Update in Endovascular Treatment of Brain AVMs

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Learning Objectives

- Curability and outcome according to AVM locations
  - Cortical & subcortical
    - Spetzler-Martin grades 1 & 2
  - Deep-seated BAVMs
  - Posterior fossa AVMs
- Techniques
  - Venous route
  - COMBIMAV

Cortical & subcortical BAVMs

- SM 1 & 2
  - Curability by EVT

	Total	Complete Exclusion	Remnant	*P* Value[b]
Location				.338
Cortical and subcortical	176 (100%)	159 (90.3%)	17 (9.7%)	
Deep	19 (100%)	19 (100%)	0 (0%)	
Infratentorial	29 (100%)	27 (93.1%)	2 (6.9%)	
Eloquent	77 (100%)	76 (98.7%)	1 (1.3%)	.004
Noneloquent	147 (100%)	129 (87.8%)	18 (12.2%)	

[a] Data are presented as No. (%).

[b] Fisher exact test.

Baharvahdat H et al. Endovascular Treatment for Low-Grade (Spetzler-Martin I-II) Brain Arteriovenous Malformations. AJNR Am J Neuroradiol. 2019 Apr;40(4):668-672.

Cortical & subcortical BAVMs

- SM 1 & 2 Complications of EVT
  - Delayed hemorrhagic complications: 5%
  - severe ischemic complication: 2%
  - new neurologic deficit: 14%
    - 9% resolved within 30 days of embo
    - 5% with a permanent deficit (3% from hemorrhagic and 2% from ischemic complications)
  - overall good outcome (mRS 0–2): 80%
  - 6% worse mRS score compared with preoperative status
  - mortality rate: 0.4%.

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Cortical & subcortical BAVMs

- SM 1 & 2 Predictive variables of poor clinical outcome (univariate)
  - hemorrhagic history (*P* < .000)
  - preoperative condition (mRS 0–1 versus mRS 2–5) (*P* < .000)
  - eloquent location of the AVM (*P* <.008)
  - no association found with:
    - Age, sex
    - SM grade (1 vs 2)
    - lateralization of the AVM
    - presence of deep drainage, presence of an intranidal aneurysm
    - number of procedures
    - volume of Onyx
    - use of *n*-butyl- 2-cyanoacrylate
    - number of embolized pedicles

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Cortical & subcortical BAVMs

- SM 1 & 2 SM 1 & 2 Predictive variables of poor clinical outcome (multivariate)
  - only the preoperative condition (poor preoperative mRS) was associated with poor outcome (mRS >2) (OR=0.029, P<0.00)
  - Hemorrhagic history, eloquence were not associated with poor outcome

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Deep-seated BAVMs

- Deep AVMs = Particular interest
    - High risk of bleeding
    - Difficulty in the management
- Heterogenous type of AVMs
- AVMs for which nidus is in the basal ganglia or the mesencephalon

Robert T et al. **A proposed grading system to evaluate the endovascular curability of deep-seated arteriovenous malformations.** J Neurol Sci. 2017 Jun 15;377:212-218.

Introduction

Interventional Neuroradiology Department, Rothschild Foundation, Paris - France

- Retrospective review of data

- Goals:
  1. To determine the anatomic factors that influence the success of the endovascular treatment
  2. To propose a classification of these AVMs (more homogenous groups)

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Material and Methods

- Retrospective analysis of prospective database
- Inclusion criteria:
  - Endovascular therapy as first line
- No exclusion criterion

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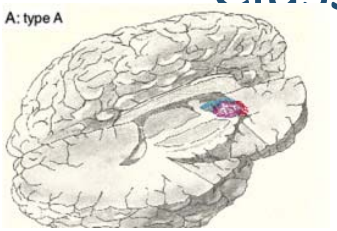
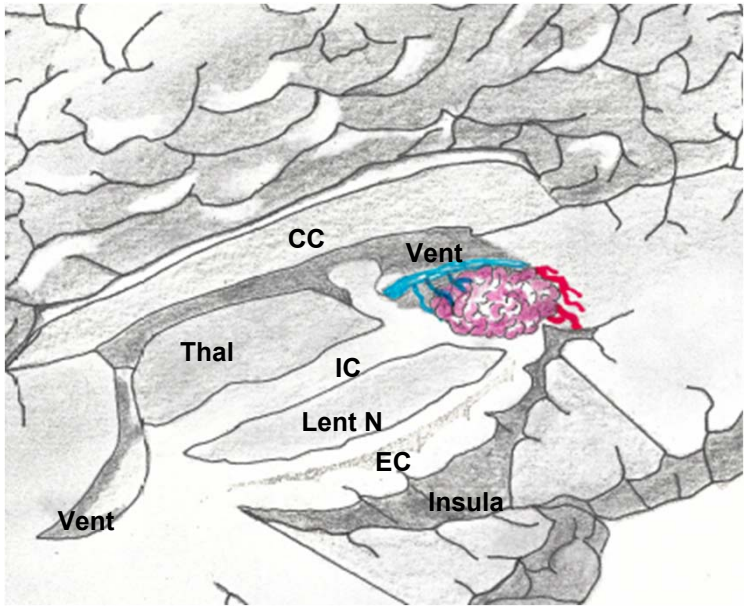
Classification of the AVM regarding the location of the AVM





Anterior type

Nidus anterior to

- Thalamus
- Anterior limb of the Internal capsule

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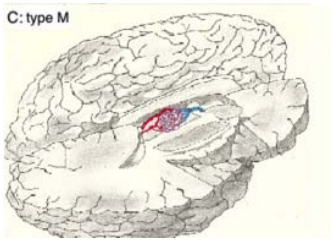

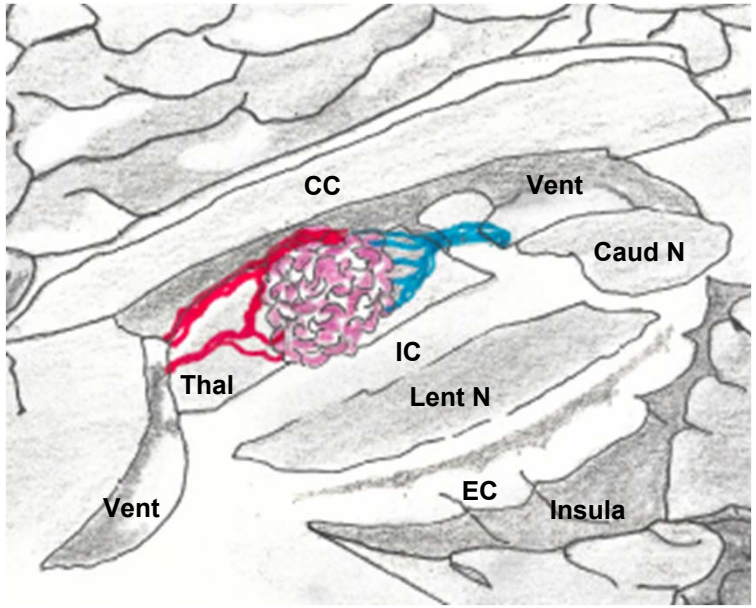

Medial type

Thalamic and ventricular nidus

Nidus medial to

- Posterior limb of the internal capsule
- Genu of the internal capsule

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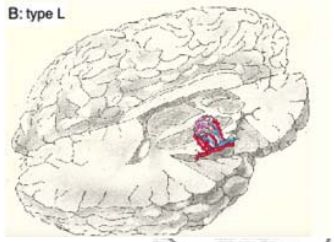

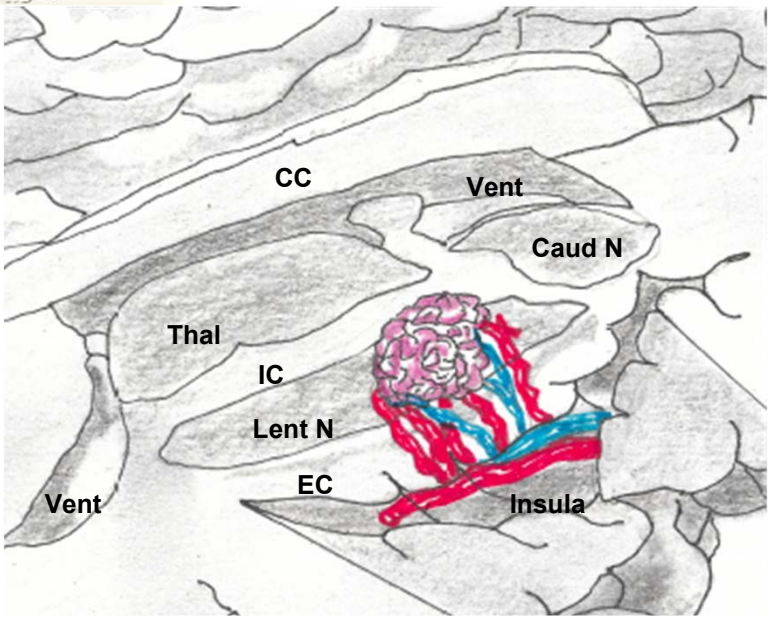

Lateral type

Nidus lateral to the internal capsule

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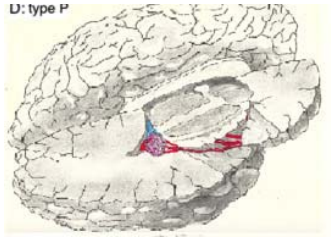

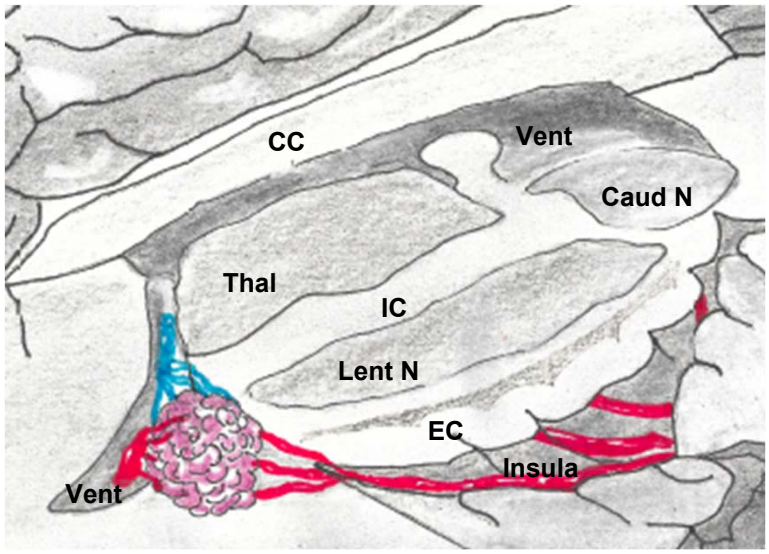

<u>Posterior type</u>

Nidus in the:

- Pulvinar
- Geniculate bodies
- Ventricles

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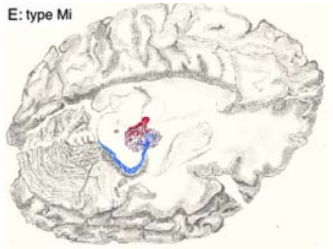
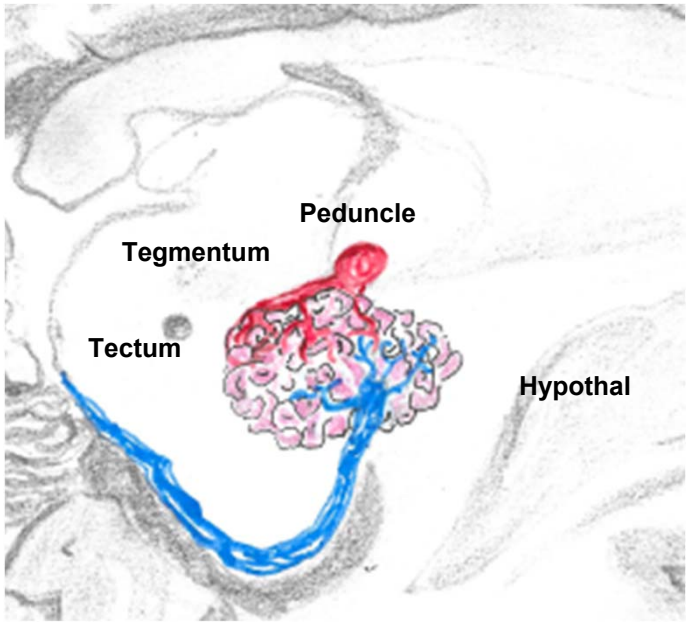
Classification of the AVM regarding the location of the AVM





<u>Mesencephalic type</u>

All AVM for which nidus centered in the midbrain

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Results: Demo Data

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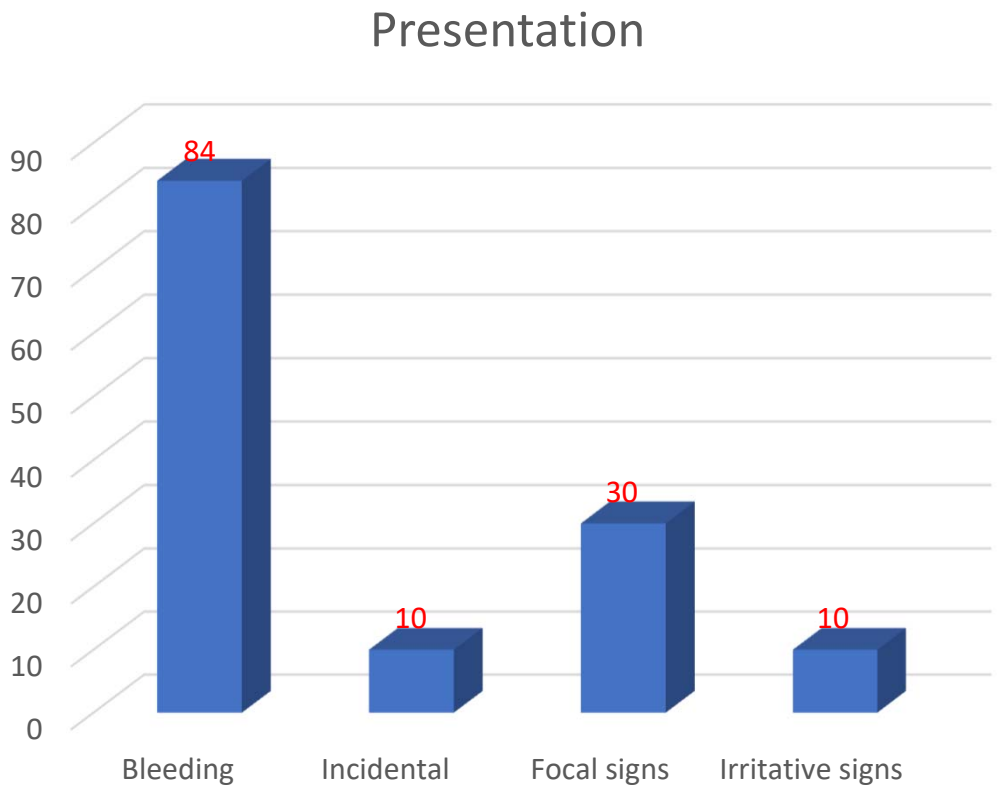
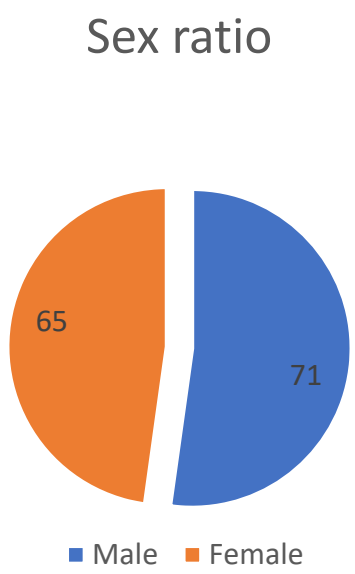
- 134 patients with inclusion criteria
- Median age: 28 year-old





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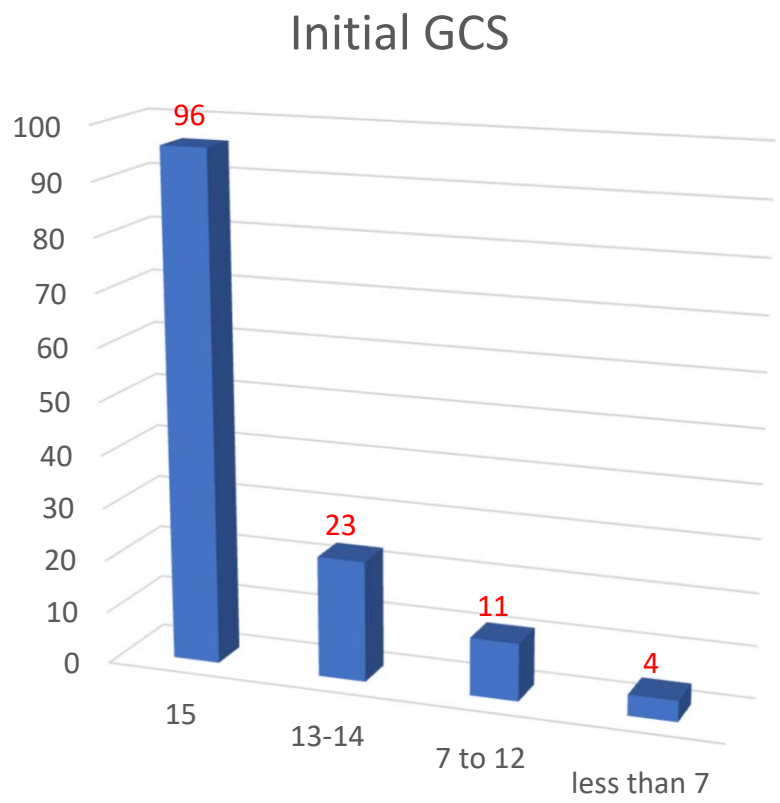
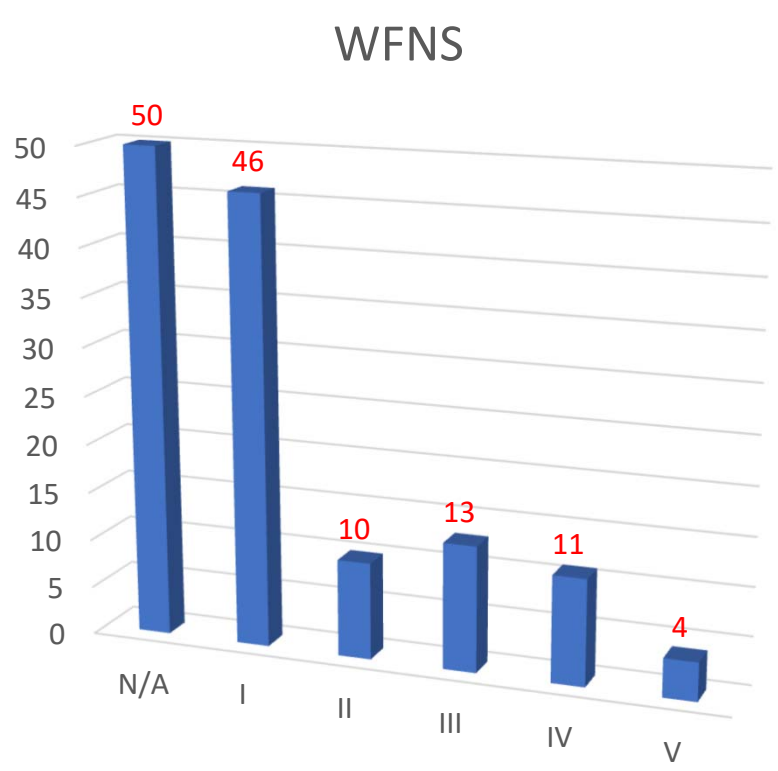
Results: Demo Data





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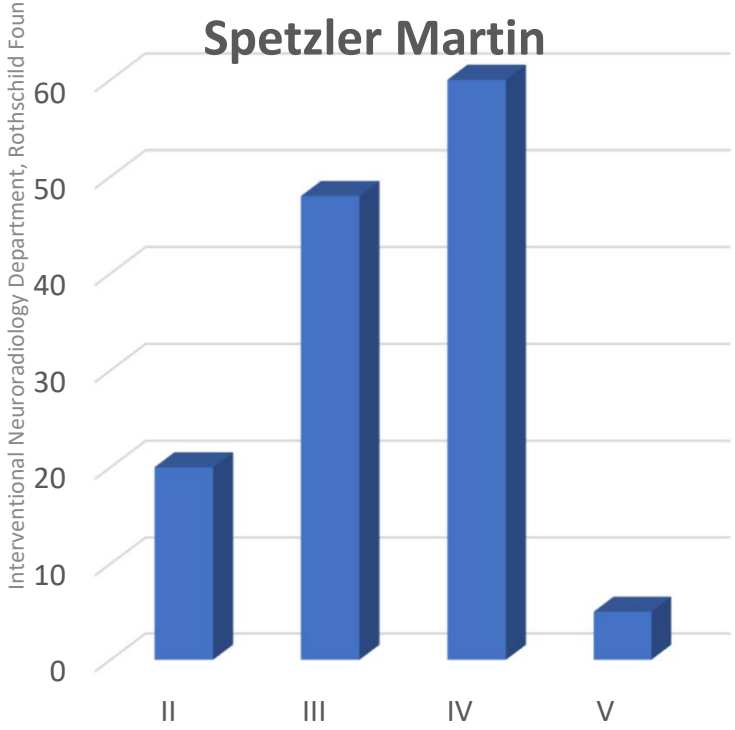

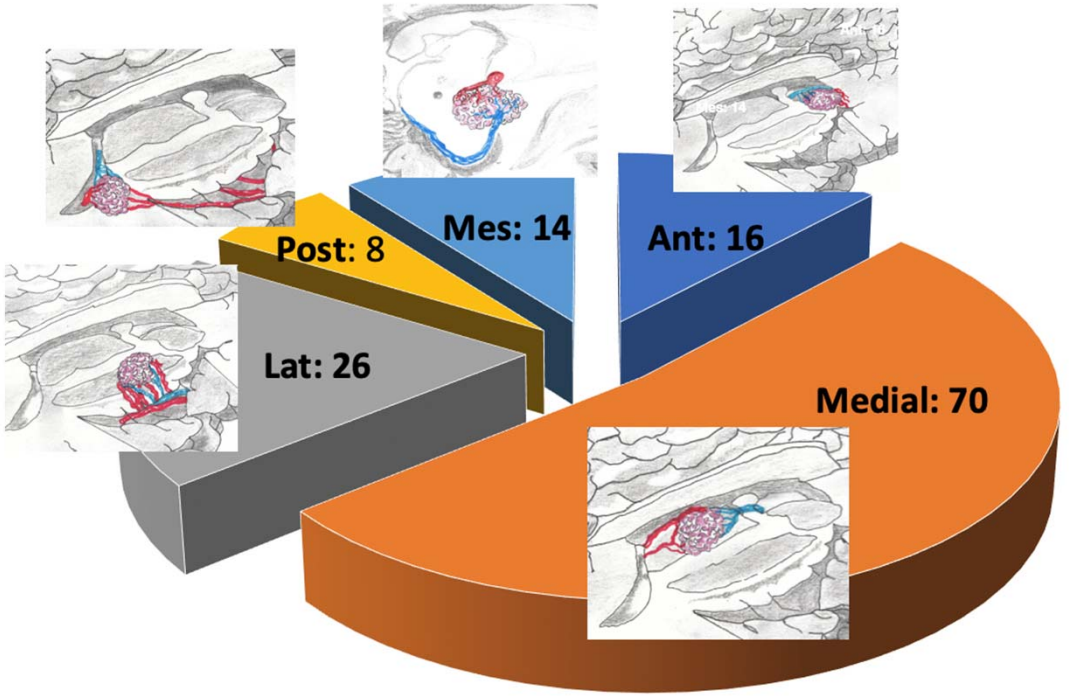

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Results: Treatment and Outcome

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- 324 embo sessions
- Embo / patient: 2.4
- Associated aneurysm coiling: 5 (3.4%)
- Associated microsurgery: 2 (1.5%)
- Ext ventriculostomy: 18 (13.4%)
- Permanent shunt: 7 (5.2%)
- Radiosurgery post embo: 24 (17.9%)

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Results: Treatment and Outcome

- Complication /session: 29 (8.9%)
- Complication /patient: 27(20.1%)
- Ischemic event: 12 (8.9%)
- Hemorrhagic event: 17 (12.6%)
- Transient neuro deficit: 11 (8.2%)
- Permanent neuro deficit: 14 (10.4%)
- Mortality: 4 (3%)

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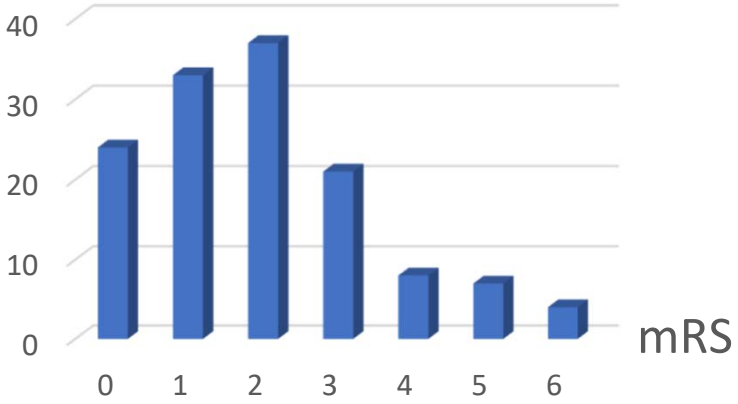
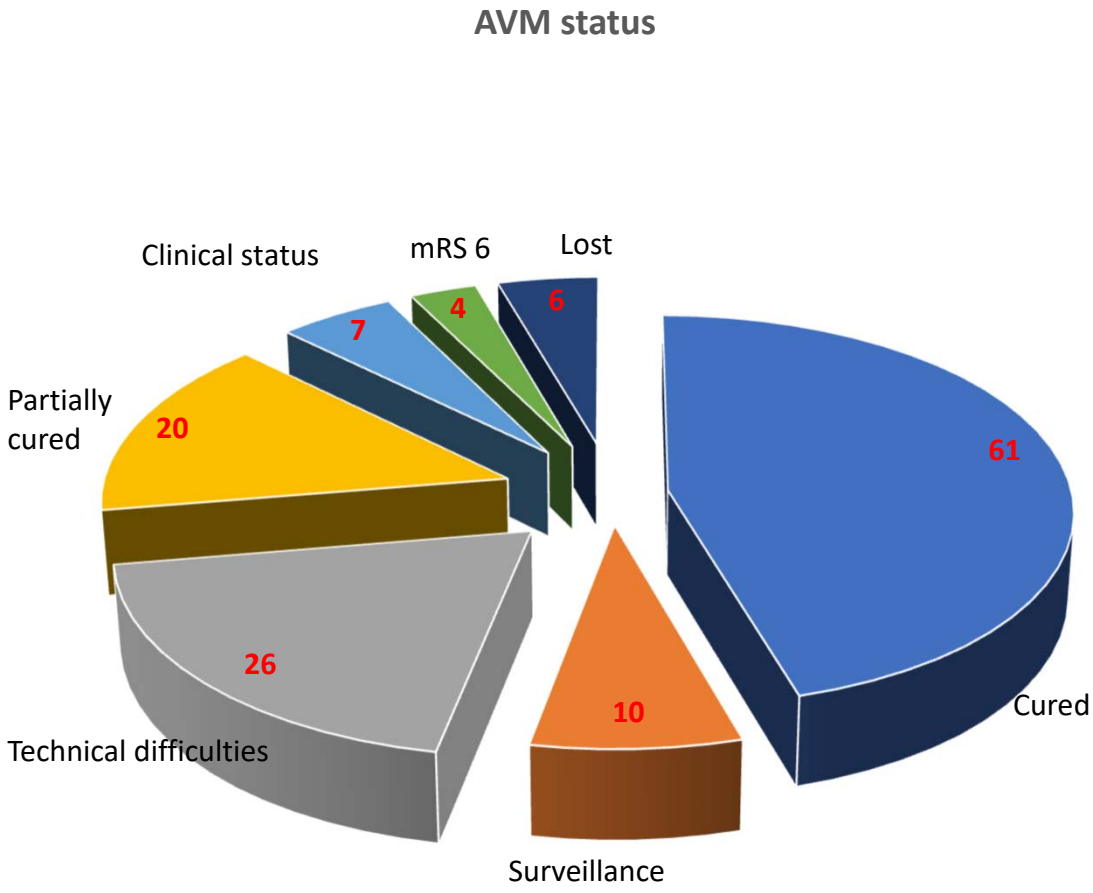
Results: Treatment and Outcome





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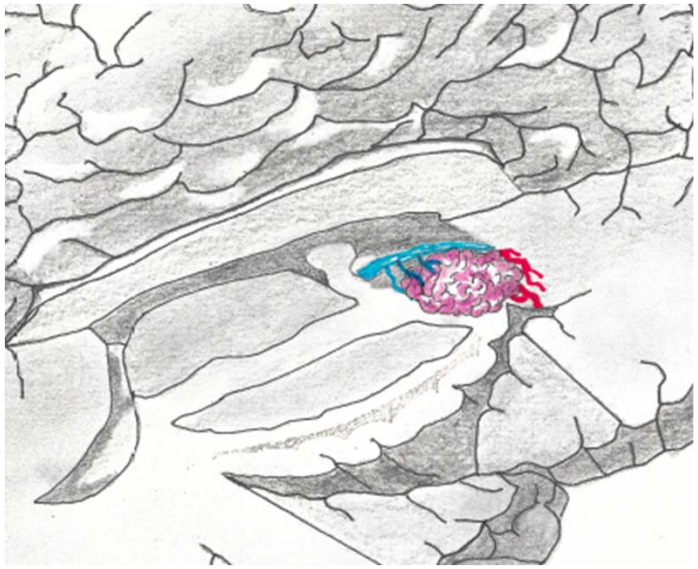
Anterior Type (N=16)

Arterial supply
A1 perf: 81%
ACA br: 31%
M1 perf: 81%
MCA br: 37%
AChA: 12%

Associated aneurysm
Flow-related: 12%
Nidal: 12%

Venous dr
Superf only: 6%
Deep only: 56%
Deep + superf: 37%

Nidus compact: 55%



Size
<3cm: 50%
3-6cm: 46%
>6cm:4%

Eloquent: 93%
50% in IC

Venous stenosis: 19%
Venous ectasia: 50%
Venous reflux: 12%

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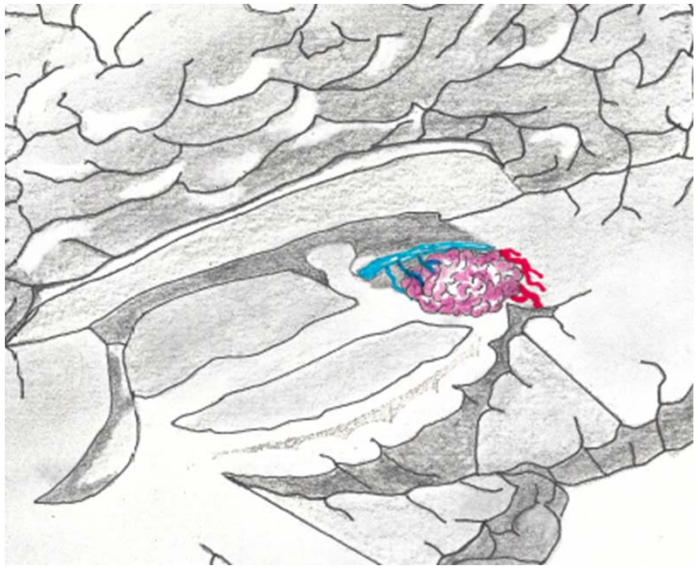
Anterior Type (N=16)

Complication/session: 7%

Complication/patient: 12%



mRS < 3: 87%
No mortality

Complete obliteration: 56%

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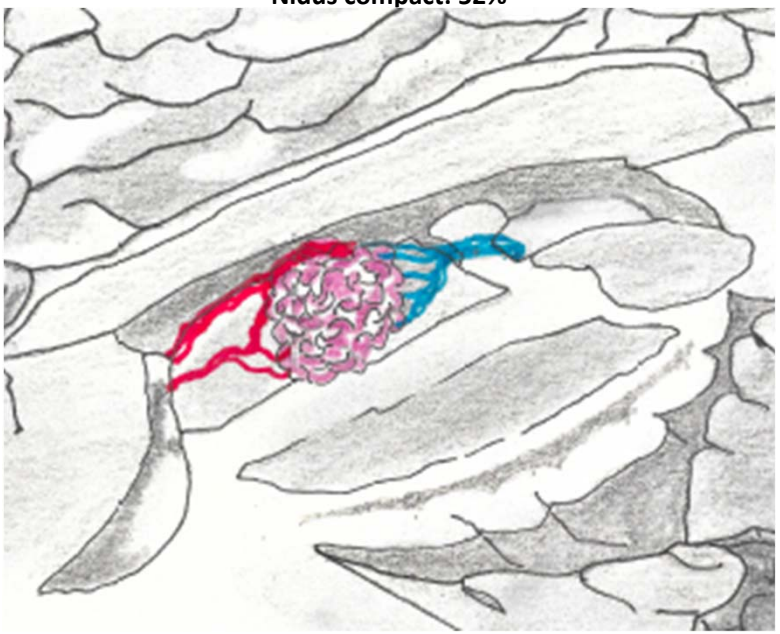
Medial Type (N=70)

Arterial supply
A1 perf: 14%
M1 perf: 15%
PCA perf: 68%
PChA: 80%
AChA: 33%

Associated aneurysm
Flow-related: 13%
Nidal: 21%

Venous dr
Deep only: 85%
Deep + superf: 15%

Nidus compact: 52%



Size
<3cm: 52%
3-6cm: 43%
>6cm:5%

Eloquent: 67%
33% in IC

Venous stenosis: 19%
Venous ectasia: 58%
Venous reflux: 38%

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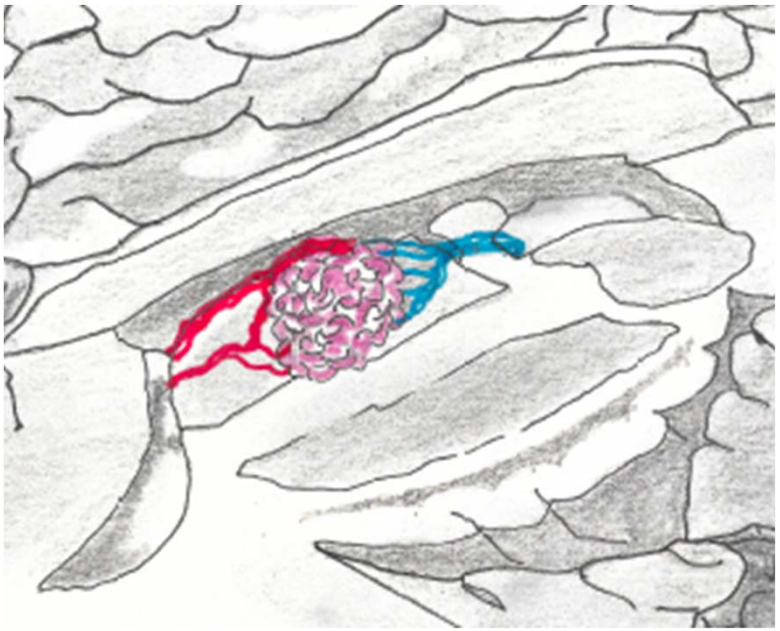
Medial Type (N=70)

Complication/session: 11%

Complication/patient: 27%



mRS < 3: 66%
Mortality: 4%

Complete obliteration: 41%

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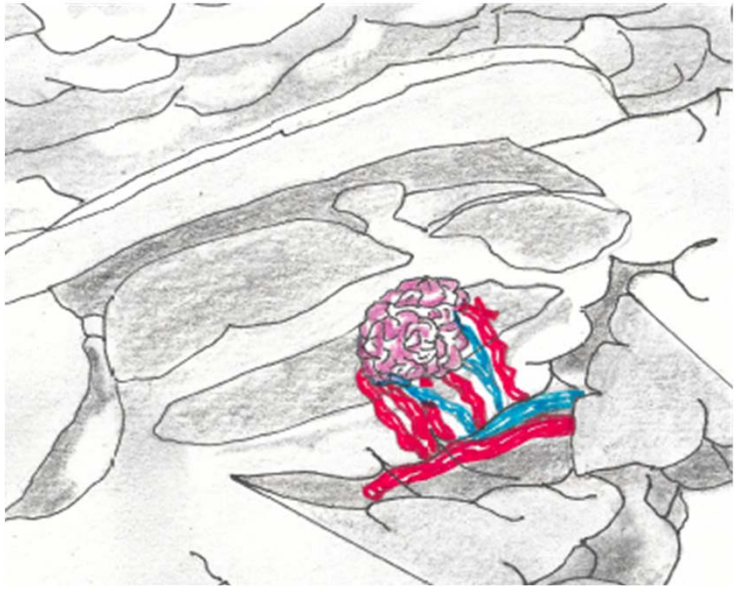
Lateral Type (N=26)

Nidus compact: 58%

Arterial supply
M1 perf: 100%
MCA br: 58%

Associated aneurysm
Flow-related: 11%
Nidal: 19%

Venous dr
Superf only: 8%
Deep only: 42%
Deep + superf: 50%



Size
<3cm: 34%
3-6cm: 53%
>6cm:11%

Eloquent: 96%
46% in IC

Venous stenosis: 19%
Venous ectasia: 46%
Venous reflux: 38%

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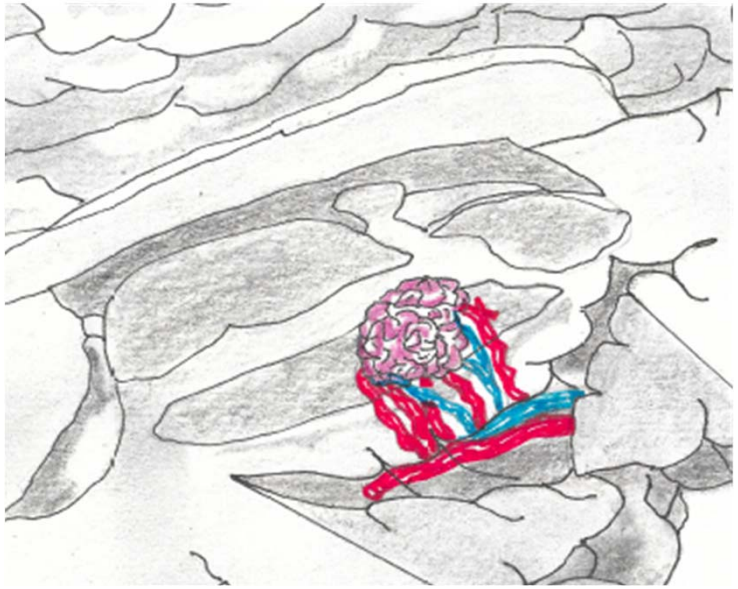
Lateral Type (N=26)

Complication/session: 4%

Complication/patient: 8%



mRS < 3: 88%
No mortality

Complete obliteration: 69%

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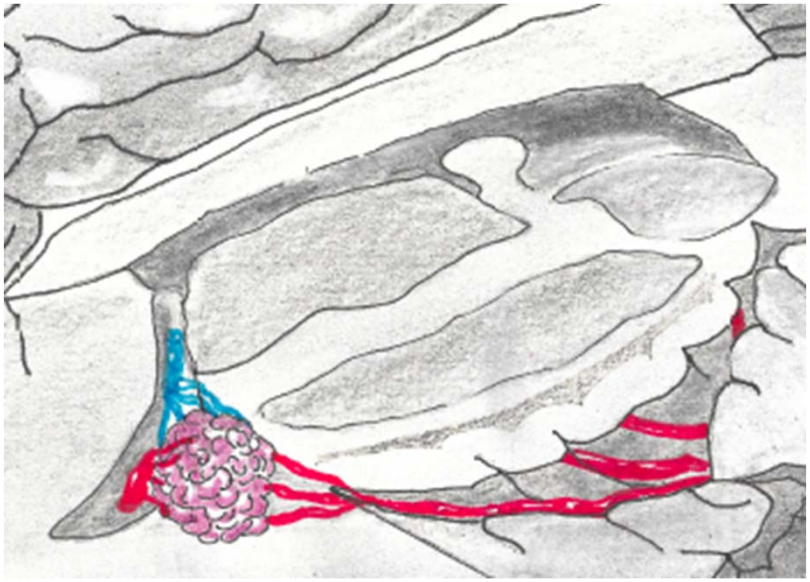
Posterior Type (N=8)

Arterial supply
PCA perf: 100%
PCA br: 62.5%
PChA: 87%
AChA: 50%

Associated aneurysm
Flow-related: 0%
Nidal: 12.5%

Venous dr
Superf only: 0%
Deep only: 37.5%
Deep + superf: 62.5%

Nidus compact: 50%



Size
<3cm: 0%
3-6cm: 87%
>6cm:13%

Eloquent: 100%
75% in IC

Venous stenosis: 37.5%
Venous ectasia: 50%
Venous reflux: 50%

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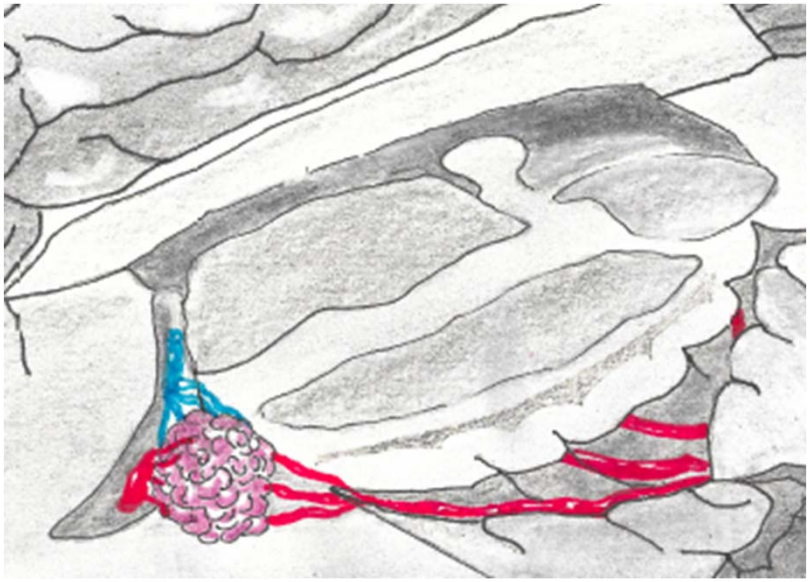
Posterior Type (N=8)

Complication/session: 6%

Complication/patient: 12.5%



mRS < 3: 62.5%
No mortality

Complete obliteration: 25%

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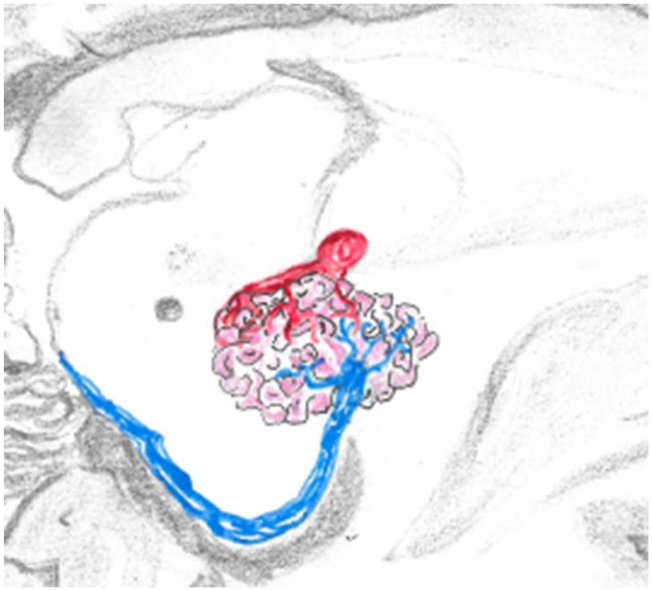
Mesencephalic Type (N=14)

Nidus compact: 57%

Arterial supply
PCA perf: 21%
BA perf: 100%
PChA: 14%

Associated aneurysm
Flow-related: 0%
Nidal: 28%

Venous dr
Superf only: 0%
Deep only: 64%
Deep + superf: 36%



Size
<3cm: 78%
3-6cm: 12%
>6cm:0%

Eloquent: 100%

Venous stenosis: 35%
Venous ectasia: 43%
Venous reflux: 14%

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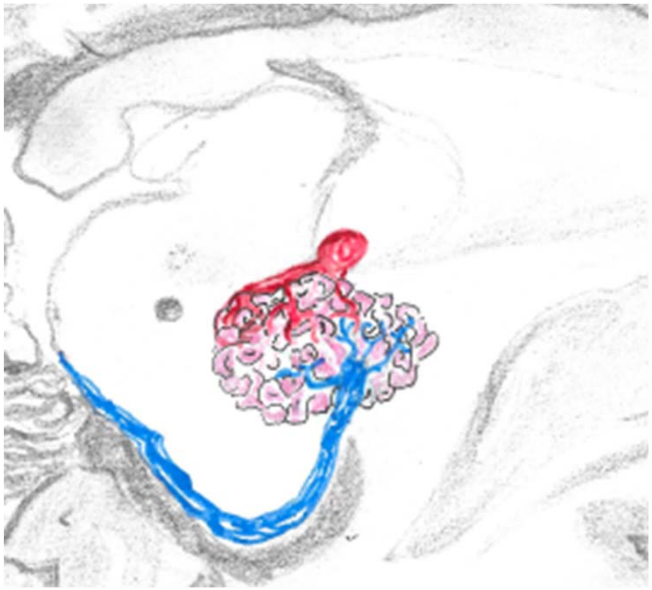
Mesencephalic Type (N=14)

Complication/session: 13%

Complication/patient: 21%



mRS < 3: 35%
Mortality: 7%

Complete obliteration: 21%

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Factors influencing the endovascular curability

- Size of nidus < 3 cm (p=0.003)
- Anatomic classification (p=0.02)
- Lateral type (p=0.007)
- Spetzler-Martin grade (p=0.001)
- Diffuse nidus (p=0.001)
- Feeders from both anterior and posterior circulation (p=0.005)
- Unique venous drainage (p=0.001)

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Factors influencing the clinical outcome

- Bleeding presentation (p=0.001)
- Anatomic classification (posterior or midbrain) (p=0.005)
- Diffuse nidus (p=0.02)
- Unique venous drainage (p=0.001)

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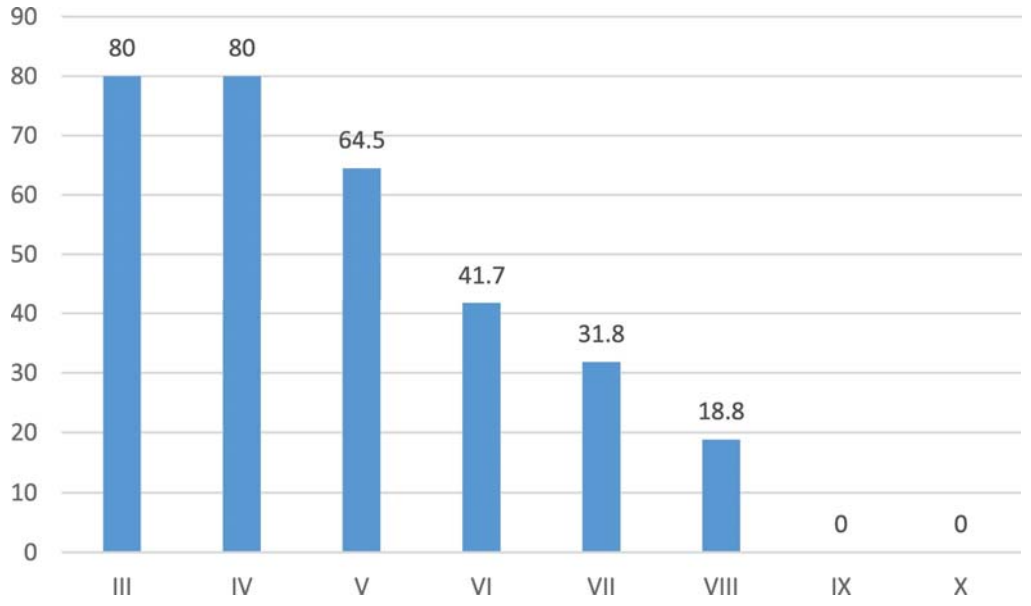
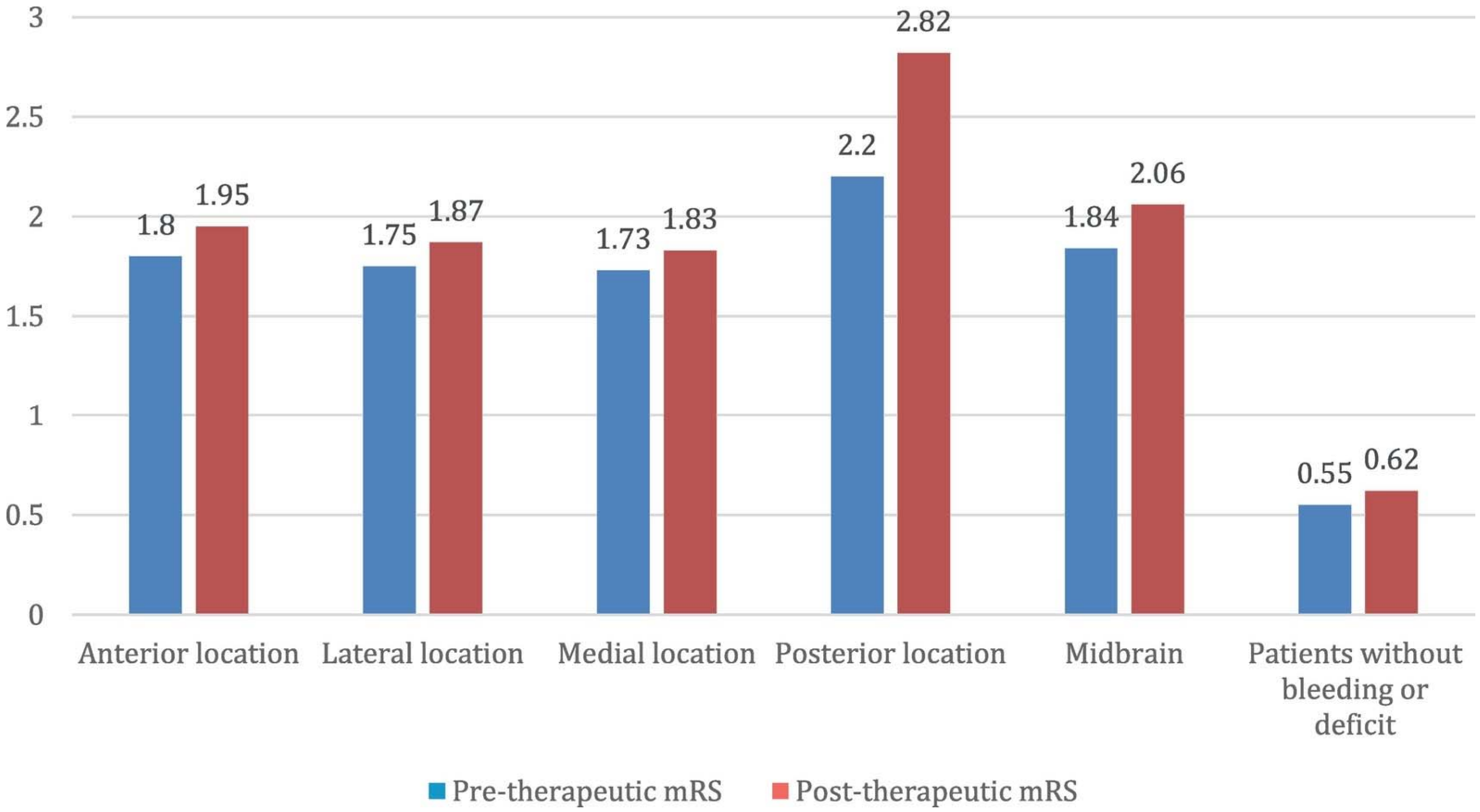
	Points
Spetzler-Martin grade	
I	**0**
II	**0**
III	**1**
IV	**2**
V	**3**
Location	
Anterior	**0**
Lateral	**0**
Medial	**1**
Posterior	**2**
midbrain	**3**
Nidus type	
Compact	**0**
Diffuse	**1**
Ant and post circulation feeders	
Absent	**0**
Present	**2**
Unique venous drainage	
Absent	**0**
Present	**1**
	Total/10

Robert T et al. **A proposed grading system to evaluate the endovascular curability of deep-seated arteriovenous malformations.** J Neurol Sci. 2017 Jun 15;377:212-218.



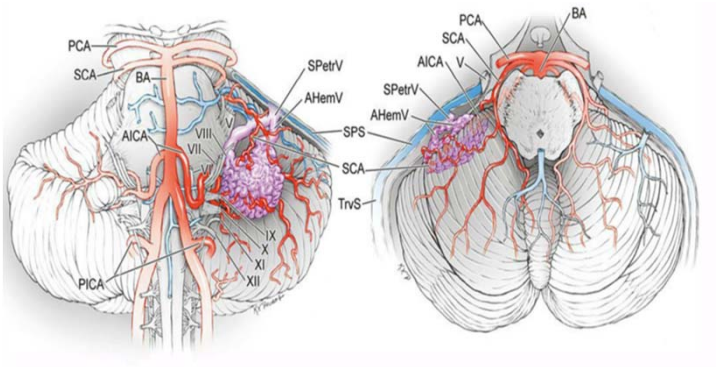
percentage of AVMs completely obliterated by grade according to scoring

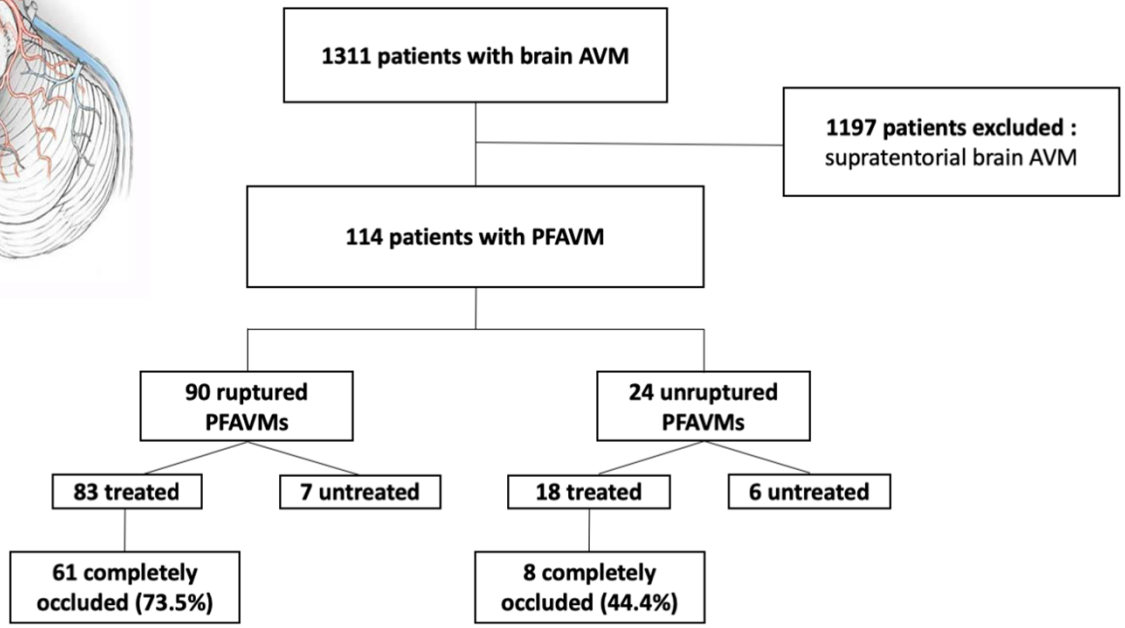
Robert T et al. **A proposed grading system to evaluate the endovascular curability of deep-seated arteriovenous malformations.** J Neurol Sci. 2017 Jun 15;377:212-218.



Robert T et al. **A proposed grading system to evaluate the endovascular curability of deep-seated arteriovenous malformations.** J Neurol Sci. 2017 Jun 15;377:212-218.

Posterior Fossa AVMs: rare lesions (8.7%)





Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment.** Journal of Neurosurgery **(in press).**

Posterior Fossa AVMs: increased bleeding risk

- a yearly hemorrhage rate of up to 11.6 % in the 5 first years after presentation (Arnaout OM et al *Neurosurg Focus 2009)*
- poorer outcome than supratentorial AVMs (Dinc N et al *J Clin Neurosci* 2018; Abla AA et al *Neurosurg Focus* 2014)

Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment. Journal of Neurosurgery (in press).**

Posterior Fossa AVMs: predictors of poor occlusion

Angioarchitecture	Completely obliterated	Not completely obliterated	UNAJUSTED (OR)	P
Location :				
- Eloquent areas	26 (57.8%)	19 (42.2%)	2.42 (1.04-5.80)	0.04
- Non-eloquent areas	43 (76.8%)	13 (23.2%)		
Arterial feeders				
- Vertebral & basilar direct perforators feeders	1 (12.5%)	6 (87.5%)	15.69 (2.52-304.03)	0.01
- Absence of Vertebral or Basilar direct perforators feeders	68 (72.3%)	26 (27.7%)		
- ≤ 2 arterial feeders	46 (75.4%)	15 (24.6%)	2.27 (0.97-5.40)	NS
- > 2 arterial feeders	23 (57.5%)	17 (42.5%)		
Venous drainage				
- Deep	33 (56.9%)	25 (43.1%)	3.85 (1.56-11.1)	0.006
- Superficial	36 (83.7%)	7 (17.3%)		
- Single	40 (76.9%)	12 (23.1%)	2.30 (0.98-5.56)	NS
- Multiple	29 (59.2%)	20 (40.8%)		
Size				
- < 3 cm	54 (75%)	18 (25%)	2.78 (1.14-7.14)	0.025
- 3-6 cm	15 (51.7%)	14 (48.3%)		
Associated aneurysms				
- Prenidal	22 (75.9%)	7 (24.1%)	0.60 (0.21-1.54)	NS
- Intranidal	13 (72.2%)	5 (27.8%)	0.80 (0.24-2.38)	NS
Spetzler & Martin (SM) grade				
- Low SM grade (1 & 2)	49 (83%)	10 (17%)	5.39 (2.22-13.89)	0.0003
- High SM grade (3 & 4)	20 (47.6%)	22 (52.4%)		

Posterior Fossa AVMs: predictors of poor occlusion

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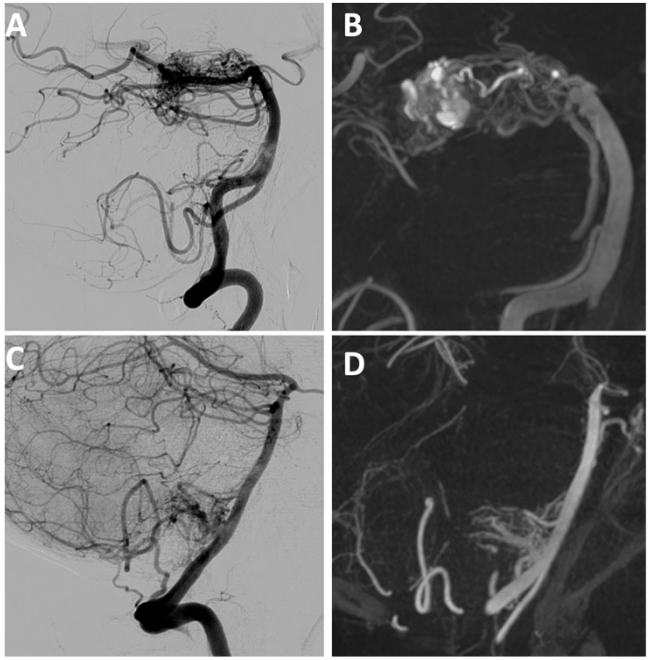
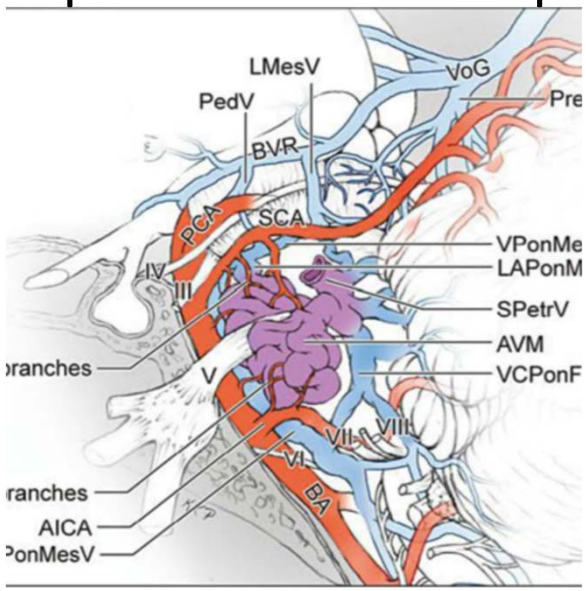
Perforators from the BA

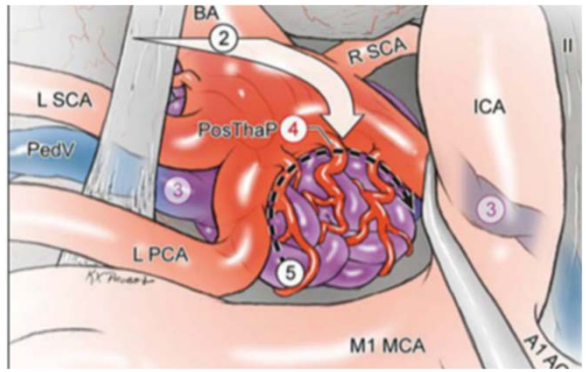
Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment.** Journal of Neurosurgery **(in press).**

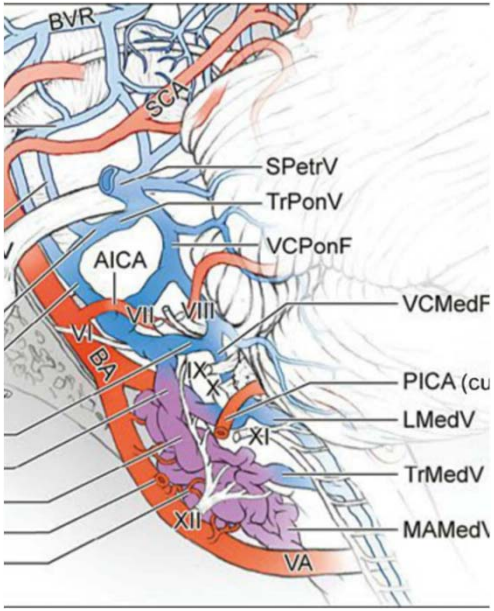
Posterior Fossa AVMs: predictors of poor occlusion

Perforators directly from BA









Seven AVMs : Tenets and techniques for resection. *M. Lawton*

Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment. Journal of Neurosurgery (in press).**

Posterior Fossa AVMs: predictors of clinical deterioration

Angioarchitecture	Good neurological outcome after treatment	Bad neurological outcome after treatment	OR	p
Location :				
- Eloquent areas	31 (68.9%)	14 (31.1%)	2.71 (1.04-7.50)	0.05
- Non-eloquent areas	48 (85.7%)	8 (14.3%)		
Arterial feeders				
- Vertebral & basilar direct perforators feeders	3 (42.9%)	4 (57.1%)	5.63 (1.15-30.76)	0.03
- Absence of Vertebral or Basilar direct perforators feeders	76 (80.9%)	18 (19.1%)		
- ≤ 2 arterial feeders	48 (78.7%)	13 (21.3%)	1.07 (0.39-2.79)	NS
- > 2 arterial feeders	31 (77.5%)	9 (22.5%)		
Venous drainage				
- Deep	42 (72.4%)	16 (27.6%)	2.35 (0.87-7.12)	NS
- Superficial	37 (86%)	6 (14%)		
- Single	43 (82.7%)	9 (17.3%)	1.73 (0.67-4.63)	NS
- Multiple	36 (73.5%)	13 (26.5%)		
Size				
- < 3 cm	57 (79.2%)	15 (20.8%)	1.21 (0.41-3.29)	NS
- 3-6 cm	22 (75.9%)	7 (24.1%)		
Associated aneurysms				
- Prenidal	23 (79.3%)	6 (20.7%)	0.91 (0.30-2.53)	NS
- Intranidal	14 (77.8%)	4 (22.2%)	1.03 (0.27-3.30)	NS
Spetzler & Martin (SM) grade				
- Low SM grade (1 & 2)	50 (84.7%)	9 (15.3%)	2.49 (0.96-6.73)	NS
- High SM grade (3 & 4)	29 (69%)	13 (31%)		

Posterior Fossa AVMs: predictors of clinical deterioration

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- Eloquent areas	31 (68.9%)	14 (31.1%)	2.71 (1.04-7.50)	0.05
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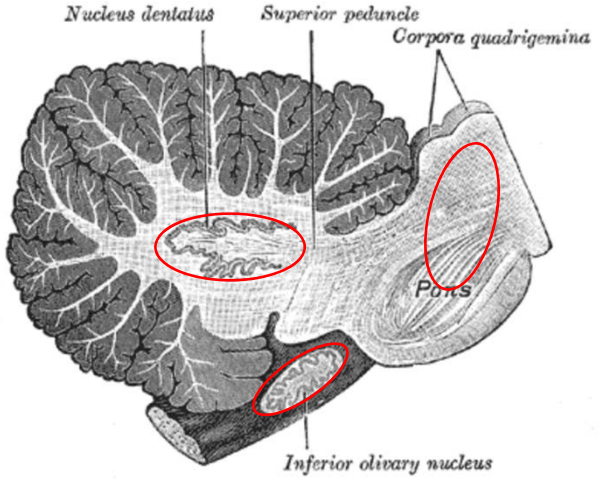
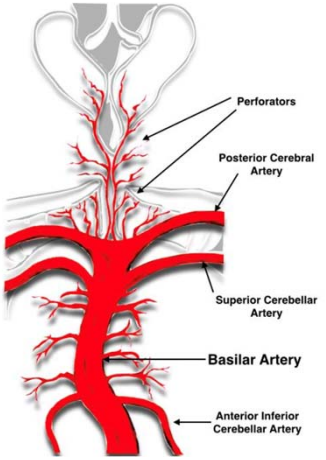




Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment.** Journal of Neurosurgery **(in press).**

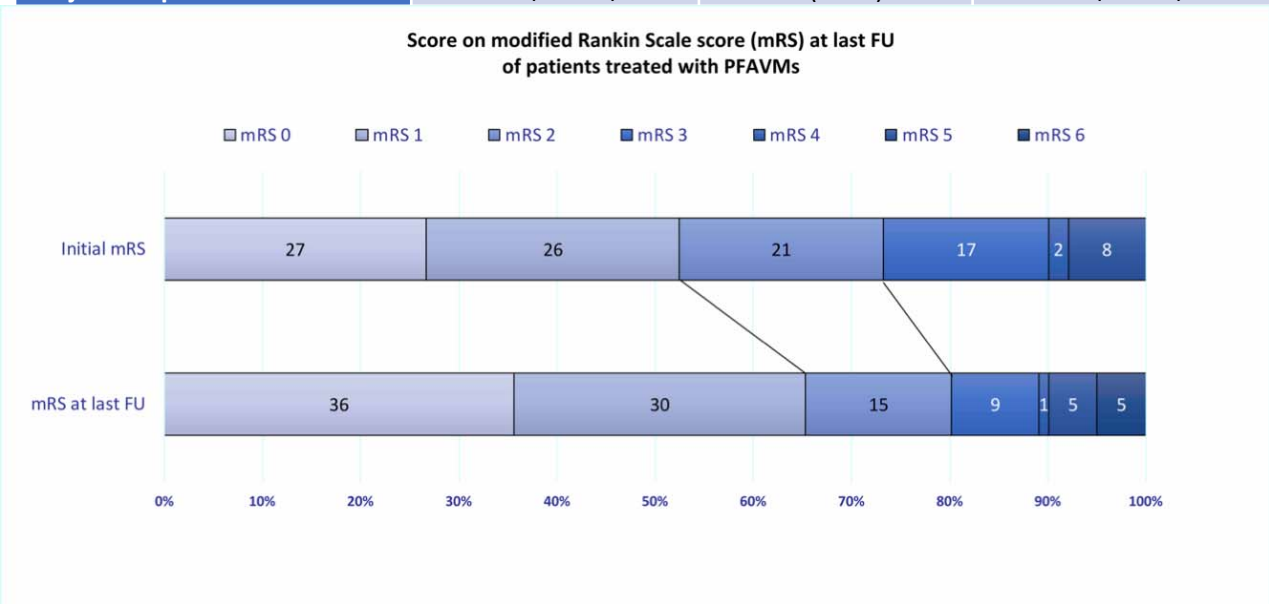
Posterior fossa AVMs: outcome

- 27.7% patients experienced a treatment-related complication
- 14.9% were ischemic and 12.9% were hemorrhagic
- Neurological deterioration in 19.8% of patients and were considered as “major complication” (resulting in a worsening of more than 1 point of mRS or death) in 11.9% of patients
- When considering the 200 procedures, the overall treatment-related complication rate was of 14% per procedure and the major complication rate was of 6% per procedure

Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment. Journal of Neurosurgery (in press).**

Posterior fossa AVMs: outcome

	Overall treated PFAVMS (n = 101)	Ruptured treated PFAVMs (n=83)	Unruptured treated PFAVMs (n=18)
mRS ≤ 2 at last FU	81 (80.2%)	68 (81.9%)	13 (72.2%)
Good neurological outcome	79 (78.2%)	67 (80.7%)	12 (66.7%)
Total obliteration	69 (68.3%)	61 (73.5%)	8 (44.4%)
Overall complication rate	28 (27.7%)	22 (26.5%)	6 (33.3%)
Major complication rate	12 (11.9%)	7 (8.4%)	5 (27.8%)



Lefevre E et al. **Presence of direct vertebrobasilar perforator feeders in posterior fossa arteriovenous malformations is strongly associated with poor neurological outcome and low occlusion rate after endovascular treatment.** Journal of Neurosurgery **(in press).**

Venous route for BAVMs embo

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THE REGISTER OF THE NEUROSURGICAL MEME

Neurosurgery. 1999 Aug;45(2):351-63; discussion 363-5.

Transvenous retrograde nidus sclerotherapy under controlled hypotension (TRENSH): a newly proposed treatment for brain arteriovenous malformations--concepts and rationale.

Massoud TF[1], Hademenos GJ.

Author information

1 Department of Radiological Sciences, University of California at Los Angeles School of Medicine and Medical Center, USA.

Abstract

PURPOSE: An alternative endovascular treatment to conventional transarterial embolization of cerebral arteriovenous malformations (AVMs) is proposed.

CONCEPT: According to this proposed treatment, selected AVMs could undergo transvenous retrograde nidus sclerotherapy under controlled hypotensive anesthesia (TRENSH).

RATIONALE: It is hypothesized that TRENSH may provide the means of avoiding delivery of embolic agents via arterial feeders (thus preventing ischemic complications), in addition to a possible more complete permeation of an AVM nidus with a sclerosant than can otherwise be obtained with current agents via arterial feeders.

DISCUSSION: Instead of relying on access to an AVM nidus from the arterial side (with its usual complexity), TRENSH would require retrograde access to the lesion via much larger and anatomically simpler draining veins. Retrograde permeation of the AVM nidus may then be possible with a liquid sclerosant (to effect a "chemical embolization") provided that the arterial inflow is reduced sufficiently by temporary controlled systemic hypotension, with or without the aid of temporary balloon occlusion of the main arterial feeder(s). Retrograde spread of sclerosant within the nidus that falls short of filling arterial feeders and their branches to normal brain tissue may then be possible. Angioarchitectural and hemodynamic considerations are addressed, as are the potential role and limitations of TRENSH in the management of cerebral pial AVMs. Future implementation of this new technique in some specific selected cases in which the anatomic configuration of the AVM and its draining veins might be favorable could prove to be a potentially useful addition to the armamentarium of AVM therapies, which currently includes microsurgery, radiosurgery, and transarterial embolotherapy. Experimental studies directed at assessing the feasibility of TRENSH before potential future clinical application seem justified.

Successful Transvenous Embolization of Brain Arteriovenous Malformations Using Onyx in Five Consecutive Patients

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Roberto Riva, MD‡
Maria Ruggiero, MD§
Monica Manisor, MD‡
Maher Al-Khawaldeh, MD‡
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Received, April 13, 2010.
Accepted, December 16, 2010.
Published Online, February 23, 2011.

BACKGROUND: There is an increasing application of endovascular treatment for brain arteriovenous malformations (BAVMs) using ethylene vinyl alcohol copolymer (Onyx). Historically, this treatment has been performed using a transarterial approach.

OBJECTIVE: To report our experience with transvenous endovascular embolization with Onyx (TVEO).

METHODS: Five consecutive patients with BAVMs underwent endovascular TVEO between June 2007 and March 2009 at the Interventional Neuroradiology Department of the University Hospital of Limoges. There were 3 men and 2 women with a mean age of 41.8 years (range, 19-57 years). The clinical presentation included symptoms caused by intracerebral hemorrhage (n = 4) and seizures (n = 1). According to the Spetzler-Martin classification scheme, 3 BAVMs (60%) were grade III, and 2 BAVMs (40%) were grade IV. Four BAVMs (80%) were supratentorial and 1 BAVM (20%) was infratentorial. Immediate and mid-term treatment (6 months) outcomes were angiographically and clinically analyzed according to the modified Rankin Scale.

RESULTS: The transvenous approach was used in all patients (100%). The success rate of complete obliteration of the arteriovenous malformation nidus was 80% (4 of 5), confirmed by follow-up angiography performed immediately and at 6 months after TVEO. No procedure-related complications occurred during or after embolization. All patients remained unchanged (modified Rankin Scale score = 0-2) and clinically stable 6 months after TVEO.

CONCLUSION: The transvenous approach using Onyx for the management of BAVMs is shown to be an efficient and safe alternative treatment in cases with no other conventional therapeutic choice and when some anatomic considerations are respected.

KEY WORDS: Brain arteriovenous malformation, Onyx, Transarterial approach, Transvenous embolization

Neurosurgery 69:184–193, 2011 DOI: 10.1227/NEU.0b013e318212bb34 www.neurosurgery-online.com

Interventional Neuroradiology

Interv Neuroradiol. 2017 Oct;23(5):504-509. doi: 10.1177/1591019917716817. Epub 2017 Jul 4.

Transvenous retrograde AVM embolization: Indications, techniques, complications and outcomes.

Lv X[1], Song C[2], He H[1], Jiang C[1], Li Y[1].

Author information

Abstract

Objective Transvenous retrograde arteriovenous malformation (AVM) embolization (TRAE) has been proposed. The present study was to review the techniques, their conjunctions and effectiveness. Methods Eligible related articles were identified by searching the PubMed and Web of Science databases using "transvenous" and "arteriovenous malformation." Results A total of 16 eligible studies, with 60 cases of AVM treated with TRAE, were analyzed. Prior to TRAE procedure, transarterial Onyx 18 was performed in 23 (38.3%), cyanoacrylate in three (5%) and coiling in two (3.3%), neurosurgery in one (1.7%) and radiosurgery in three (5%). These prior treatments were used to reduce the size of the nidus to <3 cm and TRAE was performed. One anterior choroidal artery aneurysm was coiled before TRAE. Systemic hypotension (blood pressure<100 mmHg) occurred in six (10%) patients and local hypotension (proximal arterial temporary balloon protection) in five (8.3%) patients. Complete obliteration was achieved in 56 (93.3%) AVMs, four (6.7%) with residual, of which one was supplemented with radiosurgery. During mean one-year follow-up (1 month to 3.2 years), there were five cases (8.3%) of permanent disability and one (1.7%) mortality resulting from initial hemorrhage. Fifty-four (90%) patients were independent (mRS ≤ 2) at follow-up. Ruptured AVMs and Spetzler-Martin I-III were associated with a high cure rate. Conclusion According to previous reports, selected AVMs could undergo TRAE. TRAE is safe and curative with Onyx after the nidus size is reduced sufficiently by transarterial embolization, neurosurgery or radiosurgery, with or without the aid of proximal arterial temporary balloon protection.

KEYWORDS: Transvenous; arteriovenous malformation; embolization

PMID: 28675345 PMCID: PMC5624411 [Available on 2018-10-01] DOI: 10.1177/1591019917716817

Meta-Analysis

Recent meta-analysis

Meta-Analysis

J Neurosurg Sci. 2018 Feb 13. doi: 10.23736/S0390-5616.18.04342-4. [Epub ahead of print]

Transvenous embolization of brain arteriovenous malformations: a systematic review and meta-analysis.

Fang YB[1,2], Byun JS[3,4], Liu JM[5], Krings T[3], Pereira VM[3], Brinjikji W[3,6,7].

Author information

Abstract

INTRODUCTION: The safety and efficacy of transvenous embolization of brain arteriovenous malformations (AVM) remains relatively poorly understood. We performed a systematic review of the literature to determine outcomes of transvenous embolization of brain AVMs.

EVIDENCE ACQUISITION: Data Sources include Ovid MEDLINE, Ovid EMBASE and the Web of Science. All case series with ≥4 patients receiving transvenous embolization of brain AVMs published through September 2017 were included.

EVIDENCE SYNTHESIS: A total of 8 series with 66 patients were included. All-cause mortality rate was 6.0% (95%CI=0.0%-11.0%). There were no cases of treatment related mortality. Overall good functional outcome rates were 89.0% (95%CI=82.0%-96.0%). Complete occlusion rates were 96.0% (95%CI=91.0%-100.0%). Technical complications rates were 8.0% (95%CI=2.0%-14.0%). Additional treatment rates were 6.0% (95%CI=0.0%-11.0%).

CONCLUSIONS: Patients receiving transvenous embolization of AVMs experience good long- term clinical outcomes in nearly 90% of highly selected cases. Further large case series are needed to confirm the result.

PMID: 29444556 DOI: 10.23736/S0390-5616.18.04342-4

Transvenous Curative Embolization of Cerebral Arteriovenous Malformations: A Prospective Cohort Study

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Christina Iosif, MD, PhD*
Adson F. Lucena, MD*
Rui Carvalho, MD*
Suzana Saleme, MD*
Charbel Mounayer, MD, PhD*

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Accepted, November 14, 2017.
Published Online, December 21, 2017.

BACKGROUND: Curative transvenous embolization is an emerging strategy for treatment of cerebral arteriovenous malformations (AVMs).
OBJECTIVE: To assess contemporary outcomes of transvenous embolization as a stand-alone therapy for cerebral AVMs
METHODS: We prospectively followed 40 patients with 41 AVMs who underwent transvenous endovascular therapy between January 2008 and January 2015. Patient demographics, AVM characteristics, endovascular techniques used, angiographic results, clinical outcomes, and complications were assessed independently.
RESULTS: Thirty-eight of 41 (92.6%) AVMs were anatomically cured. The mean patient age was 37.7 yr (range, 18-69 yr) and 55% were female. Twenty-seven (67.5%) patients presented with hemorrhage. The mean size of the AVM nidus was 2.8 ± 1.2 cm, and low Spetzler-Martin grade AVMs comprised 41.5% of lesions. The majority of patients were treated in 1 session (56%; n = 23). The mean follow-up period was 28.4 (range, 6-106 mo). There was 1 (2.5%) hemorrhagic complication related to microcatheter navigation and 1 (2.5%) venous infarction was observed without clinical consequences. At 6-mo follow-up, 1 (2.5%) patient had significant disability. There were no recurrences during the follow-up period. Overall mortality was 2.5% and procedure-related mortality was 0%.
CONCLUSION: This prospective contemporary series demonstrates a high rate of complete AVM obliteration and excellent functional outcomes in patients with both ruptured and unruptured AVMs treated with transvenous embolization. This approach is promising and warrants further investigation as a treatment for select AVMs

KEY WORDS: Arteriovenous malformation, Curative therapy, Transvenous, Embolization

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Squali Mohamed

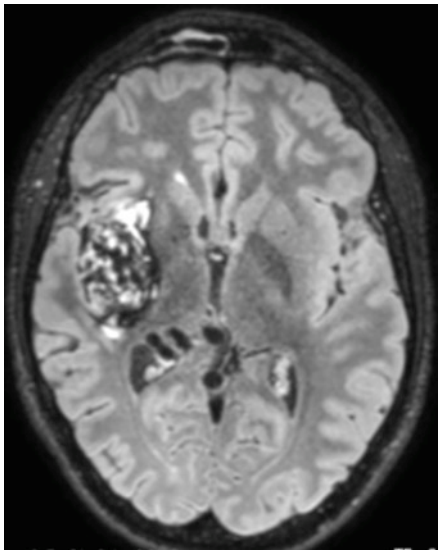
The good cases

Interventional Neuroradiology Department, Rothschild Foundation, Paris - France

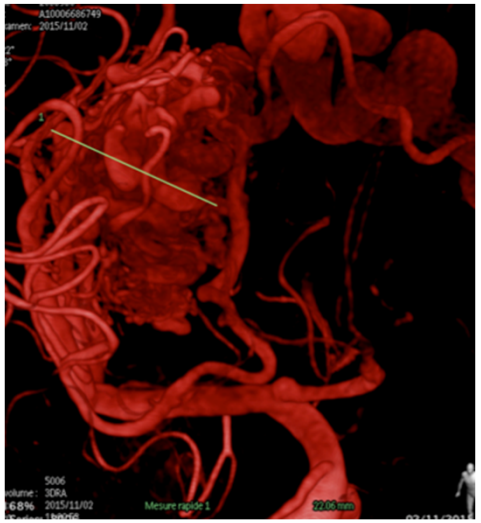
Insular & putaminal AVM Spetzler-Martin 4

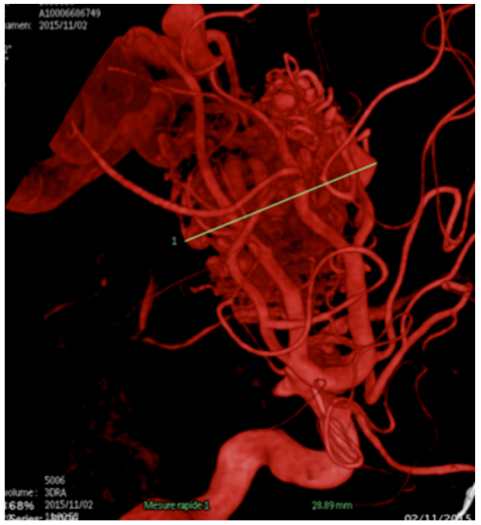
M 19
07/2015, HA, left hemiplegia, coma

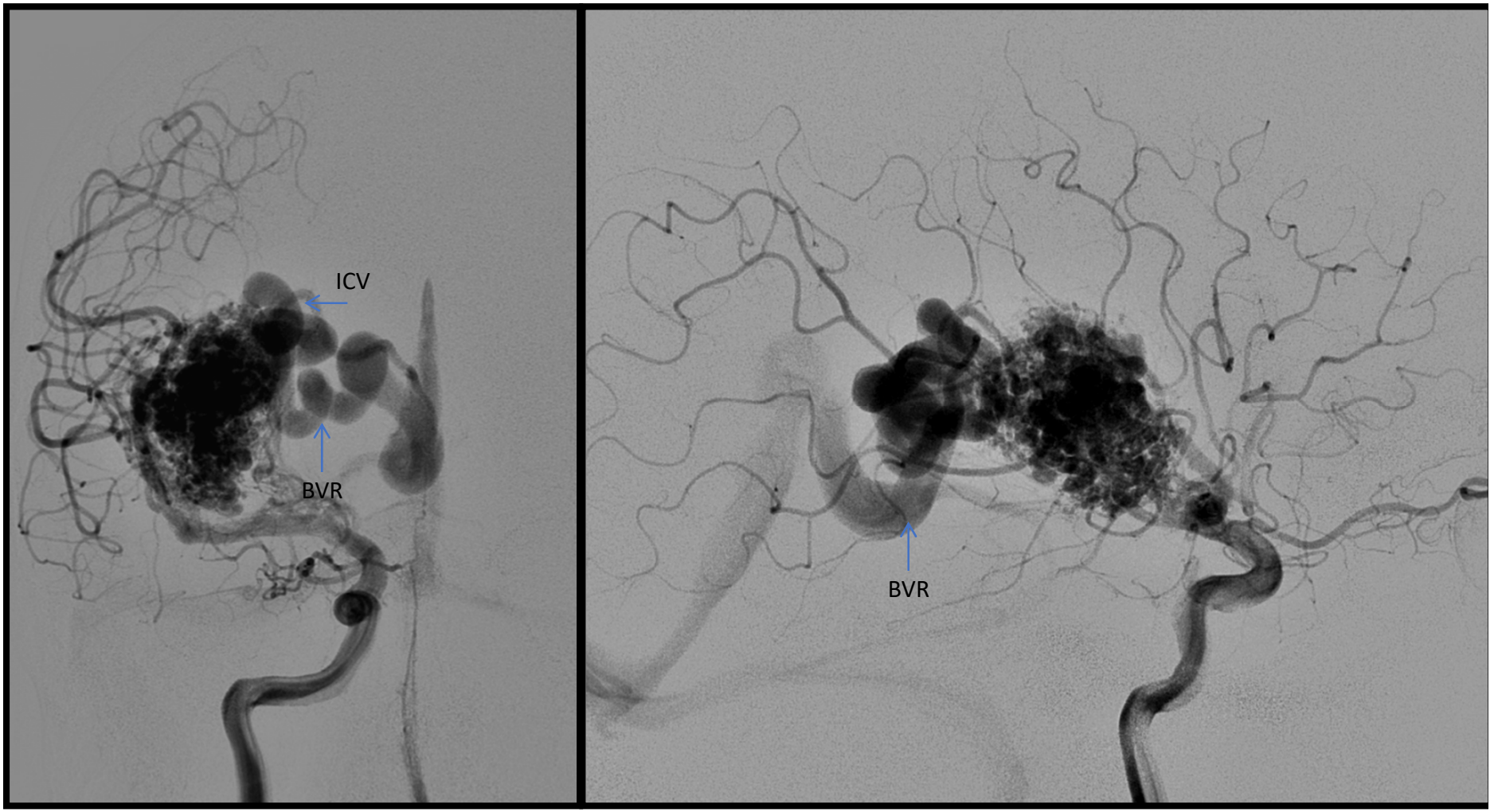
7/2015



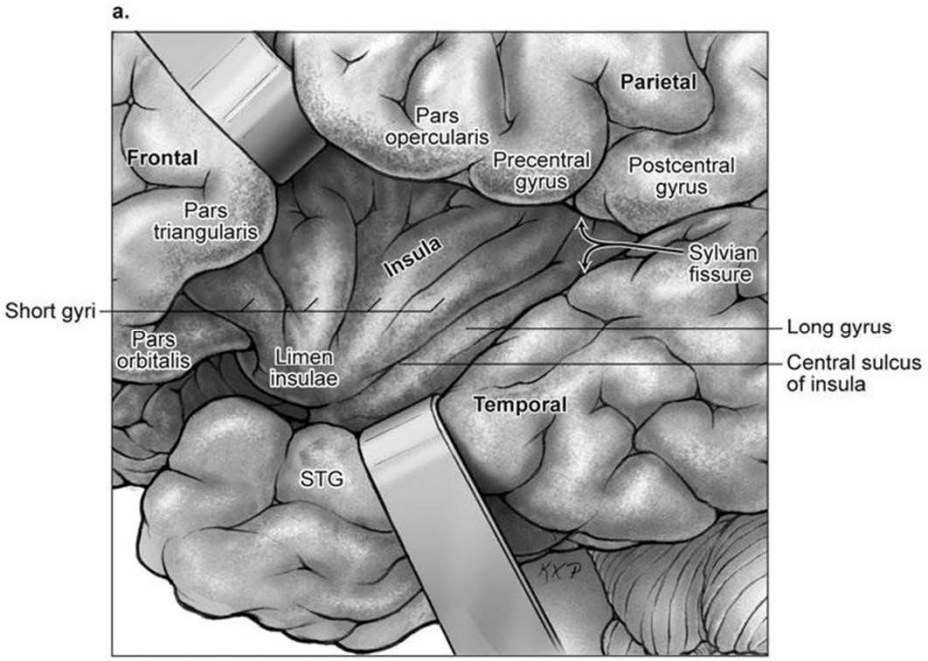
11/2015
mRs 3

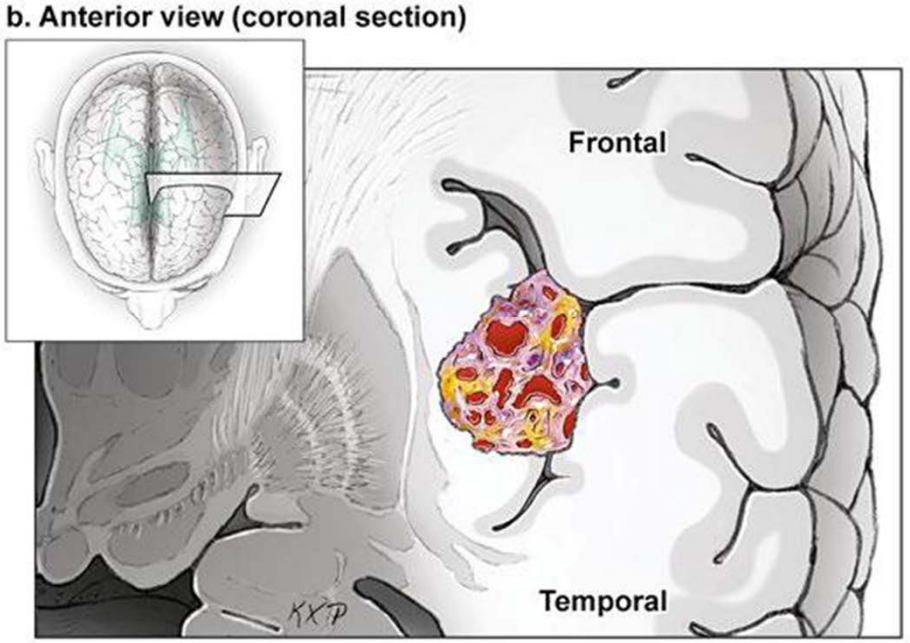






3 embo sessions (art)

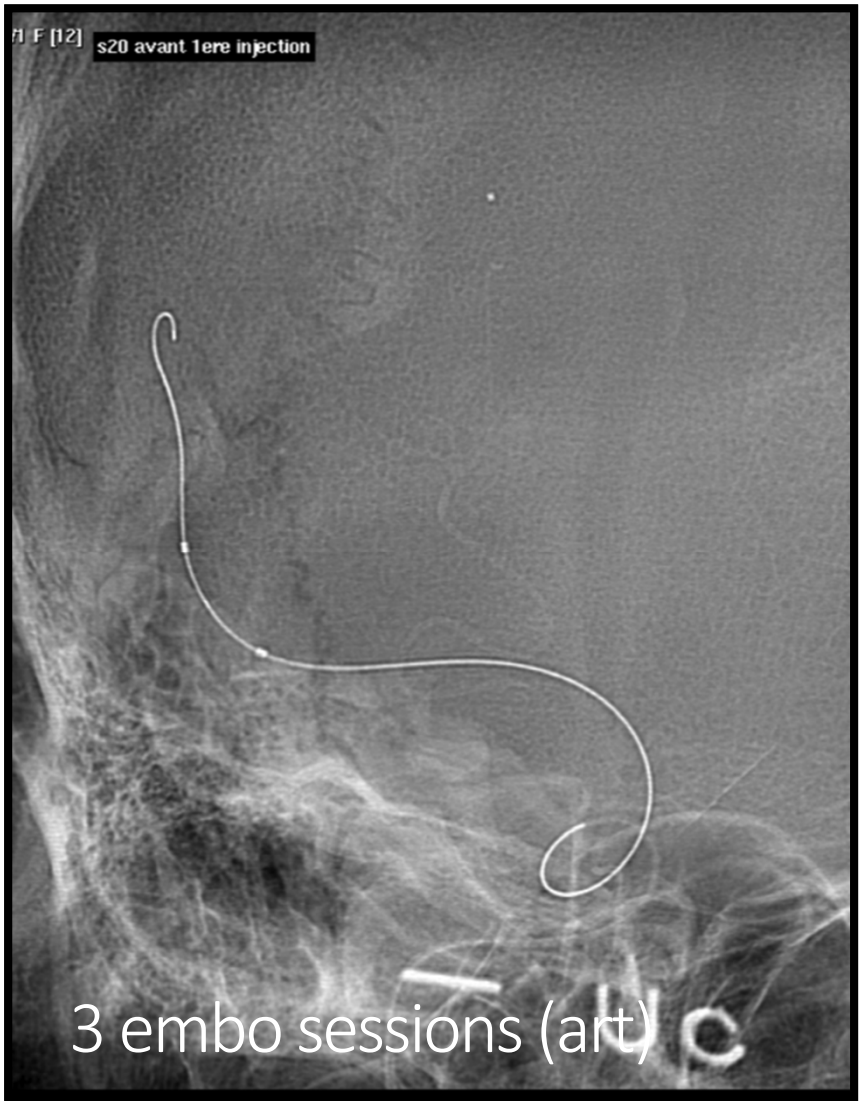




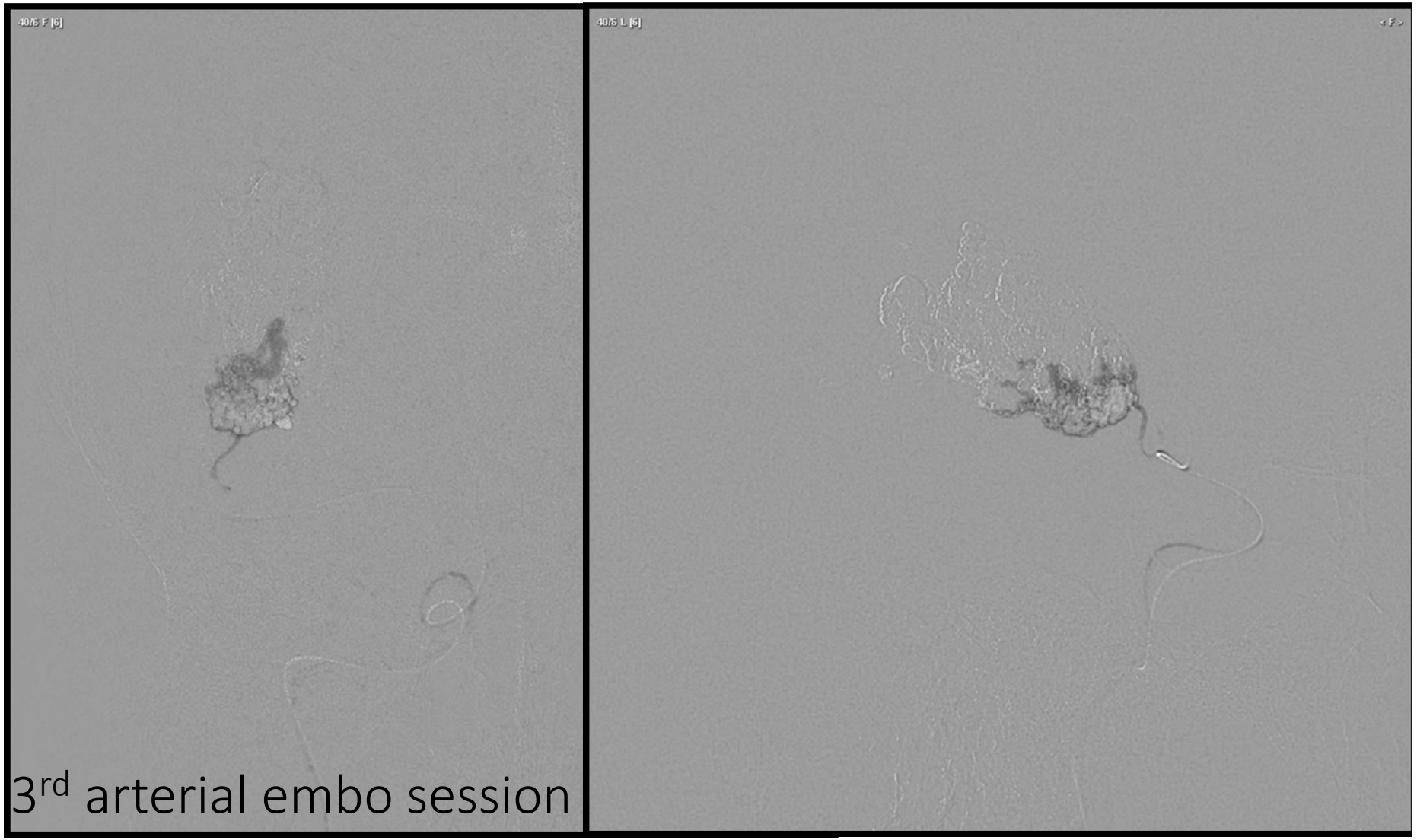
Seven AVMs

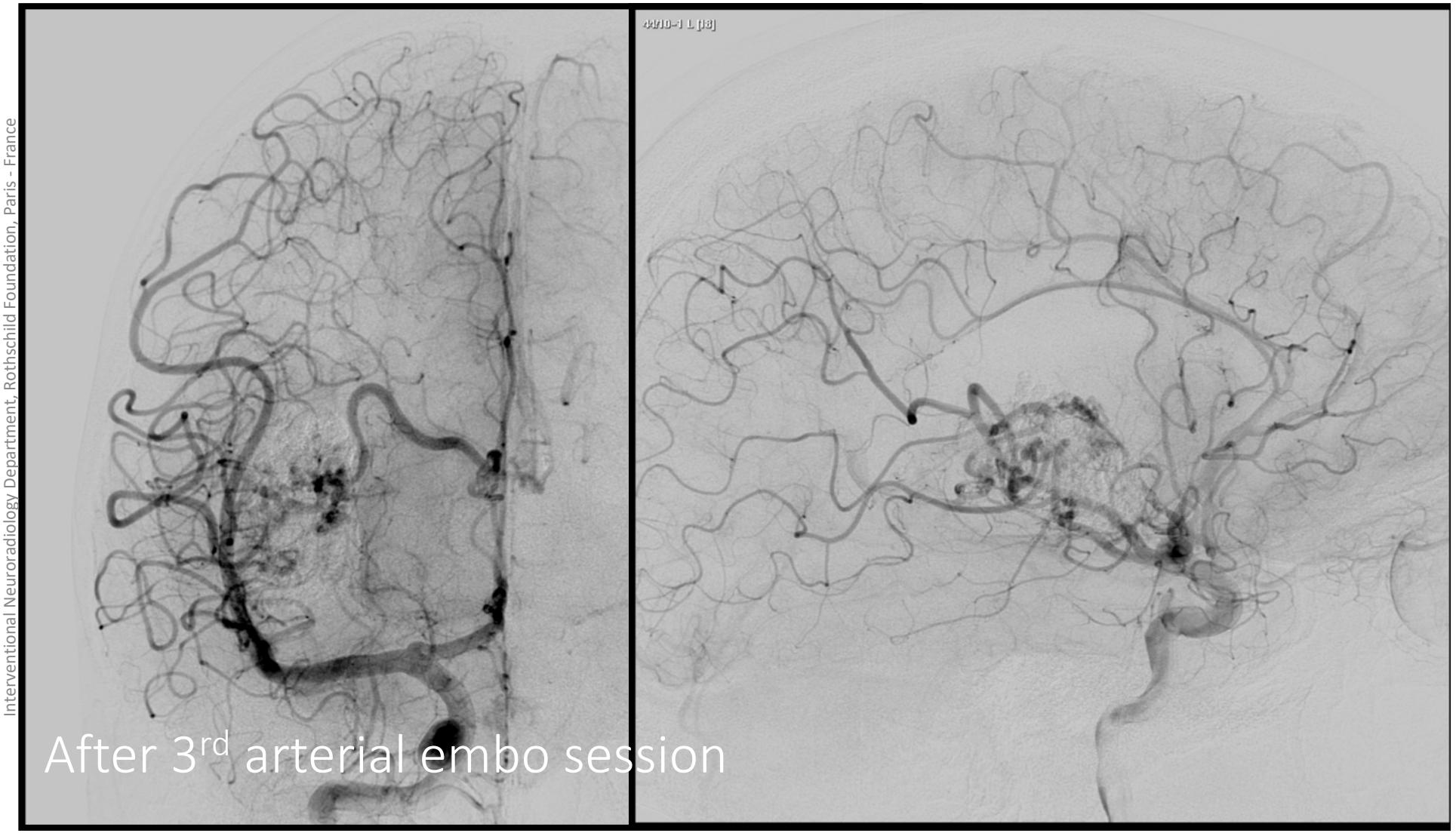
Tenets and Techniques for Resection

Michael T. Lawton

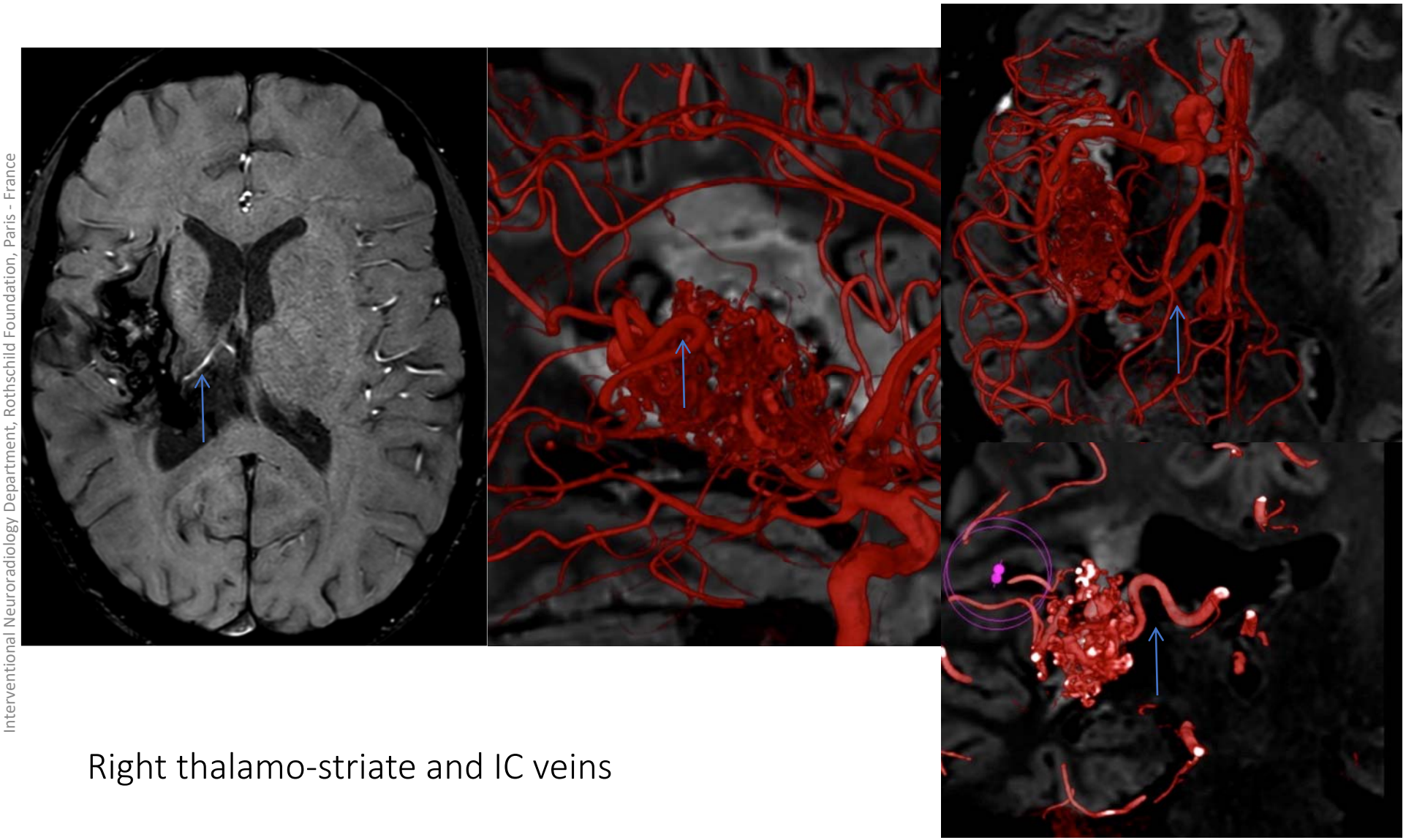


3 embo sessions (art)

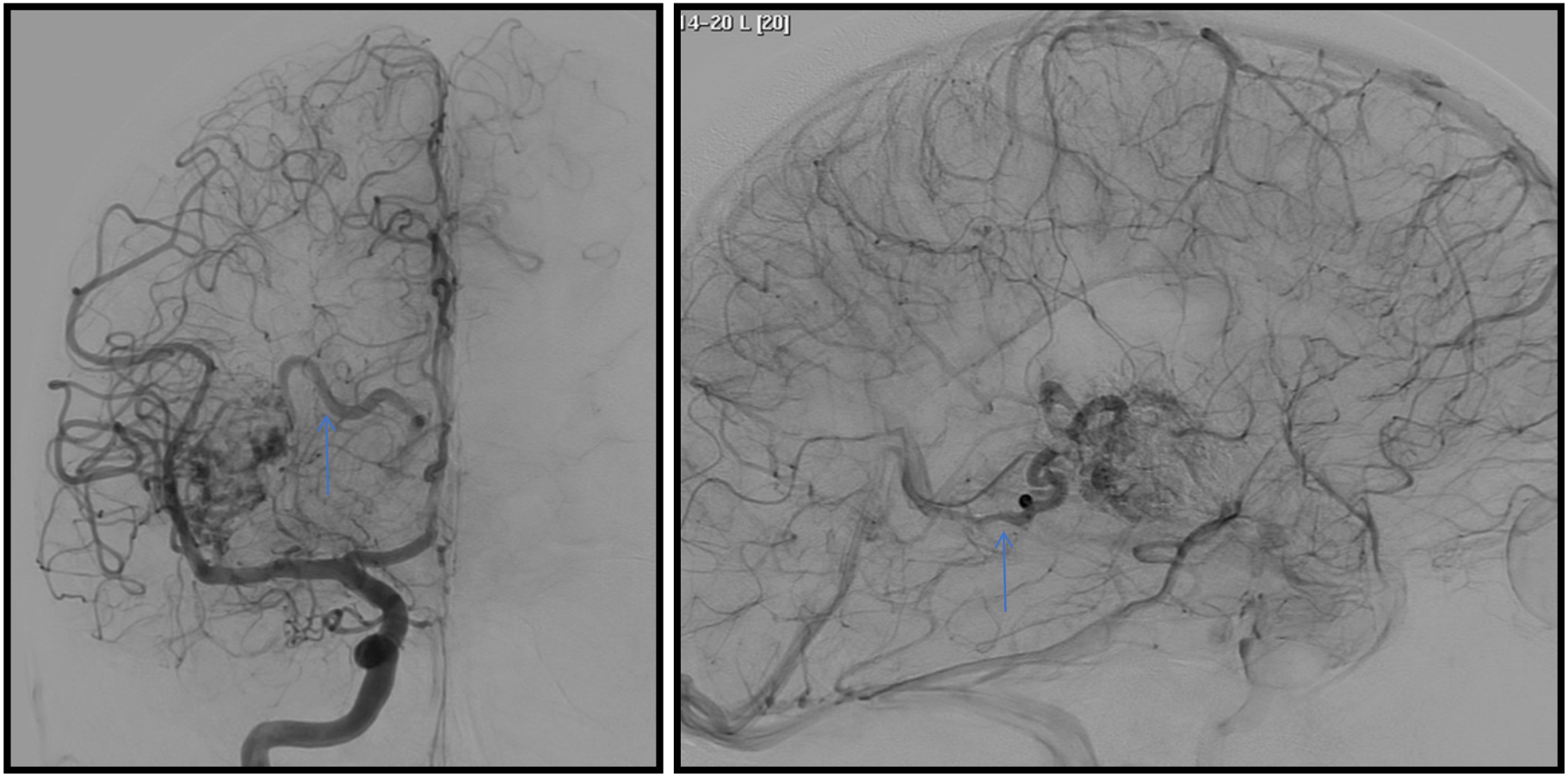




After 3rd arterial embo session

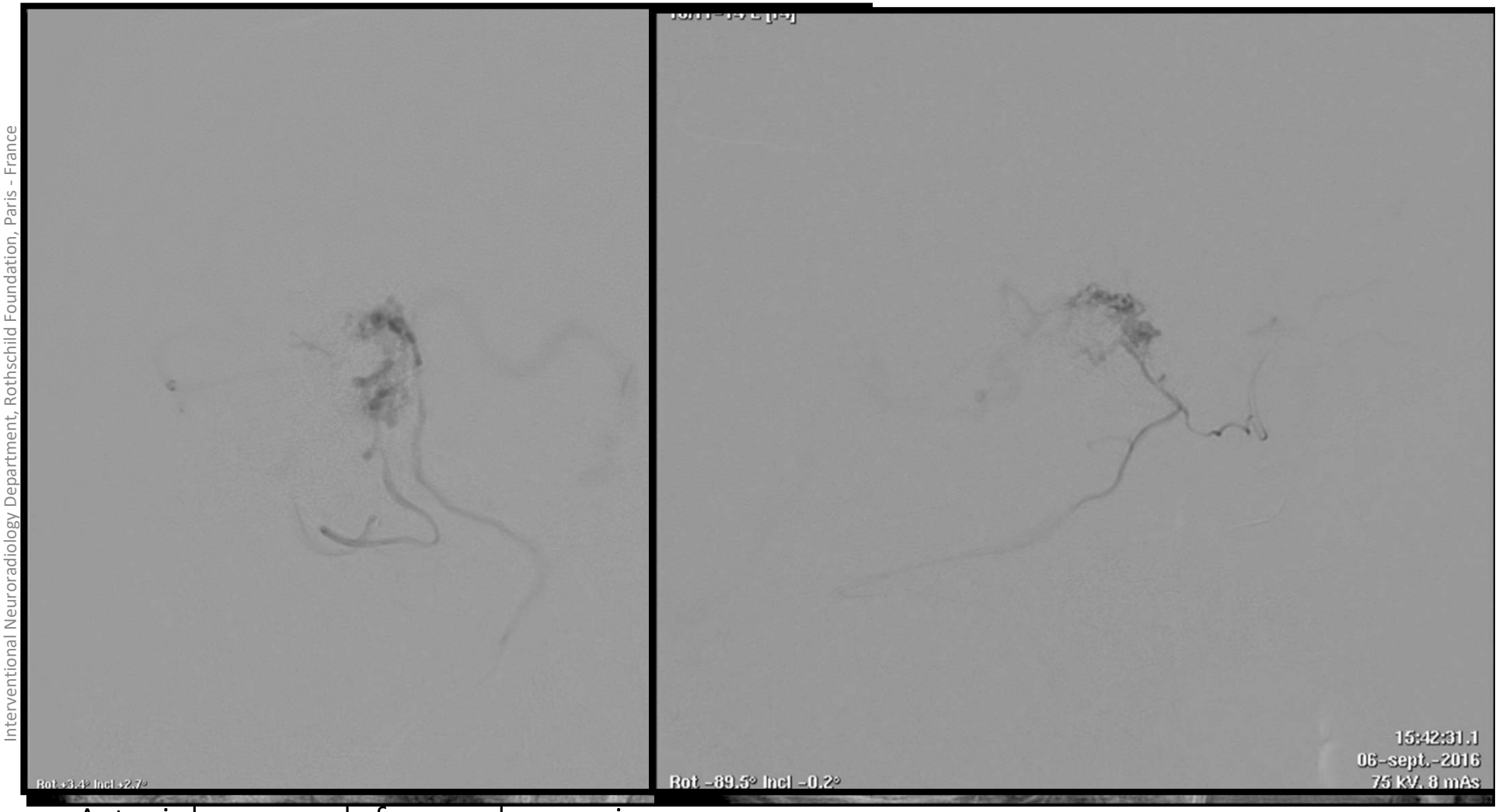


Right thalamo-striate and IC veins

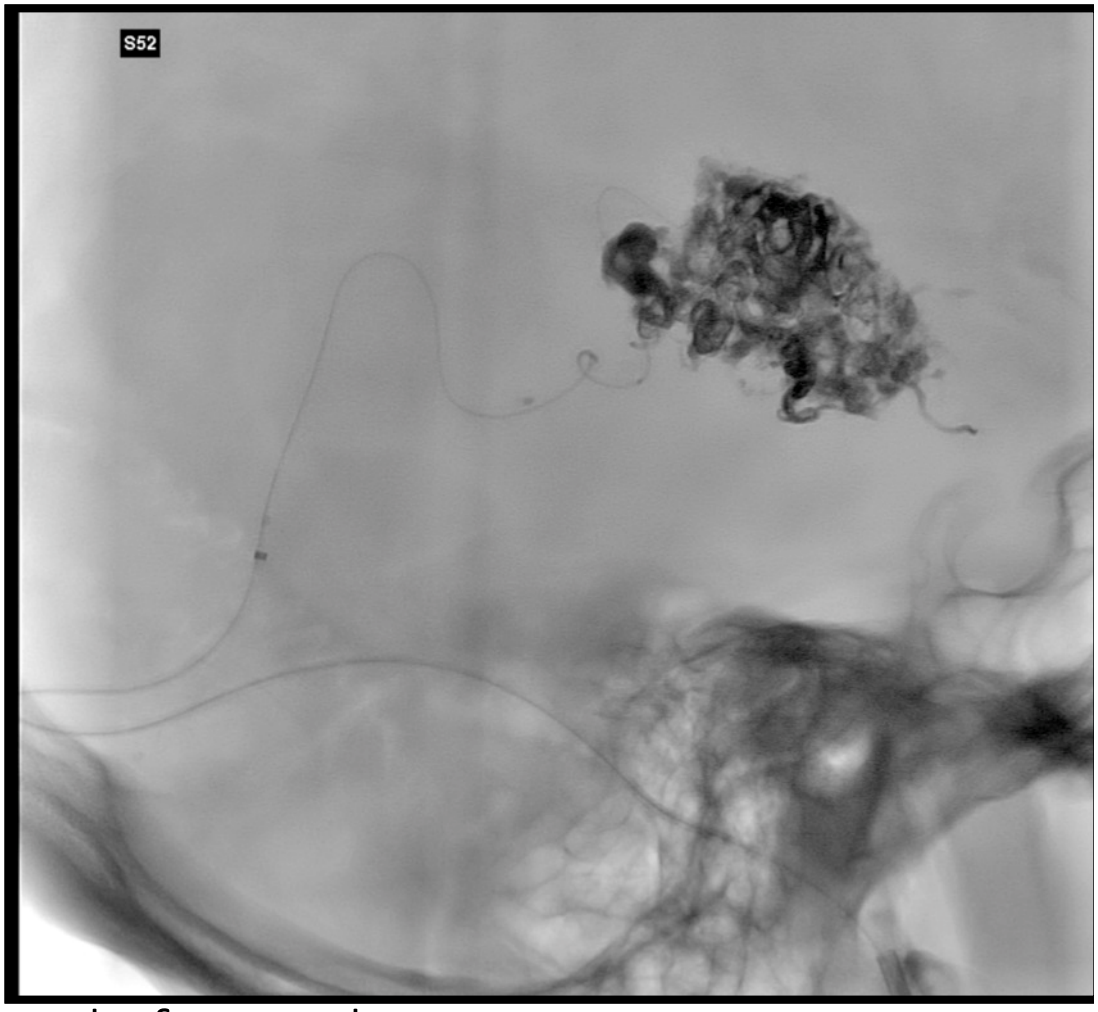


Right ICV 4th embo session, venous route

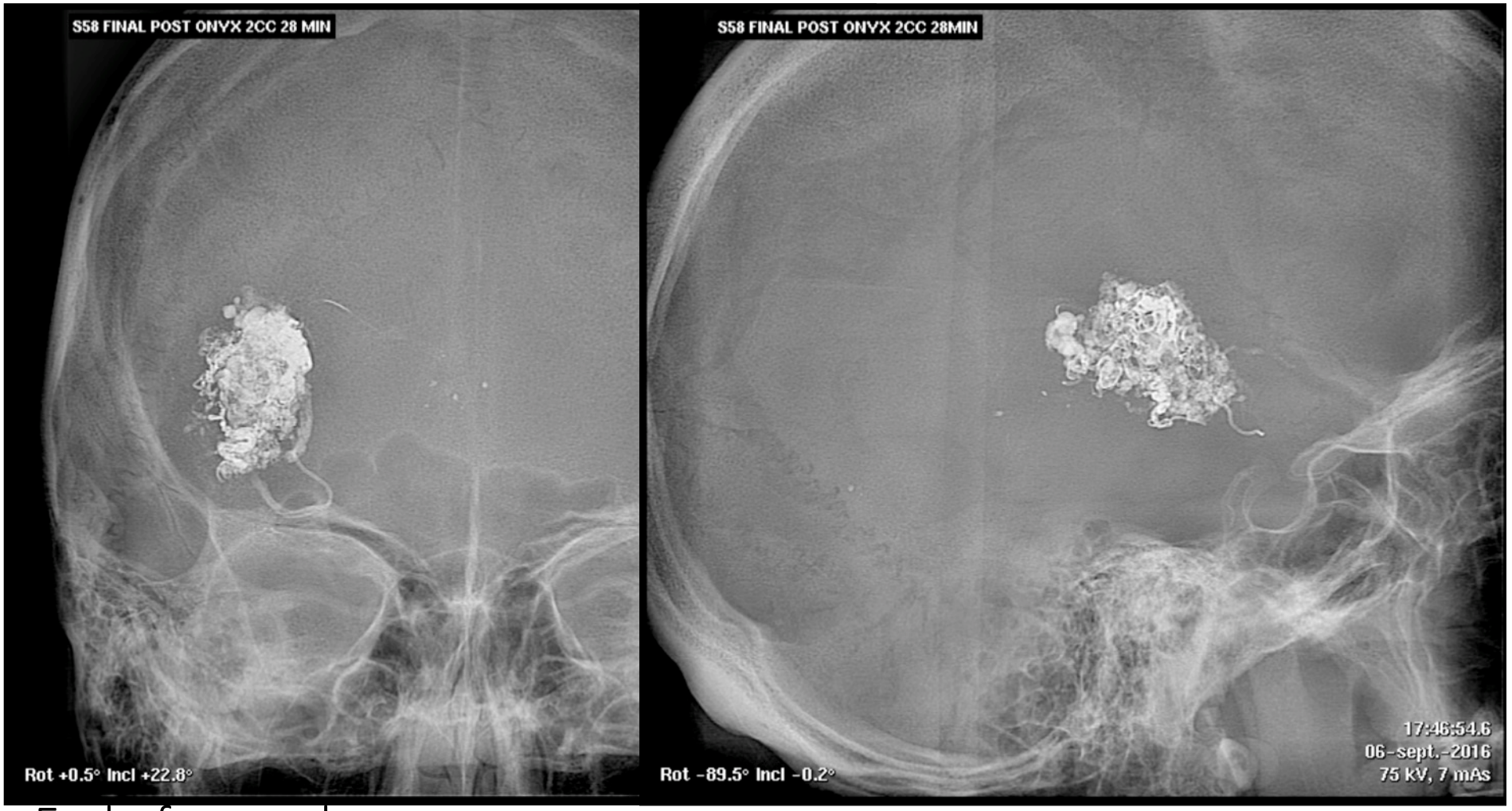
Retrograde navigation from right jugular vein



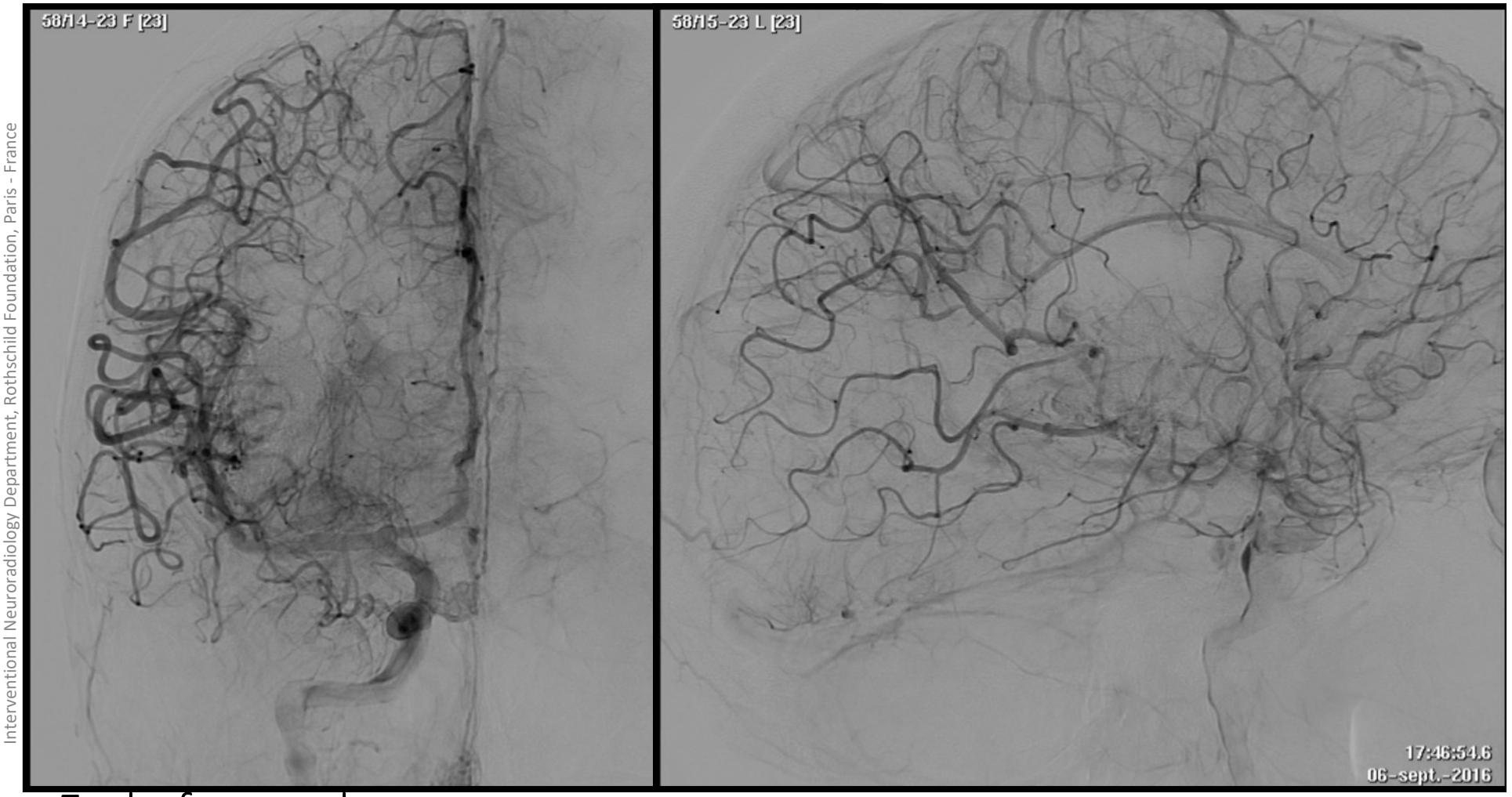
Arterial approach for road-mapping



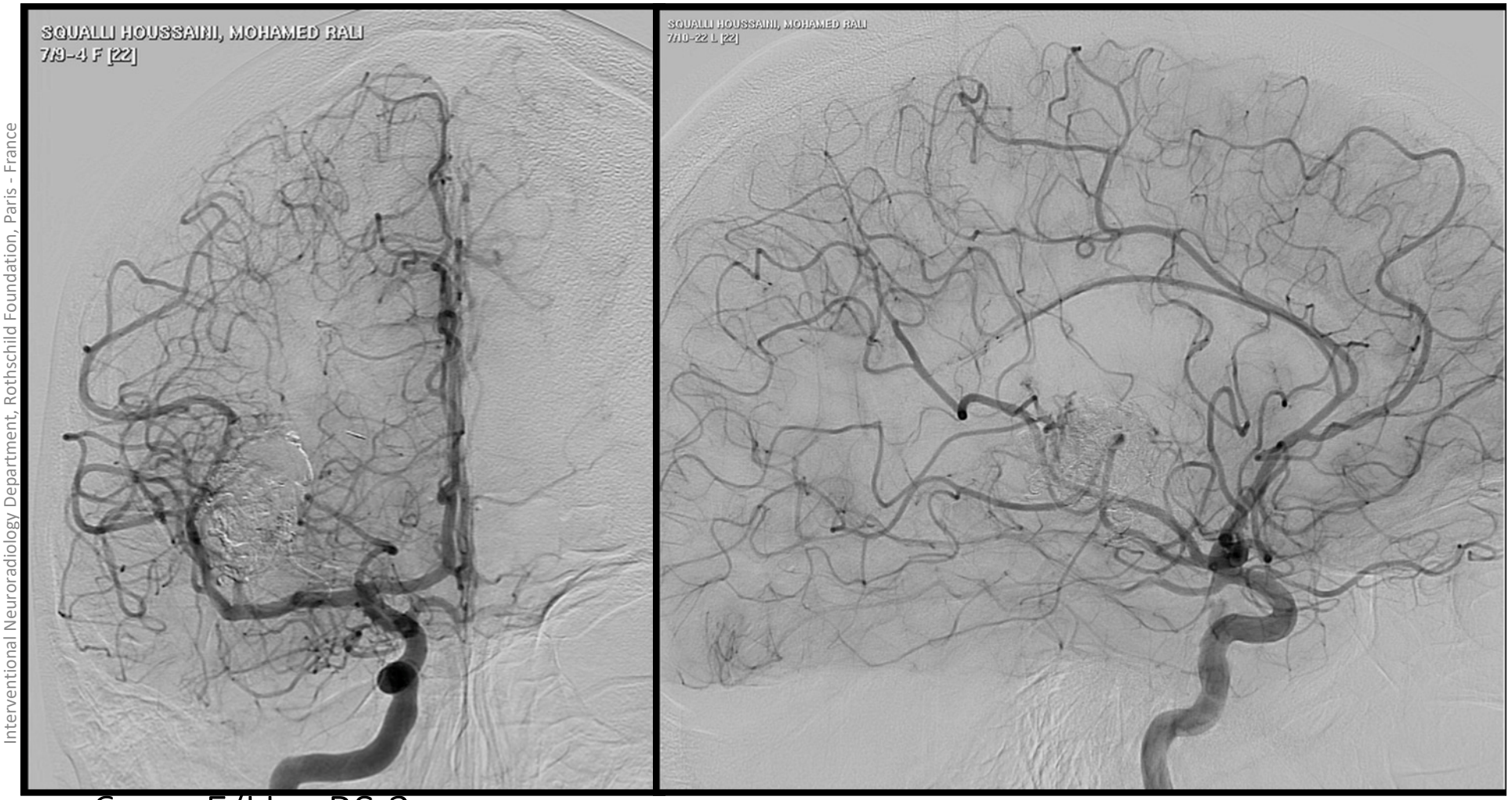
Onyx cast (deep dark) at the end of procedure



End of procedure



End of procedure



6 mo F/U mRS 3

Chouar Laid

- Echec voie veineuse

Venous Navigation Failure

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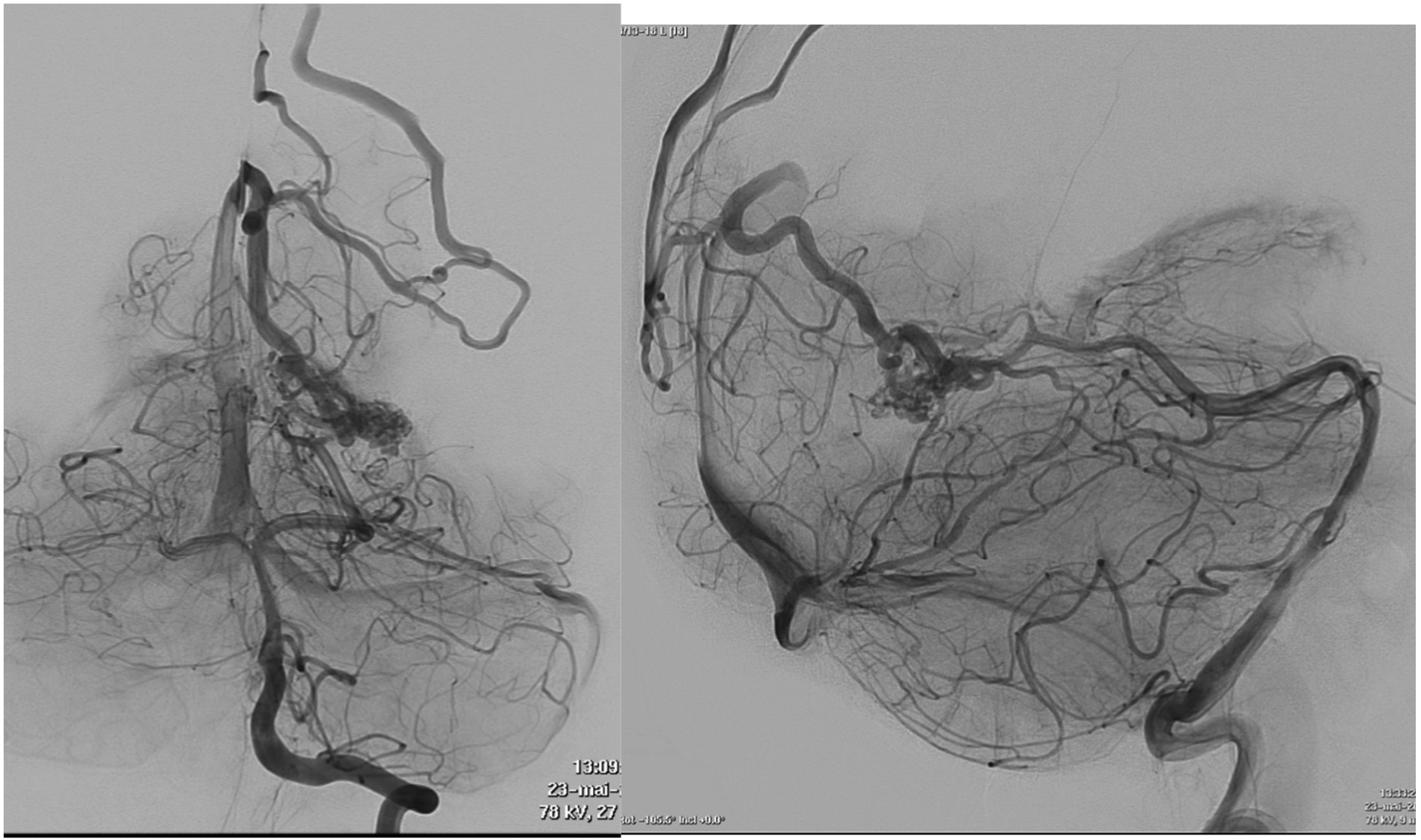

- Endovenous navigation can be hampered by angulation between sinus & cortical veins

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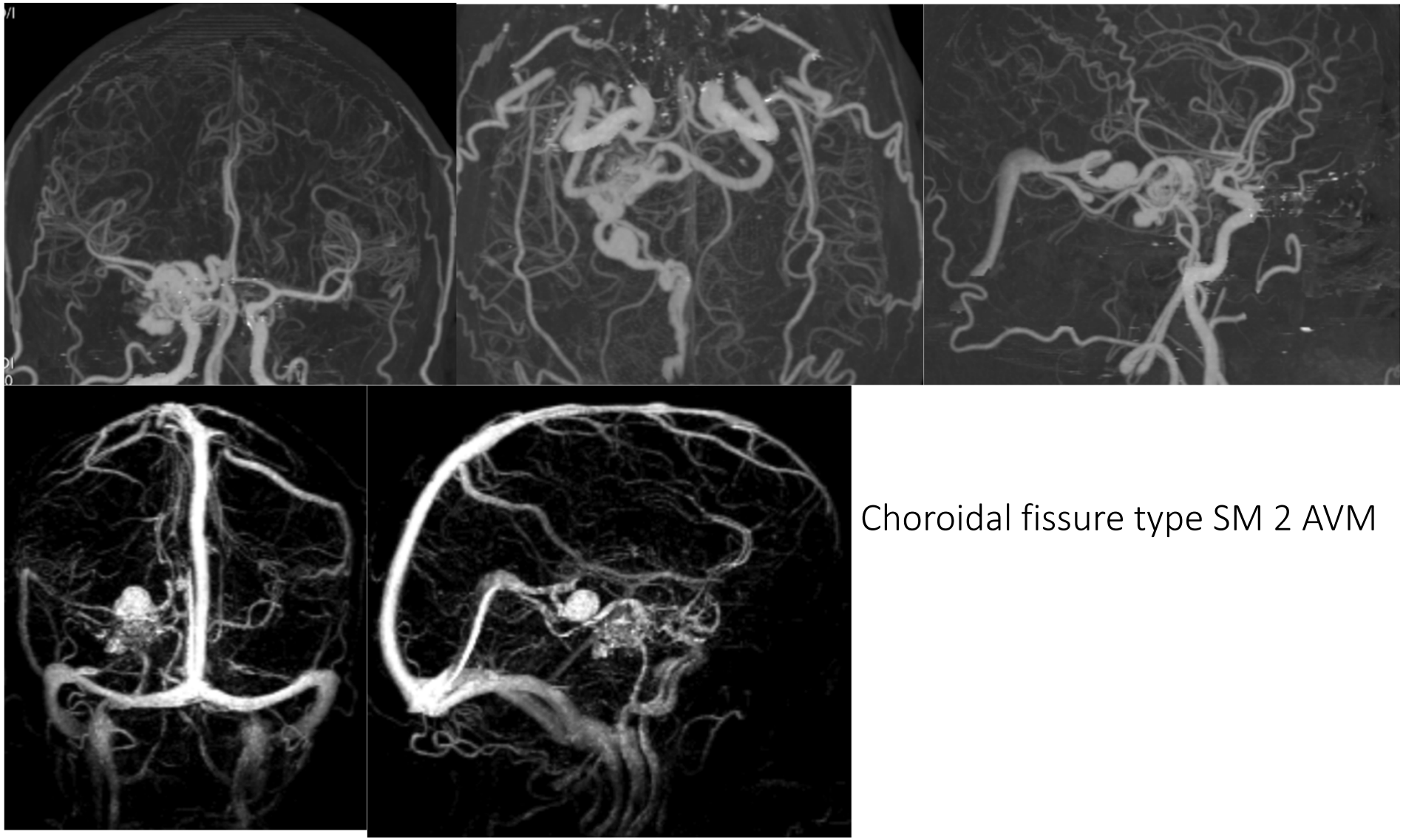
Hemorrhagic Complications

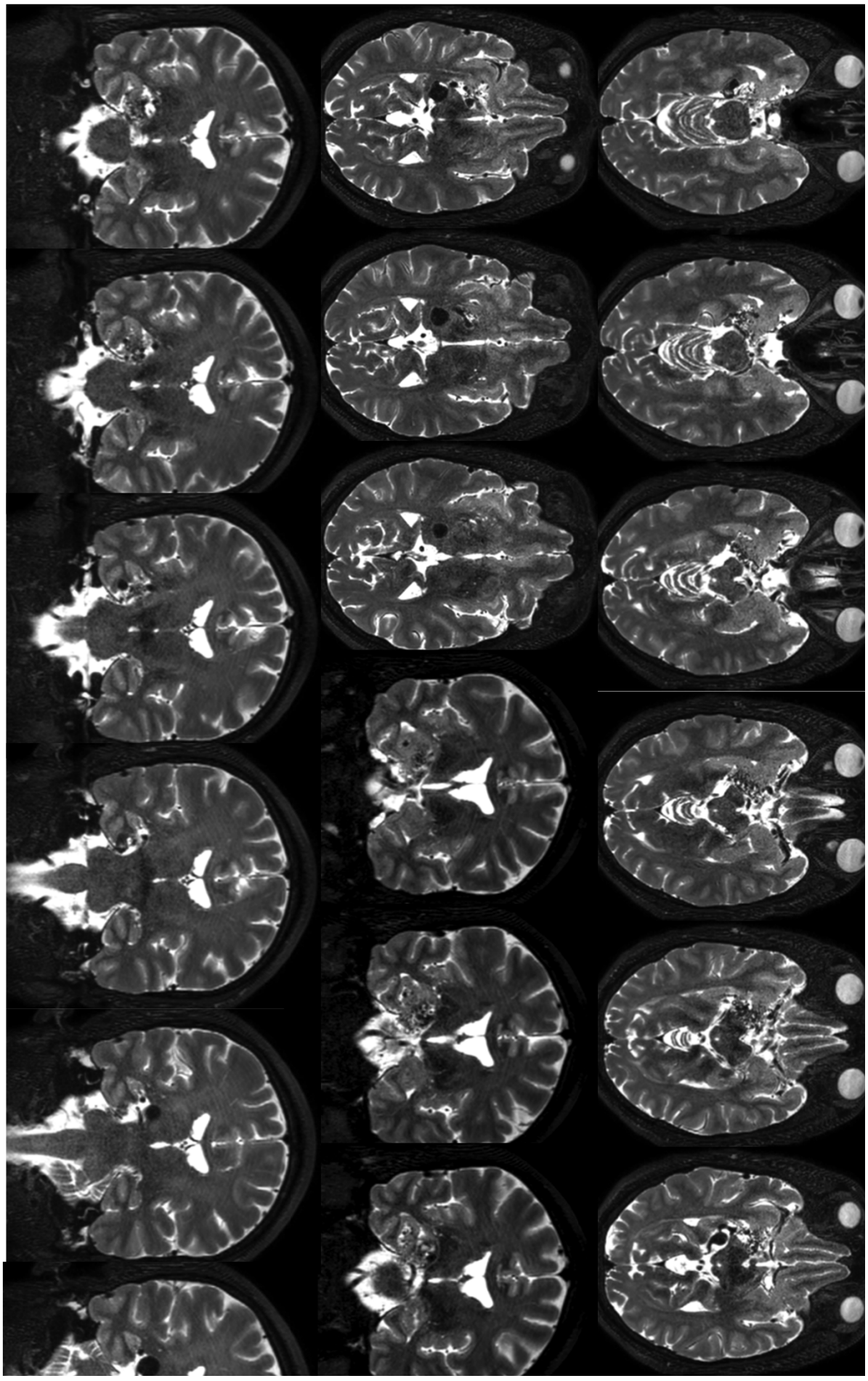
HADRI Boualem

- M 42
- Previous hemorrhage
- mRS 0

- M 42
- Previous hemorrhage
- mRS 0



Choroidal fissure type SM 2 AVM



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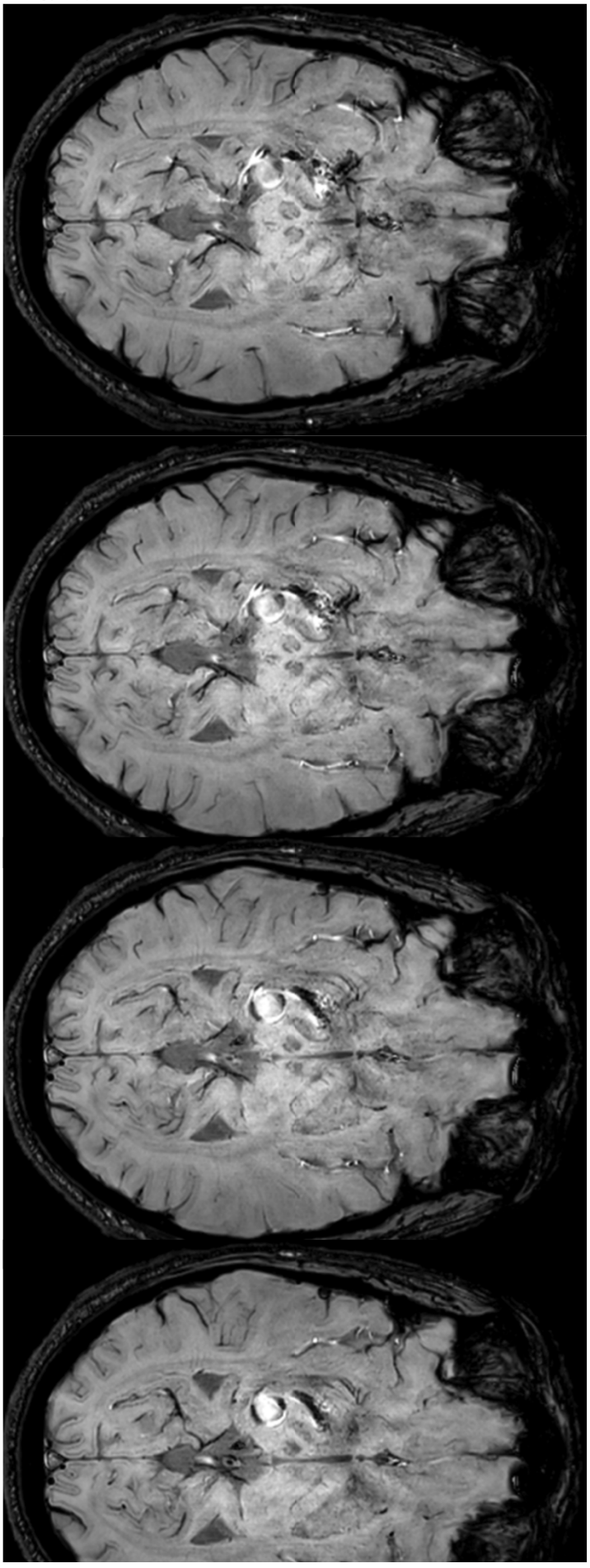
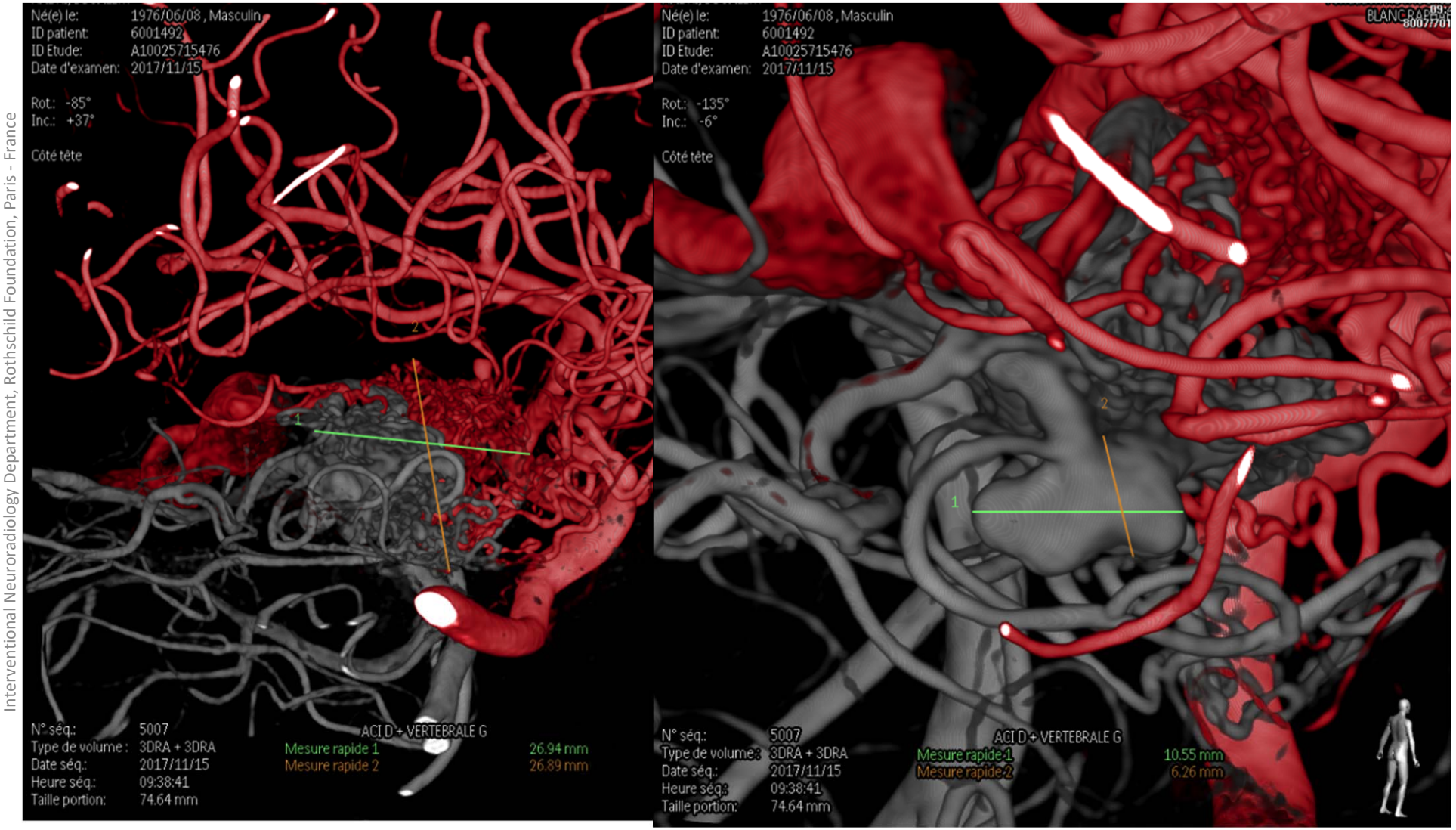
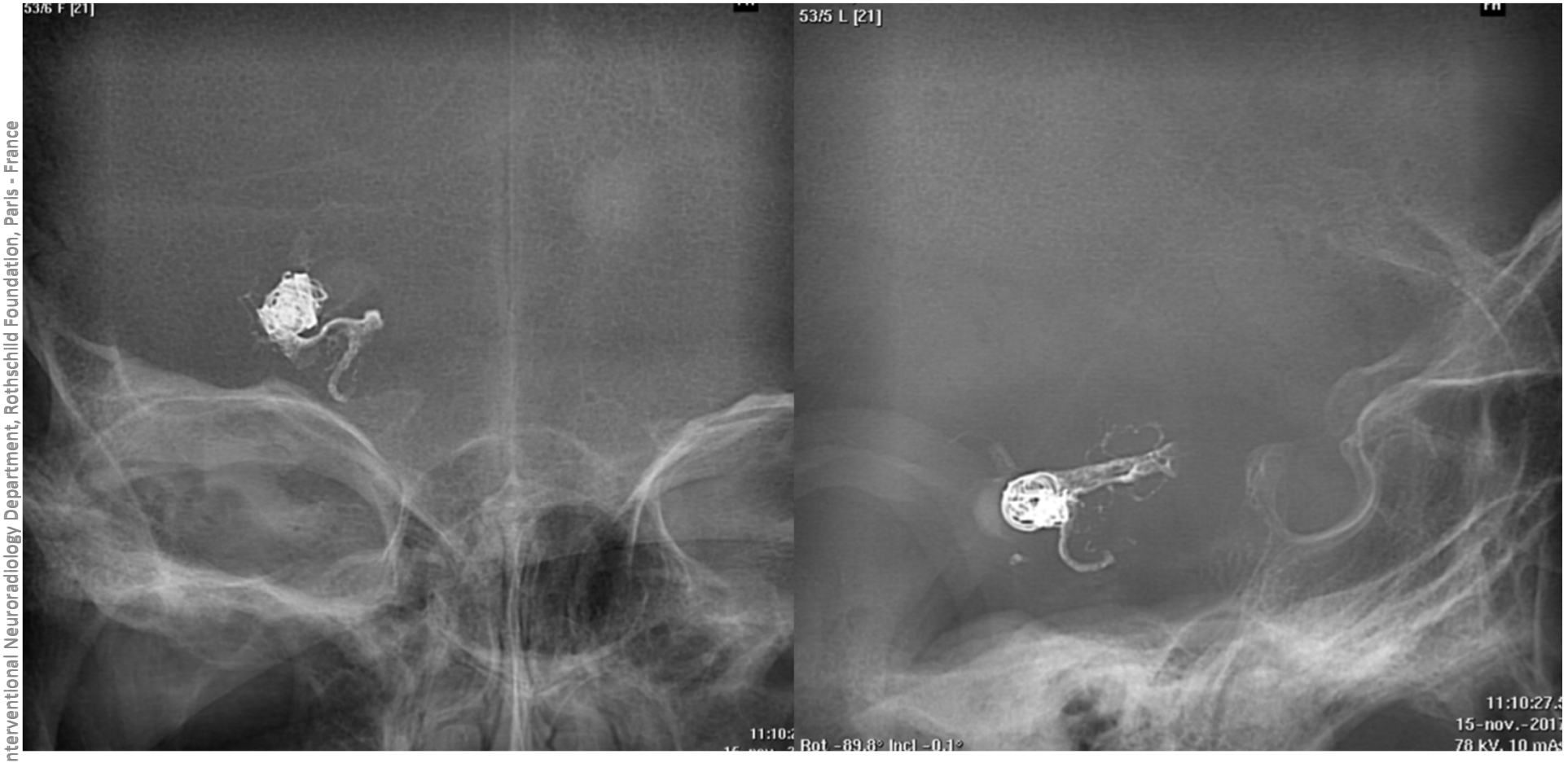


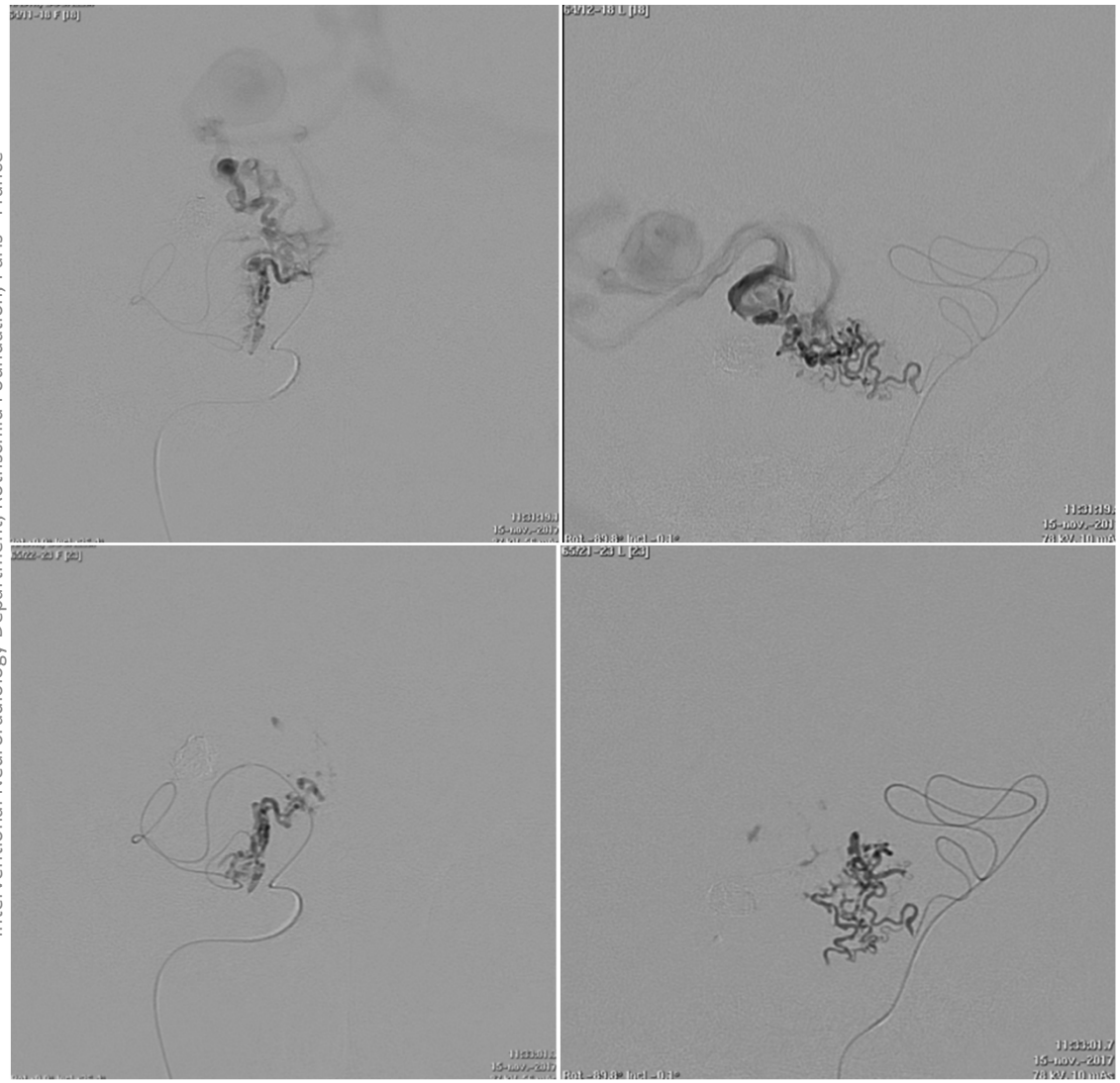


Coiling of arterial aneurysm
15/11/2017

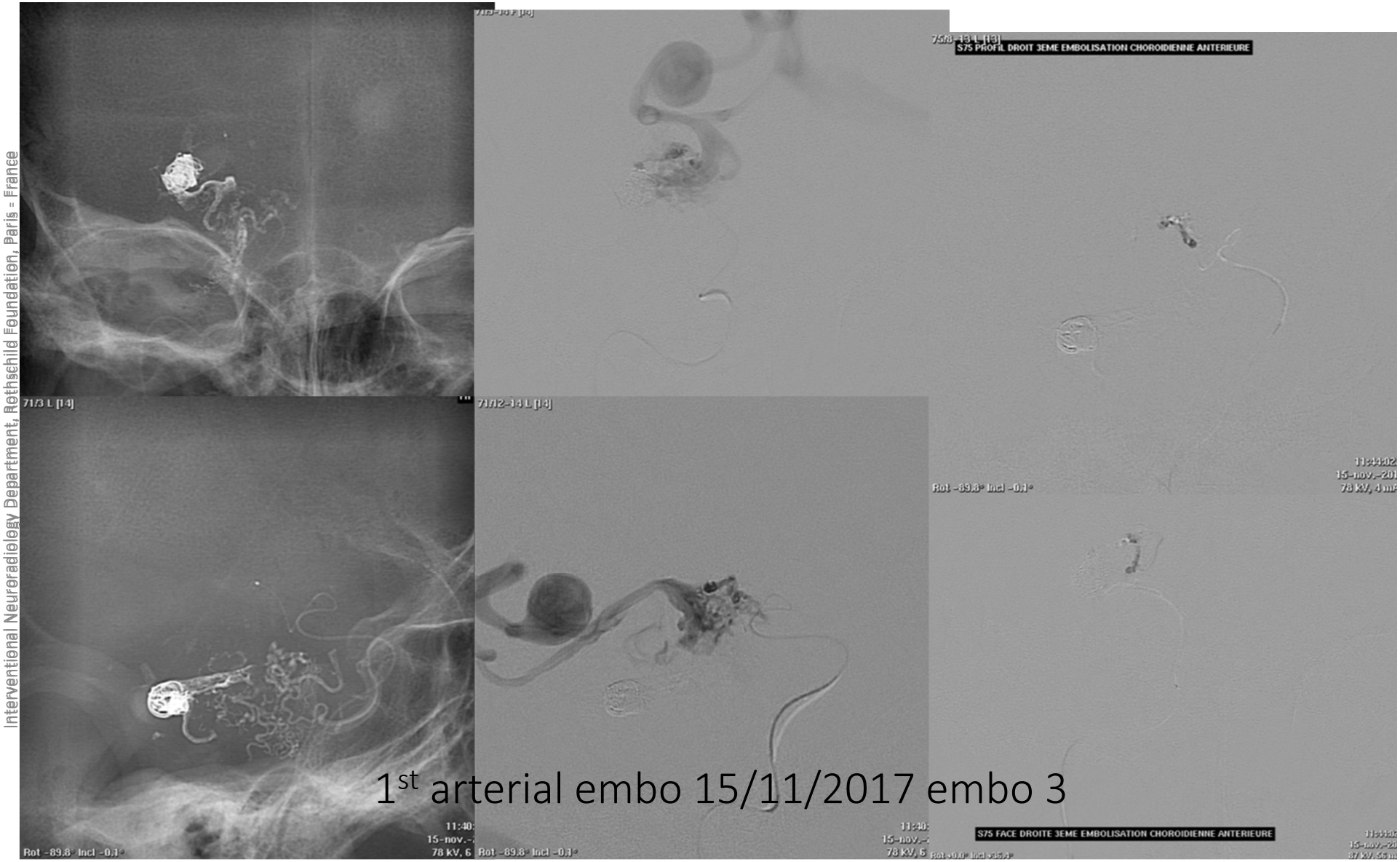
1st arterial embo 15/11/2017 embo 1



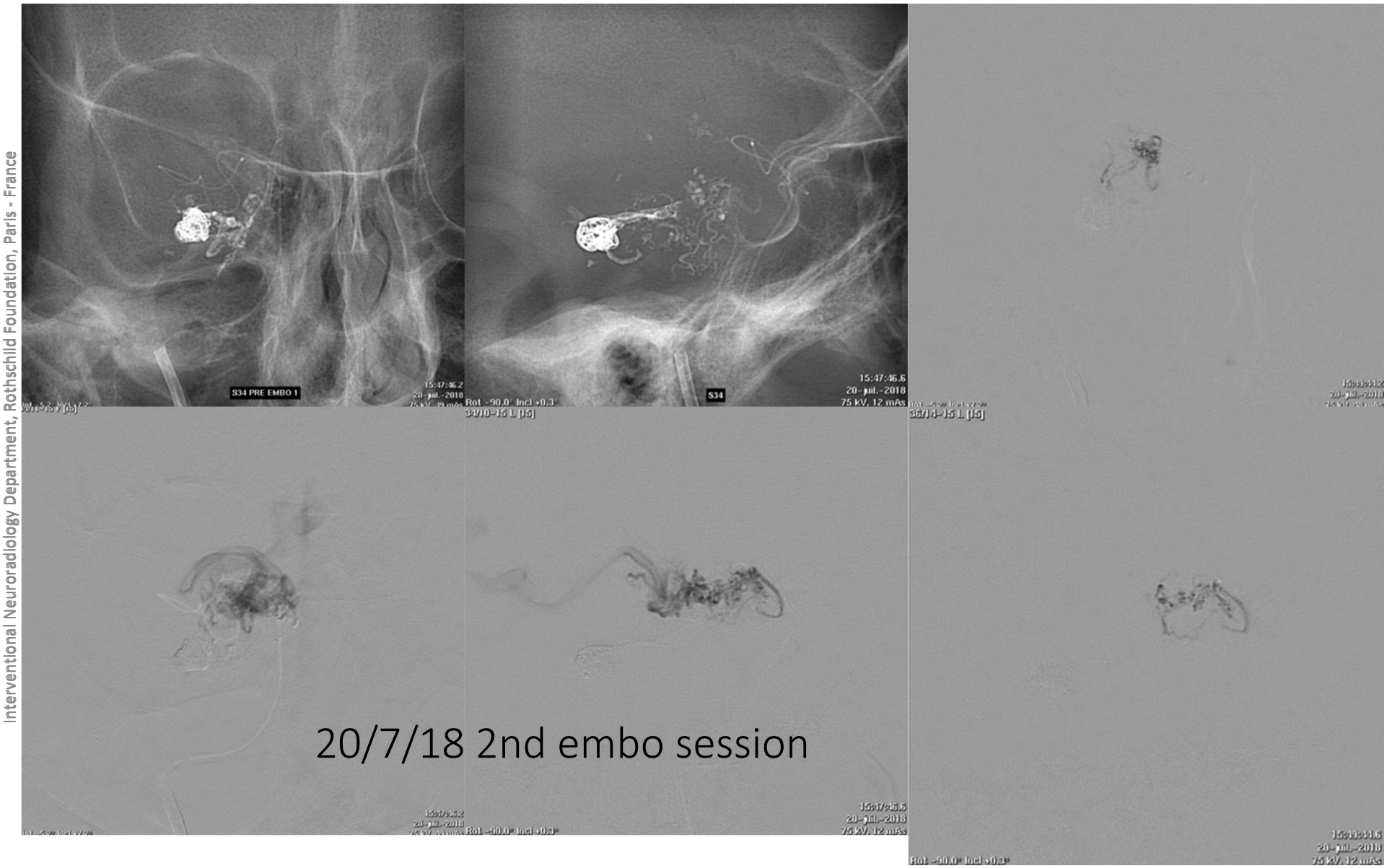
1st arterial embo 15/11/2017 embo 1



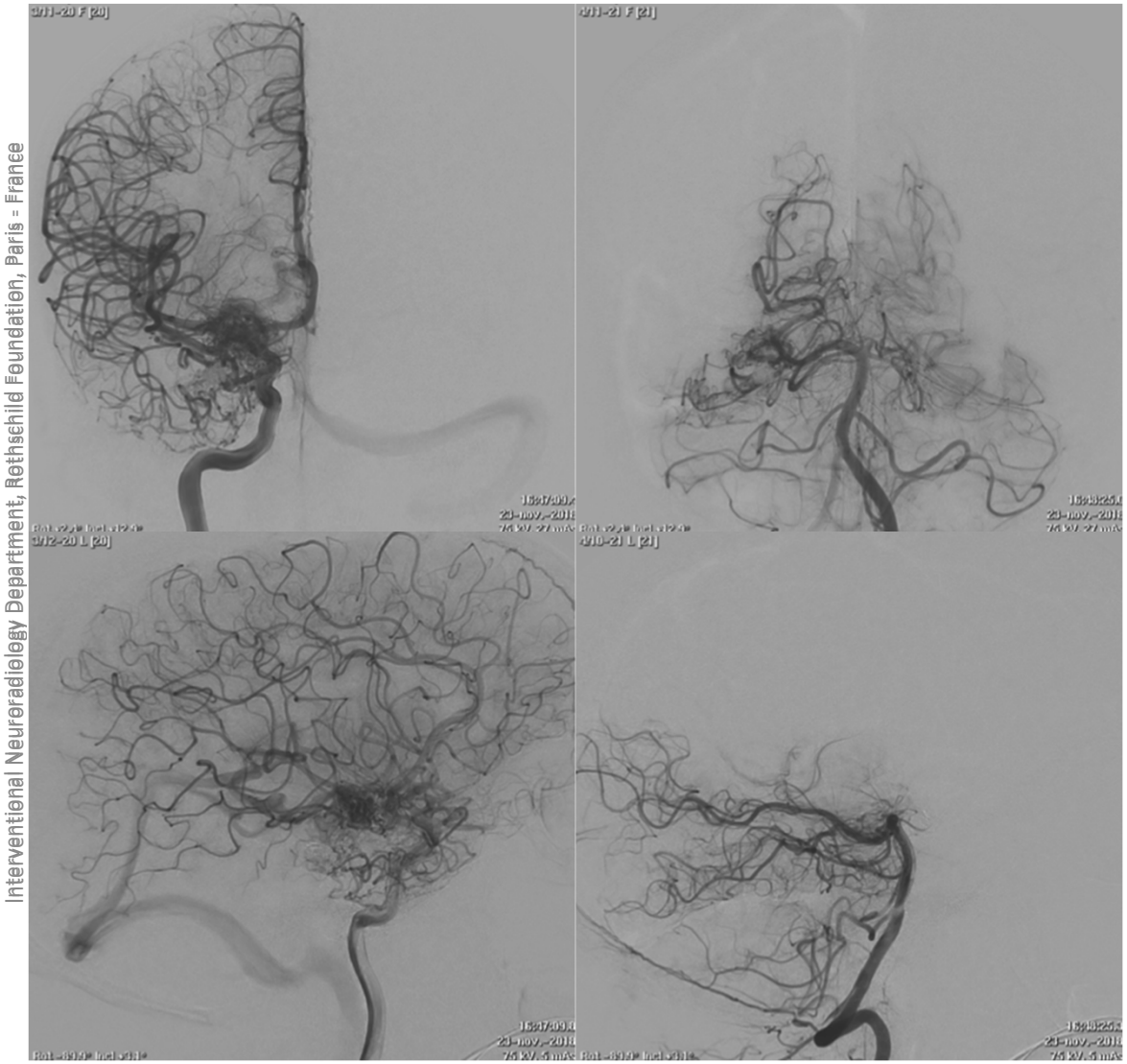
1st arterial embo
15/11/2017 embo 2



1st arterial embo 15/11/2017 embo 3



20/7/18 2nd embo session

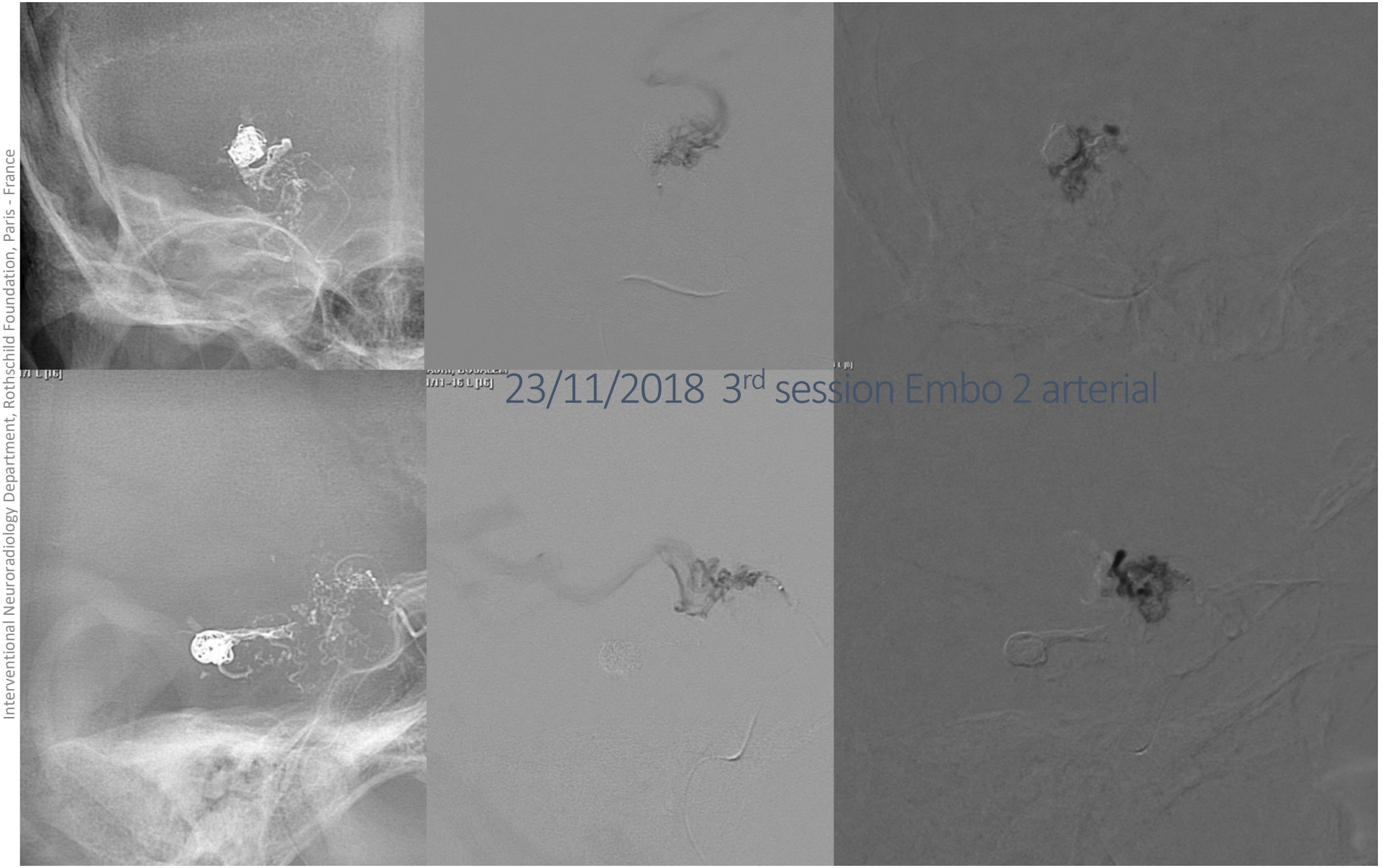


23/11/2018 3rd session

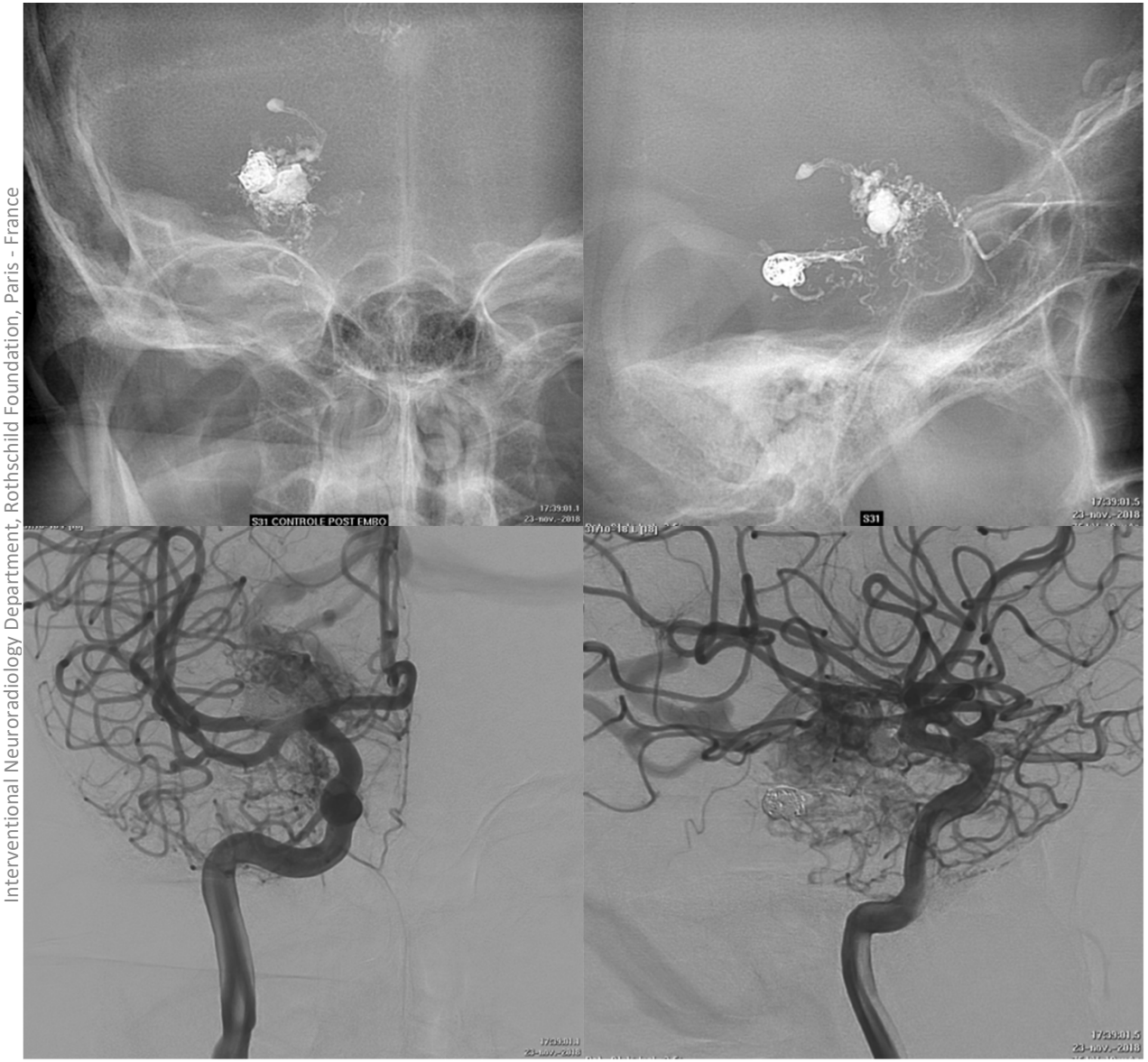
23/11/2018

3rd session

embo 1 arterial



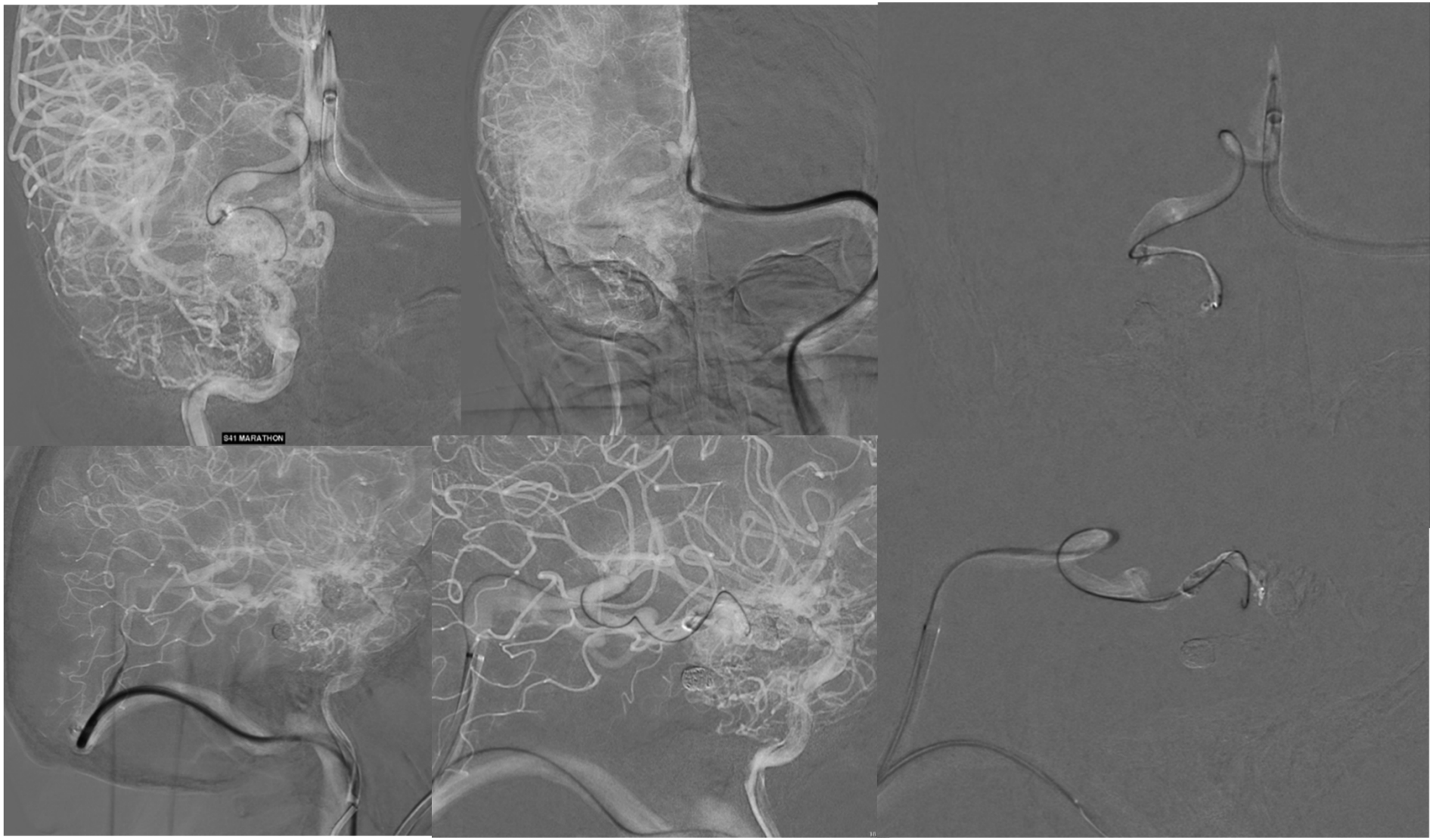
23/11/2018 3rd session Embo 2 arterial



23/11/2018

3rd session

Result before venous embo



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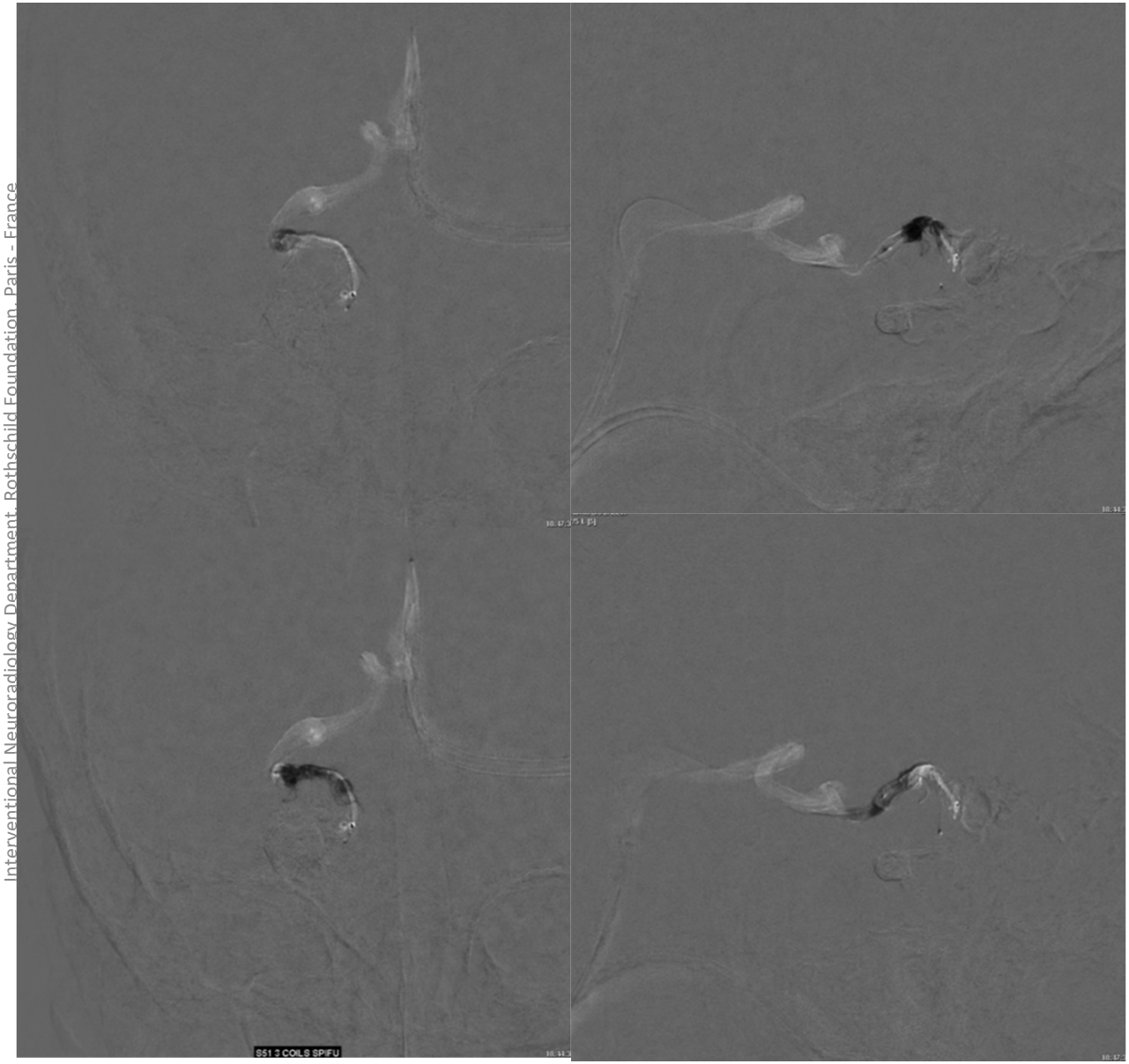

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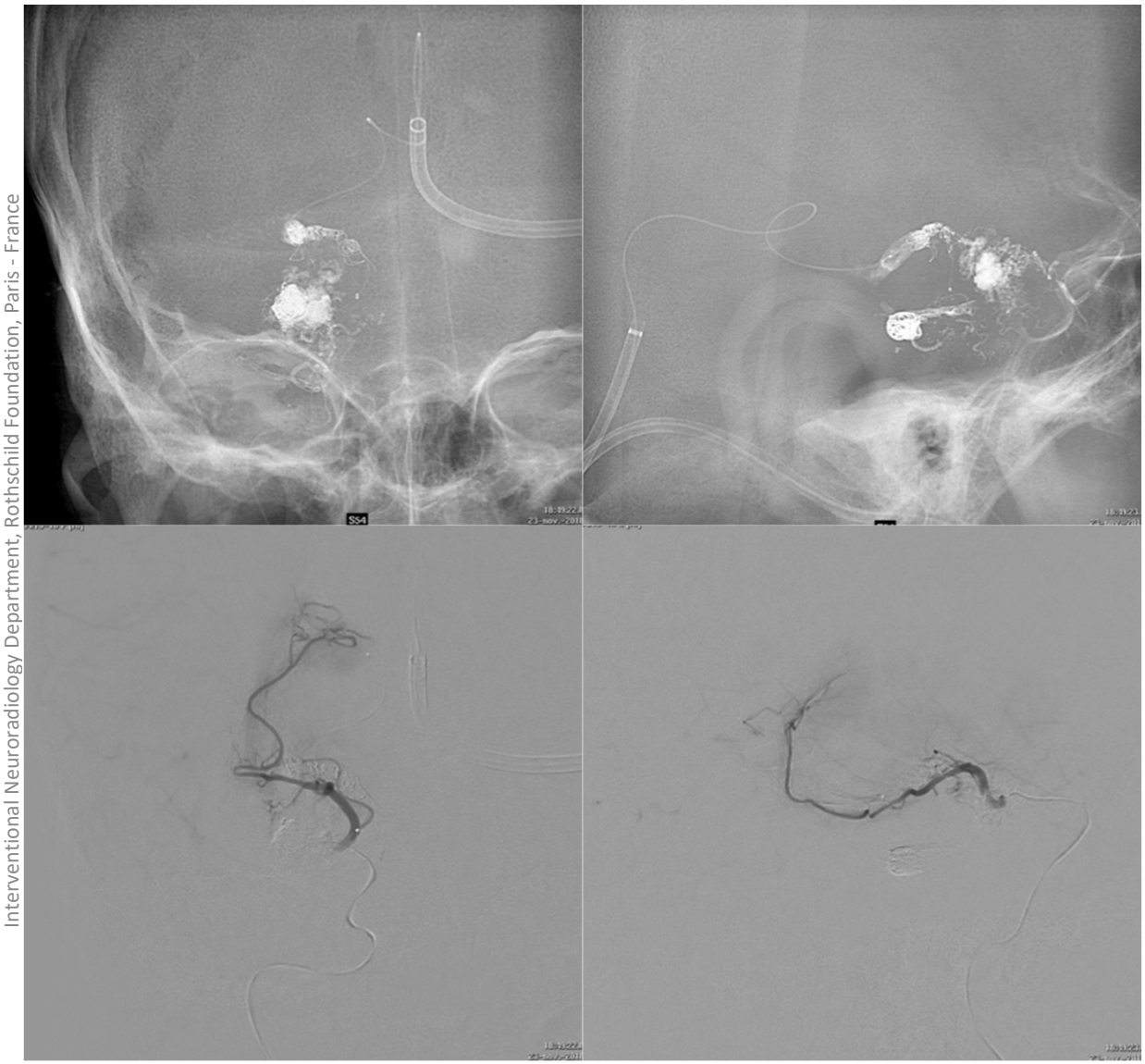
Venous pressure cooker
w liquid coils & glue



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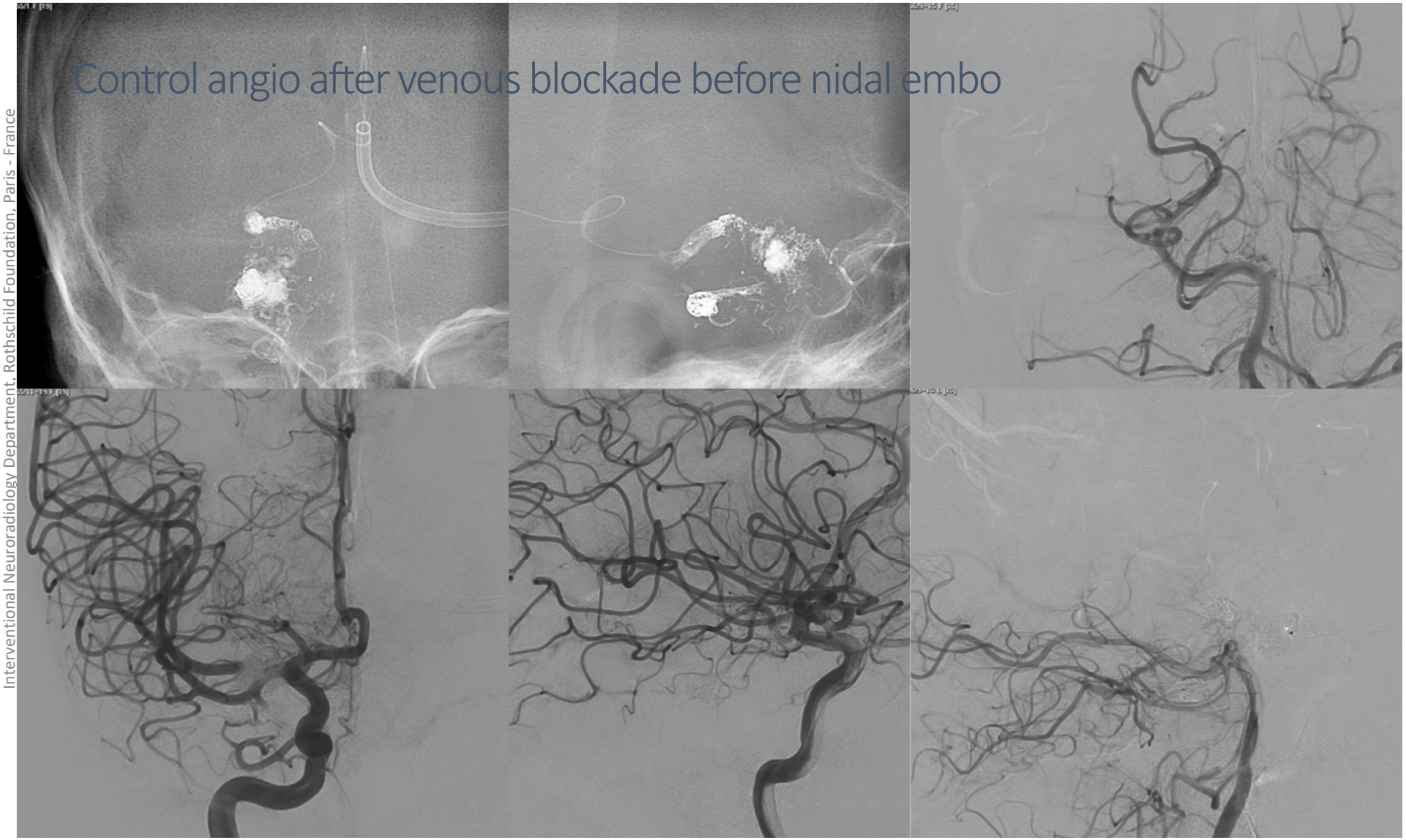
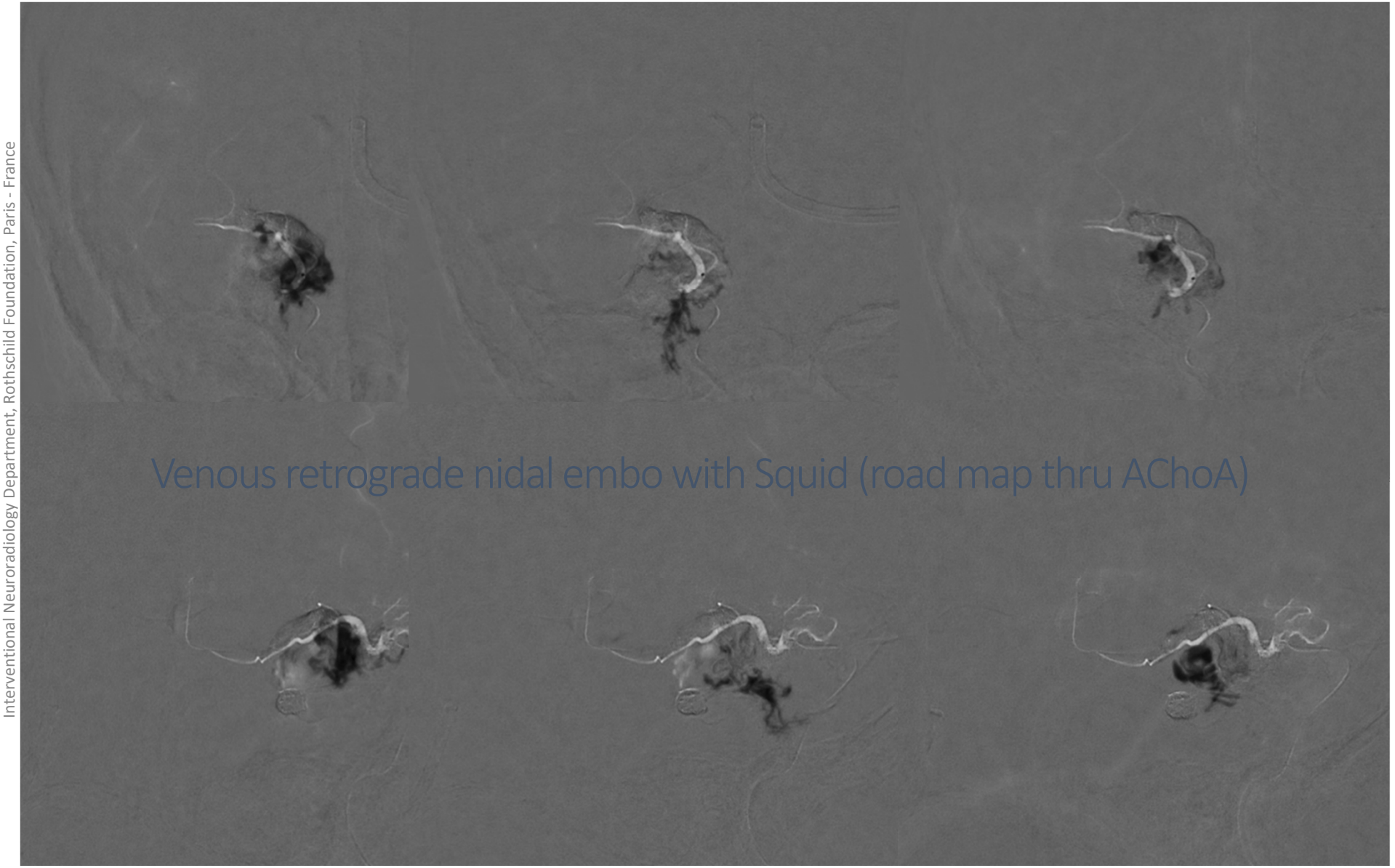
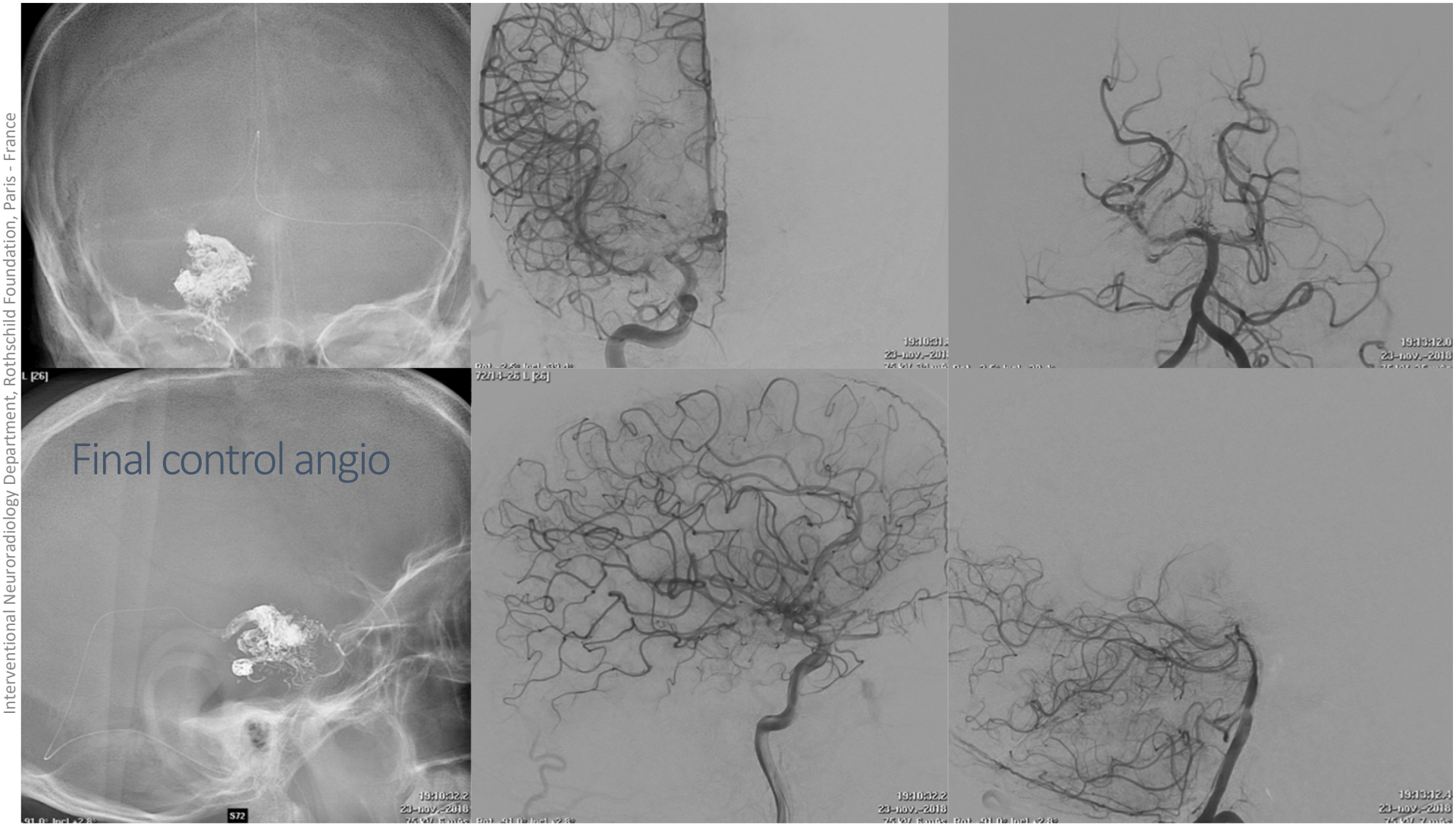
Control angio after venous blockade before nidal embo thru AChor

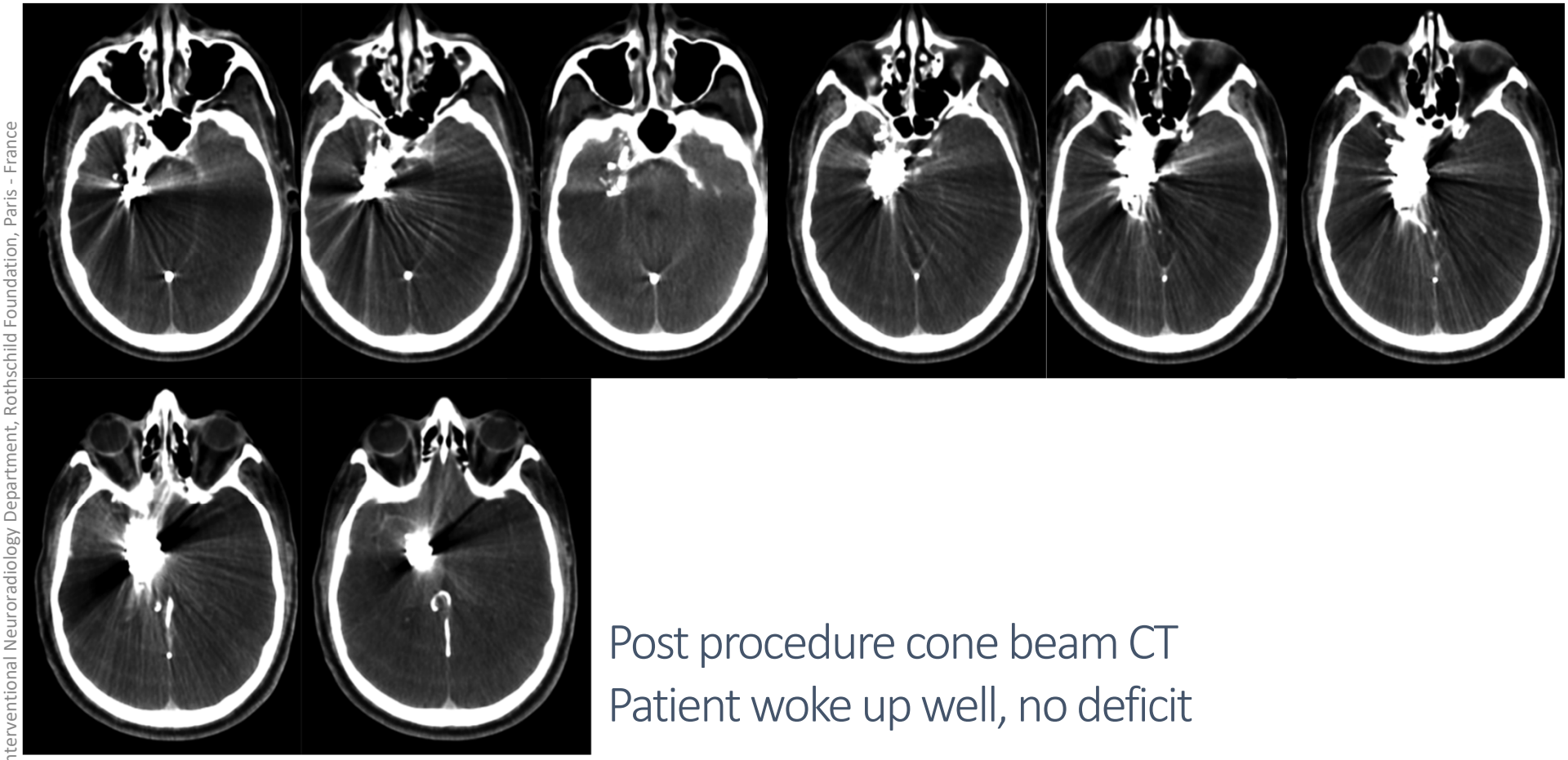
Control angio after venous blockade before nidal embo



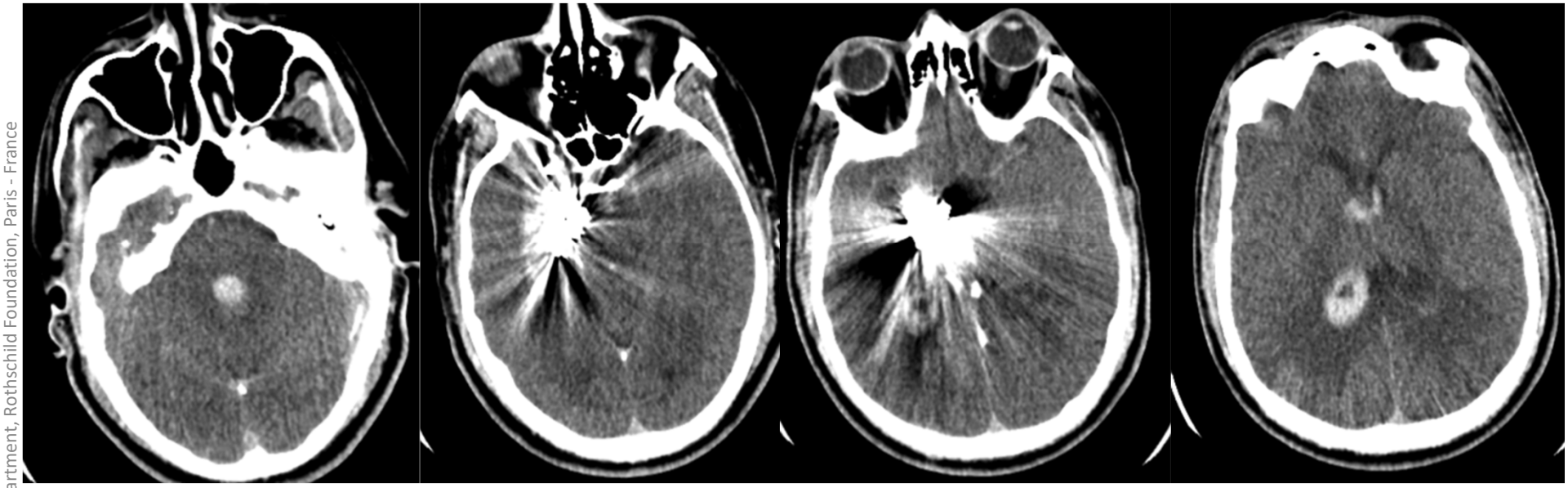


Venous retrograde nidal embo with Squid (road map thru AChoA)

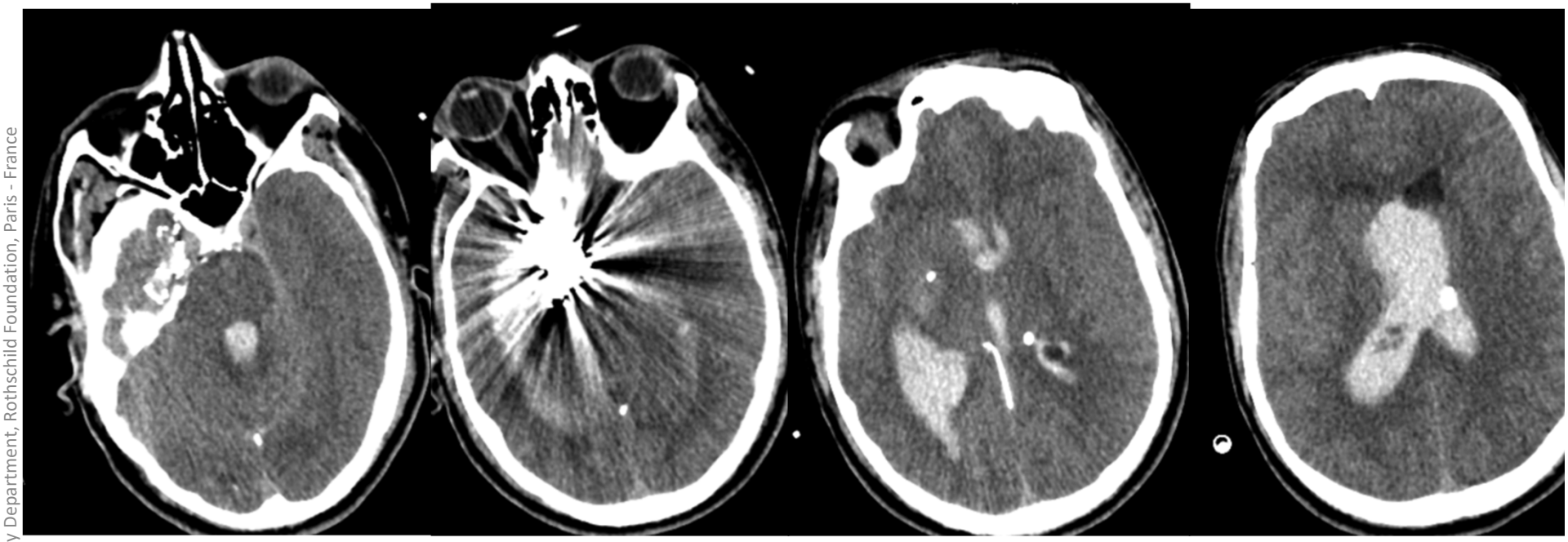




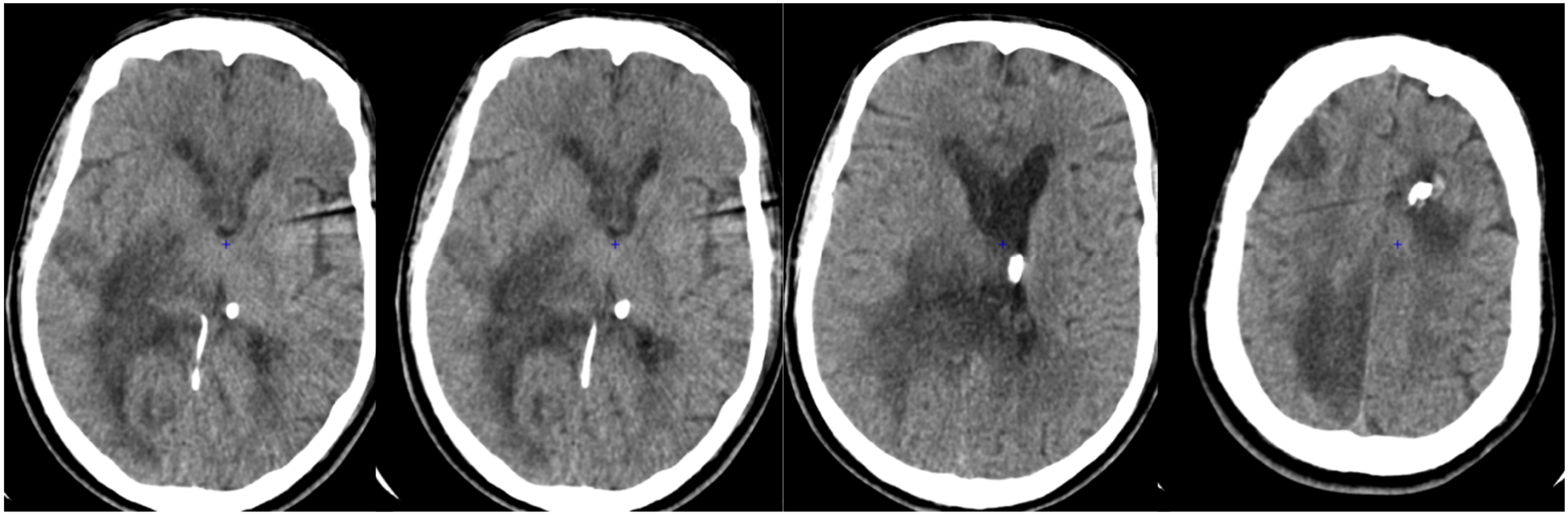
Post procedure cone beam CT
Patient woke up well, no deficit



4 hours later..



Emergent ventricular drainage, then new CT showing persisting bleeding



3 weeks after venous embo

Lessons

- Adjunctive tool for complete AVM obliteration
- Anatomy of cortical veins are limiting venous approach for cortical (superficial) lesions
- No total protection against ischemic complications
- Beware of large venous ectasia
- Our major complications came along with the treatment of ventricular AVMs with large venous ectasia

Perspective

- **Transvenous Approach for the Treatment of cerebral Arteriovenous Malformations (TATAM):**
- **Study protocol of a randomized controlled trial**
-

- Robert Fahed[1], Tim E. Darsaut[2], Charbel Mounayer[3], René Chapot[4], Michel Piotin[1],
- Raphaël Blanc[1], Vitor Mendes Pereira[5], Daniel G. Abud[6], Dana Iancu[7], Alain Weill[7],
- Daniel Roy[7], Lorena Nico[7], Suzanne Nolet[8], Ruby Klink[8], Guylaine Gevry[8], Jean Raymond[7,8]
-
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Abstract

Background

Trans-venous embolization (TVE) is a promising technique but benefits remain uncertain. We hypothesized that TVE leads to a higher rate of AVM angiographic occlusion than trans-arterial embolization (TAE).

Methods

The Transvenous Approach for the Treatment of cerebral Arteriovenous Malformations (TATAM) is an investigator initiated, multicenter, prospective, phase-2, randomized, controlled clinical trial. To test the hypothesis that TVE is superior to TAE for AVM obliteration, 76 patients with AVMs considered curable by up to 2 sessions of endovascular therapy will be randomly allocated 1:1 treatment with either TVE (±TAE) (experimental arm) or TAE alone (control arm). The primary endpoint of the trial is complete AVM occlusion, assessed by catheter cerebral angiography. Complete occlusions will be confirmed at 3 months, while incompletely occluded AVMs, considered treatment failures, will then be eligible to complementary treatments by surgery, radiation therapy, or even TVE. Standard procedural safety outcomes will also be assessed. Patient selection will be validated by a Case Selection Committee, and participating centers with limited experience in TVE will be proctored.

Discussion

The TATAM trial is a transparent research framework designed to offer a promising but still unvalidated treatment to selected AVM patients.

Clinical Trial Registration-URL: http://www.clinicaltrials.gov. Unique identifier: NCT03691870.

COMBIMAV: combined EVT & surgical approaches

Introduction

- *Historical gold standard* = microsurgery, but facilitated by preoperative embolization

- *Widespread* = Embolization, but need for multiple sessions
  - Cumulated risk of post-procedure hemorrhage

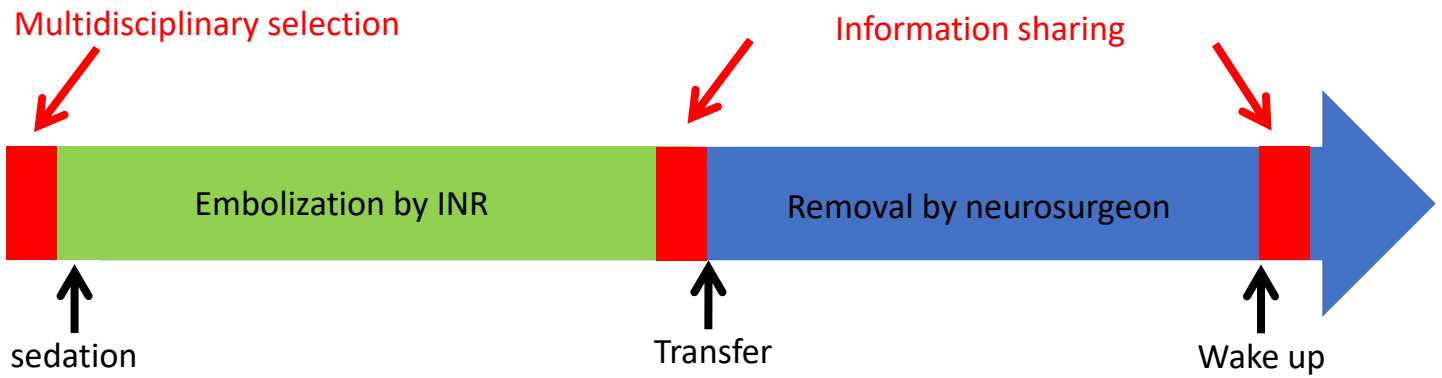
- *In vogue* = Radiosurgery, but lack of distance

idea of a combined single-phase treatment, embolization + removal

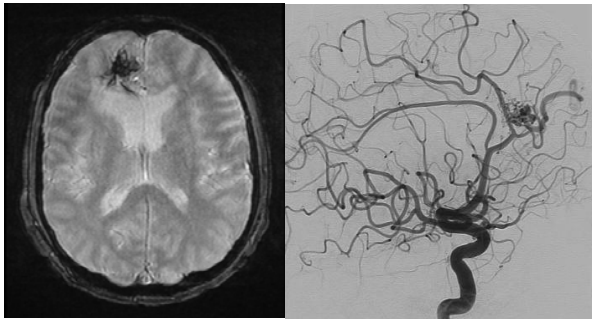
Baharvahdat H et al. Hemorrhagic Complications after Endovascular Treatment of Cerebral Arteriovenous Malformations. AJNR Am J Neuroradiol. 2014 May;35(5):978-83.

Methods

- Prospective study on selected AVM
- Sharing of informations +++
- Assessment of difference « post-embolization remnant versus intraoperative remnant »

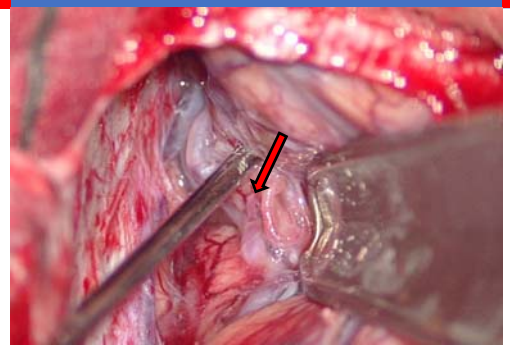


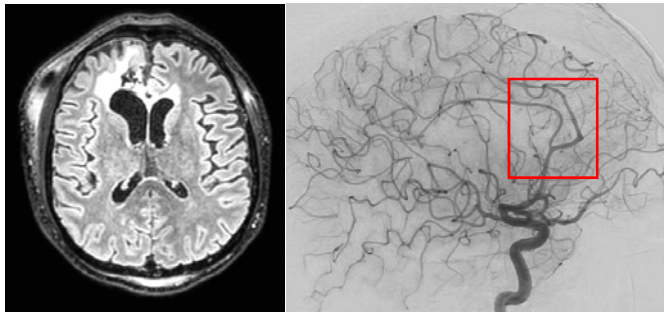
Pre-op



Embolization by INR

microsurgery



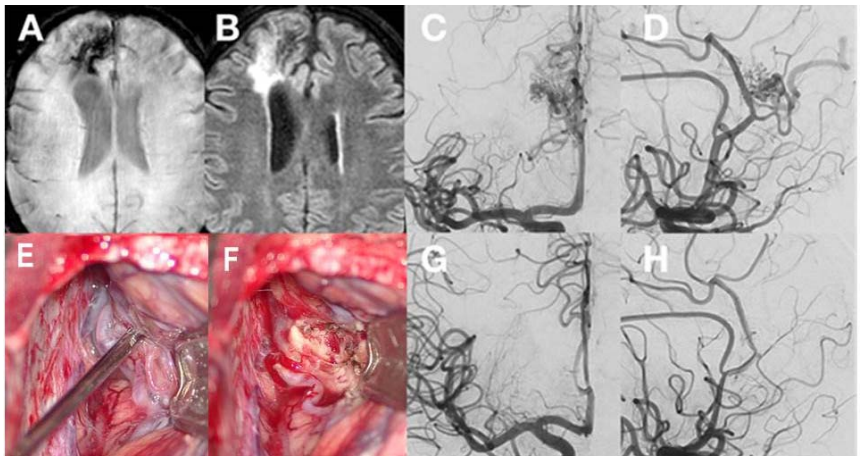


Post-op

Results

- 18 patients since january 2018; only low-grade AVM
- Good clinical outcomes

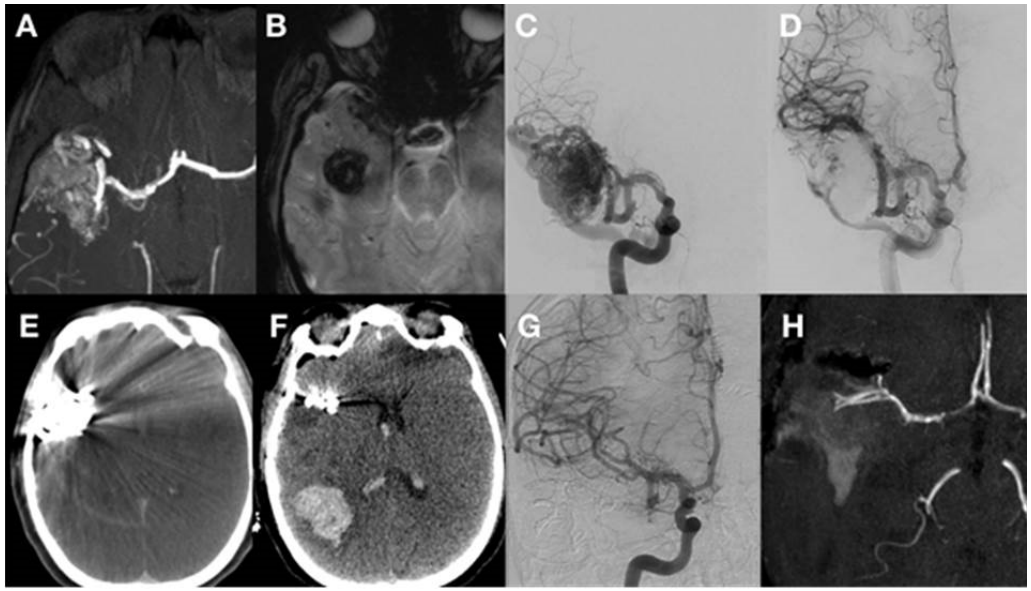
  (0<mRS<2, at 3 months, n = 18)
- Good radiological results (n = 18)
- Good correlation between INR and surgeons, regarding remnant (n = 17)
- Mean operative time = 7 hours



Results

- Clinical complications
  - 2 transient hemiparesis
  - 1 majored visual field defect

- Radiological complications
  - 1 hematoma between the 2 phases



Conclusions

- Promising strategy for low grade AVM
- Curative treatment
- So far, no delayed hemorrhage

- Need for larger series
- Need for improvment regarding high grade AVM
- Shorten the phase with hybrid OR