Vascular Anatomy and Variants

MRI/CT Course
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DISCLOSURES

• None
Outline

• Arterial Anatomy and Variants
  – Intracranial
  – Extracranial
  – Watershed

• Venous Anatomy and Variants
Arterial Anatomy

- **Intracranial**
  - Circle of Willis
  - Anterior Circulation
  - Posterior Circulation
  - Watershed
  - Other

- **Extracranial**
  - Cervical
  - Intra-Thoracic
Intracranial arterial structures
Intra-Cranial Arterial Anatomy

Circle of Willis

1. L. ICA
2. L. ACA (A1)
3. Ant. COM
4. R. Post. COM
5. R. PCA (P1)
7. MCA
8. Vertebral Art.
9. Optic Chiasm
10. L. PCA (P2)
11. ACA (A2)

Note: Many variations exist
Circle of Willis- Common Variants

- **ACOM**
  - Variants 10-15%

- **PCOM**
  - Hypoplastic or Absent 25-33%

Neuroradiology, p. 87
Anterior Cerebral Artery (ACA)

- **A1**
  - *Horizontal segment*
  - Hypoplastic in 5-18%
  - *Branch:*
    - *Medial lenticulostriate*

- **A2**
  - *Branch:*
    - *Recurrent artery of Heubner, from distal A1 or proximal A2*

- **A3**
  - *Pericallosal branch*
  - *Callosomarginal branch*
Anterior and Posterior Cerebral Arteries
ACA- Vascular Territory

Views:
A. Lateral
B. Medial
C. Superior
D. Base

Diagnostic Radiology, p. 135
Anterior Cerebral Artery - Variants

AM Accessory middle cerebral artery

Vasculature of the Brain and Cranial Base, p. 116-7
38 yo female with headache and vertigo

Azygous (or azygos) ACA
ACA Variants - Third A2 Segment

- 3T MRA
  - Time of flight (TOF)
  - Left carotid sequence
Middle Cerebral Artery

- M1 (Horizontal)
  - Lateral Lenticulostriates ↑
    - Lateral putamen
    - Caudate nucleus
    - External capsule

- M2 (Insular) ↑

- M3 (Opercular) ↑

- M4 (Cortical) ↑

Osborn's Brain, p. 176
Middle Cerebral Artery

- MRA
  - Submentovertex view
  - M1
    - Genu/Bifurcation
  - M2
  - M3
MCA- Distal Branches

- Central sulcus
- Anterior and posterior parietal branches of MCA
- Angular branches of MCA
- Posterior temporal branches of MCA
- Middle temporal branches of MCA
- Orbitofrontal branches of MCA
- Orbital branches of anterior cerebral artery
- Middle cerebral artery (MCA) in lateral sulcus
- Anterior temporal branches of MCA
- Rolandic branches of MCA
- Prerolandic branches of MCA

Neuroanatomy p. 19
MCA- Vascular Territory

Views:
A. Lateral
B. Medial
C. Superior
D. Base
Vascular Neuro-Anatomy- Posterior Fossa

- **Vertebral**
  - Branches:
    - Anterior spinal
    - PICA
    - ± AICA
  - Variants:
    - Embryonic carotid-vertebral fenestrations
    - Terminates at PICA (1%)

- **Basilar**
  - Branches:
    - AICA
    - SCA
    - Perforating arteries
  - Variants:
    - Hypoplasia
    - Fenestrations
PCA Branches

- **P1**
  - *Peduncular segment*
  - *Branches:*
    - Thalamo-perforating
    - Medial posterior choroidal

- **P2**
  - *Ambient segment*
  - *Branches:*
    - Lateral posterior choroidal

- **P3**
  - *Quadrigeminal segment*

- **Variant:**
  - Fetal PCA: from the ICA rather than basilar artery, seen in 15-20%
“Fetal PCA”:
Dominant Left PCOM, Hypoplastic Left P1
PCA- Vascular Territory

Views:
- A. Lateral
- B. Medial
- C. Superior
- D. Base
Vertebrobasilar Variants and Anomalies

- Asymmetry common
  - Right dominant in 25%

- Shared AICA-PICA trunk

- Vertebral terminates at PICA

- Extradural origin of PICA (5-18%)

- Duplicated PICA (2%)

- Conjoined origin of P1 and SCA

- Anomalous origin (5-6%)
  - Usually from aortic arch

- PICA anomalous origin
  - May be from ICA, associated with increased incidence of aneurysms

- Duplicated vertebral (<1%)
  - Two origins

- Fenestrated vertebral (<1%)
  - One origin
  - Associated with other malformations, including aneurysms and AVMs
Vertebrobasilar Variants

- A: hypoplastic right vert. ends in PICA
- B: absent right vert. (rare)
- C: hypoplastic right vert.
- D: hypoplastic left vert.
Vertebrobasilar Variants

Vertebral angiogram, AP view

Vertebral angiogram, oblique view

Double SCA

Basilar tip aneurysm

Fenestrated basilar artery
66 yo female with headache

Fenestration
Vascular Neuro-Anatomy:

- Watershed territory
  - Cerebral volume in-between multiple major vascular territories
  - Potentially at risk to ischemia with hypotension, especially with comorbid, critical, large vessel stenosis
  - Common location for metastatic lesions
Watershed Territory
Watershed Ischemia

- Left MCA/ACA watershed ischemic stroke secondary to high grade, left ICA stenosis
52 year old male with dementia
Persistent Trigeminal Artery

Lateral View, ICA angiogram
Persistent Trigeminal Artery

• Aka “Primitive trigeminal artery”

• Embryonic carotid-basilar anastamosis

• Connects cavernous ICA with dorsal longitudinal neural arteries (precursor to the vertebro-basilar arteries)

• Normally completely regresses

• Most common persistent embryonic carotid-basilar anastamosis
  ‒ Seen in 0.02%-0.6% of cerebral angiograms
Carotid-Basilar Anastomoses

**Posterior communicating artery (PCoA)**
From caudal division of embryonic internal carotid artery (ICA)
Connects cranial division of primitive ICA to developing vertebrobasilar circulation
Partially regresses
Variants
- “Fetal” origin of posterior cerebral arteries
- “Infundibulum” (junctional dilatation at origin from ICA)

**Primitive trigeminal artery (PTA)**
Embryonic carotid–basilar anastomosis
Connects cavernous ICA with embryonic dorsal longitudinal neural arteries
Normally regresses completely
Most common “persistent embryonic carotid–basilar anastomosis”

**Persistent otic artery (POA)**
Embryonic carotid–basilar anastomosis
From petrous ICA to embryonic dorsal longitudinal neural arteries
Normally regresses completely
Extremely rare; almost never identified angiographically

**Persistent hypoglossal artery (PHA)**
Embryonic carotid basilar anastomosis
Connects cervical ICA with embryonic dorsal longitudinal neural arteries
Normally regresses completely
Second most common persistent embryonic carotid–basilar anastomosis but <PTA
Identified angiographically by Origin from C1–2 level of cervical ICA
Does not pass through foramen magnum
Hypoglossal (anterior condyloid) canal is enlarged

**Proatlantal intersegmental artery (PIA)**
Embryonic carotid basilar anastomosis
Connects cervical ICA with embryonic dorsal longitudinal neural arteries (occasionally arises from external carotid)
Normally regresses completely
Identified angiographically by Origin from C2–3 level of cervical ICA
Lower origin, more vertical course compared with PHA
Horizontal suboccipital course along C1 ring
Two types (type II arises from ECA, is less common)
Aortic Arch and Great Vessels: Embryologic Development

4 weeks

5 weeks

6 weeks

7 weeks
Persistent Trigeminal Artery
Clinical Significance

• Usually none, except...
  – Associated with increased incidence of other vascular abnormalities (up to 25%) and up to 15% of PTA cases have coexistent aneurysms

Lateral View, ICA angiogram

Diagnostic Cerebral Angiography, p. 94
Internal Carotid Artery (ICA)

- Bouthillier nomenclature:
  - C1- cervical
    - Bulb and ascending segment
  - C2- petrosal
  - C3- lacerum
  - C4- cavernous
  - C5- clinoid
  - C6- ophthalmic
  - C7- communicating
# Vascular Neuro-Anatomy: Internal Carotid Artery Segments

<table>
<thead>
<tr>
<th>Location</th>
<th>Branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulb (C1)</td>
<td>Extra-cranial</td>
</tr>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Cervical (C1)</td>
<td>Extra-cranial</td>
</tr>
<tr>
<td></td>
<td>Rare</td>
</tr>
<tr>
<td>Petrous (C2)</td>
<td>Intra-osseous</td>
</tr>
<tr>
<td></td>
<td>- Tympanic</td>
</tr>
<tr>
<td></td>
<td>- Vidian</td>
</tr>
<tr>
<td></td>
<td>- Caroticotympanic</td>
</tr>
<tr>
<td>Cavernous (C4)</td>
<td>Cavernous</td>
</tr>
<tr>
<td></td>
<td>- Meningohypophyseal</td>
</tr>
<tr>
<td>Supraclinoid (C6-7)</td>
<td>Intracranial</td>
</tr>
<tr>
<td></td>
<td>- Ophthalmic</td>
</tr>
<tr>
<td></td>
<td>- PCOM</td>
</tr>
<tr>
<td></td>
<td>- Ant. Choroidal</td>
</tr>
</tbody>
</table>
17 yo female with migraine

• Bovine variant:
  – Origin of left CCA from brachiocephalic trunk
Aortic Arch and Great Vessels

- Brachiocephalic trunk
  - Aka “Innominate” art.
  - Branches:
    - Right subclavian art.
    - Right vertebral
    - Right common carotid

- Left common carotid

- Left subclavian
  - Branches:
    - Left vertebral
    - Other

Atlas of Neuroanatomy, p. 113
Aortic Arch: "Bovine origin"

"Bovine" Variant A

"Bovine" Variant B
True Bovine Anatomy
Aortic Arch- Normal Variants

• A: normal

• Most common variants
  – B-C: “bovine” variant
  – H: Left vert. off arch
  – K: Seen in Downs synd.
Venous Anatomy and Variants

Normal anatomy
Venous territories
Variants
Other
Central Venous System

- **Sinuses:**
  - Superior Sagittal Sinus
  - Inferior Sagittal Sinus
  - Straight Sinus
  - Transverse Sinus

- **Veins:**
  - Great cerebral vein (of Galen)
  - Basal vein, of Rosenthal
  - Internal Cerebral Vein
Vein of Galen

**Figure 10-12.** A posterior and lateral view of the vein of Galen from the left side.

- **is**  Inferior sagittal sinus
- **iv**  Inferior cerebral vein
- **CC**  Corpus collosum
- **FC**  Falx
- **STS**  Straight sinus
- **VG**  Vein of Galen
- **PMC**  Posterior medial choroidal artery
- **ICV**  Internal cerebral vein
- **CB**  Cerebellum
- **SDc**  Superior cerebellar vein
- **SI**  Superior colliculus
- **BV**  Basal vein of Rosenthal
- **Pi**  Pineal

Vasculature of the Brain and Cranial Base, p. 196
Superficial Veins

Vein of Trolard- to SSS
Vein of Labbé- to Trans. Sinus
Venous Territories

- **Cortex (Green)**
  - Cortical Veins
  - Superior Sagittal Sinus

- **Perisylvian region (Purple)**
  - Sphenoparietal sinus
  - Cavernous sinus

- **Deep structures (Red)**
  - Internal Cerebral Vein
  - Vein of Galen

- **Cortex (Yellow)**
  - Vein of Labbe
  - Transverse sinuses
Sinus Thrombosis?
Arachnoid Granulation (AG)

- Common variants
  - 8.3% M
  - 12.2% F

- Subarachnoid protrusion into sinus

- Function: CSF reabsorption

- Small AG usually demonstrate imaging features similar to CSF

Osborn, p. 216

Br. J. Rad, 1999
Arachnoid Granulation - Characteristics

<table>
<thead>
<tr>
<th>Location</th>
<th>% of Total</th>
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<tbody>
<tr>
<td>Sigmoid Sinus</td>
<td>2</td>
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<tr>
<td>Transverse Sinus</td>
<td>80-85</td>
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<tr>
<td>Confluence of Sinuses</td>
<td>5-6</td>
</tr>
<tr>
<td>Straight Sinus</td>
<td>1-2</td>
</tr>
<tr>
<td>Superior Sagittal Sinus</td>
<td>1-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>9.7</td>
</tr>
<tr>
<td>2-4</td>
<td>37.3</td>
</tr>
<tr>
<td>4-6</td>
<td>31.3</td>
</tr>
<tr>
<td>6-8</td>
<td>14.9</td>
</tr>
<tr>
<td>&gt; 8</td>
<td>6.7</td>
</tr>
<tr>
<td>&gt; 1cm (Giant)</td>
<td>Probably rare</td>
</tr>
</tbody>
</table>

1. AJNR, 1996,  
2. Br. J. Rad, 1999  
3. AJNR, 2010
Arachnoid Granulation vs. Other

T1W

T2W

FLAIR

???

???

???

Br. J. Rad, 1999
Arachnoid Granulation vs. Other

Arachnoid Granulation

Epidermoid

T1W

T2W

FLAIR

Br. J. Rad, 1999
DDx Venous Sinus Lesion

- Thrombus
- Arachnoid Granulation
- Sinus hypoplasia
- Variant bifurcation
- Intrasinus variants
  - Septa
  - Fenestrations
  - Duplications
- Other
  - Subdural Hematoma
  - Tumor
Venous Sinus Lesions

- Thrombus
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Venous Sinus Lesions

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Venous Sinus Lesions

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- Other
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  - Tumor

Osborn’s Brain, p. 235
Conclusions

• Vascular lesions are commonly seen in the routine practice of neuroimaging:
  – Symptomatic
  – Incidental
  – Normal variant

• Always look for the second lesion

• Thank you
References