Brain Arteriovenous Malformations
Endovascular Therapy and Associated Therapeutic Protocols

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Hospital de Santa Maria – University of Lisbon

25th SIMI BUENOS AIRES 2016
### Cerebral AVM – Clinical / Epidemiology

Brain AVM - 0.14% incidence in the population (cooperative study)

(1 / 7 of the incidence of cerebral aneurysms)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain AVM</td>
<td>4.05%</td>
</tr>
<tr>
<td>Venous angioma</td>
<td>2.6%</td>
</tr>
<tr>
<td>Cavernomas</td>
<td>0.4%</td>
</tr>
<tr>
<td>Telangiectasia</td>
<td>0.7%</td>
</tr>
<tr>
<td>AVM</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

**HEMORRHAGE - most frequent clinical presentation**

- Haemorrhagic risk: 2% / year
- Re-haemorrhagic risk: 6% / year

Wilkins 1985
Brain Arteriovenous Malformations
Endovascular Therapy and Associated Therapeutic Protocols

CEREBRAL AVM – CLINICAL / EPIDEMIOLOGY

- **SEIZURES**: ++ frontal / parietal / temporal location

- **PROGRESSIVE NEUROLOGICAL DEFICE**: related to arterial steal syndrome

- **HEADACHE**: accidental

**NATURAL EVOLUTION (Olivecrona)**

- 25% patients without treatment died with hemorrhage
- 33% presented severe morbidity
- 25% remain without symptoms during long years

**IMPORTANCE OT NEW PROSPECTIVE STUDIES** - MOHR

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CEREBRAL AVM – CLASSIFICATION

Yasargil / Berenstein – Lasjaunias / Valavanis

Location, size, arterial feeders, venous drainage, nidus pattern, presence of direct A/V fistulae

Importance of haemorrhagic risk factors

Spetzler and Martin classification

Size / venous drainage / eloquence - AVM SURGICAL RISK
Left deep AVM – intraventricular compartment presented with HEADACHES

Feeders with fistulae characteristics:
- LEFT ANTERIOR CHOROIDAL
- LEFT LENTICULOSTRIATE
- LEFT P1 PERFURATING ARTERY
- LEFT AND RIGHT POSTERIOR CHOROIDALS

Frontal and lateral left carotid angiogram

Frontal and lateral left vertebral angiogram

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Left deep AVM – intraventricular compartment presented with HEADACHES
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Left deep AVM – intraventricular compartment presented with HEADACHES

Frontal and lateral left vertebral angiogram post embolization

Frontal and lateral left carotid angiogram post embolization

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TECHNICAL CONSIDERATIONS

• General anesthesia

• Heparin 10 000 U i.v. bolus plus 1 000 U / hour

• Intranidal microcatheterism – ONYX/SQUID/PHIL

• Feeder artery microcatheterism or high flow fistulae – IBCA or GLUBRAN

• Post embolization – pharmacological medication – steroids, fraxiparine if venous thrombosis

• Surgery and Radiotherapy timing
THERAPEUTIC PROTOCOLS

- PALLIATIVE INTRAARTERIAL EMBOLIZATION
- CURATIVE INTRAARTERIAL EMBOLIZATION
- PRE SURGICAL INTRAARTERIAL EMBOLIZATION
- PRE RADIOTHERAPY INTRAARTERIAL EMBOLIZATION
- PRE SURGICAL and PRE RADIOTHERAPY INTRAARTERIAL EMBOLIZATION
Frontal and lateral left vertebral artery angiogram pre-embolization

1st embolization - GLUBRAN

Posterior choroidal feeders

Frontal and lateral left vertebral artery angiogram pos embolization

Left deep AVM – ventricular / thalamus – presenting with deep left hematoma
Left deep AVM – ventricular / thalamus – presenting with deep left hematoma

2nd embolization - GLUBRAN

Frontal and lateral left carotid artery angiogram pre-embolization

Left anterior choroidal artery

Perforating artery from left Pcom

GLUBRAN Cast

Frontal and lateral left carotid artery angiogram pos embolization

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Left inferior temporal AVM presenting with seizures

Frontal and lateral left vertebral artery angiogram pre-embolization

Feeders from left posterior cerebral artery – temporal branches

Frontal and lateral left vertebral artery angiogram pos embolization
## Brain Arteriovenous Malformations

Endovascular Therapy and Associated Therapeutic Protocols

<table>
<thead>
<tr>
<th>164 patients</th>
<th>Age</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>73 female</td>
<td>Up to 20</td>
<td>26</td>
<td>16%</td>
</tr>
<tr>
<td>45%</td>
<td>21 up to 40</td>
<td>84</td>
<td>51%</td>
</tr>
<tr>
<td>55%</td>
<td>41 up to 60</td>
<td>44</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>61 up to 80</td>
<td>10</td>
<td>6%</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Presenting symptoms</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemorrhage</td>
<td>77</td>
<td>47%</td>
</tr>
<tr>
<td>Seizures</td>
<td>62</td>
<td>38%</td>
</tr>
<tr>
<td>Progressive neurologic deficit</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>Headache and Acidental</td>
<td>23</td>
<td>14%</td>
</tr>
</tbody>
</table>
Right temporal AVM – pial fistulae presenting with temporal hematoma

Frontal and lateral carotid artery angiogram pre-embolization

Frontal and lateral carotid artery angiogram post-embolization

Right anterior temporal and middle meningeal arteries

External carotid pos embolization

GLUE (IBCA)
# Brain Arteriovenous Malformations

## Endovascular Therapy and Associated Therapeutic Protocols

<table>
<thead>
<tr>
<th>AVM Localization</th>
<th>164 patients</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal</td>
<td>31</td>
<td>19%</td>
<td>Right 8</td>
<td>Left 23</td>
<td></td>
</tr>
<tr>
<td>Parietal</td>
<td>40</td>
<td>24%</td>
<td>Right 20</td>
<td>Left 20</td>
<td></td>
</tr>
<tr>
<td>Temporal</td>
<td>47</td>
<td>29%</td>
<td>Right 21</td>
<td>Left 20</td>
<td></td>
</tr>
<tr>
<td>Occipital</td>
<td>15</td>
<td>9%</td>
<td>Right 4</td>
<td>Left 6</td>
<td></td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>4</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal ganglia</td>
<td>7</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td>20</td>
<td>13%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Therapeutic Strategy</td>
<td>164 patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre operative embolization</td>
<td>44 (27%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre radiosurgery embolization</td>
<td>61 (37%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre operative and radiosurgery embolization</td>
<td>7 (4%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curative embolization</td>
<td>37 (23%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial targeted embolization (palliative)</td>
<td>15 (9%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16 patients remain in treatment or waiting follow-up angiogram (10%)
8 patients lost for follow-up (5%)
Right parietal AVM presented with hemorrhage

CURATIVE EMBOLIZATION - CYANOCRILATE

Lateral right carotid artery angiogram pre-embolization

Microcatheterism of the nidus

Lateral X-Ray without subtraction - cyanocrylate cast

Follow-up right and frontal carotid artery angiogram five years pos-embolization and radiosurgery

Lateral right carotid artery angiograms pos-embolization (glue)
Left parietal / temporal AVM with seizures

PRE RADIOSURGERY EMBOLIZATION - CYANOCRILATE

Frontal left carotid artery angiogram pre-embolization

Frontal X-Ray without subtraction – cyanocrylate cast

Frontal left carotid artery angiogram post-embolization (glue)

Follow-up left carotid angiogram three years post-embolization and radiosurgery
Right cerebellum AVM presented with hemorrhage

PRE SURGERY EMBOLIZATION - CYANOCRILATE

CT scan

Frontal left vertebral artery angiogram pre-embolization

Microcatheterism of the left PICA

Frontal left vertebral artery angiogram pos-embolization (glue) and surgery

Microcatheterism of the right AICA – shows a small intranidal aneurism

Frontal right vertebral artery angiogram pos-embolization (glue) and surgery
Vermian AVM presented with headache

**CURATIVE EMBOLIZATION - ONYX**

- Lateral microcatheterism of the right PICA
- Frontal right vertebral artery angiogram pre-embolization
- Frontal X-Ray without subtraction – onyx cast
- Lateral microcatheterism of the right AICA
- Follow-up right and left vertebral artery angiograms one year pos-embolization (onyx)
Left frontal AVM presented with hemorrhage

**PRE-SURGERY EMBOLIZATION - ONYX**

A: Lateral left carotid artery angiogram pre-embolization

B: Microcatheterism of the nidus – shows a proximal aneurysm in the feeder artery

C: Lateral X-Ray without subtraction – onyx cast

D: Lateral left carotid artery angiogram post-embolization (onyx)

E: Lateral and frontal left carotid artery angiograms pos-embolization and surgery

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Left occipital AVM presenting with seizures

**PRE-SURGERY EMBOLIZATION - ONYX**

- **Embolization**
  - Frontal and lateral left vertebral angiogram
  - Left occipital and parieto-occipital feeders
  - Onyx – exclusion > 90%

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Left occipital AVM presenting with seizures

**PRE-SURGERY EMBOLIZATION - ONYX**

Onyx – exclusion > 90%

Surgery – complete exclusion
Left temporal AVM presented with hemorrhage

EMBOLIZATION + SURGERY + RADIOSURGERY
CYANOCRILATE

Frontal left carotid artery angiogram pre-embolization

Microcatheterism of the left anterior temporal artery.

Follow-up left carotid artery angiogram six years post-embolization (glue), surgery and radiosurgery
Intraarterial embolization – embolic material

<table>
<thead>
<tr>
<th>Material</th>
<th>Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLUE</td>
<td>113</td>
<td>69 %</td>
</tr>
<tr>
<td>Ethylene-vinyl alcohol copolymer – ONYX/SQUID</td>
<td>35</td>
<td>21 %</td>
</tr>
<tr>
<td>GLUE + ONYX/SQUID</td>
<td>16</td>
<td>10 %</td>
</tr>
</tbody>
</table>
Left parietal AVM presented with seizures

Frontal left carotid artery angiogram pre-embolization

Microcatheterism of the nidus – frontal view

Frontal X-Ray without subtraction – cyanocrylate cast

Follow-up left carotid artery angiogram, one month post-embolization (glue)

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CURATIVE EMBOLIZATION
CYANOCRILATE

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Male, 49  
Epilepsy  
Right Internal  
Parietal AVM

CURATIVE INTRANIDAL  
ONYX EMBOLIZATION

Microcatheterization right A2 – Parietal feeder

Right Carotid Angiograms

Intranidal angiography – Onyx cast
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Male 49
Epilepsy
Right Internal parietal AVM

CURATIVE INTRANIDAL ONYX EMBOLIZATION

9 monthes follow-up
Female, 43
Epilepsy
Left temporal AVM

CURATIVE INTRANIDAL SQUID EMBOLIZATION

Left carotid artery angiogram

Intranidal microcatheterization
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Female, 43
Epilepsy
Left Temporal AVM

CURATIVE INTRANIDAL SQUID EMBOLIZATION

Left carotid artery angiogram
Pre Embolization

Left carotid artery angiogram
One week Post Embolization
Female, 55
Intraventricular Hemorrhage
Right Lateral Ventricle AVM

CURATIVE INTRANIDAL SQUID EMBOLIZATION

Left vertebral artery angiogram

Microcatheterization
Right posterior lateral choroid artery
Female, 55
Intraventricular Hemorrhage
Right Lateral Ventricle AVM

CURATIVE INTRANIDAL SQUID EMBOLIZATION

Left vertebral artery angiogram
Pre Embolization

Left vertebral artery angiogram
Follow up 9 months

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### Curative Embolization

<table>
<thead>
<tr>
<th>Total 37 (23%)</th>
<th>Angiographic Exclusion</th>
<th>In treatment</th>
<th>Lost for Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue (21)</td>
<td>21</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Onyx (14)</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Squid (2)</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Embolization + Radiosurgery

<table>
<thead>
<tr>
<th>Total 61 (37%)</th>
<th>Angiographic Exclusion</th>
<th>In treatment</th>
<th>Lost for Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue (34)</td>
<td>26</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Onyx (13)</td>
<td>6</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Onyx + Glue (13)</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Squid (1)</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
## Embolization + Surgery

<table>
<thead>
<tr>
<th>Total 44 (27%)</th>
<th>Angiographic Exclusion</th>
<th>In treatment</th>
<th>Lost for Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue (36)</td>
<td>35</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Onyx (4)</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Onyx + Glue (3)</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Squid (1)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

## Embolization + Radiosurgery

<table>
<thead>
<tr>
<th>Total 7 (4%)</th>
<th>Angiographic Exclusion</th>
<th>In treatment</th>
<th>Lost for Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue</td>
<td>6</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

## Paliative Embolization

<table>
<thead>
<tr>
<th>Total 15 (9%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue (15)</td>
</tr>
</tbody>
</table>
## Radiological Angiographic Results

<table>
<thead>
<tr>
<th>Category</th>
<th>Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete Angiographic Exclusion</td>
<td>125</td>
<td>76%</td>
</tr>
<tr>
<td>Incomplete Angiographic Exclusion (remaining in treatment)</td>
<td>16</td>
<td>10%</td>
</tr>
<tr>
<td>Paliative Embolization</td>
<td>15</td>
<td>9%</td>
</tr>
<tr>
<td>Lost for follow-up</td>
<td>8</td>
<td>5%</td>
</tr>
</tbody>
</table>

Total patients: 164

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**Brain Arteriovenous Malformations**
**Endovascular Therapy and Associated Therapeutic Protocols**

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Radiological Angiographic Results

<table>
<thead>
<tr>
<th>Complete Angiographic Exclusion</th>
<th>141 cases</th>
<th>89 %</th>
</tr>
</thead>
</table>

141 patients that completed treatment
Clinical Complications

164 patients

Morbidity

<table>
<thead>
<tr>
<th>Condition</th>
<th>Patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent neurologic defice</td>
<td>4 patients</td>
<td>2%</td>
</tr>
<tr>
<td>ischemic</td>
<td>2 cases</td>
<td></td>
</tr>
<tr>
<td>haemorrhage</td>
<td>2 cases</td>
<td></td>
</tr>
</tbody>
</table>

Only one patient dependent
### Intraarterial embolizations

<table>
<thead>
<tr>
<th></th>
<th>Mortality 2 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(164 patients)</td>
<td></td>
</tr>
</tbody>
</table>

#### 4 patients

Severe hematoma probably caused by venous outflow occlusion

- glue – 3
- onyx - 1

|                      |
|----------------------|---------------|
| 4 cases              |               |
CONCLUSIONS

Intra-arterial embolization holds a central point in therapeutic protocol of brain AVM – used on its own (curative and palliative) or associated with surgery and / or radiosurgery.

The enormous progress in microcatheter and microguiding systems and new embolic materials – GLUBRAN and ONYX/SQUID + Phil -made possible that a higher percentage of patients with excellent clinical outcome and the reduction of morbidity and mortality.

New long term retrospective and prospective studies are needed to evaluate the new therapeutic reality of brain AVMs.
The End