Untangling Cerebral Dural Arteriovenous Fistulas

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dAVFs

- Definition
- Clinical Presentation
- Natural History
- Treatment
What is a dAVF?
dAVFs

- Definition
- Clinical Presentation
- Natural History
- Treatment
Right Temporal Stroke

- 74 year old male
- Atrial Fibrillation on Coumadin
- “Small Temporal Stroke” 2 months prior
- New Confusion, Hemiparesis
- Admitted for new “stroke”
MRI
Angiogram

Superselective R MMA
“Painless Sixth”
Three Weeks Later

- Severe headache
- Dysarthria
- Dysphonia
- Dysmetria
Transvenous Coil
Dural arteriovenous fistula–induced thalamic dementia: report of 4 cases

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Dural Arteriovenous Fistula-Associated Reversible Parkinsonism with Presynaptic Dopaminergic Loss

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dAVFs

- Definition
- Clinical Presentation
- Natural History
  - Venous Drainage
  - Presentation
- Treatment

*Intracranial Dural Arteriovenous Malformations*

O. Wayne Houser, M.D., Hillier L. Baker, Jr., M.D., Albert L. Rhoton, Jr., M.D., and Haruo Okazaki, M.D.

ABSTRACT—Twenty-eight patients with dural arteriovenous malformations, mostly located along the cranial base and in the occipitomastoid region, were studied angiographically. It was often possible to define a relationship between the clinical syndrome and the angiographic pattern of venous drainage. Intracranial hemorrhages occurred in those patients in whom the venous drainage of the arteriovenous malformation was limited to the pial veins, while the syndrome of a cavernous sinus fistula was present when retrograde venous drainage from the anomaly extended through the distensible ophthalmic veins. If the venous outflow was antegrade through the usual channels, the clinical syndrome reflected only the presence and volume of the arteriovenous shunt.

INDEX TERMS: Arteries, meningeal • Malformations, Arteriovenous, cerebral • Meninges, blood supply

Radiology 108:55–64, October 1972
Prof Rene Djindjian 1978

- Type I: Sinus drainage
- Type II: Sinus drainage with cortical reflux
- Type III: Direct cortical drainage
- Type IV: Direct cortical drainage with ectasia
A proposed classification for spinal and cranial dural arteriovenous fistulous malformations and implications for treatment

Jonathan A. Borden, M.D., Julian K. Wu, M.D., and William A. Shucart, M.D.

We are proposing a classification system that unifies spinal and cranial dural AVFMs and provides a rationale for modes of treatment. Our system is based upon the classification system for cranial dural AVFMs of Djindjian and Merland. It incorporates spinal dural AVFMs into

<table>
<thead>
<tr>
<th>dAVF drainage</th>
<th>Djindjian 1978</th>
<th>Borden 1995</th>
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</thead>
<tbody>
<tr>
<td>Antegrade drainage into a sinus</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Drainage into a sinus with cortical venous reflux</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>Direct cortical venous drainage</td>
<td>III</td>
<td>III</td>
</tr>
<tr>
<td>Direct cortical venous drainage with venous ectasia</td>
<td>IV</td>
<td>III</td>
</tr>
</tbody>
</table>

Cerebral Dural Arteriovenous Fistulas: Clinical and Angiographic Correlation with a Revised Classification of Venous Drainage

Table 1
Frequency of Aggressive and Nonaggressive Symptoms according to Type of Venous Drainage

<table>
<thead>
<tr>
<th>AVF Type</th>
<th>I (n = 84)</th>
<th>IIA (n = 27)</th>
<th>IIB (n = 10)</th>
<th>IIA + b (n = 18)</th>
<th>III (n = 25)</th>
<th>IV (n = 29)</th>
<th>V (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhage</td>
<td>16</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>16</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Intracranial hypertension</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Focal neurologic deficit</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Seizures</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Cardiac deficiency</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Myelopathy</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nonaggressive symptoms</td>
<td>83</td>
<td>17</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>
# Natural History – Key Factors

- Venous Drainage
- Presentation
- Venous Ectasia

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type II-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age</td>
<td>51</td>
<td>60</td>
<td>59</td>
<td>57</td>
<td>59</td>
</tr>
<tr>
<td>M : F</td>
<td>0.7</td>
<td>0.7</td>
<td>1.9</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Location</td>
<td>51% TS</td>
<td>61% TS</td>
<td>28% Tentorial</td>
<td>42% Tentorial</td>
<td>31% TS</td>
</tr>
<tr>
<td></td>
<td>38% Cav</td>
<td>10% Cav</td>
<td>13% Petrosal</td>
<td>17% Ant Fossa</td>
<td>17% Tent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8% Ant Fossa</td>
<td>17% Petrosal</td>
<td>9% Petrosal</td>
</tr>
<tr>
<td>Annual Bleed Rate</td>
<td>0%</td>
<td>6%</td>
<td>10%</td>
<td>21%</td>
<td>Asymptomatic 2% Prior NHND 10% Prior Hemorrhage 46%</td>
</tr>
</tbody>
</table>

Natural History

- Venous Drainage
- Presentation
- Venous Ectasia

dAVFs

- Definition
- Clinical Presentation
- Natural History
- Treatment
  - Endovascular – Transarterial/Transvenous
  - Surgical – Disconnection / Skeletonization
  - Radiosurgery
Barrow Endovascular Experience

• 1996-2015
• 260 dAVFs
  • 102 Type I (39%)
  • 72 Type II (27%)
  • 53 Type III (20%)
  • 33 Type IV (13%)
• Obliteration Rate: 70% (76% in Onyx Era)
• Complications: 8%
• Recurrence: 3%

The Impact of Onyx

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Cases</td>
<td>87</td>
<td>173</td>
<td></td>
</tr>
<tr>
<td>Obliteration Rate</td>
<td>60%</td>
<td>76%</td>
<td>0.01</td>
</tr>
<tr>
<td>Transarterial Only Approach</td>
<td>43%</td>
<td>61%</td>
<td>0.008</td>
</tr>
<tr>
<td>Cure Via Transarterial Only Approach</td>
<td>23%</td>
<td>43%</td>
<td>0.002</td>
</tr>
<tr>
<td>Cure Via Single Arterial Pedicle</td>
<td>11%</td>
<td>29%</td>
<td>0.002</td>
</tr>
<tr>
<td>Need For Subsequent Surgery</td>
<td>14%</td>
<td>8%</td>
<td>0.19</td>
</tr>
</tbody>
</table>
Convexity / Superior Sagittal Sinus

- 3:1 Male:Female
- Venous Drainage
  - 6% Type 1  
  - 13% Type 2  
  - 50% Type 3  
  - 31% Type 4  
- 97% MMA Supply
- 97% Transarterial Treatment
  - 94% MMA  
- 75% Obliteration Rate
  - 82% Post-Onyx
Transverse-Sigmoid dAVF

- Male:Female 1.2:1
- 80% Pulsatile Tinnitus
- Arterial Supply
  - 96% Occipital Artery
  - 93% MMA
  - 53% Tentorial Artery
  - 44% Ascending Pharyngeal Artery
- 49% Cortical Venous Reflux
- ~70% Obliteration Rate
Tentorial / Petrosal

- 3.7:1 Male:Female
- Presentation
  - 40% NHND
  - 30% Hemorrhage
- Arterial Supply
  - 85% MMA
  - 64% Occipital Artery
- Venous Drainage
  - 60% Type III
  - 38% Type IV
- 81% Transarterial Treatment
  - 77% MMA; 30% Occipital
- 87% Obliteration Rate
  - 91% Post-Onyx
- 13% Complication Rate
- 9% Subsequent Surgery
Carotid-Cavernous Fistulas

- 1.4:1 Female : Male
- Presentation
  - 92% Ocular Sx
  - 3% Hemorrhage
- 31% Cortical Venous Reflux
- Approach
  - 71% Transvenous
  - 24% Direct Puncture
- 73% Obliteration Rate
  - 91% Post-Onyx
- 7% Complication Rate, 3% Permanent
- Ocular Symptom Follow-Up (Mean 2 yr)
  - Resolved in 37%
  - Improved in 45%
  - Persistent in 18%
Ethmoidal / Anterior Fossa
“80%”

- Obliteration Rate
  - Lower for torcular and ethmoidal dAVFs
- Tinnitus Improvement Rate
  - Overall and for Transverse-Sigmoid Fistulas
- Ocular Symptom Improvement Rate

Surgical interruption of leptomeningeal drainage as treatment for intracranial dural arteriovenous fistulas without dural sinus drainage


Massimo Collie, M.D., Giuseppe D’Aliberti, M.D., Giuseppe Talamonti, M.D., Vincenzo Branca, M.D., Edoardo Boccardi, M.D., Giuseppe Scialli, M.D., and Pietro P. Versari, M.D.

A

Arterial Feeders
Patient Dural Sinus
Fistula
Recruited Vein
Not-Recruited Vein

B

Arterial Feeders
Patient Dural Sinus
Clip
Vein with Restored Flow (Windows Effect)
Thrombosis (injured)
Not-Recruited Vein


Gross BA, Ducruet AF, Jankowitz BT, Gardner PA. World Neurosurg 2017—IN PRESS.
## Surgery for Ethmoidal dAVFs

<table>
<thead>
<tr>
<th>Series</th>
<th>Cases</th>
<th>Mean Age</th>
<th>Male</th>
<th>Venous Ectasia</th>
<th>Obliteration</th>
<th>Permanent Comps</th>
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</thead>
<tbody>
<tr>
<td>Abrahams et al. 02</td>
<td>5</td>
<td>61</td>
<td>60%</td>
<td>100%</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Agid et al. 09</td>
<td>15</td>
<td>59</td>
<td>92%</td>
<td>46%</td>
<td>100%</td>
<td>7%</td>
</tr>
<tr>
<td>Al-Mahfuodh et al. 15</td>
<td>8</td>
<td>59</td>
<td>88%</td>
<td></td>
<td>100%</td>
<td>0</td>
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<tr>
<td>Lawton et al. 99</td>
<td>16</td>
<td>62</td>
<td>69%</td>
<td>69%</td>
<td>100%</td>
<td>0</td>
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<tr>
<td>Martin et al. 90</td>
<td>6</td>
<td>52</td>
<td>83%</td>
<td>83%</td>
<td>100%</td>
<td>0</td>
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<tr>
<td>Mayfrank et al. 96</td>
<td>6</td>
<td>56</td>
<td>100%</td>
<td></td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Reul et al. 93</td>
<td>5</td>
<td>57</td>
<td>100%</td>
<td>40%</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Signorelli et al. 15</td>
<td>4</td>
<td></td>
<td></td>
<td>75%</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Tanei et al. 08</td>
<td>3</td>
<td>72</td>
<td>100%</td>
<td></td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>BNI 2000-2015</td>
<td>24</td>
<td>62</td>
<td>67%</td>
<td>59%</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pooled</strong></td>
<td><strong>92</strong></td>
<td><strong>60</strong></td>
<td><strong>80%</strong></td>
<td><strong>62%</strong></td>
<td><strong>100%</strong></td>
<td><strong>1%</strong></td>
</tr>
</tbody>
</table>

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Surgical Treatment of High-Risk Intracranial Dural Arteriovenous Fistulæ: Clinical Outcomes and Avoidance of Complications

53 cases, 91% obliteration rate

<table>
<thead>
<tr>
<th>Complications</th>
<th>Perioperative</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Infection</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Seizure</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Stroke</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Hydrocephalus/ventriculoperitoneal shunt</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Facial palsy</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Spasm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Aphasia</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cerebrospinal fluid leak</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Intolerance</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>19 (36%)</td>
<td>7 (13%)</td>
</tr>
</tbody>
</table>

Role of Endovascular Therapy

All DAVFs should be explored endovascularly with the intent of embolization to obtain a cure. At minimum, endovascular exploration guides the surgical approach and treatment of the fistula. Arterial embolization of the fistula reduces the risks of the surgical approach and also simplifies the angiographic anatomy. Its importance cannot be overstated; however, the lack of transvenous or transarterial access can prevent effective endovascular management of the fistula. In some cases, simply exposing the sinus with a craniotomy or craniectomy can provide access and enable endovascular obliteration of the fistula. In other cases, residual filling of the fistula after surgery can be obliterated with embolization. In this manner, endovascular and surgical techniques complement each other in the management of these lesions.
Radiosurgery

Embolization Failure / Contraindication

Symptomatic Type I dAVF
ASx Type II dAVF, Surgically Adverse
SRS Results

• 14 Series, 558 dAVF Treated
• Obliteration Rate: 71%
• Transient Deterioration 9.1%; Permanent 2.4%
• Post SRS Hemorrhage in 1.6% of Cases
• 1 Death From Hemorrhage (0.2%)
• Repeat SRS successful in 1/3 cases.

Factors Influencing SRS Results

Obliteration:

- **Location** – Cavernous Best (p = 0.03)
- **CVD** – No CVD Better (p < 0.0001)
- **Size** – Smaller Better (Trend)

<table>
<thead>
<tr>
<th>Location / Drainage</th>
<th>dAVFs</th>
<th>Obliteration</th>
<th>Hemorrhage</th>
<th>Transient Worsening</th>
<th>Permanent Worsening</th>
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</thead>
<tbody>
<tr>
<td>Cavernous</td>
<td>262</td>
<td>84%</td>
<td>0.8%</td>
<td>9.3%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Transverse-Sigmoid</td>
<td>78</td>
<td>58%</td>
<td>1.6%</td>
<td>4.8%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Tentorial</td>
<td>24</td>
<td>59%</td>
<td>0%</td>
<td>11%</td>
<td>4.2%</td>
</tr>
<tr>
<td>No CVD</td>
<td>136</td>
<td>80%</td>
<td>0.7%</td>
<td>3.4%</td>
<td>0.9%</td>
</tr>
<tr>
<td>+CVD</td>
<td>128</td>
<td>60%</td>
<td>4.8%</td>
<td>7.3%</td>
<td>2.4%</td>
</tr>
</tbody>
</table>
Management Algorithm

EMBOLIZATION

Type I, Can Wait 2 yrs
Type II, ASx, Surgery Adverse

Type I, Intolerable Sx
Type II-IV

SRS (5%)  
SURGERY (10%)

OBSERVATION: Type I dAVF, Minimal or Tolerable Sx
Summary

• Natural History
  • Venous Drainage
  • Presentation
  • Venous Ectasia

• Treatment
  • Endovascular - First
  • Surgical Disconnection – High Grade
  • Radiosurgery – Low Grade, CCF
Acknowledgments