

Contemporary AVM Embolization: Cure or Adjunct

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Disclosures

Consultant/ Speaker: Covidien

Consultant: Codman Neurovascular

Consultant: Microvention

Consultant, Stock Holder: Stryker

Classification

CVMs with arteriovenous shunting

- Arteriovenous malformations
 - Plexiform nidus
 - Mixed nidus
- Arteriovenous fistulas (AVF)
 - Single or multiple fistulae
 - Mono or multipedicular

CVM without shunting (capillary malformations)

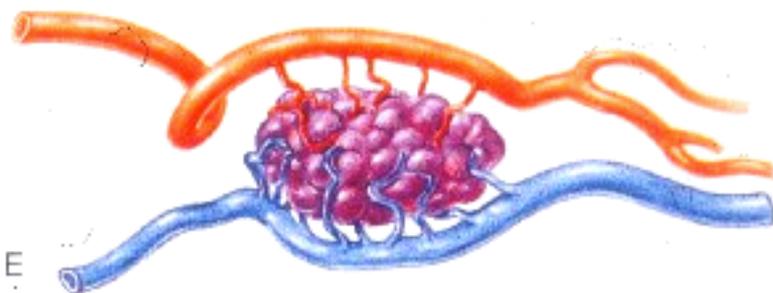
- Venous malformations
 - Developmental venous anomalies
 - Venous angiomas
- Cavernous malformations



A



C



E

Fig 3.1A-G Artist's drawing of the different types of cerebral vascular malformations.

A Arterial malformation.

B Arteriovenous fistulous malformation.

C Arteriovenous plexiform malformation.

D Arteriovenous plexiform micro-malformation.

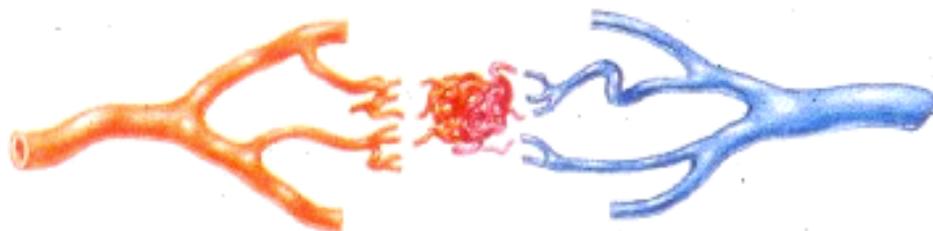
E Cavernous malformation.

F Capillary malformation (telangiectasia).

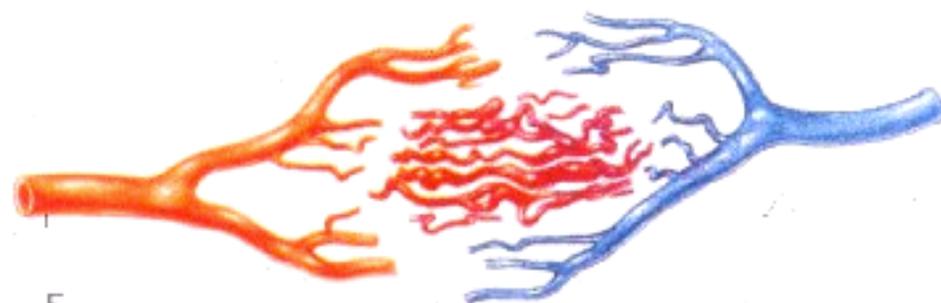
G Venous malformation.



B



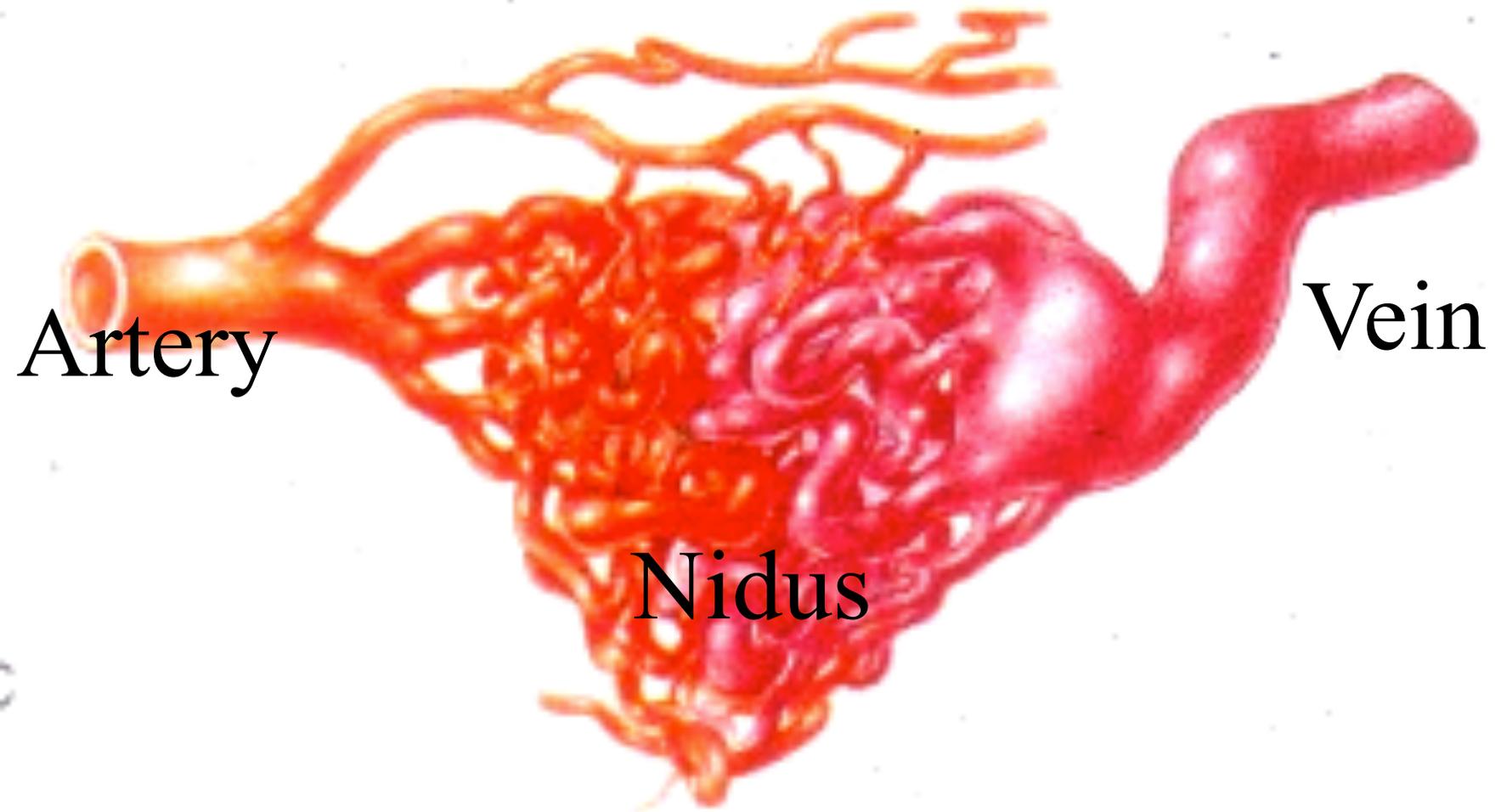
D



F



G



Artery

Vein

Nidus

AVM Spetzler-Martin Classification

•Size	Points
–< 3 cm	– 1
– 3 - 6 cm	– 2
–> 6 cm	– 3

•Eloquence	
–yes	– 1
–no	– 0

•Venous Drainage	
–deep	– 1
–superficial	– 0

Cerebral AVMs

- 2% of intracranial hemorrhages
- Incidence of AVMs: 1.2/100 000 person-years
- AVM hemorrhage is 0.42/100 000 person-years
- Supratentorial location 85 %
- Posterior Fossa 15%
- Spontaneous thrombosis in 2-3%
- Incidence of multiple AVMs: rare outside of HHT or Wyburn-Mason Syndrome

Presentation and Symptoms

- Uncommon in children (asymptomatic)
- Present before age of 40
- 65% present with intracranial hemorrhage (ICH + SAH + IVH)
- 15 - 35% seizures
- 15% headaches

Graf et al. J Neurosurg 1983

Brown et al. J Neurosurg 1988

Ondra et al. J Neurosurg 1990

Crawford et al. J Neurol Neurosurg Psychiatry 1996

Types of Intracranial Hemorrhage

- N = 119
- N = 115 hemorrhage presenting symptoms
- N= 27 second hemorrhage during fu
- Mean fu time 16.2 months
- 23% ICH
- 31% ICH + IVH
- 16% IVH
- 30% SAH

Intracranial Hemorrhage

- 241 AVM patients Prospective Columbia Database Registry
- 12% recurrent ICH
- Annual hemorrhage rate 0.9 %- 34%
- Predictive factors (622)
 - Age
 - Deep brain location
 - Deep venous drainage
 - Aneurysm

Risk Factors for Hemorrhage

- Vertebrobasilar system
- Location (basal ganglia)
- Deep venous drainage
- Perforators are feeders
- Intranidal aneurysms
- Multiple aneurysms

Turjman et al. Neurosurgery 1995

Treatment

- Surgery
- Embolization + Surgery
- Radiosurgery
- Embolization + Radiosurgery
- Embolization

Goal of Endovascular Treatment



Positioning of the microcatheter



Onyx

- Ethylene-vinyl alcohol copolymer (EVOH) is dissolved in dimethyl sulfoxide (DMSO), and tantalum powder
- First data: phase-I study 23 patients with cerebral AVM average 63% reduction in AVM volume with Onyx (Jahan et al Neurosurgery 2001; 48:984-997)
- Non-adhesive, high nidal penetration, low visibility in small AVMs

Embolization

- Initially, large variability in “neurological complications” (10% to 50%) 1% to 4% mortality
- Haw et al (*J Neurosurg.* 2006;104:183–186) 306 patients who underwent 513 embolization sessions: mortality rate was 2.6% and the morbidity was 4.9%
- Location of the AVM in an eloquent part of the brain, large fistula, liquid embolic in the vein were related to complications
- Reduction in the rate of death and disabling morbidity occurred in the second half of the study period

Embolization

- 11- year period, 295 embolization procedures (761 pedicles embolized) in 168 patients
- Embolization as the primary treatment modality (16) or as an adjunct to surgery (124) or radiosurgery (28)
- There were a total of 27 complications, of which 11 were clinically significant.
- Excellent or good outcomes (GOScale 4) 152 (90.5%) patients.
- Unfavorable outcomes (GOS 1 to 3) 3.0% at discharge
- 1.2% embolization-related mortality

Ledezma CJ. et al *Neurosurgery*. 2006;58:

Embolization

- Predictors of unfavorable outcome by univariate analysis were:
 - (1) deep venous drainage ($P0.05$)
 - (2) *Spetzler-Martin Grade III to V* ($P0.05$)
 - (3) *periprocedural hemorrhage* ($P0.0001$)

Published series of AVM embolization within the past five years with 100 or more patients

Series	Patients (n)	Permanent D &D	Notes
Ledezma ⁷³	168	6.5%	Described as clinically significant complication,
Haw ⁷⁴	306	3.9%	Eloquence, presence of fistula or venous glue embolization related to morbidity.
Kim ⁷²	153	11.8%	Did not distinguish between transient or permanent, disabling or non-disabling,
Jayaraman ⁴⁹	192	1.6%	No factors reached statistical significance for complications
Katsaridis ⁴¹	101	11%	
Gao ⁷⁵	115	3.5%	
Starke ²	202	5%	5% rate improved to 0.5% at long-term follow-up

Embolization as “Cure”

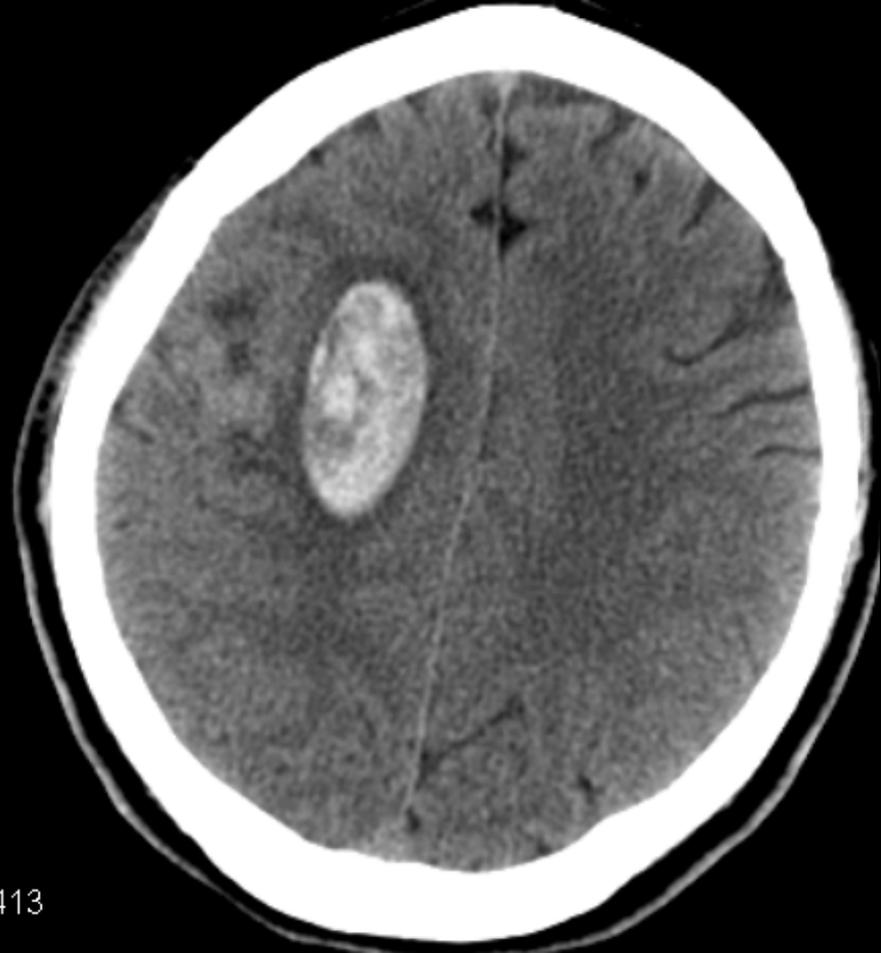
- 82 patients in 119 sessions
- Angiographic “cure” 24.4%
- dropped to 19.5% at follow-up (4 angiographic recurrences)
- Overall 11.3% rate of permanent disabling deficit or death.
- Additional treatment including open microsurgical resection and stereotactic radiosurgery in 63% of their patients

Conclusions

- The treatment of brain AVMs is challenging, permanent morbidity and mortality of 3% to 11%
- Downsize the AVM in preparation for Surgery or Radiation
- Cure by embolization alone is possible (deep location or spine).
- Recurrence?
- Learning curve effect with the use of liquid embolics

Patient

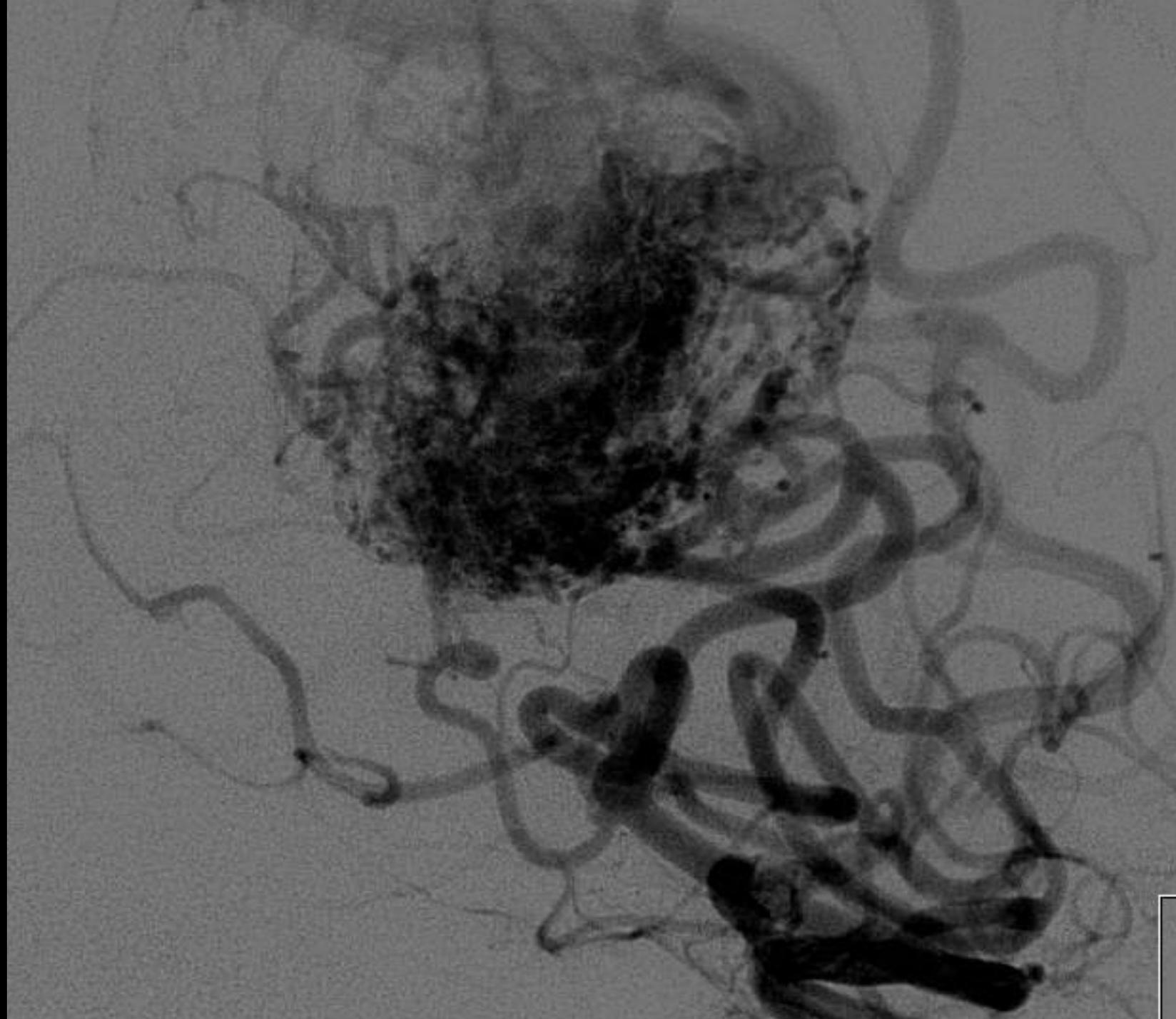
- 24 year-old man who developed a generalized tonic-clonic seizure followed by left hemiparesis that almost completely resolved over the course of 2 months
- CT shows ICH

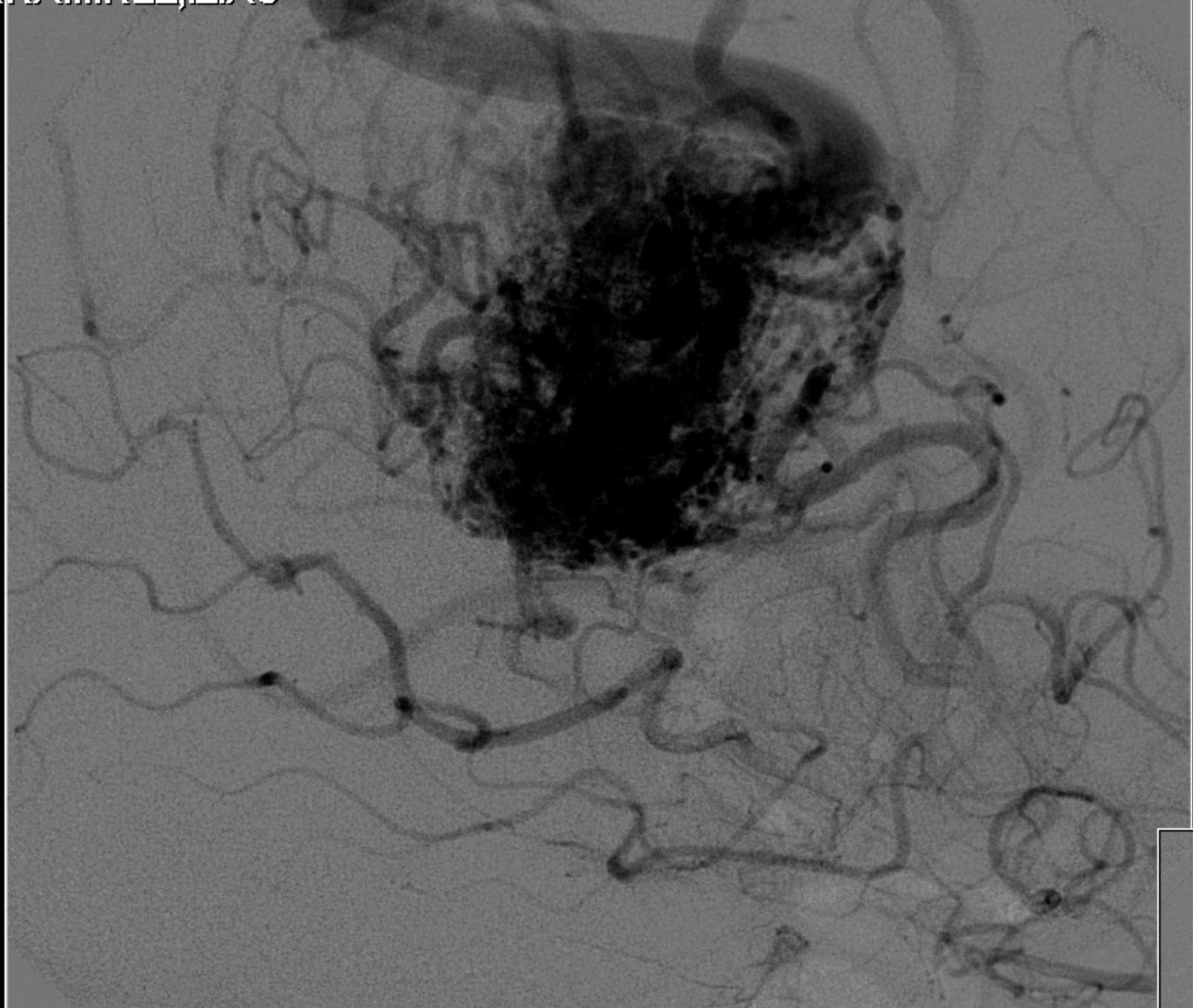


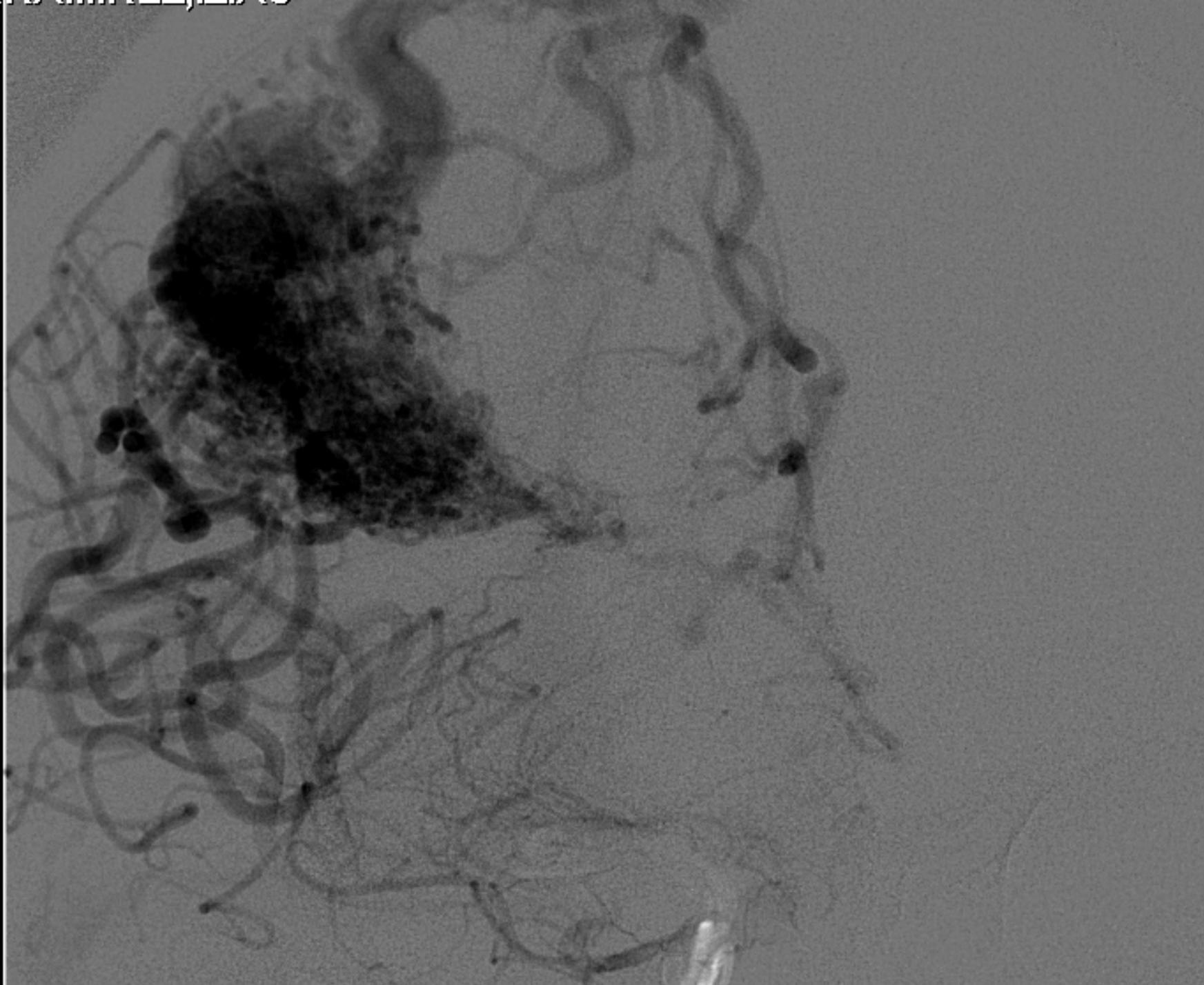
25.413

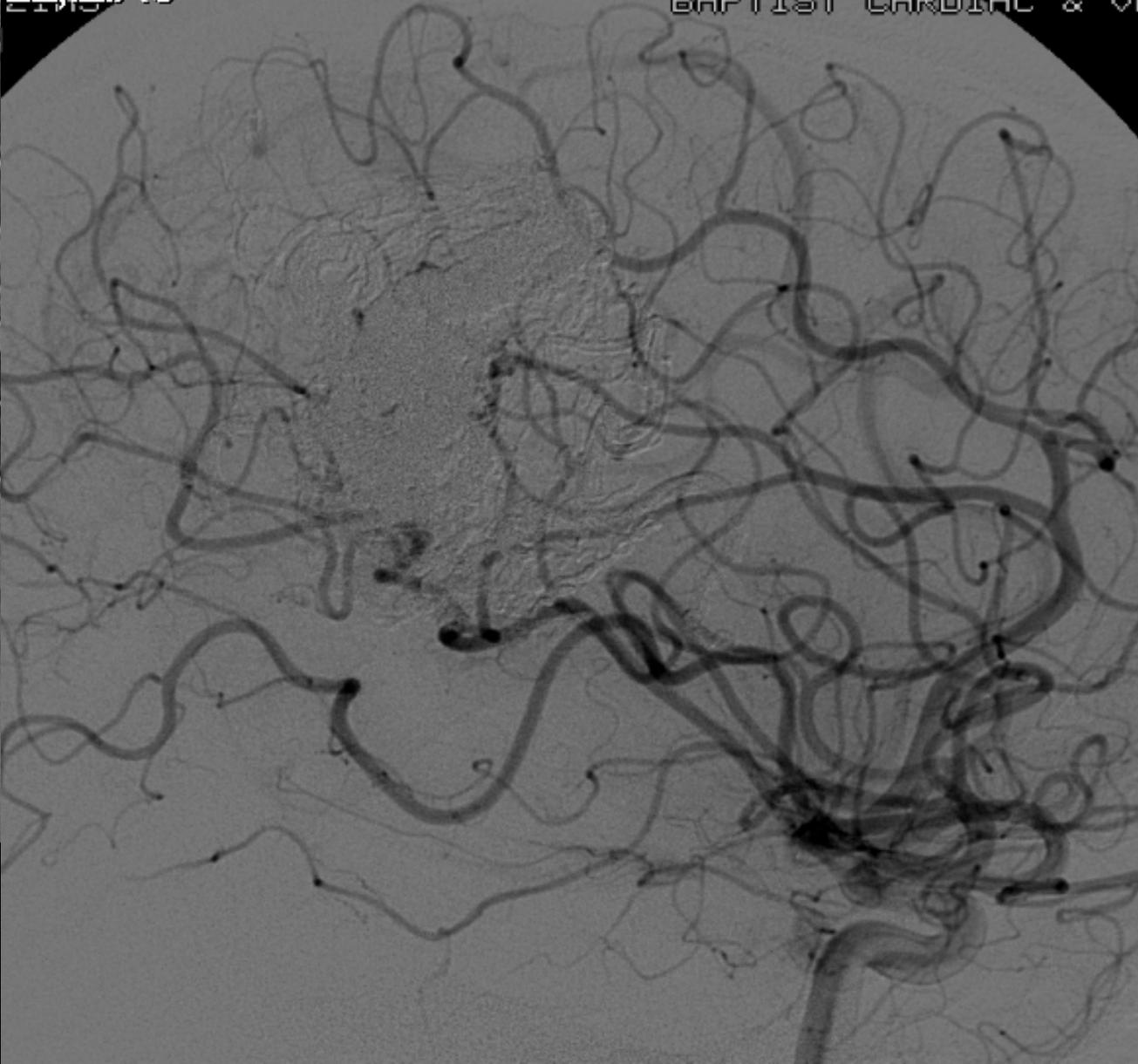
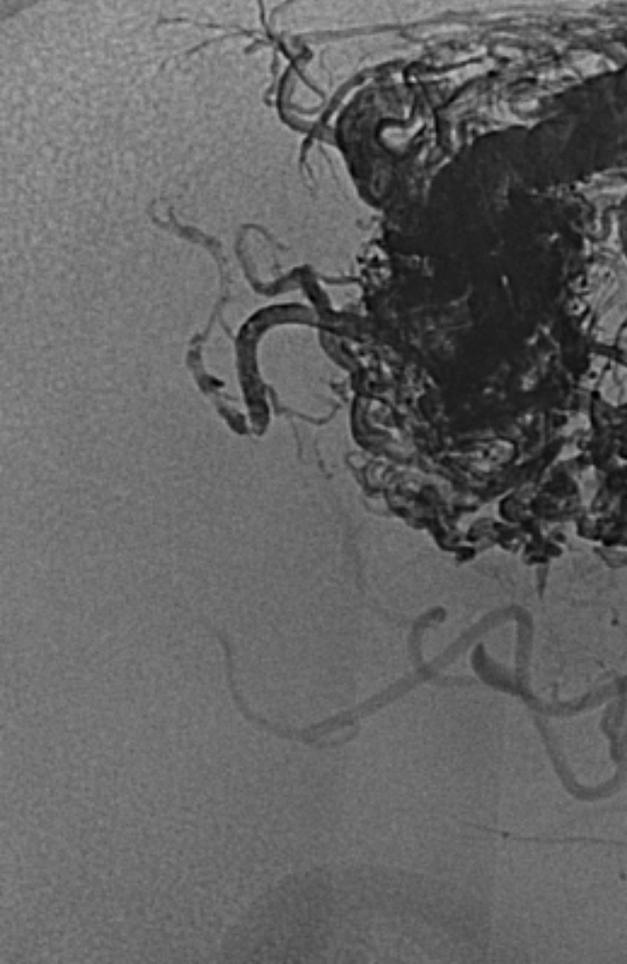


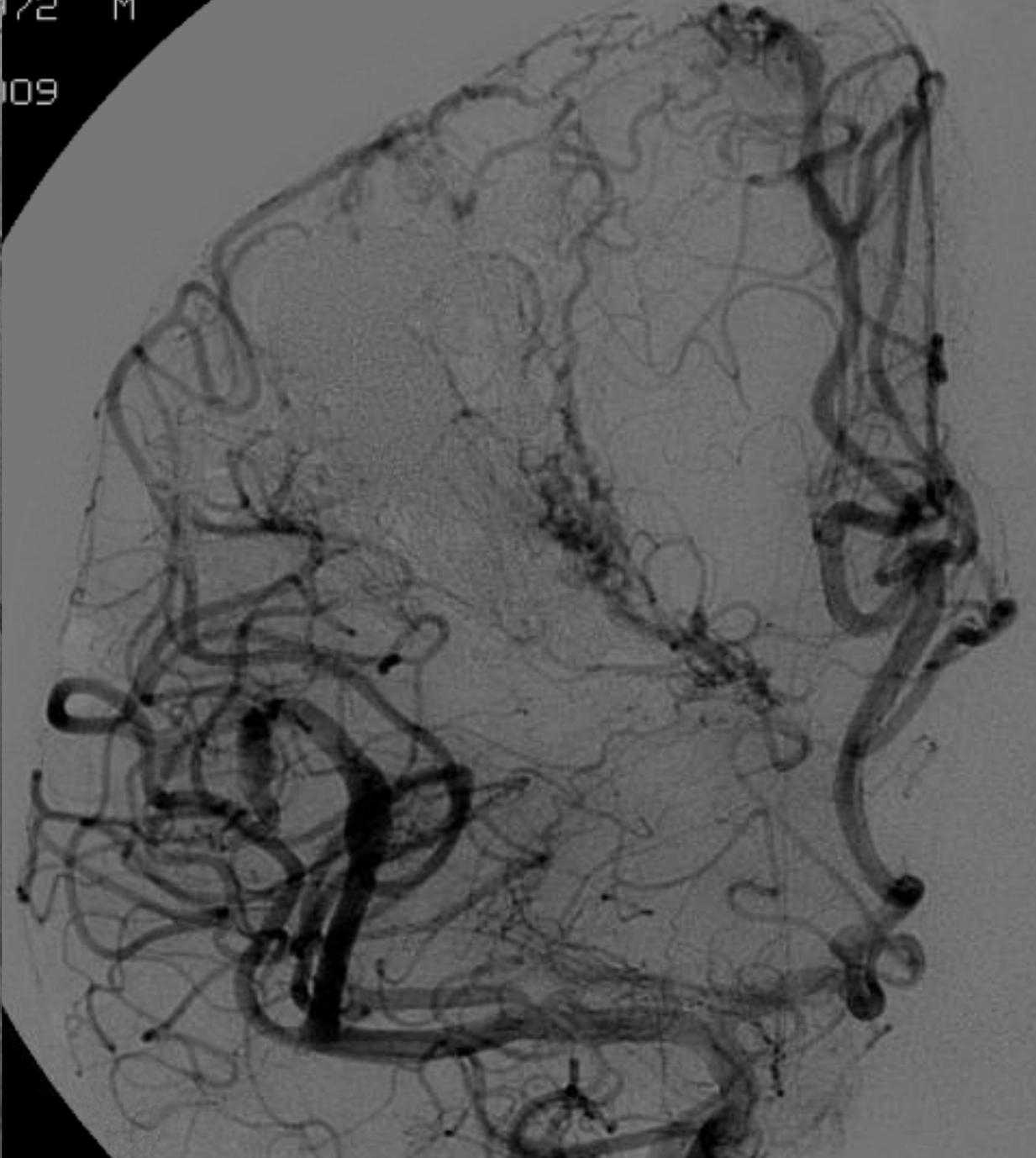
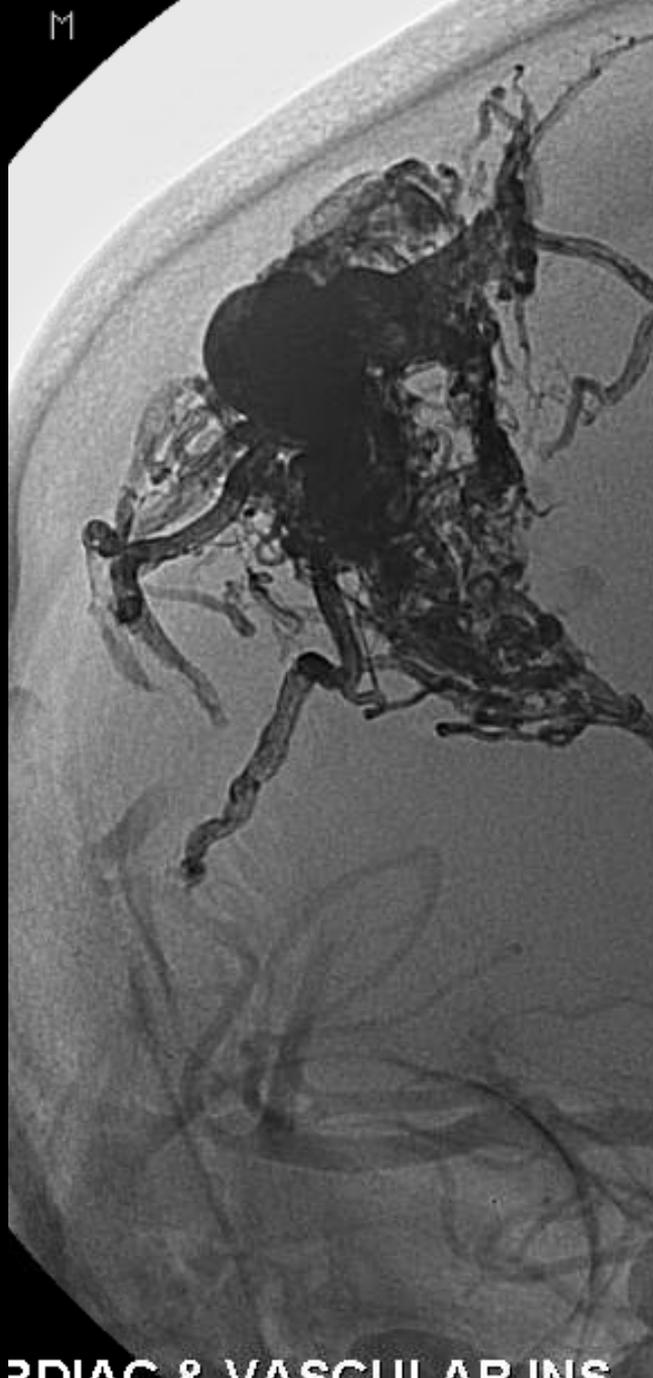
1.717



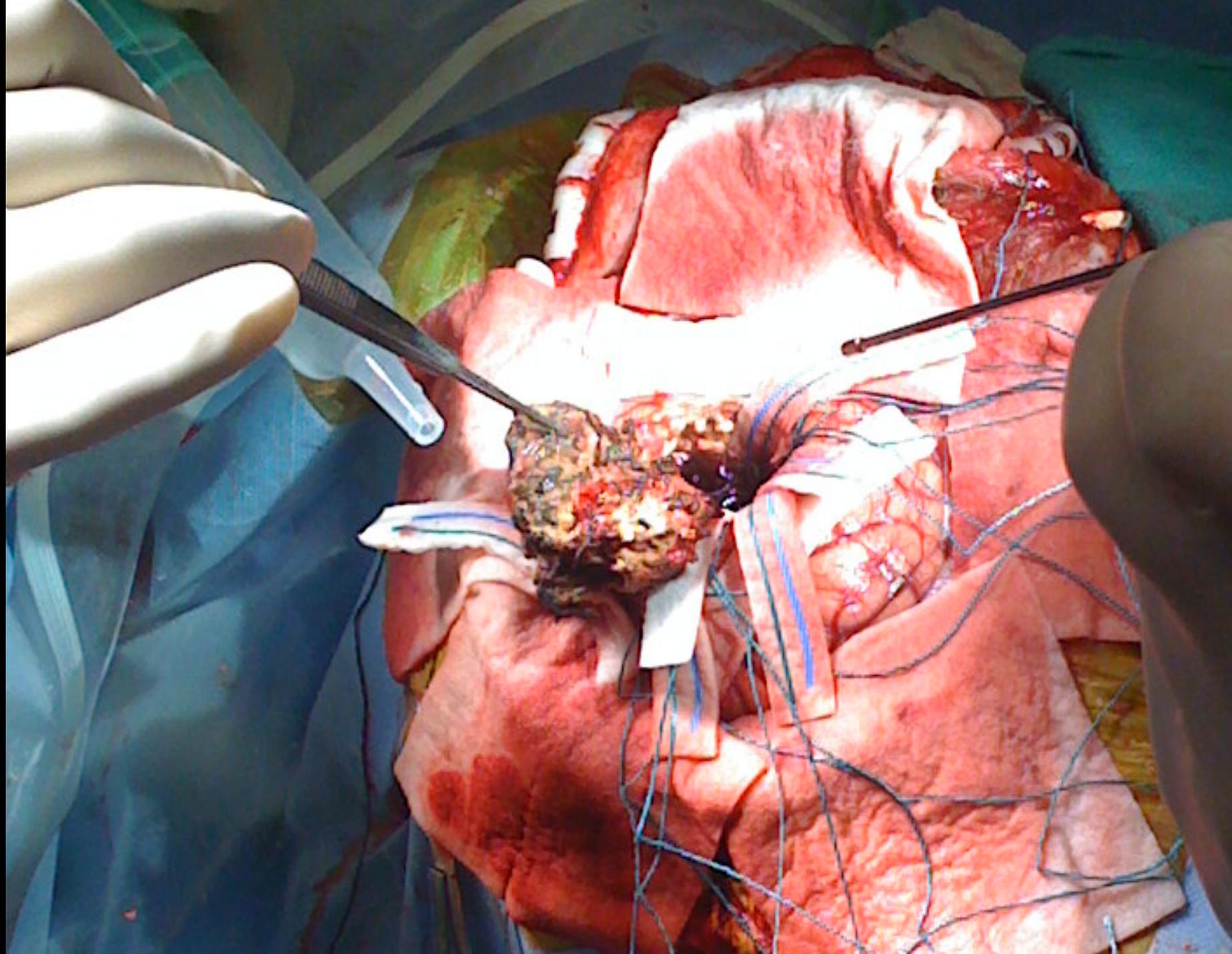


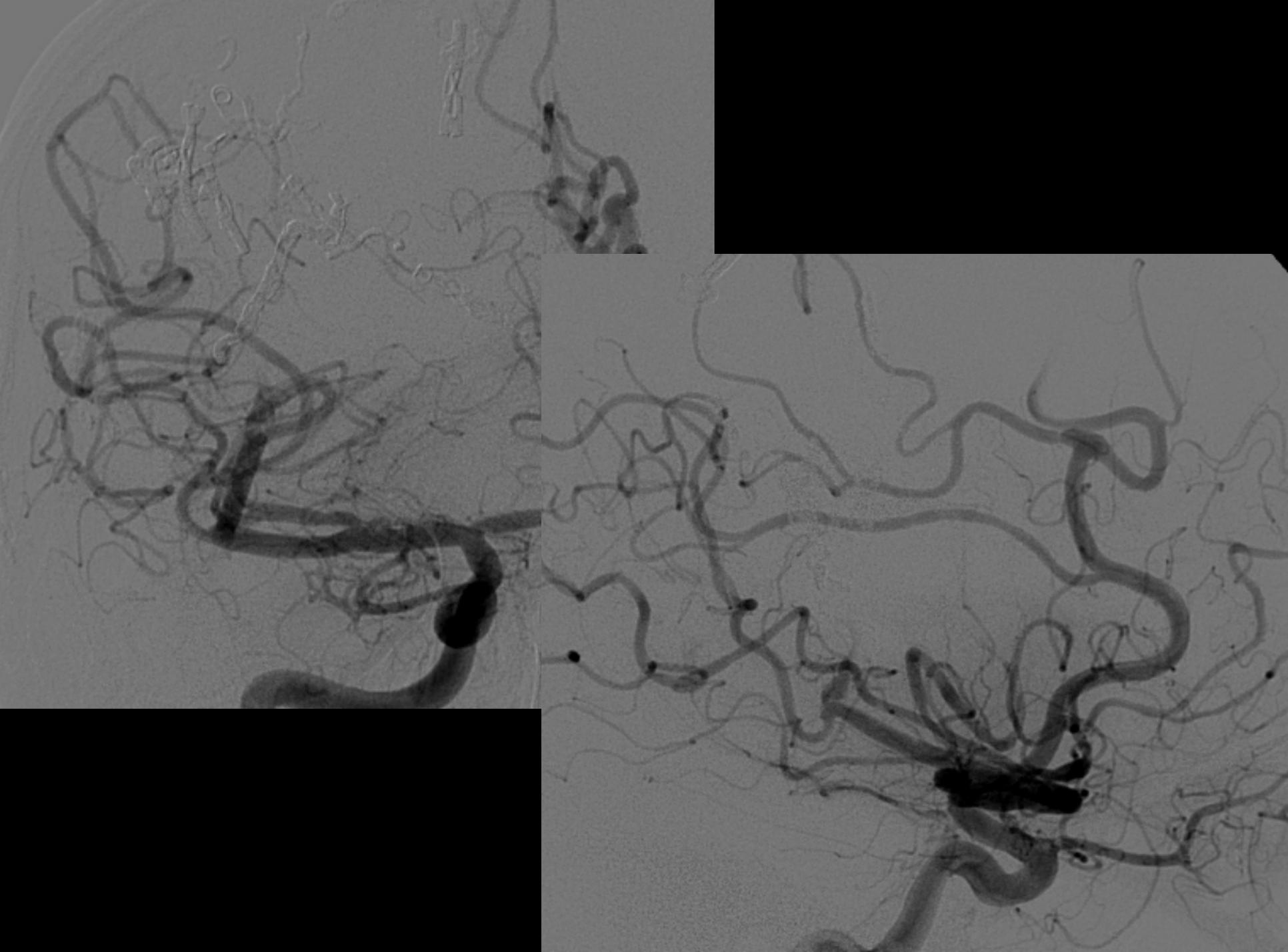






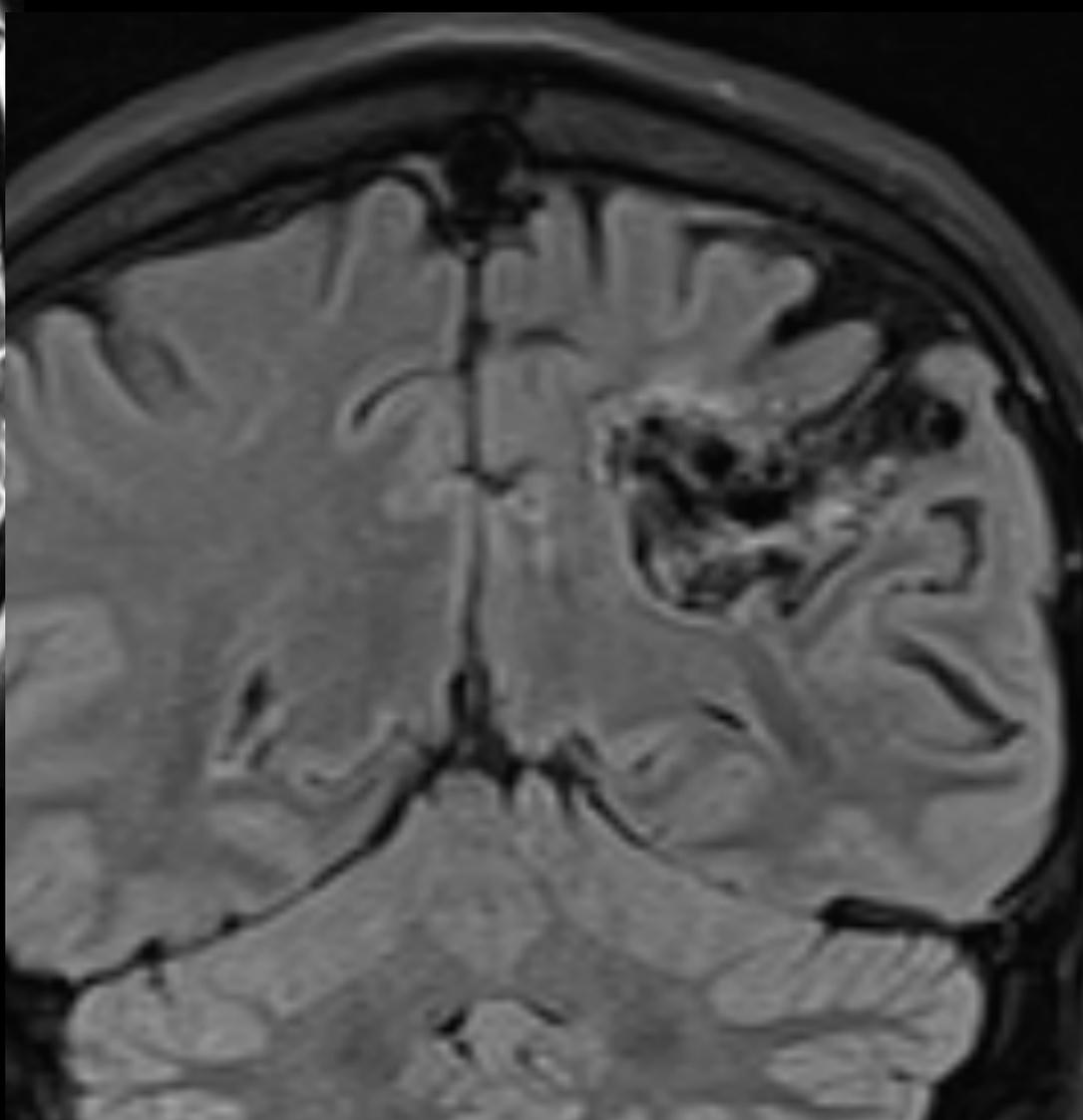
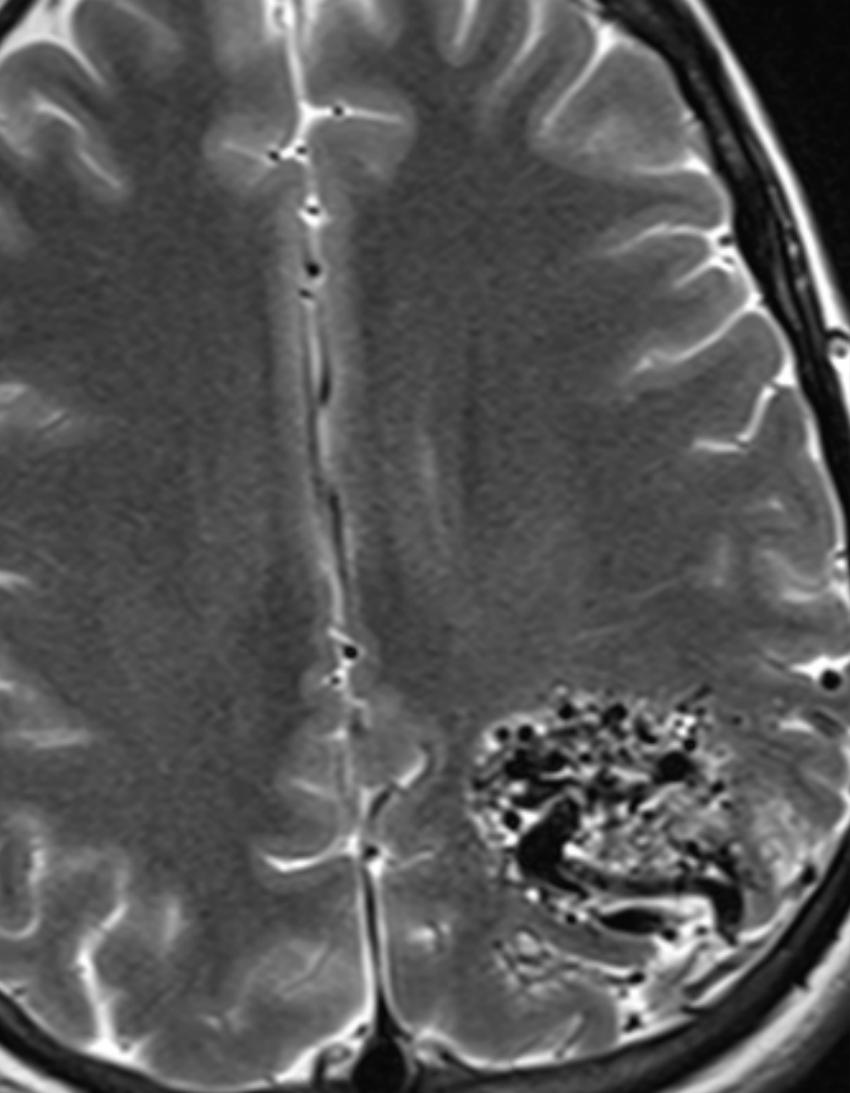
RDIAC & VASCULAR INS

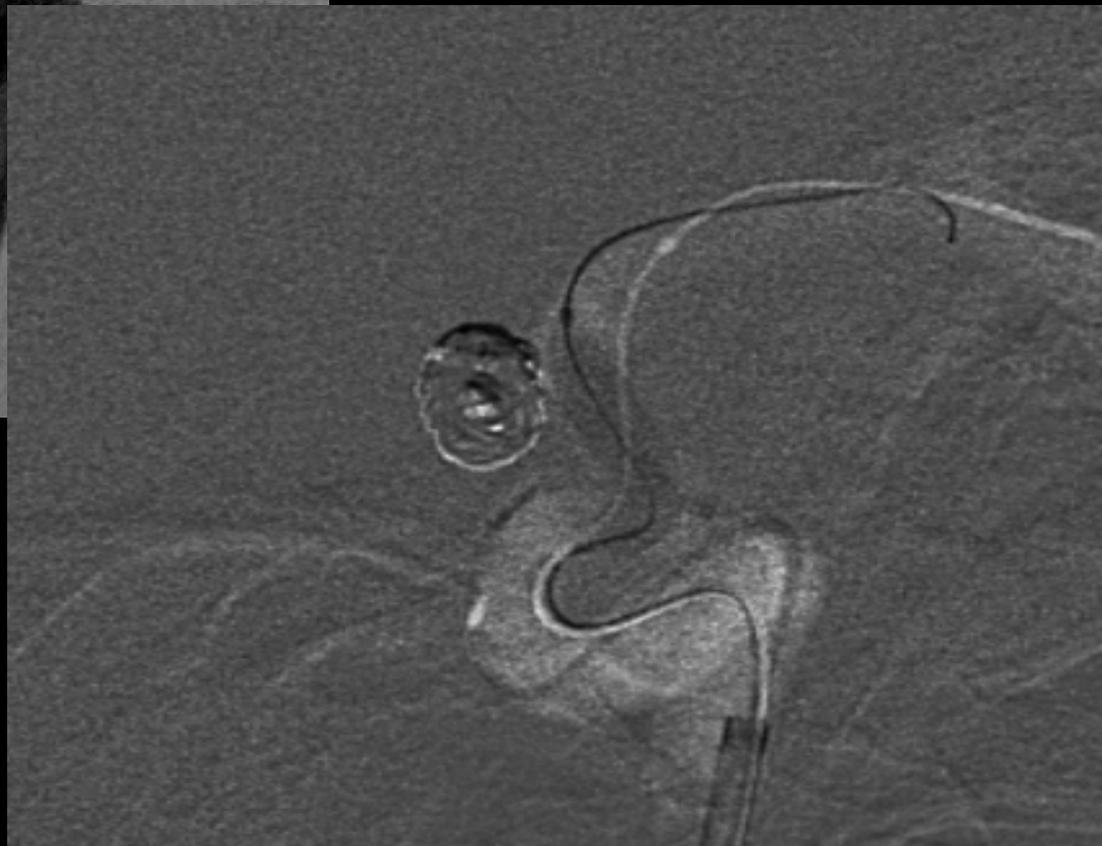


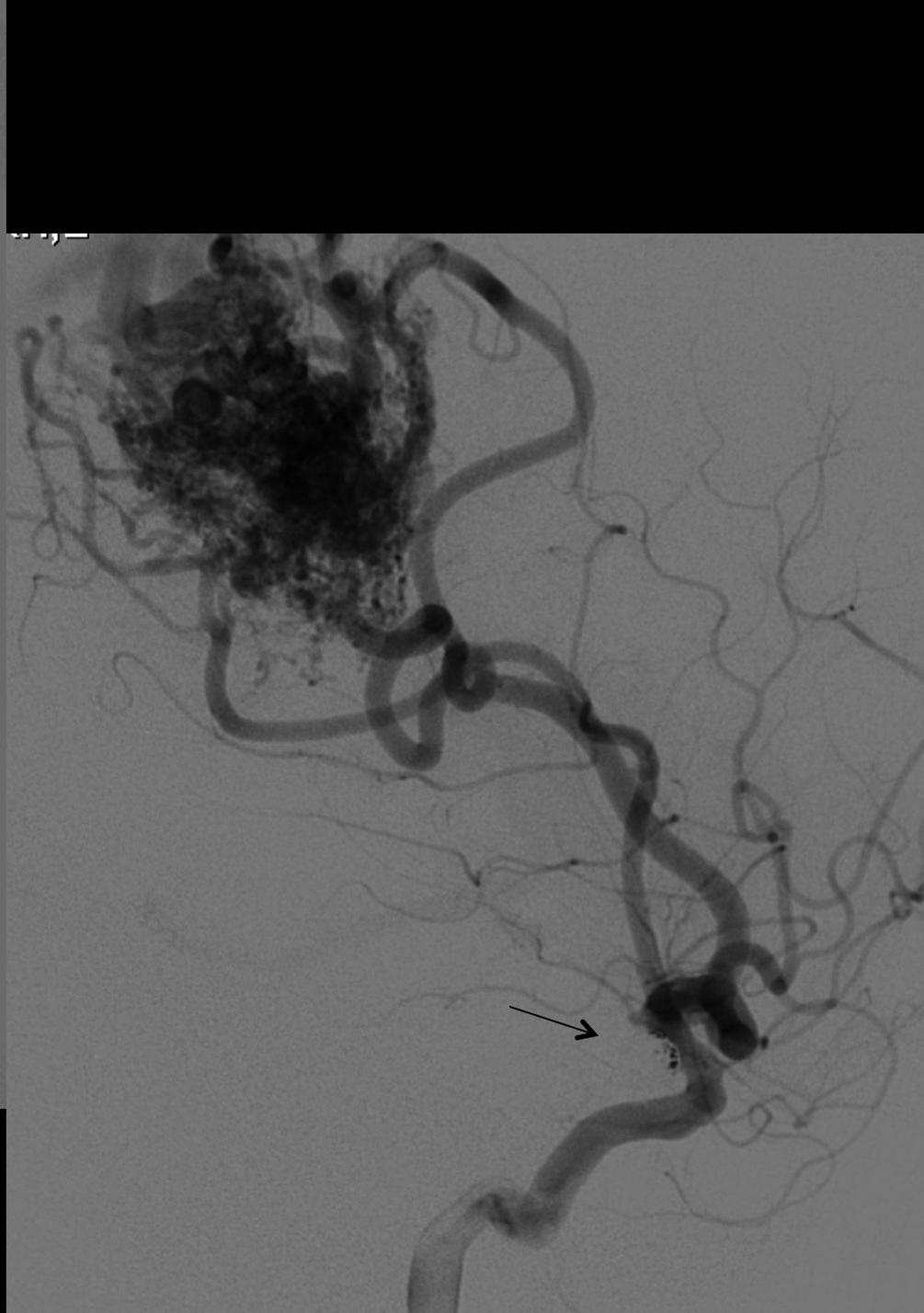
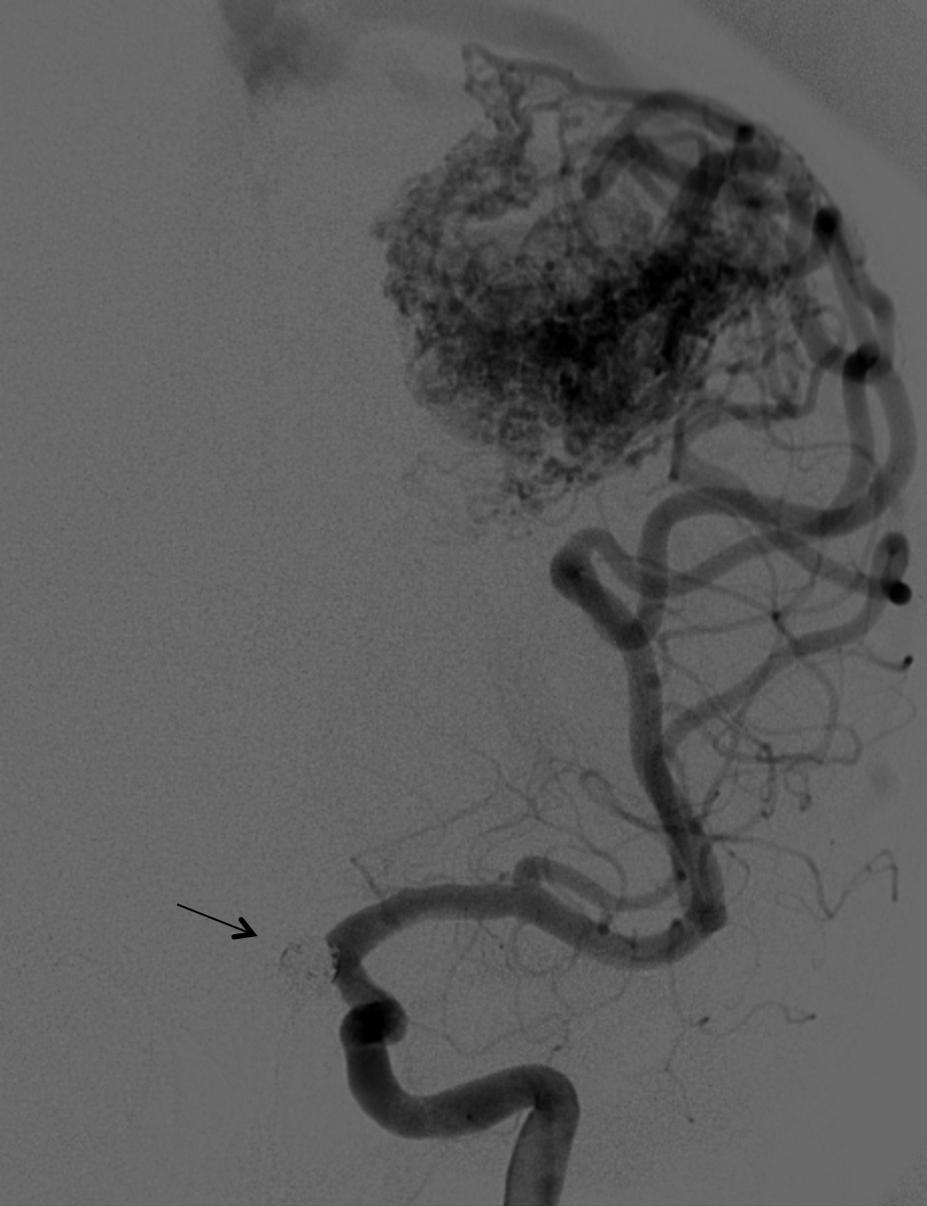


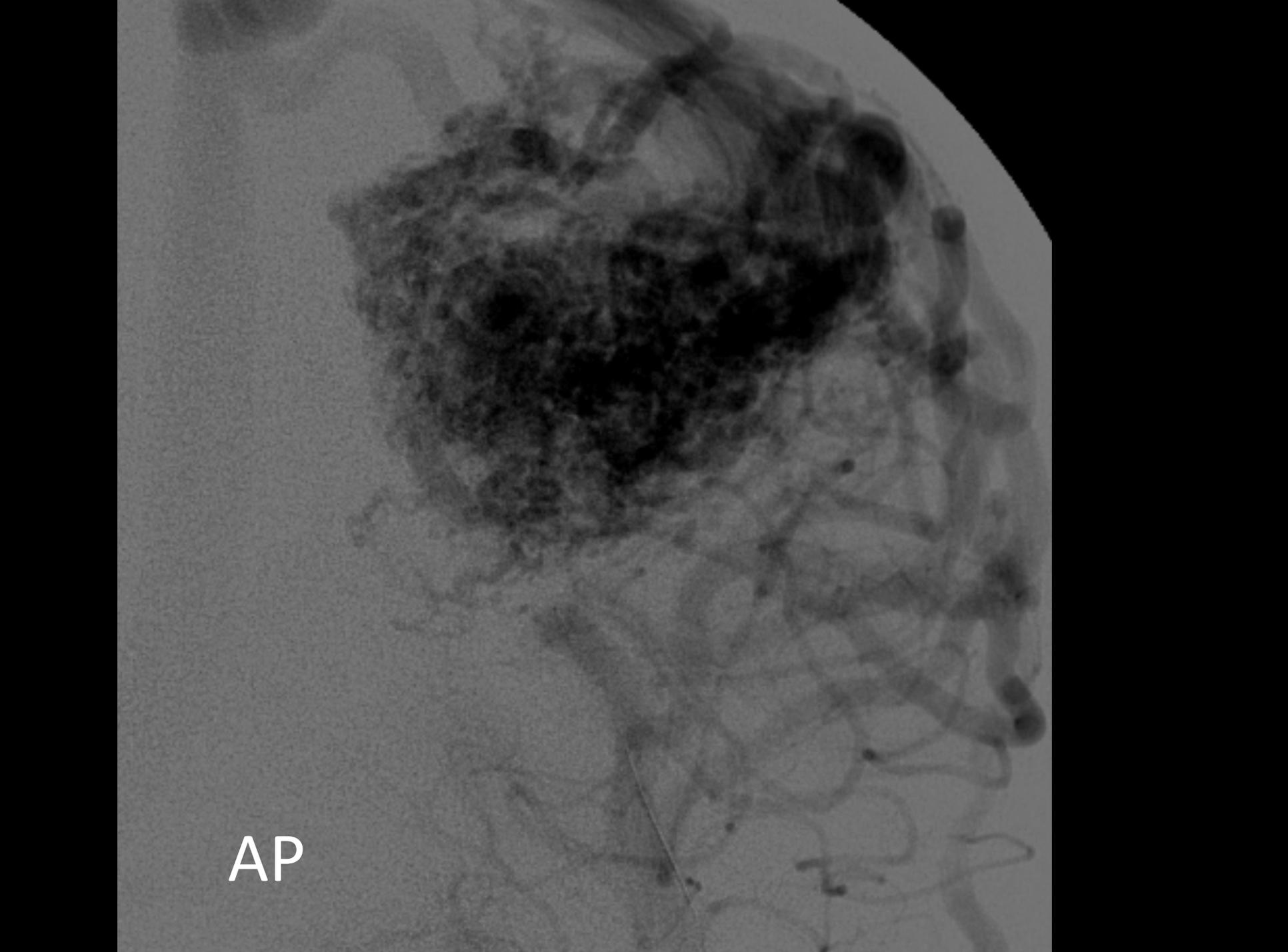
Patient

- 30 year-old woman who developed headache and blurred vision
- MRI shows an AVM and an aneurysm







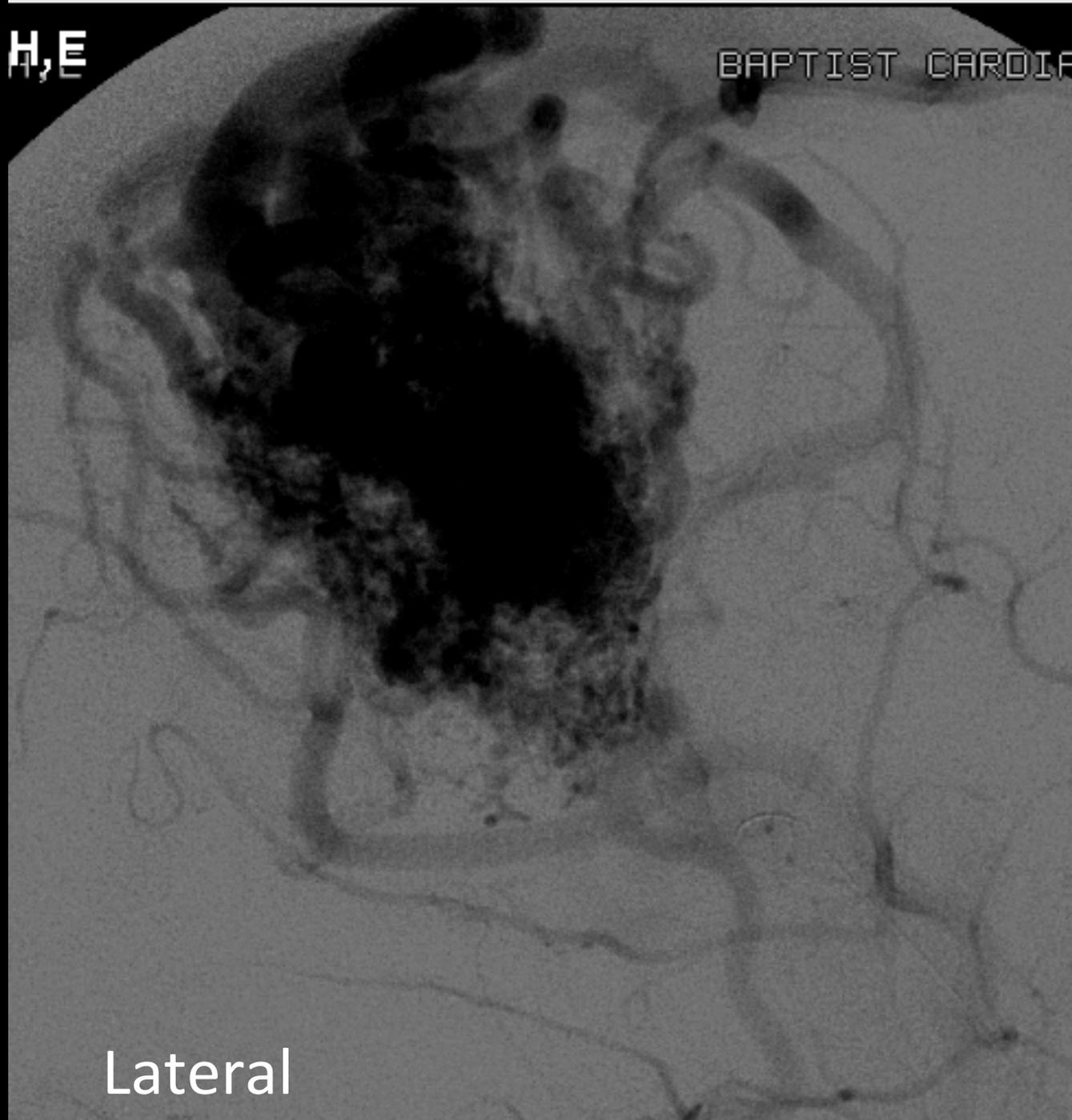


AP

This is an anteroposterior (AP) radiograph of a lumbar vertebra. The image shows a large, dark, irregularly shaped fracture fragment in the upper portion of the vertebral body. The surrounding bony structures, including the pedicles and the rest of the vertebral body, are visible in a lighter gray tone. The overall image has a grainy texture and is set against a dark background.

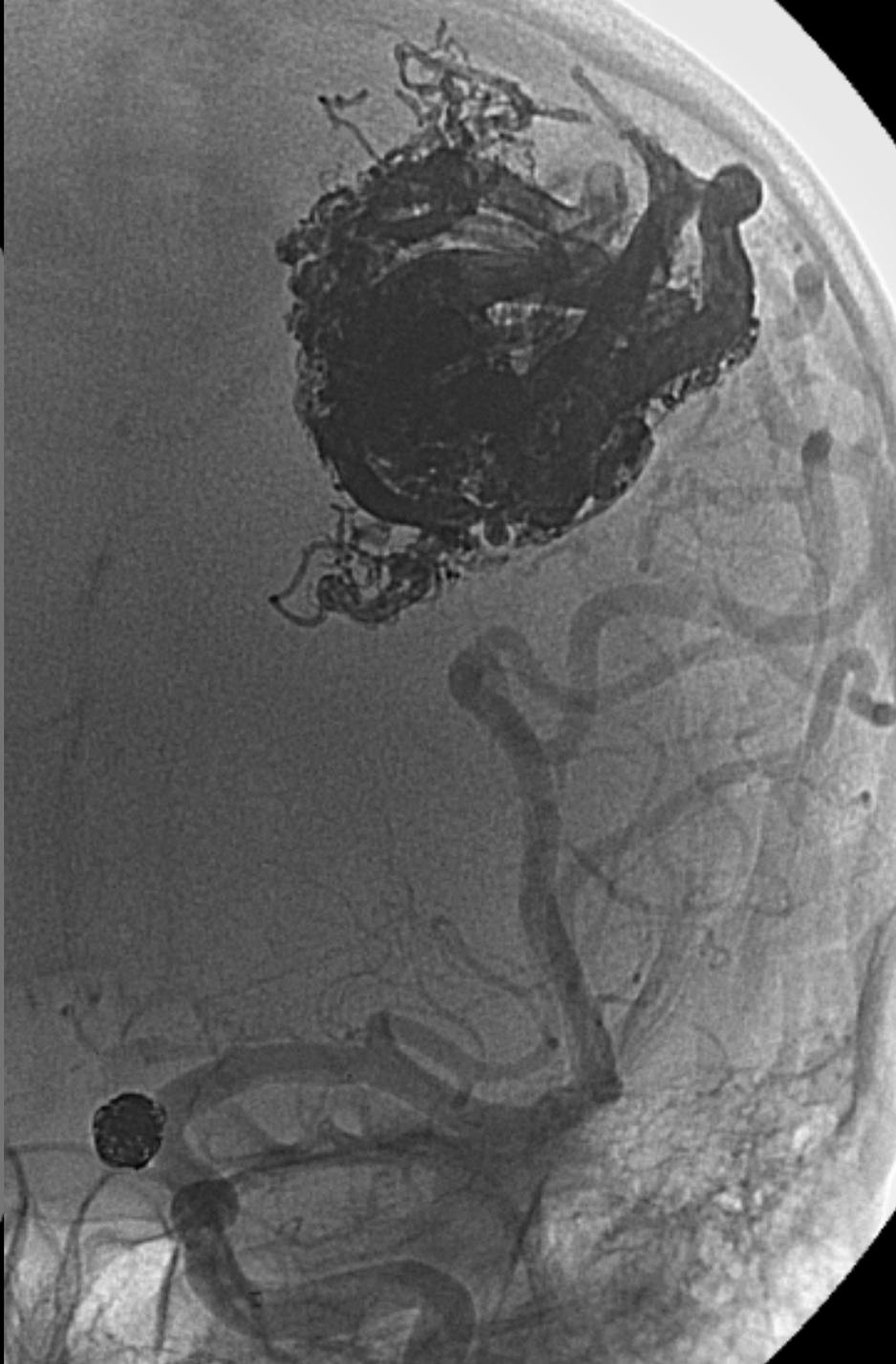
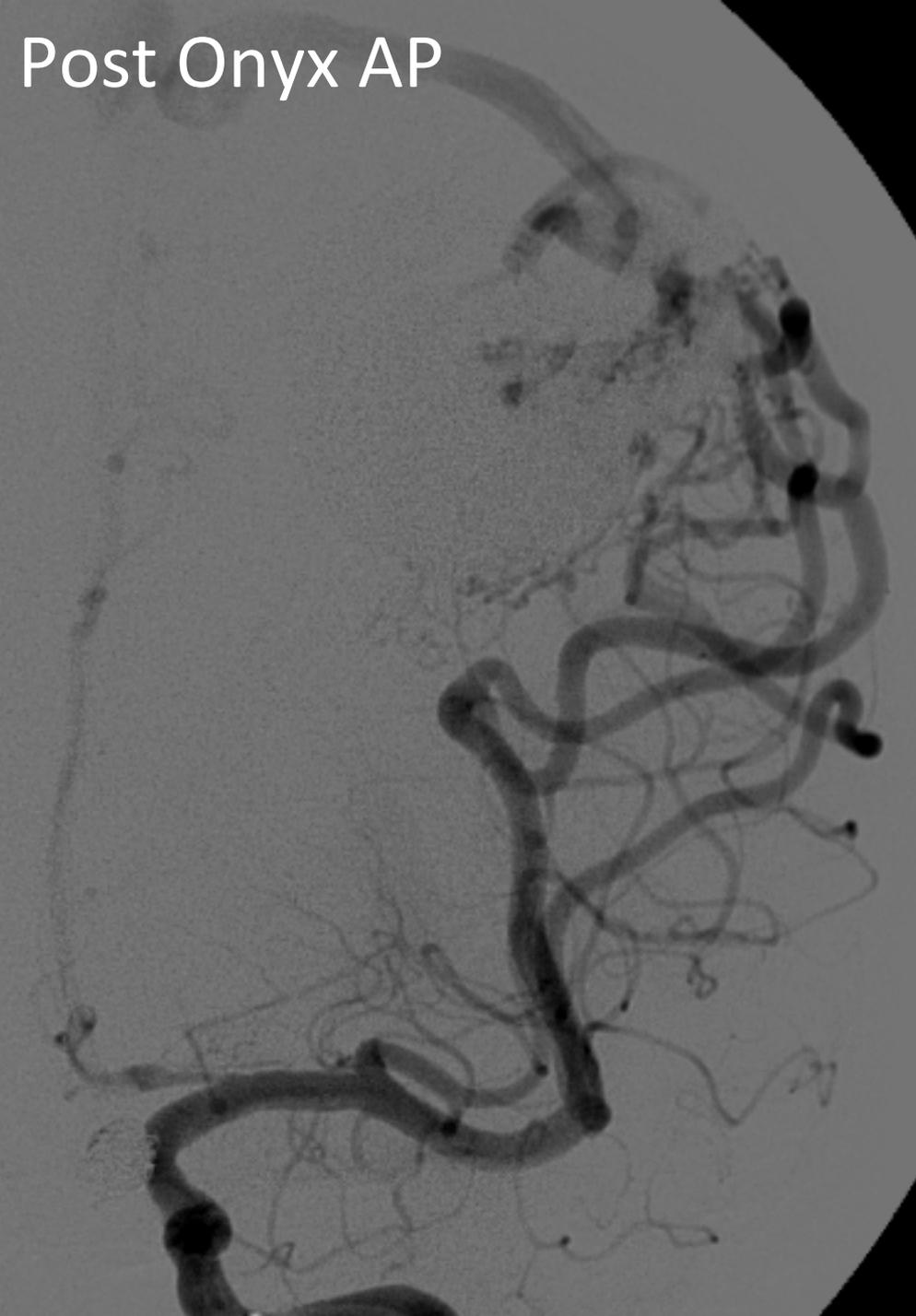
H, E

BAPTIST CARDIA



Lateral

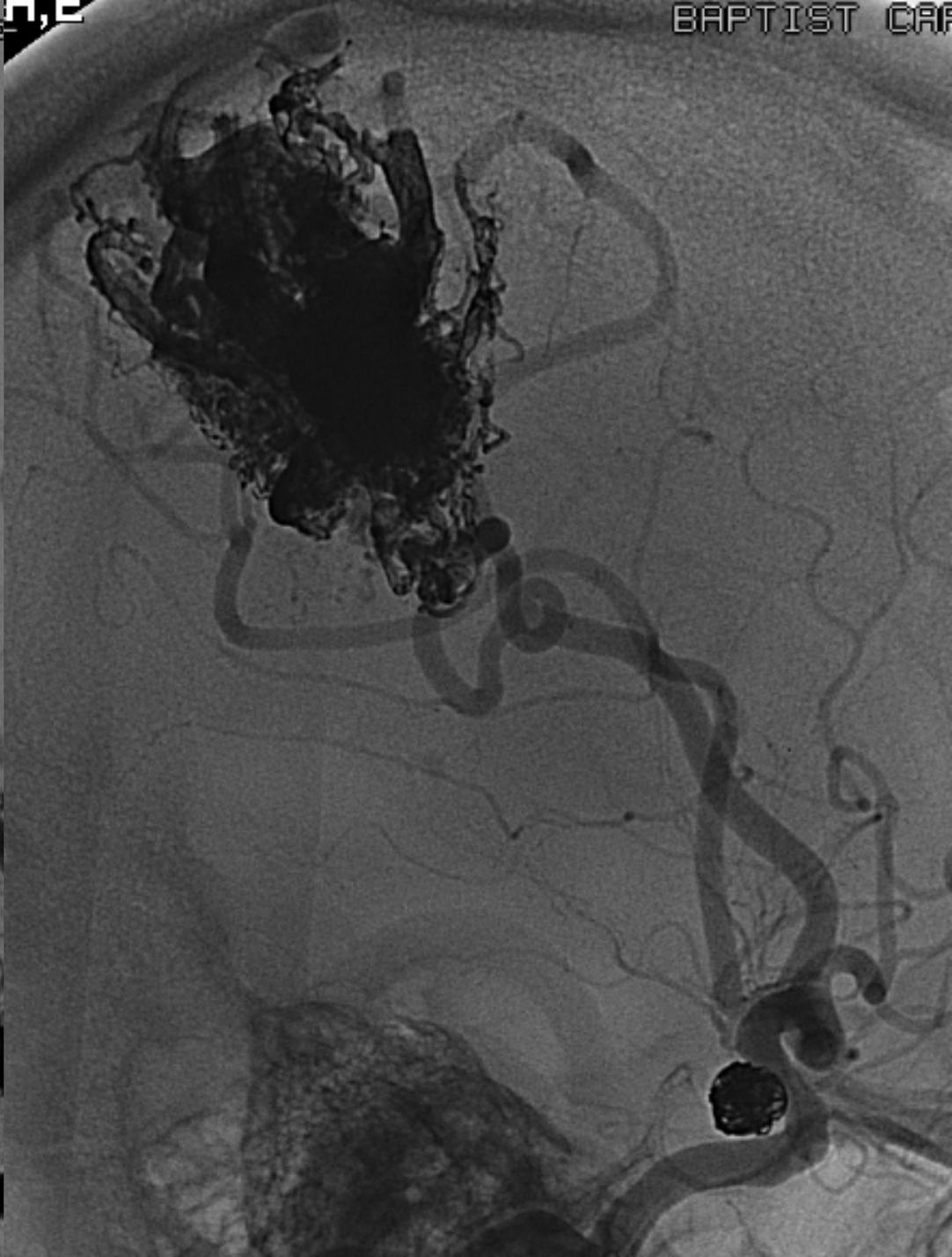
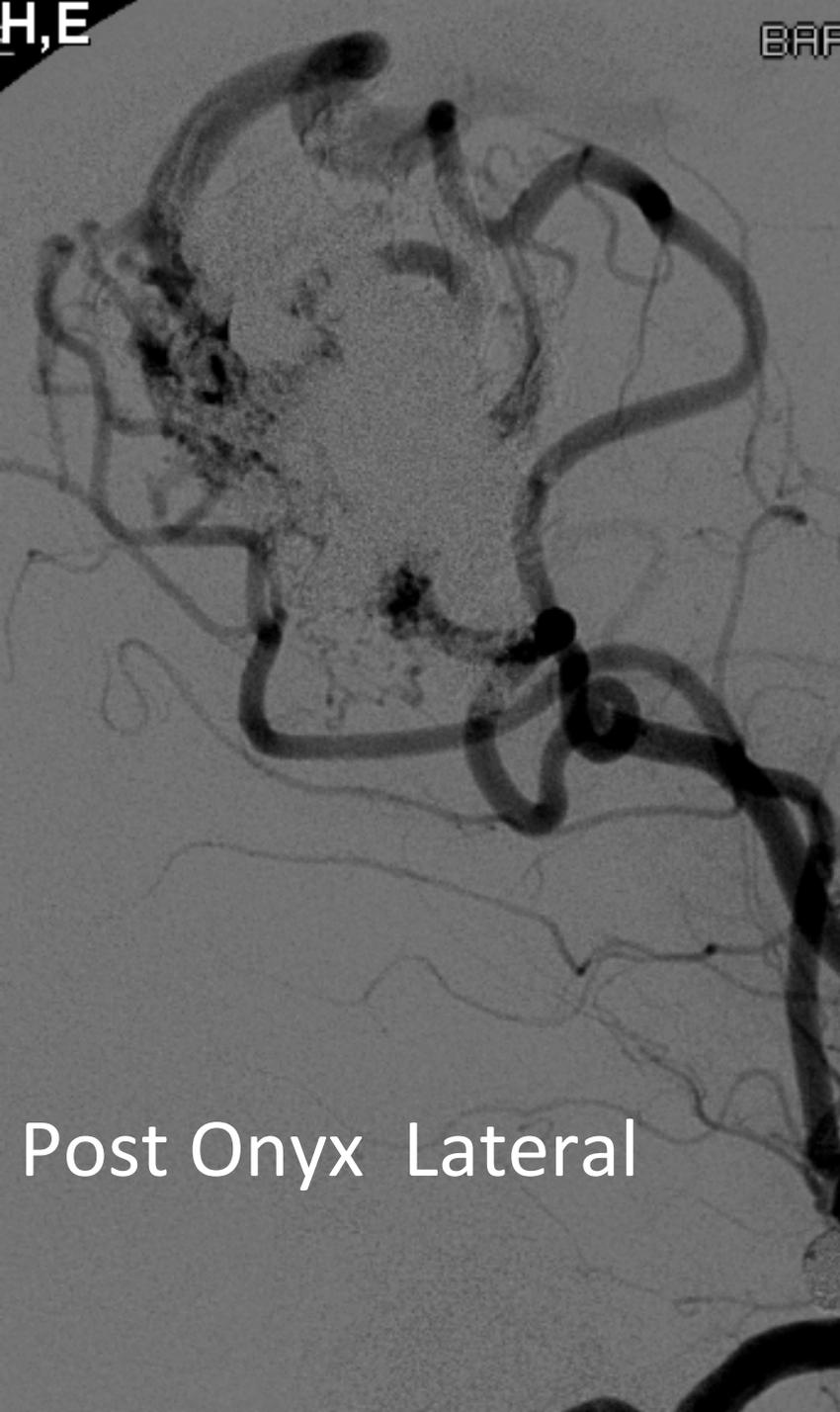
Post Onyx AP



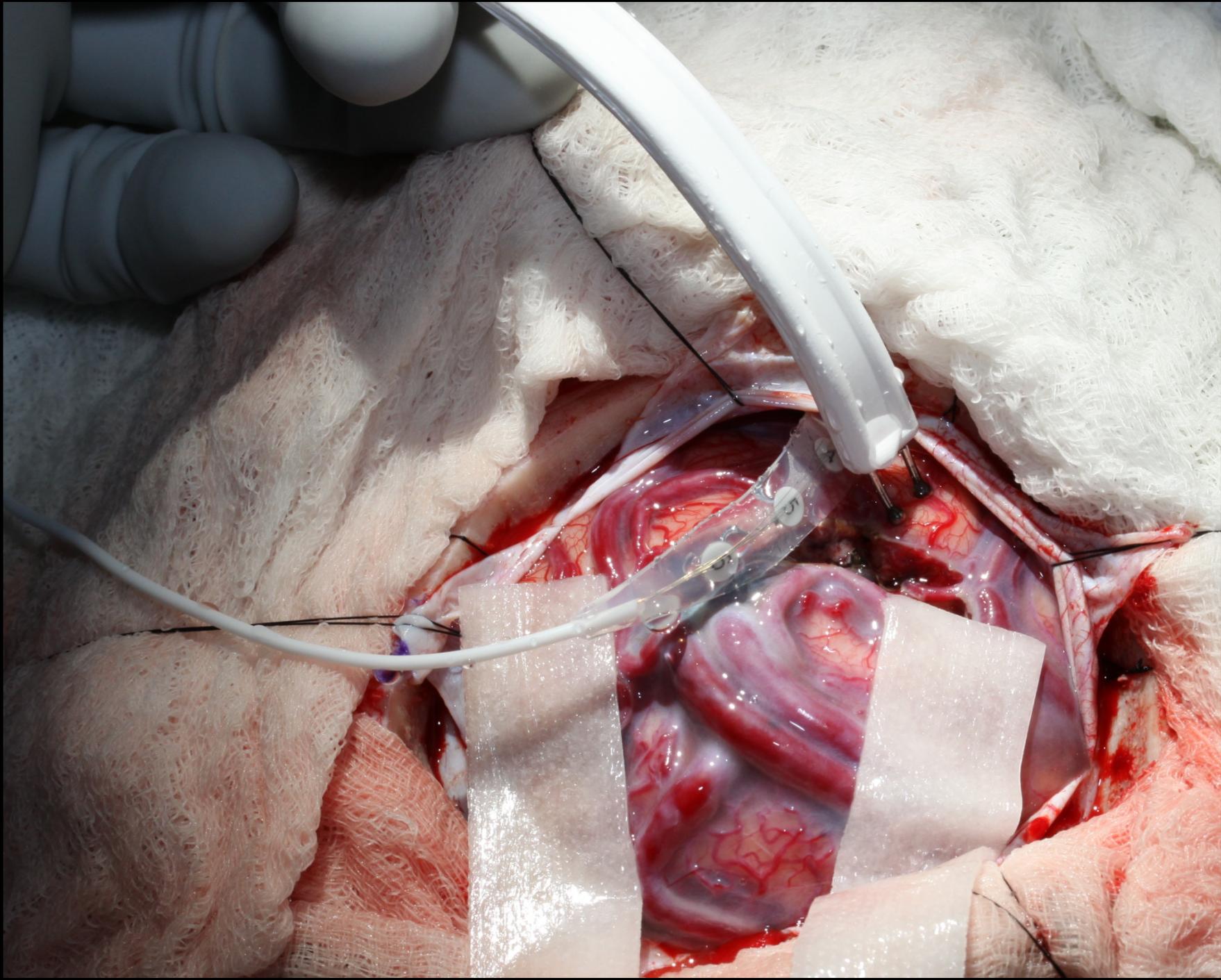
H,E

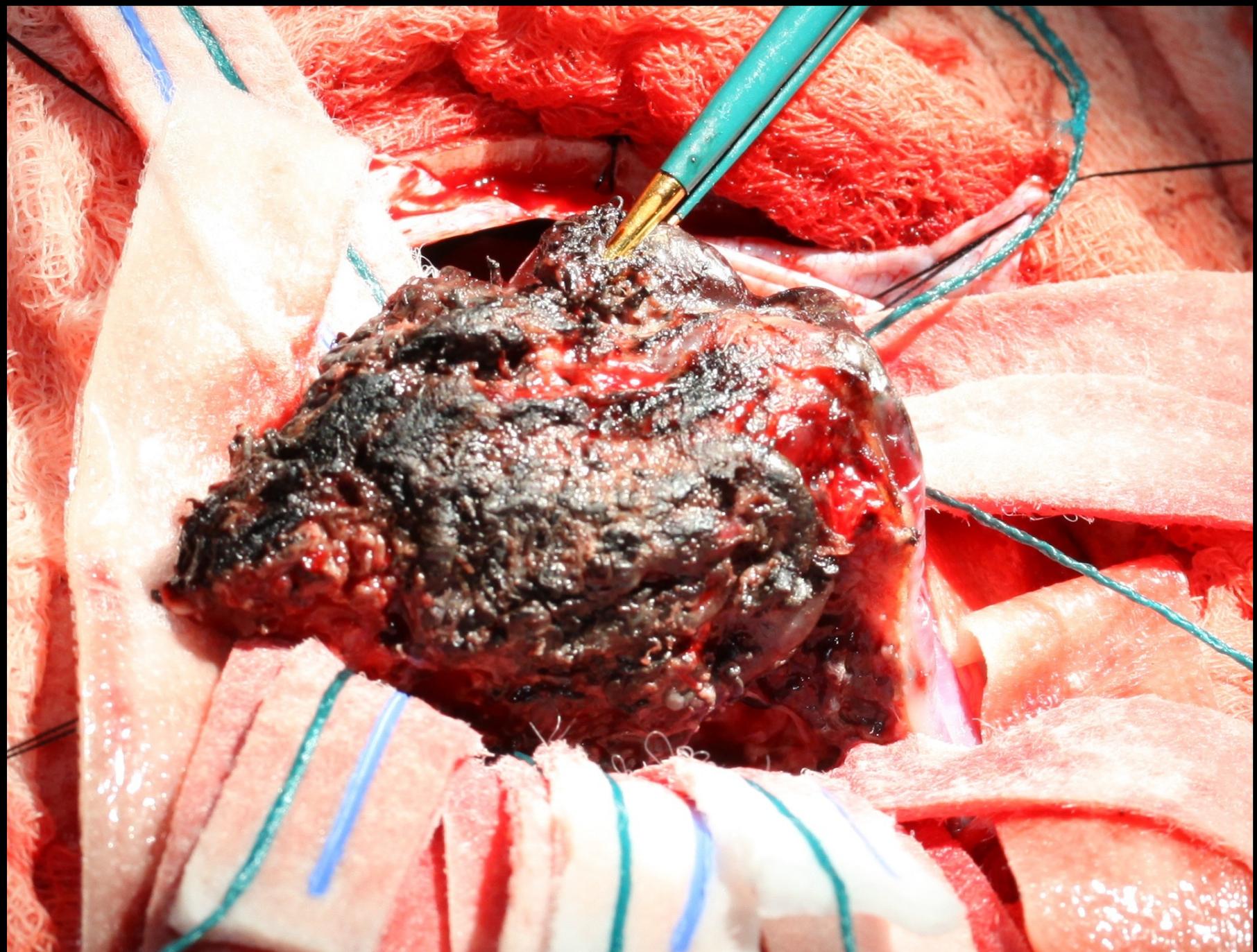
BAF H,E

BAPTIST CAP

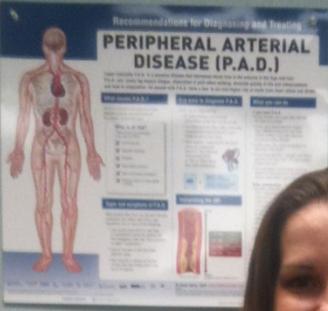
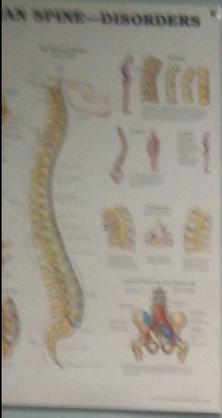


Post Onyx Lateral







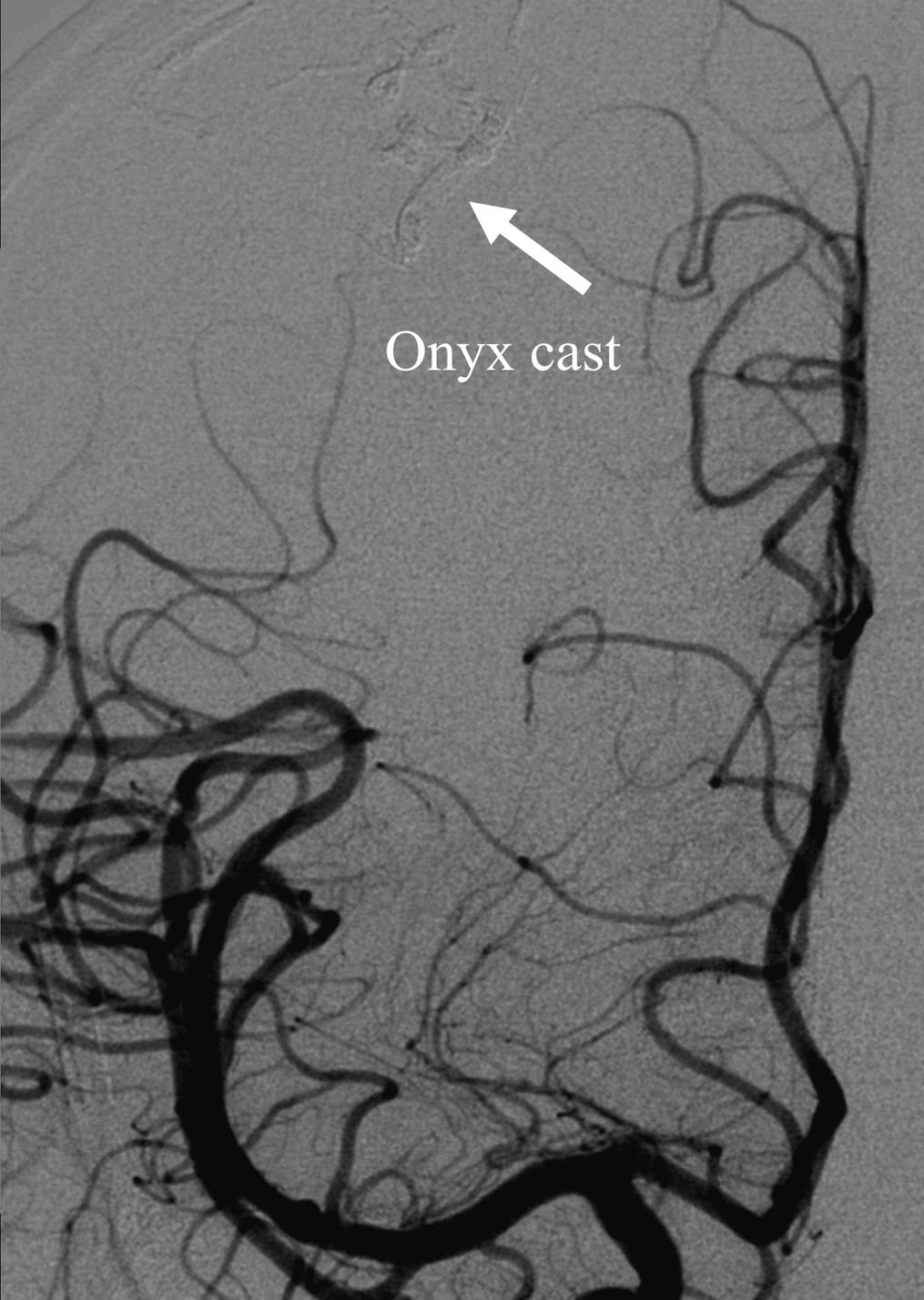
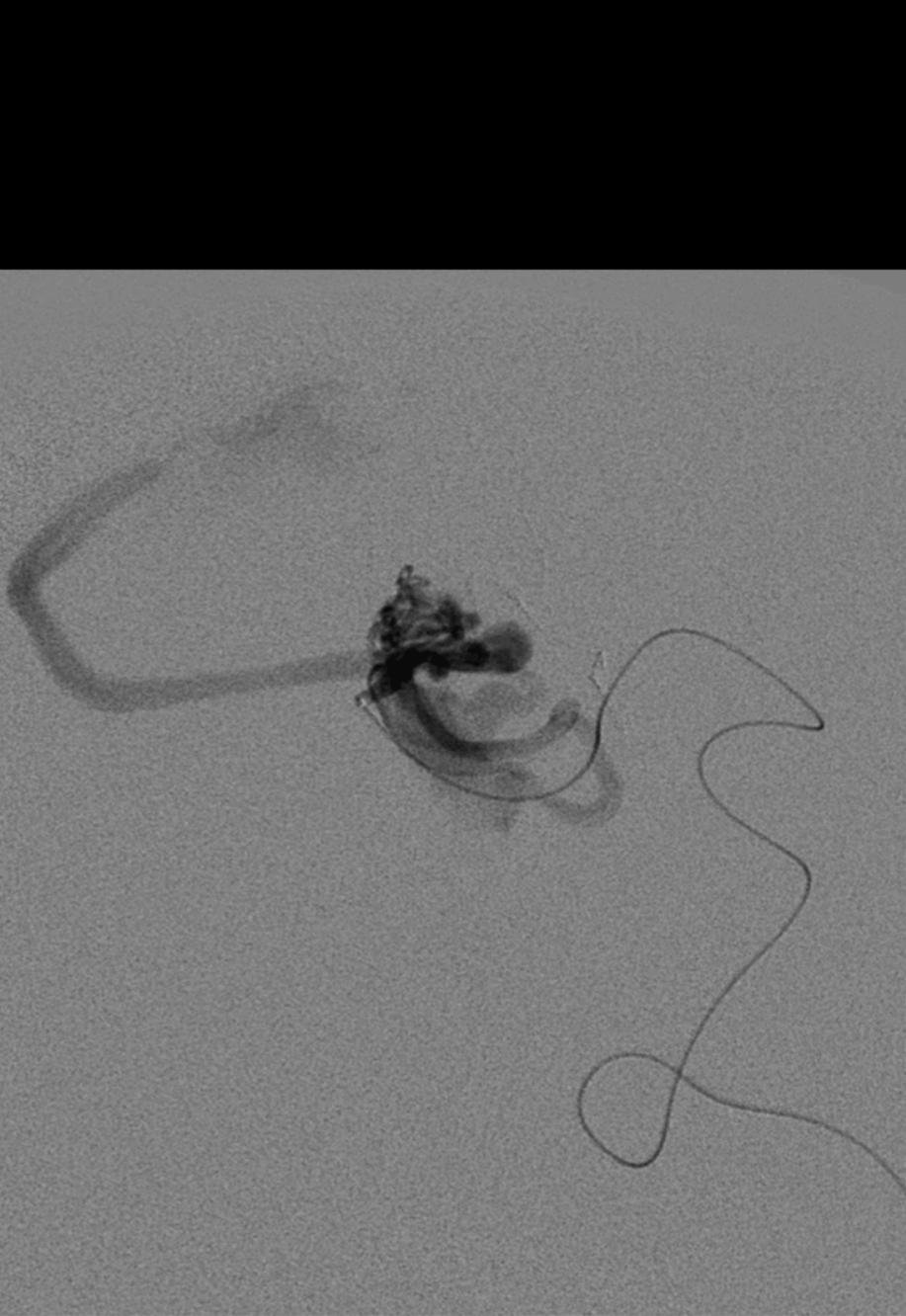


Cure by Embolization Alone

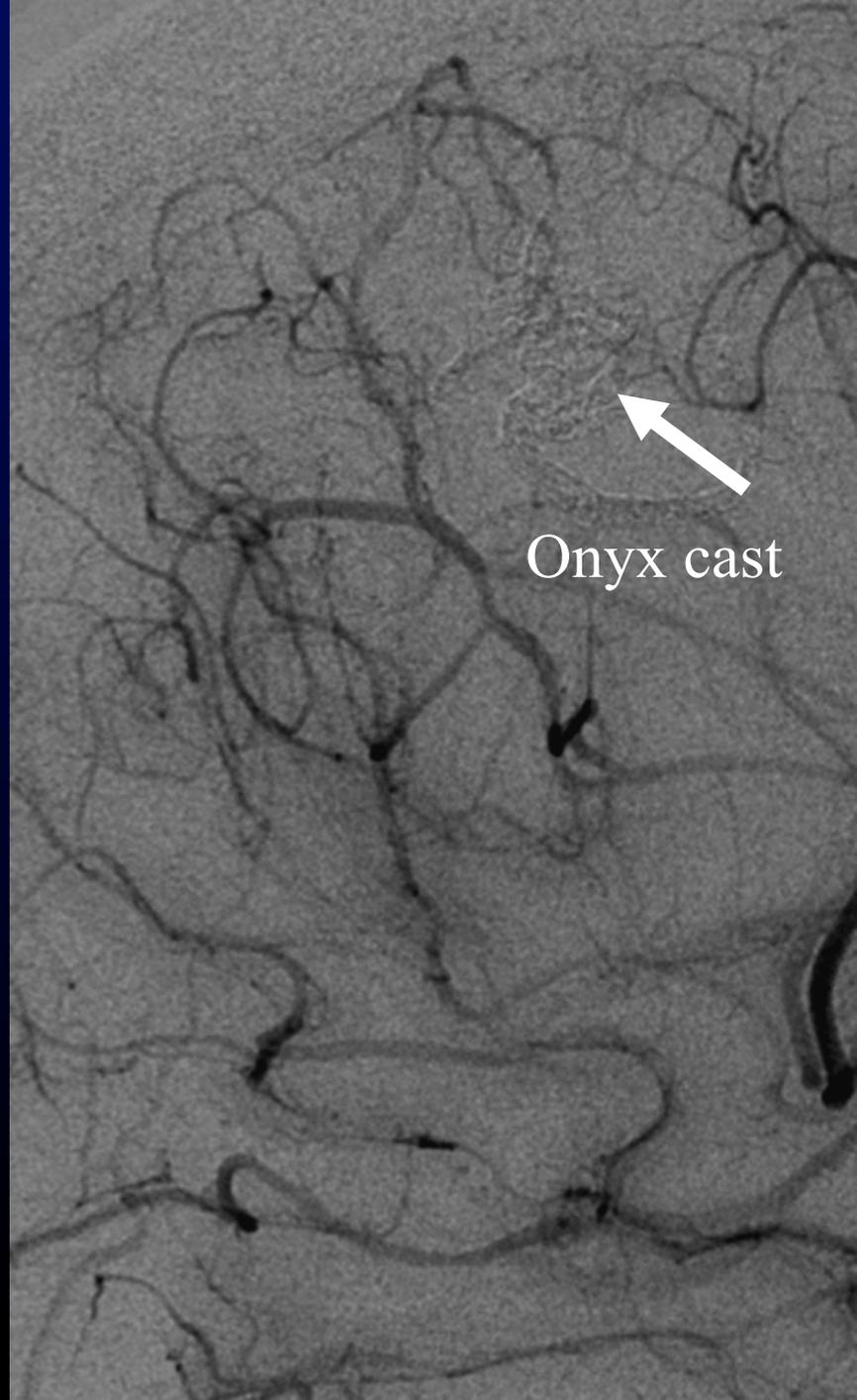
Patient

- 18 year old woman with seizures and a small right cortical bleed
- Right Frontal AVM, motor cortex, single draining vein
- Embolized with Onyx liquid embolic system
- Cure after one session





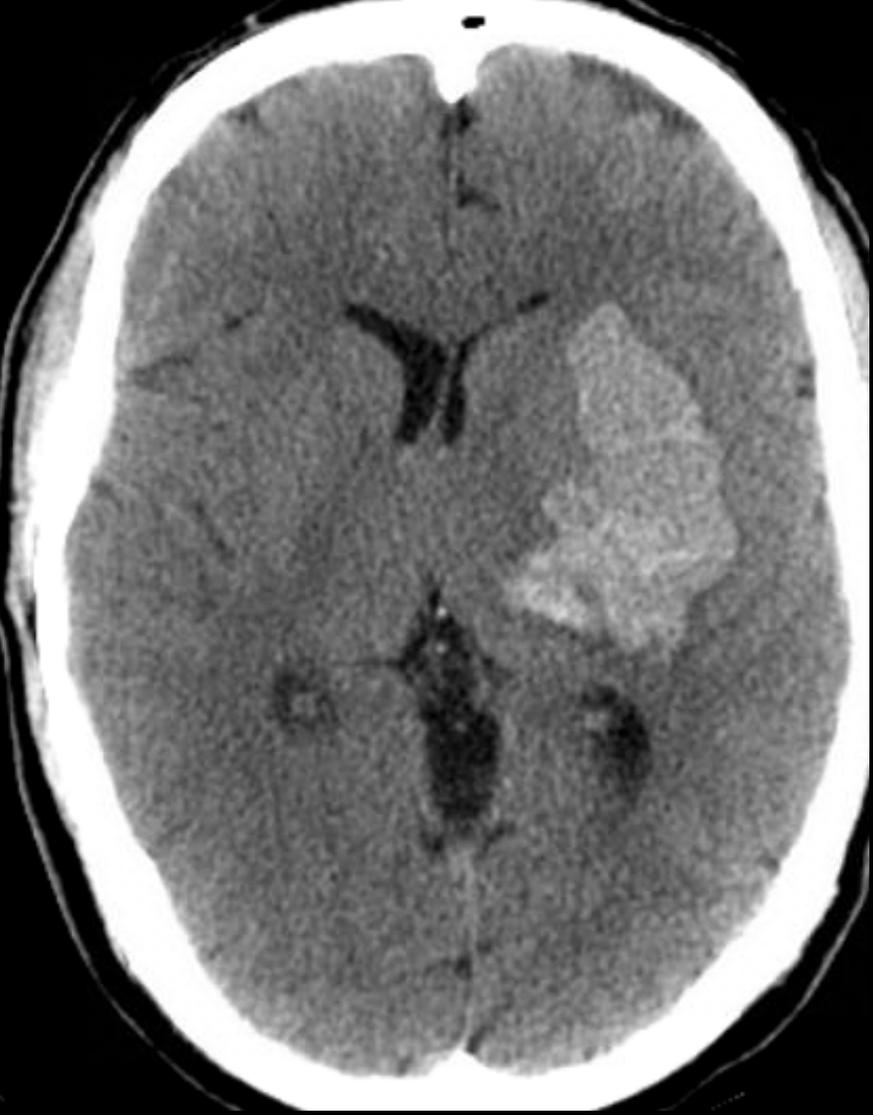
Onyx cast

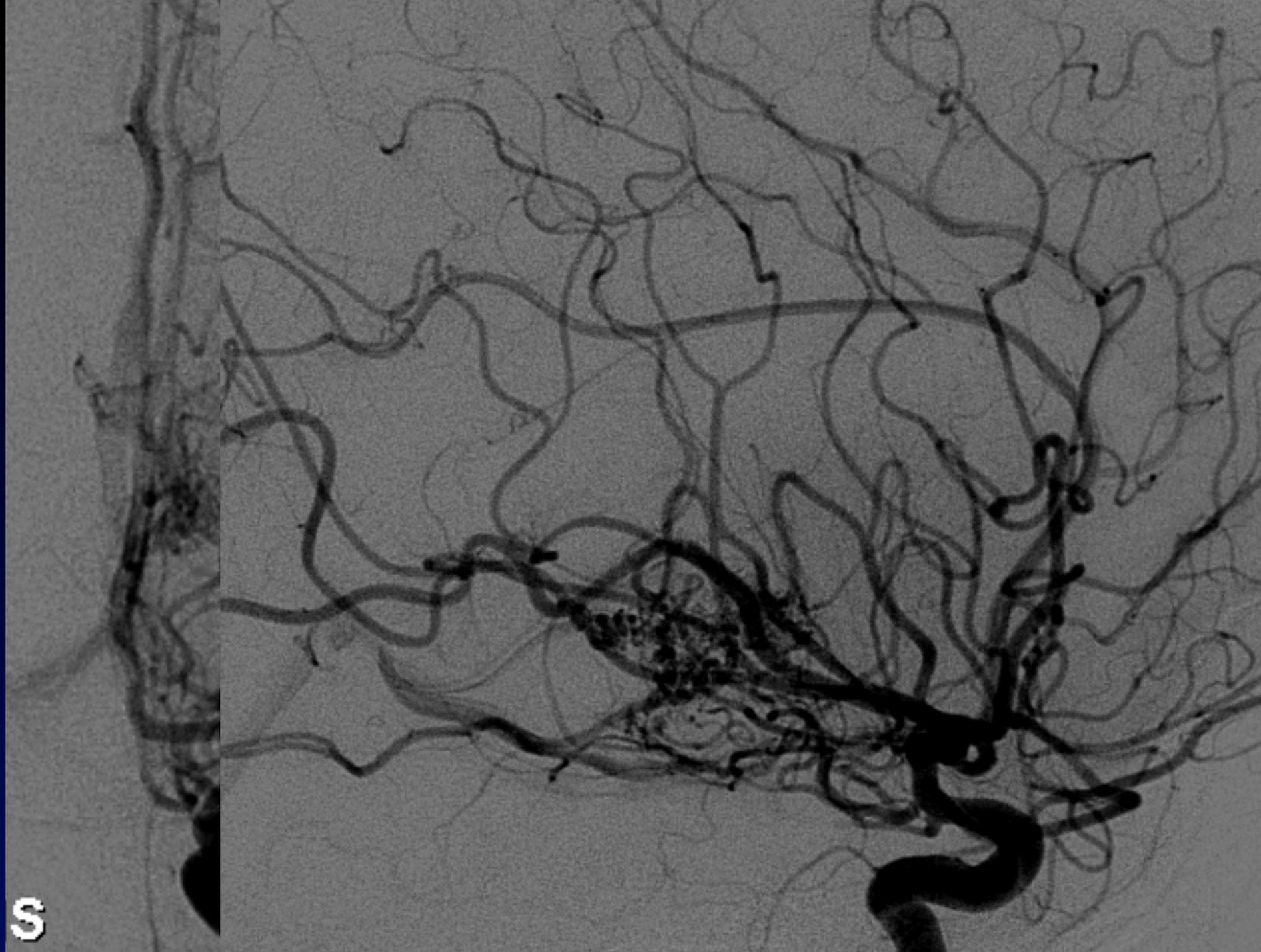


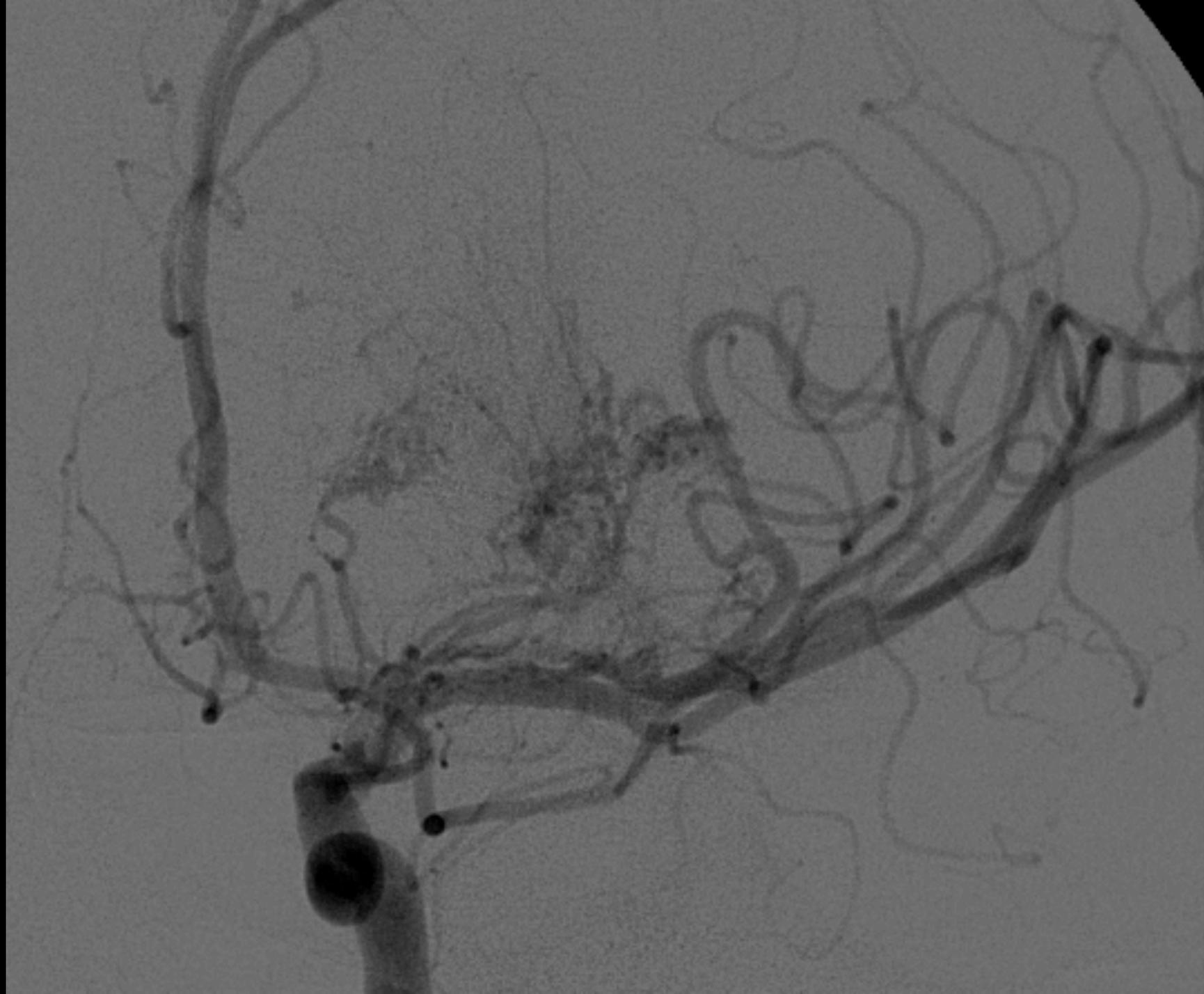
Onyx cast

Patient

- 26 year old with sudden onset of headache and right hemiplegia, head and eye deviation to the left
- Left basal ganglia hemorrhage
- Deep, basal ganglia AVM



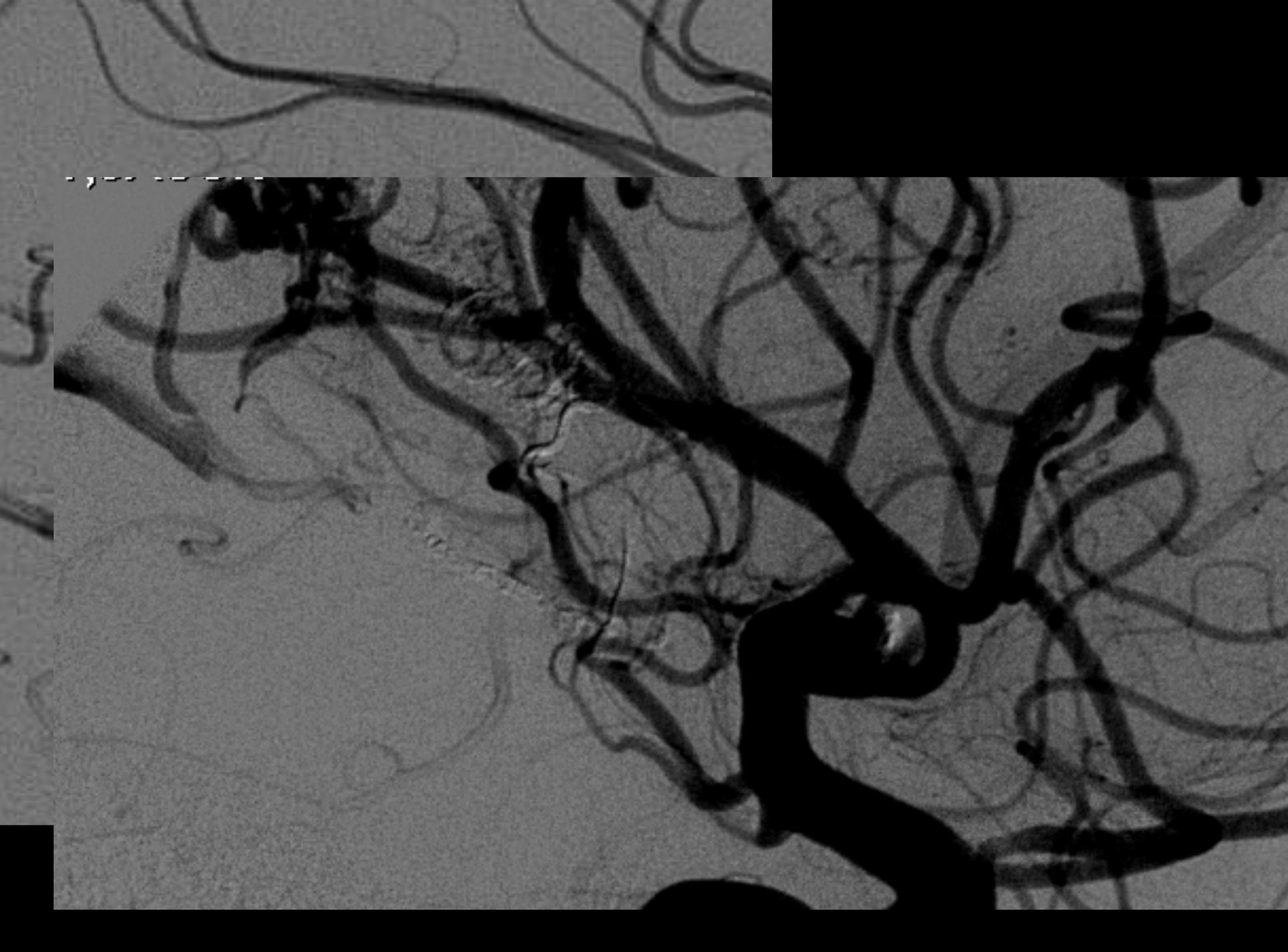




Patient

- Deep basal ganglia AVM
- Feeders from lenticulo-striate and anterior choroidal artery
- Embolized with Onyx

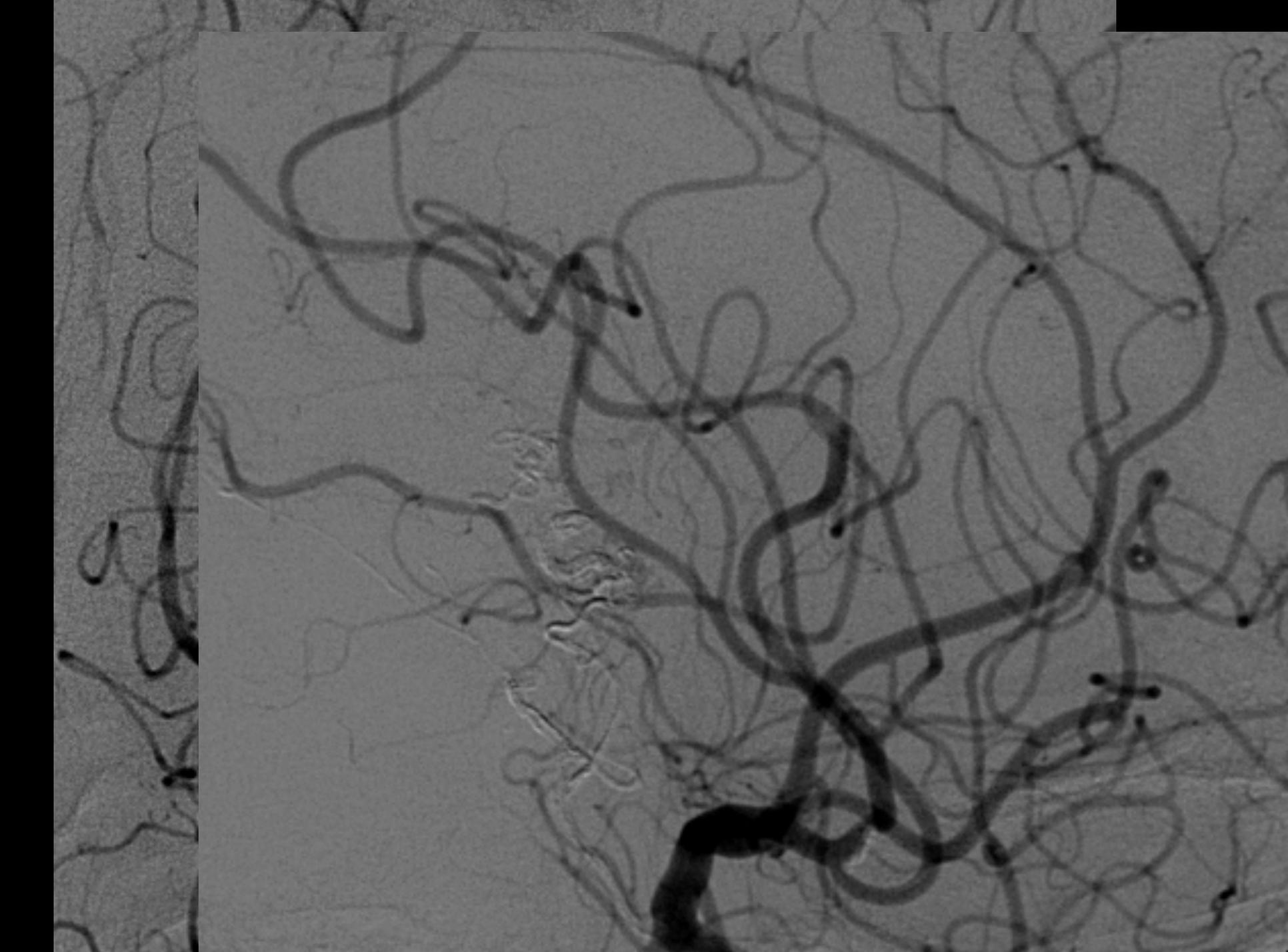




ON



ASCULAR IN





**Spinal arteriovenous malformation associated
with spinal metameric syndrome: a treatable cause
of long-term paraplegia?**

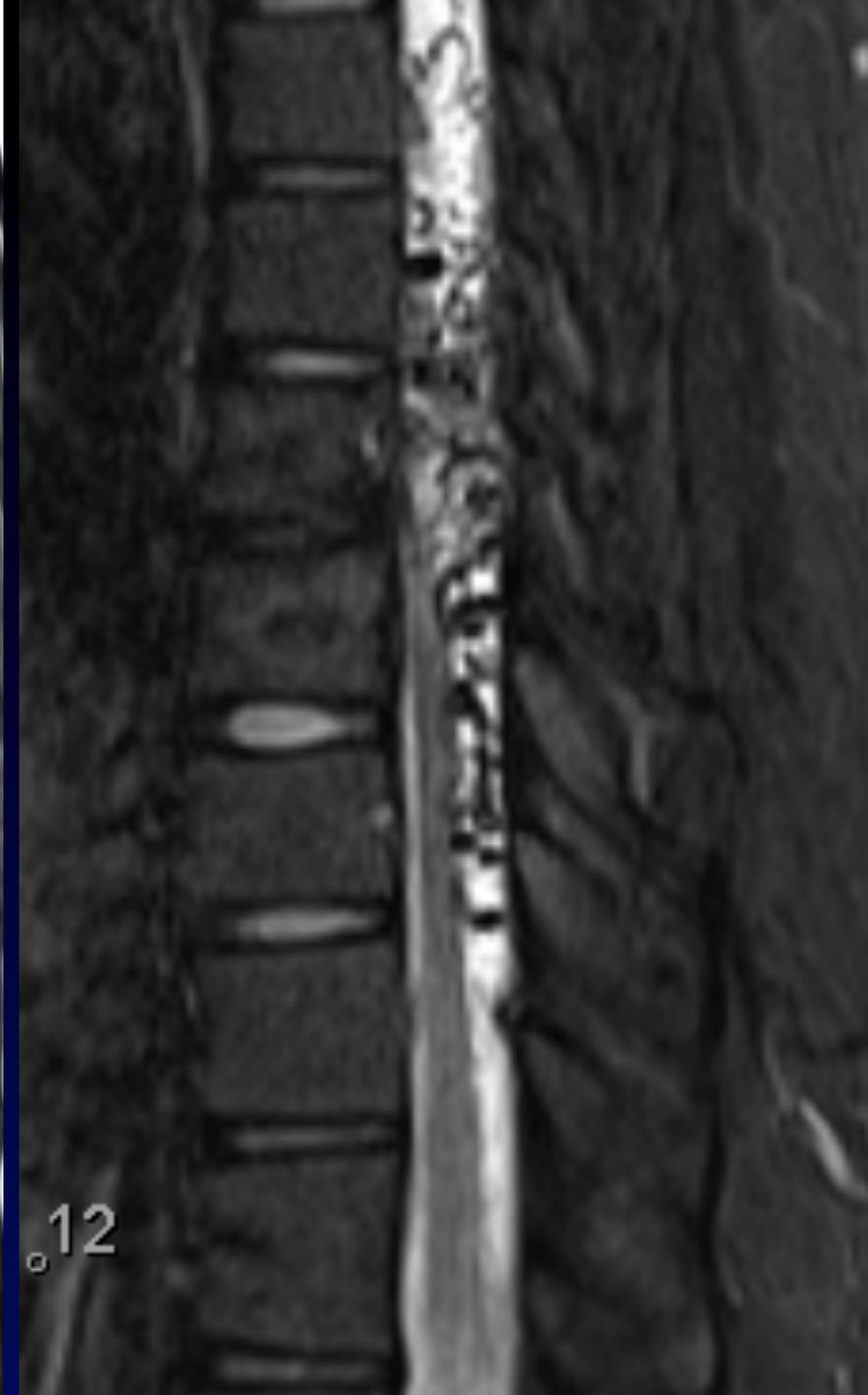
**Linfante I, Tari-Capone T, Dabus G, Gonzales-Arias S, Samaniego
JNS 2012;16:408-13**



**Baptist
Health**

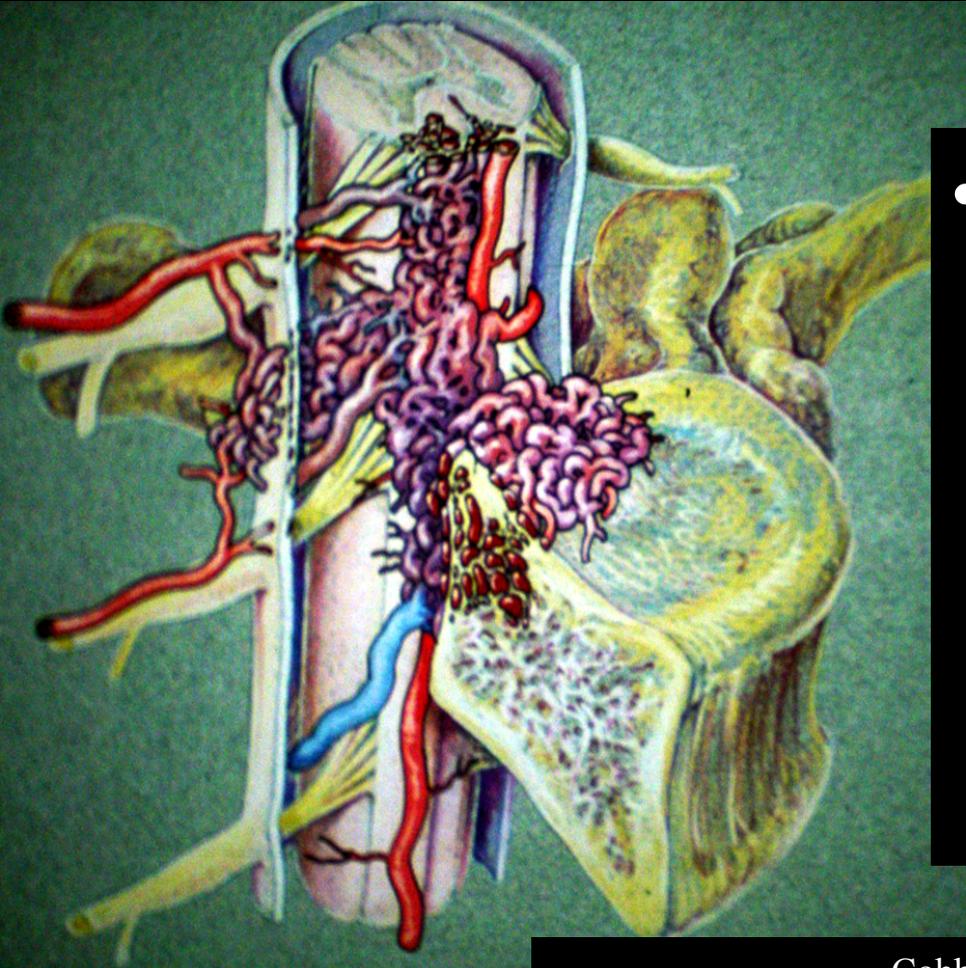
Patient

- 14 year old with 4 year history of spastic paraplegia
- Wheel chair bound for the past 4 year
- Developing bilateral arm weakness and shortness of breath
- On exam: spastic paraplegia with sustained clonus
- 4/5 bilateral proximal arm weakness
- Sensory anesthesia at T8
- Spastic bladder (self-catherized her bladder)
- Bowel incontinence



12

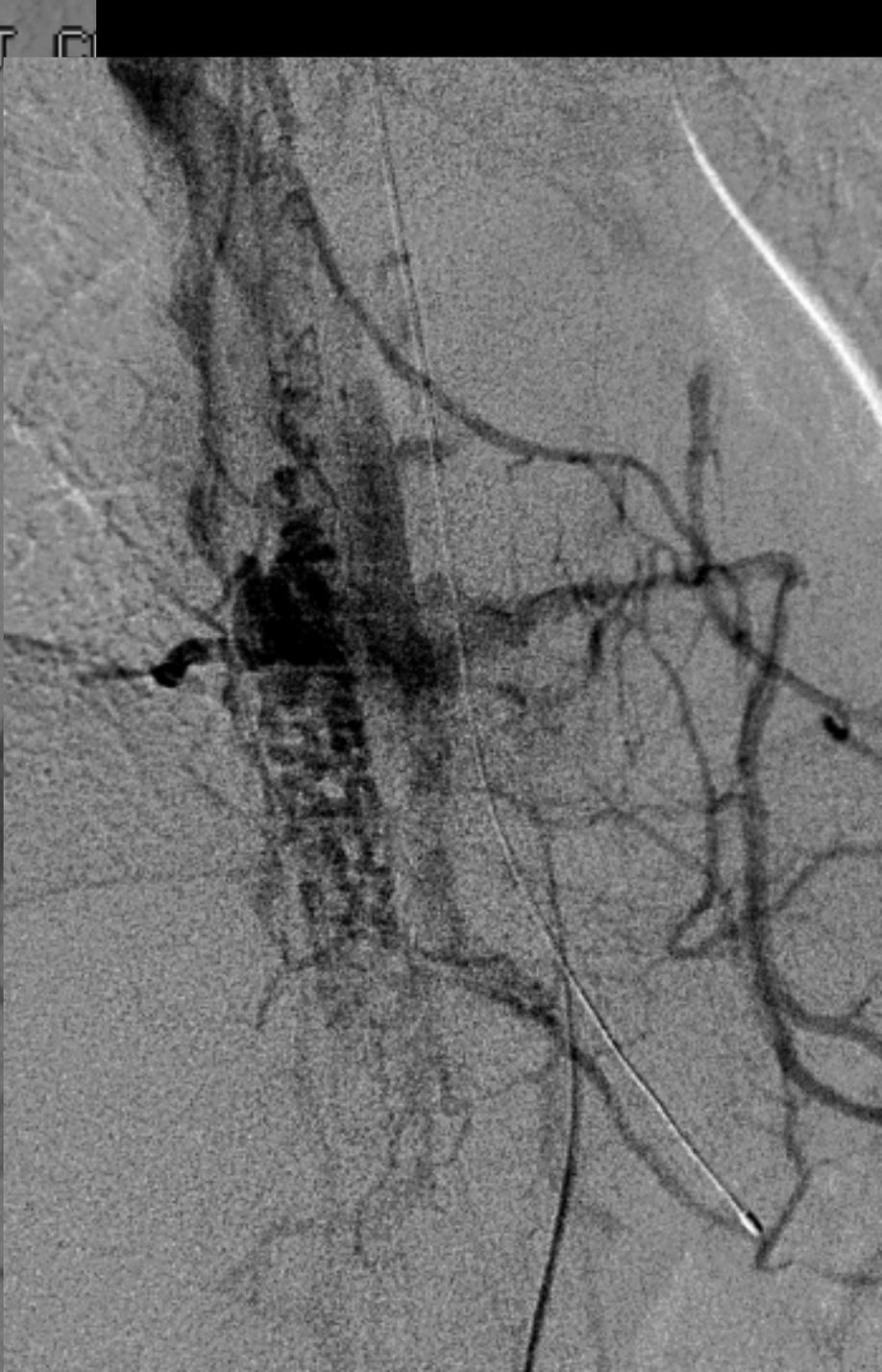
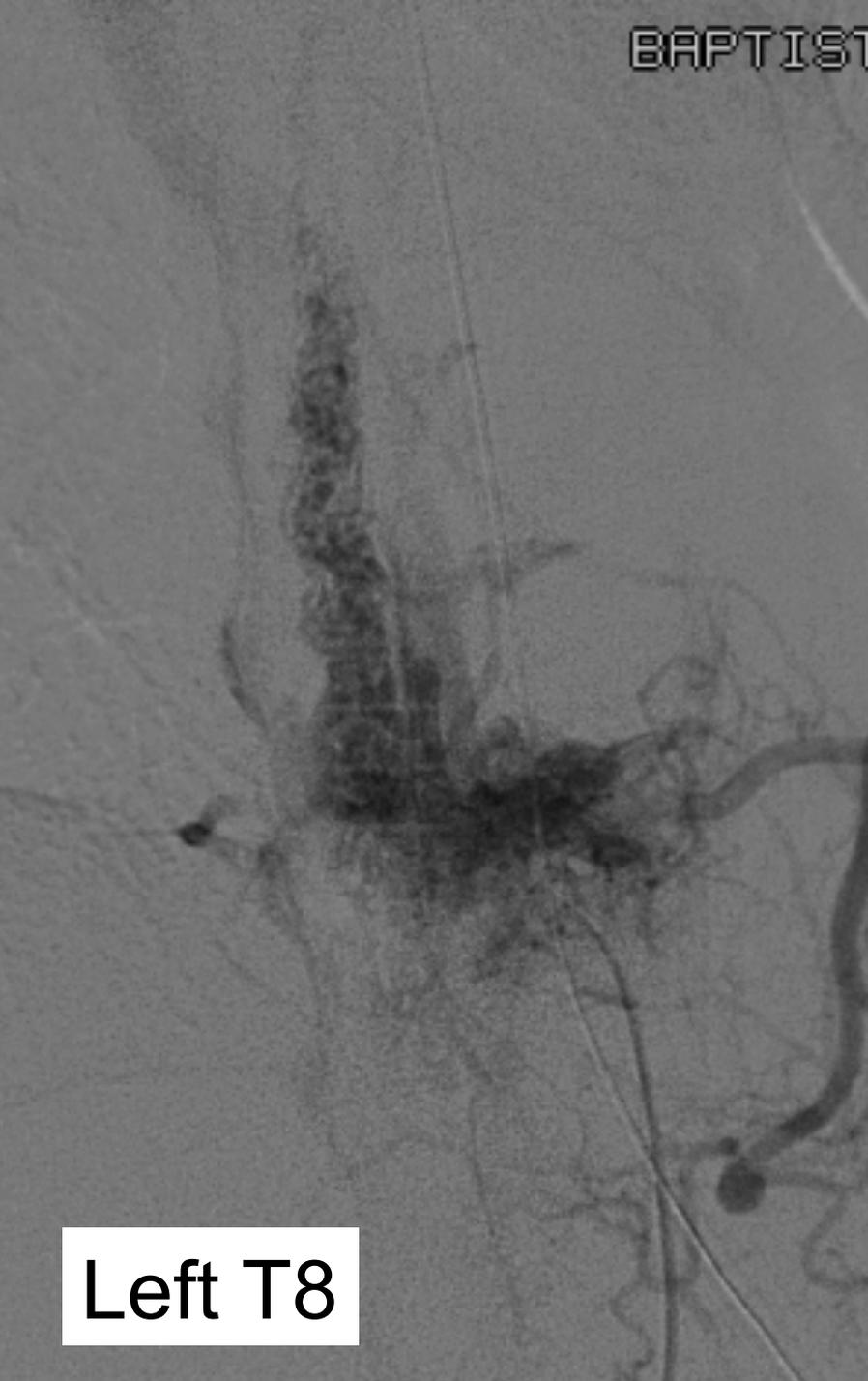
Extra-dural/intra-dural AVM (Type III)



- metameric or juvenile AVM's.
- if entire metamere, i.e. skin, muscle, bone, dura and cord is involved, known as **Cobb's syndrome**

Cobb S. Haemangioma of the Spinal Cord:

Associated with Skin Naevi of the Same Metamere. Ann Surg. 1915 Dec;62(6):641-9 •

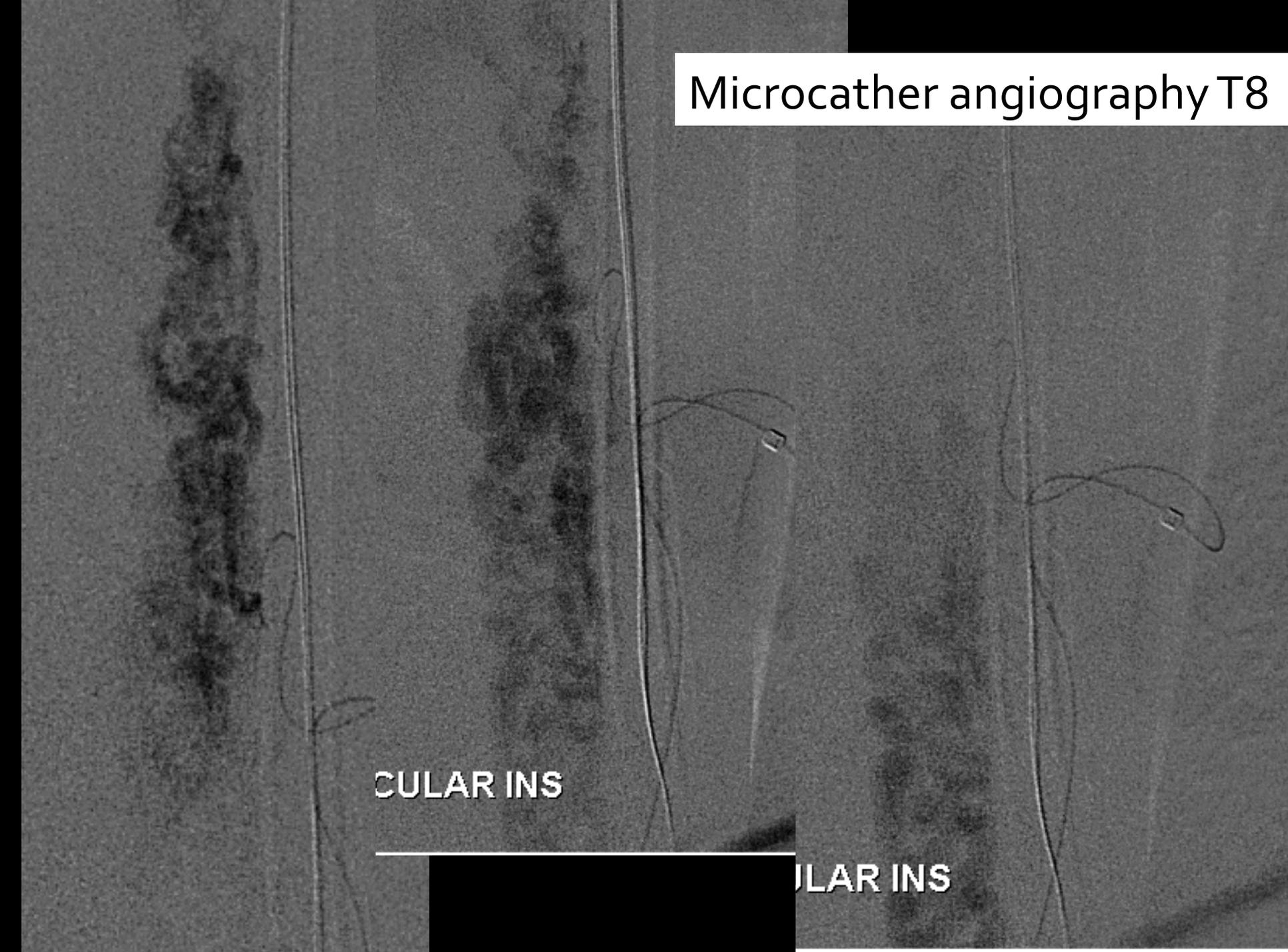


Left T8

Microcather angiography T8

CULAR INS

ULAR INS



Post embo

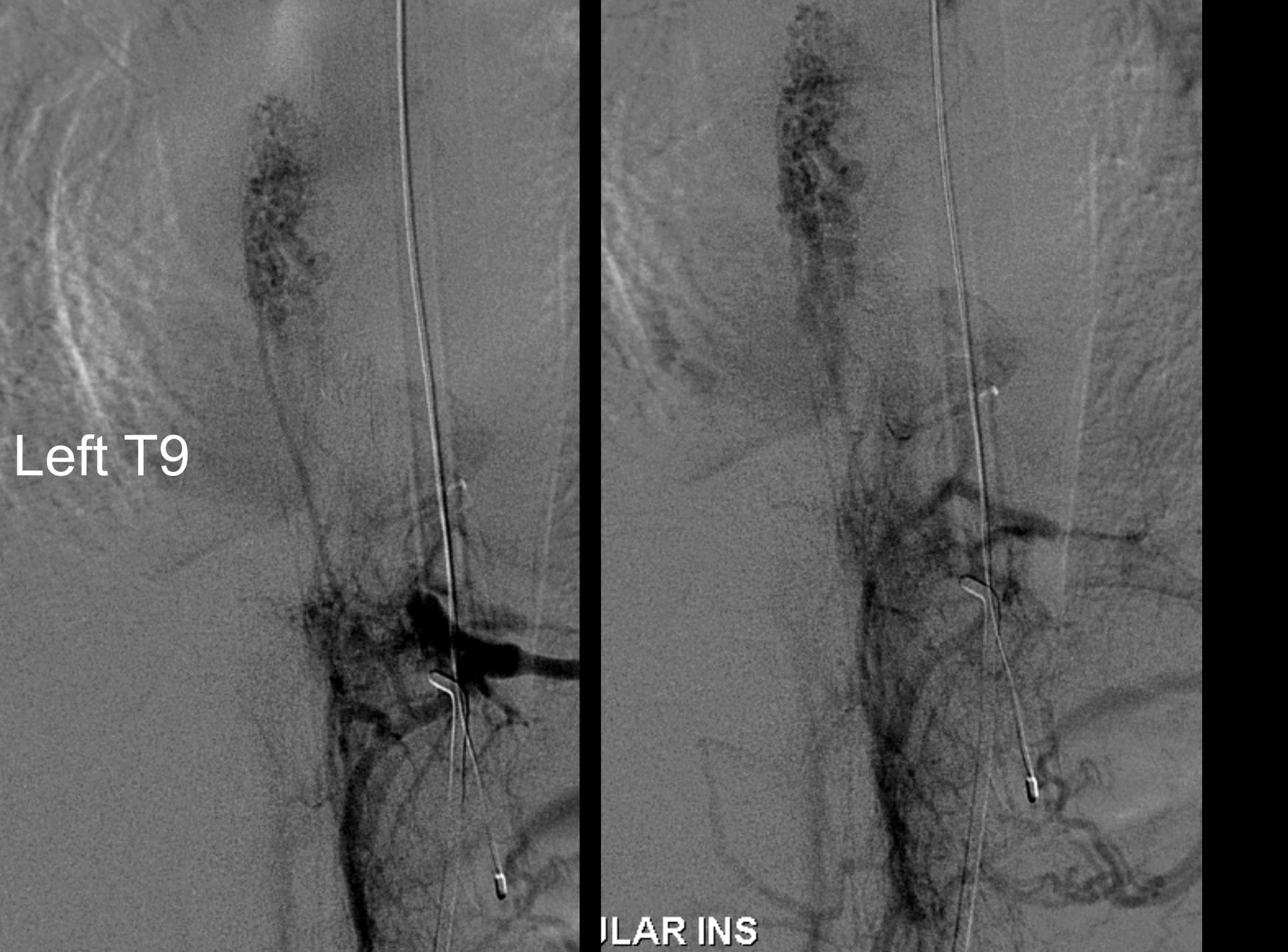
ILAR INS

ASCULAR INS



Left T9

ULAR INS



Microcatheter

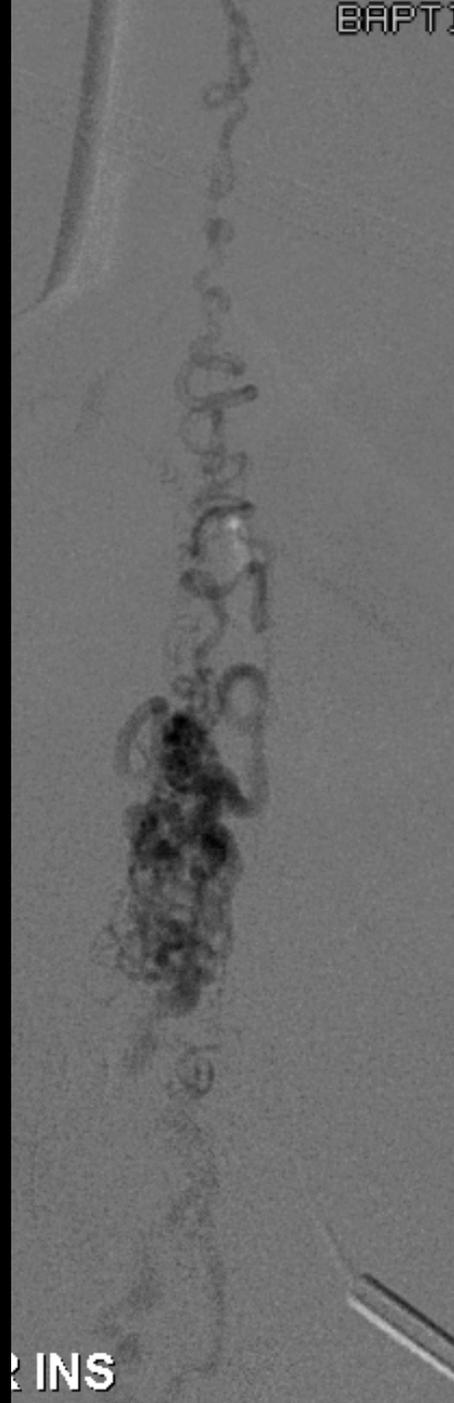
T9 Post embo

BAP

Right T8

ULAR INS





BAPTI

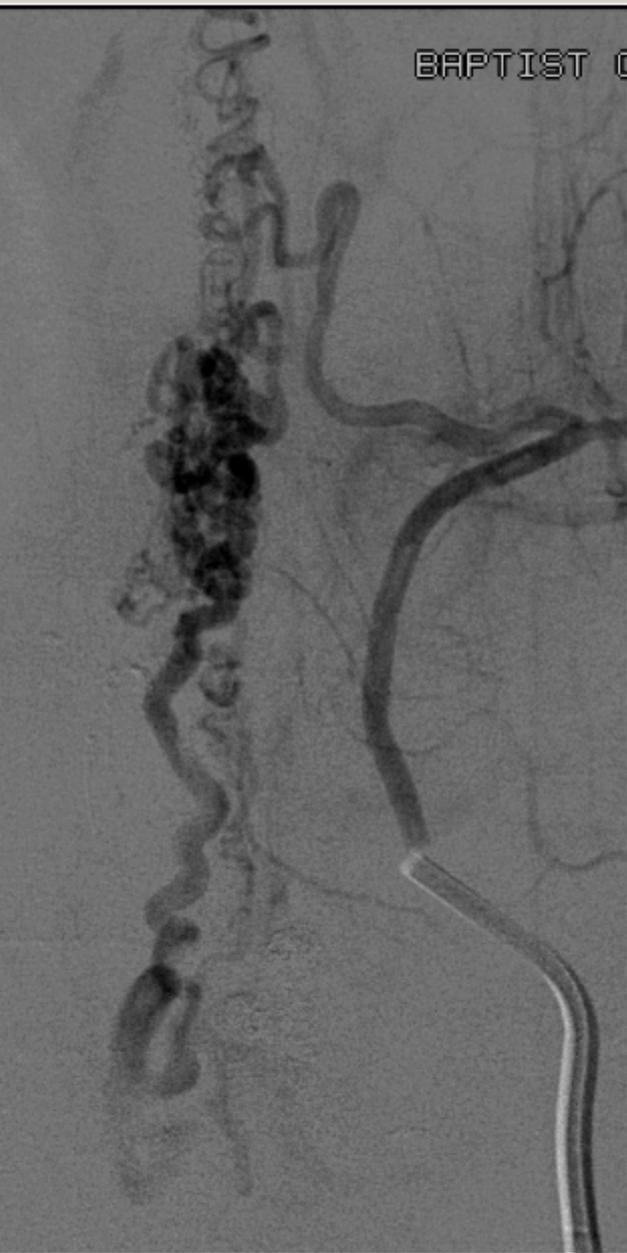
Left T6

INS

Patient

- Day after she started to have sensation in her legs
- Two days later had some minimal proximal movement
- One month later was able to make steps at the parralel bar with support

BAPTIST C



INS

R INS

3

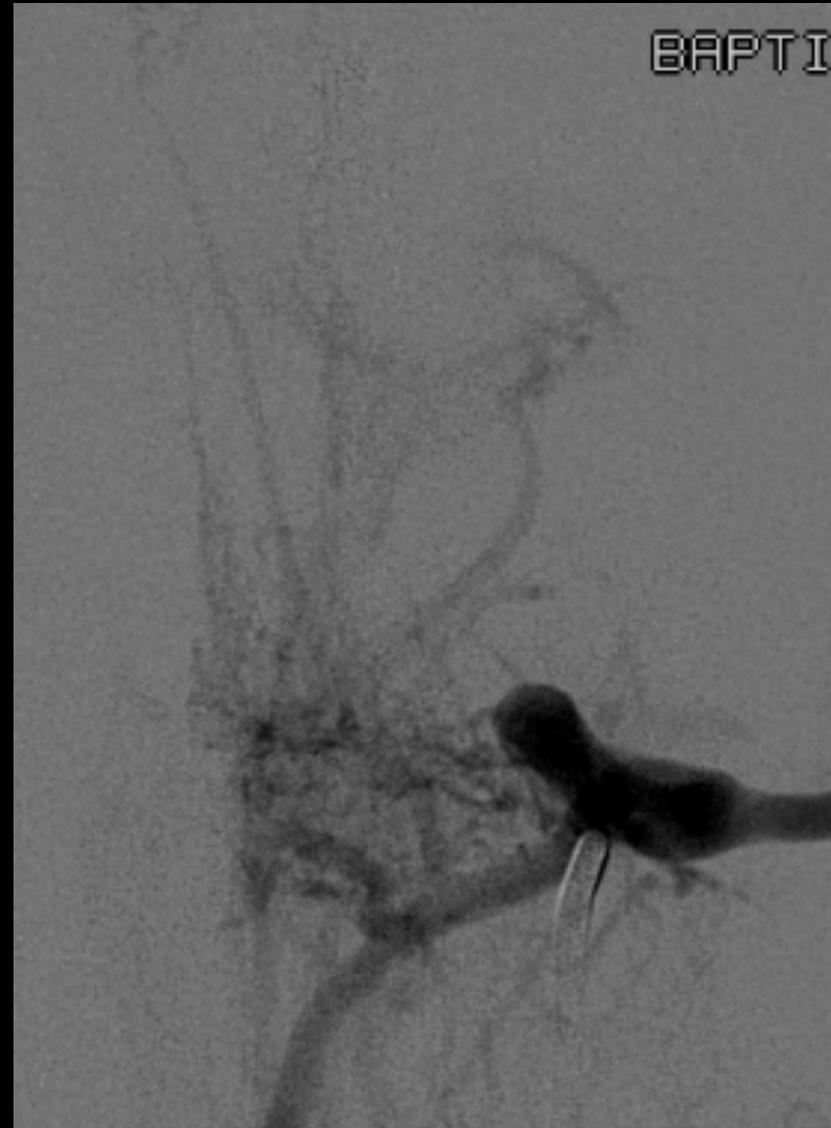
LT8

SCULAR INS



Left t9

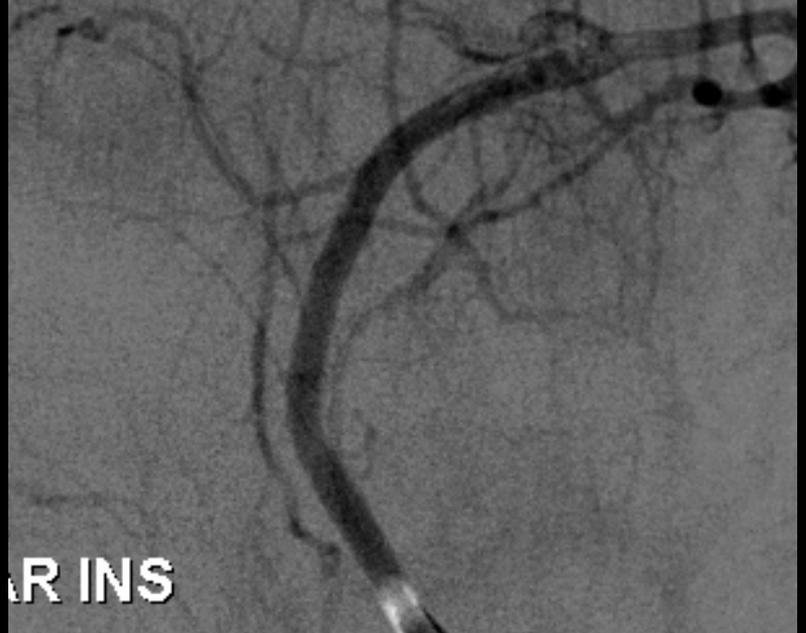
BAPTI

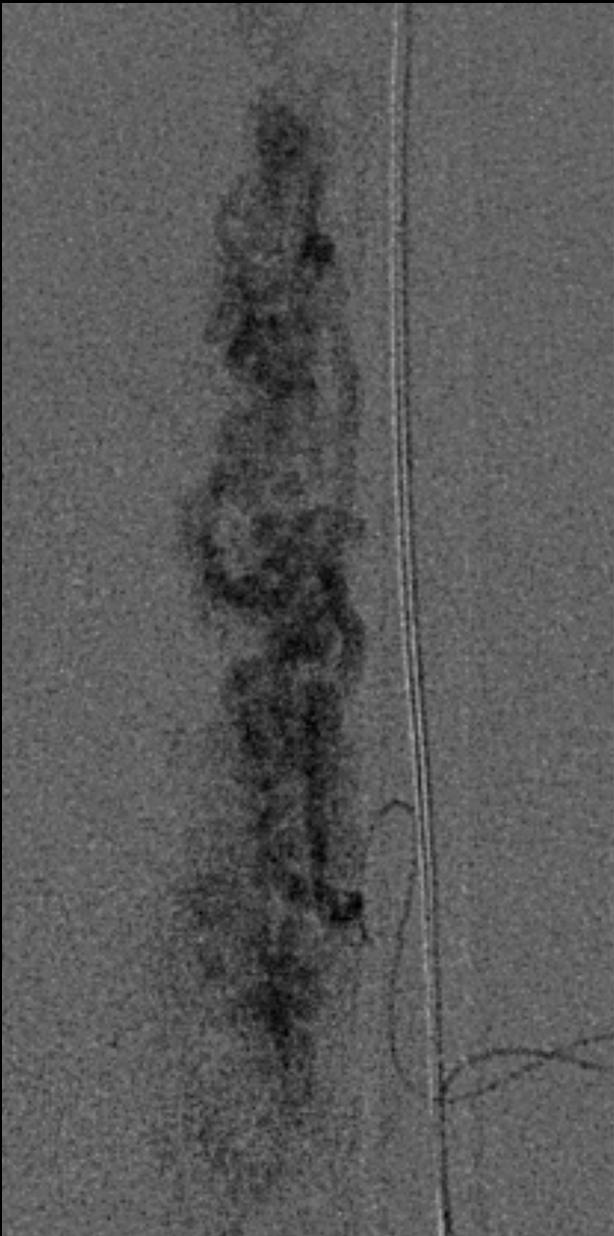


Right T8



Left T6

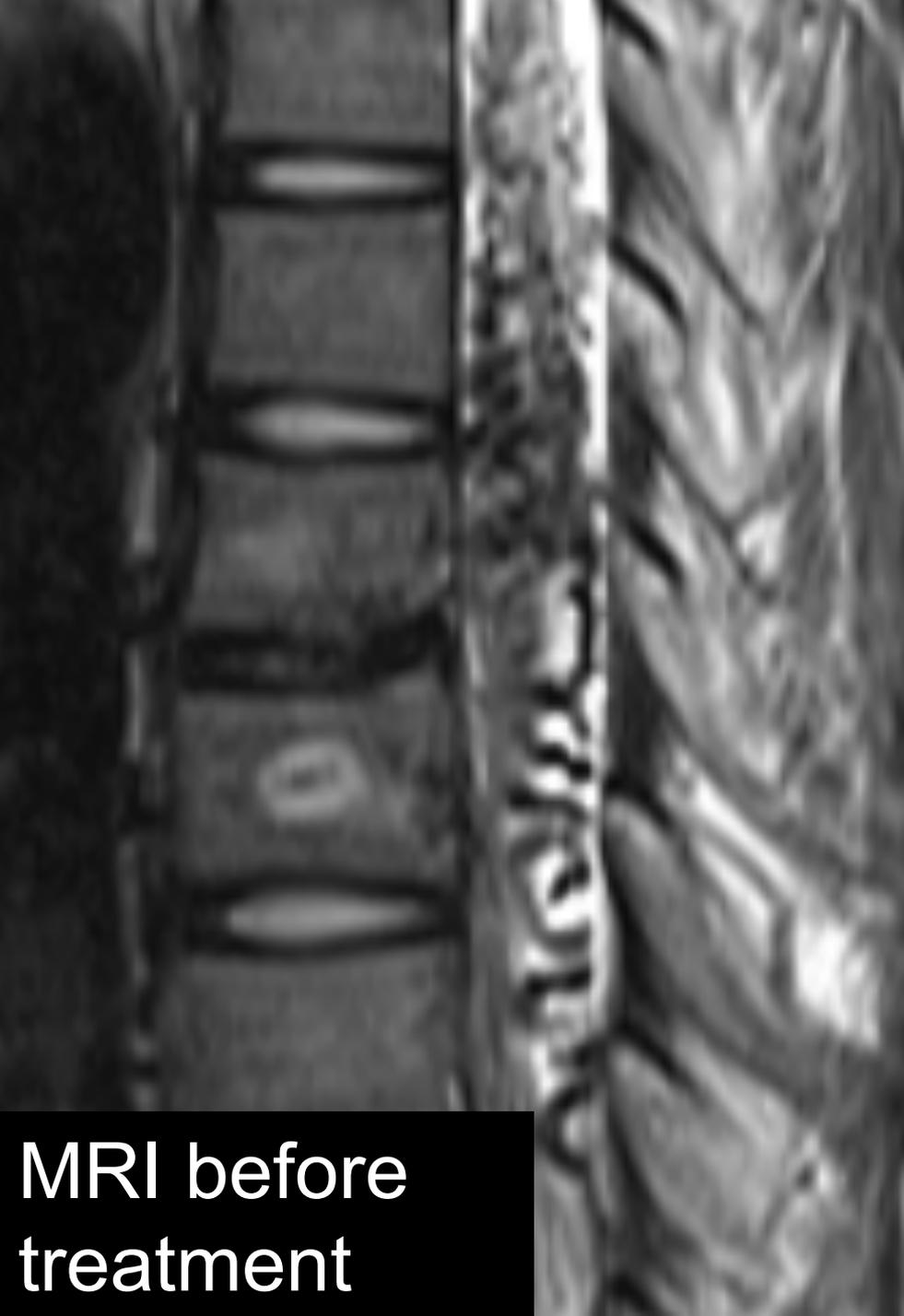




AVM before treatment



AVM after treatment



MRI before
treatment



MRI after treatment



Conclusions

- Downsize the AVM in preparation for surgery for surgically accessible lesion
- Embolization alone may result in an “angiographic cure”, however cases of recurrences have been described
- For surgical inaccessible lesions Embolization followed by Radiation
- Outcomes of has dramatically improved with embolization

