Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF’S)

ENDOVASCULAR THERAPY PROTOCOLS

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25th SIMI – Buenos Aires 2016
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

DEFINITION

• region of arteriovenous shunting confined to a leaflet of pachymeninges often adjacent to a major dural sinus
• 10 to 15% of all AVM’s
• older population; female predominance
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ANGIO-ARCHITECTURE

• meningeal arterial feeders related to the location

• pial supply and transosseous extracranial arterial collaterals can be recruited

• nidus or single hole fistula

• venous drainage type

Lateral sinus DAVM

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ETIOLOGIC FACTORS

- trauma
- surgery
- vascular diseases
- tumor
- infection
- hormonal effects
- congenital origin

Congenital middle cranial fossa DAVM (right paracavernous sinus)

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Unlike pial AVM’S regarded as congenital lesions the pathogenesis of DAVM’s is controversial with arguments for congenital and acquired etiology.

Importance of venous thrombosis.

Left Cavernous sinus DAVM type II
(arterial pedicles from left ICA and ECA, thrombosis of both ophtalmic veins and inferior petrosal sinus)
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

CLASSIFICATION

Location / Topography

- cavernous sinus
- transverse-sigmoid sinus
- superior sagital sinus
- tentorial
- anterior fossa

Unusual

- deep straight sinus / vein of Galen
- middle cranial fossa
- torcula and posterior fossa

Superior sagital sinus  DAVM type III

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CLASSIFICATION

Venous Drainage pattern

(Djindjian)

I – into a sinus with normal direction of flow

II – into a sinus with reflux to cortical veins

III – into a cortical vein with retrograde flow

IV – presence of venous lake

(Cognard)

IIa – only into sinus

II b – only into cortical veins

IIa+b – into sinus and cortical veins

Right lateral sinus DAVM type IV

High hemorrhagic risk

V – into perimedullary veins

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CLINICAL SPECTRUM

Clinical presentation is related to the venous drainage pattern, flow, topography and rarely arterial symptoms

<table>
<thead>
<tr>
<th>Location</th>
<th>SAH</th>
<th>ICH</th>
<th>SDH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior fossa</td>
<td>63%</td>
<td>50%</td>
<td>25%</td>
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<tr>
<td>Cavernous sinus</td>
<td>Proptosis 83%</td>
<td>CNP 44%</td>
<td>Bruit 42%</td>
</tr>
<tr>
<td>Tentorium</td>
<td>SAH 80%</td>
<td>ICH 60%</td>
<td>CNS 42%</td>
</tr>
<tr>
<td>Lateral sinus</td>
<td>Bruit 70%</td>
<td>Headache 40%</td>
<td>ICH 15%</td>
</tr>
</tbody>
</table>

DAVM’ s in children – high flow – cardiac disorders

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CLINICAL SPECTRUM

Dynamic nature of DAVM’S

Agressive clinical course

• risk of hemorrhage
• focal neurological symptoms
• hydrocephalus and papilledema
• visual loss
• intractable pain
• dementia

Left lateral sinus DAVM type II
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

IMAGING

Plain Skull Films
Increased vascular markings or bone density

CT (nonenhanced, enhanced)
DAVM itself is rarely detected

Epiphenomena may be detected
• thrombosed sinus
• dilated veins
• hemorrhage (acute)
• hydrocephalus

Cavernous dural AV Fistulae
(Enhanced CT – dilated supra-ophtalmic veins)

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IMAGING

MRI plain and Gad-enhanced
same problems as CT in
demonstrating DAVM

Angio-MR
Arterial / Venous is important

Angiography
Indispensable to diagnose and to evaluate a DAVM in order
to plan the treatment

feeding arteries – nidus – venous drainage and functional
hemodynamic analysis

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

PARTICLES - PVA

• proximal meningeal arteries supplying cranial nerves in the skull base
• low flow shunts
• low risk patients
• Low number of arterial feeders
• Frequently in cavernous sinus, lateral sinus type I/II shunts
• Rare in other locations

Left cavernous sinus DAVM type I

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Left cavernous sinus DAVM type I

Intra-arterial embolization - particles PVA – left accessory meningeal and ascending pharyngeal arteries

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Left cavernous sinus DAVM type I
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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

GLUE - NBCA

• distal meningeal arteries
• high risk patients
• high flow fistula
• Low number of arterial feeders
• Frequently superior sagital sinus, lateral sinus, posterior fossa type II / III / IV shunts
• Also tentorial e anterior fossa

Posterior fossa DAVM type III

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Posterior fossa DAVM type III

Intra-arterial embolization with GLUE – left posterior meningeal artery

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Endovascular Therapy Protocols
Intra-Arterial Embolization

Posterior fossa DAVM type III

Left vertebral artery Post-Emb

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Right lateral sinus DAVM type III

Right temporal hematoma

Intra-arterial embolization with GLUE of left middle meningeal and occipital arteries

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Superior sagital sinus  DAVM type IV
epilepsy

Intra-arterial embolization with GLUE right and left middle meningeal arteries and right occipital artery

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

PARTICLES PVA + GLUE - NBCA

- Multiple shunts – high and low flow feeders
- Different type of arterial feeders
- Frequently lateral sinus and cavernous sinus type I / II

Right cavernous sinus DAVM type II

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Right cavernous sinus DAVM type II

Distal internal maxilary artery with PVA
Middle meningeal artery with COIL and GLUE

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Right cavernous sinus DAVM type II

Distal internal maxilary artery with PVA
Middle meningeal artery with COIL and GLUE

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

ONYX / SQUID / PHIL

• impossible microcatheterisation of some arterial feeders

• alternative to venous approach

• type I / II complex DAVF´S with multiple AV shunts and high number of arterial feeders

• type III-IV lesions

• Frequently lateral sinus, superior sagital sinus and tentorial

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

ONYX – right middle meningeal artery

PRE – EMB
Right and left internal carotid – cavernous meningeal branches
Right external carotid – middle meningeal, ascending pharyngeal and occipital arteries

Tentorial DAVF Type III

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

ONYX

ONYX CAST

POST – EMB – Control angiogram
Right internal and external carotid
Left internal carotid

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Right lateral sinus DAVM type II

2007 right lateral sinus thrombosis

2009 Headache + right bruit + seizures

right and left middle meningeal and occipital arteries; right posterior auricular artery; left posterior meningeal artery; right meningo-tentorial artery

ONYX

PRE – EMB

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Right lateral sinus DAVM type II

PRE – EMB

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Right middle meningeal artery microcatheter and ONYX cast (5.2 cc)

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Right lateral sinus DAVM type II
Multiple shunts

5 months follow-up – arterio-venous shunt exclusion
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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

DAVM type II torcular region

72 y with dementia

right and left middle meningeal and occipital arteries

exclusion of both lateral sinus

ONYX

PRE-EMB right and left external carotid angiograms

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

DAVM type II torcular region

Left middle meningeal artery
ONYX cast – final result

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

DAVM type II torcular region

Follow-up right and left ext. carotid angiograms Arterio-venous shunt exclusion – clinical improvement

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

SQUID

60 y. o.

Cerebellar hematoma

DAVF type IV falx cerebelli
	right and left middle meningeals, ascending pharyngeals and occipitals

Right meningotentorial branch of right ACI

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF’S)

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

DAVF type IV falx cerebelli

right and left middle meningeals, ascending pharyngeals and occipitals

Right meningotentorial branch of right ACI

SQUID injection – left and right middle meningeals and left ascending pharyngeal

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-VENOUS EMBOLIZATION

SINUS OCCLUSION (Coils)

• type I / II
• multiple shunts
• high number of arterial feeders
• alternative to intra-arterial embolization with Glue / ONYX / SQUID / PHIL or PVA

• frequently cavernous sinus and lateral sinus

Left cavernous sinus DAVM type I

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF’S)

ENDOVASCULAR THERAPY PROTOCOLS

INTRA-VENOUS EMBOLIZATION

Left cavernous sinus DAVM type I

Coils - Venous approach

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Left cavernous sinus DAVM type I

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Post Emb
Dural Arteriovenous Malformations and Fistulae (DAVM’s – DAVF’s)

Endovascular Therapy Protocols

Intra-venous Embolization

Right lateral sinus DAVM type I

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Dural Arteriovenous Malformations and Fistulæ (DAVM’S – DAVF’S)

ENDOVASCULAR THERAPY PROTOCOLS

INTRA-VENOUS EMBOLIZATION

Right lateral sinus  DAVM type I

Coils - Venous approach

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Right lateral sinus  DAVM type I

Right carotid and vertebral arteries
POST – EMB

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ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

DRAINAGE VEIN OCCLUSION (Coils)

• type III / IV DAVF
• impossible microcatheterization of arterial feeders
• alternative to intra-arterial embolization
  • GLUE, ONYX, SQUID and PHIL

Left lateral sinus DAVM type III

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ENDOVASCULAR THERAPY PROTOCOLS INTRA-VENOUS EMBOLIZATION

Left lateral sinus DAVM type III

Left carotid angiogram POST – EMB

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ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Superior Longitudinal Sinus Occlusion

Male, 74 years, right parietal haemorrhagic stroke + dementia

Superior sagital sinus DAVF type II
Multiple shunts – arterial feeders:
Left anterior and posterior meningeal, right and left superficial temporal and occipital arteries (transosseous branches)

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ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Superior Longitudinal Sinus Occlusion with Coils

Pre-emb angiogram - DAVF type II Functional exclusion of the SLS

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Superior Longitudinal Sinus Occlusion with Coils

Pos-emb angiogram
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ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Direct Percutaneous Venous Punction - Coil Embolization

Female, 60 years, lytic occipital skull lesion + dementia

Right lateral sinus DAVF type IV
Arterial feeders: Right middle meningeal and right occipital arteries
Venous hypertension pattern

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ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Direct Percutaneous Venous Punction - Coil Embolization

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Intra-arterial embolization and Radiosurgery

Post. Embolization residual high risk shunts
Problematic surgery (craniotomy)
Frequently tentorial

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Male 46 y.o.

Headache and Bruit ++ Right

**DAVF type III** – right middle meningeal, right occipital, meningeal branches of petrous and cavernous segm. of right ICA

5 previous intra-arterial embolizations and PVA – 2007/2008

Residual shunt

**ENDOVASCULAR THERAPY PROTOCOLS**

**INTRA-ARTERIAL EMBOLIZATION**

Intra-arterial embolization and Radiosurgery

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Post Radiosurgery
Exclusion of the shunt
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS

INTRAR-ARTERIAL EMBOLIZATION

Intra-arterial embolization and Surgery

Residual shunt
Low surgical risk
Frequently anterior fossa

Male 51 y.o.
SAH
DAVF type IV left anterior fossa

2 previous intra-arterial embolizations left middle meningeal (PVA), left anterior ethmoidal (Glue)

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ENDOVASCULAR THERAPY PROTOCOLS

INTRA-ARTERIAL EMBOLIZATION

Intra-arterial embolization and Surgery (craniotomy)

DAVF type IV  left anterior fossa
left middle meningeal (PVA),
left anterior ethmoidal (GLUE)

Post-surgery follow up
Exclusion of the shunt

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR SURGERY RISKS AND COMPLICATIONS

ISCHEMIA

• cerebral embolism – anastomosis ECA – ICA / ECA – VA
• cranial nerves palsy

HEMORRHAGE

• intracranial hemorrhage – arterial rupture or venous outflow occlusion without complete embolization of the AV shunt
• transformation of a benign DAVM (type I/II) into a high risk lesion (type III/IV)
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR SURGERY RISKS AND COMPLICATIONS

Right temporal fossa DAVM type IV
Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)

ENDOVASCULAR SURGERY RISKS AND COMPLICATIONS

Right temporal fossa DAVM type IV

Post Emb

Subdural hematoma after embolization

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Endovascular embolization - RESULTS

**119 patients**

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavernous sinus</td>
<td>51</td>
<td>tentorial</td>
</tr>
<tr>
<td>lateral sinus</td>
<td>42</td>
<td>anterior fossa</td>
</tr>
<tr>
<td>SLS</td>
<td>11</td>
<td>temporal fossa</td>
</tr>
<tr>
<td>Skul base / posterior fossa</td>
<td>6</td>
<td></td>
</tr>
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</table>

**COMPLETE ARTERIOVENOUS SHUNT EXCLUSION** – **87 %**

(6 patients remain in treatment and 5 abandoned the therapeutic protocol)

**Clinical improvement or cure** – **97 %**

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Dural Arteriovenous Malformations and Fistulae (DAVM’S – DAVF´S)
Hospital Santa Maria – University of Lisbon

Endovascular embolization - RESULTS

119 patients

CLINICAL COMPLICATIONS  2%
1 right internal carotid embolism
1 left subdural hematoma (venous approach)

MORTALITY  0 %

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Endovascular surgery is the first treatment modality in DAVF with excellent clinical results and arteriovenous shunt occlusion.

Presents a low morbidity and mortality.

We should avoid a dogmatic attitude and according to the location and angioarchitecture of the lesion make use of different therapeutic techniques – venous and arterial approach; different embolic materials (PVA particles, Coils, GLUE and ONYX / SQUID / PHIL).
The therapeutic options and results depend mainly:

- detailed angioarchitecture and functional haemodynamic analysis
- clinical criteria
- some cases need emergent therapy
- personal experience