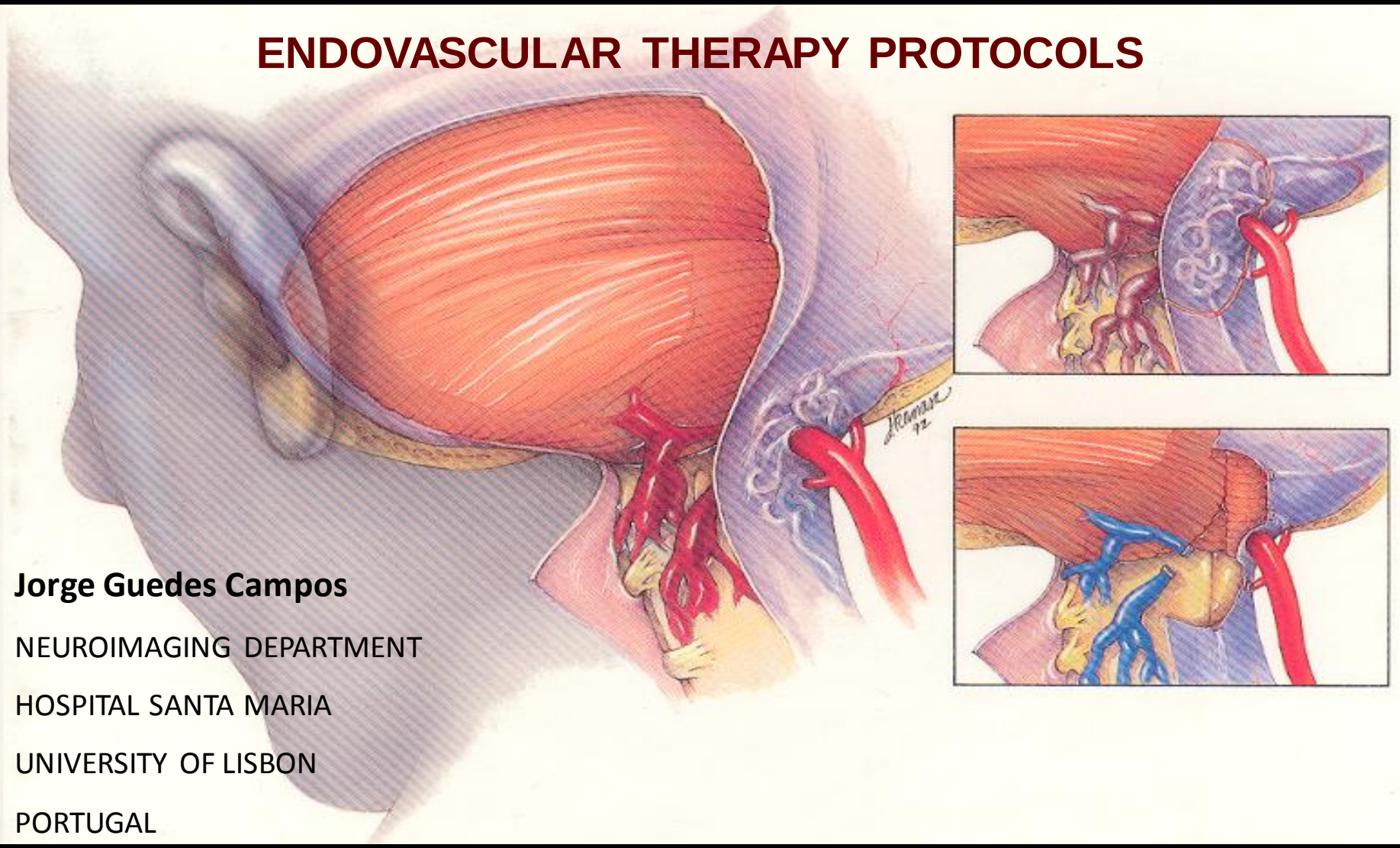
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS



Jorge Guedes Campos

NEUROIMAGING DEPARTMENT

HOSPITAL SANTA MARIA

UNIVERSITY OF LISBON

PORTUGAL

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

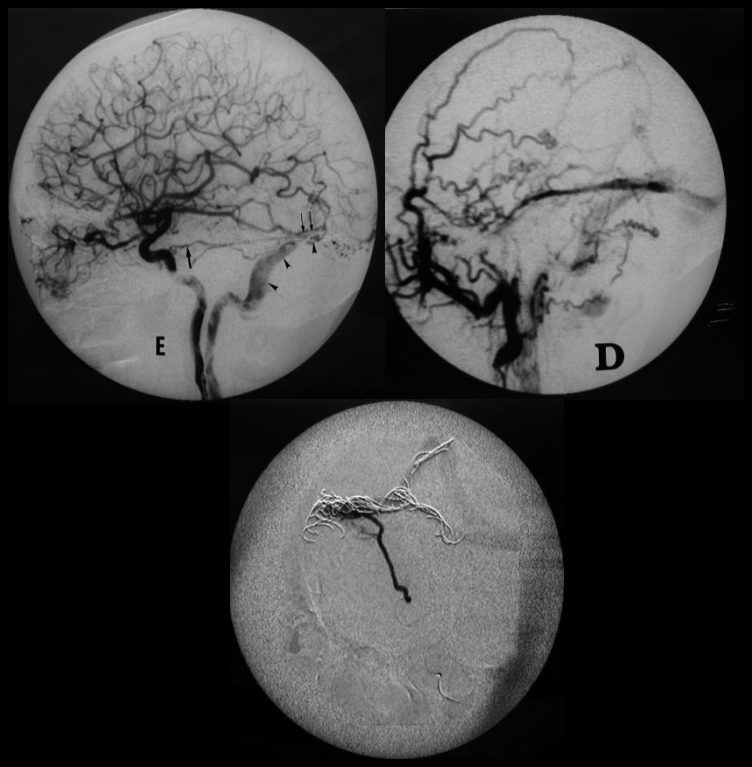
DEFINITION

- region of arteriovenous shunting confined to a leaflet of packymeninges 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

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

ETIOLOGIC FACTORS

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

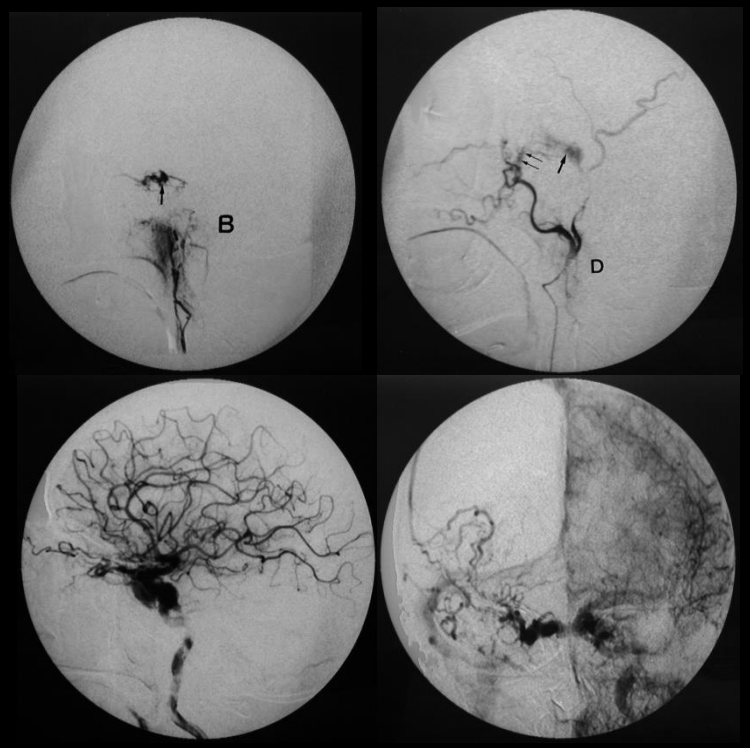
Congenital middle cranial fossa DAVM
(right paracavernous sinus)

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

PATHOPHYSIOLOGY

- 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)

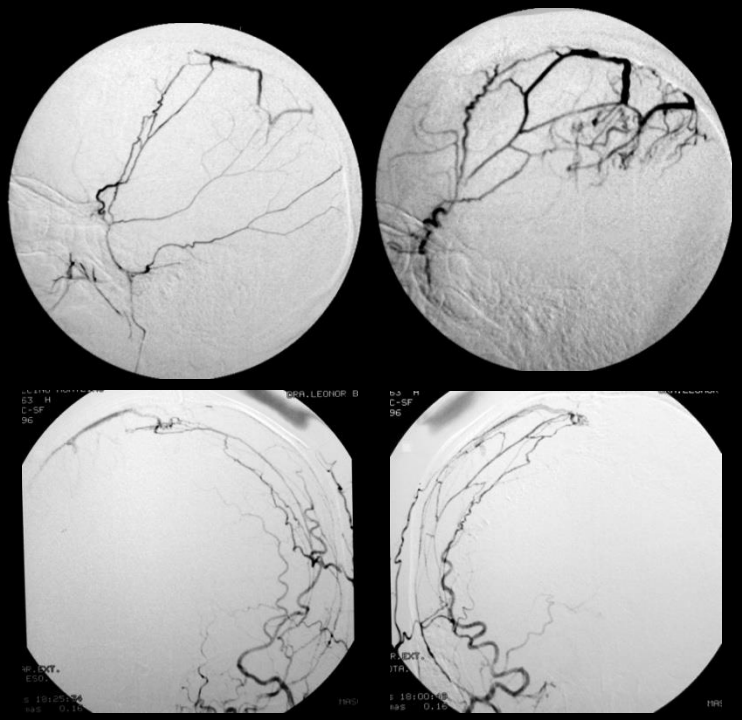
CLASSIFICATION

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

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

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

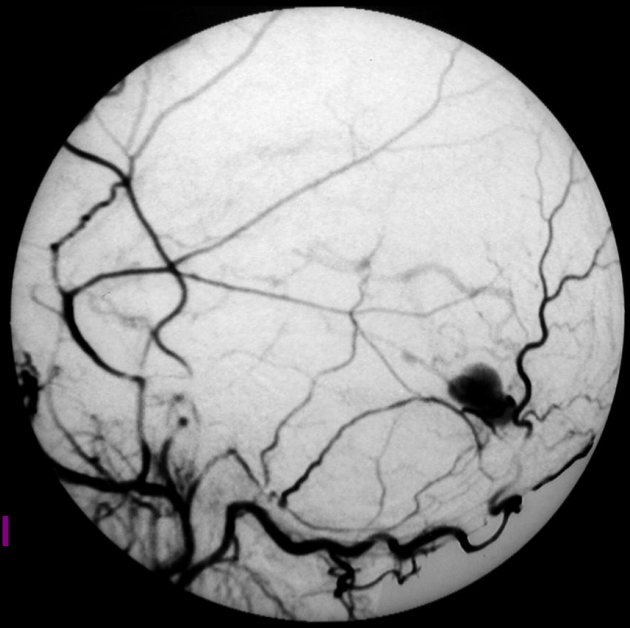
(Cognard)

IIa – only into sinus

II b – only into cortical veins

IIa+b – into sinus and cortical veins

V – into perimedullary veins



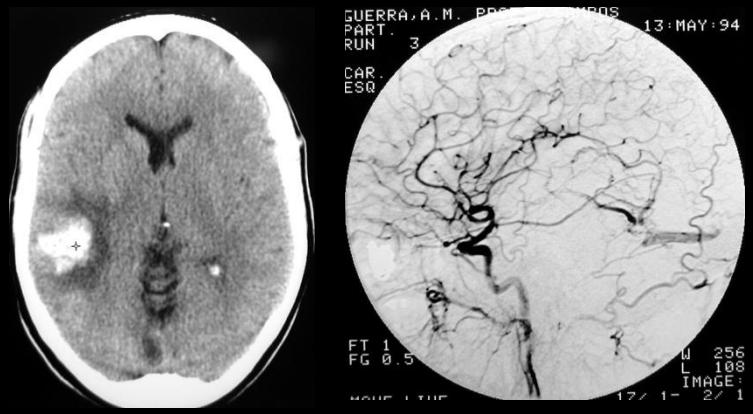
Right lateral sinus DAVM type IV

High hemorrhagic risk

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

CLINICAL SPECTRUM

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



Right lateral sinus DAVM type III

Anterior fossa		Cavernous sinus		Tentorium		Lateral sinus	
SAH	63%	Proptosis	83%	SAH	80%	Bruit	70%
ICH	50%	CNP	44%	ICH	60%	Headache	40%
SDH	25%	Bruit	42%	CNS	42%	ICH	15%
						CNS	13%

DAVM's in children – high flow – cardiac disorders

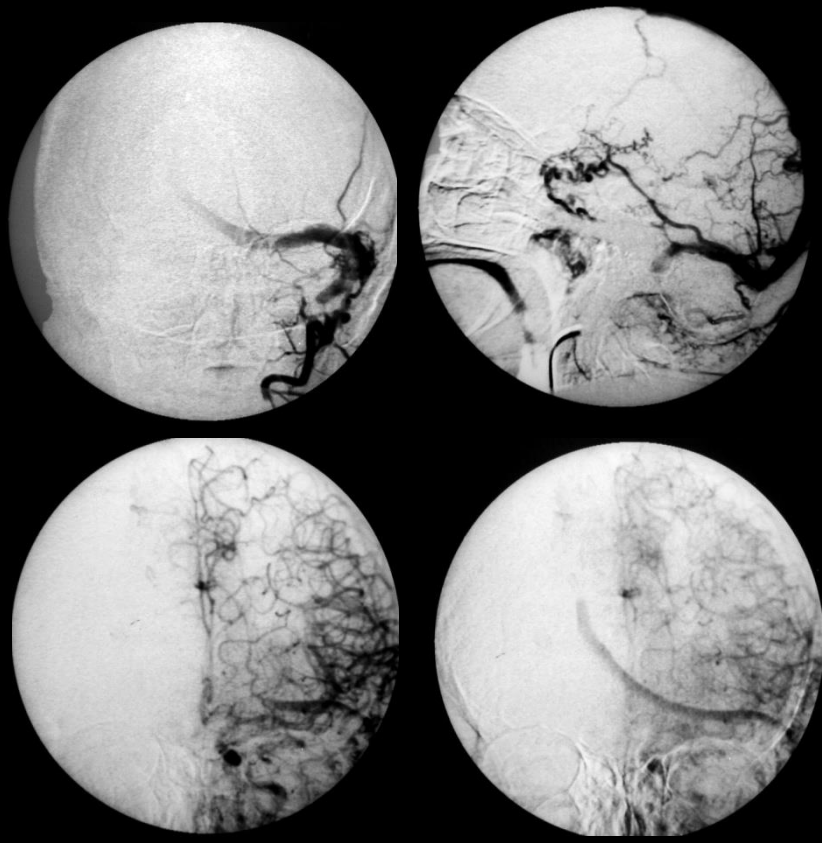
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

CLINICAL SPECTRUM

Dynamic nature of DAVM' S

Agressive clinical course

- **risk of hemorrhage**
- **focal neurological symptons**
- **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)

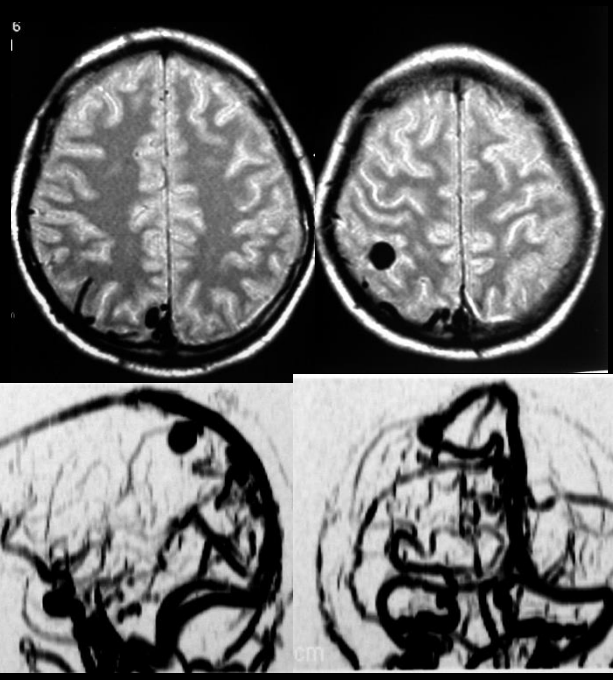
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

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



Superior sagital sinus DAVM

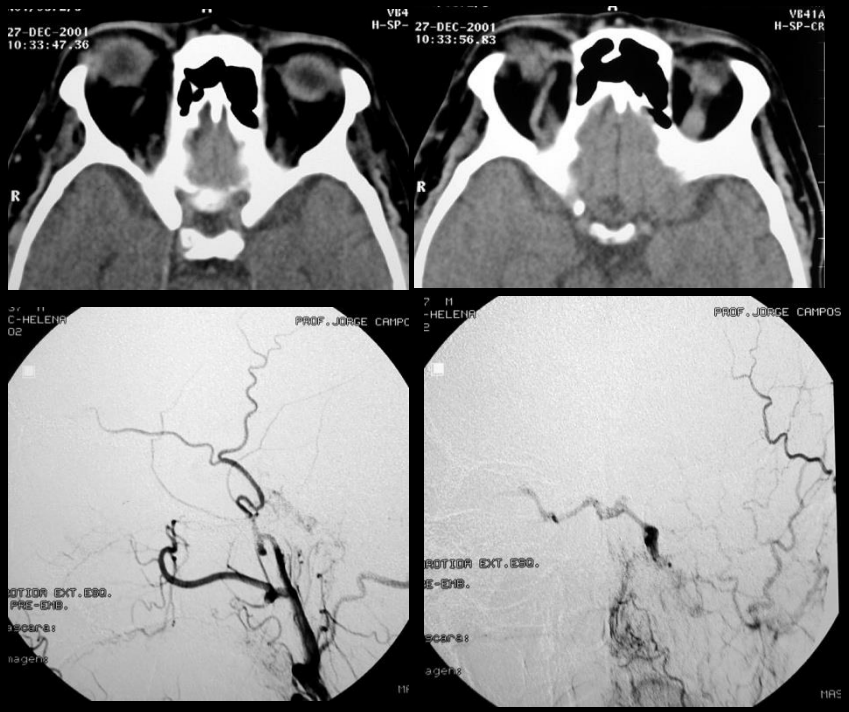
feeding arteries – nidus – venous drainage and functional hemodynamic analysis

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

PARTICLES - PVA

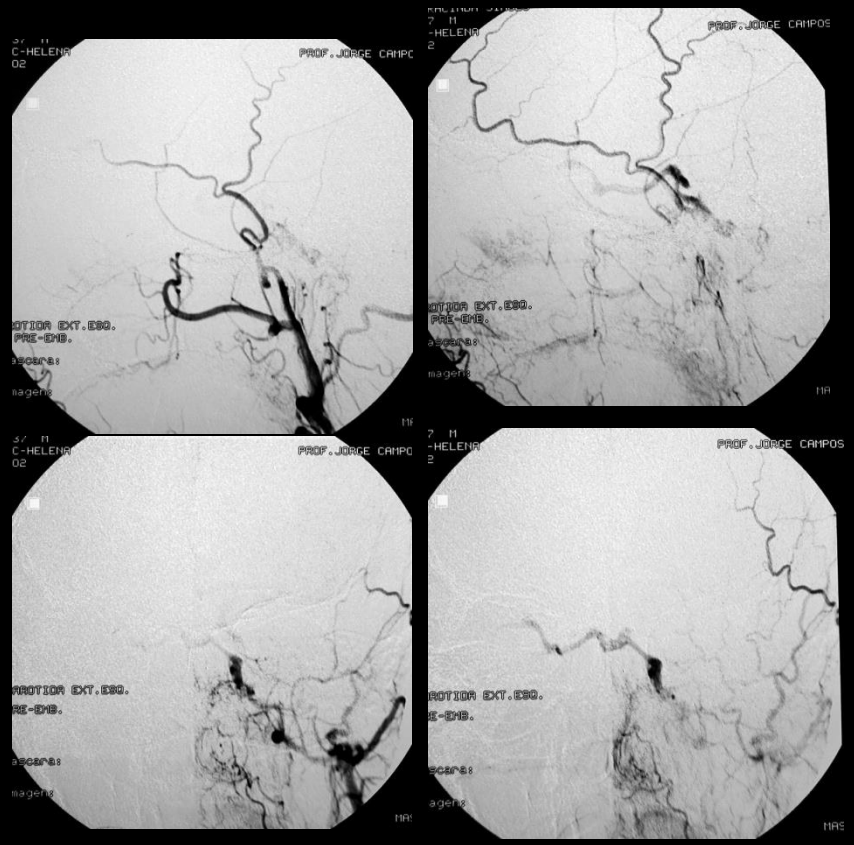
- proximal meningeal arteries supplying cranial nerves in the skull base
- low flow shunts
- low risk patients
- Low number of arterial feeders
- Frequently in cavernous sinus, lateral sinus type I/II shunts
- Rare in other locations



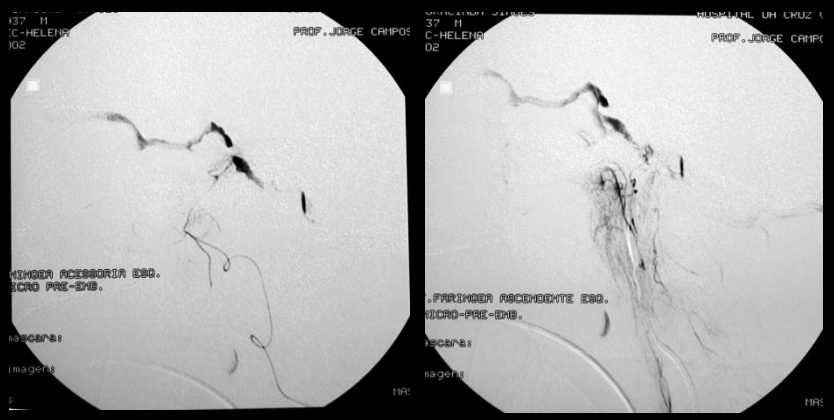
Left cavernous sinus DAVM type I

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION



Left cavernous sinus DAVM type I

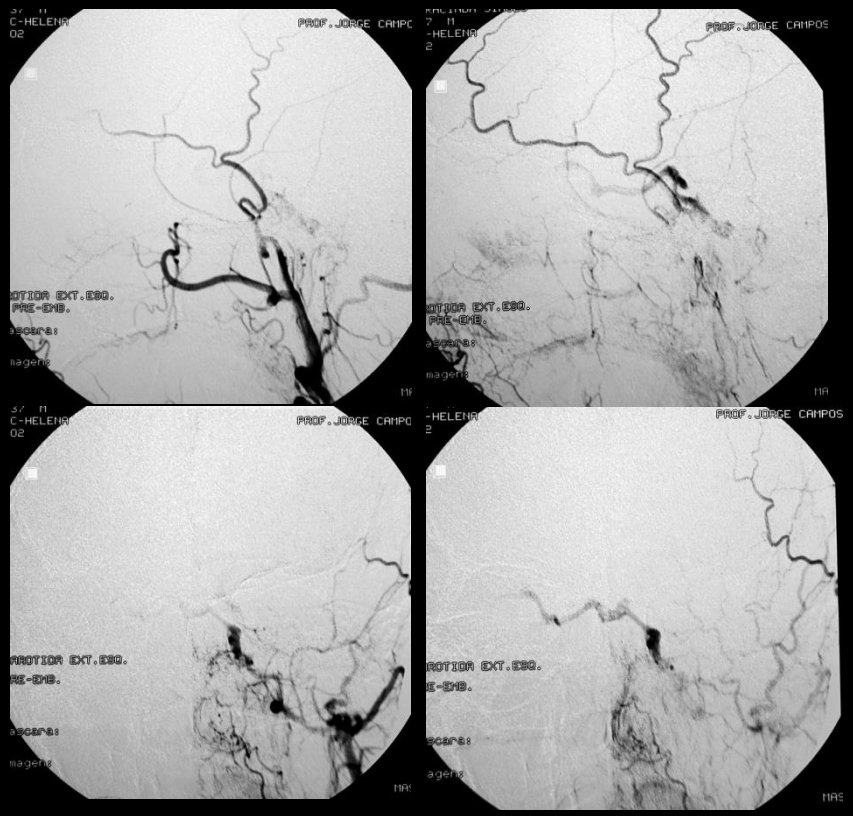


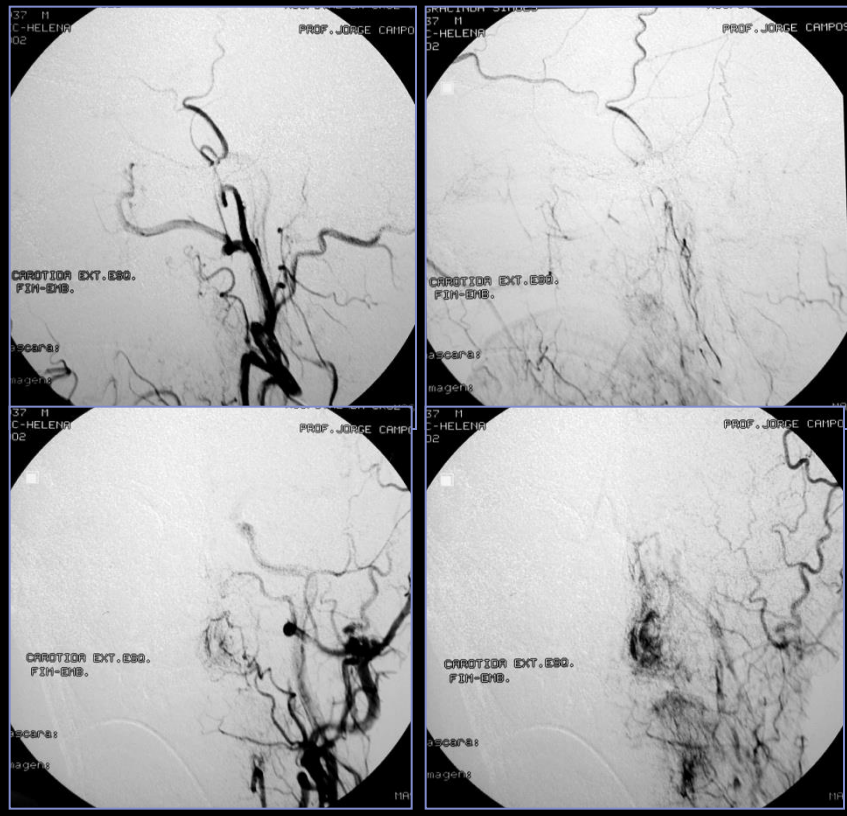
Intra-arterial embolization - particles PVA – left acessory meningeal and ascending pharingeal arteries

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Left cavernous sinus DAVM type I



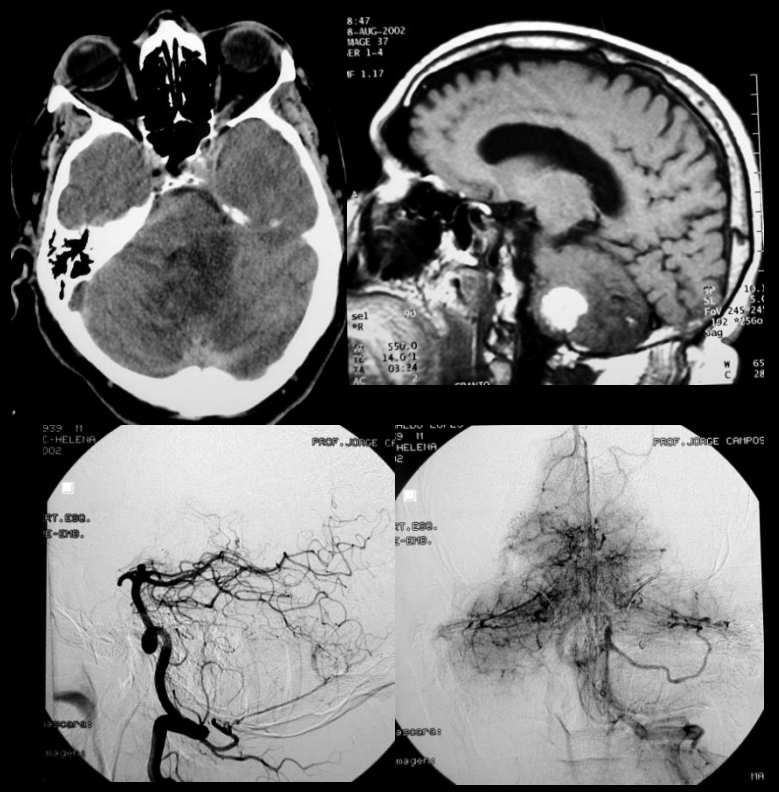


Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

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

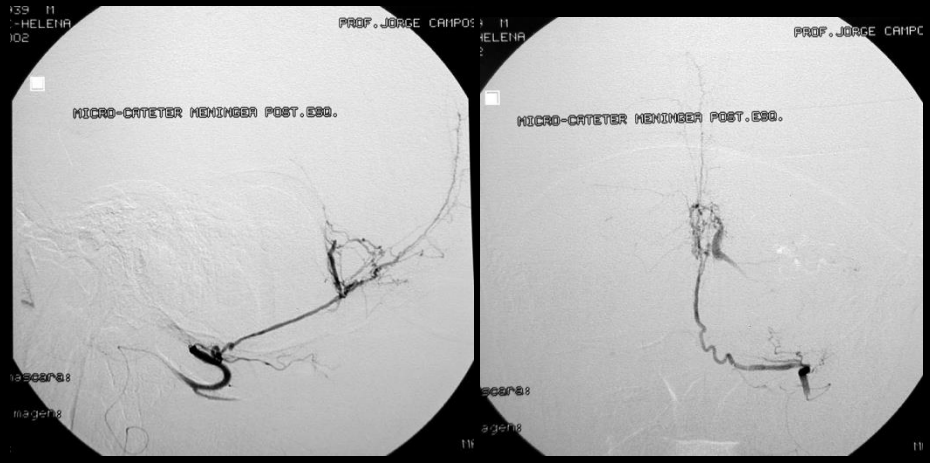


Posterior fossa DAVM type III

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Posterior fossa DAVM type III

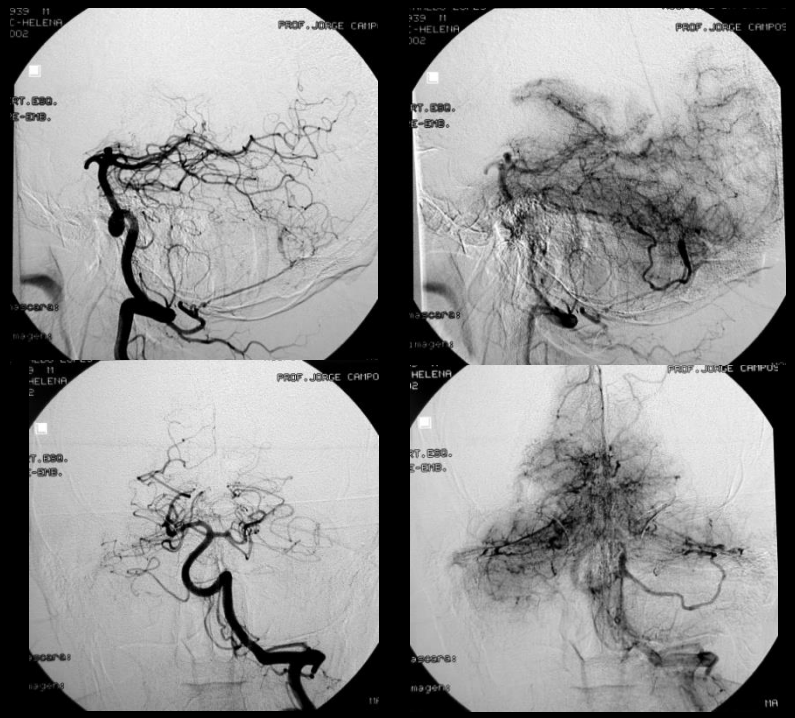


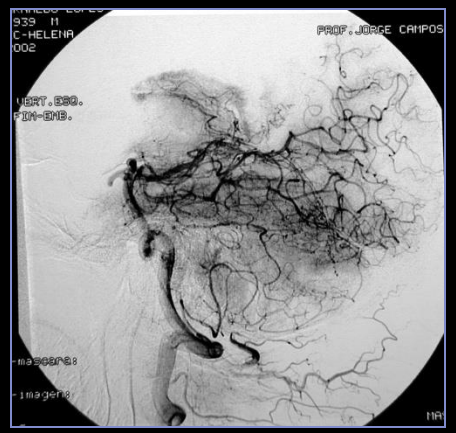
Intra-arterial embolization with GLUE – left posterior meningeal artery

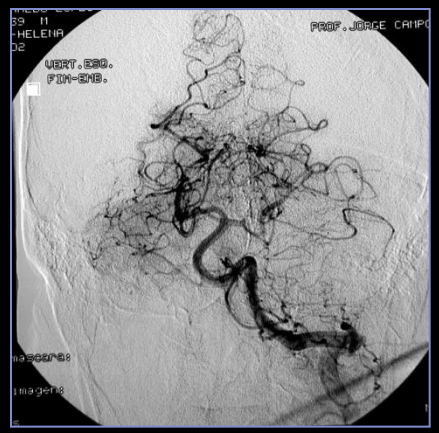
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Posterior fossa DAVM type III







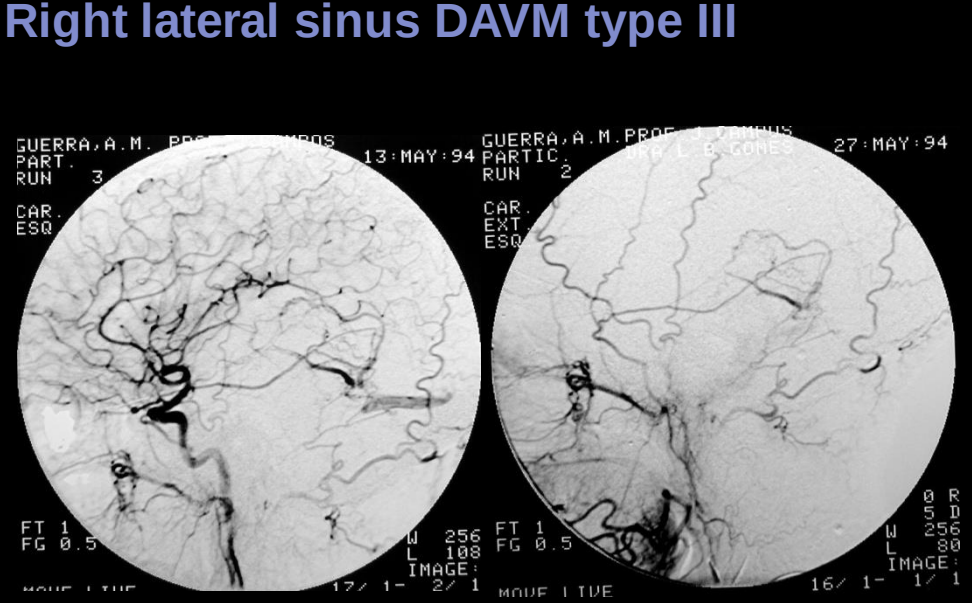
Left vertebral artery Post-Emb

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

ENDOVASCULAR THERAPY PROTOCOLS

INTRA-ARTERIAL EMBOLIZATION

Right lateral sinus DAVM type III



Right temporal hematoma

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

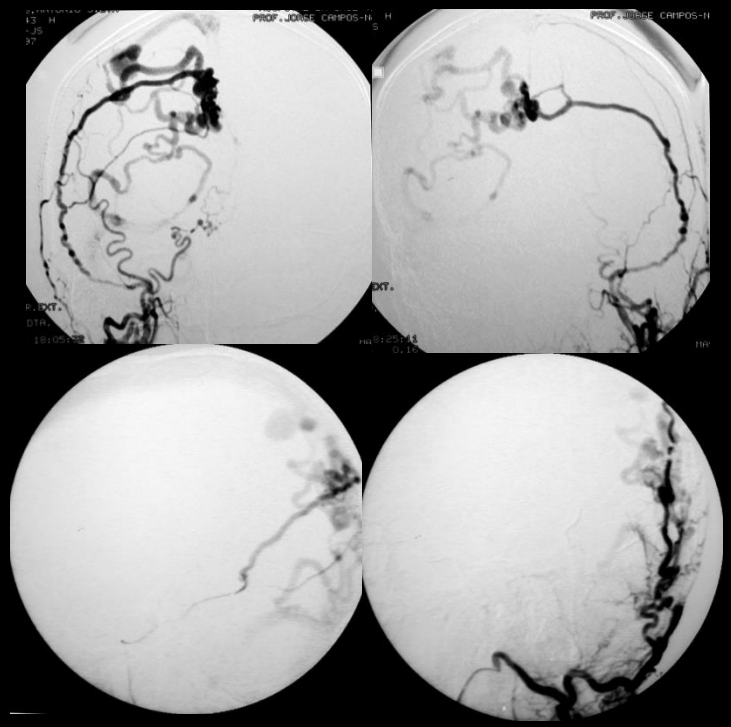
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

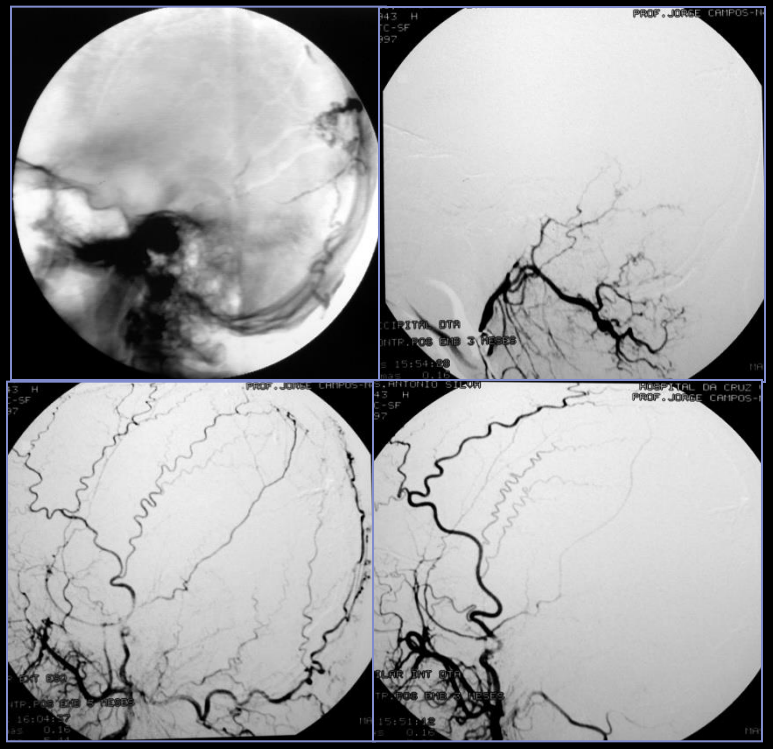
ENDOVASCULAR THERAPY PROTOCOLS

INTRA-ARTERIAL EMBOLIZATION

Superior sagital sinus DAVM type IV

epilepsy





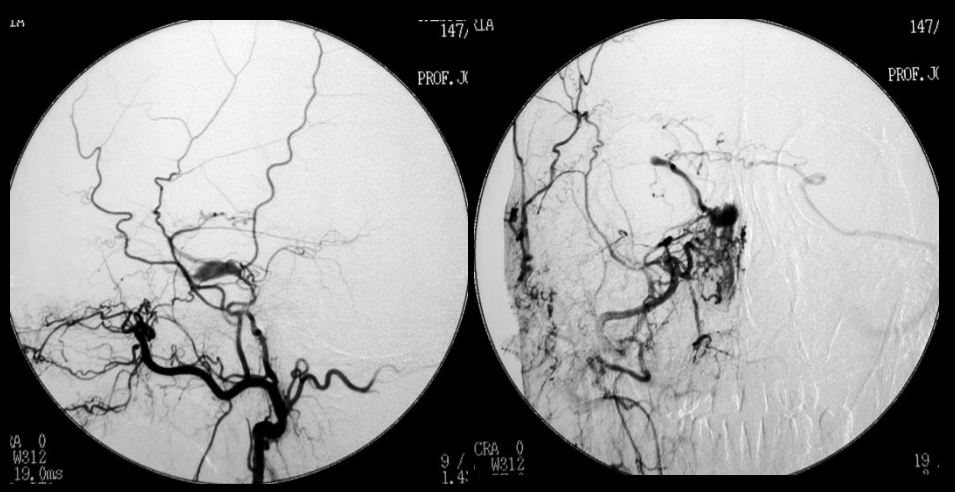
Intra-arterial embolization with GLUE
right and left middle meningeal arteries
and right occipital artery

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

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

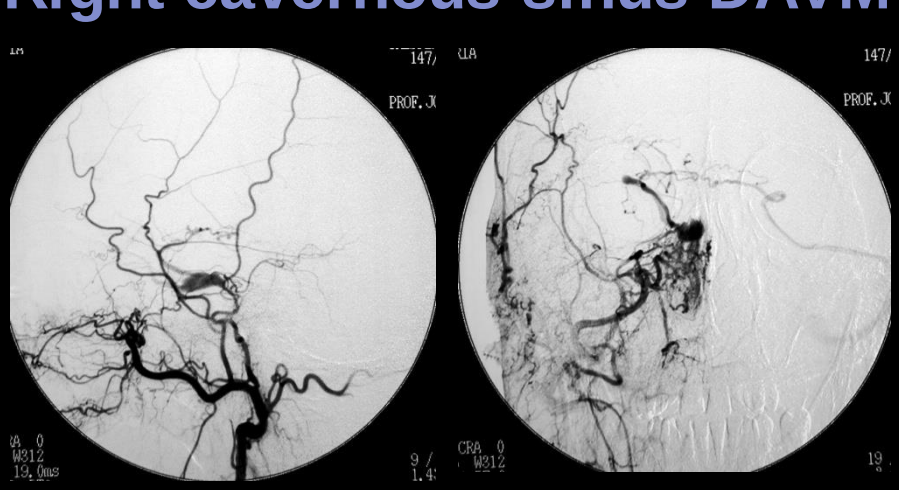


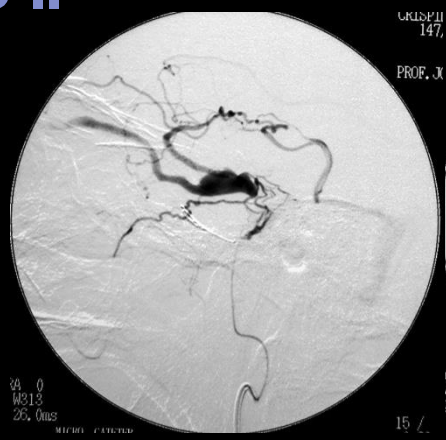
Right cavernous sinus DAVM type II

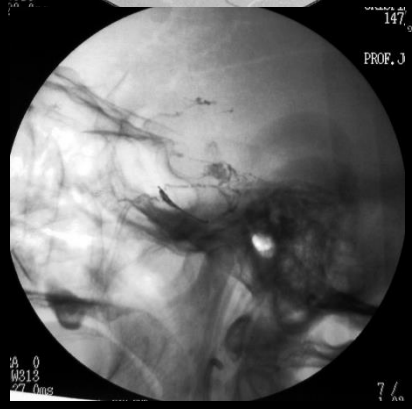
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Right cavernous sinus DAVM type II







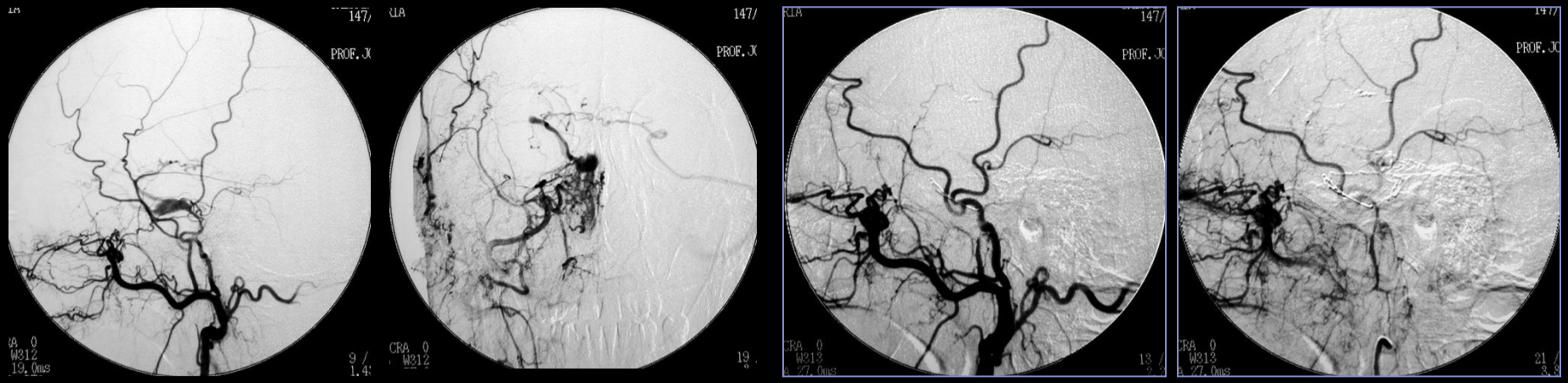
Distal internal maxilary artery with PVA

Middle meningeal artery with COIL and GLUE

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

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

25th SIMI – Buenos Aires 2016

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

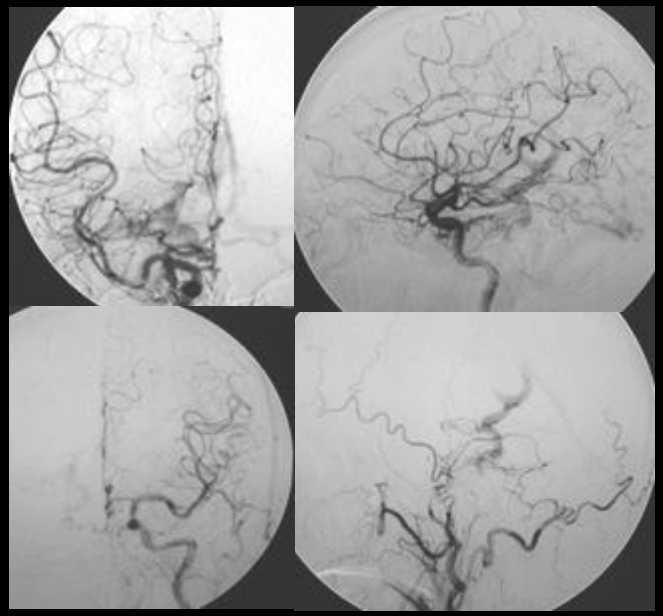
ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

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

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

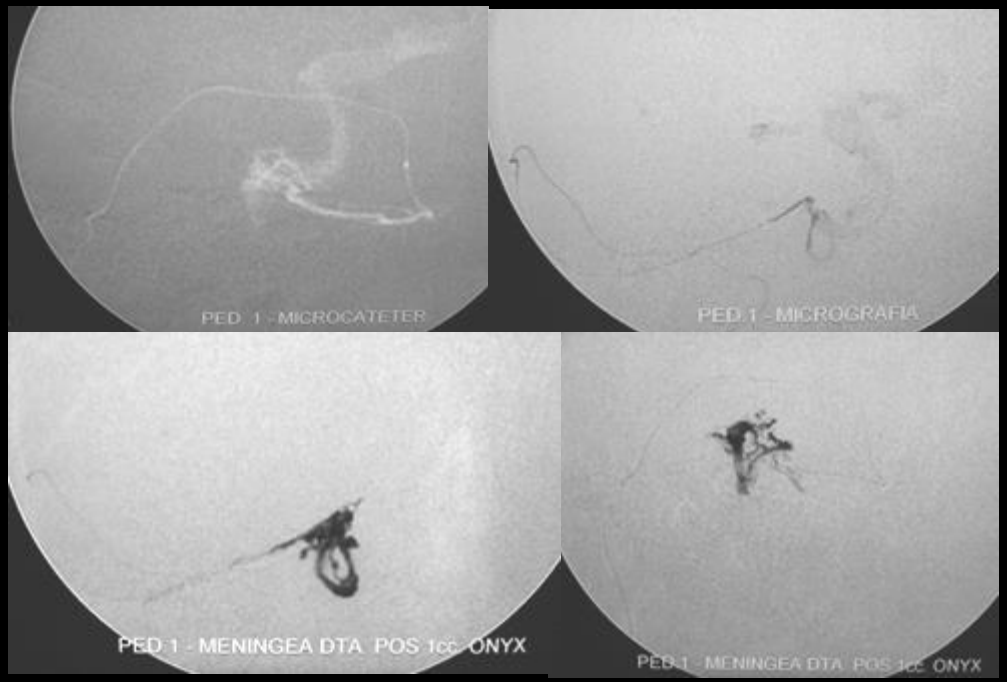


PRE – EMB

Right and left internal carotid – cavernous meningeal branches

Right external carotid – middle meningeal, ascending pharingeal and occipital arteries

ONYX – right middle meningeal artery



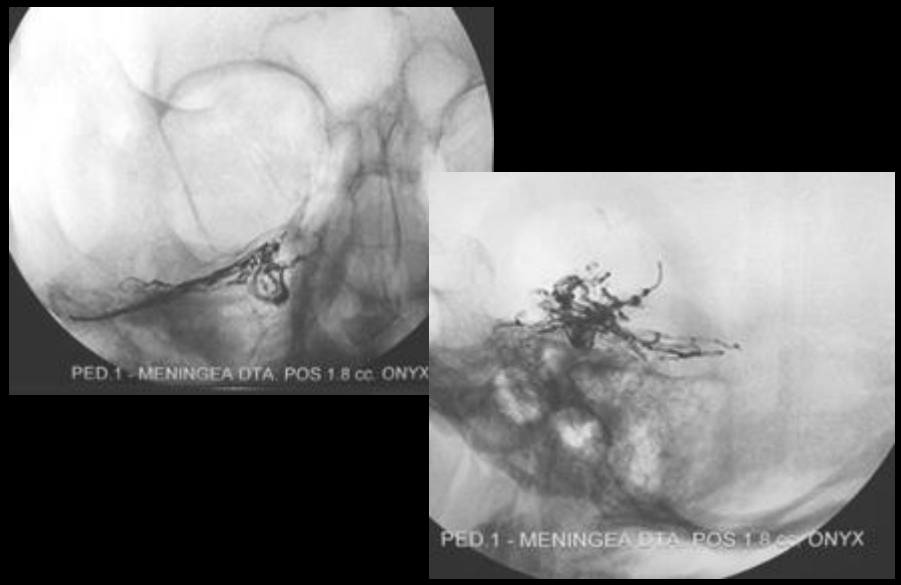
Right distal middle meningeal artery ONYX CAST

Tentorial DAVF Type III

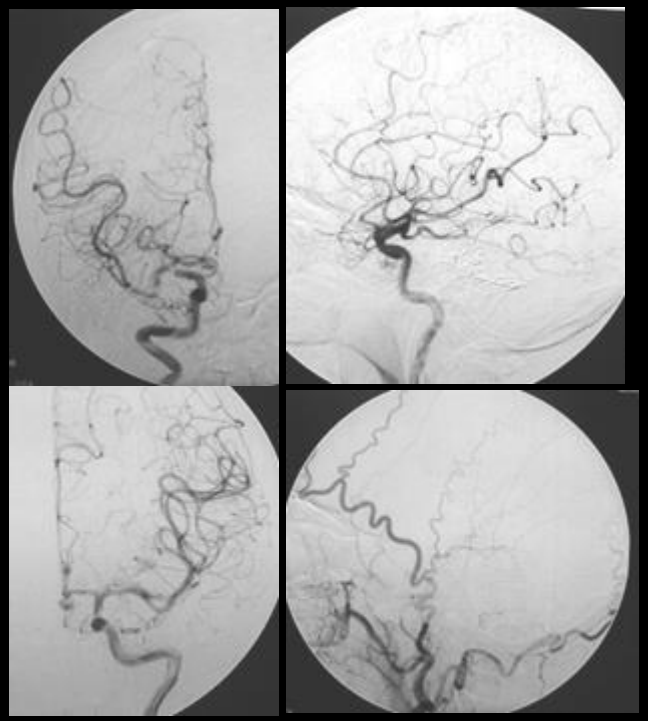
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

ONYX



ONYX CAST



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

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

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

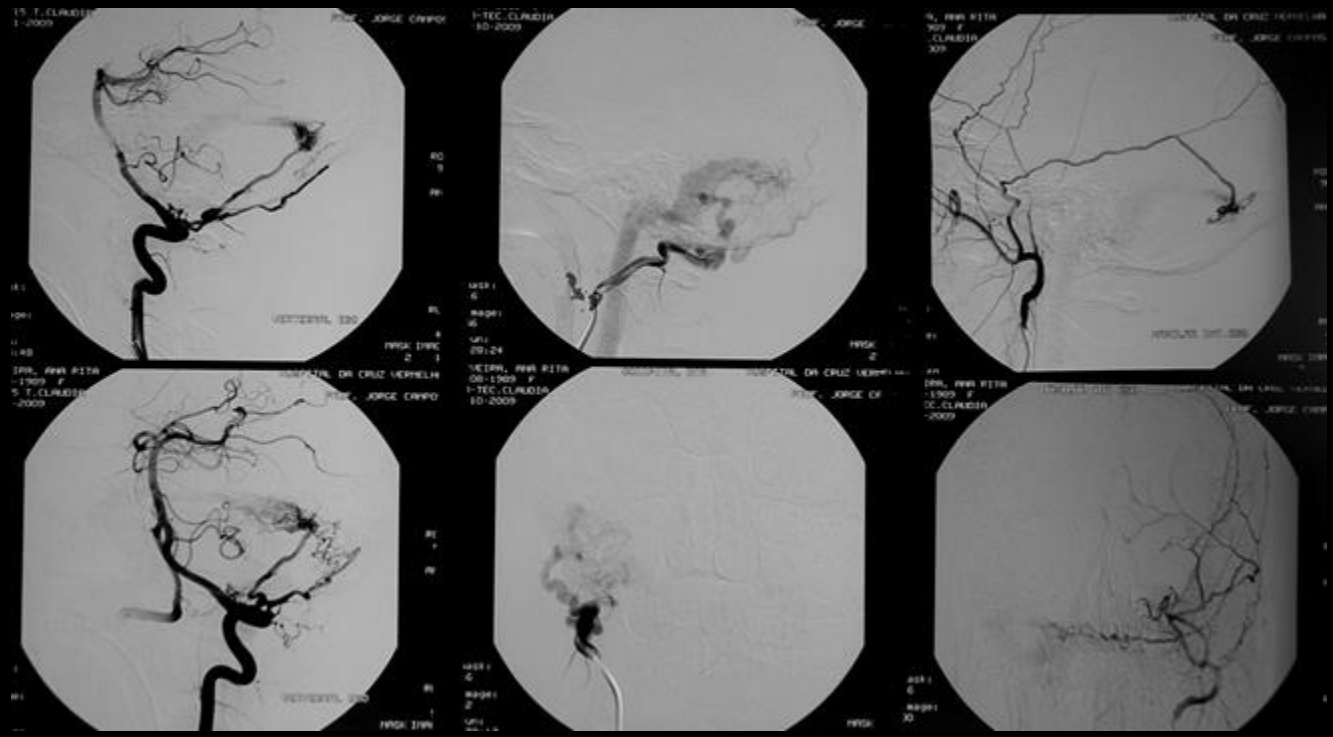
PRE – EMB

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Right lateral sinus DAVM type II

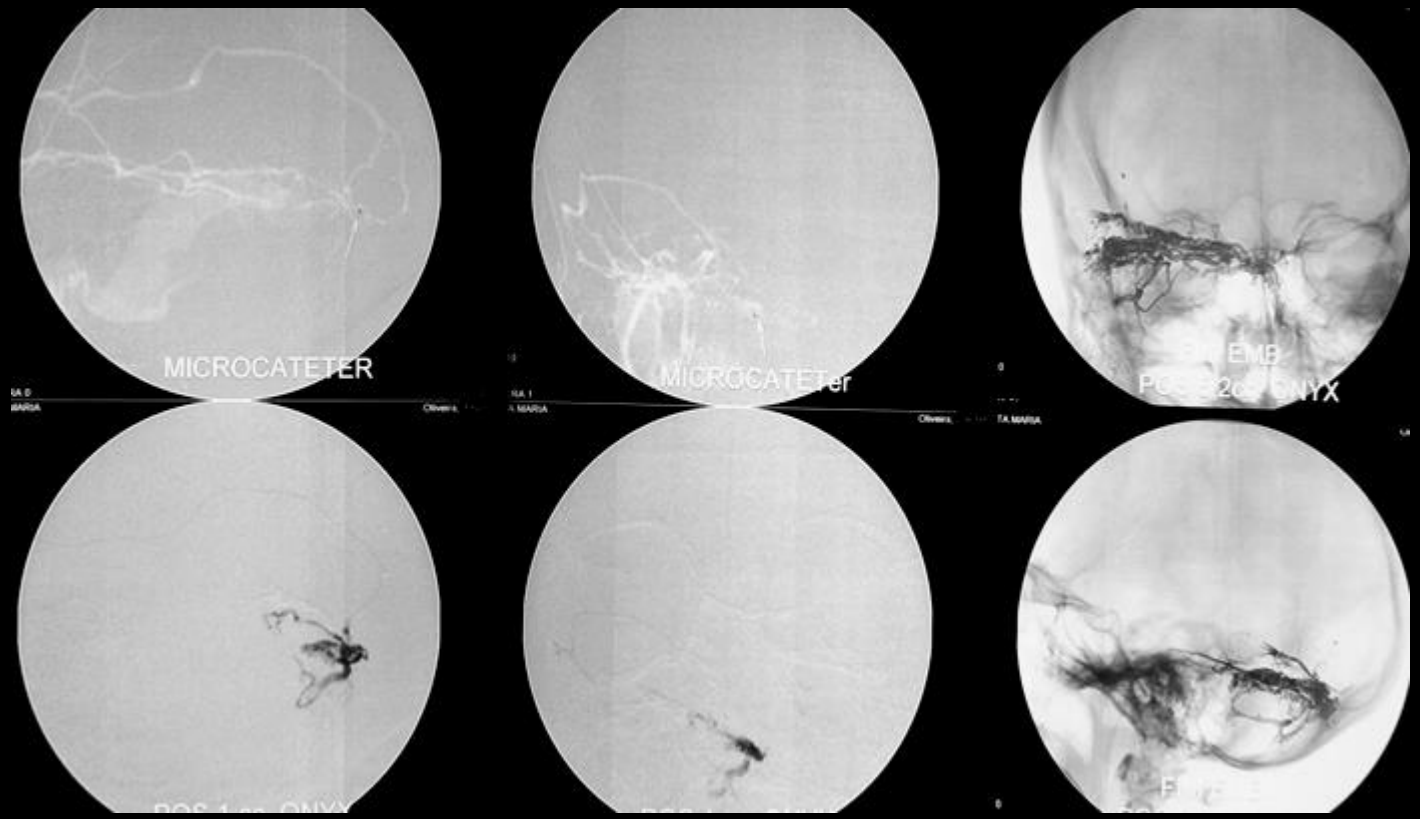
PRE – EMB



25th SIMI – Buenos Aires 2016

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION



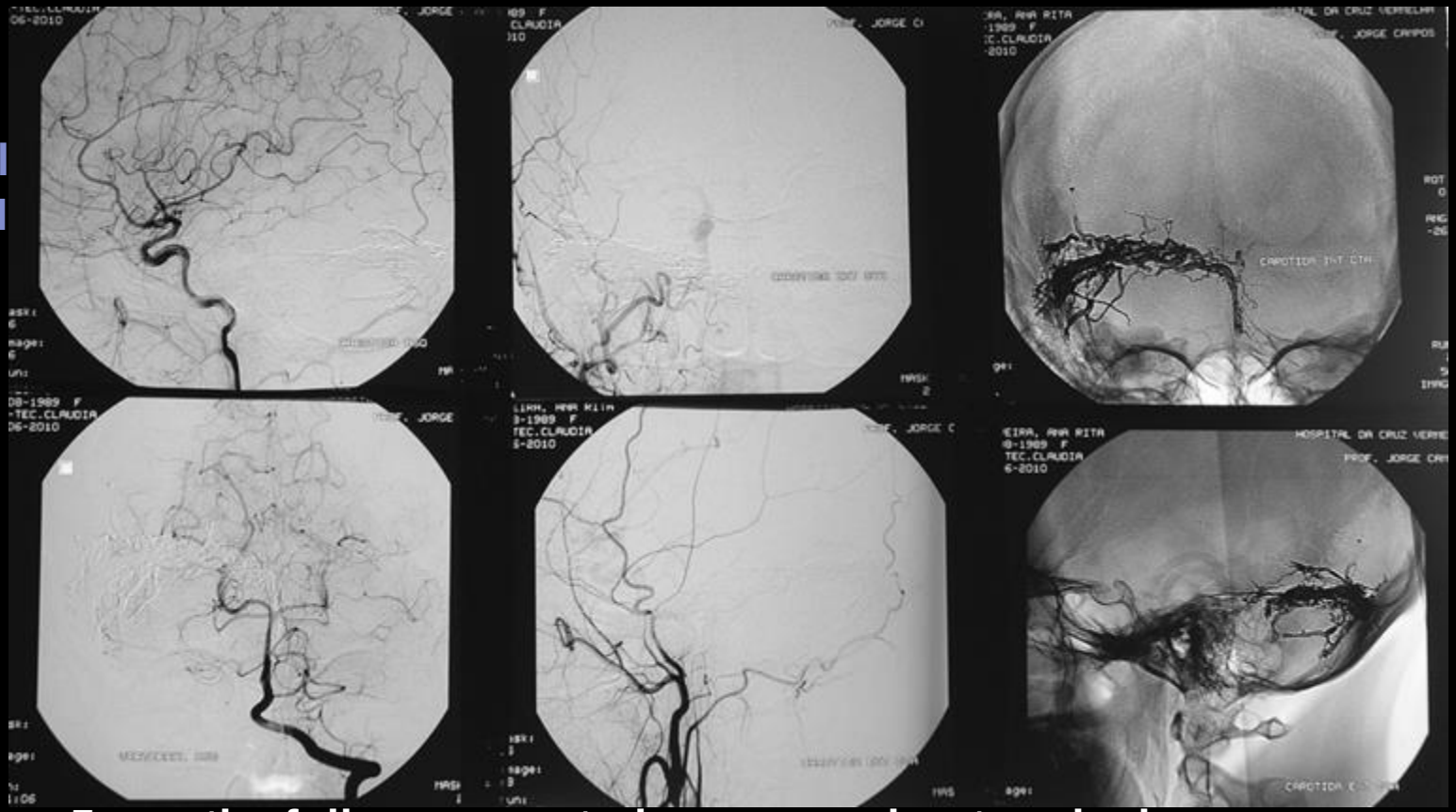
Right middle meningeal artery microcatheter and ONYX cast (5.2 cc)

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Right lateral sinus DAVM type II

Multiple shunts



5 months follow-up – arterio-venous shunt exclusion

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

ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

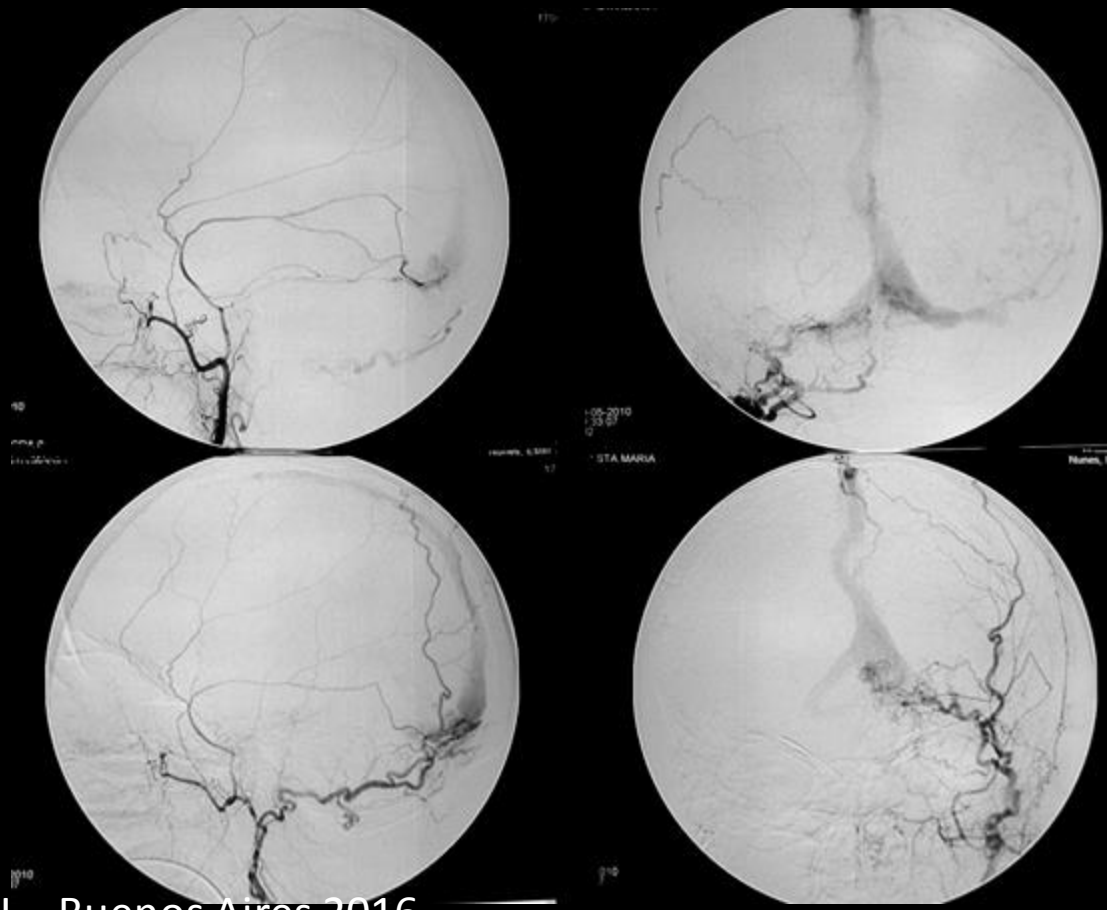
DAVM type II torcular region

72 y with dementia

right and left middle meningeal and occipital arteries

exclusion of both lateral sinus

ONYX

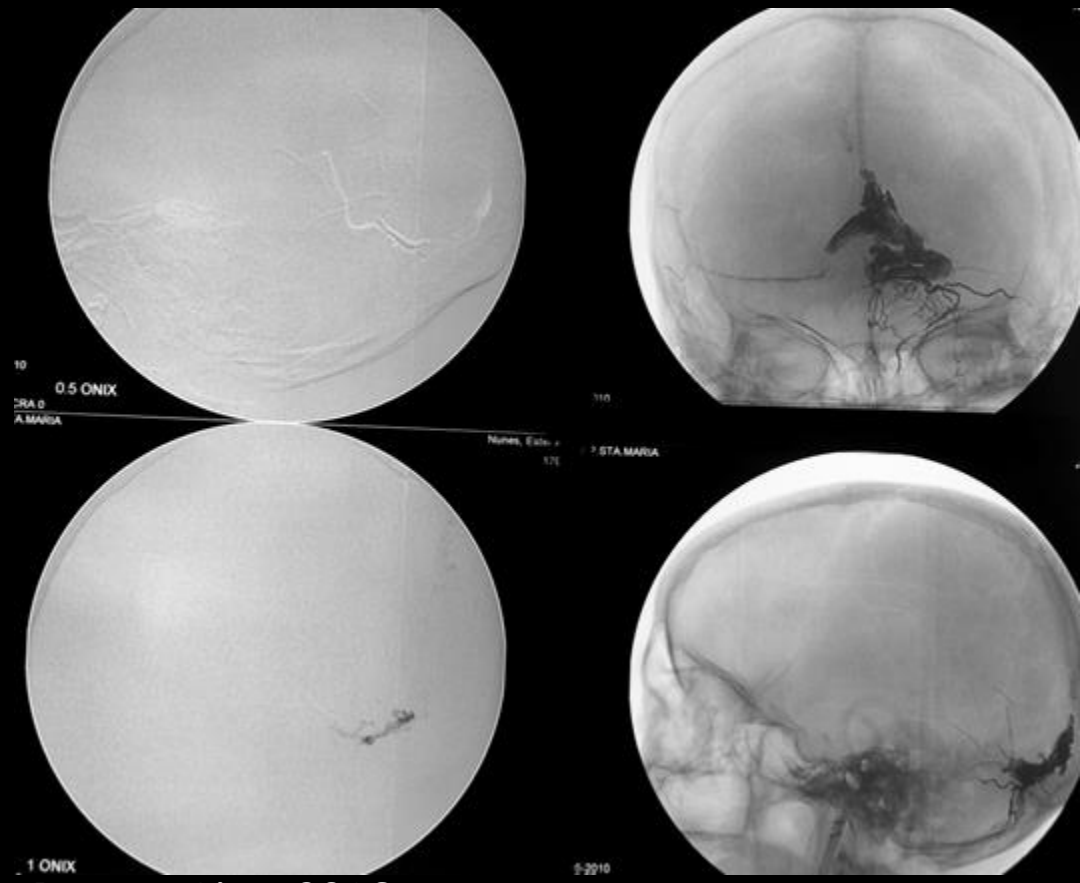


PRE-EMB right and left external carotid angiograms

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

DAVM type II torcular region

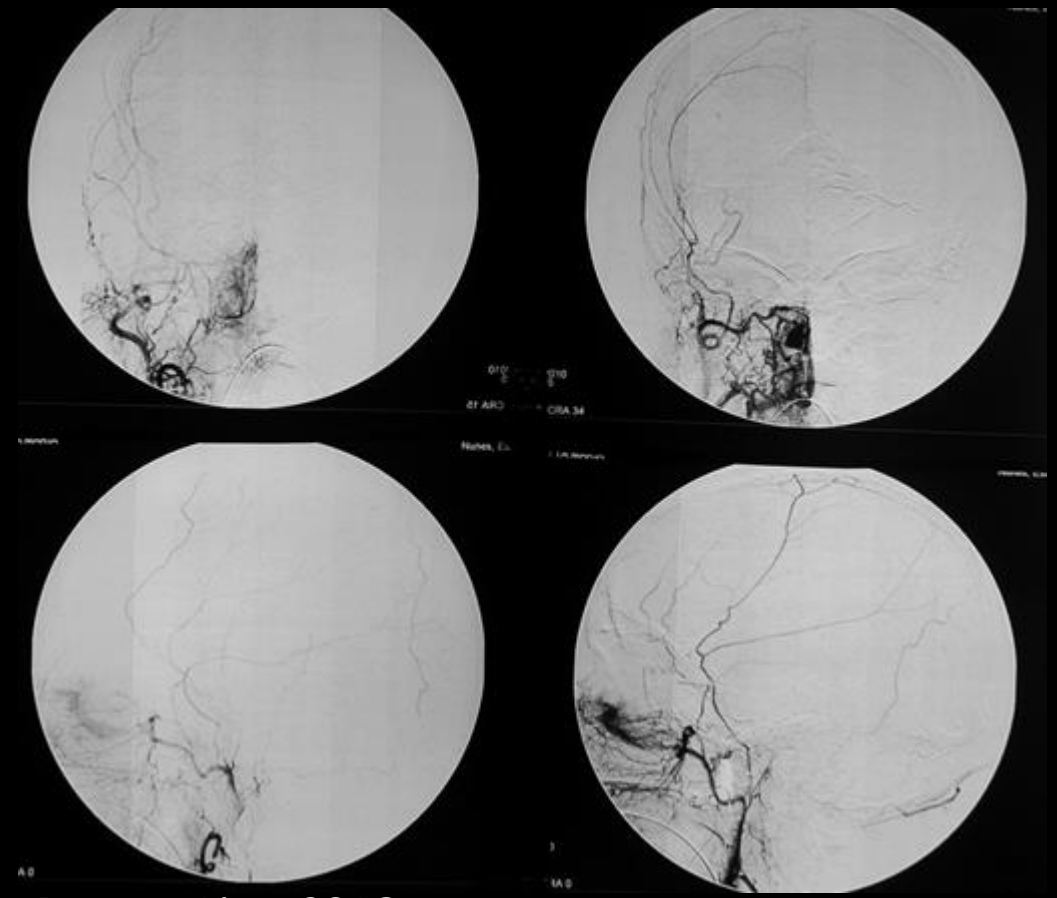


Left middle meningeal artery
ONYX cast – final result

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

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

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

SQUID

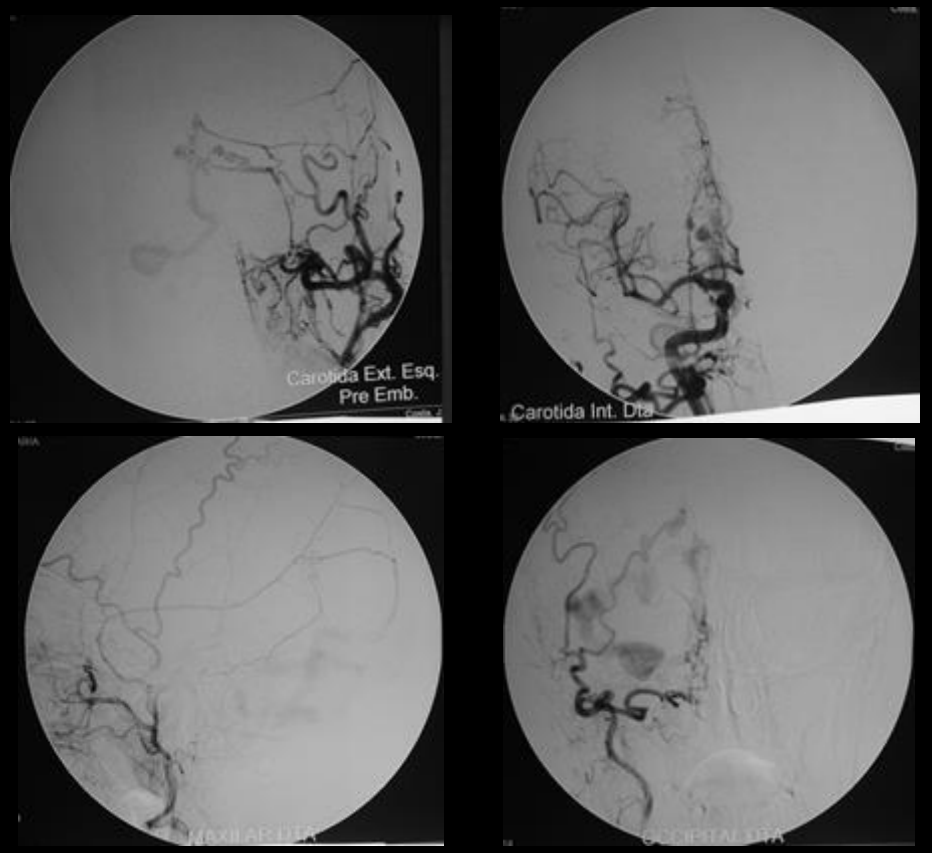
60 y. o.

Cerebellar hematoma

DAVF type IV falx cerebelli

right and left middle meningeals, ascending pharyngeals and occipitals

Right meningotentorial branch of right ACI



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

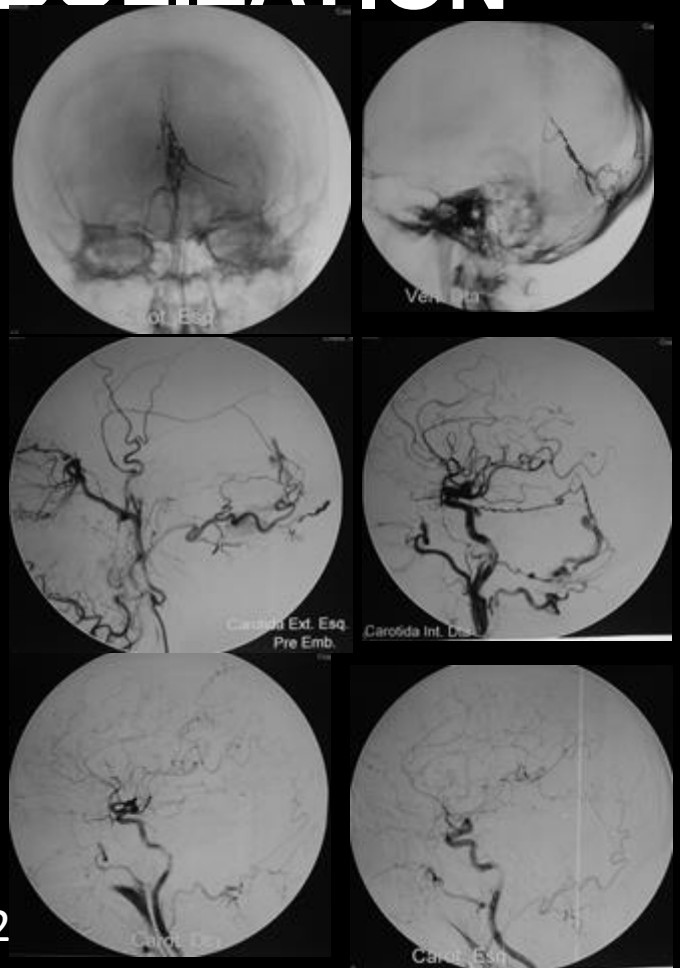
ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

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

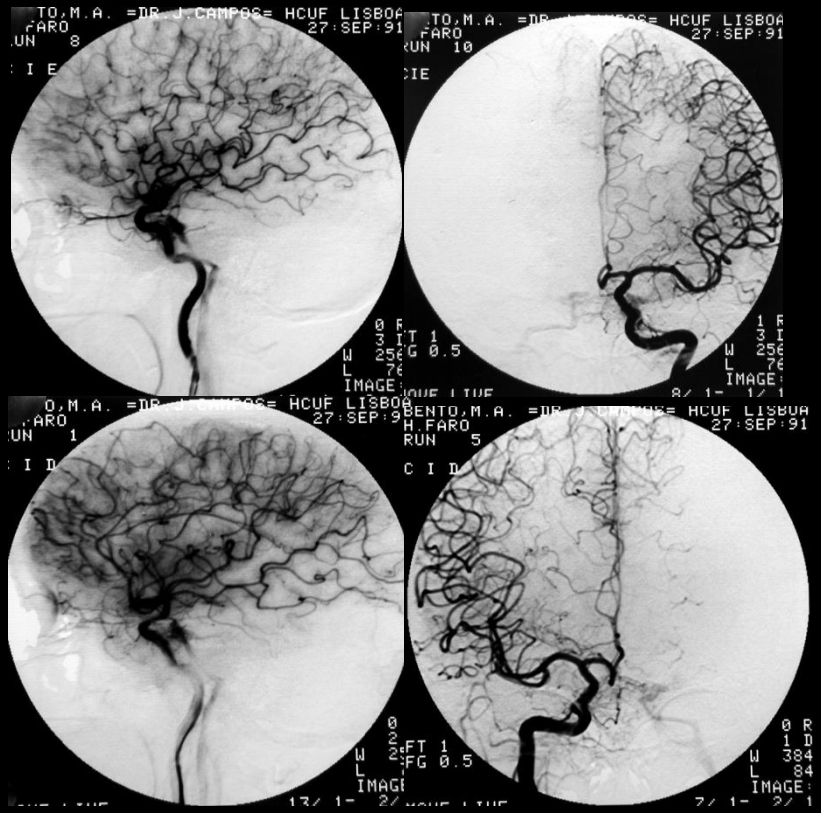


Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

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

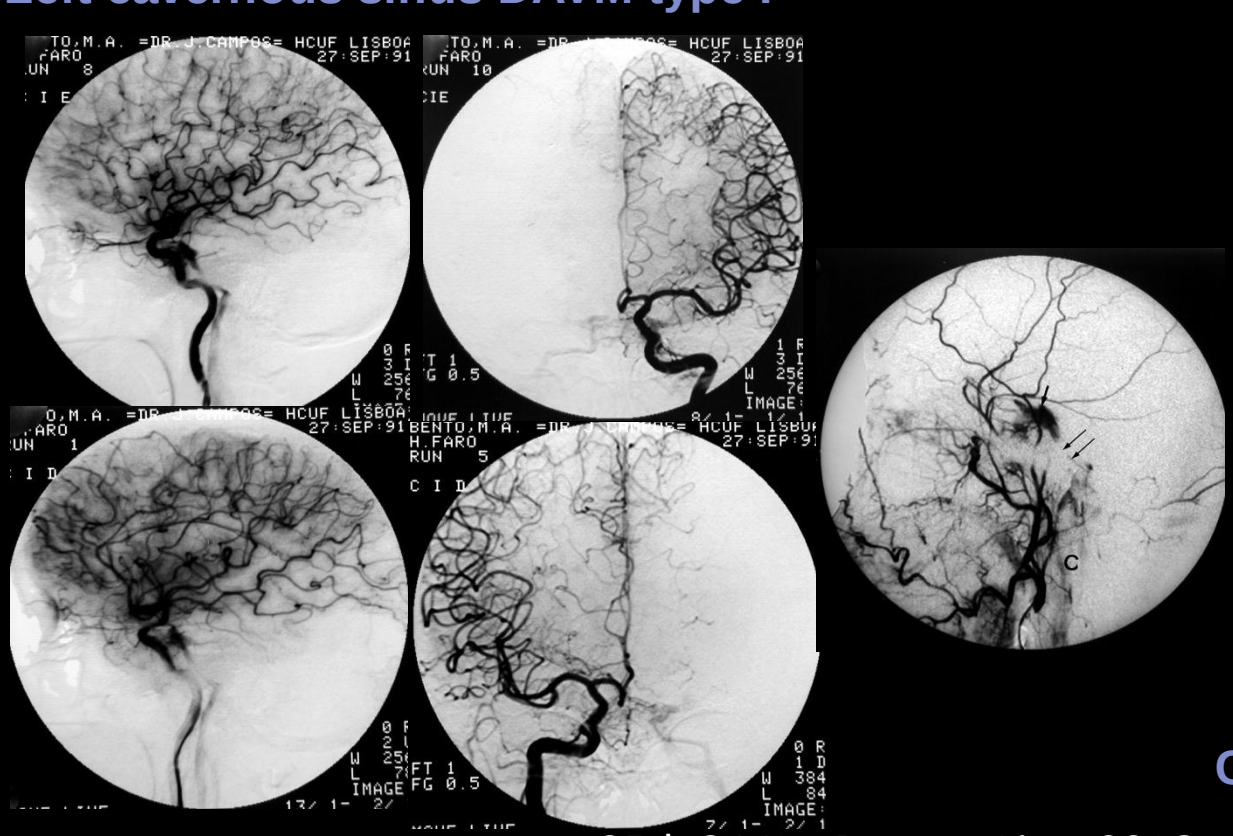


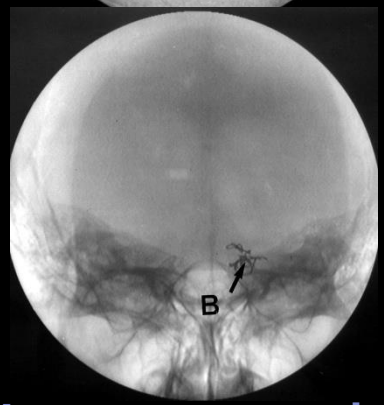
Left cavernous sinus DAVM type I

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Left cavernous sinus DAVM type I



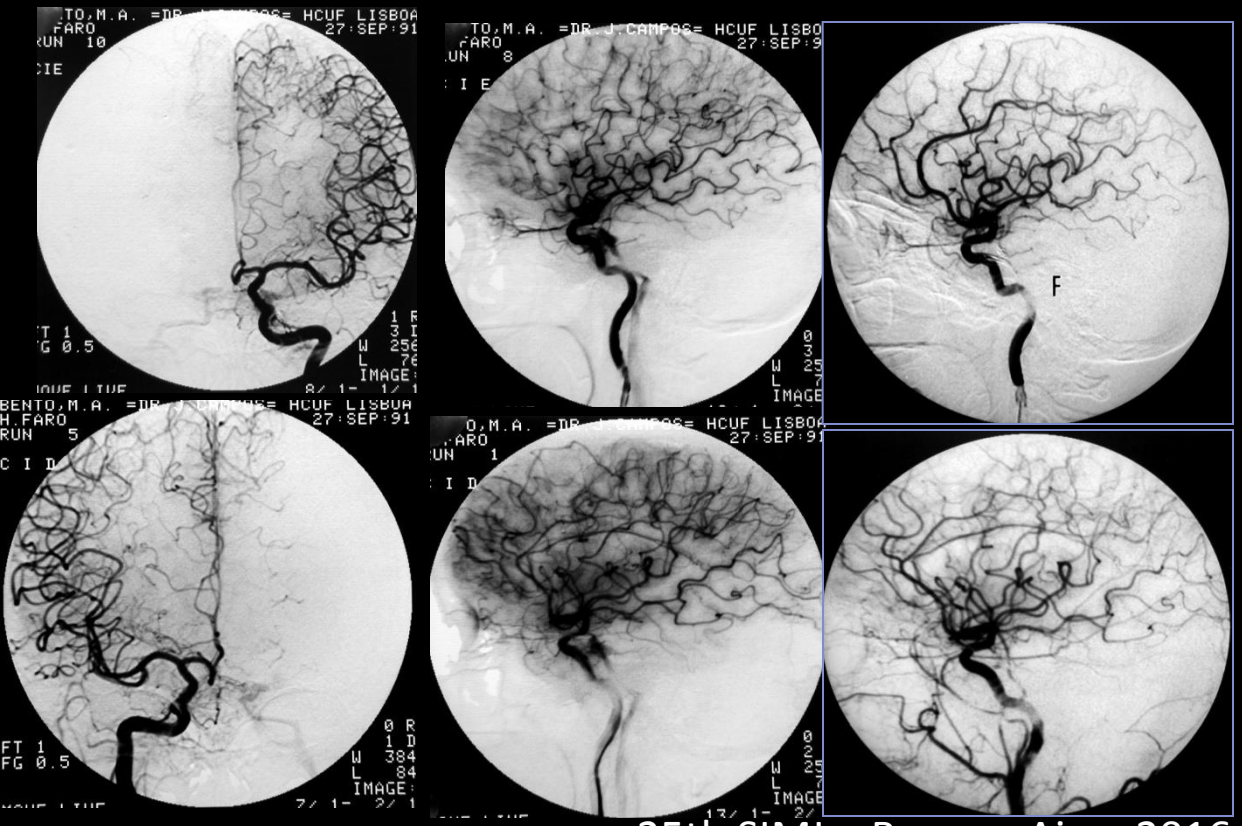


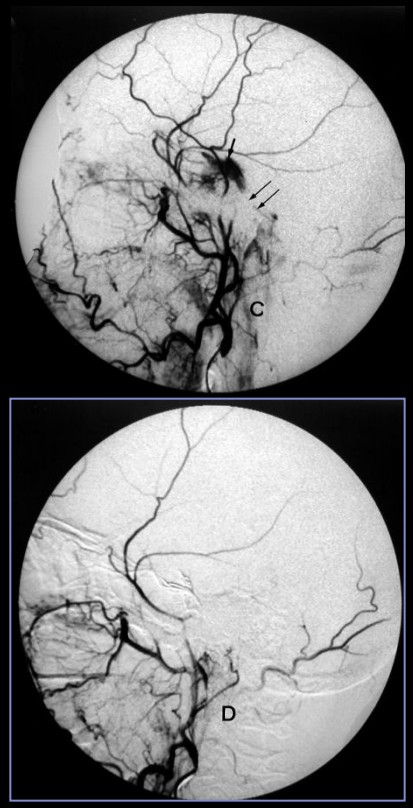
Coils - Venous approach

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Left cavernous sinus DAVM type I



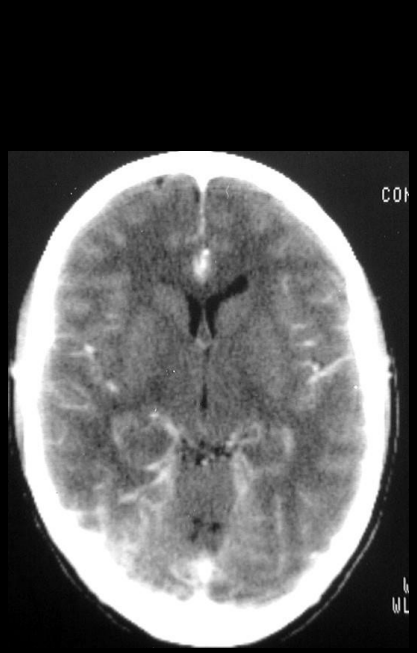


Post Emb

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

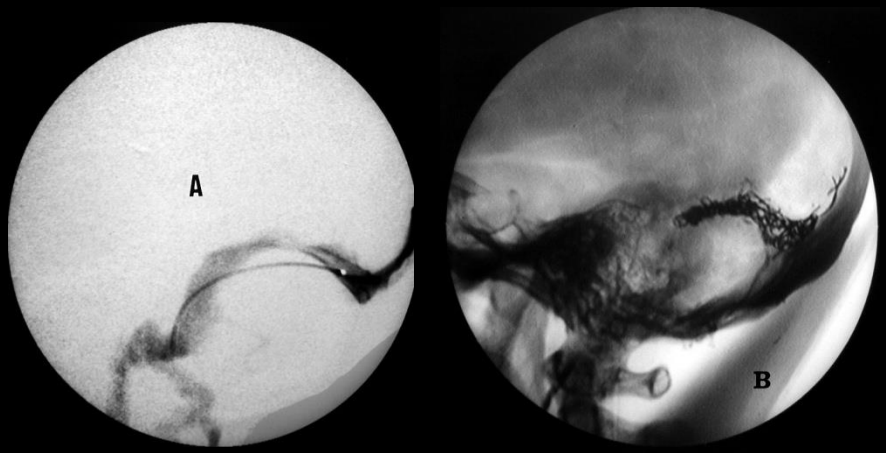
Right lateral sinus DAVM type I



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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Right lateral sinus DAVM type I



Coils - Venous approach

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

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Right lateral sinus DAVM type I

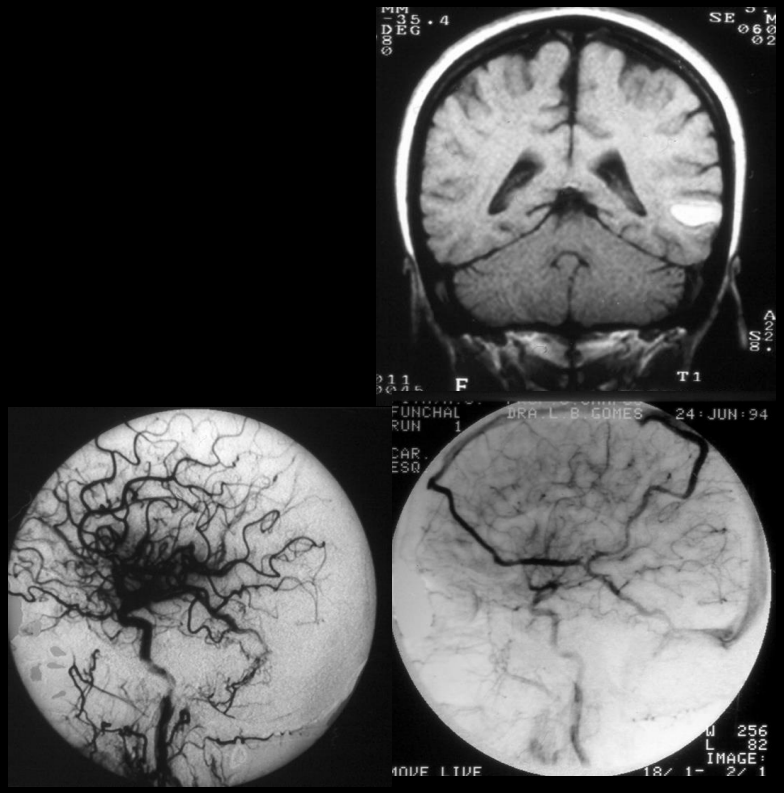
Right carotid and vertebral arteries
POST – EMB

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

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**

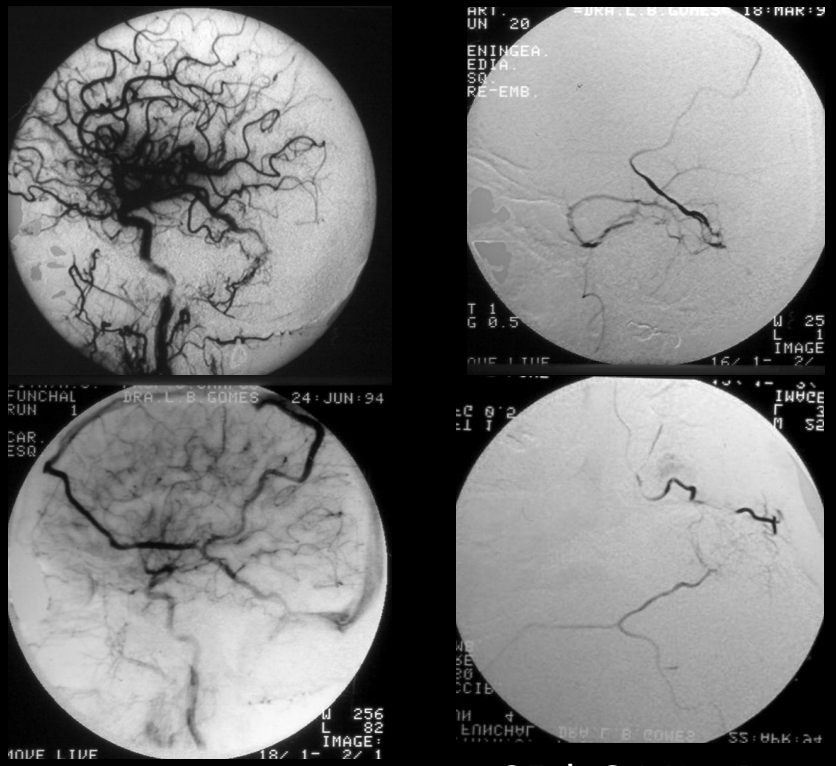


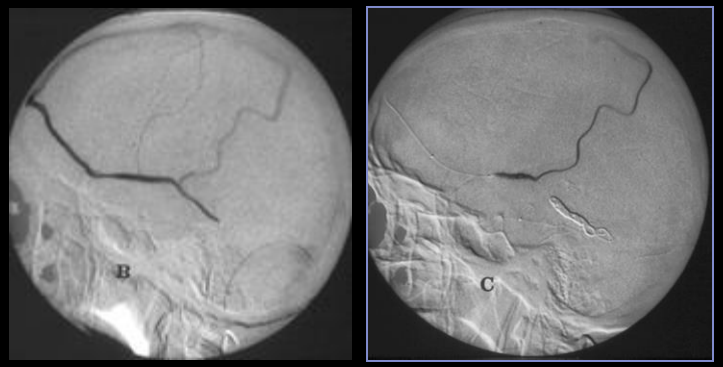
Left lateral sinus DAVM type III

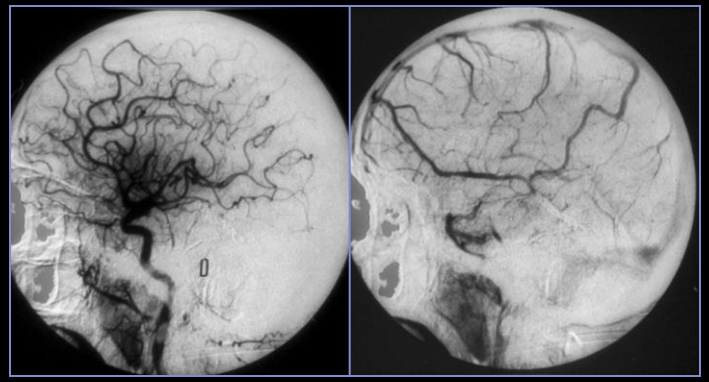
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS
INTRA-VENOUS EMBOLIZATION

Left lateral sinus DAVM type III







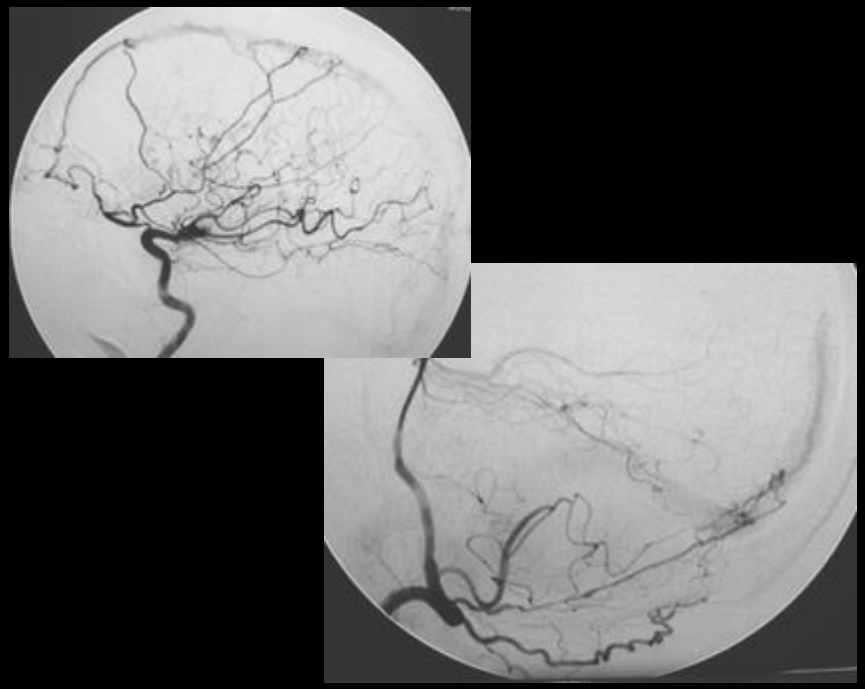
Left carotid angiogram
POST – EMB

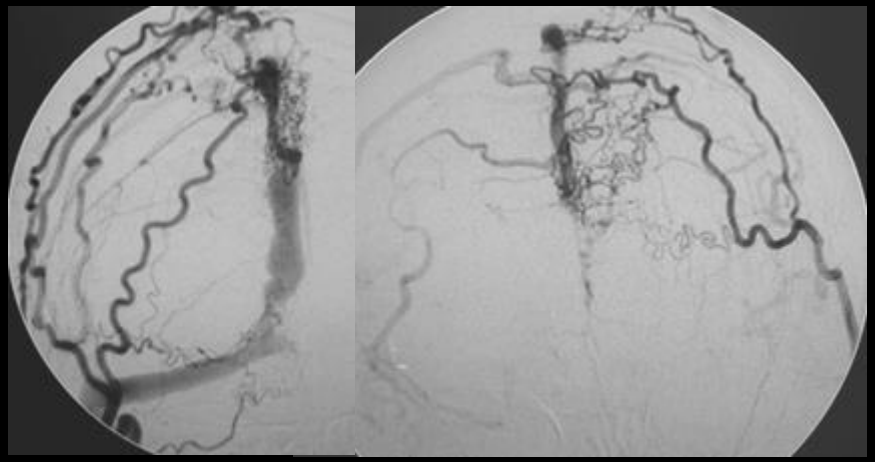
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS UNUSUAL INTRAVENOUS EMBOLIZATION

Superior Longitudinal Sinus Occlusion

Male, 74 years, right parietal haemorragic stroke + dementia



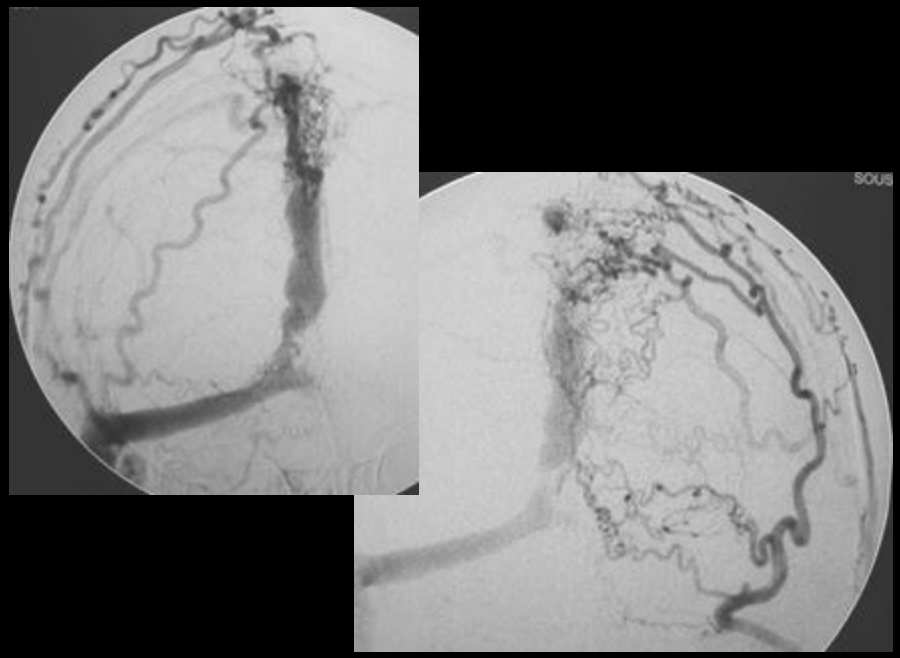


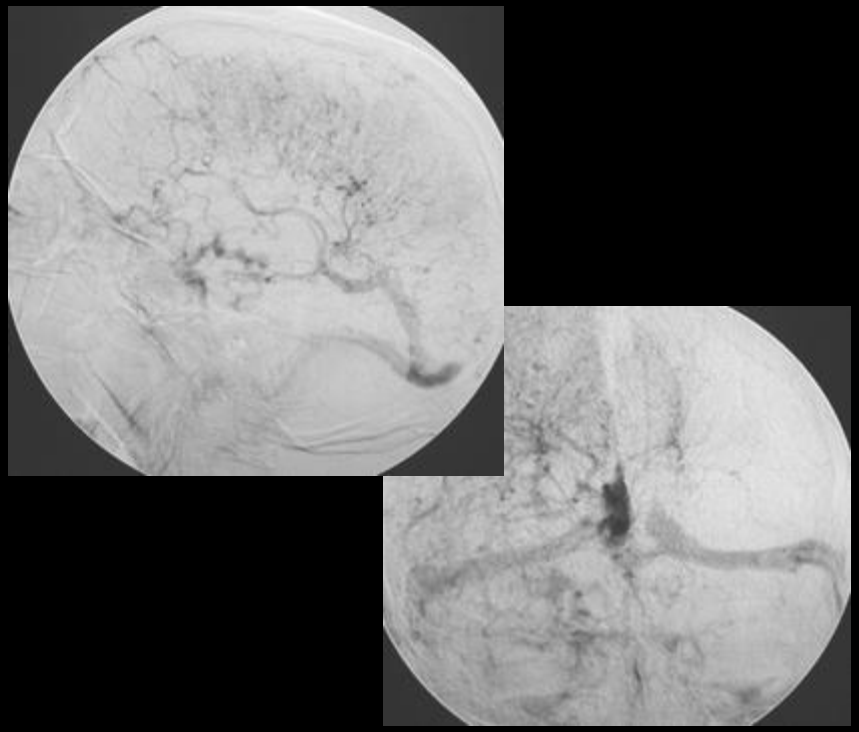
Superior sagital sinus DAVF type II
Multiple shunts – arterial feeders:
Left anterior and posterior meningeal, right and left superficial temporal and occipital arteries (transosseous branches)

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

ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Superior Longitudinal Sinus Occlusion with Coils



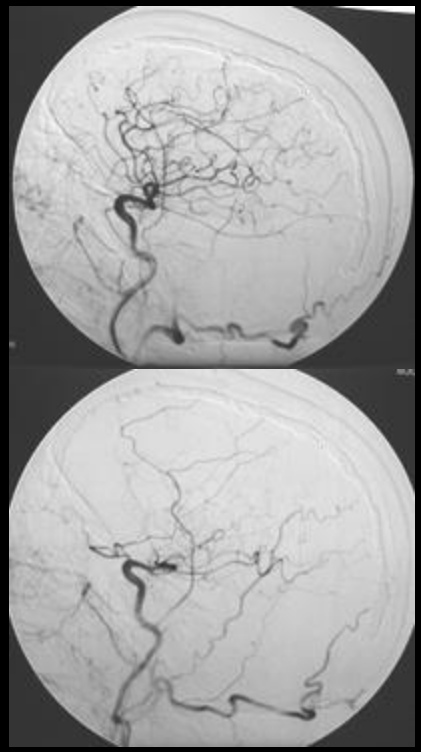


Pre-emb angiogram - DAVF type II
Functional exclusion of the SLS

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

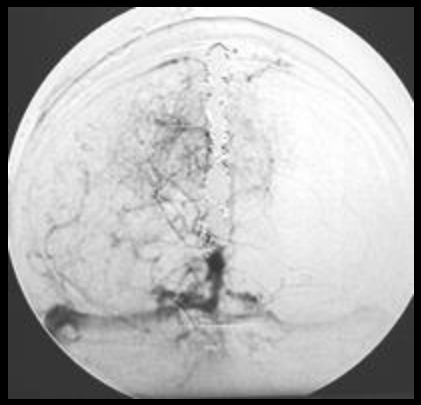
ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Superior Longitudinal Sinus Occlusion with Coils



Left

Right



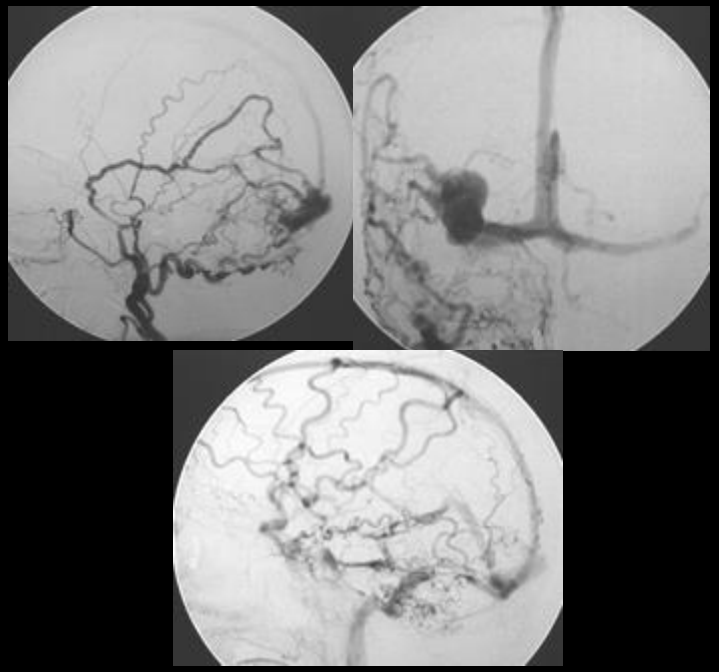
Pos-emb angiogram

25th SIMI – Buenos Aires 2016

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

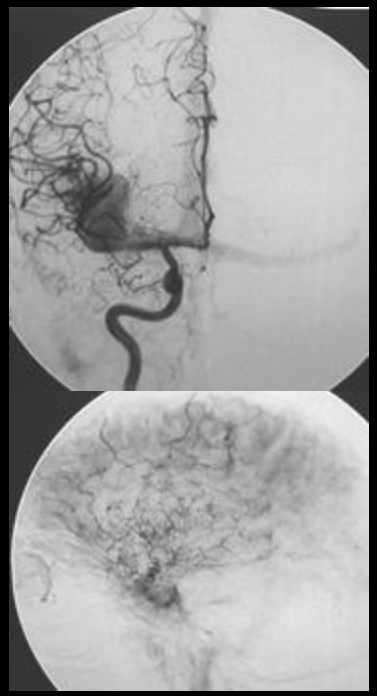
ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Direct Percutaneous Venous Punction - Coil Embolization



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

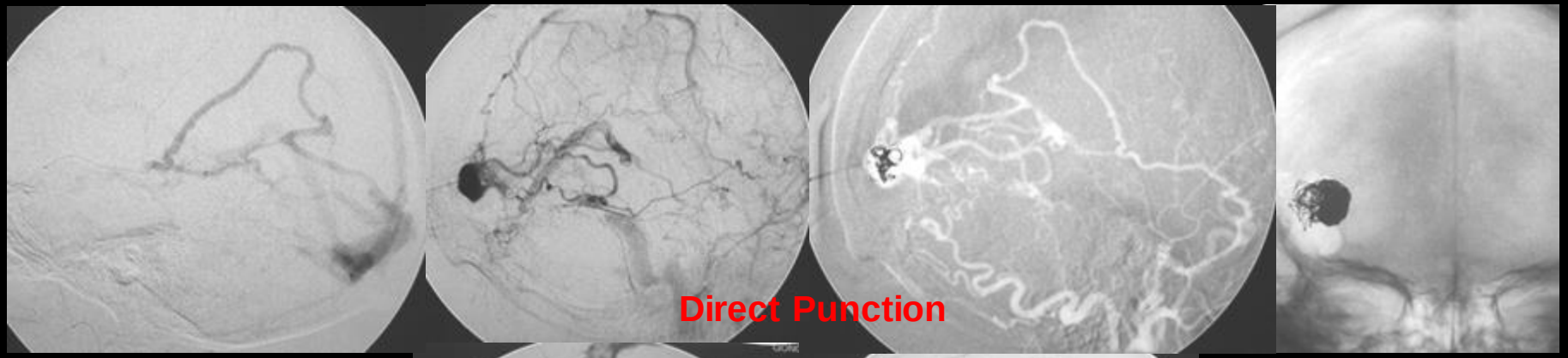
Female, 60 years, lytic occipital skull lesion + dementia

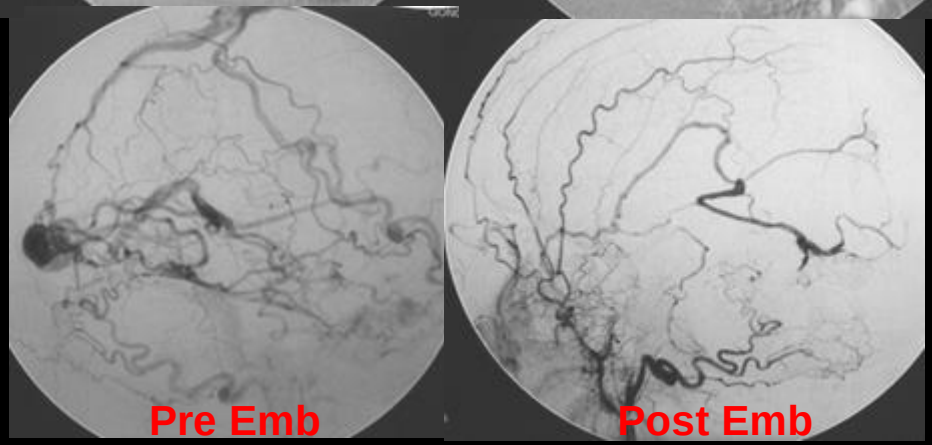


Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR THERAPY PROTOCOLS
UNUSUAL INTRAVENOUS EMBOLIZATION

Direct Percutaneous Venous Punction - Coil Embolization





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

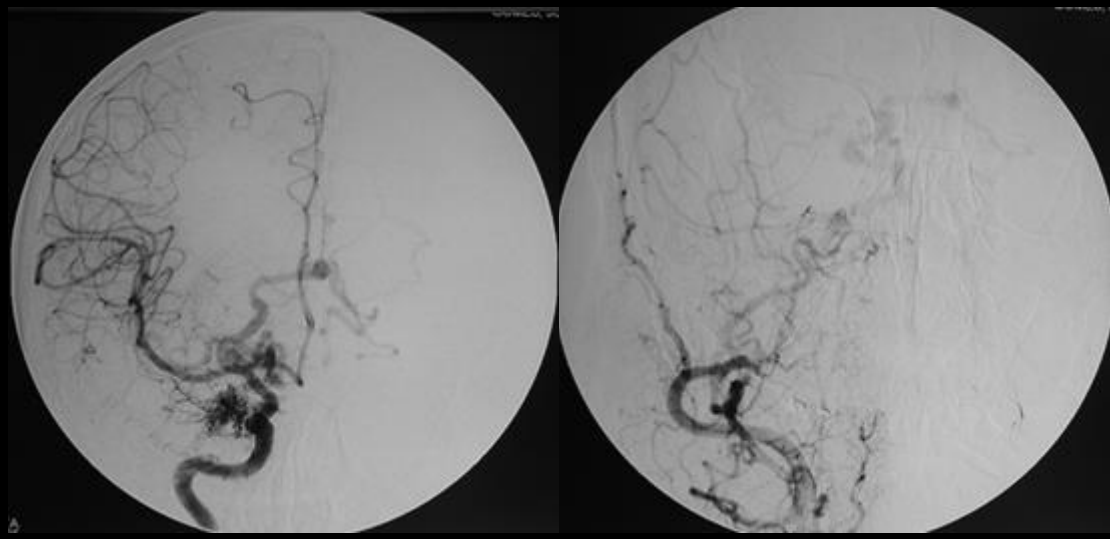
ENDOVASCULAR THERAPY PROTOCOLS
INTRA-ARTERIAL EMBOLIZATION

Intra-arterial embolization and Radiosurgery

Post. Embolization residual high risk shunts

Problematic surgery (craniotomy)

Frequently tentorial



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

ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

Intra-arterial embolization and Radiosurgery

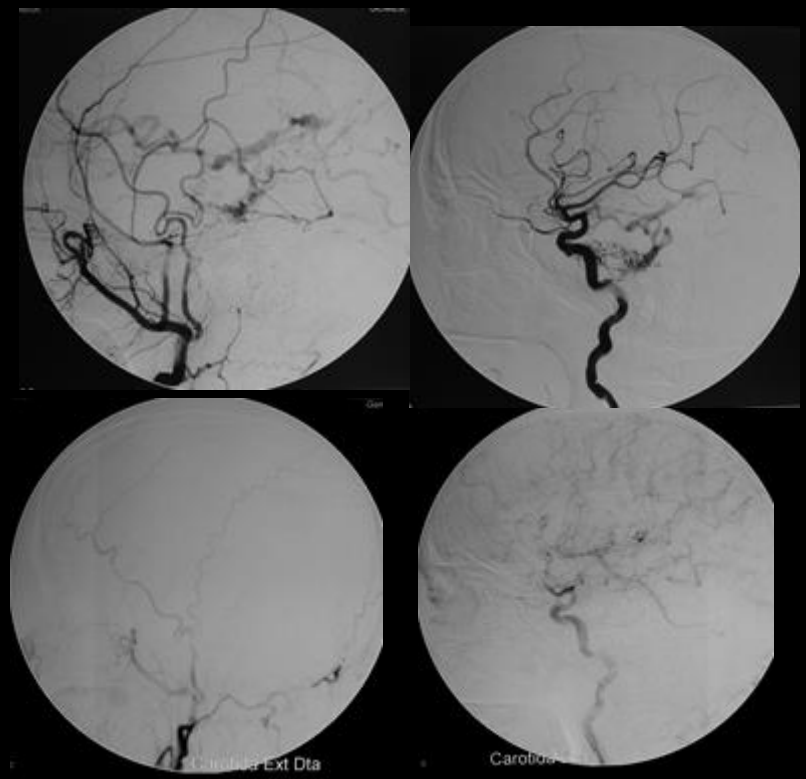
Male 46 y.o.

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



Post Radiosurgery
Exclusion of the shunt

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

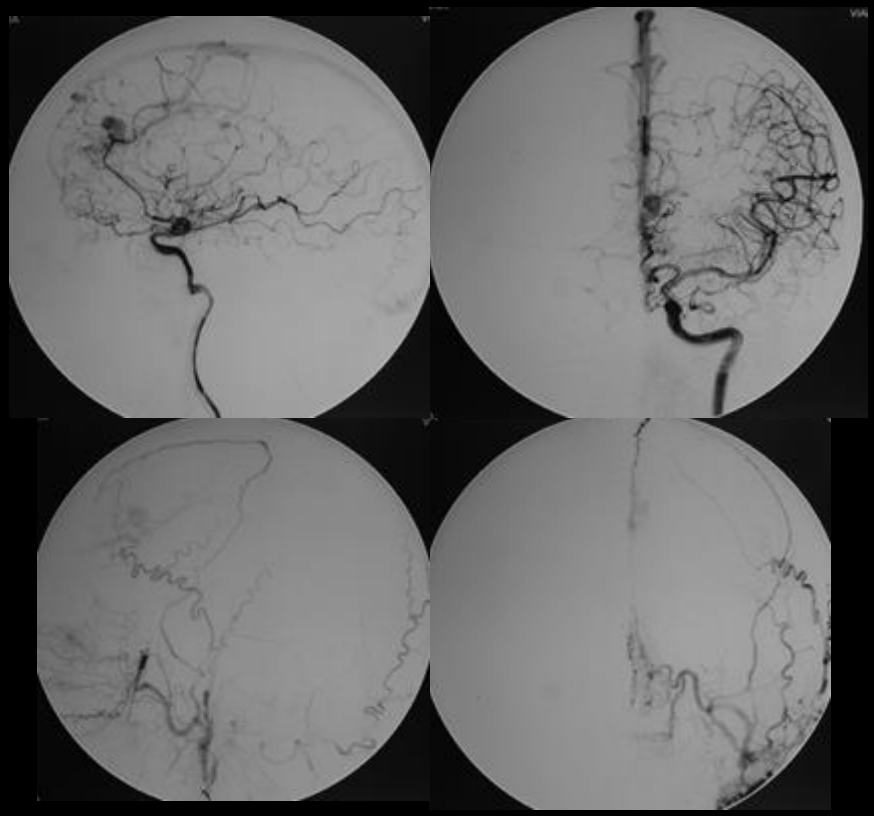
ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

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)

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

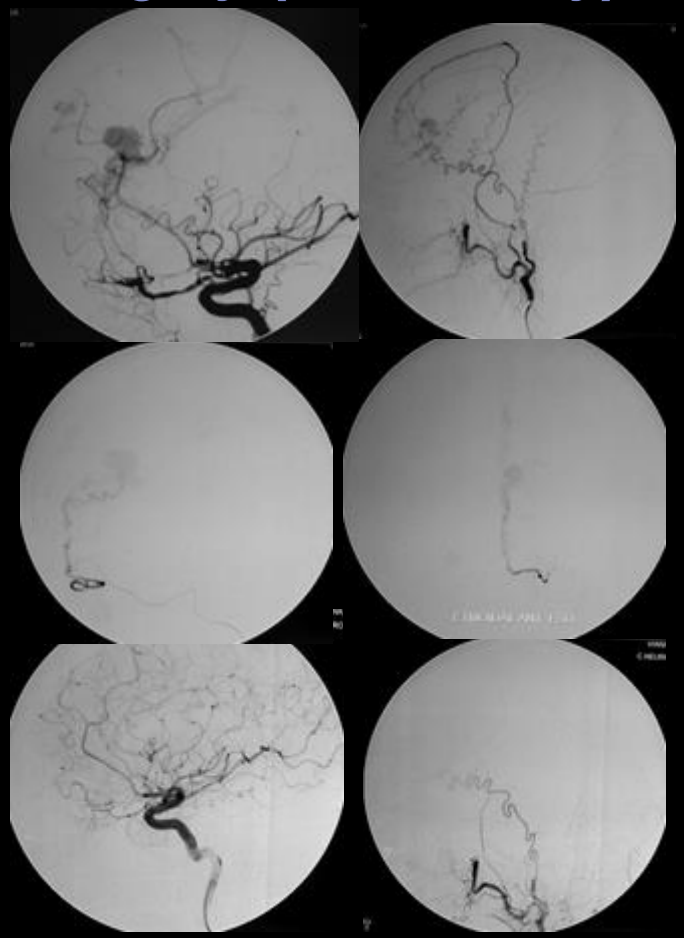
ENDOVASCULAR THERAPY PROTOCOLS INTRA-ARTERIAL EMBOLIZATION

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**

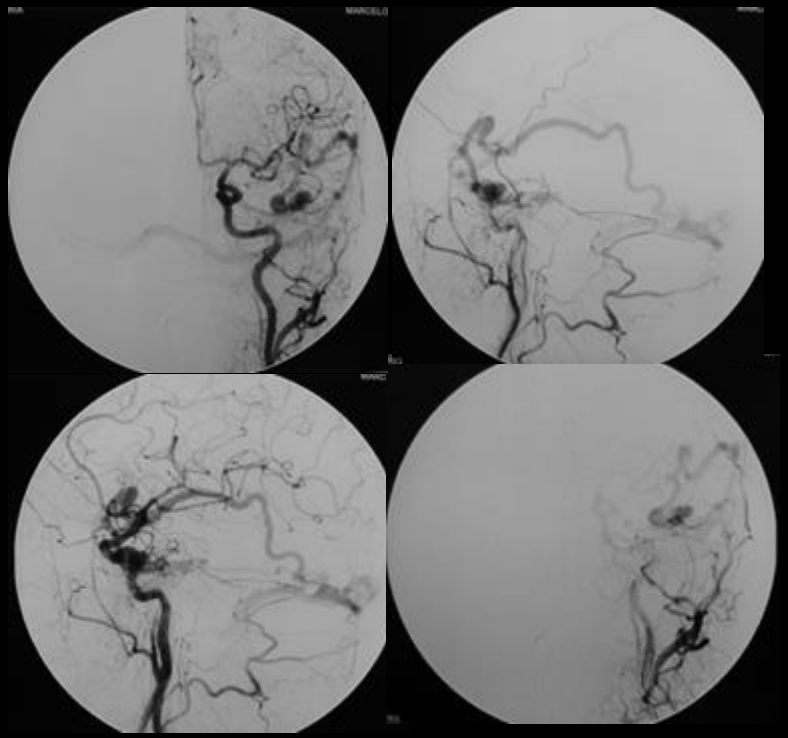
HEMORRHAGE

- **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

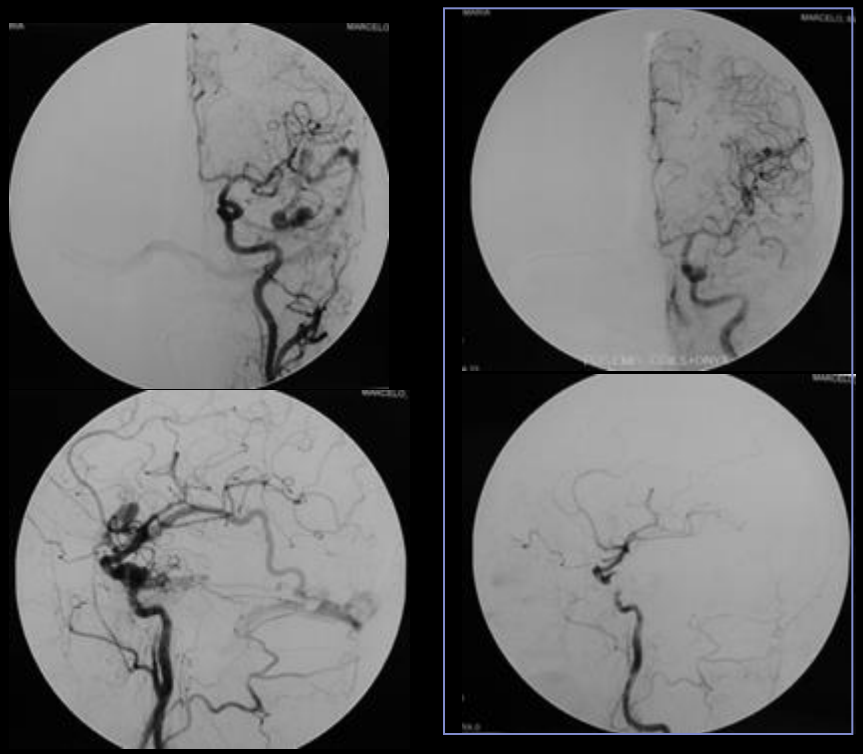
Right temporal fossa DAVM type IV



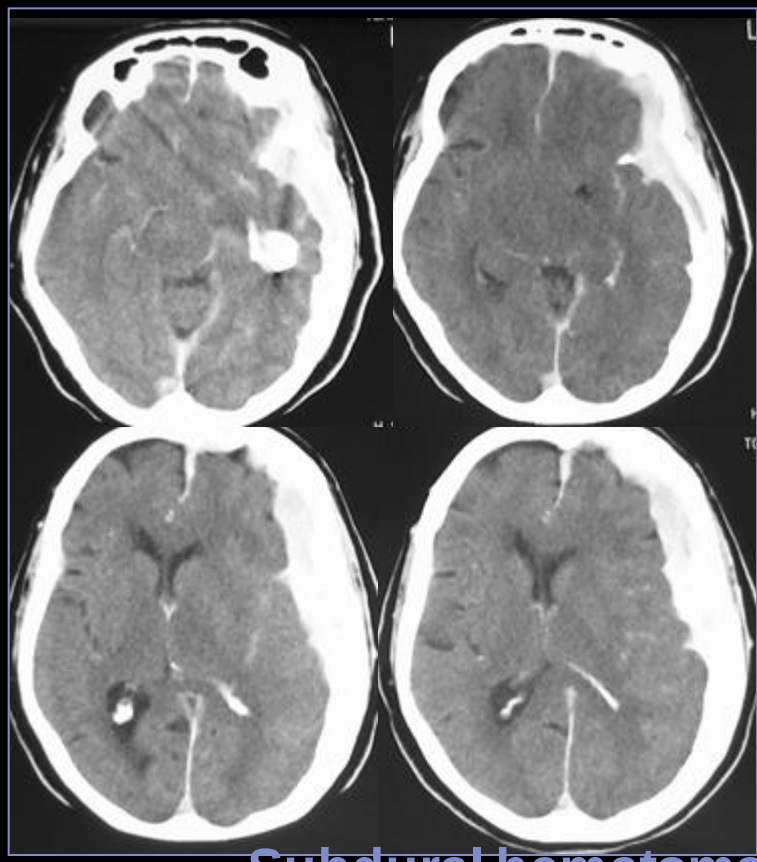
Dural Arteriovenous Malformations and Fistulae (DAVM'S – DAVF´S)

ENDOVASCULAR SURGERY RISKS AND COMPLICATIONS

Right temporal fossa DAVM type IV



Post Emb



Subdural hematoma after embolization

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

Endovascular embolization - RESULTS

119 patients

Cavernous sinus	51	tentorial	4
lateral sinus	42	anterior fossa	1
SLS	11	temporal fossa	4
Skul base / posterior fossa	6		

COMPLETE ARTERIOVENOUS SHUNT EXCLUSION – 87 %

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

Clinical improvement or cure – 97 %

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 %

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

ENDOVASCULAR SURGERY

CONCLUSIONS

- Endovascular surgery is the first treatment modality in DAVF with excelent 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).

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

CONCLUSIONS

ENDOVASCULAR SURGERY

The therapeutic options and results depend mainly:

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