Intracranial Vascular Malformations

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Patient Presentation

• 43 y/o RHW with no significant PMH presents to ED after isolated episode sz activity
• FH significant for mother & brother with intracranial aneurysms; mother also has Hx sz activity
• PE demonstrates no focal findings
• Labs benign
• Imaging studies performed
Imaging Findings

• CT +/- contrast
  – 2 rounded, hyperdense, ill-defined, non-enhancing lesions in R frontal & temporal lobes
  – No mass effect, surrounding hypodensity
Imaging Findings

- CT +/- contrast
  - 2 rounded, hyperdense, ill-defined, non-enhancing lesions in R frontal & temporal lobes
  - No mass effect or surrounding hypodensity

Image source: BIDMC PACS.
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- **MR +/- Gado**
  - T1 & T2 images showing heterogeneous SI in corresponding regions
  - GE images showing marked susceptibility
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• Dx Cavernous Angioma

Image source: BIDMC PACS.
Agenda

- Introduction to Intracranial Vascular Malformations
  - Terminology
  - Classification
  - Pathology
  - Clinical Presentation
  - Diagnostic Evaluation & Imaging Findings
- Review of Vascular Anatomy of the Brain
- MR Principles
  - T1 vs. T2 contrast
  - Evolution of blood & blood break-down product SI
Intracranial Vascular Malformations

- Classification
  - Arteriovenous malformations (AVMs)
    - Parenchymal (pial)
    - Dural
    - Mixed Pial-dural
  - Capillary telangiectasias
  - Cavernous angiomas
  - Venous malformations
    - Venous angioma
    - Vein of Galen malformations
    - Venous varix
Intracranial Vascular Malformations—Terminology

- **Angioma**
  - *angeion* (vessel, cavity) + *oma* (tumor, swelling)
  - defn: swelling due to proliferation with or without dilatation of vessels
    - hem–angioma
    - lymph–angioma

- **Telangiectasia**
  - *telos* (end) + *angeion* + *ektasis* (stretching out)
  - defn: dilatation of the previously existing small or terminal vessels

- **Varix**
  - *varix* (dilated vein)
  - defn: dilated vein or vessel
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Cavernous Angiomas (Cavernomas)

- **Pathology**
  - lobulated collection of dilated endothelial-lined vascular channels
  - no normal brain in lesion
  - contain hemorrhage at different stages

- **Etiology**
  - congenital

- **Location**
  - 80% supratentorial
  - 50-80% multiple

- **Age at presentation**
  - 20-40 y/o

- **Symptoms**
  - sz, focal neuro deficits, HA

- **Hemorrhage risk**
  - <1%/year (risk ↑ with Hx prior bleed)
  - occult bleeds common

Cavernous Angiomas

- Imaging
  - CT
    - iso-/hyperdense
    - little/no mass effect, edema
    - minimal enhancement
    - occasional calcification
  - Angio
    - usually angiographically occult

CT (top) & MRA (bottom).
Image source: BIDMC PACS.
Revising Anatomy

- Arterial Circulation
  - Anterior
    - ICA
    - MCA
    - ACA
    - AComm
  - Posterior
    - Vertebral
    - ASA
    - PICA
    - Basilar
    - AICA
    - SCA
    - PCA
    - PComm

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Revising Anatomy

Our lesion?

ICA (intrapetrous)
ICA (extracranial)
Vertebral

MCA
ACA
PCA
SCA
Basilar

Image source: BIDMC PACS.
Revising Anatomy

• Venous Circulation
  – Superior sagittal sinus (1)
  – Inferior sagittal sinus
  – Cavernous sinus
  – Basal vein (of Rosenthal)
  – Great cerebral vein (of Galen) (6)
  – Straight sinus (2)
  – Confluence of sinuses (3)
  – Transverse sinuses (4)
  – Sigmoid sinus (5)
  – Internal jugular
Cavernous Angiomas

• Imaging
  – MR
    • Focal area with mixed hypointense & hyperintense signal
    • “blooms” on GE sequences

• MR Take-home
  – Appearance of cavernoma on MR reflects presence of blood products of different ages

Clockwise from top left: T1, T2, flair and susceptibility MR.
Image source: BIDMC PACS.
Protons & Magnetic Fields

Image source: Mitchell, MRI Principles.
Energy In, Energy Out

Image source: Mitchell, MRI Principles.
Energy In, Energy Out

Excitation (RF) pulse

Longitudinal magnetization

Transverse magnetization
Energy In, Energy Out

Excitation (RF) pulse

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Energy In, Energy Out

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Excitation (RF) pulse
Energy In, *Energy Out*

- Longitudinal magnetization
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Energy In, *Energy Out*

- Longitudinal magnetization
- Transverse magnetization
Energy In, *Energy Out*

Longitudinal magnetization

Transverse magnetization
Energy In, Energy Out

Longitudinal magnetization

Transverse magnetization
T1 Contrast: Recovery of Longitudinal Magnetization

Image source: Mitchell, MRI Principles.
Susceptibility: Local Magnetic Effects

Image source: Mitchell, MRI Principles.
T1 Contrast: Recovery of Longitudinal Magnetization

Image source: Mitchell, MRI Principles.
T2 Contrast: Decay (Dephasing) of Transverse Magnetization

Image source: Mitchell, MRI Principles.
Evolution of Hemorrhage SI

- Oxyhemoglobin: Hyperintense
- Deoxyhemoglobin: Slightly Hyper
- Methemoglobin: Isointense
- Hemosiderin: Hypointense

Figure adapted from Zimmerman, *Neuroimaging*. 

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## Evolution of Hemorrhage SI

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
<th>Blood Product</th>
<th>T1</th>
<th>T2</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>Minutes to hours</td>
<td>Oxyhemoglobin</td>
<td>–</td>
<td>↑</td>
<td>Isointense to fluid.</td>
</tr>
<tr>
<td>Acute</td>
<td>Hours to several days</td>
<td>Deoxyhemoglobin</td>
<td>↓</td>
<td>↓↓</td>
<td>Can have surrounding high SI on T2W.</td>
</tr>
<tr>
<td>Subacute</td>
<td>24 hours to 2 weeks</td>
<td>Methemoglobin</td>
<td>↑↑↑</td>
<td>early ↓ then ↑</td>
<td>Begins at periphery.</td>
</tr>
<tr>
<td>Chronic</td>
<td>Weeks to years</td>
<td>Hemosiderin</td>
<td>↑</td>
<td>↓↓↓↓</td>
<td>Begins at periphery.</td>
</tr>
</tbody>
</table>

Adapted from Zimmerman, *Neuroimaging*. November 2002
Cavernous Angiomas – “Blooming”

Image source: BIDMC PACS.
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Bloomin’ Conclusion

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References

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