key stages of embryological development



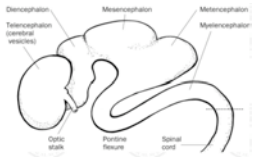
Historical Aspects

- Anatomical studies by Da Vinci, Vesalius, Willis and others laid the foundation for modern medicine
- Principal stages of neuroembryology and vascular development described by Padget in early 20th century
- Rhoton - microsurgical anatomy
- Lasjaunias - developmental and functional anatomy



Neural tube to brain and spinal cord .....

- Neurulation
- Flexures and dilatations
- Vesicles
- The development of cerebral arteries is a continuous process of adaptation to changes in the size, shape, and metabolic demands of the brain

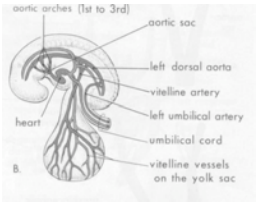


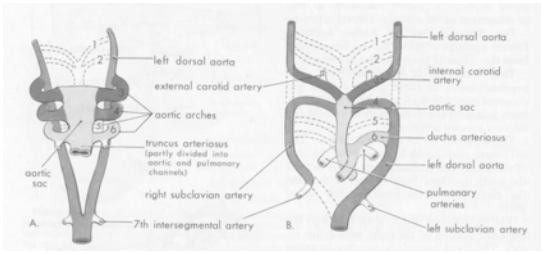
Concepts of Vascular Embryology

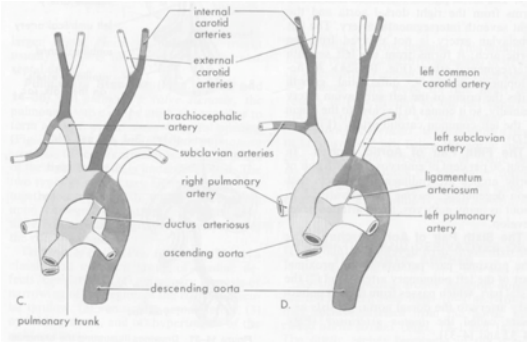
- Vasculogenesis
  - de novo formation of blood vessels
- Angiogenesis
  - succession of morphogenetic events including sprouting, splitting, and remodeling
- Vascular Remodeling
  - an active, adaptive process of structural alteration resulting from interaction between local growth factors, vasoactive substances, and hemodynamic stimuli

Branchial Arches

- As the branchial arches develop during the fourth week, they receive arteries from the aortic sac, called "aortic arches"
- The aortic arches terminate in the dorsal aorta of the corresponding side
- During the sixth to eighth week the primitive aortic arch pattern is transformed into the adult arterial arrangement





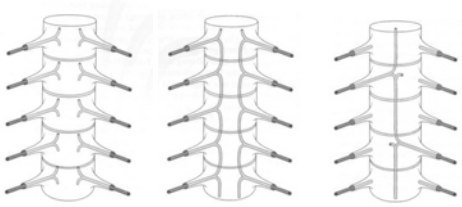


Intradural Arteries

- Prior to closure of the neural tube, nutrients diffuse directly from amniotic fluid through ependymal surface layer
- With continuous increase in thickness of the cerebral mantle, metabolic demand induces intense angiogenesis
- The paired carotid arteries (aortic arch derivatives) end ventral to the prosencephalon
- Ventral to the rhombencephalon, two longitudinal arterial channels form

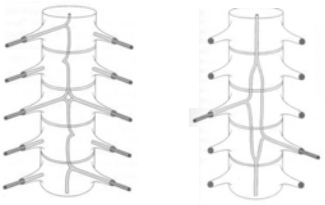
Fusion and Desegementation

Formation of paired ventral longitudinal arteries



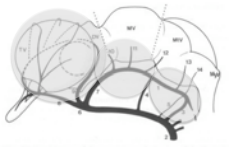
Failed Fusion

Formation of "fenestrated" and "duplicated" arteries



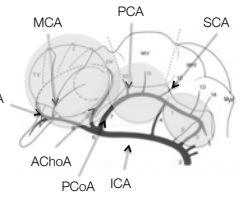
Primitive Intracranial Vasculature

- Two branches arise from carotid tree, an anterior branch around the telencephalon, and a posterior branch that reaches the cephalic end of the ventral longitudinal neural artery
- A series of anastomoses occur between the carotid and ventral longitudinal arteries - proatlantal, hypoglossal, otic, trigeminal



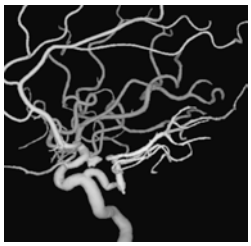
Progression to Adult Form

- Fusion of posterior branch from carotid system with ventral longitudinal artery triggers regression of earlier, caudal anastomoses
- Simultaneously, the ventral longitudinal arteries fuse in the midline to form the basilar artery, in a craniocaudal direction
- The initial point of fusion is at the level of the trigeminal artery, i.e. SCA and PCA are derivatives of primitive carotid system



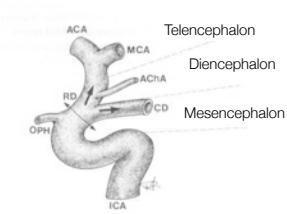
Progression to Adult Form

- Fusion of posterior branch from carotid system with ventral longitudinal artery triggers regression of earlier, caudal anastomoses
- Simultaneously, the ventral longitudinal arteries fuse in the midline to form the basilar artery, in a craniocaudal direction
- Failure of regression leads to persistent fetal anastomosis
- Most common is PTA



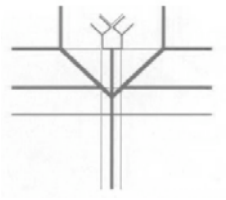
Anatomical Implications of Embryology

- The termination of the original carotid artery is at the PComm
- The anterior branch of the ICA becomes the ACA
- MCA and Anterior Choroidal are branches of ACA
- The posterior branch of ICA becomes the PComm / PCA and upper basilar trunk (including SCA)



Distal Basilar Artery Fusion

- The basilar artery is a result of two fusion processes
  - fusion of the caudal divisions of the ICAs
  - fusion of the ventral longitudinal neural arteries
- This creates a large range of variations
- The later the trigeminal artery involutes, the more caudal will be the upper basilar fusion

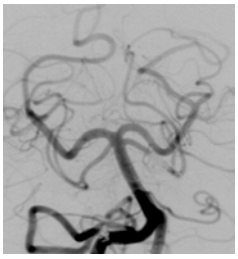


Basilar Tip Anatomy

- Three types of basilar tip anatomical dispositions, based on the relationship of SCA and PCA
- symmetrical cranial fusion
  - SCA arises separately from basilar trunk
- symmetrical caudal fusion
  - SCA arises from PCA
- asymmetrical fusion
  - In cases of asymmetrical fusion, the most cranial P1 segment gives rise to a common perforator trunk with bilateral supply

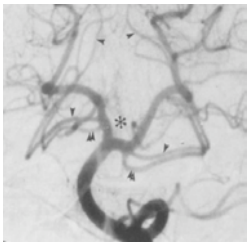
symmetrical cranial fusion

SCA arises separately from basilar trunk



symmetrical caudal fusion

SCA arises from PCA

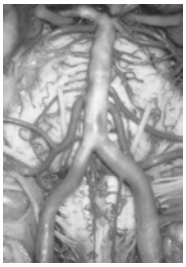


asymmetrical fusion

In cases of asymmetrical fusion, the most cranial P1 segment gives rise to a common perforator trunk with bilateral supply

Basilar Artery

- Continuation of anterior spinal axis developmentally
- Vertebral arteries are actually "radiculomedullary" analogs
- Perforators follow the same pattern as the spinal cord
- Network of pial anastomoses

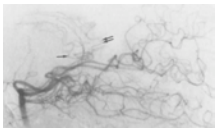


Perforating Branches

- Direct
- Short circumferential
- Long circumferential

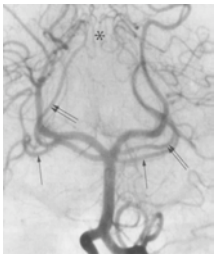
Posterior Cerebral Artery

- Choroidal branches
  - Medial posterior choroidal artery
  - Lateral posterior choroidal artery
- Cortical branches
  - hippocampal a.
  - anterior, middle, and posterior temporal aa.
  - occipital temporal a.
  - calcarine a.
  - medial parietal a.
  - splenial a.
- Critical thalamoperforators



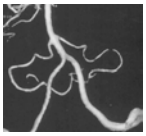
Superior Cerebellar Artery

- The more caudal the basilar fusion, the greater the likelihood of SCA origin from P1
- Cerebellar territory includes vermian (medial and superior) and hemispheric (lateral and inferior) branches, which may have a separate basilar origin
- Supply to deep cerebellar nuclei arises primarily from lateral branch of SCA



Anterior Inferior Cerebellar Artery

- Variable origin from basilar
- 75% from lower third of basilar trunk
- Consistent internal auditory artery branch
- Territorial balance with PICA



Posterior Inferior Cerebellar Artery

- The most variable cerebellar artery
- A hypertrophied radiculopial artery
- Gives rise to lateral spinal artery in 75%
- Territory varies with origin and branching
- 20% originate at or below foramen magnum
- Territorial balance with AICA

Level of PICA Origin

- Proximal origin corresponds to dorsal radiculopial vessel; i.e. no medullary branches, less eloquent supply. In this case the medullary branches arise directly from vertebral or basilar
- The more distal the PICA origin, the more likely to have medullary branches