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

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

Disclosures: None

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 ......
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

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.
  - Calcineurine 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 vermal (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