Interventional Neuroradiology APP: Anatomy, Pathology, Procedures
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Things you need to know and things that are nice to know
Arches and Cows
Aortic Arch

Profile the great vessels: LAO or RPO 30-45 degrees obliquity

A: Ascending Aorta
B: Aortic Arch
C: Descending Aorta
Bovine Arch
Left Common Carotid shares a common origin with the Brachiocephalic/Innominate (about 13% of the population)
The Great Vessels

angiogram of the aortic arch
Figure 1. Arch complexity can be assessed by the relationship of the target vessels either to the parallel planes perpendicular to the greater (outer) curvature and lesser (inner) curvature of the arch, or to the horizontal line across the upper inner aspect of the arch. Type I (a) represents a relatively level aortic arch. Angulation of the aortic arch is classified as type II (b) and type III (c), with both representing increasing degrees of angulation, and with the innominate and left common carotid rising essentially from an ascending aortic configuration.
Common Carotid Artery

- Bifurcates into the ECA and ICA at the level of the fourth cervical vertebrae.
Circle of Willis
The circle of Willis encircles the stalk of the pituitary gland and provides important communications between the blood supply of the forebrain and hindbrain.

A complete circle of Willis is present in most individuals, although a well-developed communication between each of its parts is identified in less than half of the population.
ACA
The Intracranial Circulation: Overview

- Composed of numerous blood vessels arising from bilateral Internal Carotid and Vertebral Arteries

- The anterior portion of the brain is supplied by the ICAs and is therefore called the *anterior circulation*

- The posterior portion of the brain is supplied by the VA’s and is therefore referred to as the *posterior circulation*

- The anterior and posterior circulations communicate via the Circle of Willis
VIEWS & CIRCULATION
Anatomy: Anterior Circulation, A/P View

- The “Clock”
- 3 O’clock (Left)
- 9 O’clock (Right)

- Internal Carotid (ICA)
- Middle Cerebral (MCA)
- Anterior Cerebral (ACA)
- Anterior Communicating (ACoA)

¼ Slice: Usually only the right or left hemisphere will fill at injection
The Anterior Circulation: Overview

AP views of the Anterior Circulation

ICA

ACA

ACoA

MCA

ICA
Internal Carotid Artery

- 1. Pericallosal artery
- 2. Callosomarginal artery
- 3. Anterior cerebral artery
- 4. Ophthalmic artery
- 5. Internal carotid artery
- 6. Anterior choroidal artery
- 7. Lenticulostriate arteries
Carotid Sinus

- Where the common carotid artery bifurcates.
- Contains specialized nerve end organs that produce a slight dilatation of the carotid artery which respond to changes in blood pressure by mediating changes in the heartbeat rate.
Internal Carotid Siphon

- The carotid siphon is the S-shaped part of the ICA
- It begins at the posterior bend of the cavernous ICA and ends at the ICA bifurcation.
- Cavernous and supraclinoid portions of the ICA form the carotid siphon.
- Cavernous portion contributes to the greater part of the carotid siphon.
The Posterior Circulation: Overview

The Vertebrobasilar System:

- Composed of the **vertebral arteries** which join intracranially to form the Basilar Artery
- The **Basilar Artery** terminates as the **Posterior Cerebral Arteries** (PCAs)
- Supplies the brainstem, cerebellum, and posterior cerebrum
The Posterior Circulation: Basilar Artery

Angiography

R L

PCA SCA BA AICA PICA VA
Aneurysm Embolizations
Onyx 500
Stent Coil of Basilar Tip Aneurysm

- Enterprise through the Neuroform stent.
Left ICA Aneurysm
Pipeline Embolization Device

Images Provided by Ev3
Left ICA AVM
AVM Superior Cerebellar
Post Onyx
Meningioma Embolization

- PVA used to embolize tumor preoperatively to reduce bleeding
Vasospasm

- Verapamil
- Balloon Angioplasty (Hyperglide and Hyperform balloons)
- 4 mg of TPA given with no decrease in clot
- Unsuccessful attempts with the 26 and 32 Penumbra
- Single pass with 41 Penumbra
LCCA Angioplasty and Stent; Protection Device

- Precise Stent and Angioguard Protection Device.
- Angioguard by Cordis and Spider FX by ev3.
Subclavian Steal

- The primary lesion causing vertebral artery flow reversal is proximal subclavian artery stenosis or occlusion, resulting in decreased blood pressure in the arm distal to the steno-occlusive disease.
Aneurysm Repair

- Understanding the history of coil embolization
- Familiarization with the causes of aneurysms
- Defining what an aneurysm is and where they tend to develop
- Fundamentals of treatment strategy
**Aneurysm**

Isolated areas along a vessel wall can weaken and begin to stretch. These balloon-shaped structures, which often occur where an artery branches, are called **aneurysms**. If they burst, the resulting hemorrhagic stroke damages tissue and creates pressure that often results in catastrophic neurological injury.
TYPES / CLASSIFICATIONS OF ANEURYSMS

- SIDEWALL
- BIFURCATIONS
- TERMINAL
- FUSIFORM
- DISSECTING
- MYCOTIC

(MOST COMMON)
FLOW PATTERNS

SIDE WALLS ANEURYSMS

1

2

3

Green circle = Stress Points
Strike zone

Red circle = Swirl Effects

Slipstream Effects

BIFURCATED ANEURYSMS

1

2

3

Green circle = Stress Points
Strike zone

Red circle = Swirl Effects

Slipstream Effects

Green circle = Stress Points
Strike zone

Red circle = Swirl Effects

FLOW PATTERNS
ETIOLOGY

- CONGENITAL
- ACQUIRED

CAUSATION

- HEMODYNAMICALLY INDUCED FLOW PATTERNS
- DEGENERATIVE VASCULAR DISEASE
- HYPERTENSION
- CONNECTIVE TISSUE DISORDERS
- ARTERIAL OCCLUSIVE LESIONS
- IMBALANCE OF BLOOD FLOW AT ARTERIAL FORKS
- ATHEROSCLEROSIS
CANINE SIDE WALL ANEURYSMS

FLOW PATTERNS
I = inflow
O = outflow
FLOW MODELS OF CADAVER ANEURYSMS

Bulbous PCom aneurysm, irregular flow. In the sac, highly disturbed flow.

Flow distal basilar aneurysm. Complex flow into sac. Swirls in basilar then hits opposite wall in sac then out into PCA.
Cause of Cerebral Vasospasm

Angiographic appearance of severe vasospasm
Fusiform Basilar Aneurysm

Dilatation along a long segment of a vessel
SAH

CT SCAN WITH SAH

CADAVER SAH/ IVH/ ICH
1. Anterior Communicating Artery: ACom
2. Posterior Communicating Artery: PCom
3. Middle Cerebral Artery: MCA
4. Internal Carotid Artery: (cavernous, supraclinoid, paraclinoid)
5. Vertebrobasilar: (basilar tip, PCA, SCA, PICA)
6. Carotid-Ophthalmic

Site of Intracranial Aneurysms
Aneurysms Indicated for Endovascular Tx.

1. Vertebrobasilar
2. Cavernous carotid
3. Carotid-ophthalmic/paraclinoid
4. High Surgical risk
5. Temporary protection for delayed surgery

“Are all aneurysms are indicated for endovascular therapy?”
Endovascular Treatment

GOAL OF ENDOVASCULAR TREATMENT

• FLOW DIVERSION AT THE INFLOW ZONE
  • THROMBUS FORMATION
  • TRANSFORMATION INTO CELLULAR TISSUE
  • DEVELOPMENT OF ENDOTHELIAL CELLS AT NECK
  • DEVELOPMENT SMOOTH MUSCLE CELLS ALONG INFLOW
  • COLLAGEN DEPOSITS AND FIBROCELLULAR OR GRANULATION TISSUE INSIDE SAC
Aneurysm Components

- Apex or dome
- Wall
- Ostium
- Neck
- Inflow/outflow zone
- Parent artery junction
Aneurysm Characteristics

Aneurysm Size
- Small  <10 mm diameter
- Large  10-25 mm diameter
- Giant  >25 mm diameter

- Neck Size is an important predictor of potential EV outcome
  - Small neck  2 to 1 dome to neck ratio or greater
  - Large neck  2 to 1 dome to neck ratio or less

- Other factors
  - Parent artery interface (sidewall, bifurcated)
  - Dome angle
  - Geometry
  - Inflow zone
  - Size and tortuosity of parent vessel
  - Perforators
What is an AVM?

- Appear as a tangle of vessels
- Well circumscribed center (“nidus”)
- No brain tissue contained within the nidus
- Can occur anywhere in the brain tissue or its coverings
- Tend to enlarge with age and progress from low flow lesions at birth to high flow lesions in adulthood
AVM
Disease Presentation

- AVMs are relatively rare lesions
  - It is a congenital disease
  - Occur in 1% of the population
    - In comparison ~ 6% of the US population is living with an aneurysm
  - Most of AVMs present with a brain Hemorrhage (>50%)
- DAVFs are really rare vascular anomaly
  - More likely Acquired Disease (Venous thrombosis…)
  - Can be benign (Pulsatile tinnitus) but can bleed
Epidemiology

Occur in ≤1% of the population

- More common in men
- Congenital – may be related to a primary abnormality of primordial capillary of venous formation
- Average age of patients diagnosed with AVM is approximately 33 y/o

1. Hemorrhage (>50%)
2. Seizures (20-25%)
3. Headaches (15%)
4. Mass effect
5. Ischemia & focal neuro deficit (due to vascular steal)/less frequent

Whenever a young person presents with intracranial hemorrhage, vascular imaging is required to rollout vascular malformation
Presentation: Hemorrhage

- Most common presentation
- Peak age: 15-20 y/o
- 10% mortality and 30-50% morbidity with each bleed
Location of Hemorrhage

1. Intraparenchymal (ICH) – 82%

2. Intraventricular (IVH)
   - Usually accompanied by ICH
   - Pure IVH may indicate an intraventricular AVM

3. Subarachnoid (SAH) – may be due to rupture of aneurysm on feeding artery

4. Subdural (SDH) – uncommon, but should be thought of if SDH is spontaneous
Risk of Hemorrhage

- Average risk of hemorrhage is ~2-4% per year
- Risk of bleeding at least once in 25 years is ~ 53%
- After one hemorrhage the risk of rebleeding is ~ 6% per year
- Small AVMs are more likely to hemorrhage (higher pressure in feeding arteries)

Pollock, B et al Stroke 1996
AVMs at high risk of bleeding:
- History of bleeding
- Diffuse nidus
- Only 1 draining vein

<table>
<thead>
<tr>
<th>Risk Group</th>
<th>Annual Hemorrhage Rate</th>
<th>Cumulative Hemorrhage Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5 y</td>
</tr>
<tr>
<td>Low (n=98)</td>
<td>0.99% (1.14%)</td>
<td>5%</td>
</tr>
<tr>
<td>Intermediate-low (n=217)</td>
<td>2.22% (2.55%)</td>
<td>11%</td>
</tr>
<tr>
<td>Intermediate-high (n=36)</td>
<td>3.72% (4.28%)</td>
<td>17%</td>
</tr>
<tr>
<td>High (n=160)</td>
<td>8.94% (10.28%)</td>
<td>37%</td>
</tr>
</tbody>
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AVMs and Aneurysms

• 7% of patients with AVMs have aneurysms

• 75% of these are located on a major feeding artery (due to increased flow)

• If it is not clear if the AVM bleed or the aneurysm – odds are it was the aneurysm

• 66% of aneurysms will regress following AVM treatment
Consequences of Hemorrhage

Symptoms of hemorrhage depend on location of the AVM and hemorrhage pattern

- Acute Symptoms:
  - Severe HA
  - Nausea/vomiting
  - LOC

- If IVH is present – may result in acute hydrocephalus

- Lasting neurological deficits due to damage to brain tissue from blood/blood break down products
Diagnosis/Evaluation

**CT Scan**

- Usually the first study completed when the patient presents with acute symptoms
- Non-enhanced CT is the best study to r/o hemorrhage
- Can demonstrate calcifications within the lesion
Diagnosis/Evaluation

**MRI/MRA**

- More sensitive than CT at diagnosing AVM
- Provides better information on exact location and surrounding structures
- Characteristic “serpentine” flow voids
- GRE sequences demonstrate surrounding hemorrhages which suggest a prior hemorrhage
- Useful for Stereotactic Radiosurgery planning and f/u
- MRI takes approx 1 hour so typically done once patient is stabilized
AVM AP
Diagnosis/Evaluation

**Angiography**

- Provides detailed angioarchitecture
- Can identify associated aneurysms
- Provides hemodynamic information including dominant arterial filling
- Note – draining veins are present in the arterial phase
Need to know....

- Great Vessels- those coming off the arch
COW

- Circle of Willis components
  - Basilar (tip)
  - Internal Carotid (tip)
  - Posterior Cerebrals
  - Anterior Cerebrals
  - Pcomm(s)
  - Acomm (1)
Circle of Willis
Know Basic Internal Carotid Artery
Nice to know…

- **Variants**
  - Bovine Arch (Left Carotid off Innominate on the right)
  - What happens with incomplete COWs

- **Diagnoses**
  - Vasospasm
  - SAH on CT as predictor of aneurysm location

- Carotid Siphon from Carotid Sinus

- When to stop coiling
Thank you!