

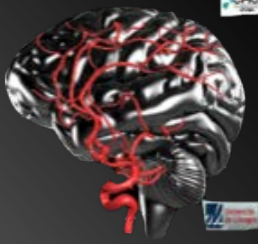
Basal Ganglia AVMs: Endovascular Treatment (transarterial vs transvenous)

Charbel Mounayer

Dupuytren University Hospital, Limoges, France



Summary



➤ Introduction

Principles of AVM EVT

Arterial approach for BG AVM:

Adhesive VS non-adhesive LA

Limitations

Introduction to the venous approach

Venous approach for BG AVM

Engage in debate

Liquid agents

Porcelain vein

Nidus size

Arterial Balloon

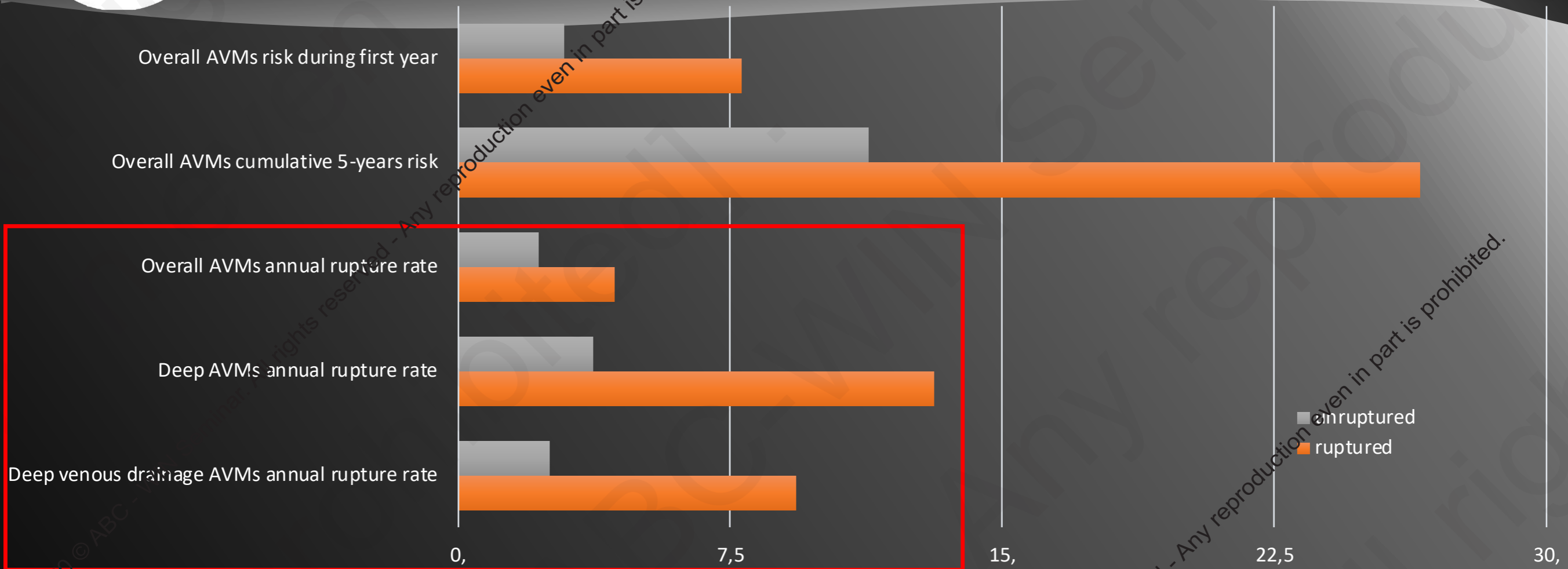
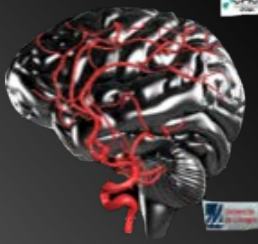
Could it be partial?

What about the venous ischemia?

Take home message



BG AVM Bleeding Risk



	Overall AVMs risk during the first year	Overall AVMs cumulative 5-years risk	Overall AVMs annual rupture rate	Deep AVMs annual rupture rate	Deep venous drainage AVMs annual rupture rate
Unruptured	2,9 (1)	11,3 (1)	2,2 (1)	3,7 (2)	2,5 (2)
Ruptured	7,8 (1)	26,5 (1)	4,3 (1)	13,1 (2)	9,3 (2)

(1) Natural history of brain arteriovenous malformations: systematic review; Goldberg et al.; Journal of Neurosurgical Sciences; 2018 August
 (2) Predictors of hemorrhage in patients with untreated brain arteriovenous malformation; Stapf et al.; Neurology 2005
 (2) Risk factors for subsequent hemorrhage in patients with cerebral arteriovenous malformations; Yamada et al.; J Neurosurg; 2007 Nov

Hemorrhage-Free Survival after initial diagnosis

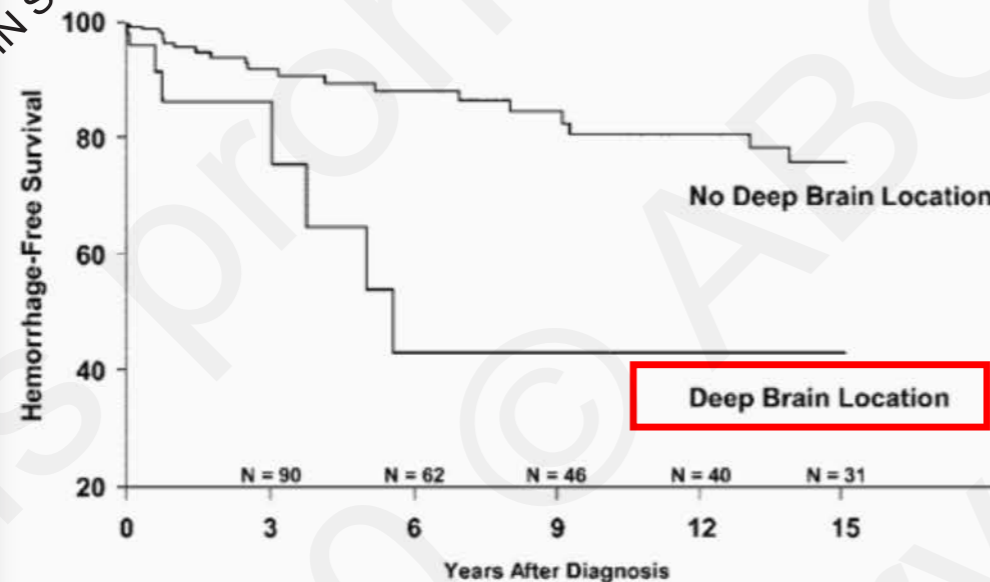
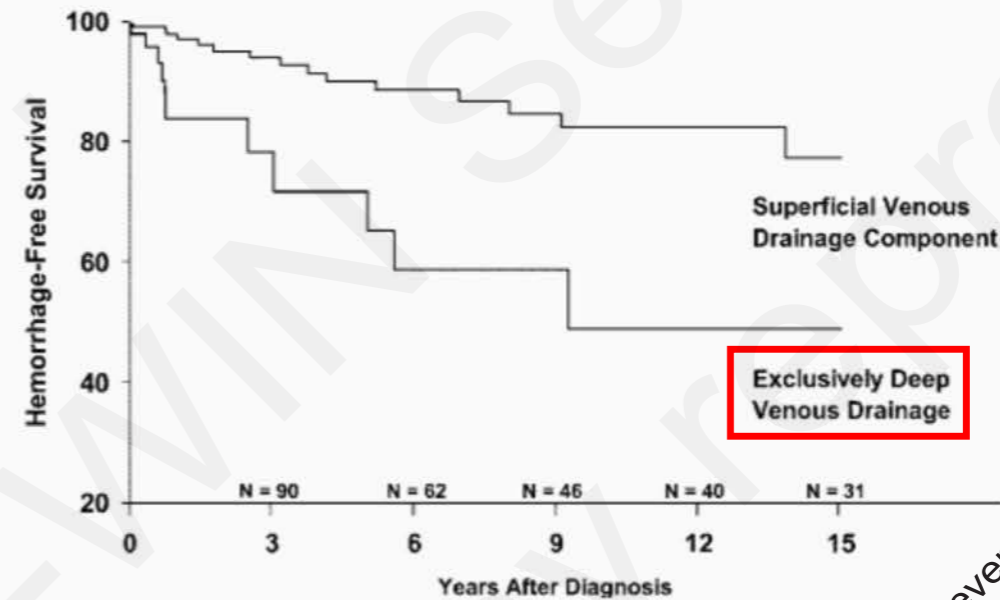
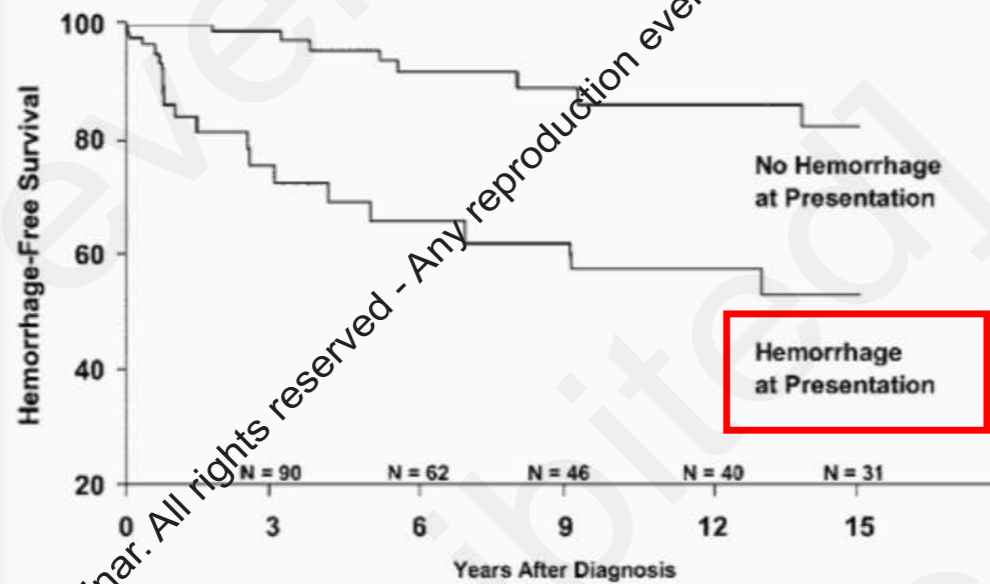
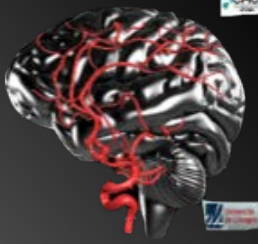


Figure 1. Kaplan-Meier survival curves of hemorrhage-free survival after initial arteriovenous malformation (AVM) diagnosis in 622 untreated patients. The three survival graphs are based on model estimates for hemorrhagic vs nonhemorrhagic AVM presentation (top), exclusive deep venous drainage vs any superficial drainage component (middle), and deep vs nondeep AVM location (bottom).



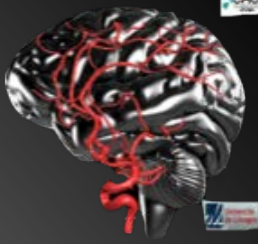
SRS

Review

Stereotactic radiosurgery for deep intracranial arteriovenous malformations, part 2: Basal ganglia and thalamus arteriovenous malformations

Or Cohen-Inbar*, Dale Ding, Jason P. Sheehan

Department of Neurological Surgery, University of Virginia, PO Box 800212, Charlottesville, VA 22908, USA



RESULTS

Table 1
SRS for AVM of thalamus basal ganglia reported in the literature

Authors	Number of patients	Median volume (ml)	MMD (Gy)	Total obliteration rate	
				First SRS (%)	Repeat SRS (%)
Sasaki et al. [8]	60	NA	NA	85.7	---
Pollack et al. [14]	56	3.8 (0.3-40.2)	18 (15-25)	40 ⁺	55, 66 ⁺
Andrade-Souza et al. [15]	42	4.7 (0.2-18.3)	16.2 (15-20)	61.9 ⁺	---
Koga et al. [16]	48	3.3 (0.1-18)	21 (16-28)	65	74, 82 ^{**}
Cheng et al. [10]	182 (85/97)	3.4 (0.1-29.4)	21.3 (10-28)	57.7 ⁺	69.1 ⁺
Kano et al. [17]	133 (56/77)	2.7 (0.1-20.7)	20 (15-25)	72 ⁺	---

521 treated patients

40 – 85,7%

55.66 -74.82%

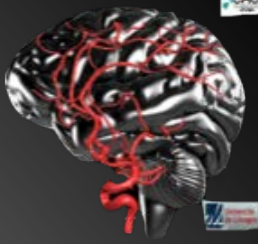


Table 1

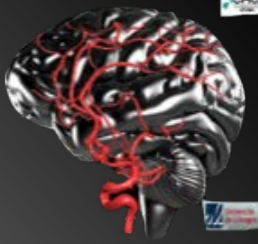
SRS for AVM of thalamus basal ganglia reported in the literature

Authors	Hemorrhage after SRS (%)	Annual bleeding rate 1 year after SRS (%)	Permanent RIC induced deficits (%)	FU (months)
Sasaki et al. [8]	5	3.3	5	30 (NA)
Pollack et al. [14]	12	7	12	45 (12-121)
Andrade-Souza et al. [15]	14.3	9.5	11.9	45.8 (25-90)
Koga et al. [16]	2.1	0.36	17	66 (6-198)
Cheng et al. [10]	11.5	2.9	4.9	80 (24-222)
Kano et al. [17]	11	6.3	4.5	61 (2-265)

2,1 – 14,3 %

4.5 - 17%

30 – 80 months



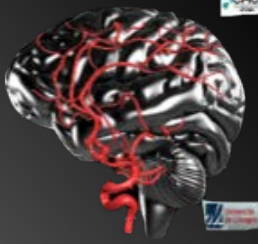
SRS

VS

SRS+EVT

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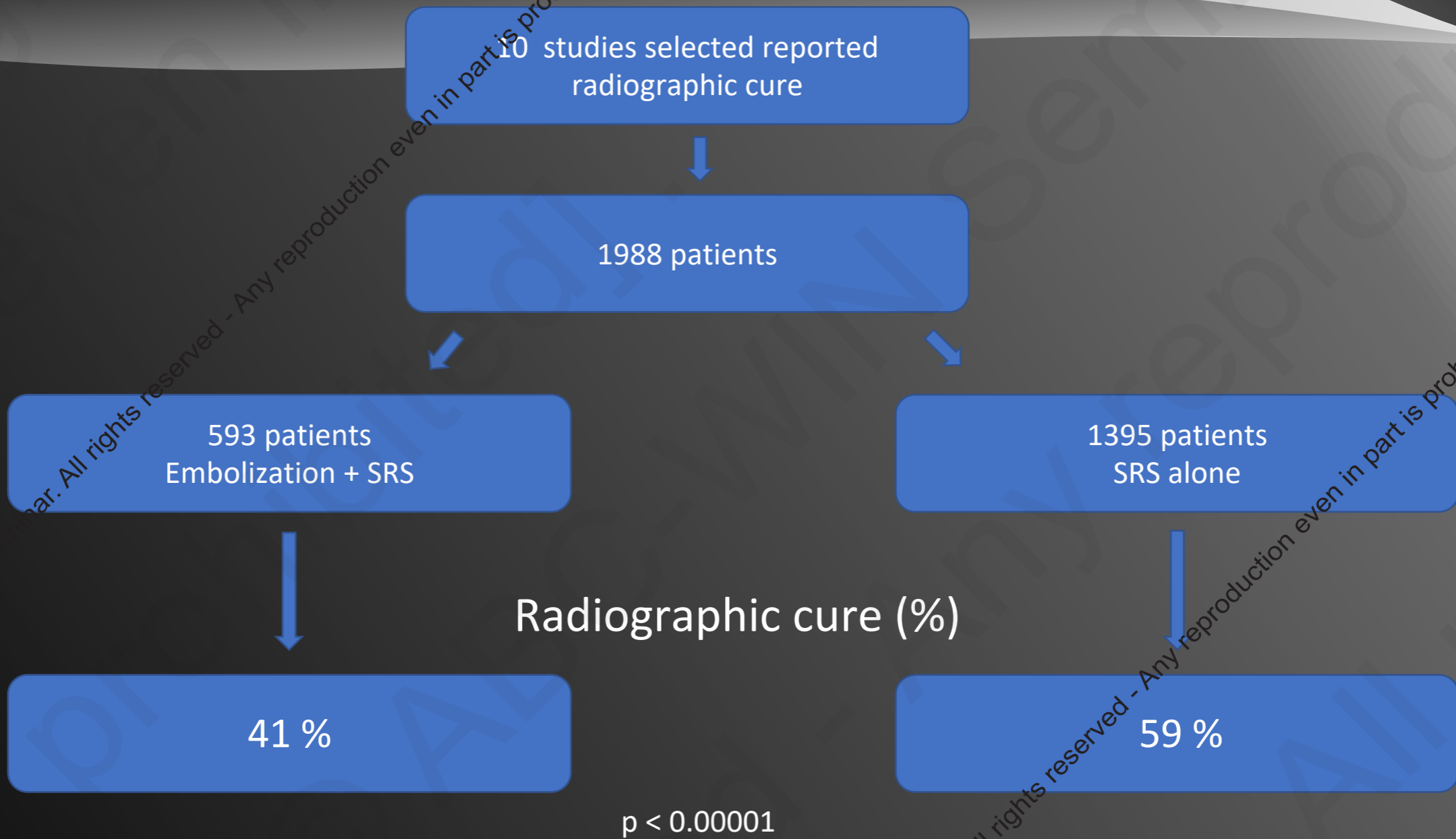
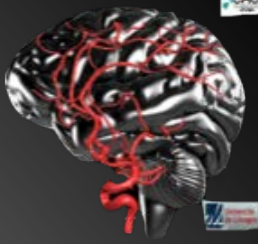


Stereotactic radiosurgery with and without embolization for intracranial arteriovenous malformations: a systematic review and meta-analysis

***FENG XU, M.D., PH.D.,^{1,2} JUNJIE ZHONG, M.D.,³ ABHISHEK RAY, M.D.,¹
SUNIL MANJILA, M.D.,¹ AND NICHOLAS C. BAMBAKIDIS, M.D.¹**

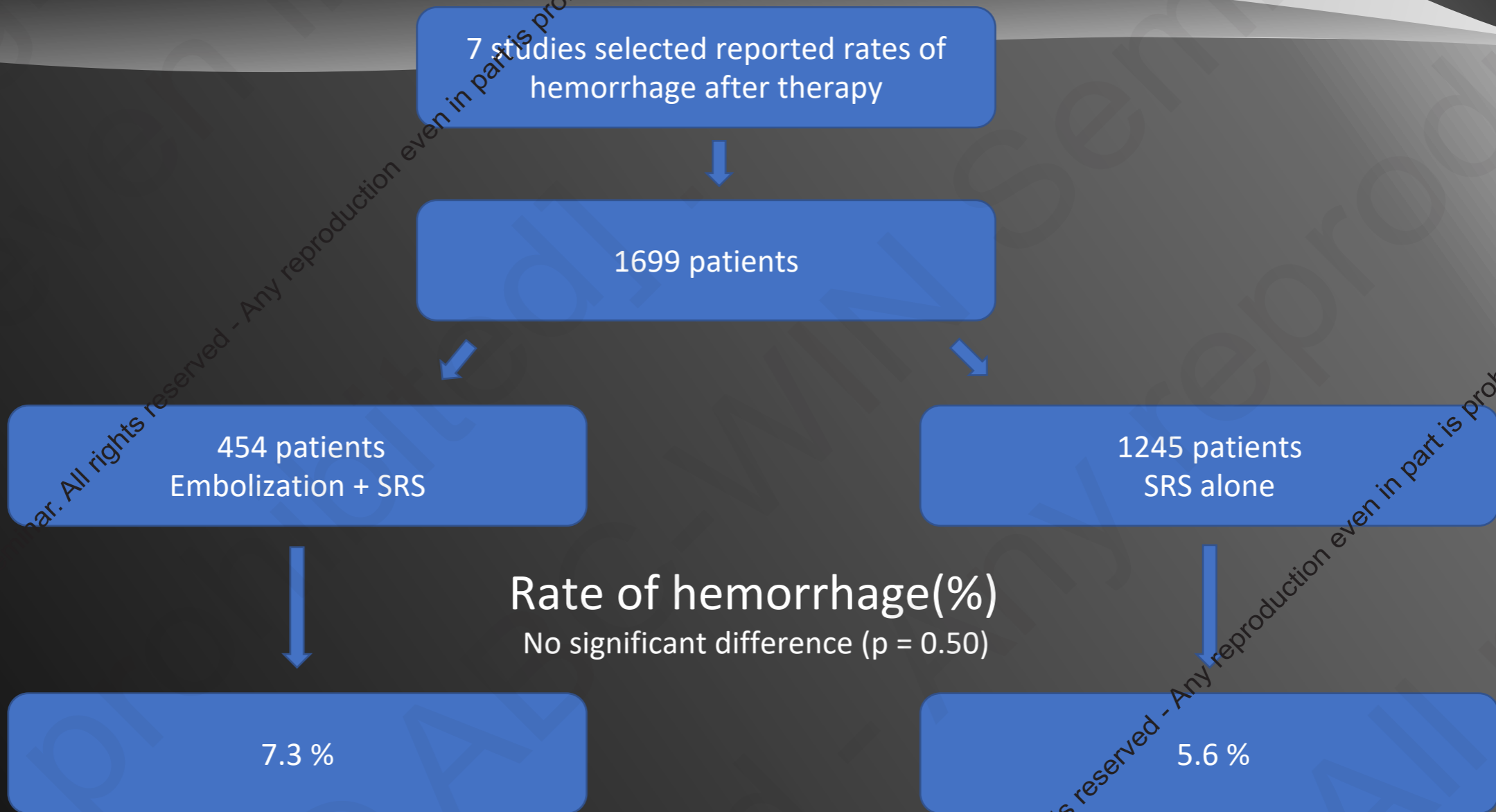
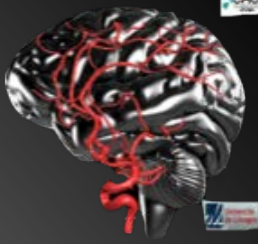
¹Department of Neurological Surgery, Neurological Institute, University Hospitals Case Medical Center, Cleveland, Ohio; ²Department of Neurosurgery, Huashan Hospital, Shanghai Medical School, Fudan University, Shanghai; and ³Department of Neurosurgery, Affiliated Hospital of Nantong University, Nantong, Jiangsu, People's Republic of China

*Not specific about BG AVM (general bAVMs)

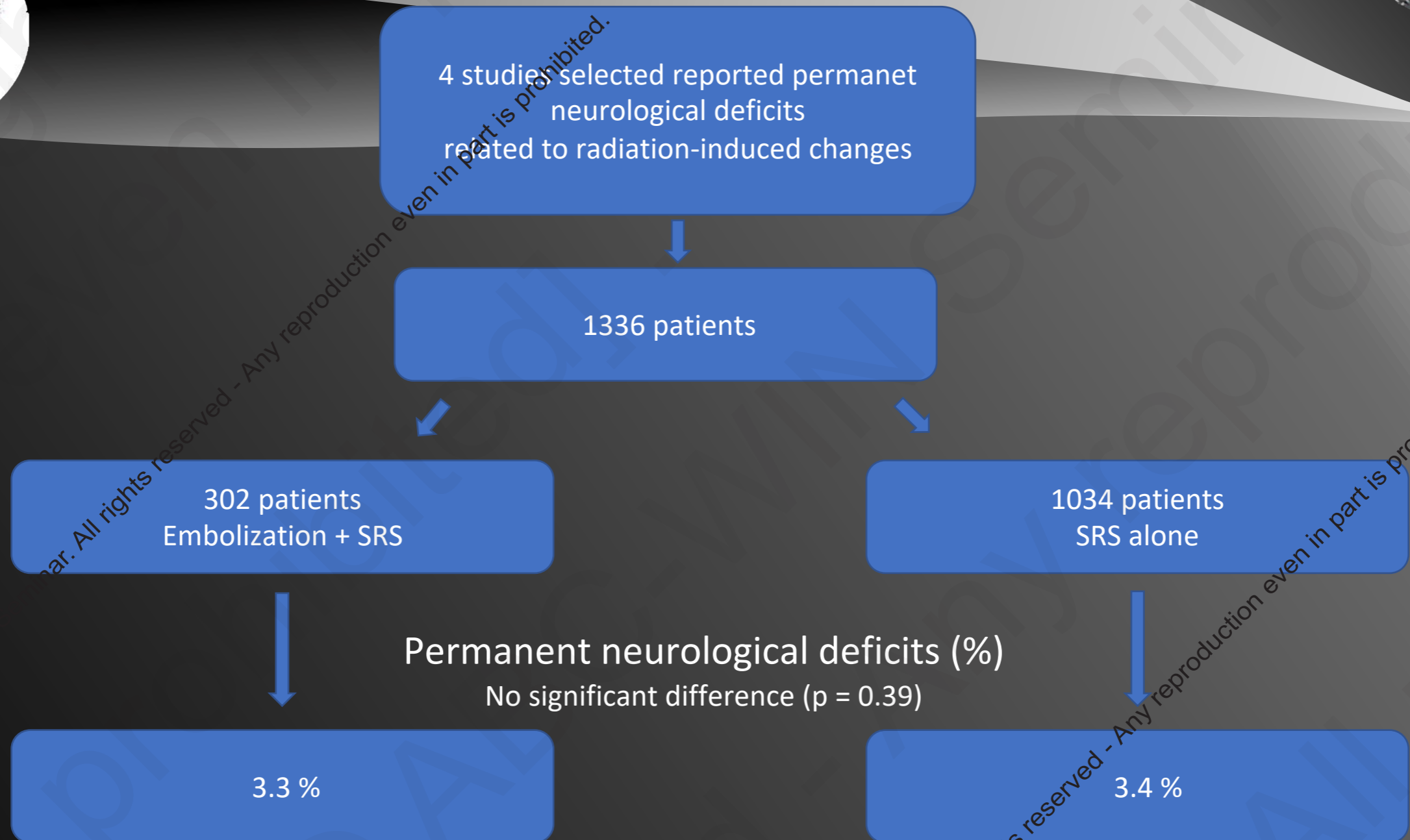
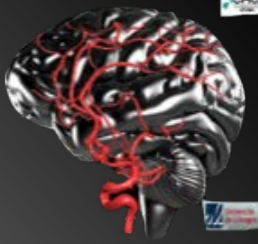


* SRS doses ranged from 16-21 Gy

** 3-year follow-up angiogram

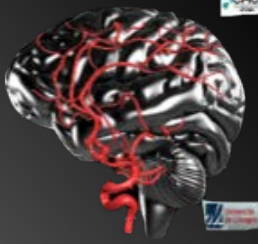


* SRS doses ranged from 16-21 Gy
** Rates of hemorrhage at 3-year



*SRS doses ranged from 16-21 Gy

**3-year follow-up



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Porcelain vein

Nidus size

Arterial Balloon

Could it be partial?

What about the venous ischemia?

Take home message

(ARUBA): a multicentre, non-blinded, randomised trial

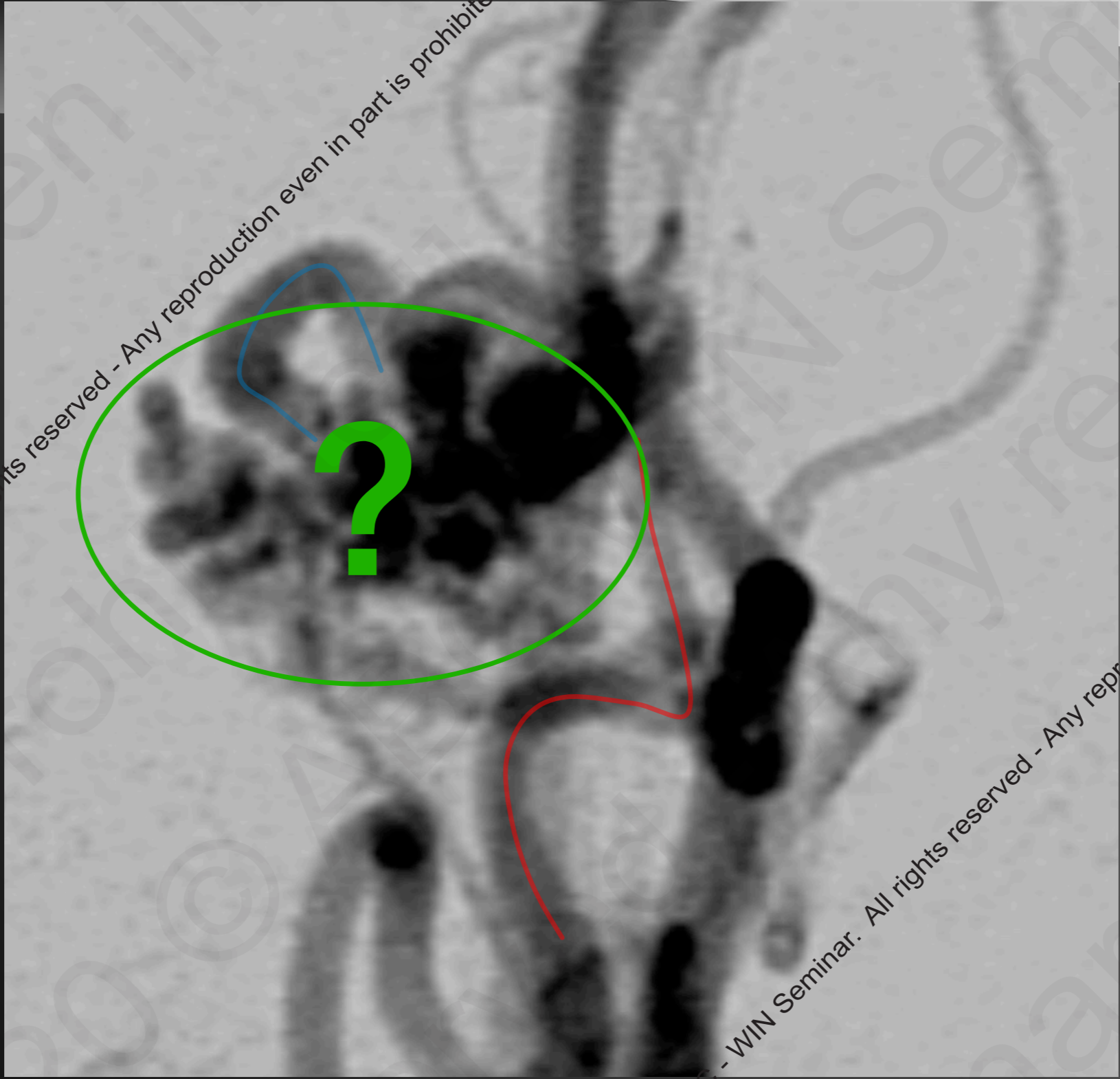
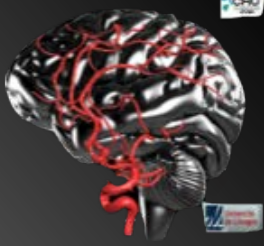
J P Mohr*, Michael K Parides*, Christian Stapf*, Ellen Moquete, Claudia S Moy, Jessica R Overbey, Rostam Al-Shahi Salman, Eric Vicaut, William L Young†, Emmanuël Houdart, Charlotte Cordonnier, Marco A Stefani, Andreas Hartmann, Rüdiger von Kummer, Alessandra Blondi, Joachim Berkefeld, Catarina J M Klijn, Kirsty Harkness, Richard Libman, Xavier Barreau, Alan J Moskowitz, for the international ARUBA investigators‡

Introduction

Brain arteriovenous malformations are diagnosed most often in adults aged about 40 years. Haemorrhage was the usual means of discovery before non-invasive imaging, but in the past three decades such imaging has helped with the detection of brain arteriovenous malformations and the proportion being diagnosed unruptured has almost doubled.^{1,2}

An earlier retrospective series¹ estimated a 4% crude annual rupture rate for brain arteriovenous malformations, but this risk was derived from combined outcomes, including those already having bled. More

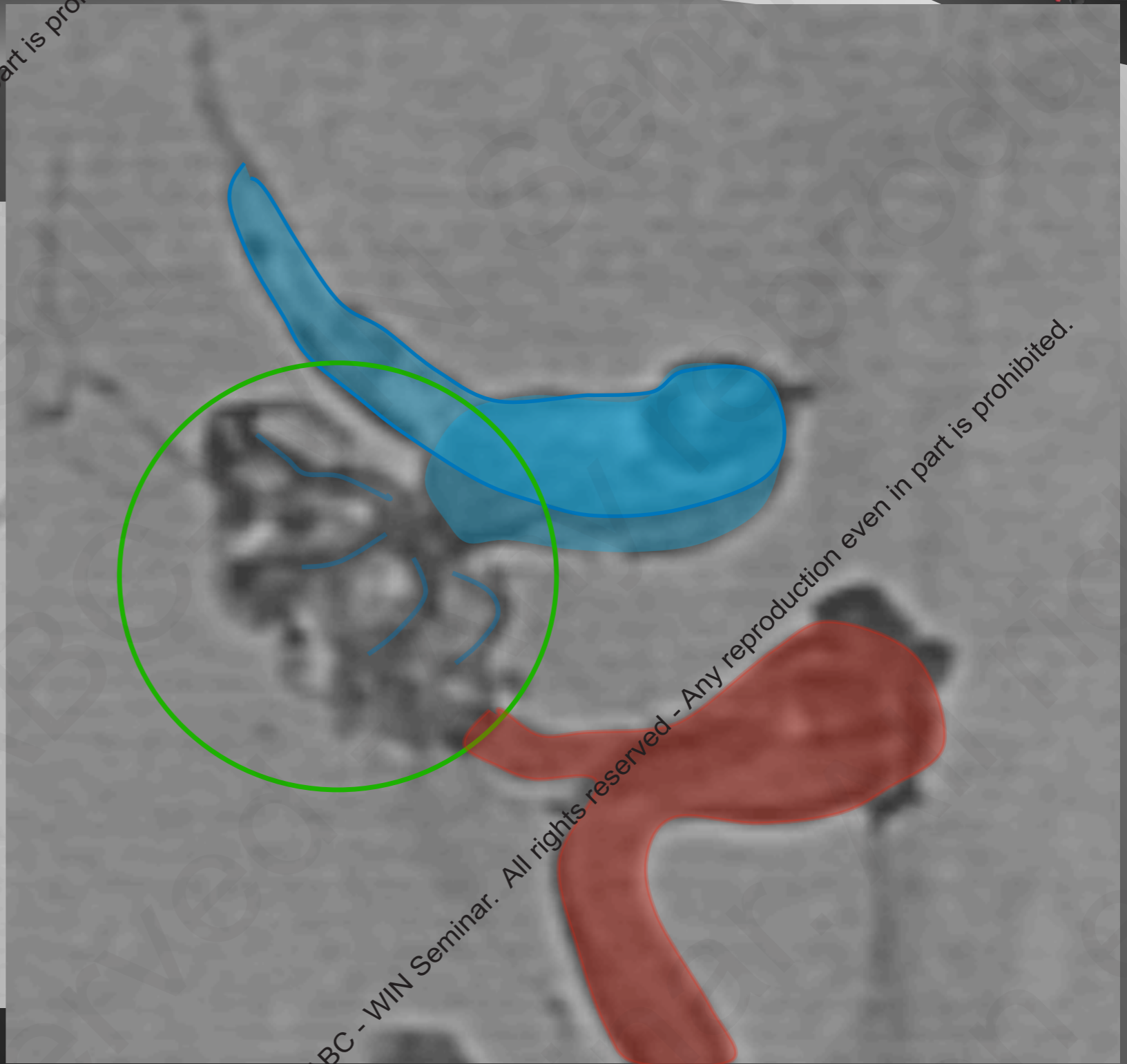
recent prospective studies^{4,5} report bleeding rates as low as 1% per year for those discovered unruptured. Furthermore, first haemorrhage syndromes are often mild, with bleeding often mainly confined to the brain arteriovenous malformation itself or originating from the venous side of the malformation.^{4,7} Approaches to eradicate a brain arteriovenous malformation, bled or not, include various treatment techniques (neurosurgery, endovascular embolisation, and stereotactic radiotherapy) used alone or in combination with varying degrees of treatment-associated morbidity and mortality.^{4,9}



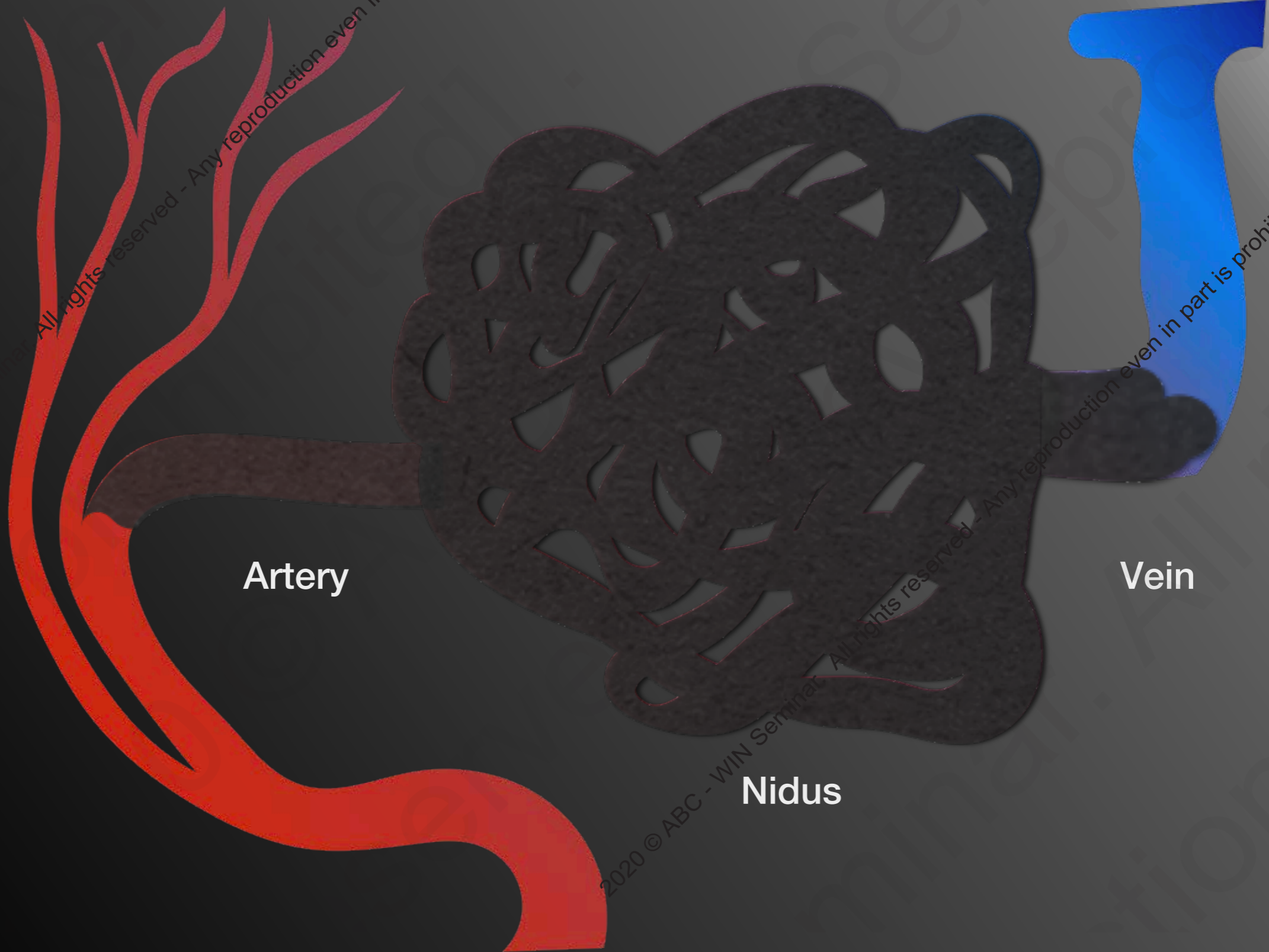
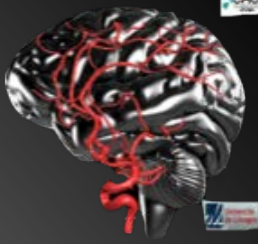
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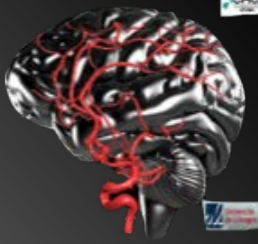
Globus pallidus



Artery

Vein

Nidus



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Liquid agents

Porcelain vein

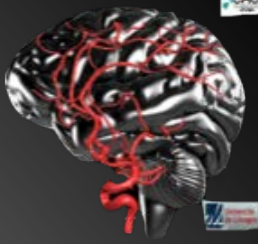
Nidus size

Arterial Balloon

Could it be partial?

What about the venous ischemia?

Take home message



ORIGINAL RESEARCH

Neurological outcomes and cure rates of embolization of brain arteriovenous malformations with n-butyl cyanoacrylate or Onyx: a meta-analysis

Abdussalam Elsenousi, Victor A Aletich, Ali Alaraj

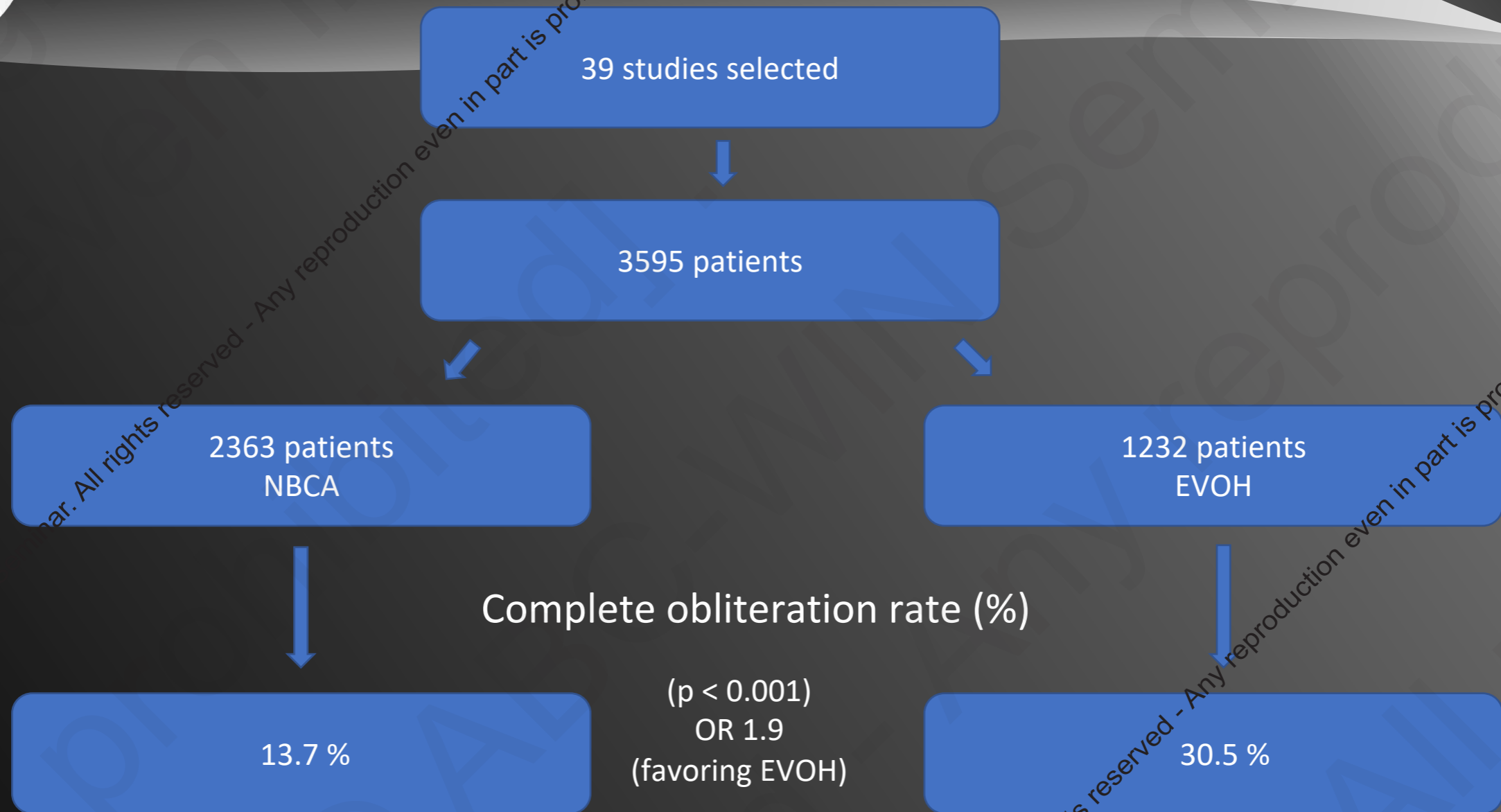
Arterial approach

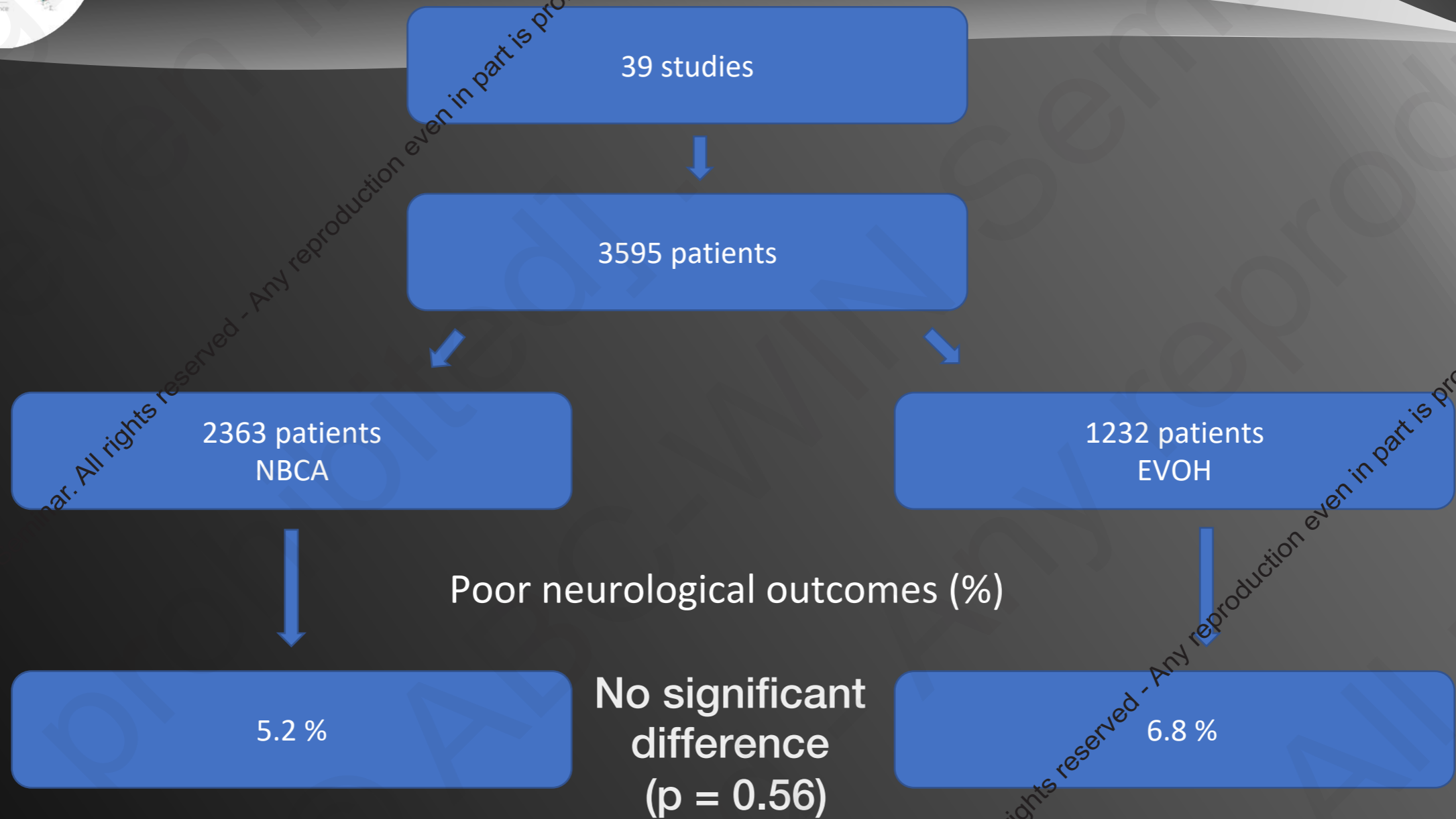
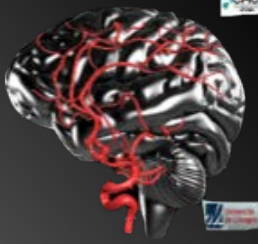
Department of Neurosurgery,
University of Illinois at
Chicago, Chicago, Illinois, USA

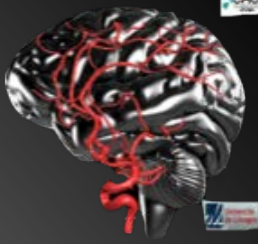
* Not specific about BG AVM (general bAVMs)

** January 1980 – November 2013

Elsenousi A, et al. J NeuroIntervent Surg 2014;0:1–8.







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➤ Adhesive VS non-adhesive LA

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Porcelain vein

Arterial retrograde filling control

Nidus size

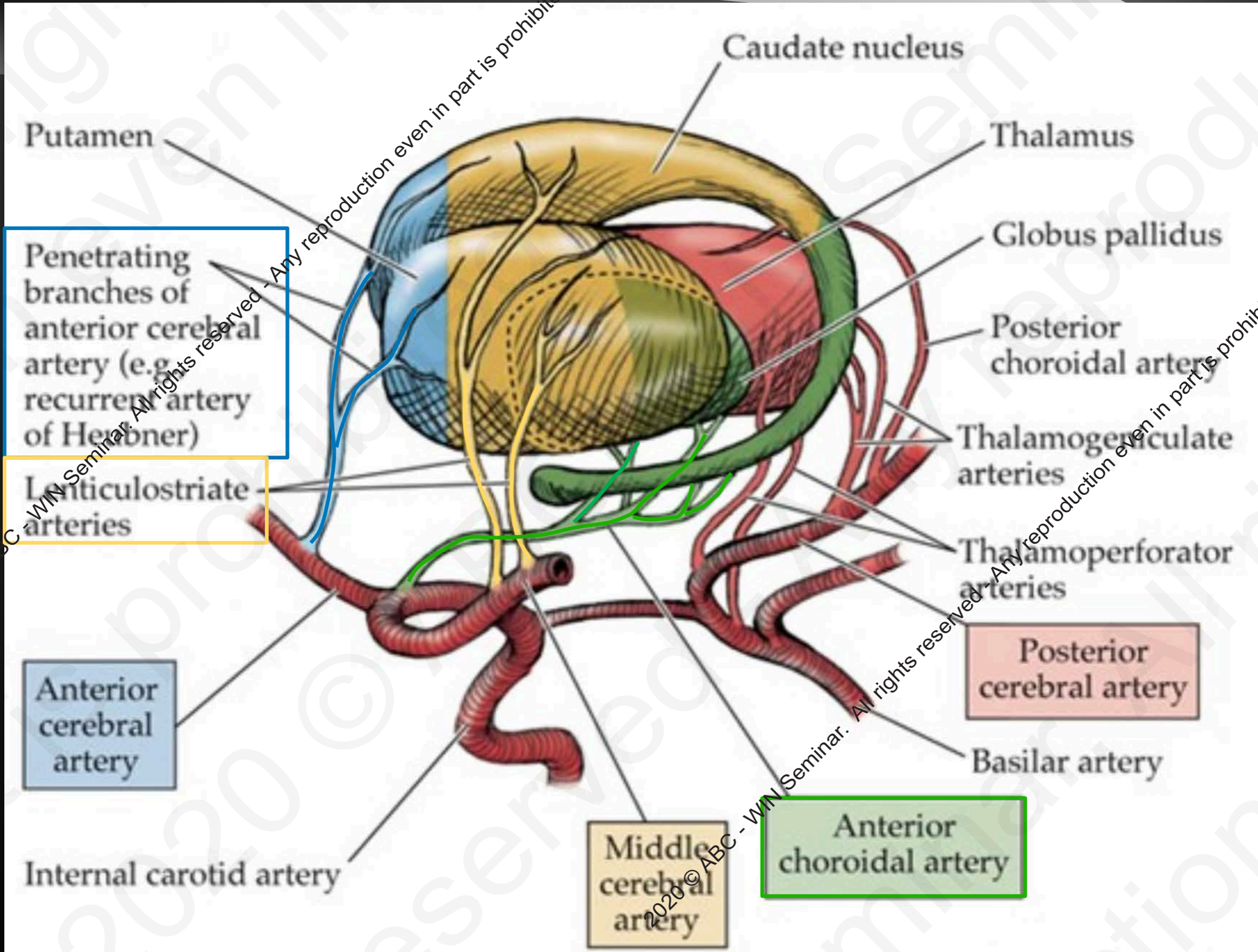
Arterial Balloon

Could it be partial?

What about the venous ischemia?

Take home message

Terminal



Putamen

Caudate nucleus

Thalamus

Penetrating branches of anterior cerebral artery (e.g. recurrent artery of Heubner)

Globus pallidus

Lenticulostriate arteries

Posterior choroidal artery

Thalamogeniculate arteries

Thalamoperforator arteries

Posterior cerebral artery

Anterior cerebral artery

Basilar artery

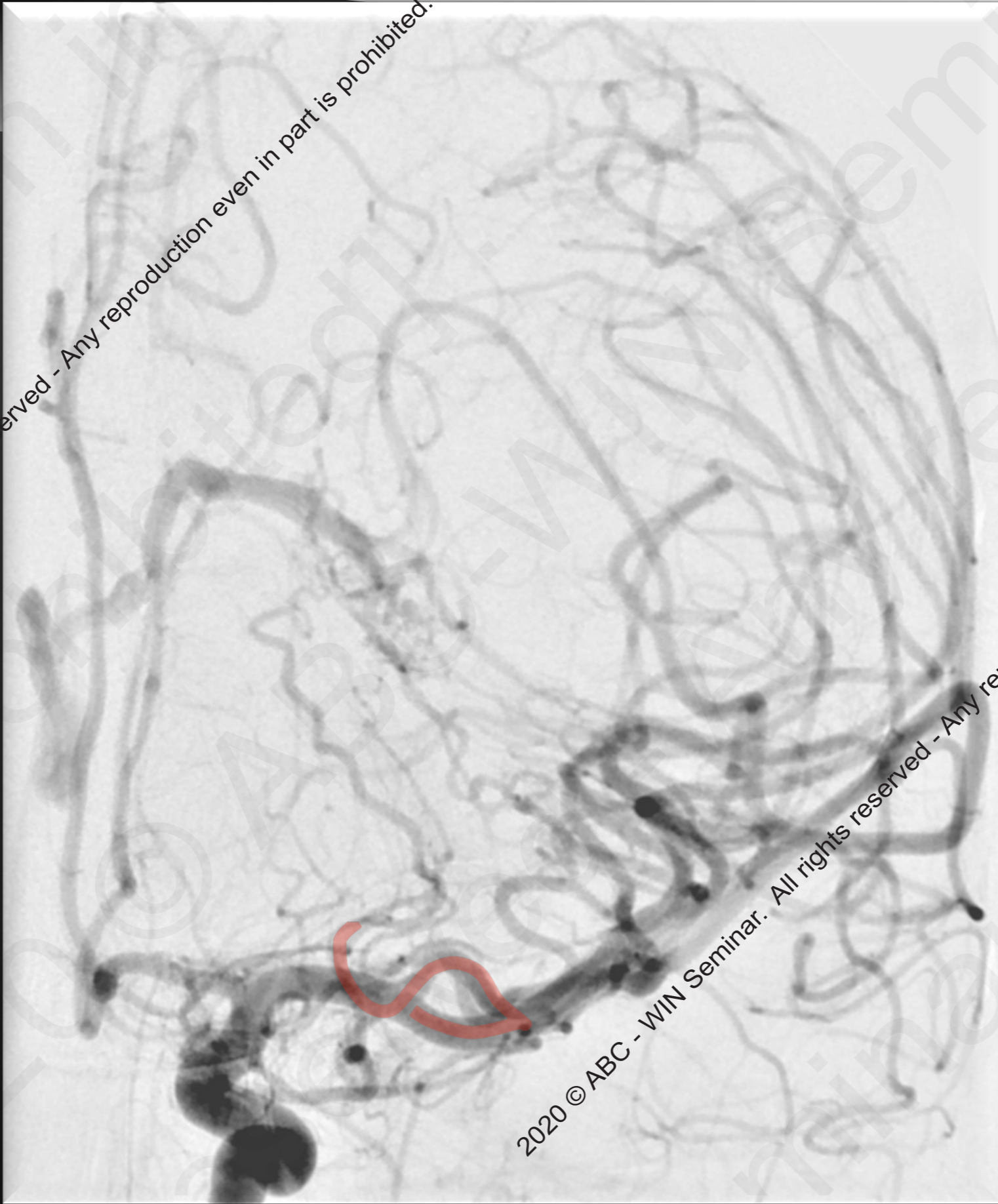
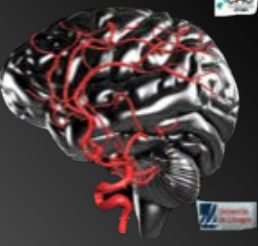
Internal carotid artery

Middle cerebral artery

Anterior choroidal artery



Tortuous



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Thin



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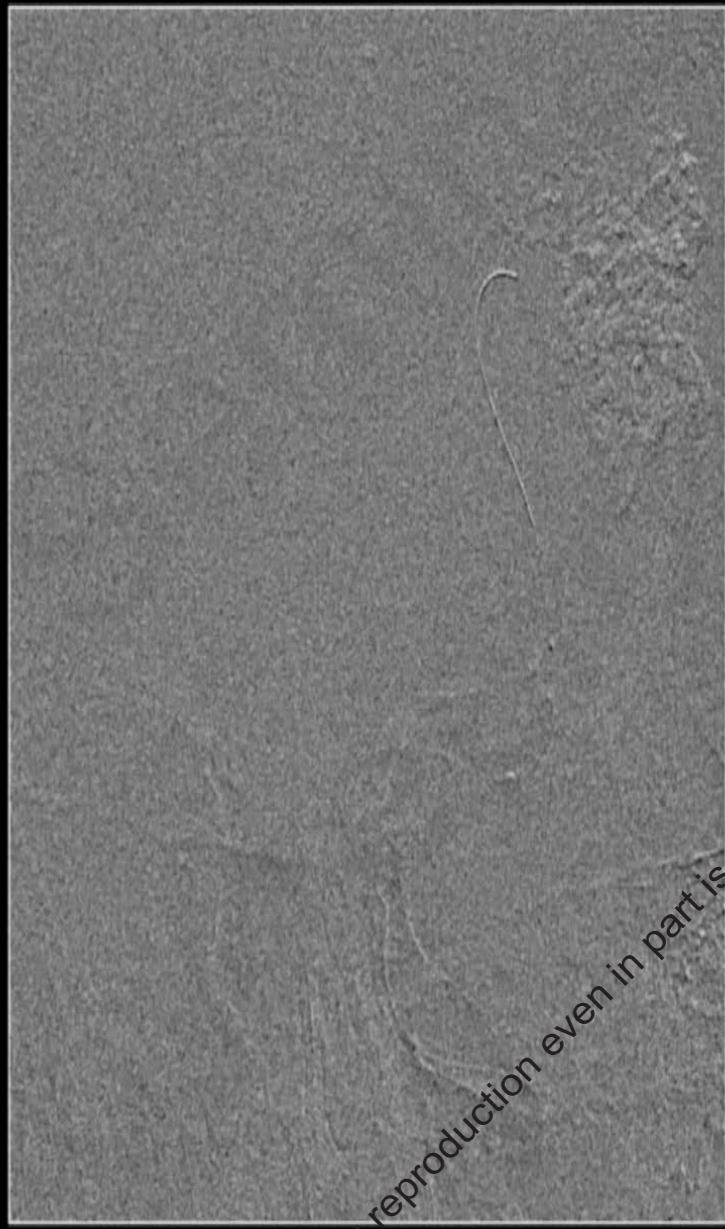
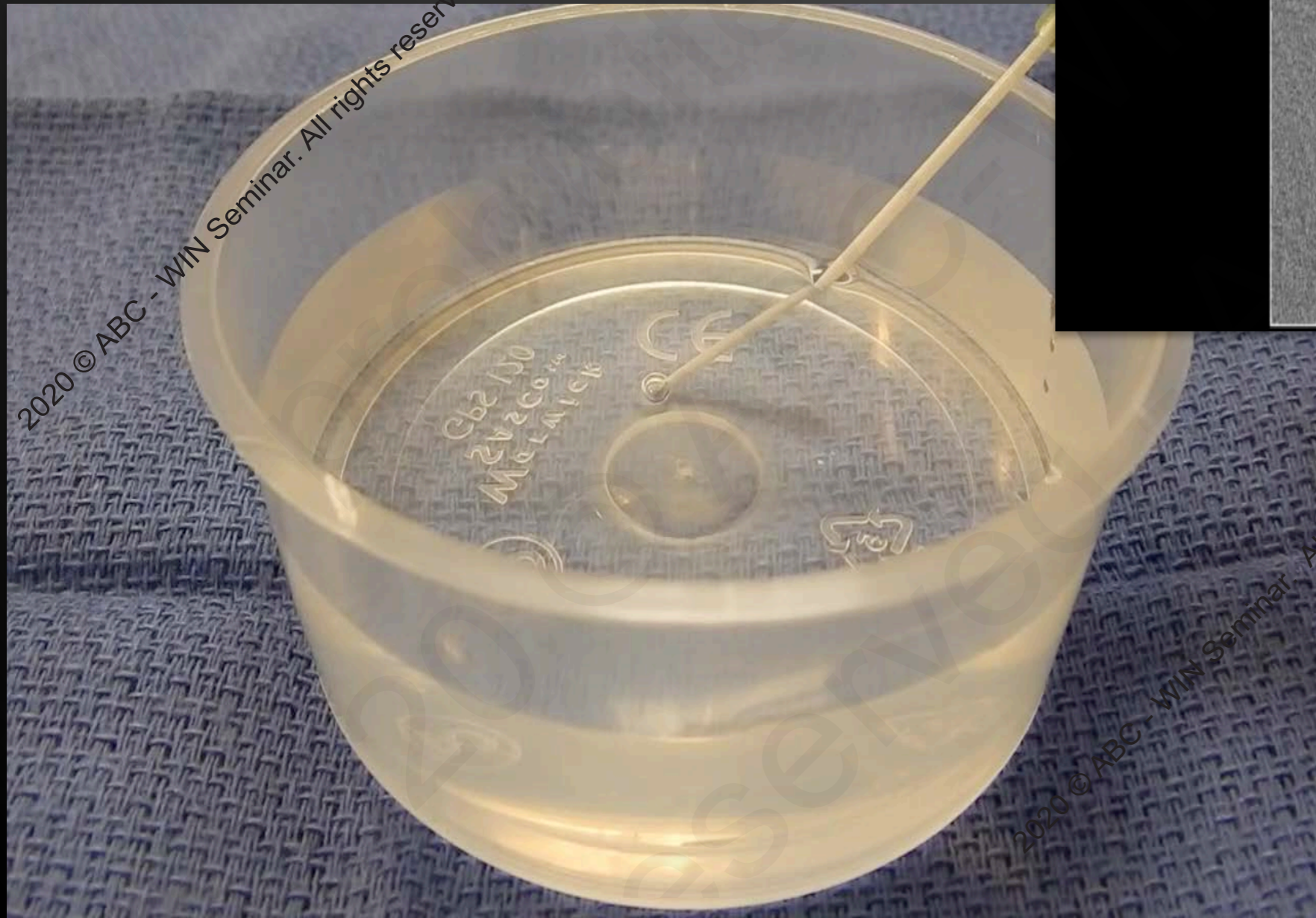
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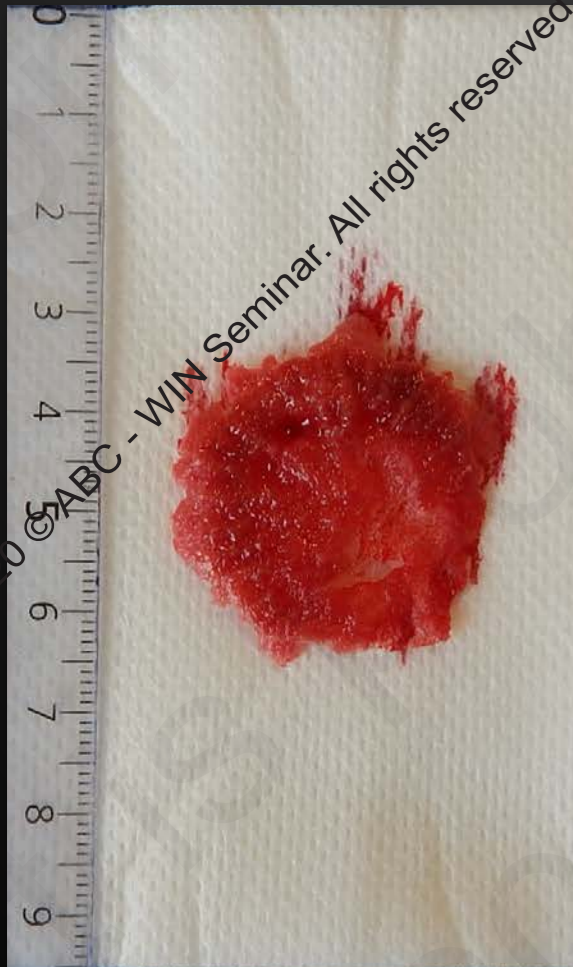
NBCA



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0,5 cc of the EMBOLIC AGENTS inside blood



Glue: 50%



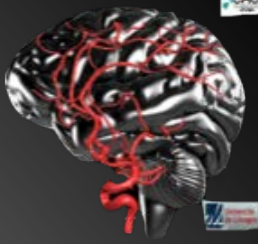
Glue: 20%



Onyx 18™



PHIL™

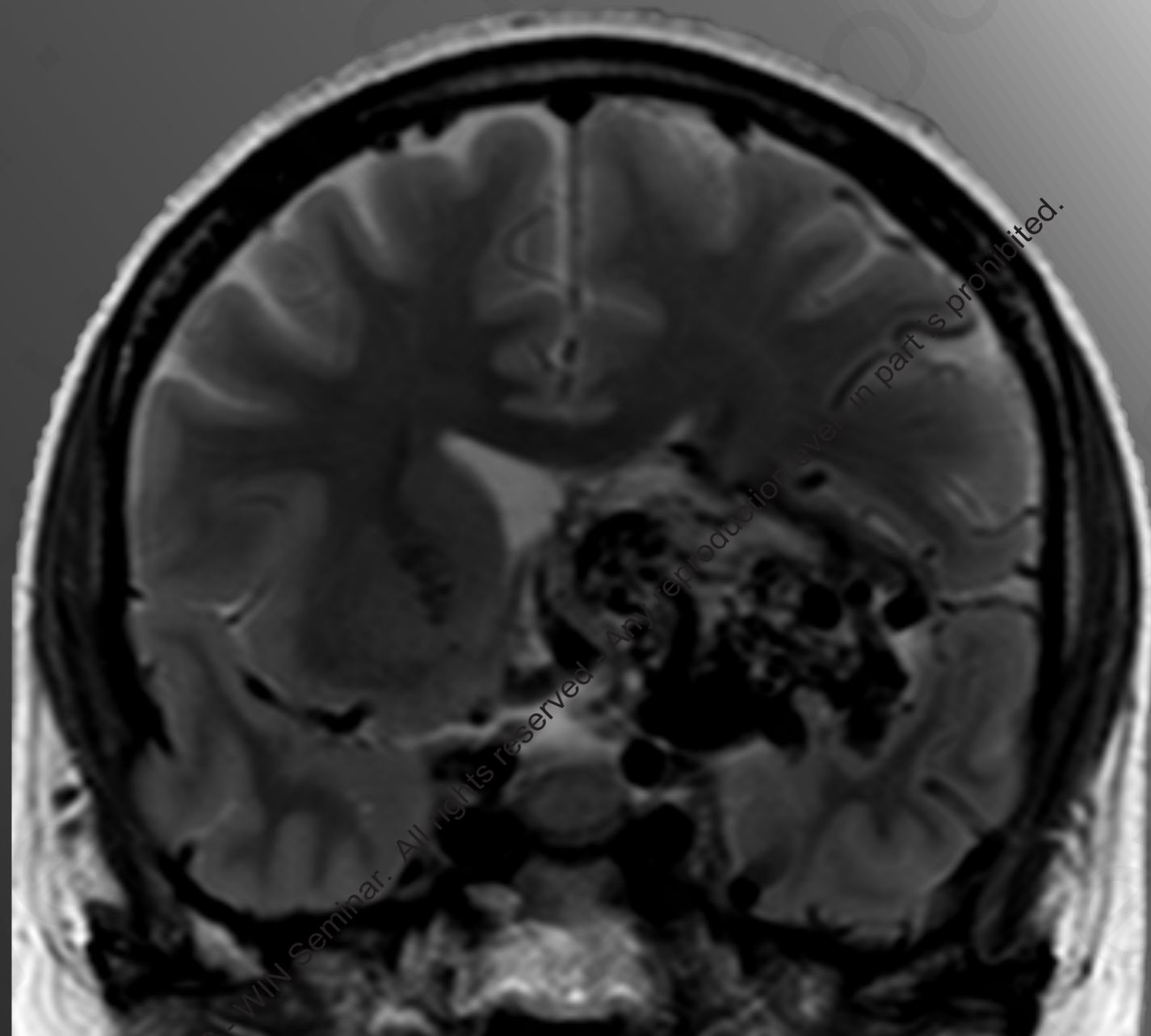
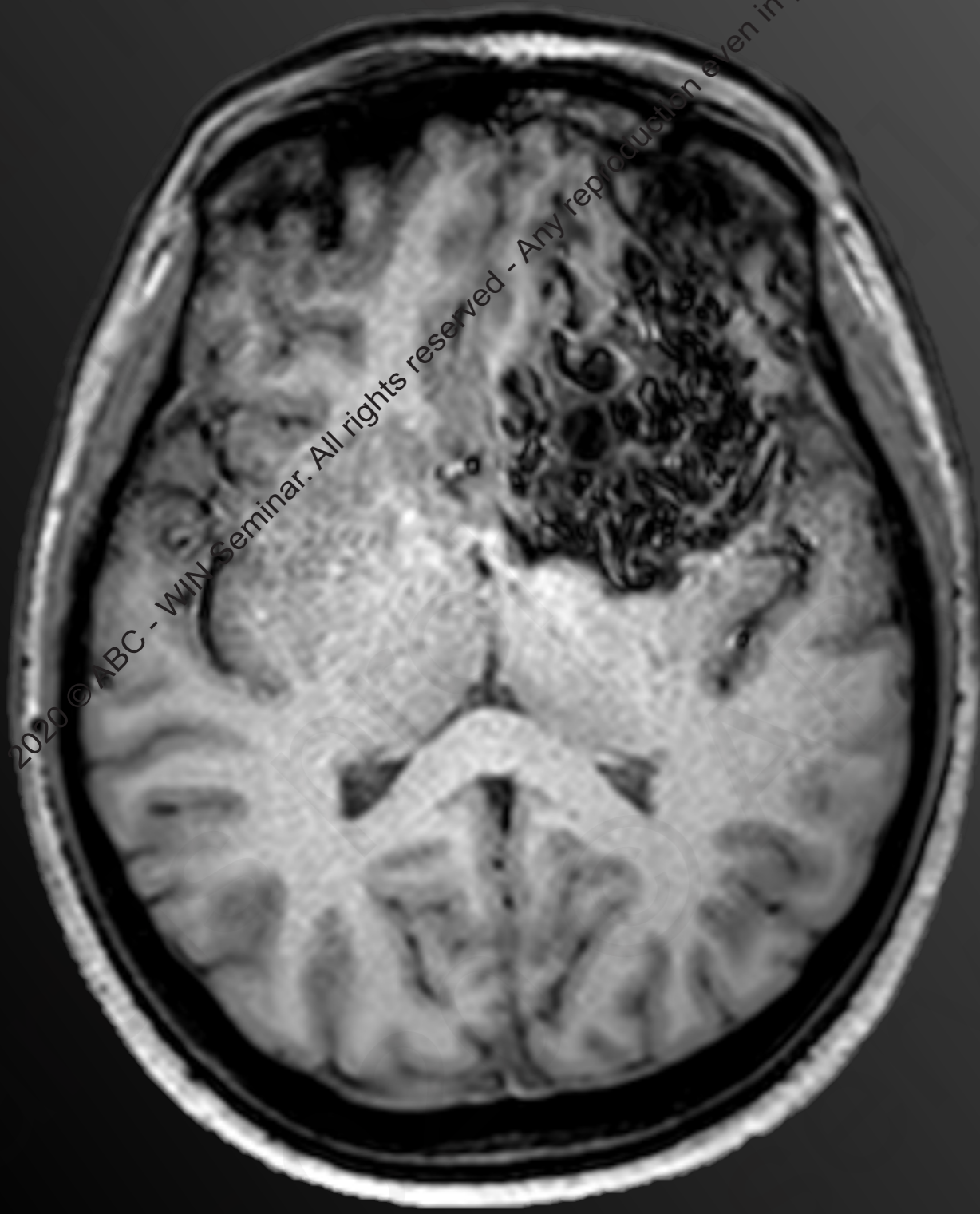


Risk of Reflux → Arterial Ischemia



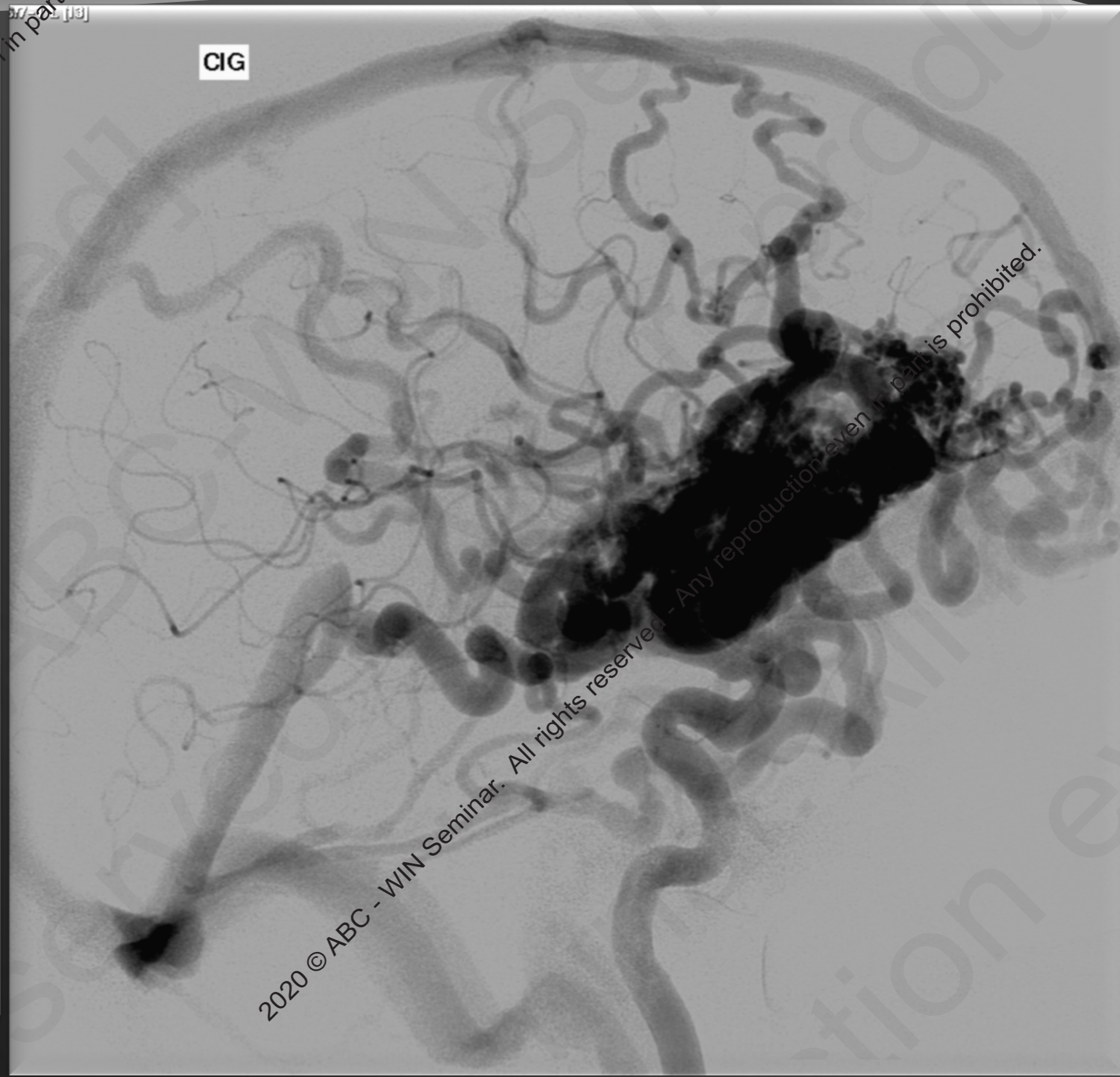
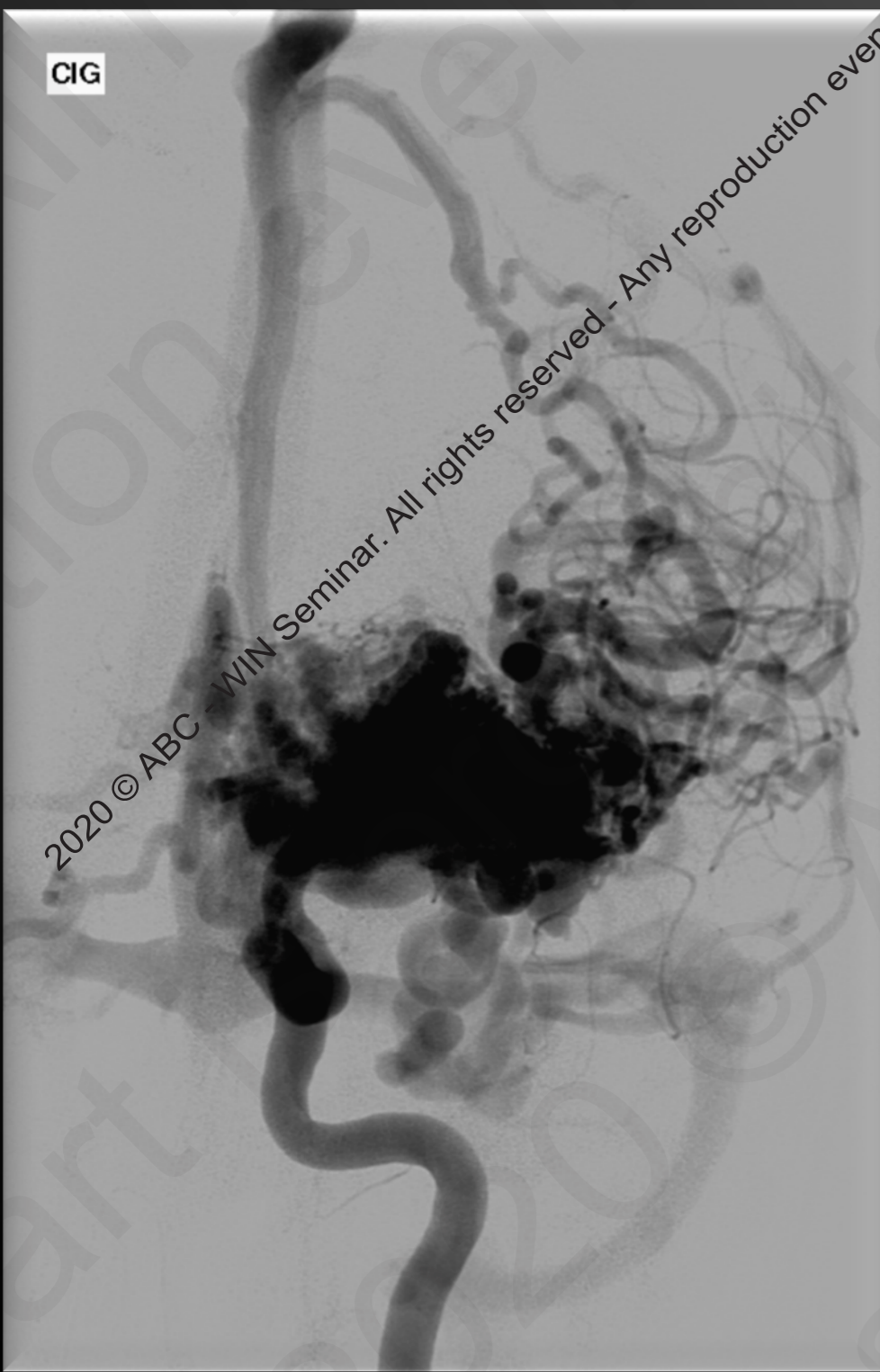


Large AVM – Accessible Arteries

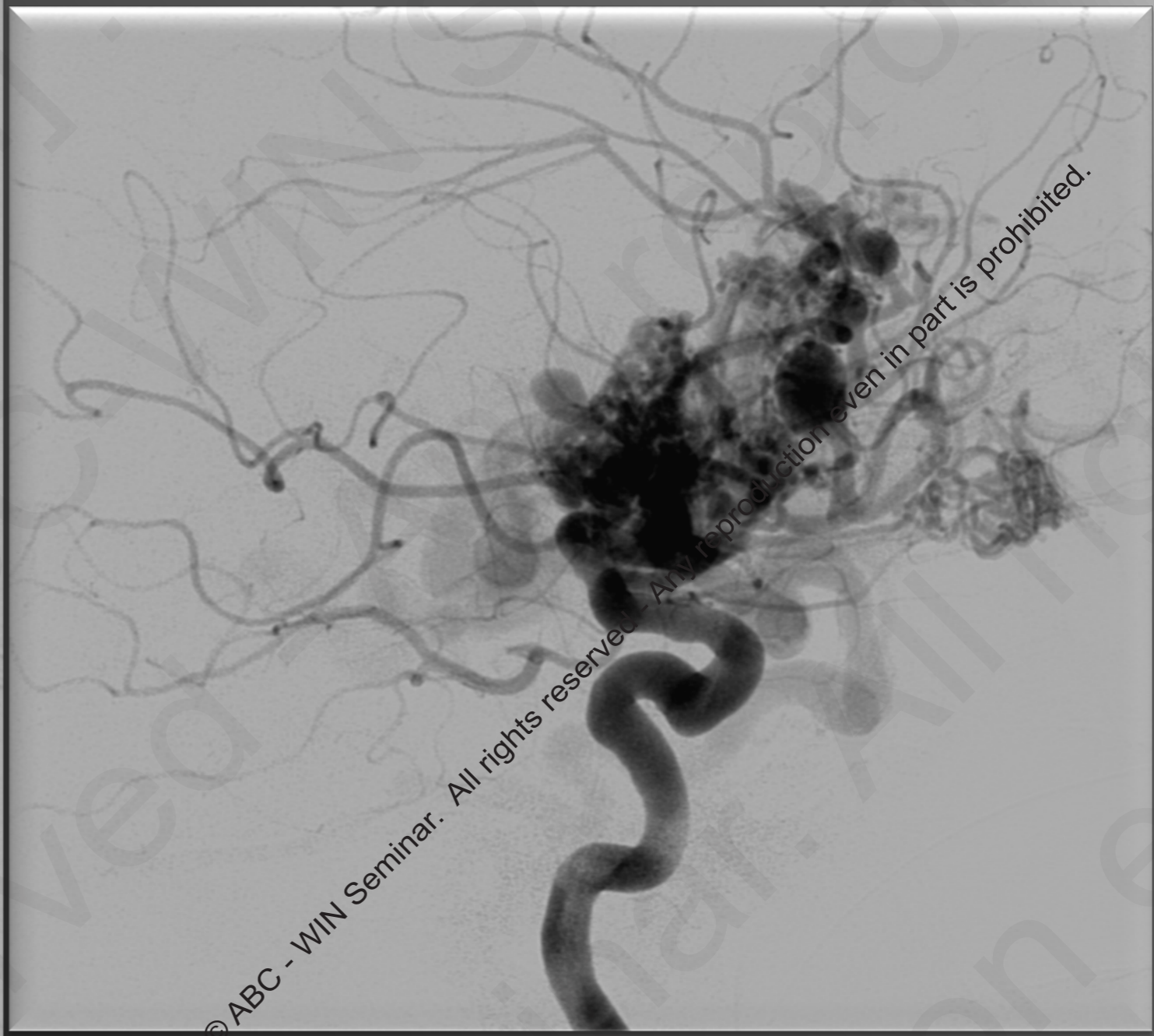




Large AVM – Accessible Arteries

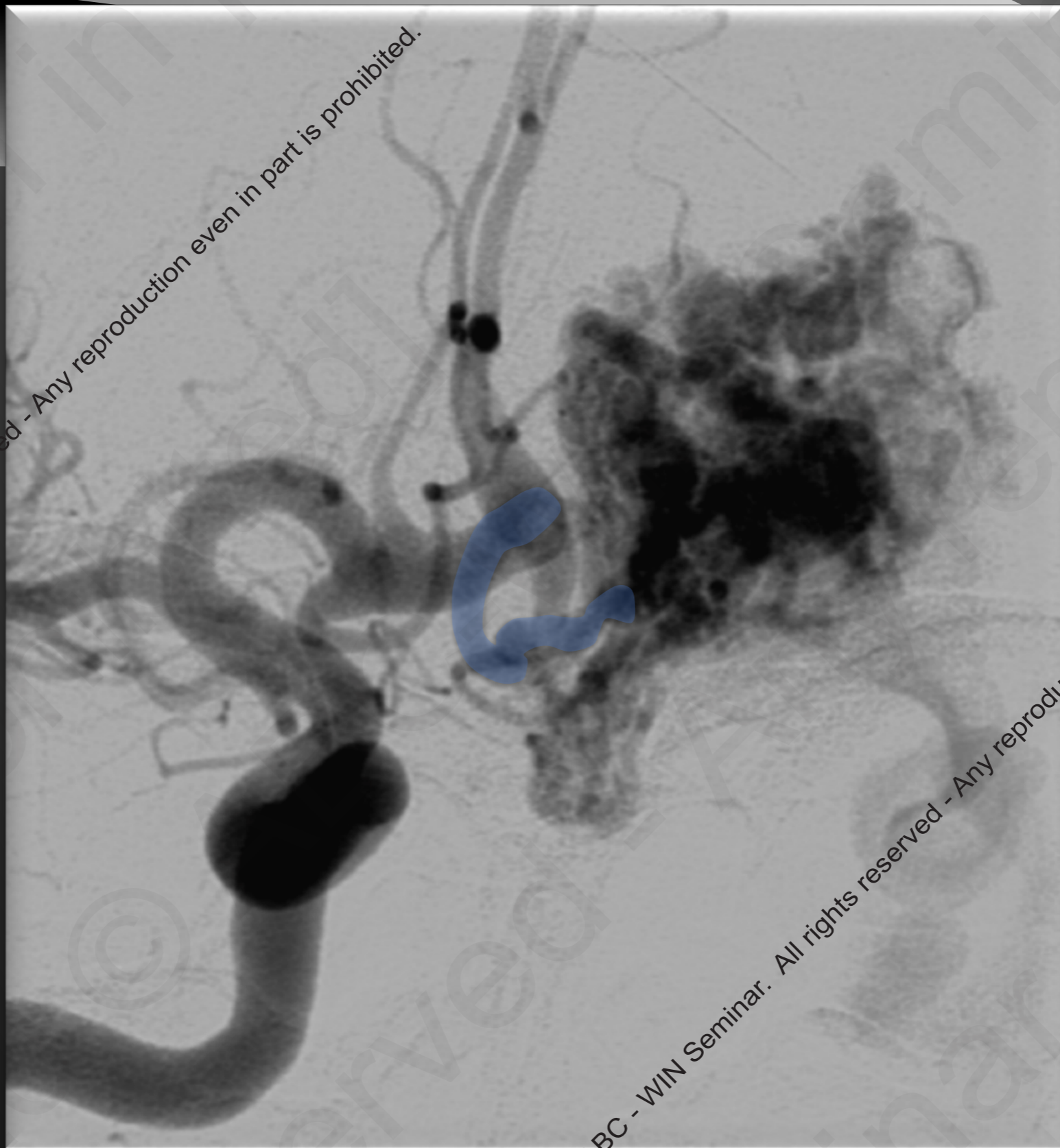


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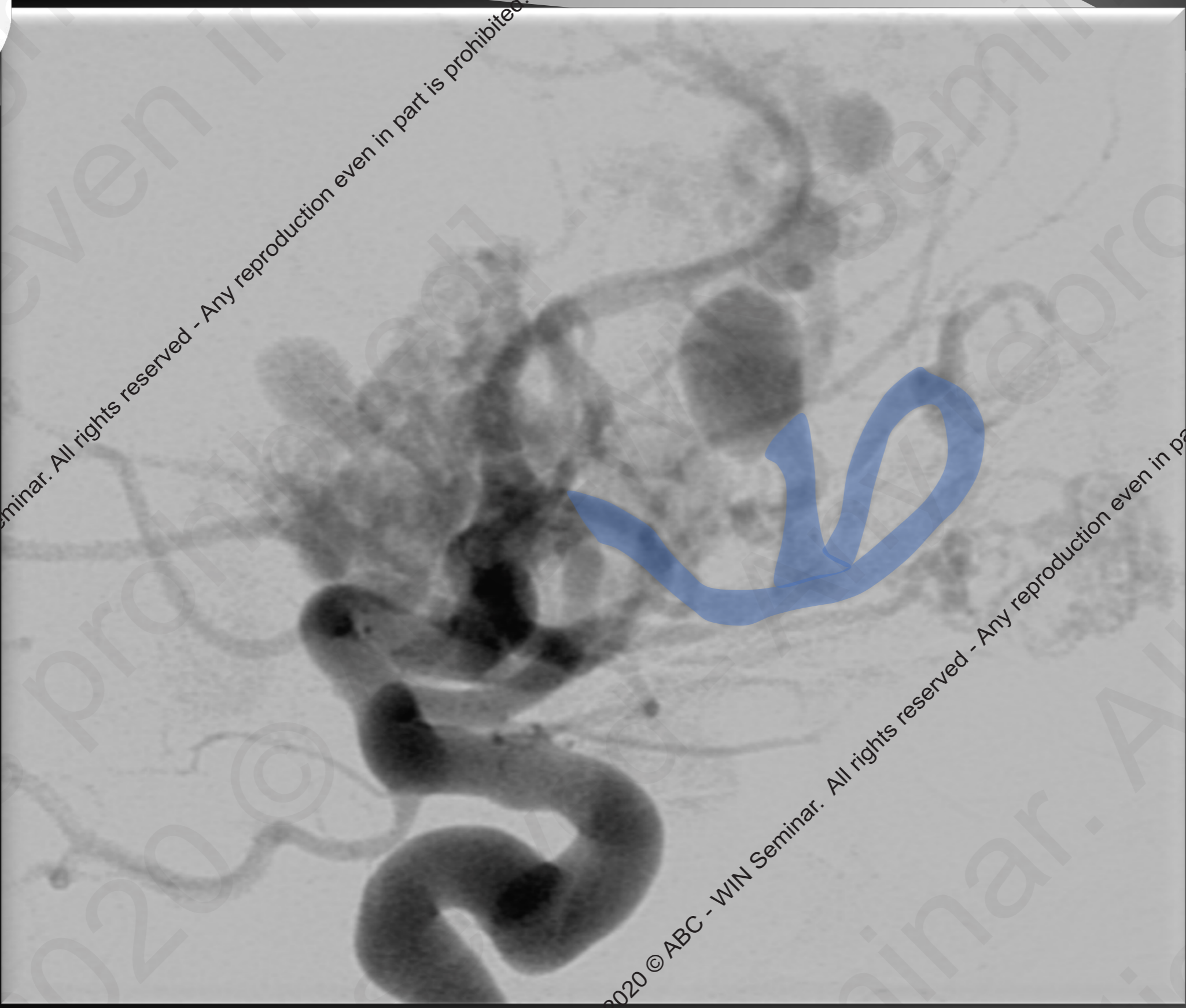
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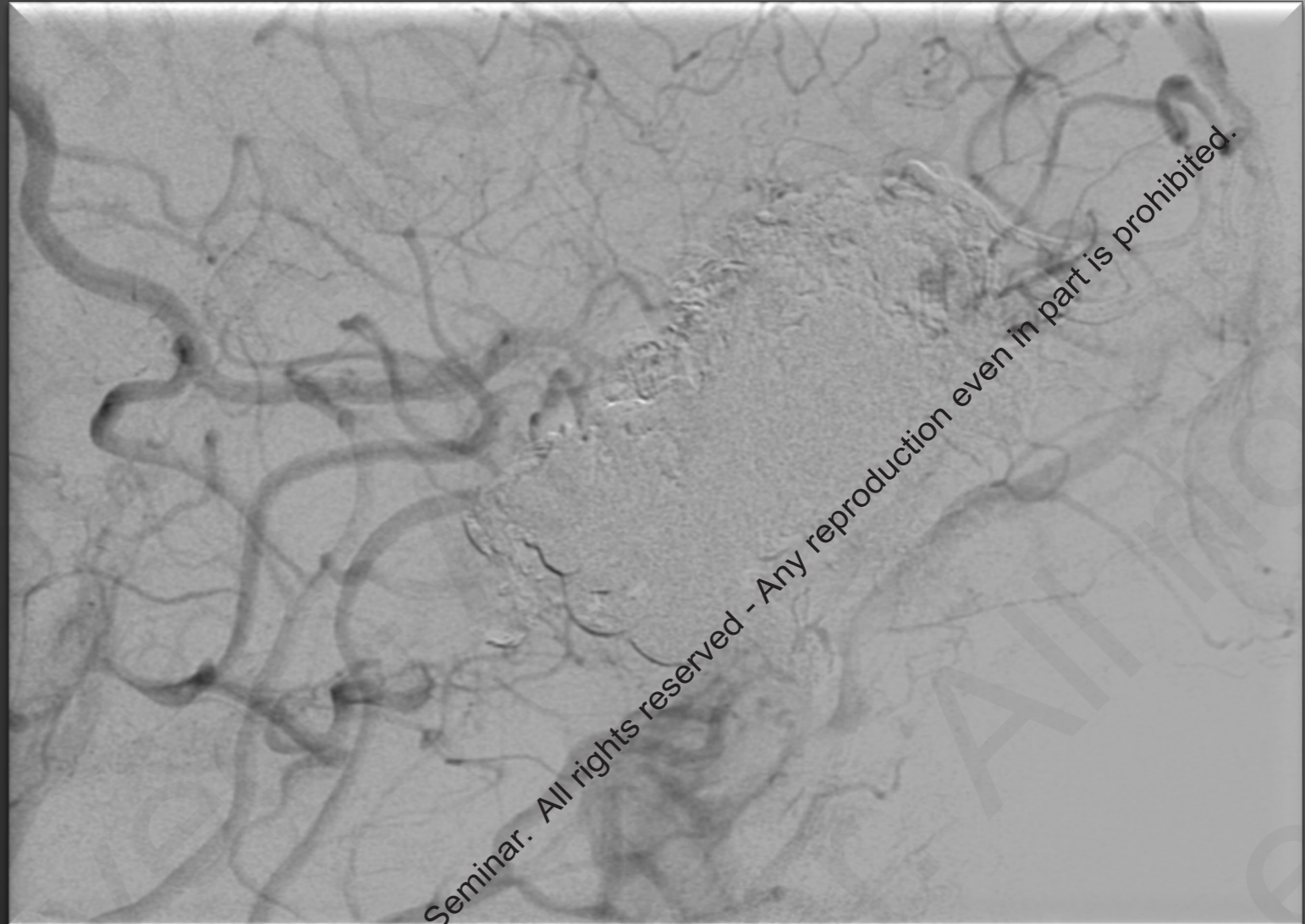
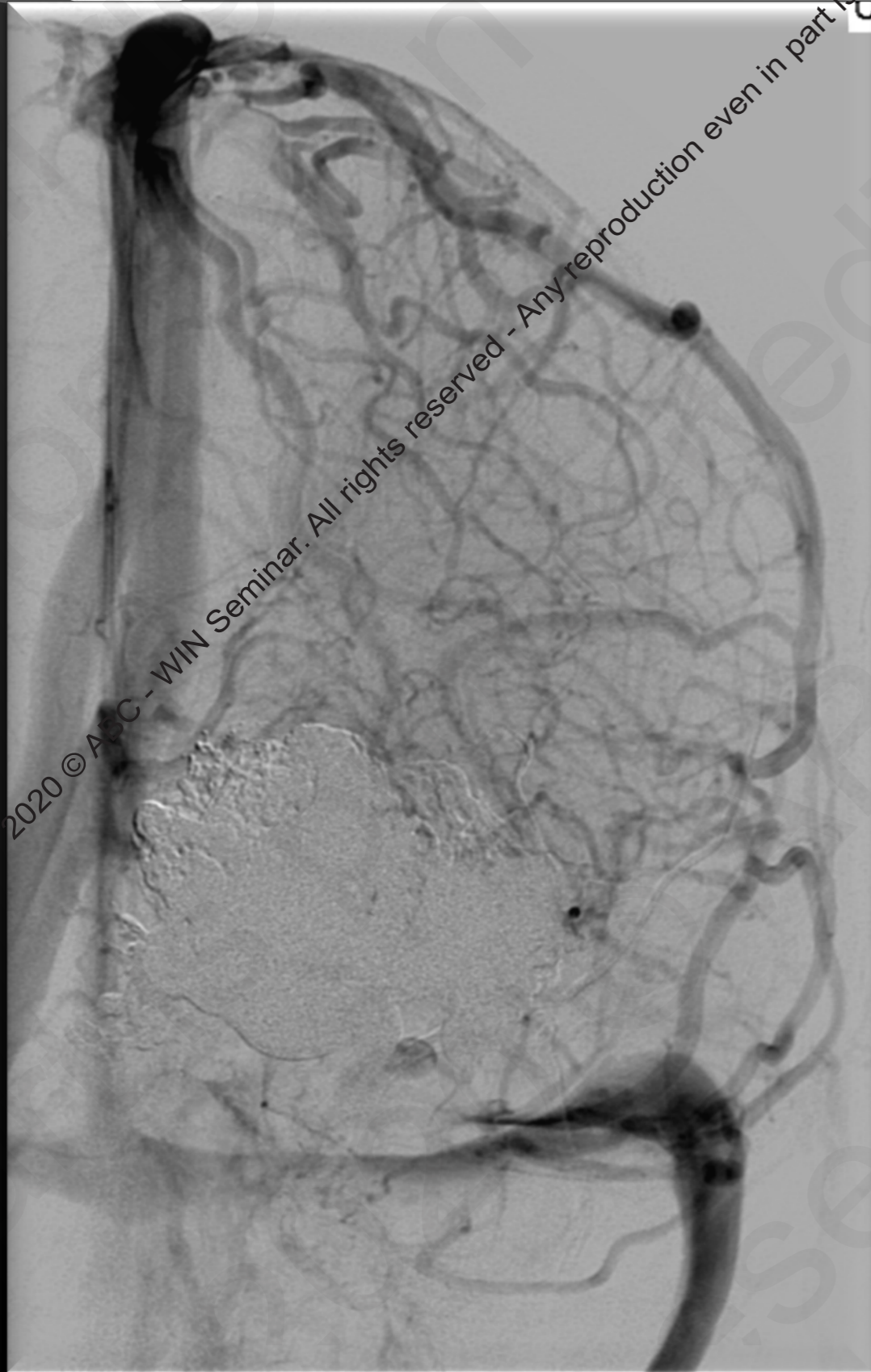
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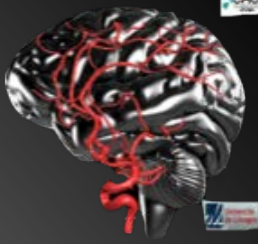
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➤ Limitations

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Porcelain vein

Nidus size

Arterial Balloon

Could it be partial?

What about the venous ischemia?

Take home message



Our Initial indication

- Ruptured AVM
- Deep located
- Limited nidus
- Deep and single draining vein
- Last therapeutic option

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

Iruena Kessler, MD, PhD*
 Roberto Riva, MD†
 Maria Ruggiero, MD‡
 Monica Manisor, MD‡
 Maher Al-Khawaldeh, MD‡
 Charbel Mounayer, MD, PhD‡

*Department of Interventional Neuroradiology, University of Brasilia, Brasilia, Brazil;
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 Published Online, February 23, 2011.

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 Congress of Neurological Surgeons

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.

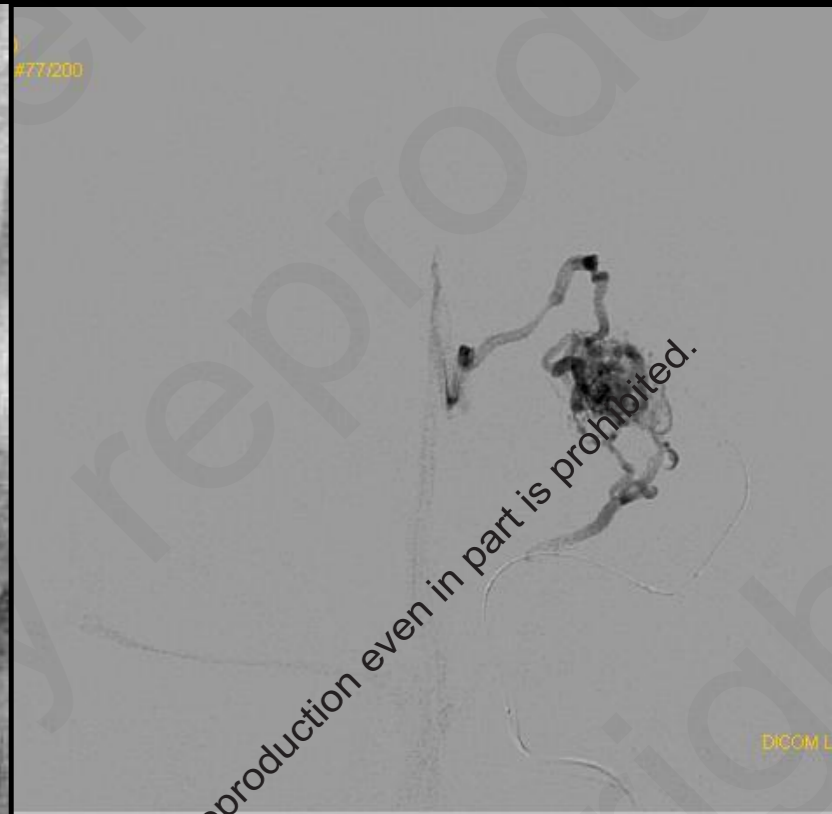
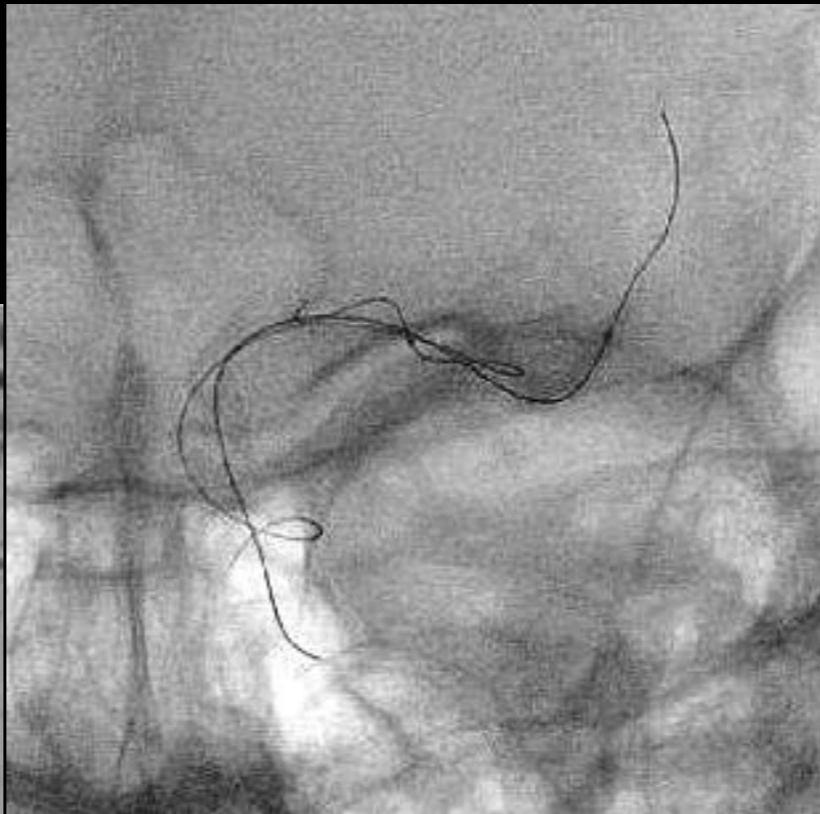
CONCLUSION: The transvenous approach using Onyx for the management of BAVMs is shown to be an efficient and safe alternative treatment in cases with no other conventional therapeutic choice and when some anatomic considerations are respected.

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

Neurosurgery 69:184-193, 2011 DOI: 10.1227/NEU.0b013e3182126634 www.neurosurgery-online.com



..... Arterial catheterization is impossible



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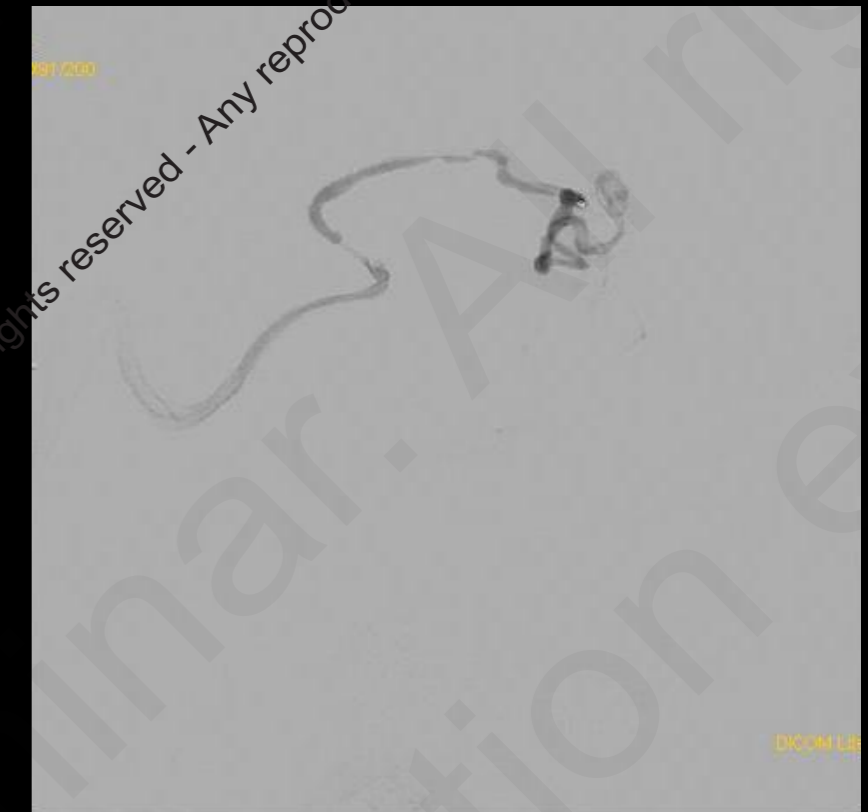
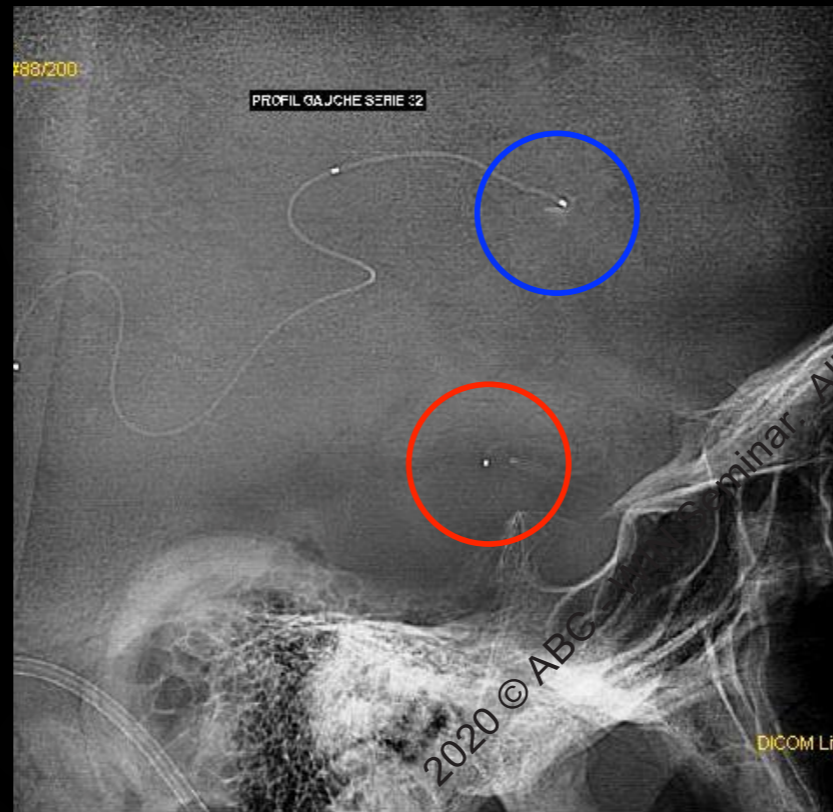
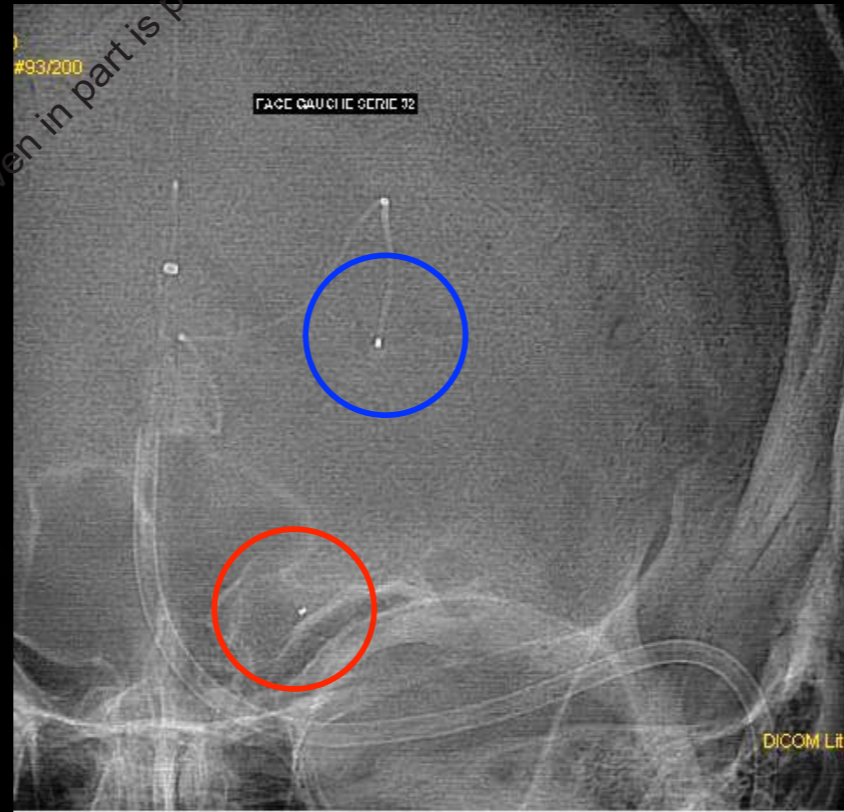
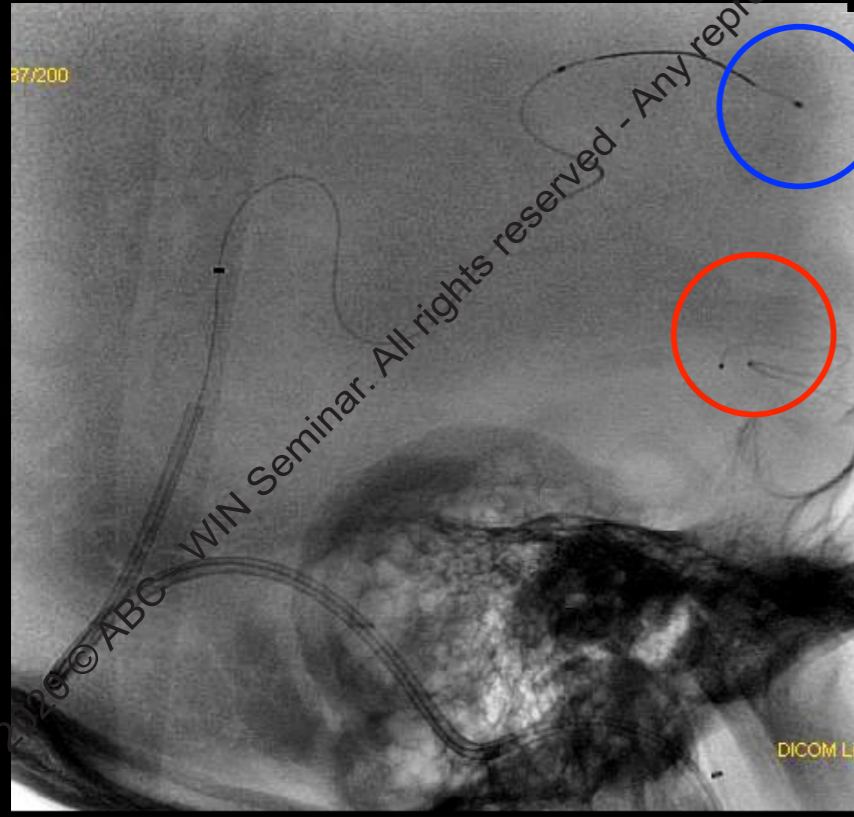
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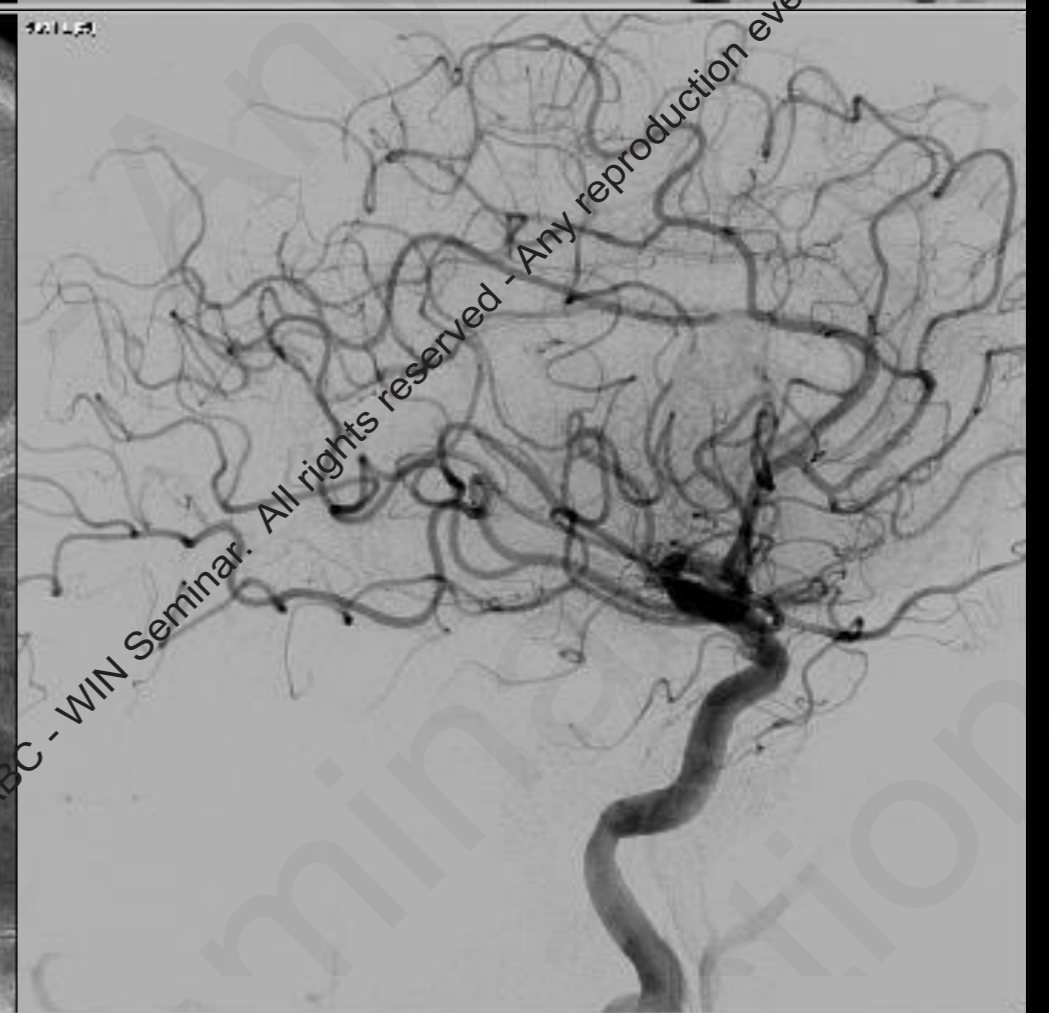
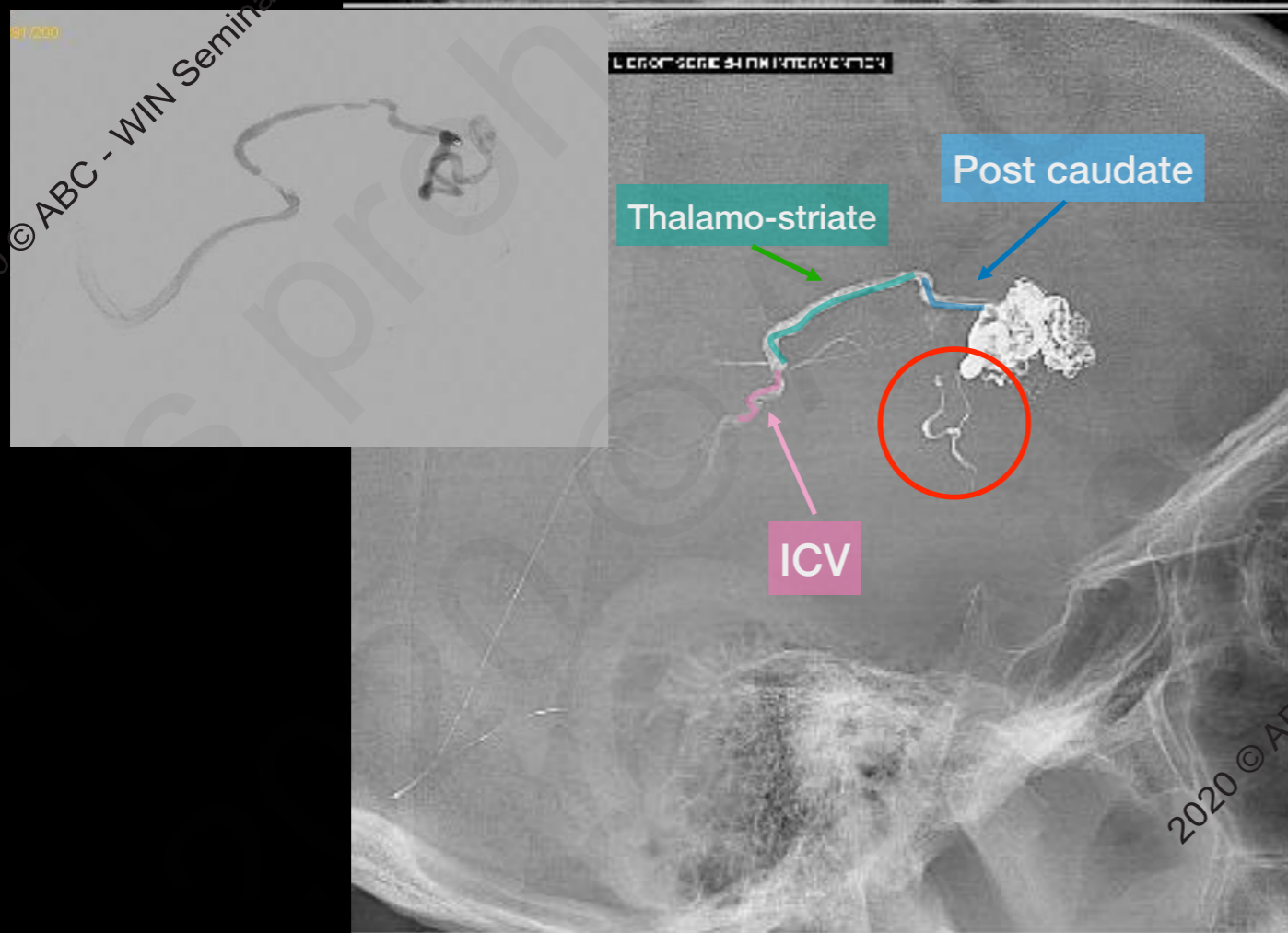
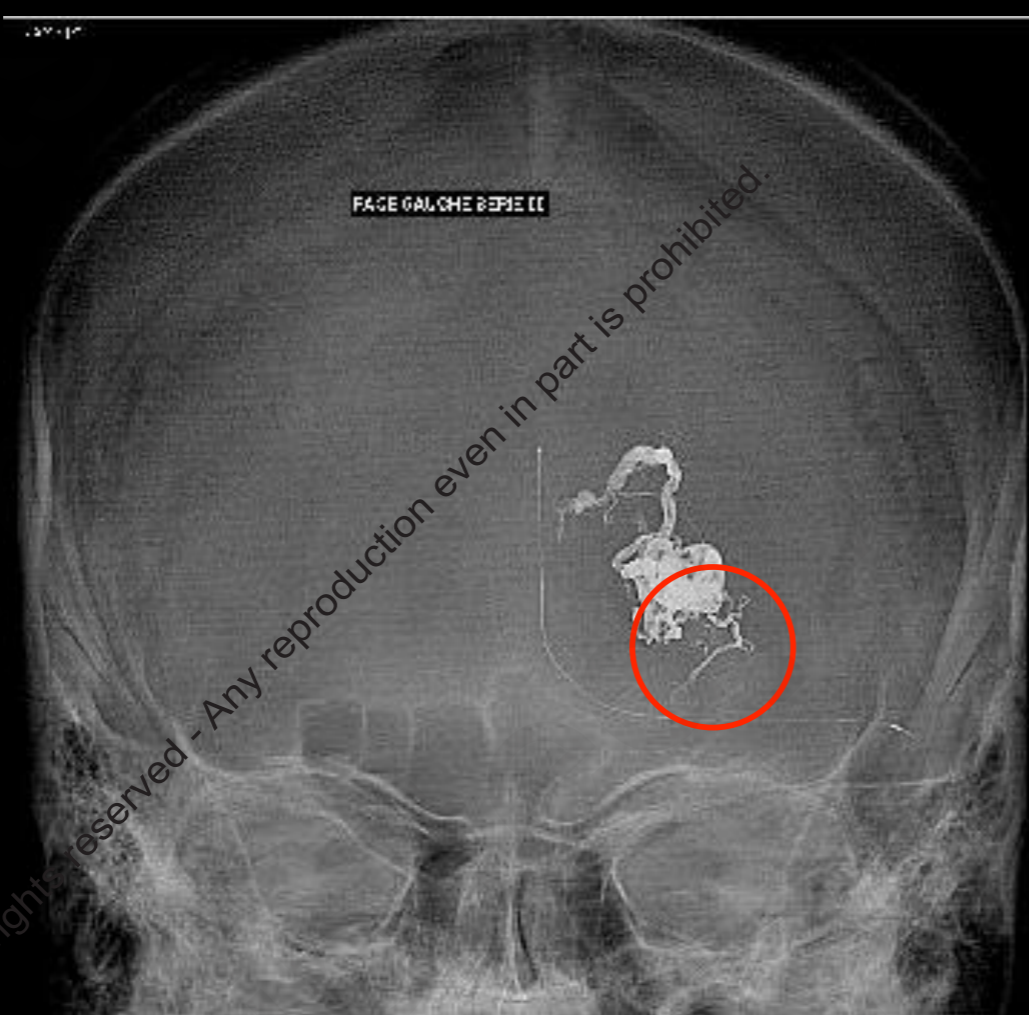
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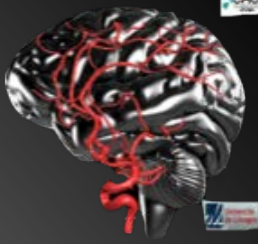
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Venous approach?.....







Introduction

Principles of AVM/EVT

➤ Arterial approach for BG AVM:

Adhesive VS non-adhesive LA

Limitations

Introduction to the venous approach

Venous approach for BG AVM

Engage in debate

Liquid agents

Porcelain vein

Nidus size

Arterial Balloon

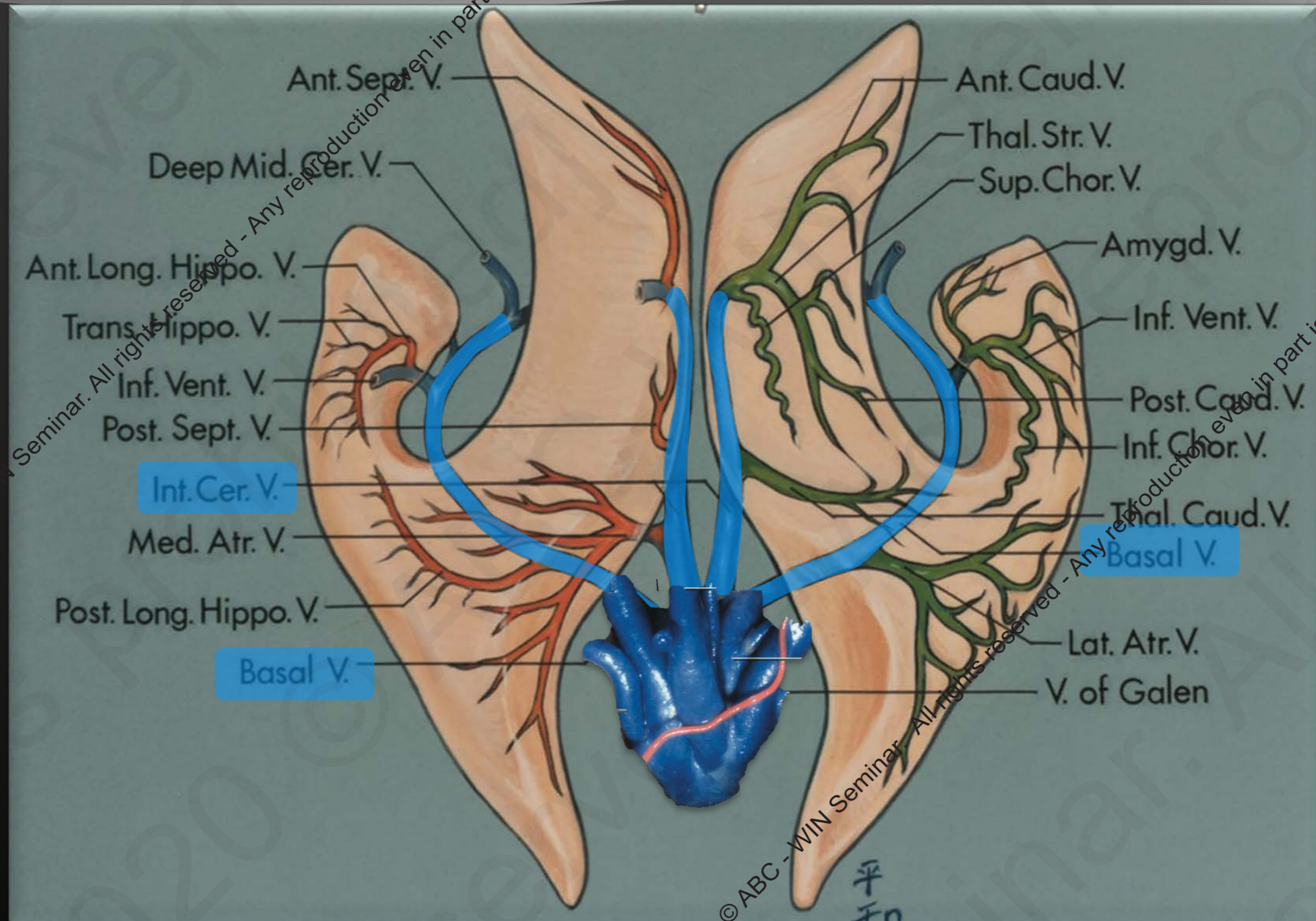
Could it be partial?

What about the venous ischemia?

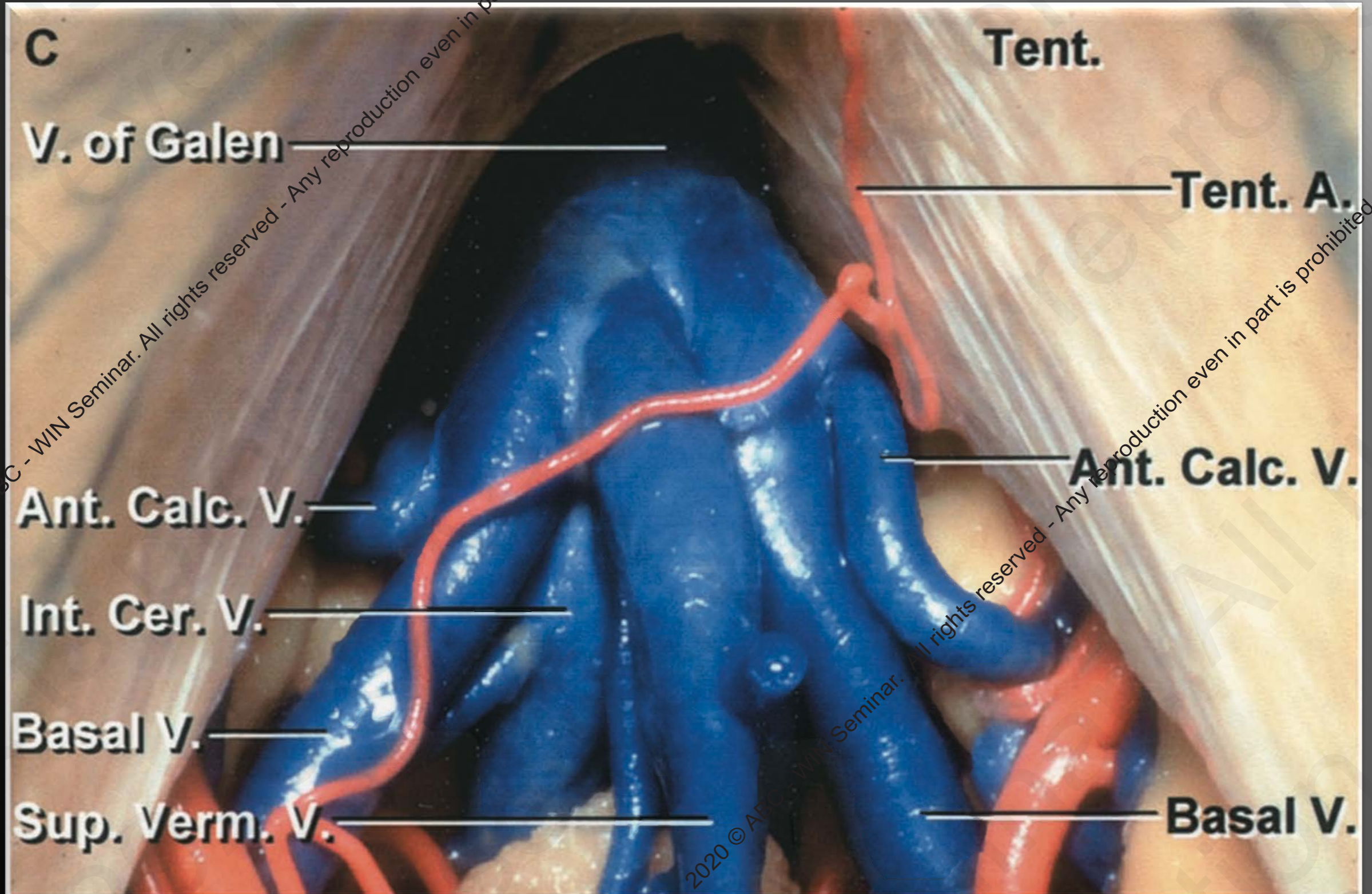
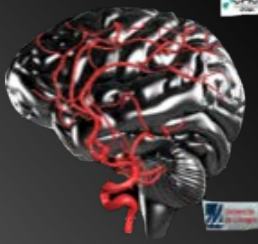
Take home message



Venous Anatomy

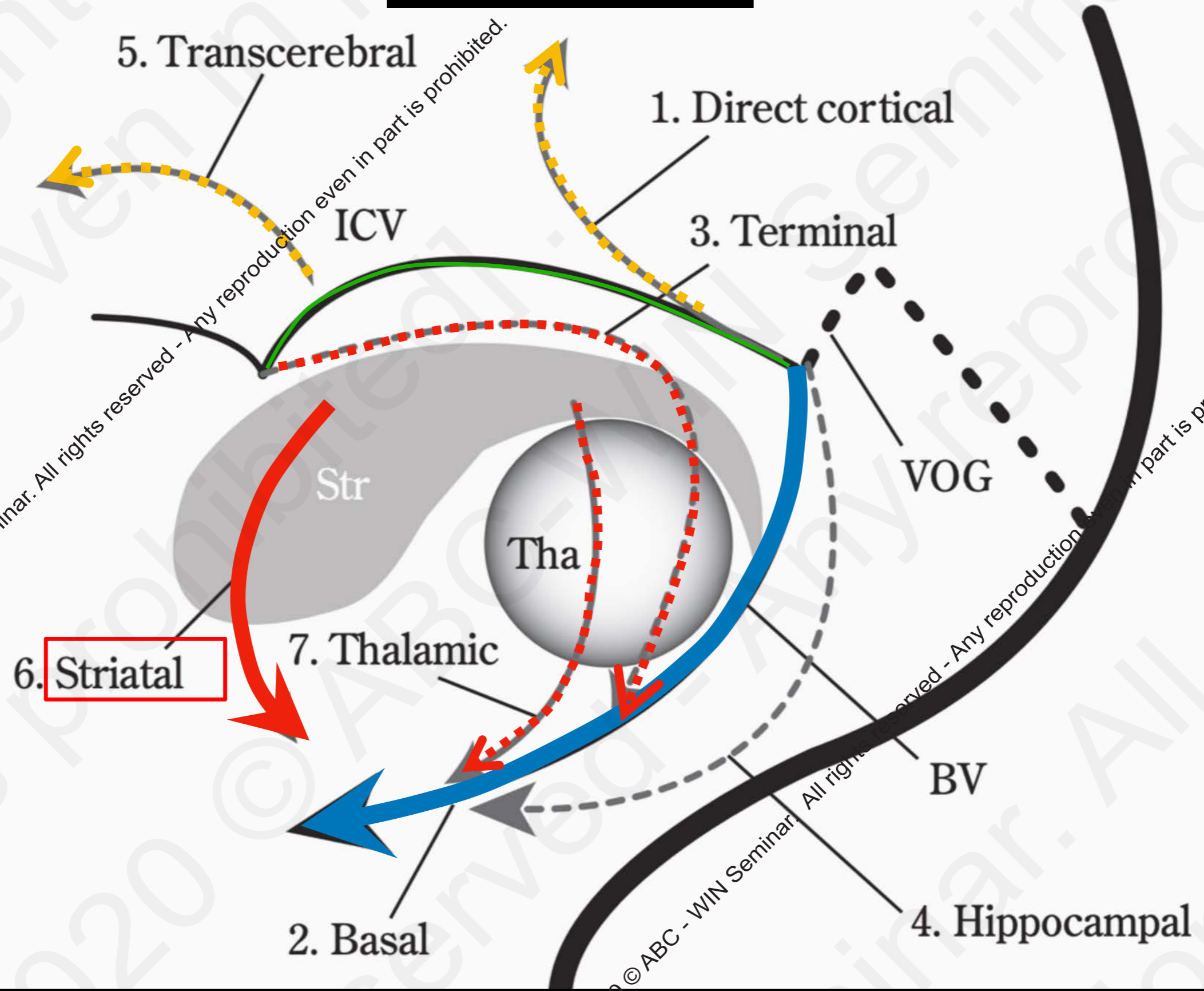


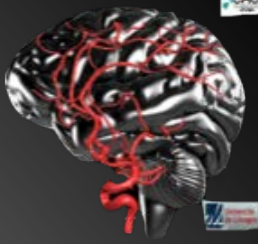
Venous Approach – Difficulties





Venous anastomosis





Introduction

Principles of AVM/EVT

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Porcelain vein

Nidus size

Arterial Balloon

Could it be partial?

What about the venous ischemia?

Take home message

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Avoid Proximal Deep Arterial Reflux

Safety and Efficacy of Transvenous Embolization of Ruptured Brain Arteriovenous Malformations as a Last Resort: A Prospective Single-Arm Study



Y. He, Y. Ding, W. Bai, T. Li, F.K. Hui, W.-J. Jiang, and J. Xue



ABSTRACT

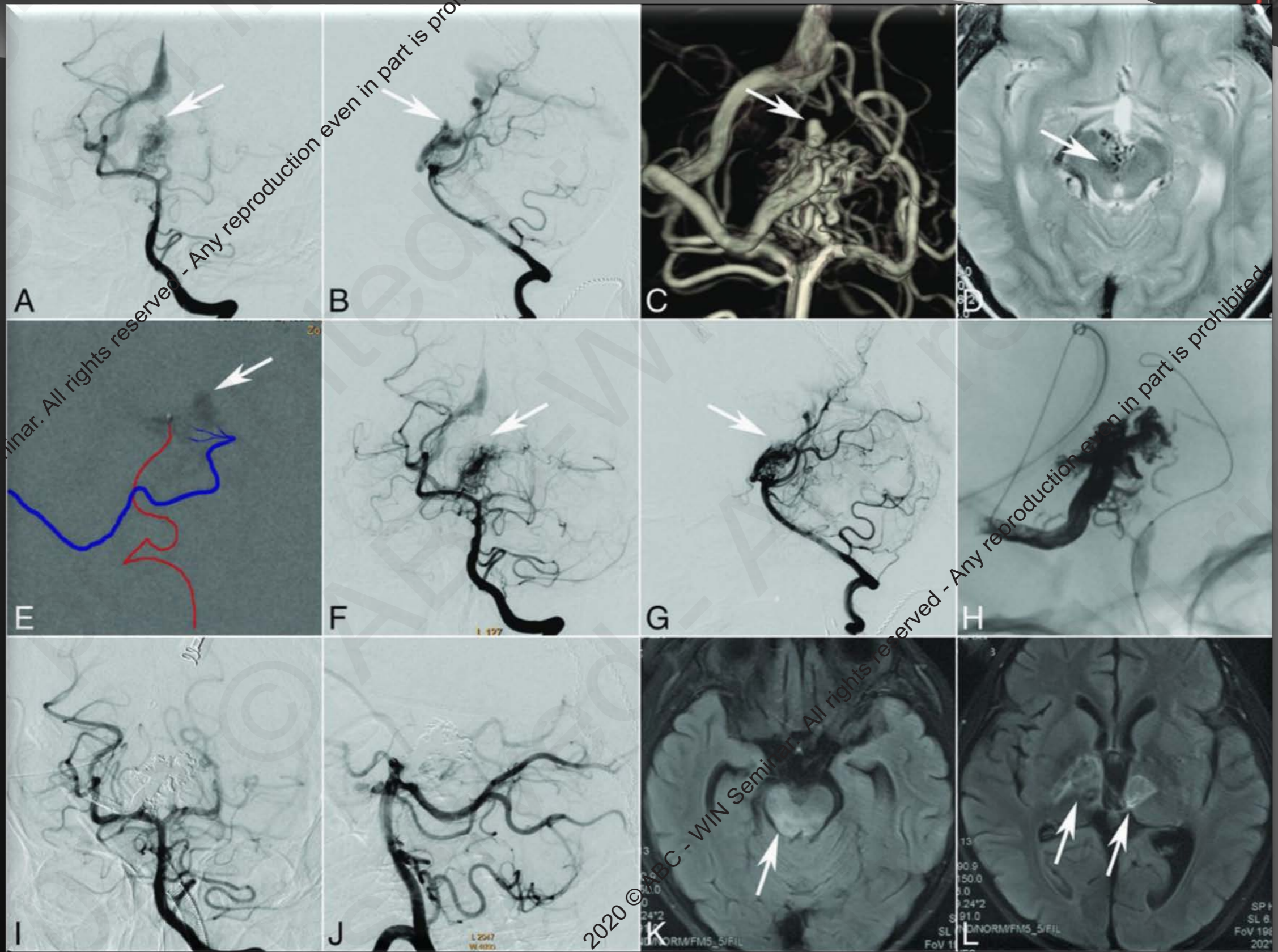
BACKGROUND AND PURPOSE: The efficacy and safety of transvenous embolization for brain arteriovenous malformations remains unclear, given the very limited number of cases reported. This prospective study was performed to assess this technique in ruptured AVMs.

MATERIALS AND METHODS: Twenty-one consecutive patients with ruptured brain AVMs who underwent transvenous embolization were prospectively followed between November 2016 and November 2018. The Spetzler-Martin grade was I in 5 AVMs (14.3%), II in four (19.0%), III in eleven (52.4%), and IV in three (14.3%). The complete AVM occlusion rate was calculated from 6-month follow-up DSA images. Occurrence of hemorrhage and infarction after embolization was evaluated using CT and MR imaging within 1 month after the operation. The mRS was used to assess the functional outcomes.

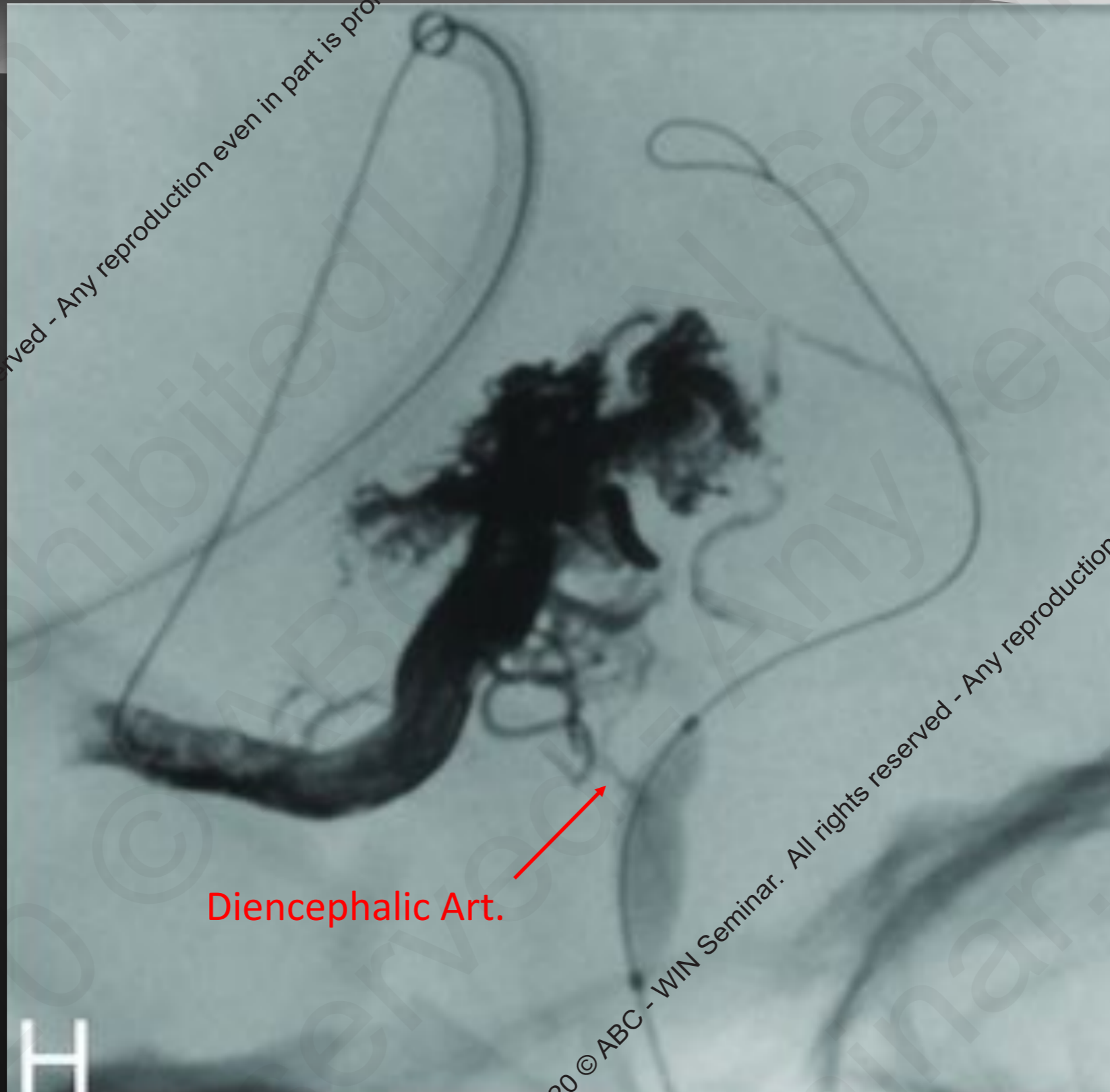
RESULTS: Complete AVM nidus obliteration was shown in 16 (84%) of 19 patients with technically feasible AVMs immediately after embolization. One (5%) patient with a small residual nidus after treatment showed complete obliteration at 13-month follow-up. There were 5 hemorrhages and 1 infarction; 4 patients' symptoms improved gradually. The percentage of cases with mRS ≤ 2 rose from 57.1% (12/21) before embolization to 66.7% (14/21) at 1-month follow-up. Both the morbidity and mortality rates were 4.8% (1/21).

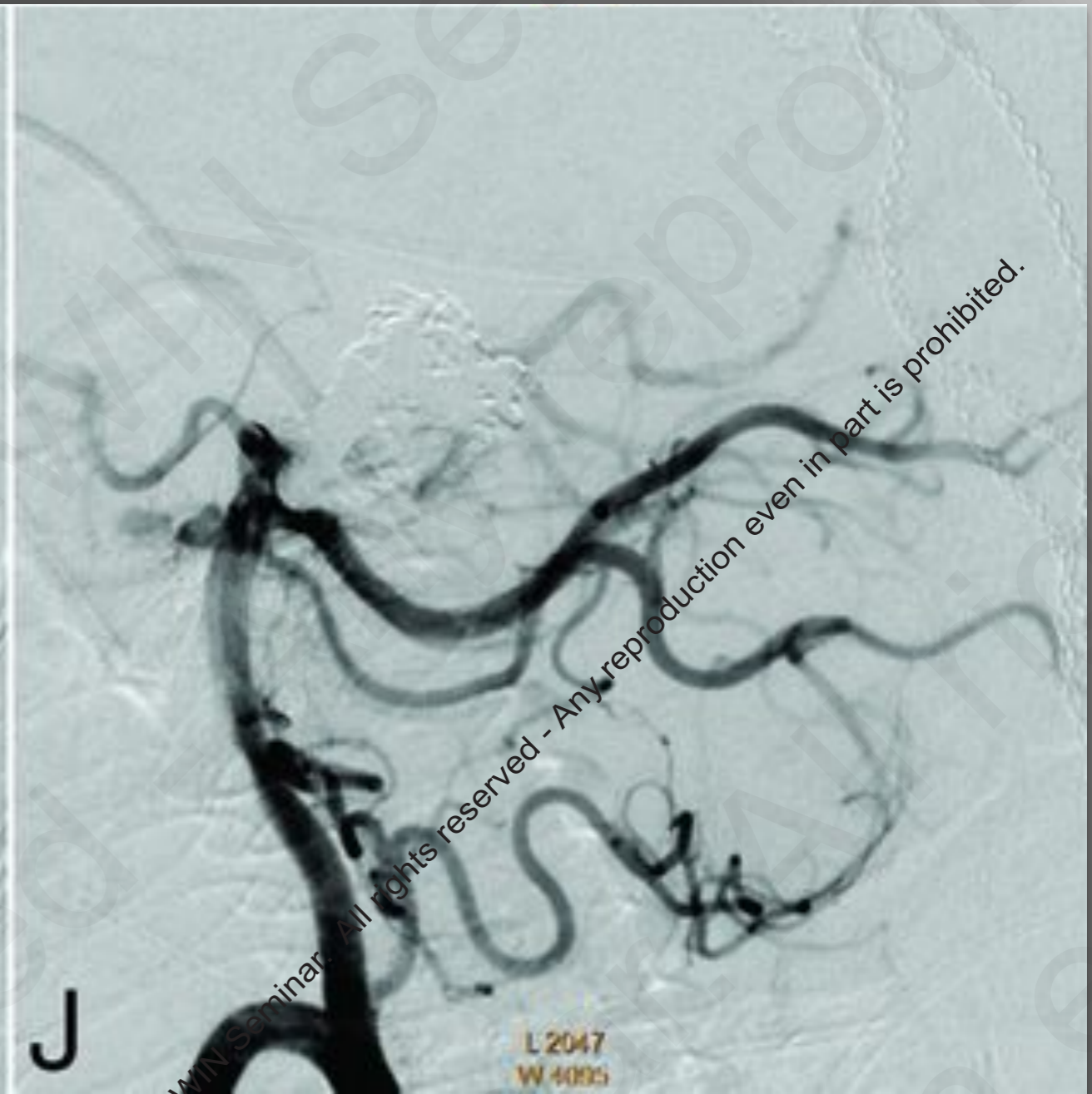
CONCLUSIONS: Transvenous embolization can be performed only in highly selected hemorrhagic brain AVMs with high complete obliteration rates, improved functional outcomes, and acceptable morbidity and mortality rates, but it should not be considered as a first-line treatment.

An 8-year-old boy who presented with sudden headache and vomiting.

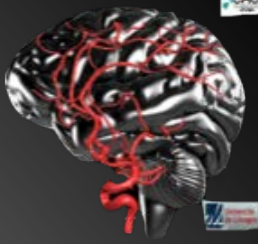


An 8-year-old boy who presented with sudden headache and vomiting.





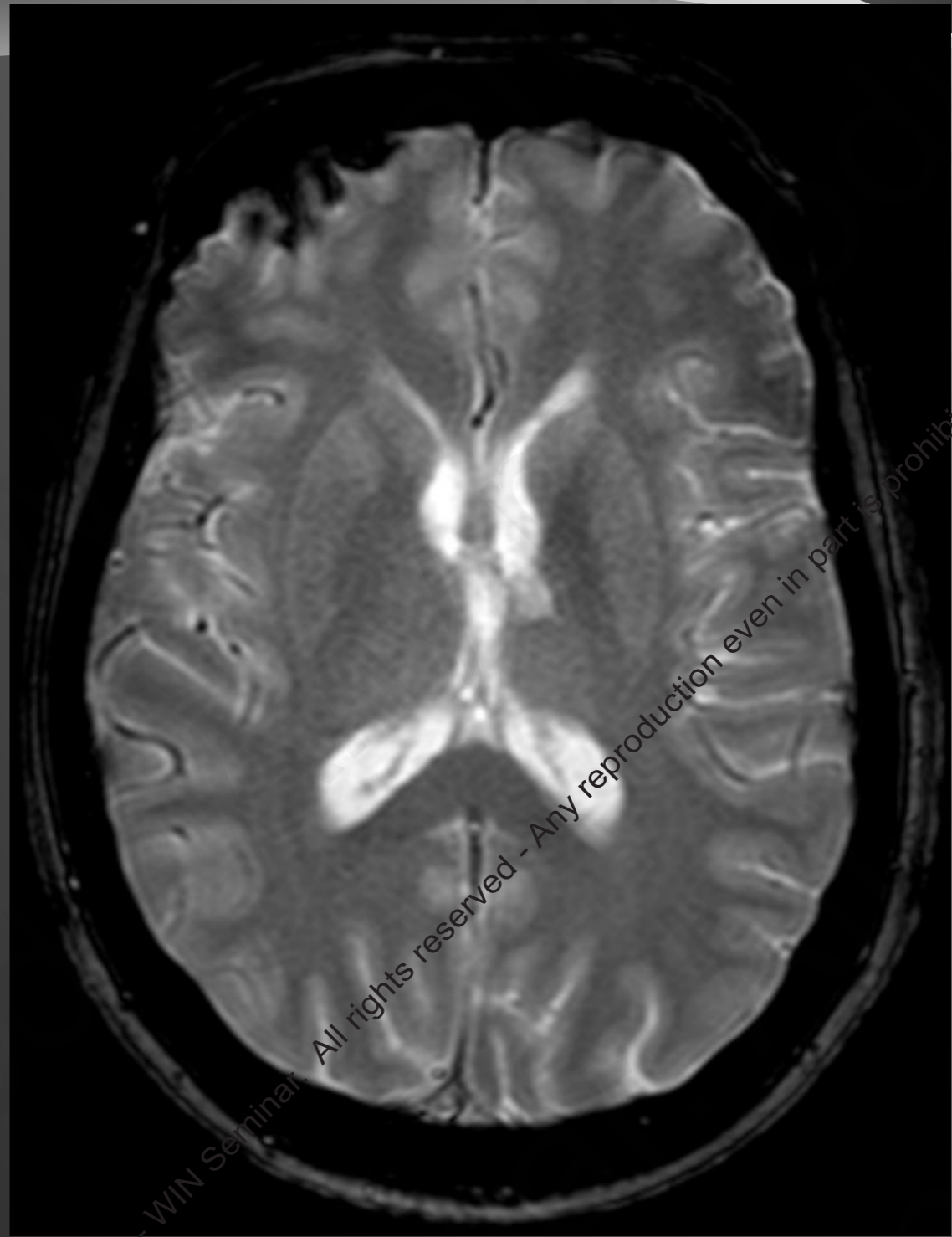




How to avoid such a complication ?

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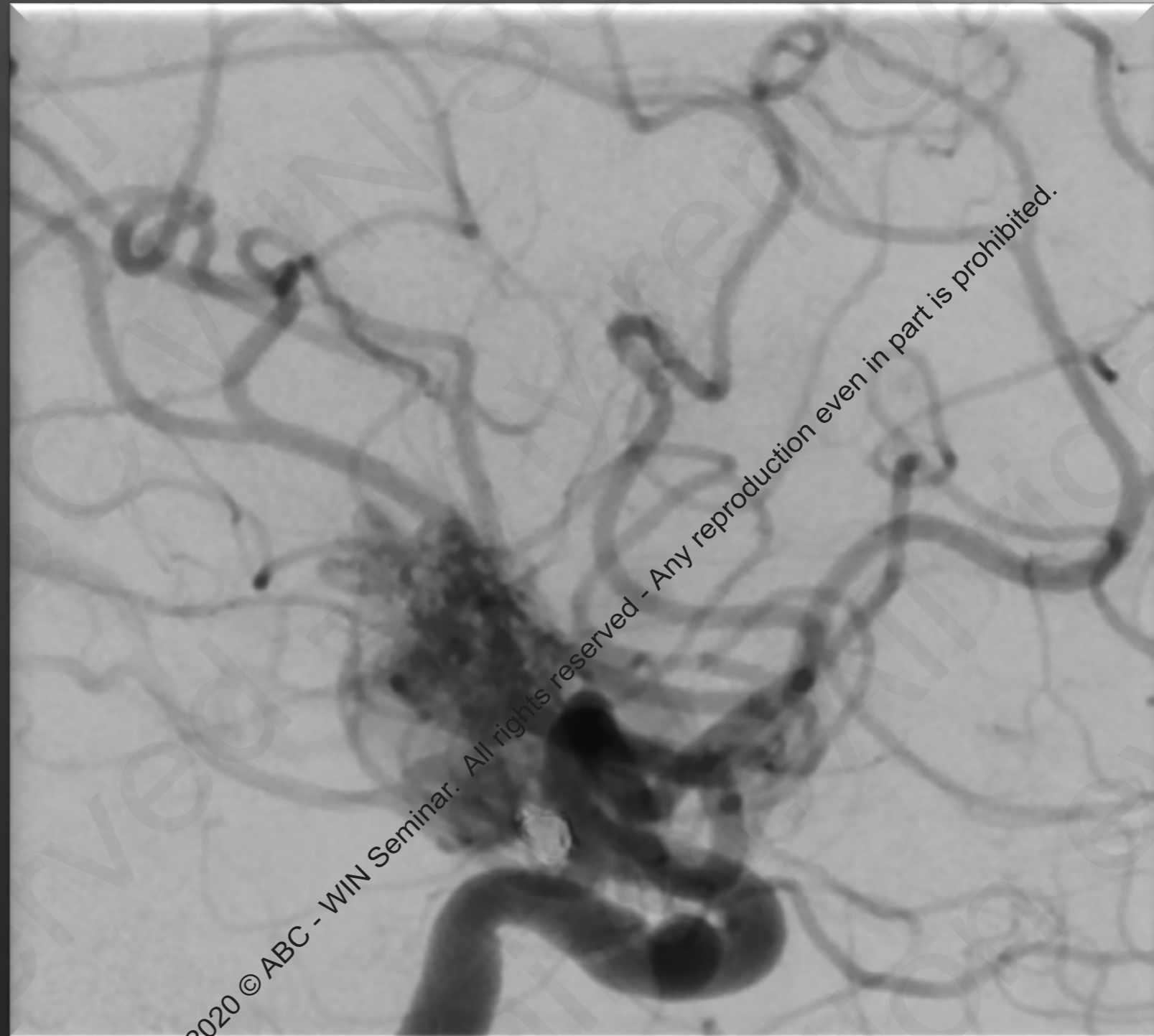


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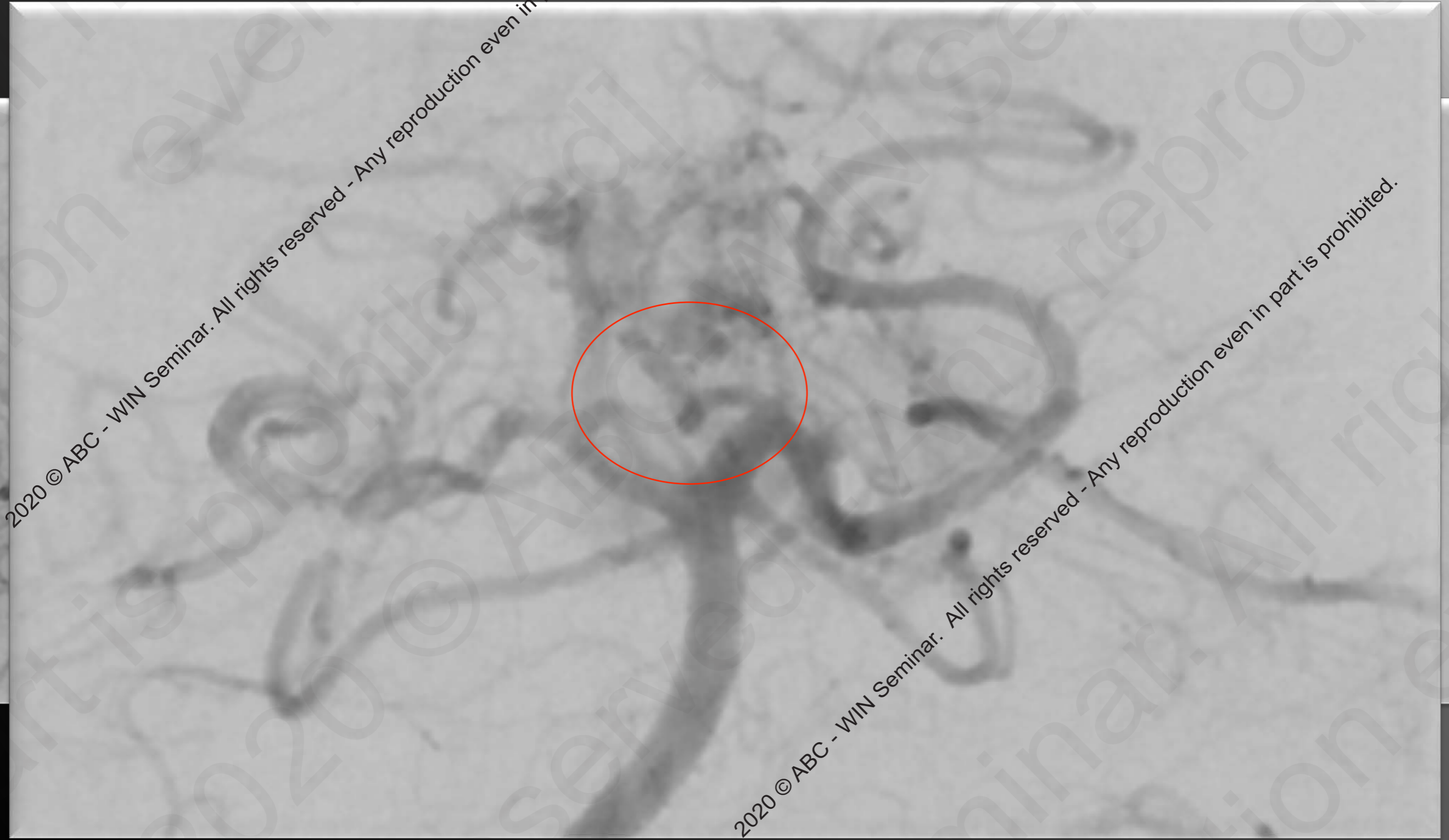


Avoid Proximal Deep Arterial Reflux





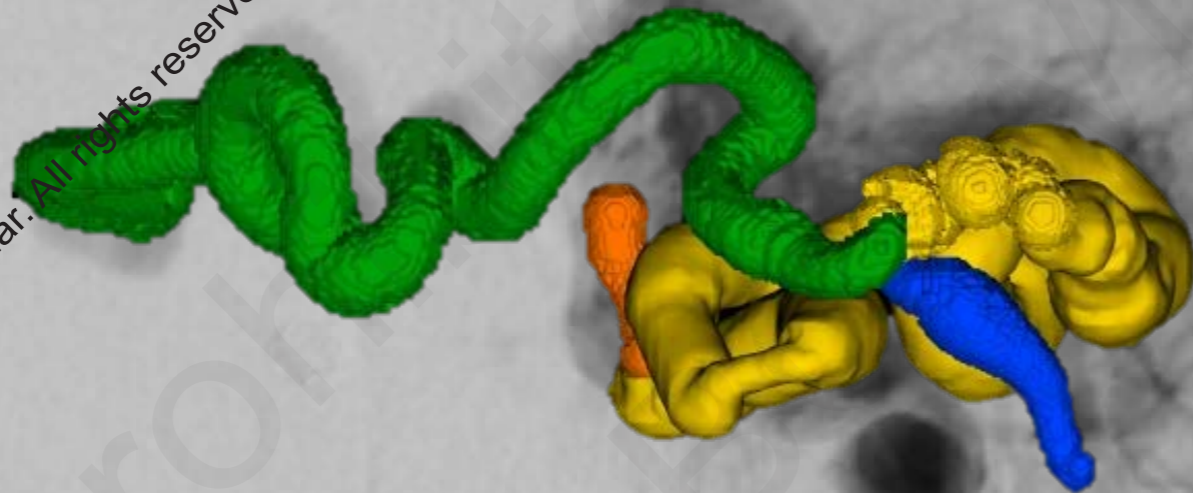
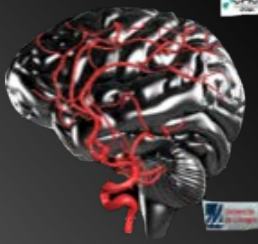
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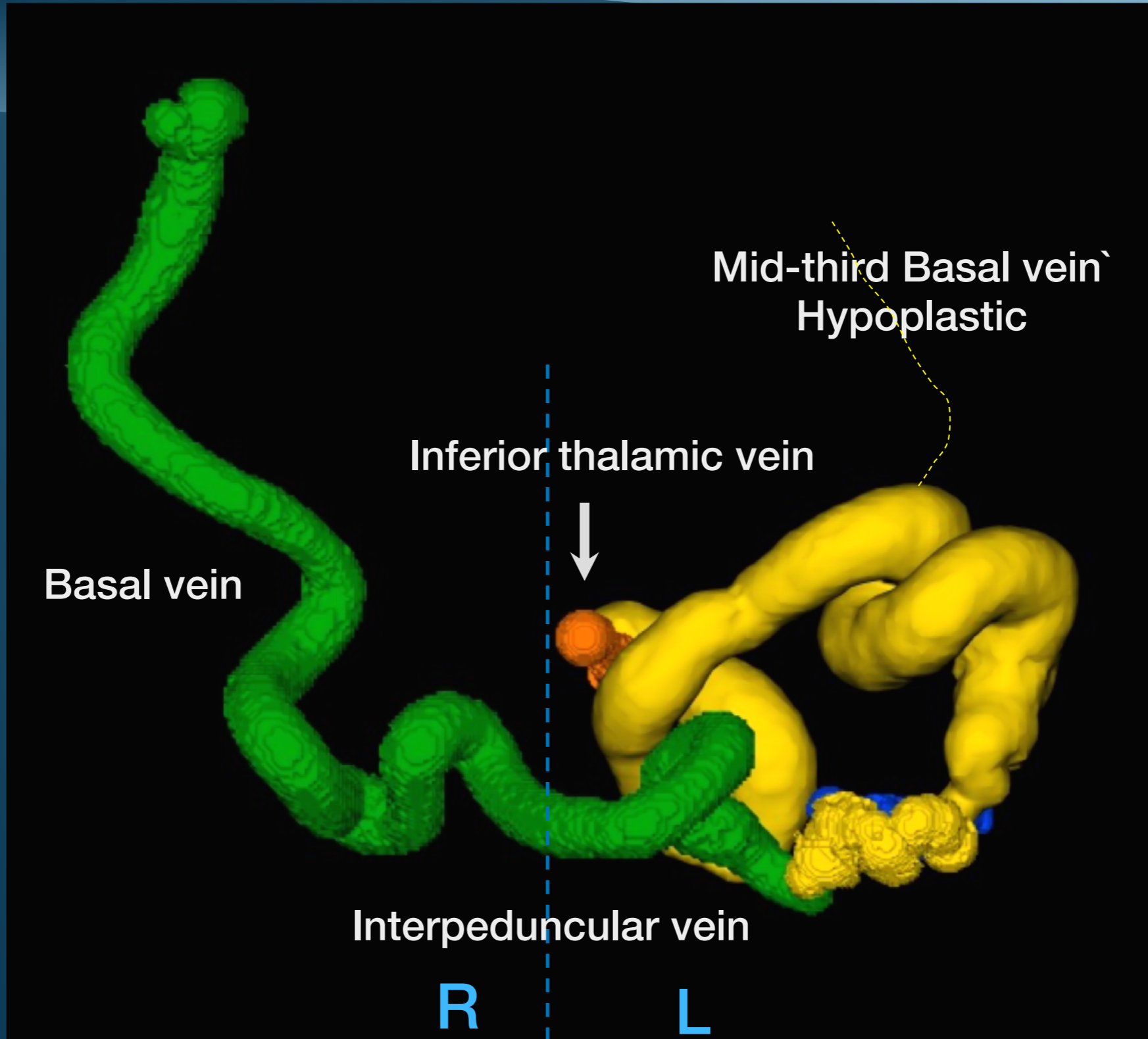


Draining Veins (anterior view)

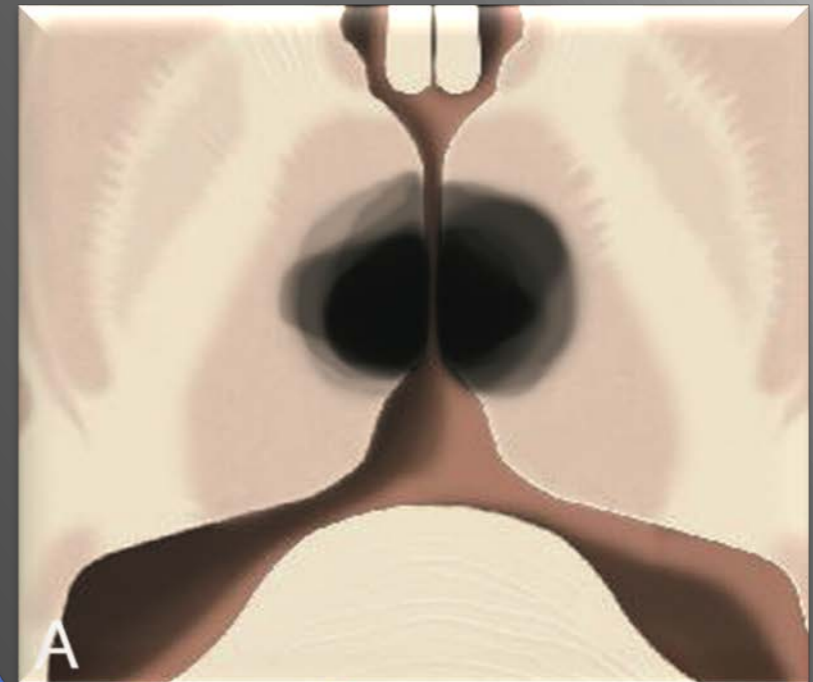
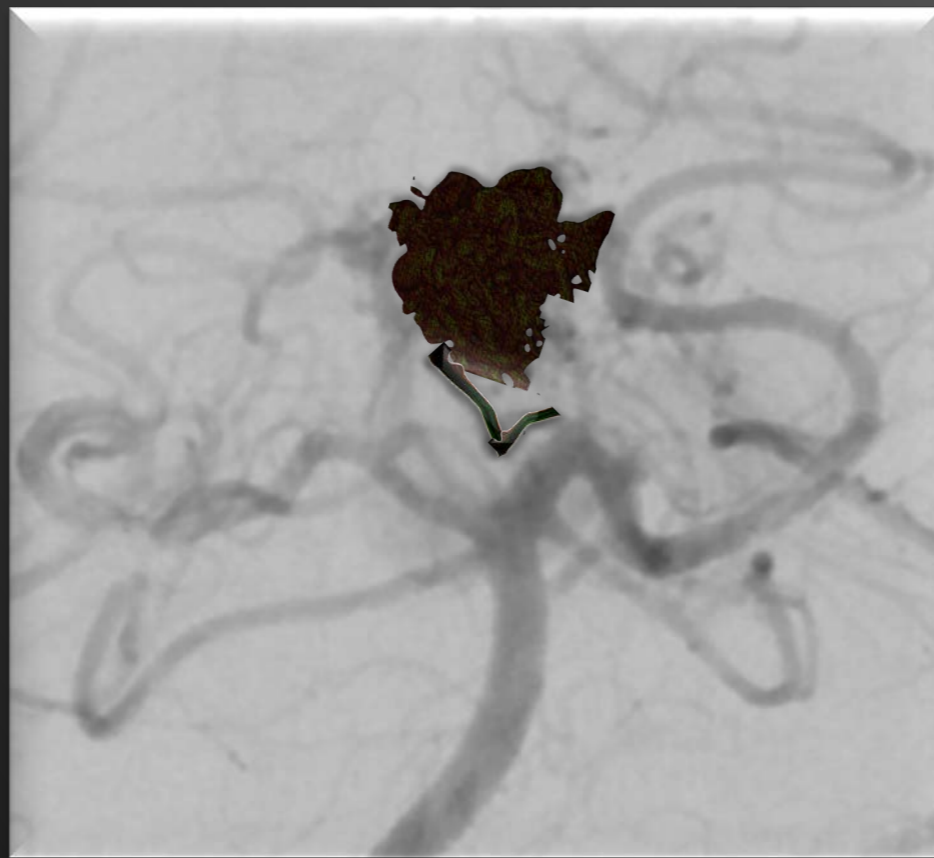
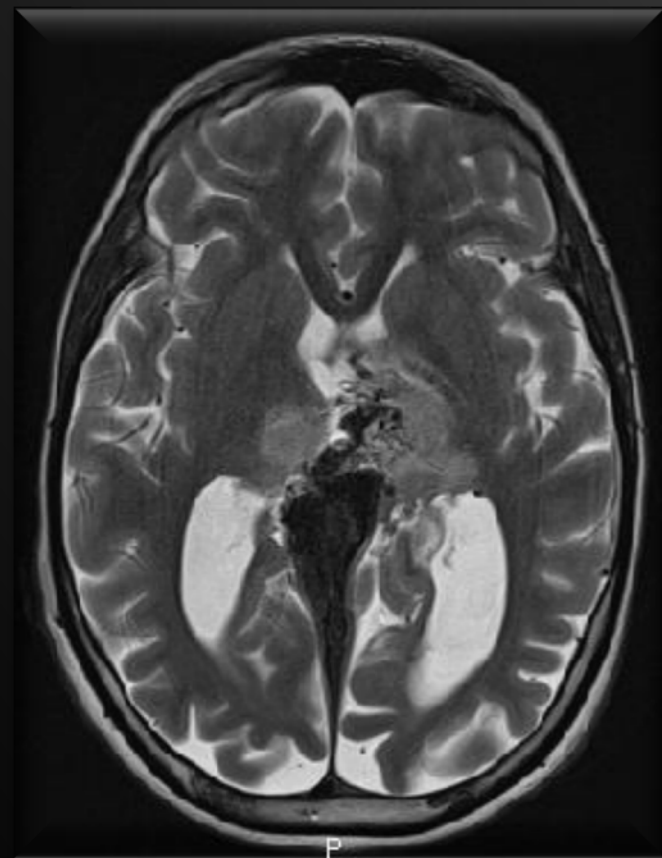


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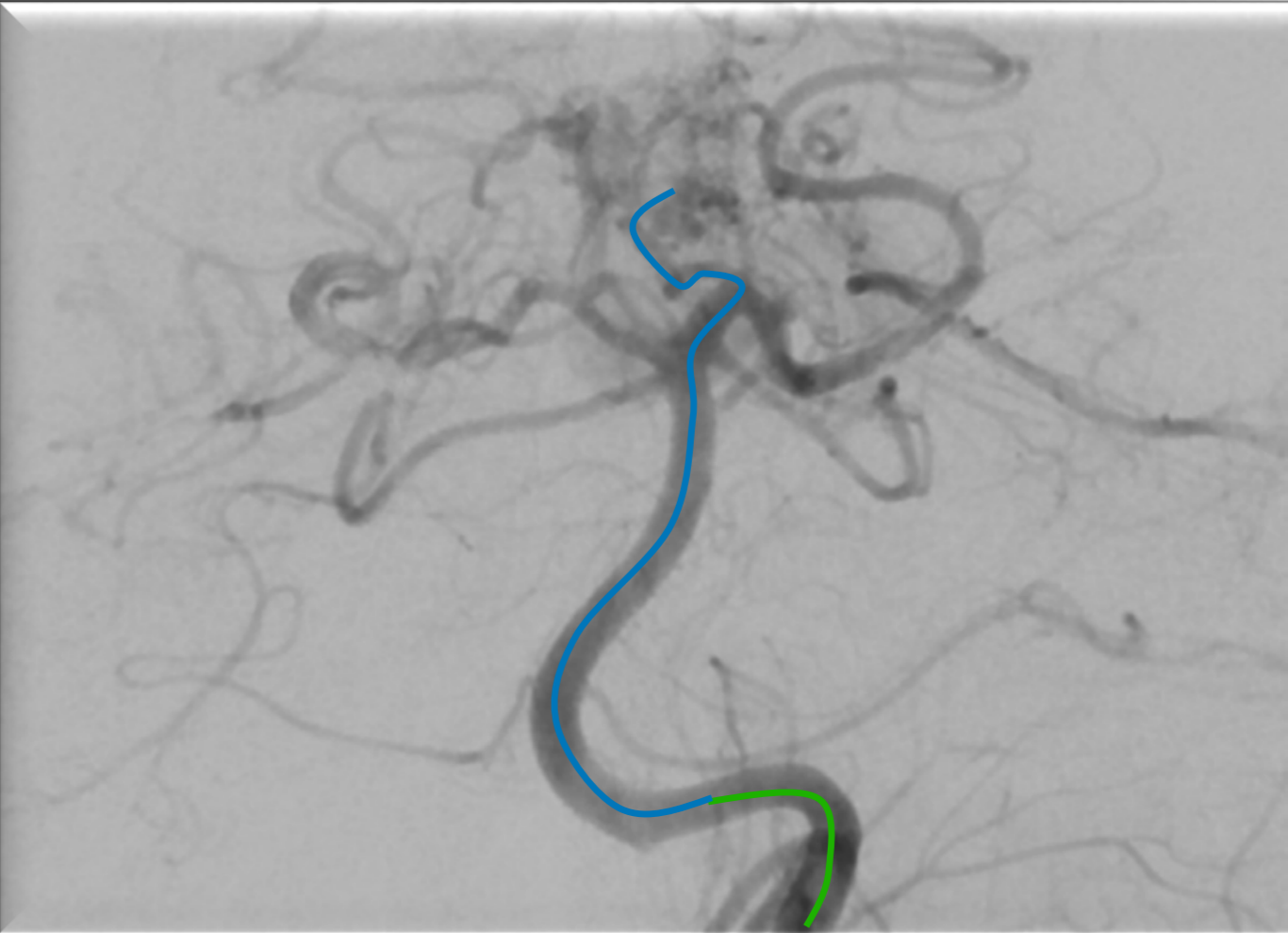
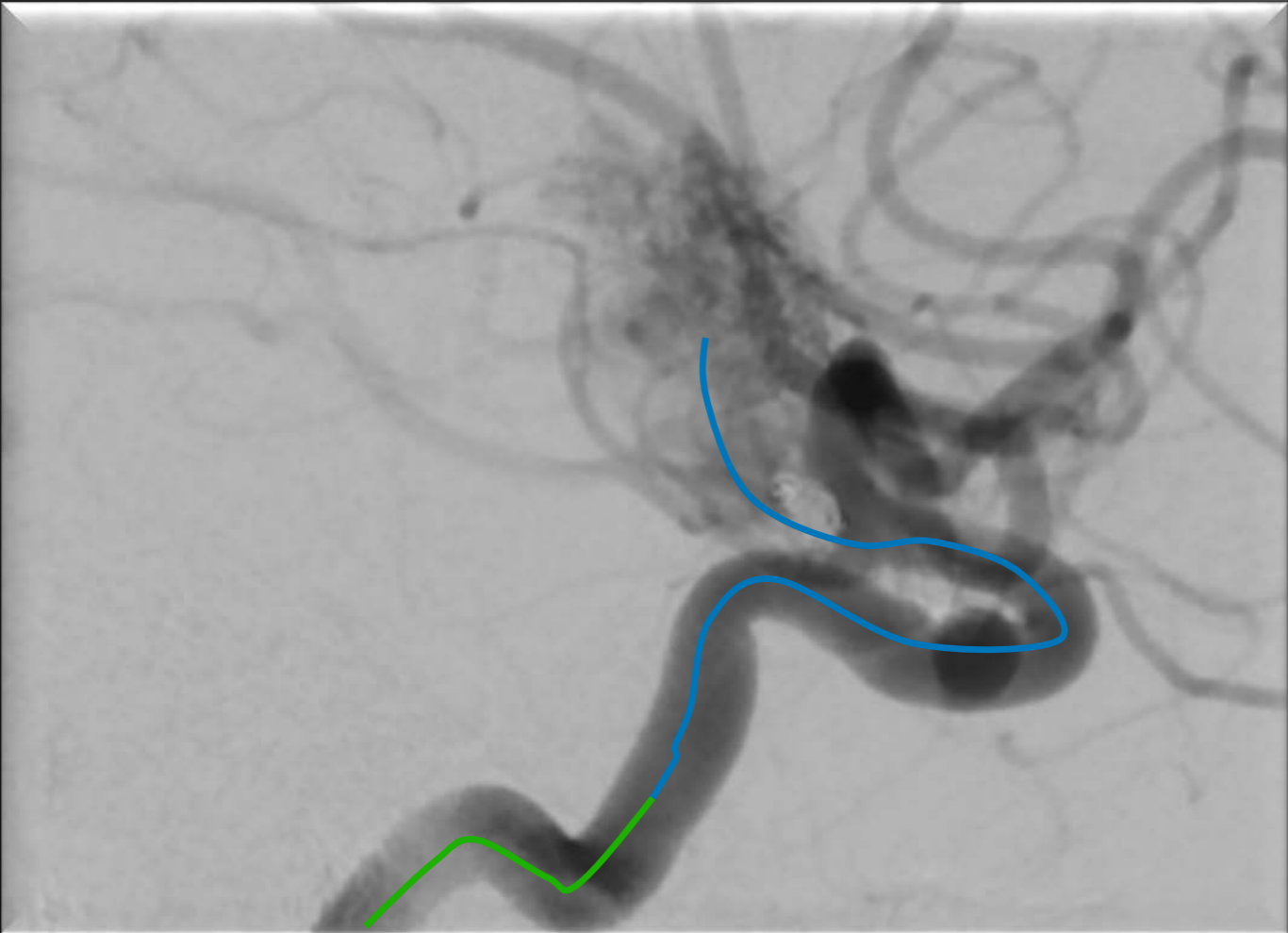


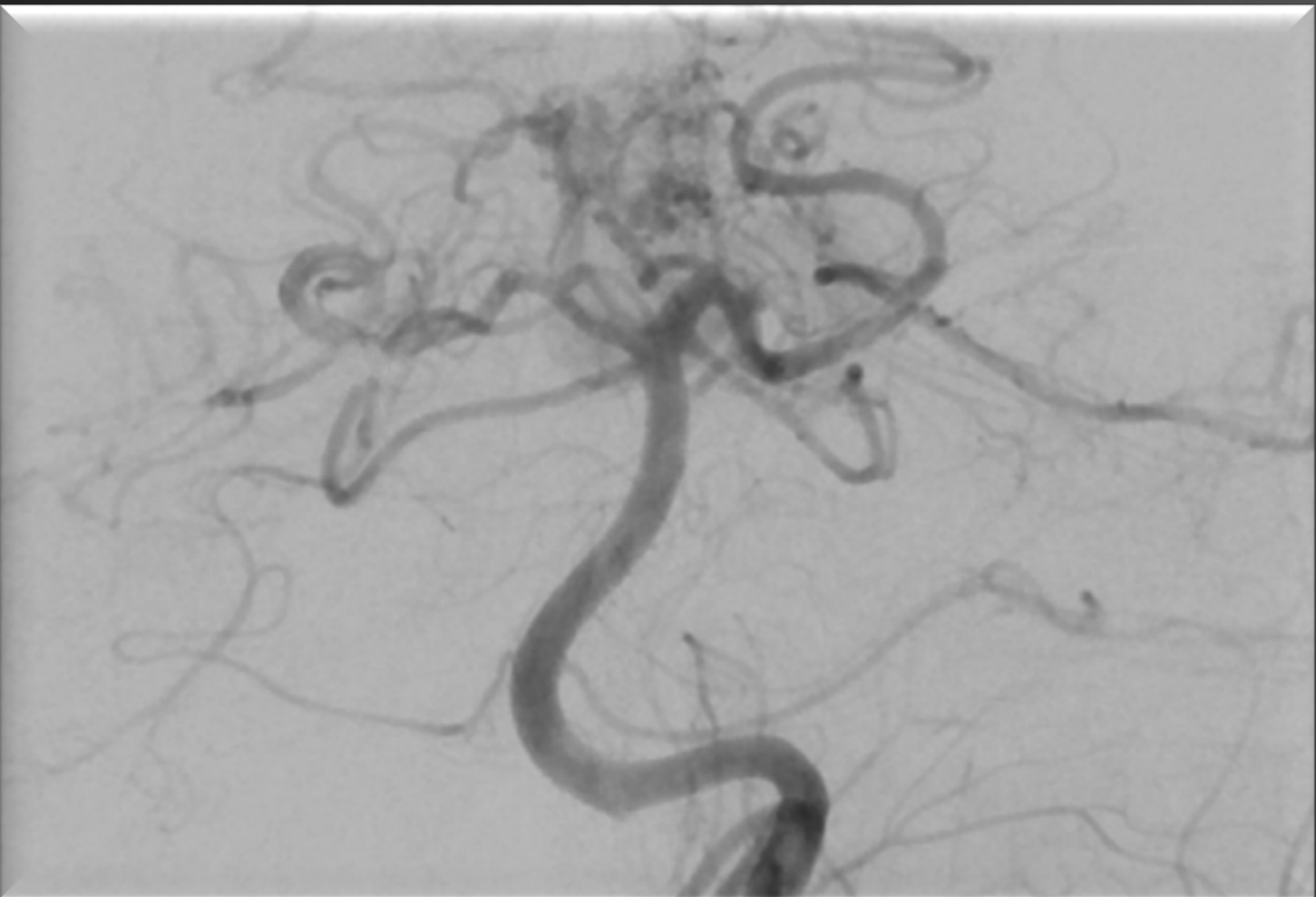
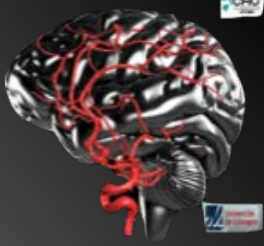
If direct venous approach

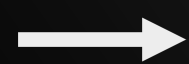


Bilateral Thalamic and Midbrain Ischemia

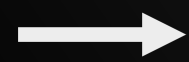
First session



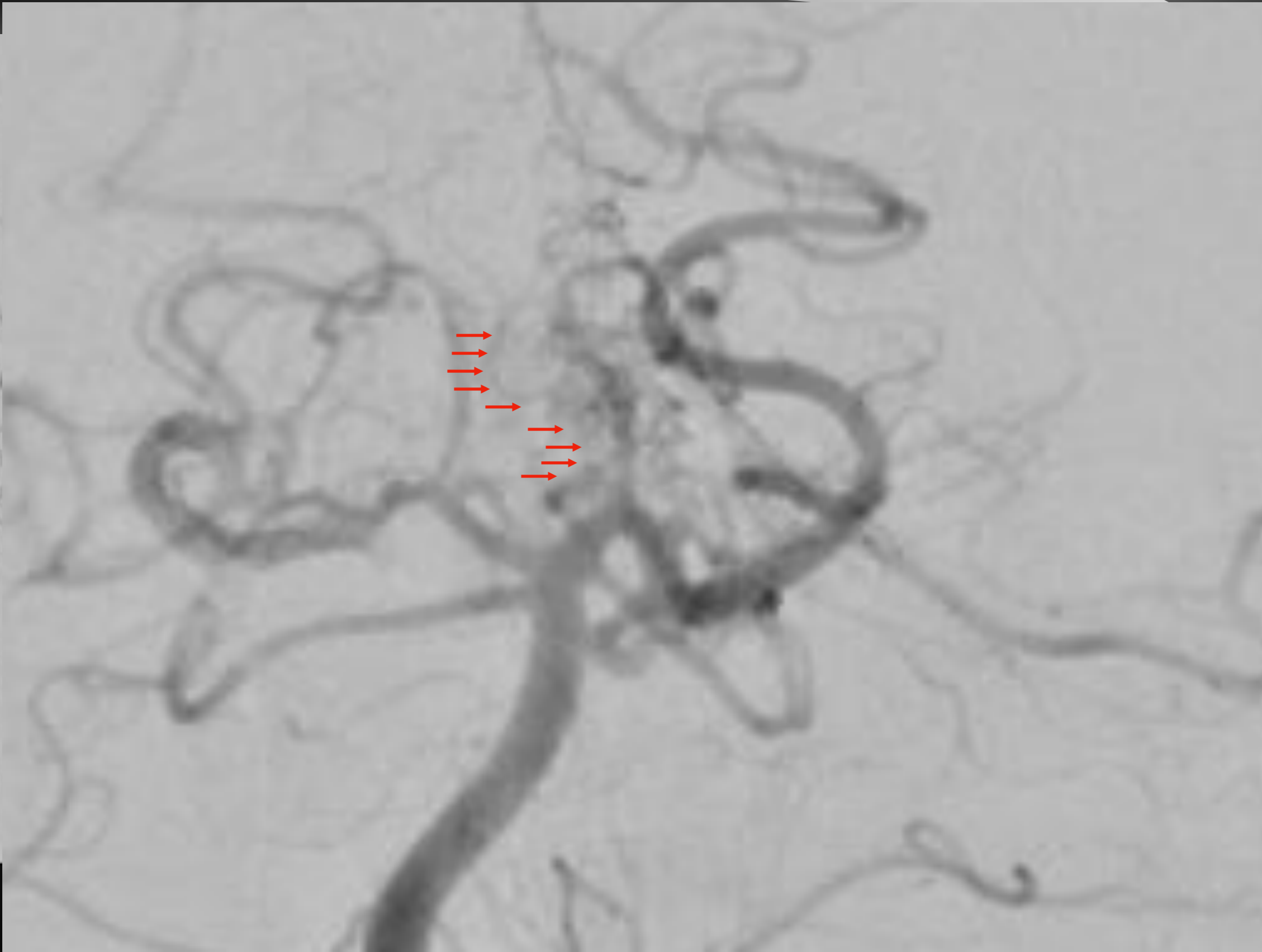




Reduces the size of the Nidus



Avoids retrograde proximal arterial reflux during the venous session





Introduction

Principles of AVM EVT

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➤ Venous approach for BG AVM

➤ Engage in debate

Liquid agents

Porcelain vein

Nidus size

Arterial Balloon

Could it be partial?

What about the venous ischemia?

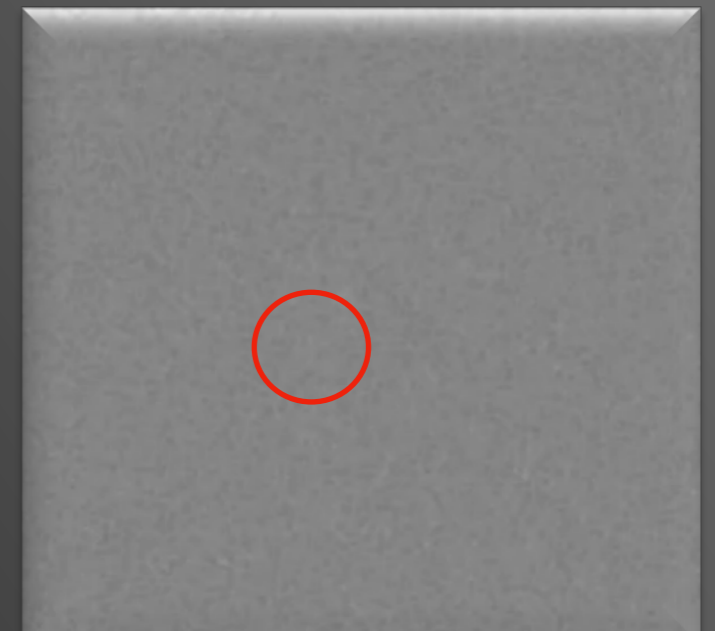
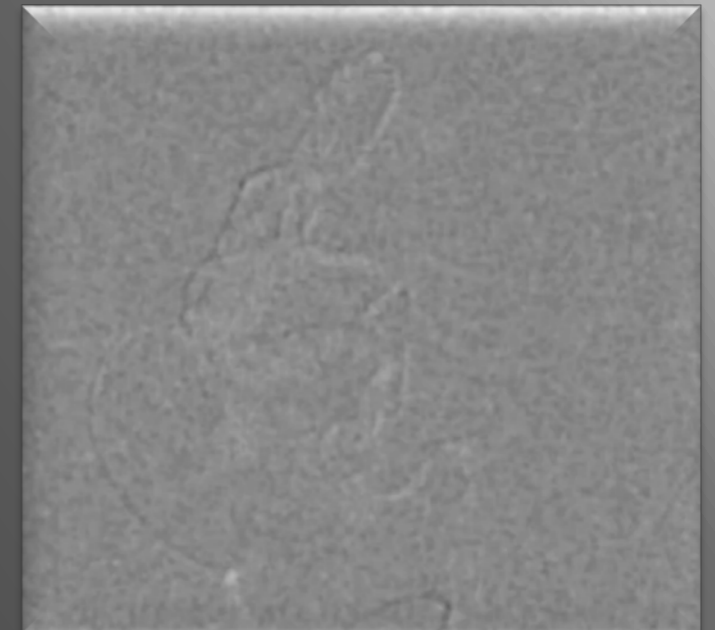
Take home message



Which liquid agent?



- *Adhesive liquid embolic agent*
 - *Glue*
- *Non-Adhesive liquid embolic agent*
 - **EVOH – Ethylene vinyl alcohol (Onyx/Squid)**
 - **Phil**





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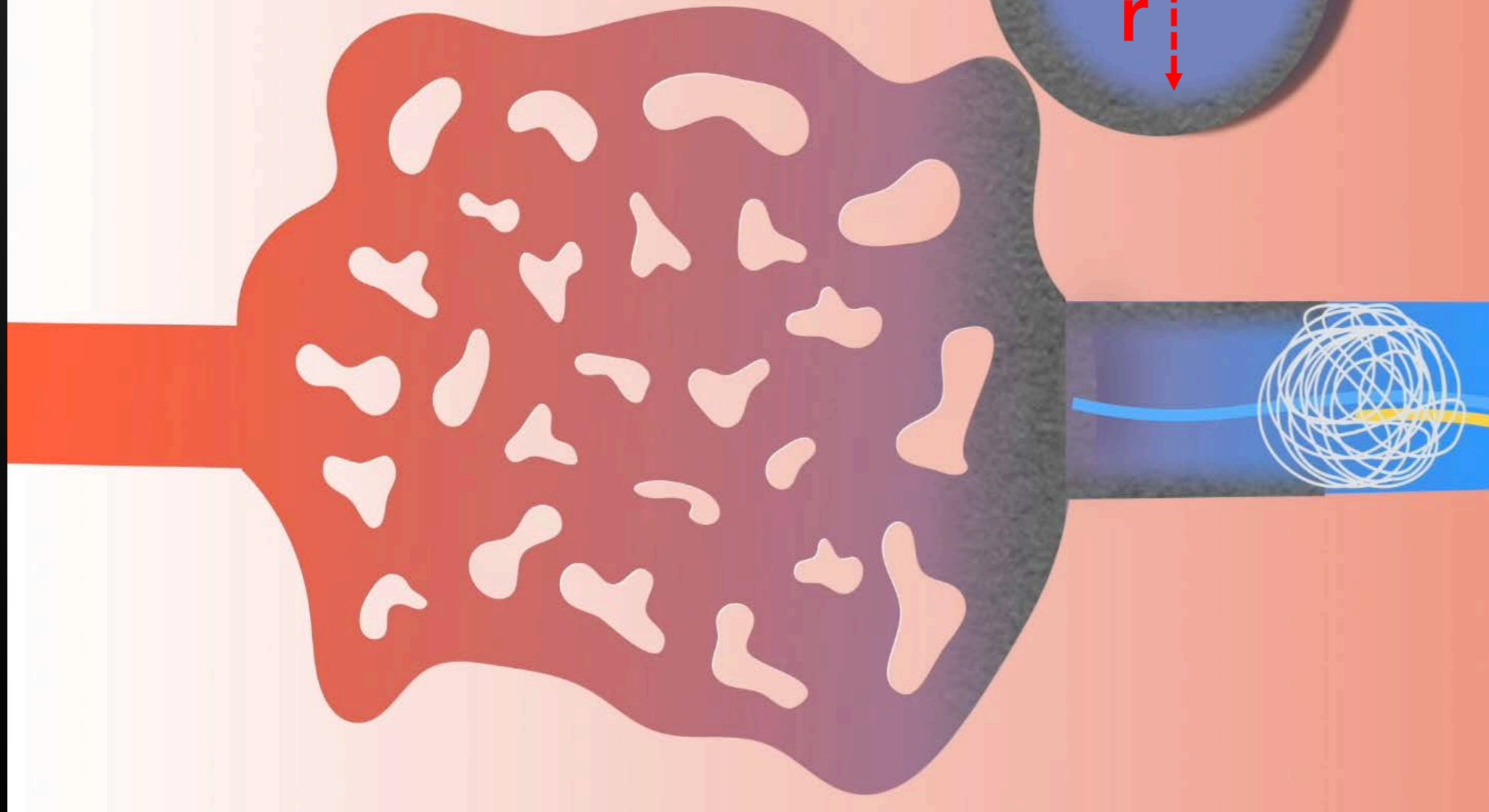
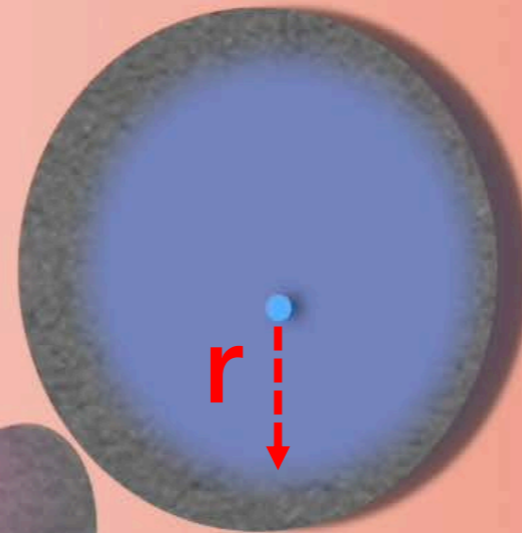
What about the venous ischemia?

Take home message

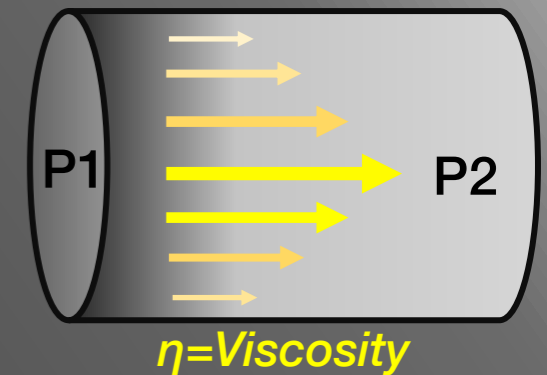
Porcelain Vein



*Porcelain
Vein*

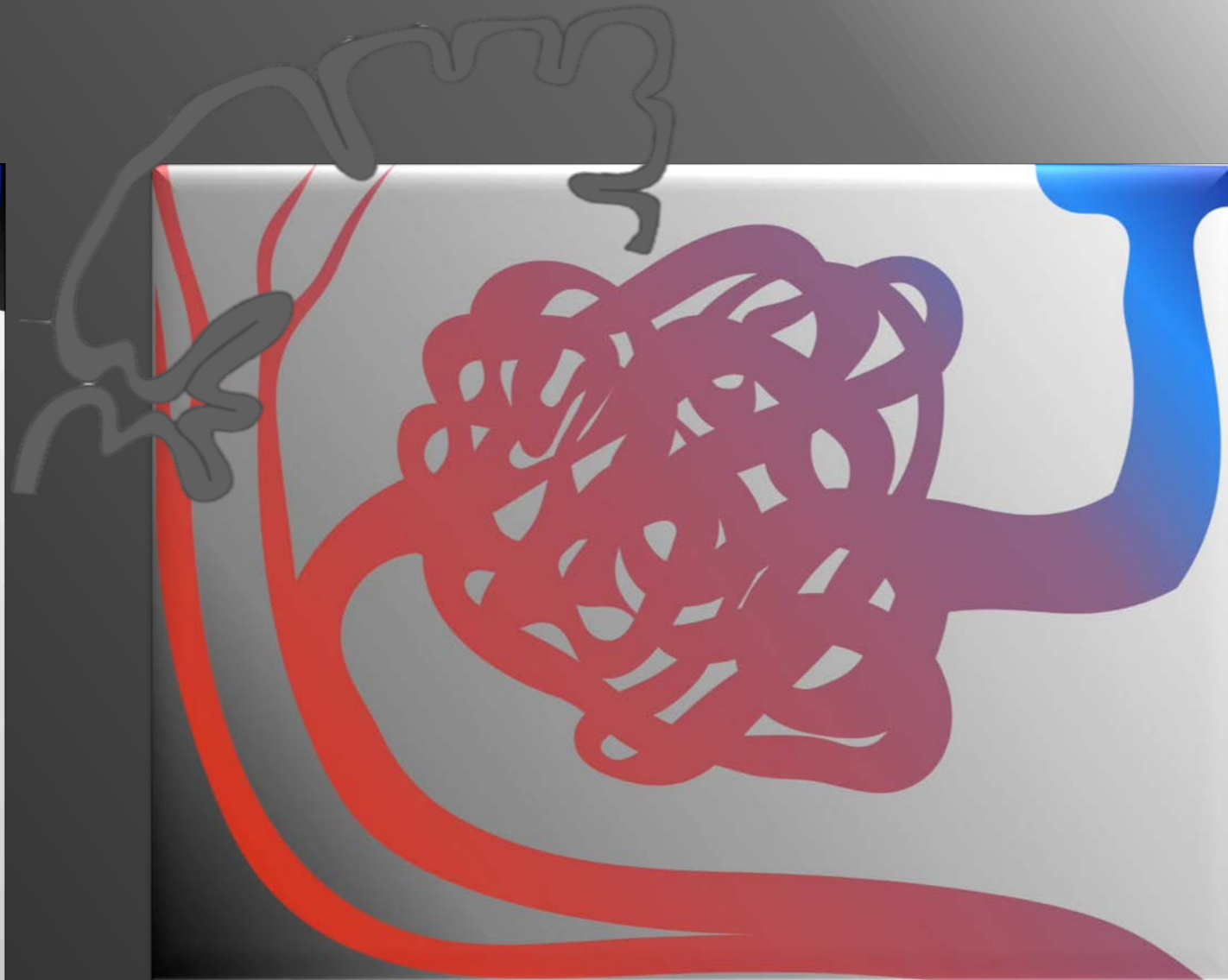
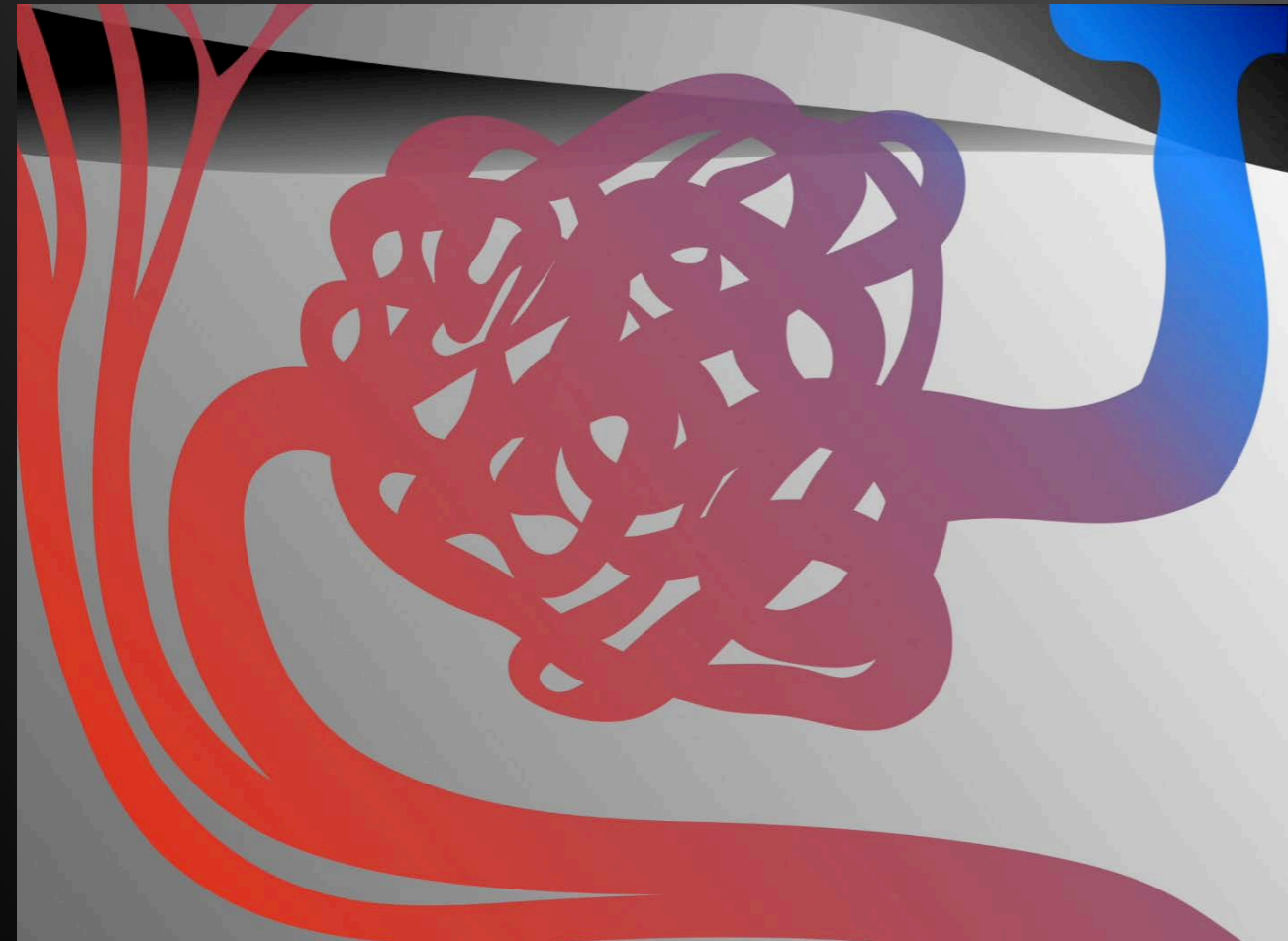


Laminar Flow



Resistance

$$R = \frac{8\eta L}{\pi \Delta r^4}$$



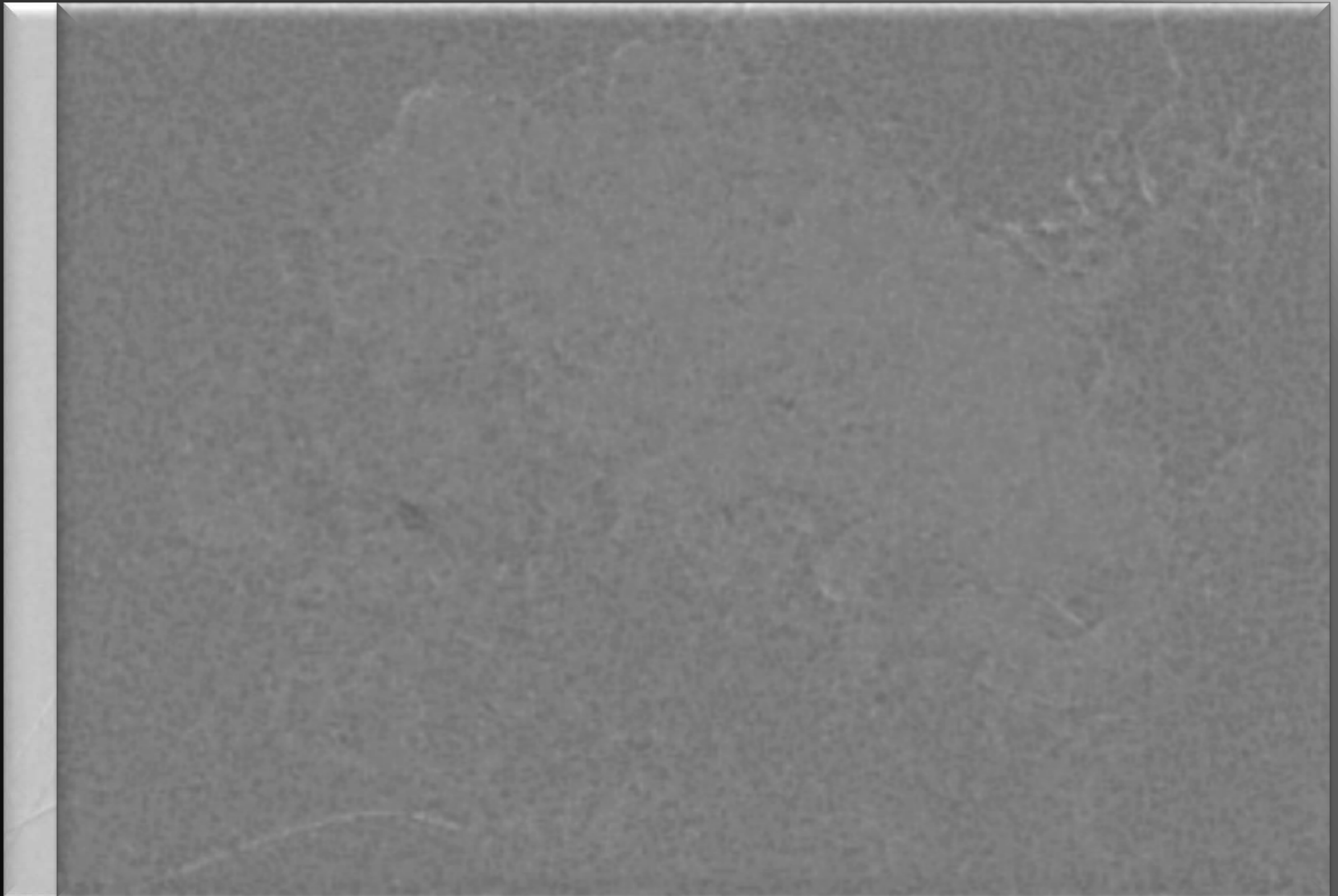
Porcelain vein

vs

Pressure Cooker



Porcelain Vein



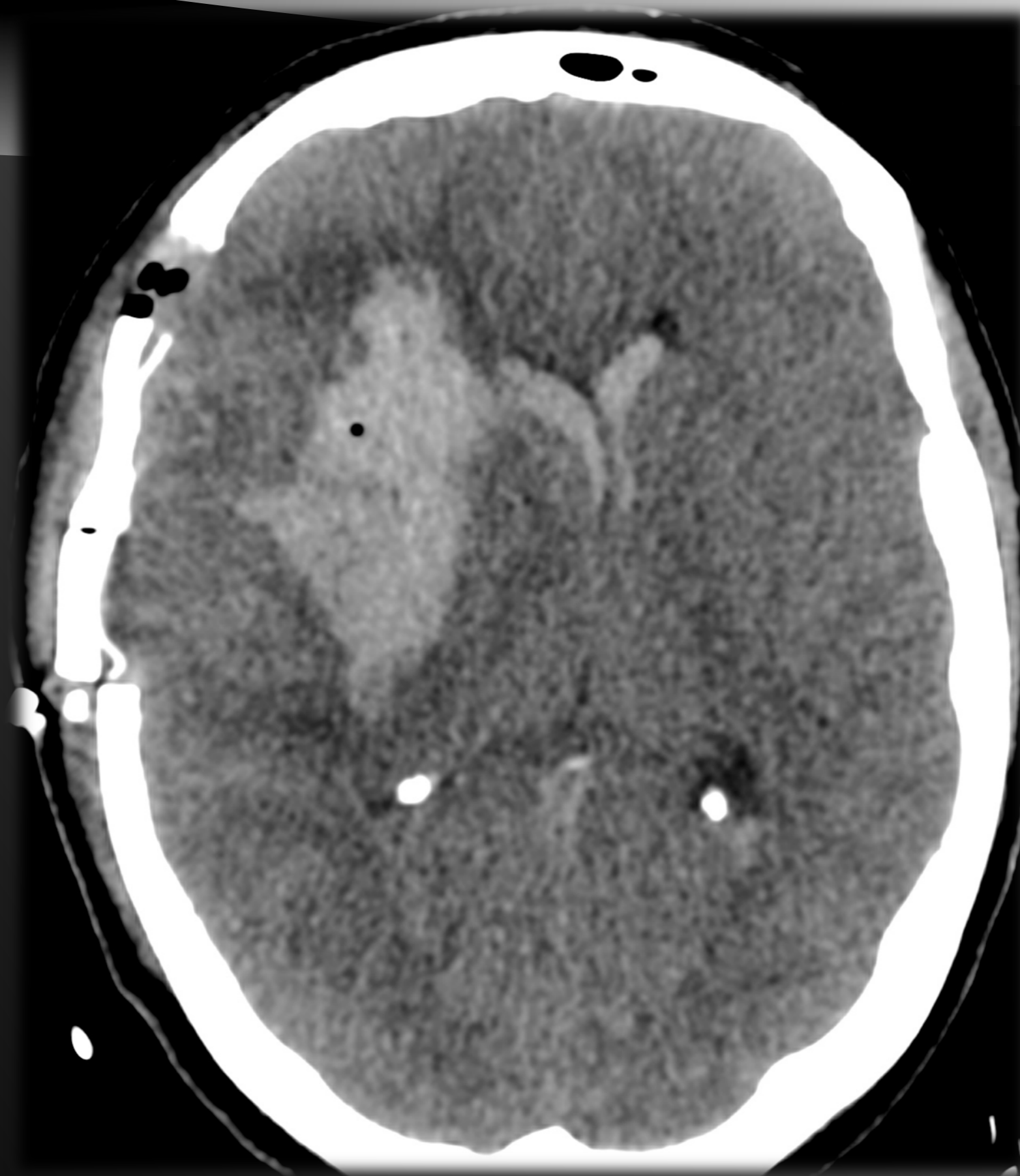
Porcelain Vein

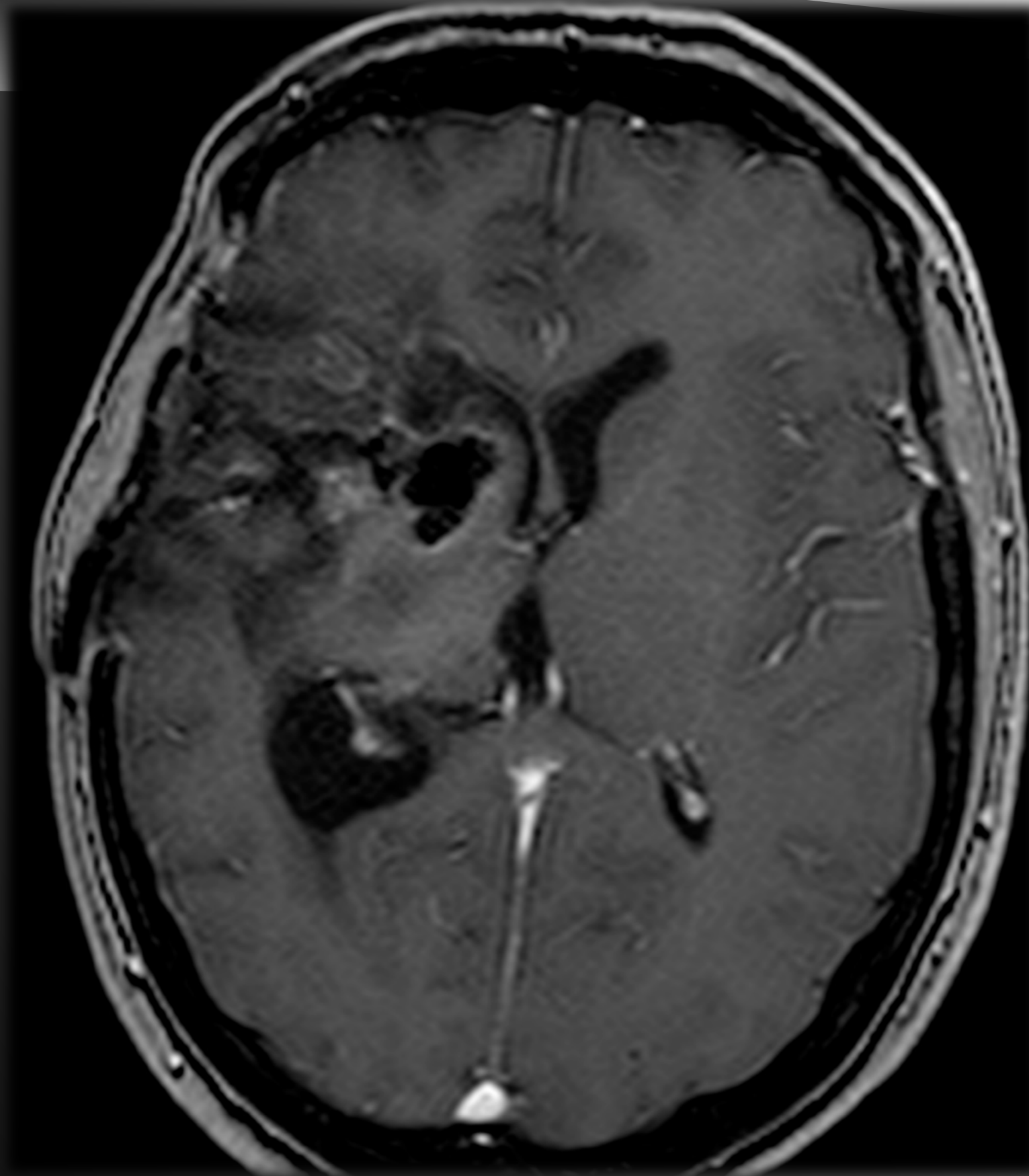
With Coils

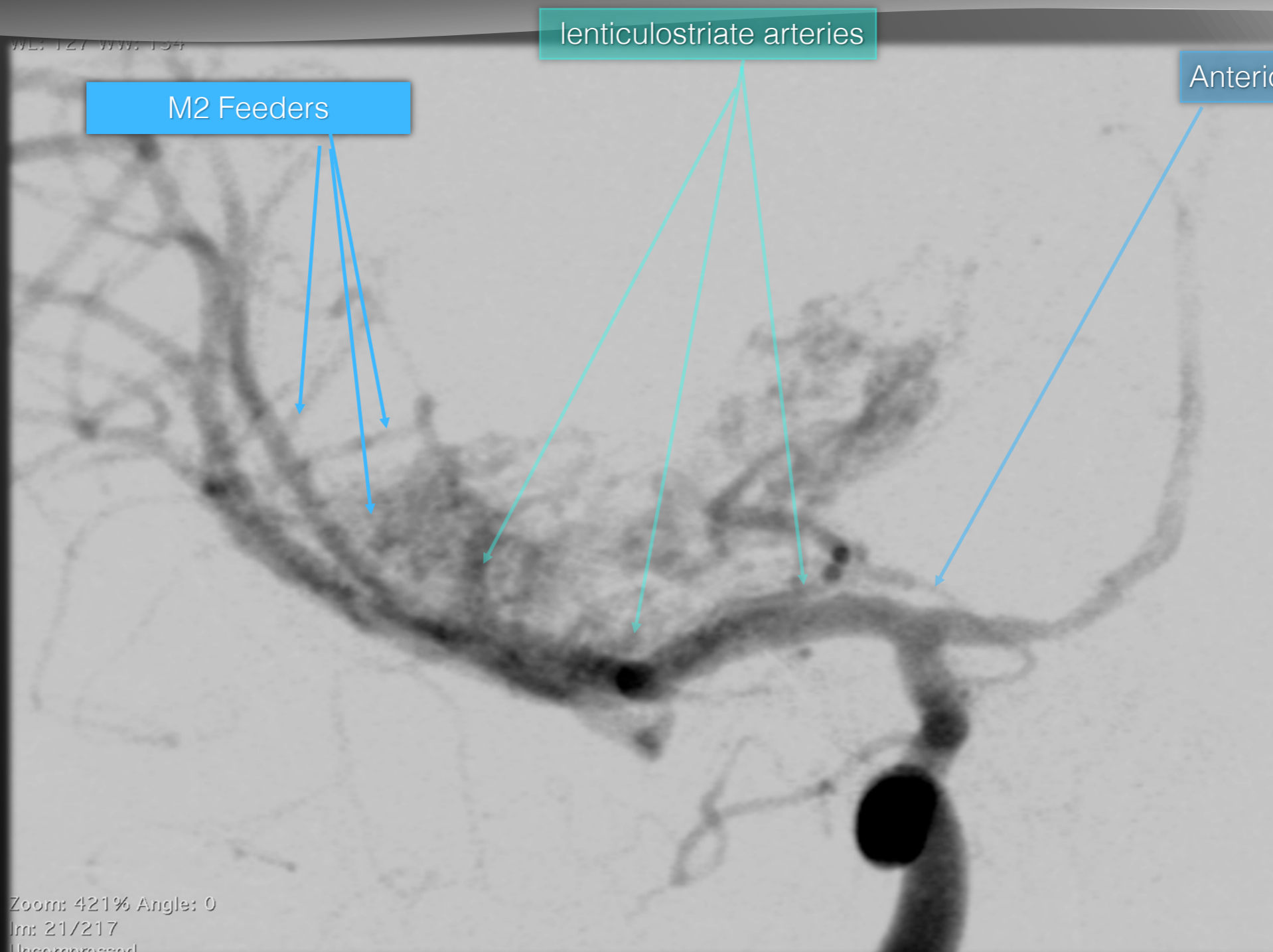
Without Coils

Lentiform nucleus & Sylvian fissure Haematoma





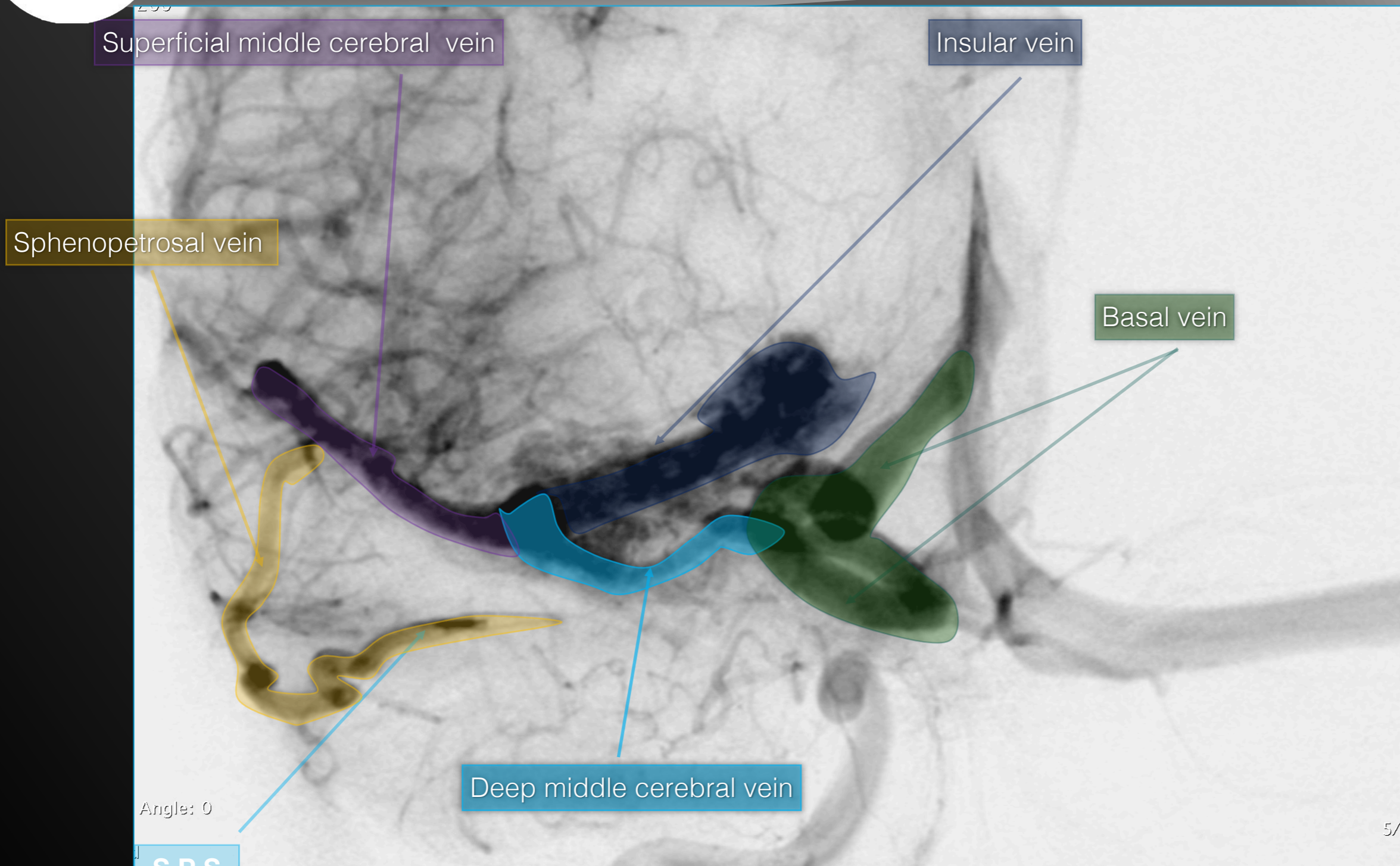




M2 Feeders

lenticulostriate arteries

Anterior choroidal artery



Sphenopetrosal vein

Superficial middle cerebral vein

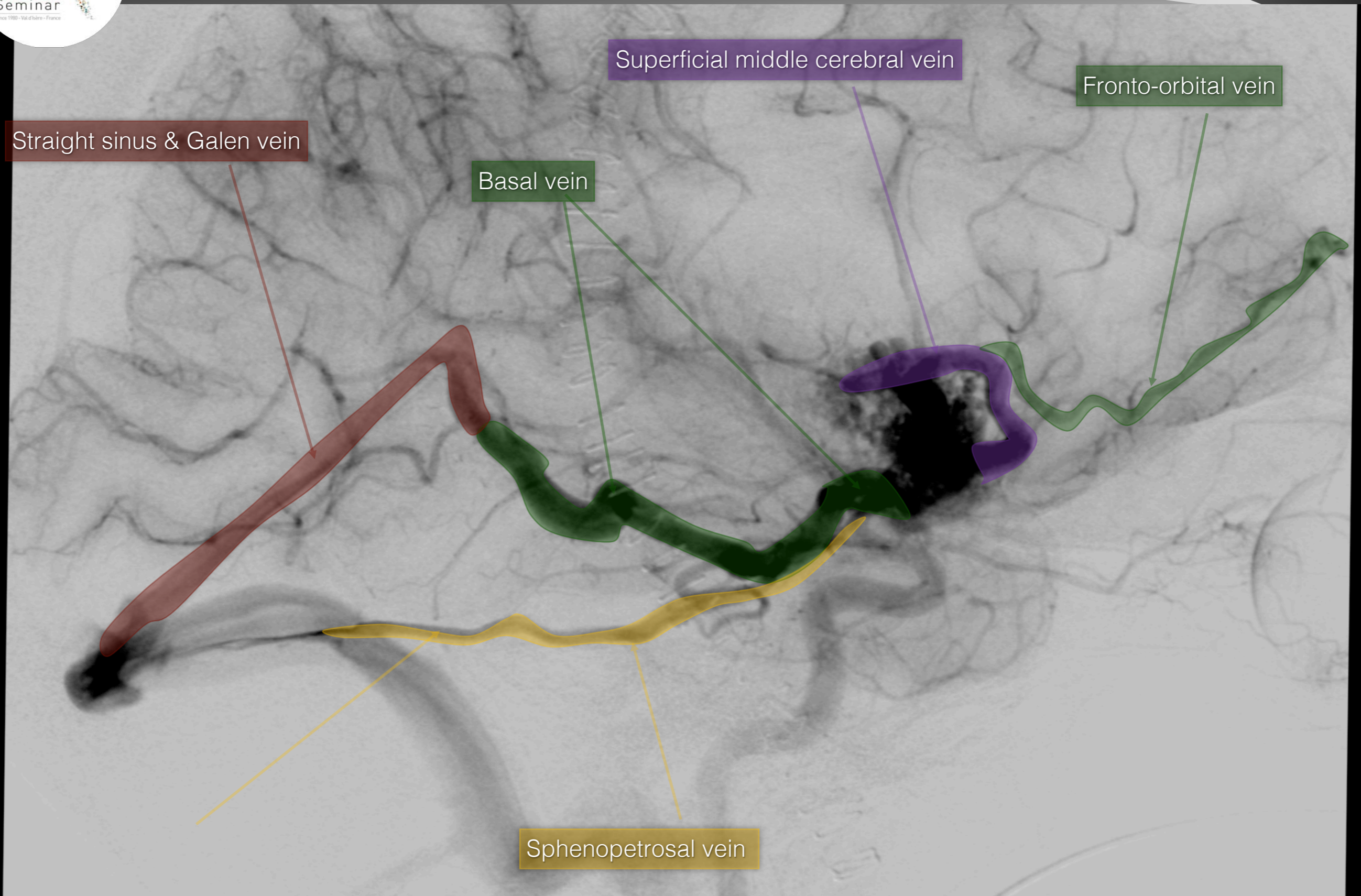
Insular vein

Basal vein

Deep middle cerebral vein

Angle: 0

S.P.S



Straight sinus & Galen vein

Basal vein

Superficial middle cerebral vein

Fronto-orbital vein

Sphenopetrosal vein



View size: 2658 x 1524
WL: 113 WW: 224

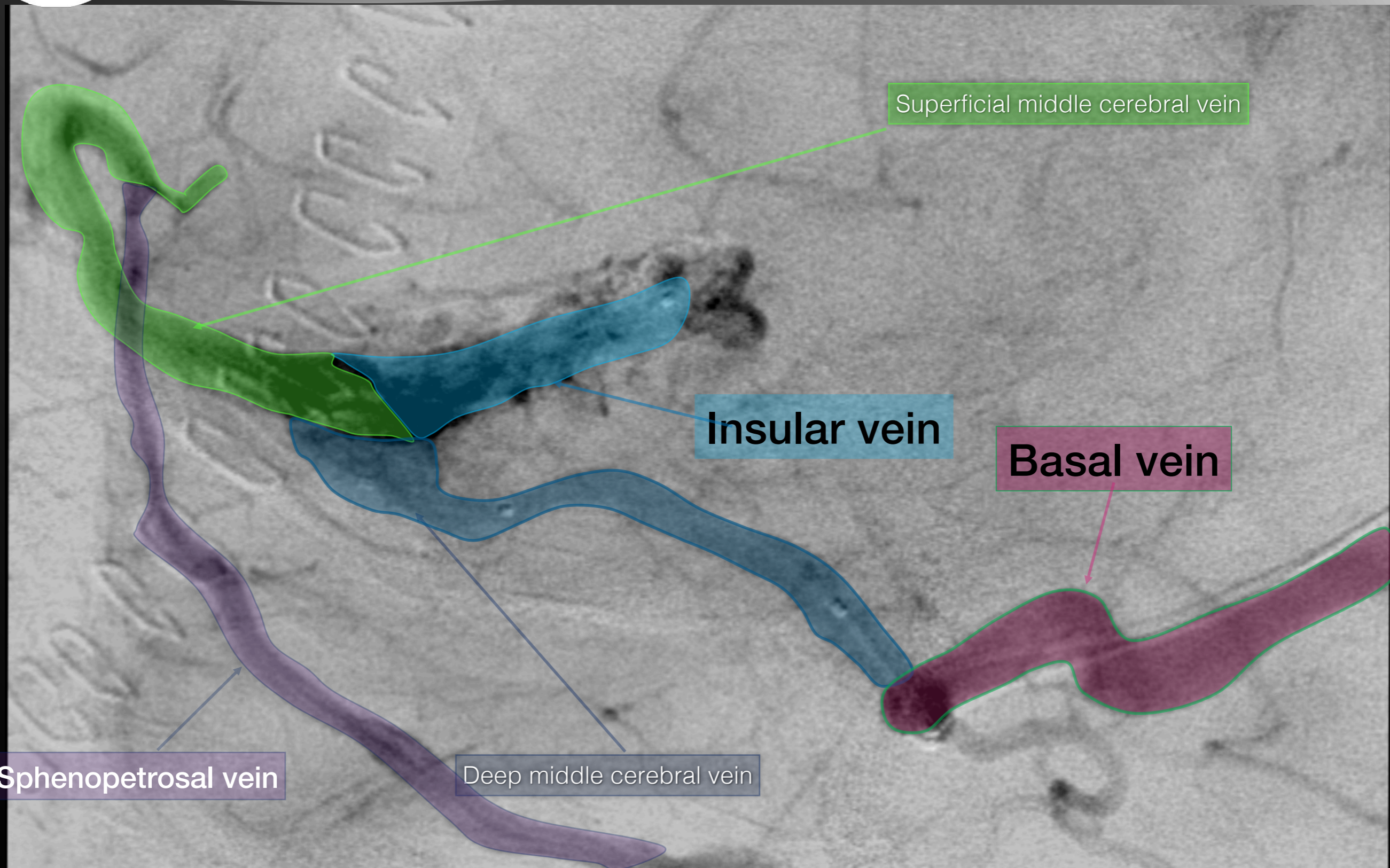
Unnamed
clossier photo nv
145



Basal vein

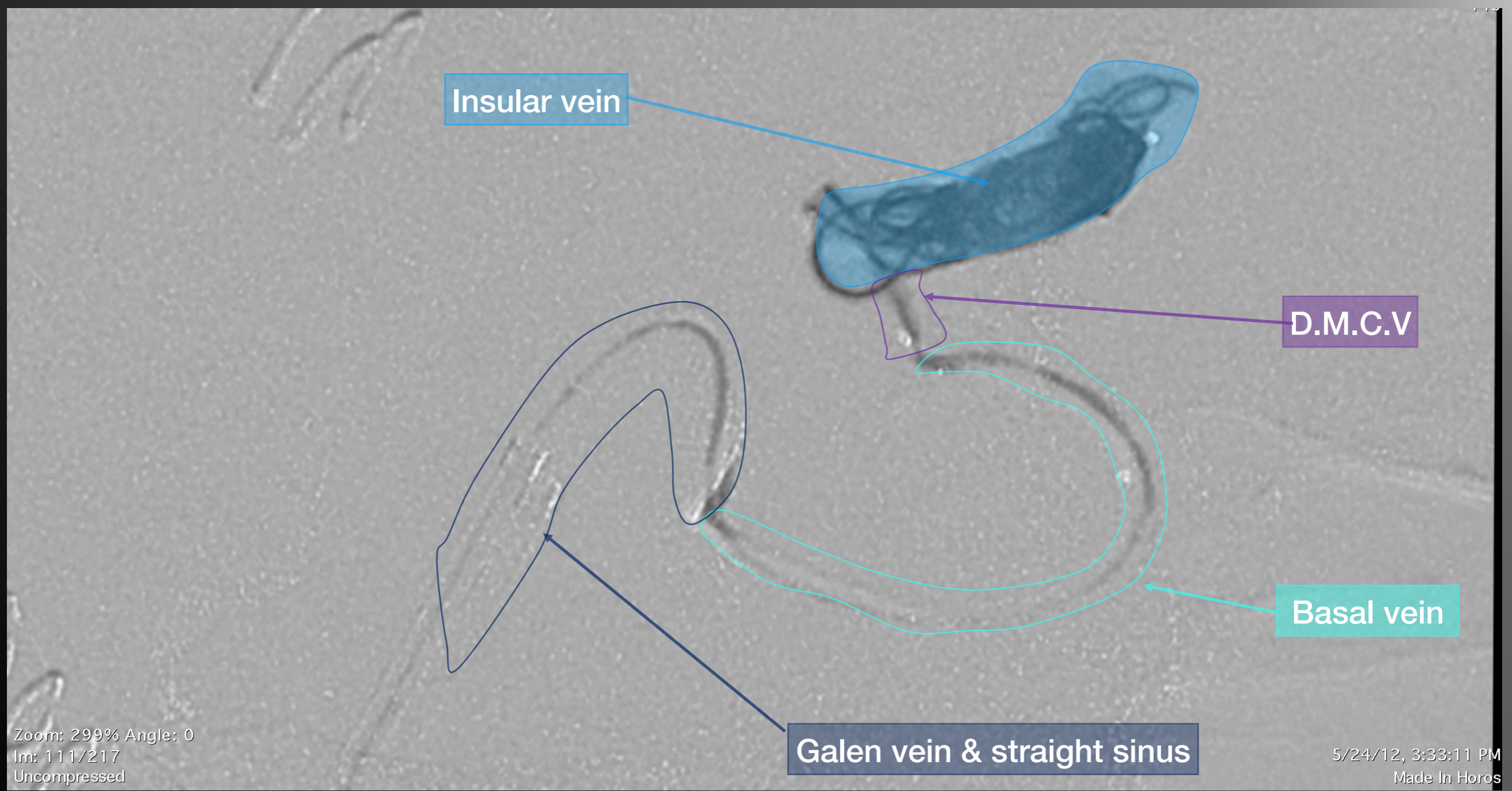
Zoom: 305% Angle: 0
Im: 87/217
Uncompressed

5/24/12, 2:52:10 PM
Made In Horos





Tip of microcatheter





Zoom: 299% Angle: 0
m: 117/217
Uncompressed

5/24/12, 3:36:12 PM
Made In Horos

Final control



140

Superficial middle cerebral vein

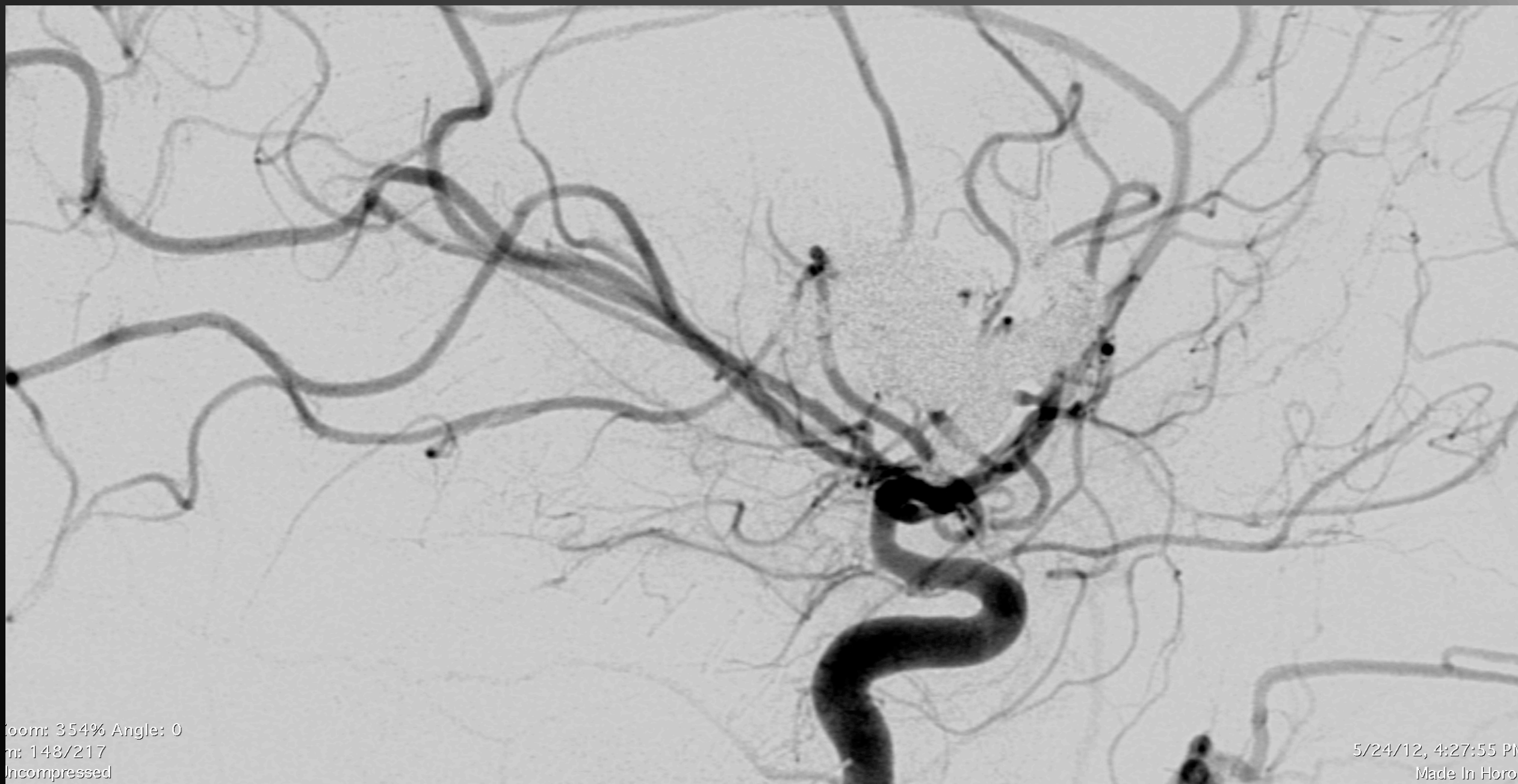
Insular vein

Distal retrograde arterial occlusion

Deep middle cerebral vein

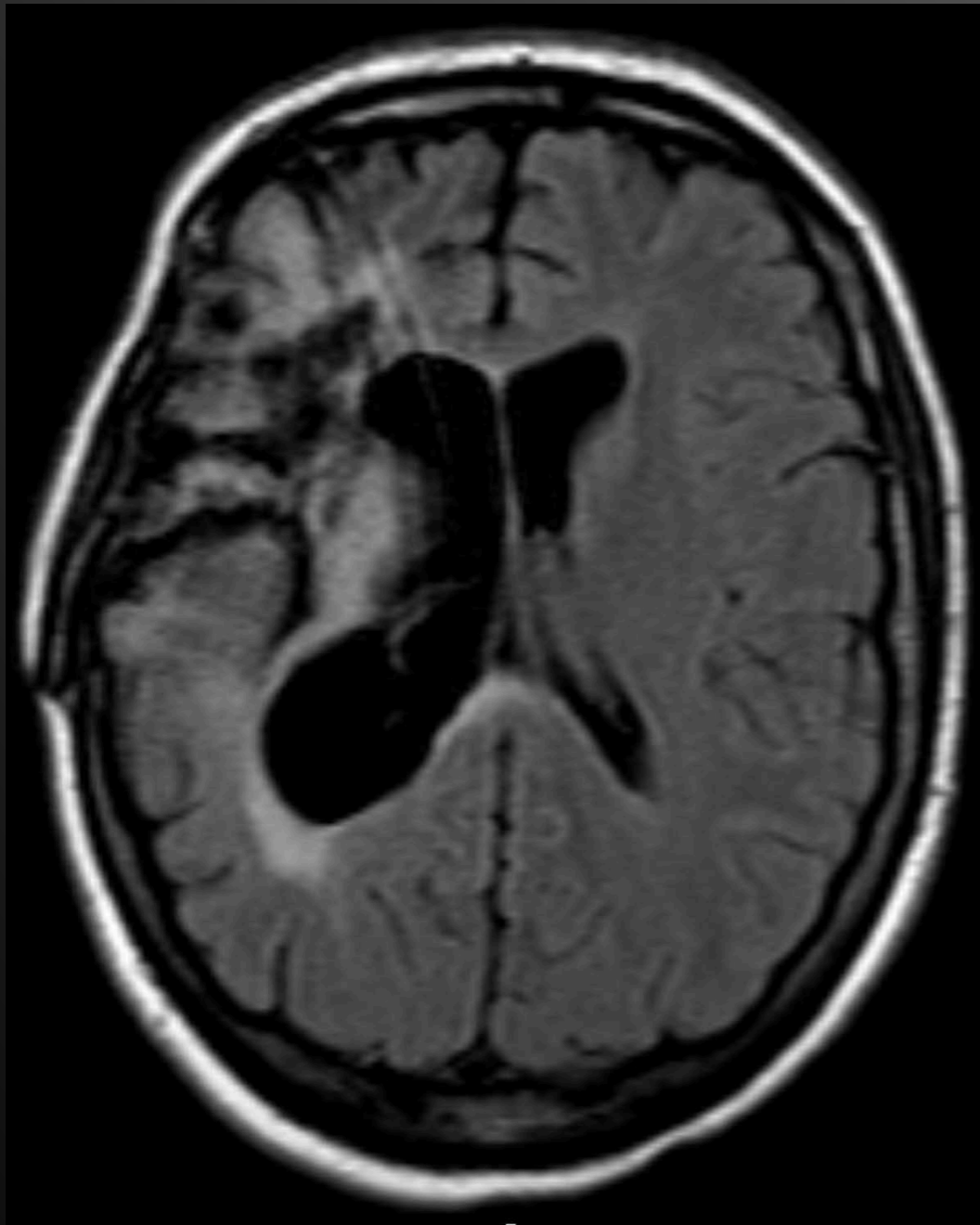


Final control

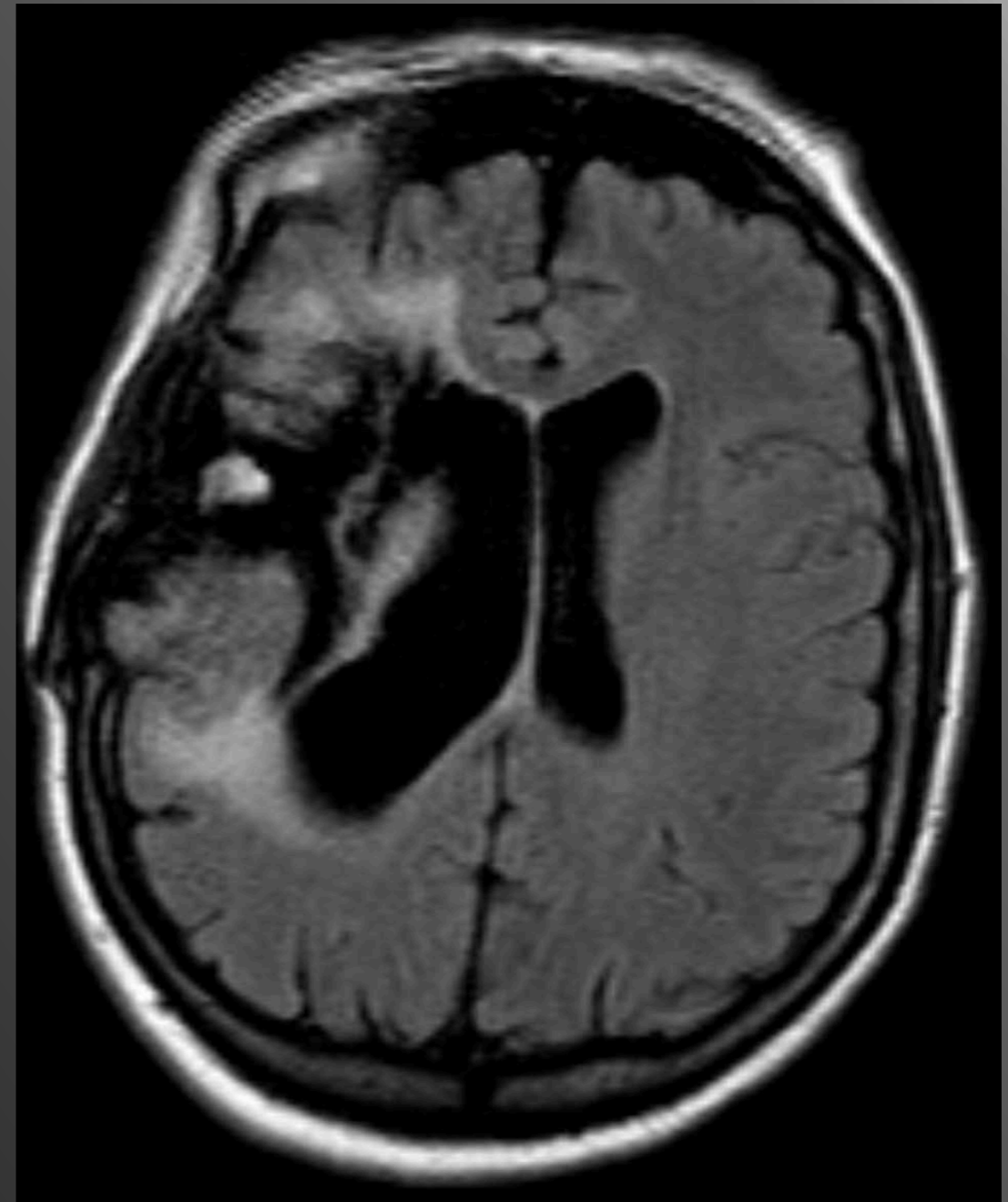


Zoom: 354% Angle: 0
Frame: 148/217
Incompressed

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Made In Horos



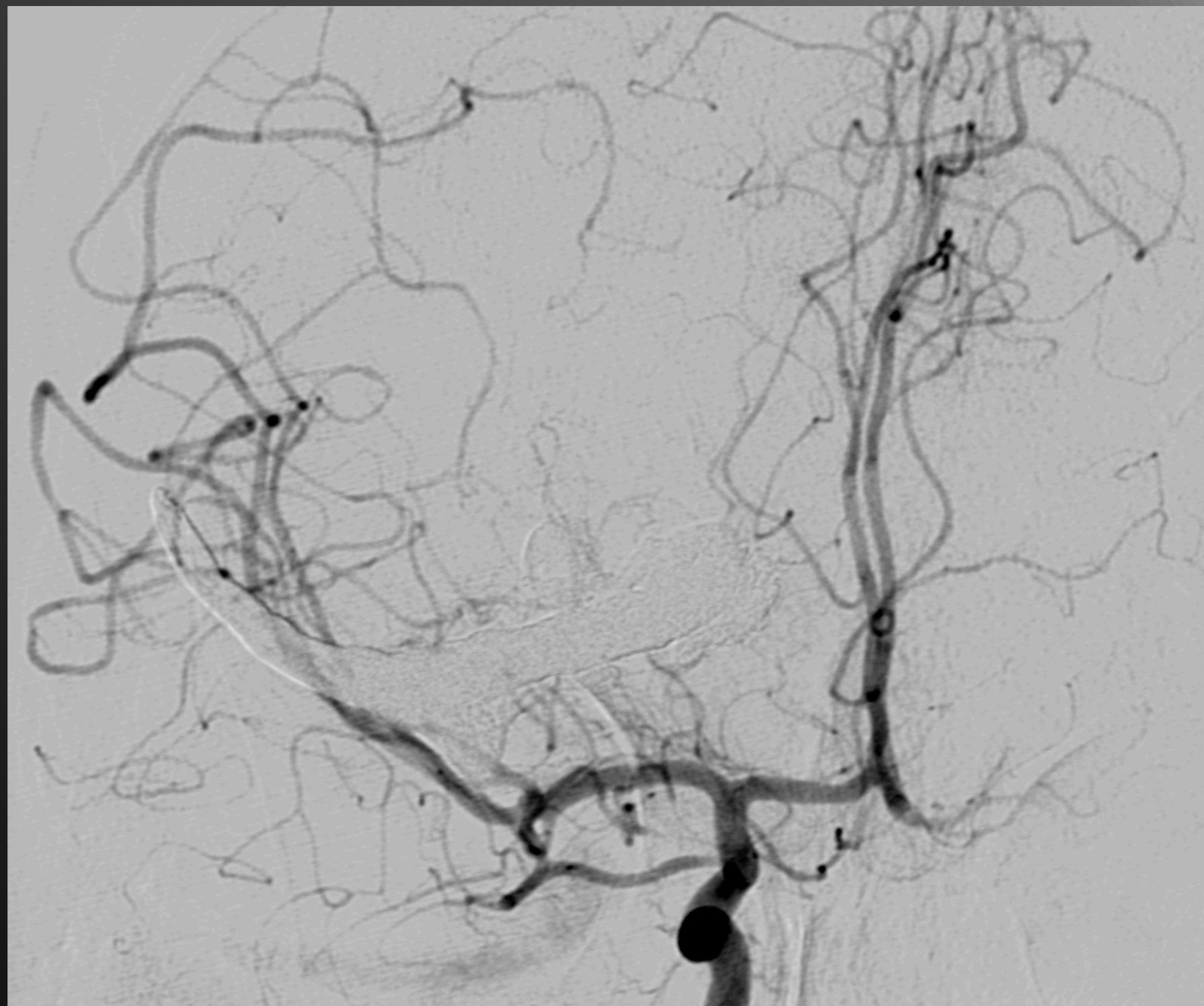
Before Treatment
14.01.2013



After Treatment
22.07.2013

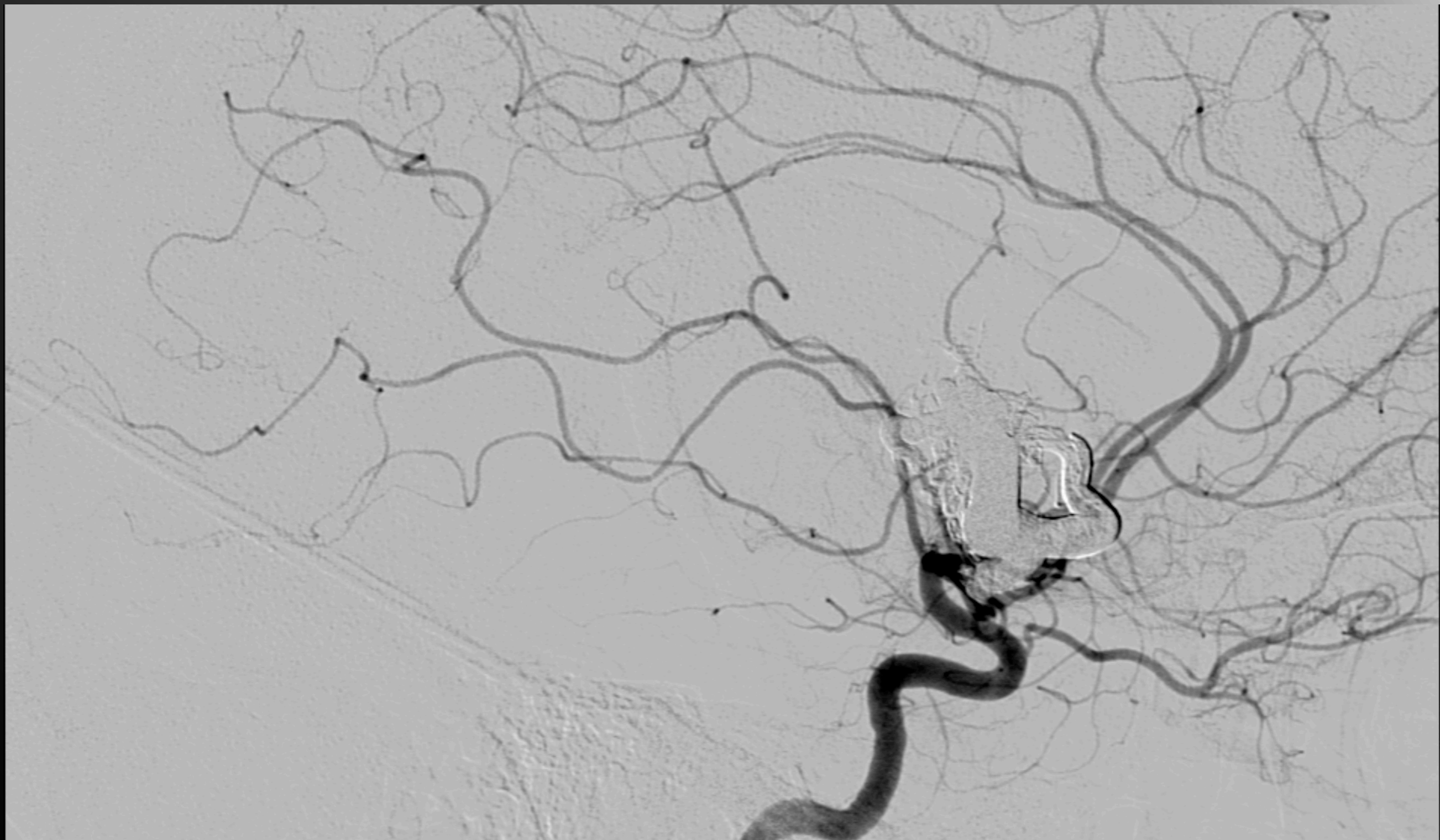


six-month follow-up





six-month follow-up



Porcelain Vein

With Coils

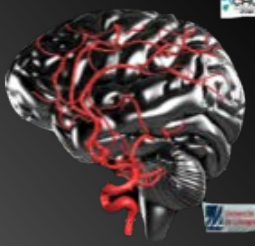
Without Coils



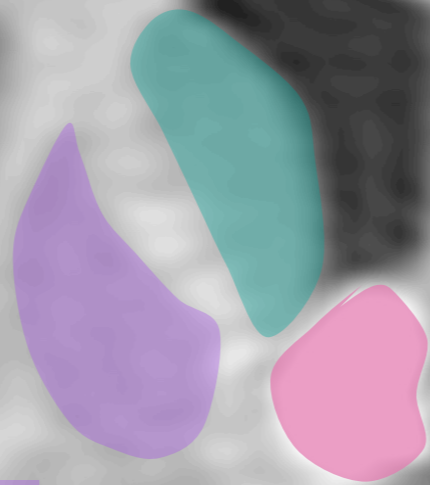
Nucleus accumbens AVM



Right Nucleus Accumbens bleeding

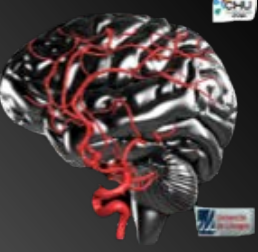
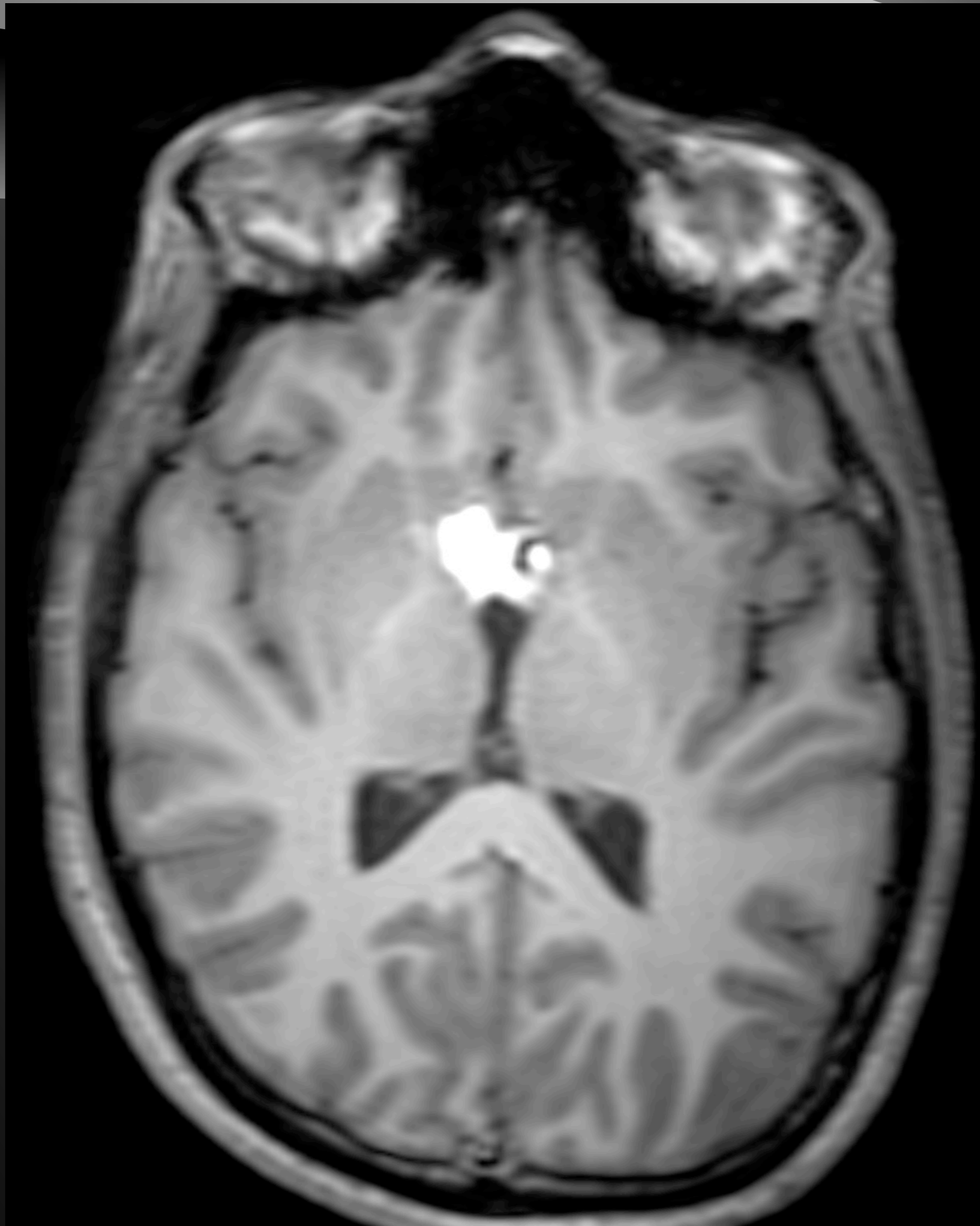


Caudate



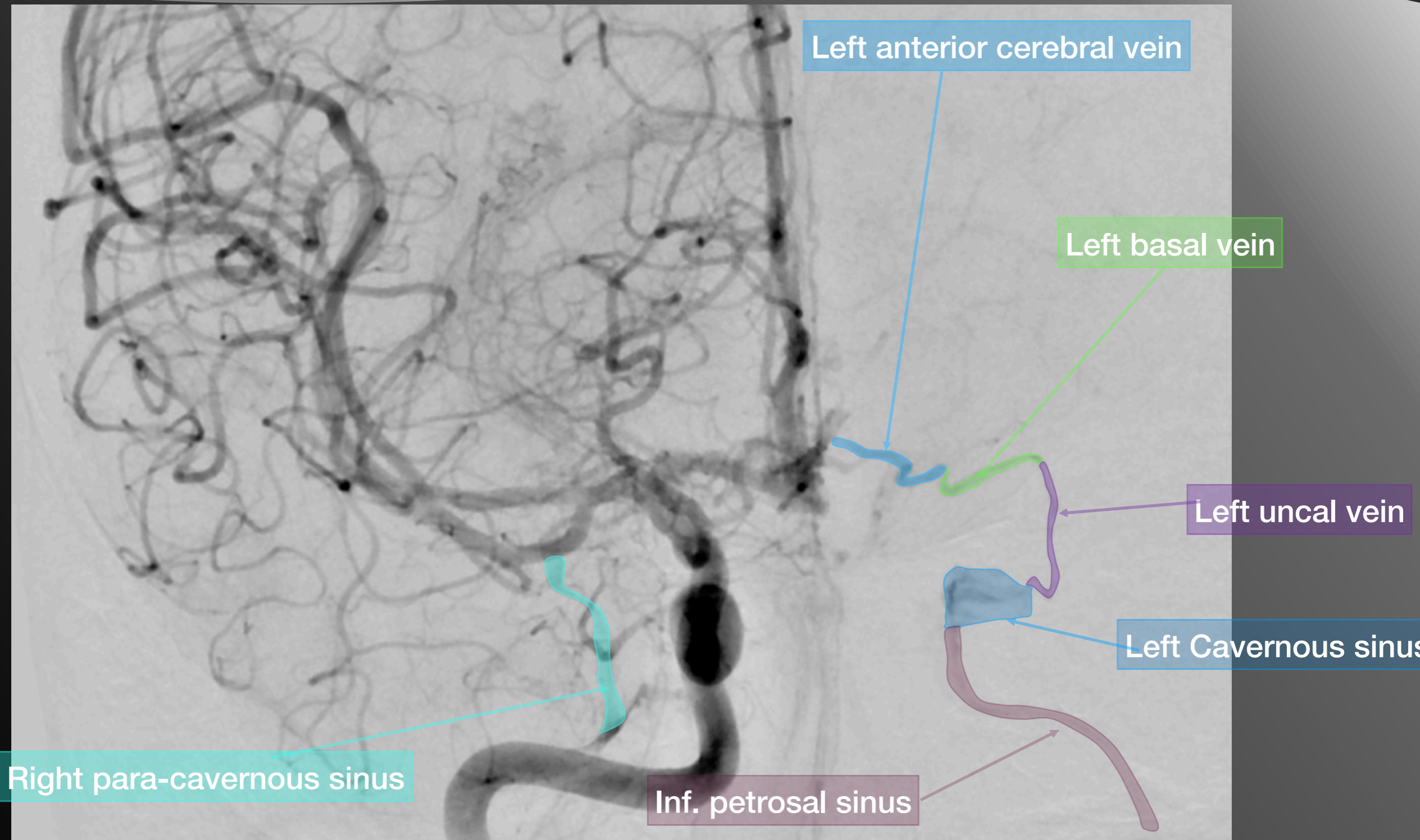
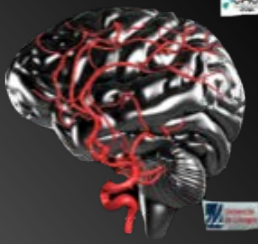
nucleus accumbens

Lentiform
nucleus





NIDUS



Left anterior cerebral vein

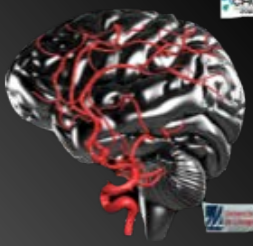
Left basal vein

Left uncal vein

Left Cavernous sinus

Inf. petrosal sinus

Right para-cavernous sinus



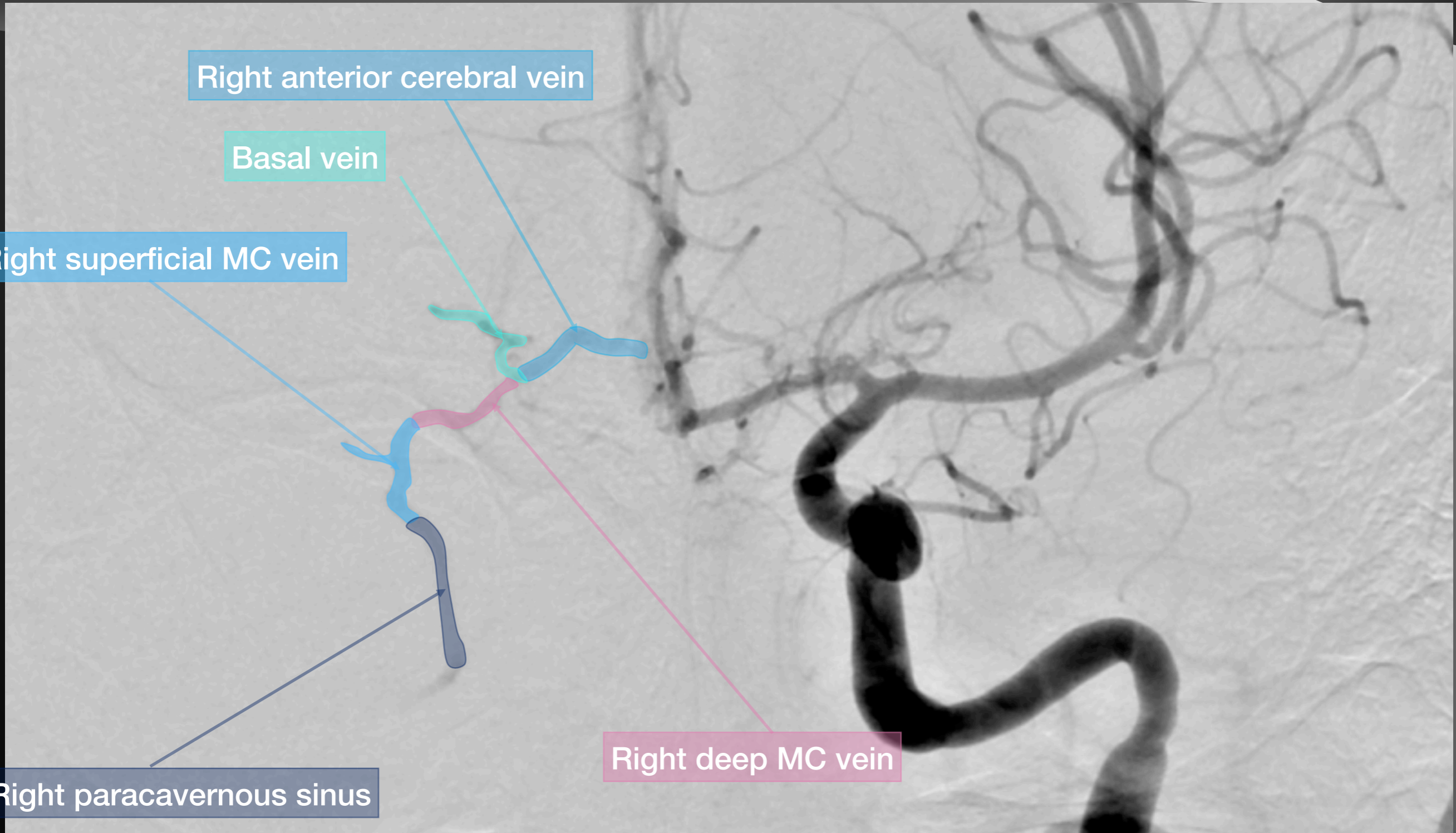
Right anterior cerebral vein

Basal vein

Right superficial MC vein

Right deep MC vein

Right paracavernous sinus





Ant. Comm. vein

Superior chiasmatal vein (Collecting vein)

Left anterior cerebral vein

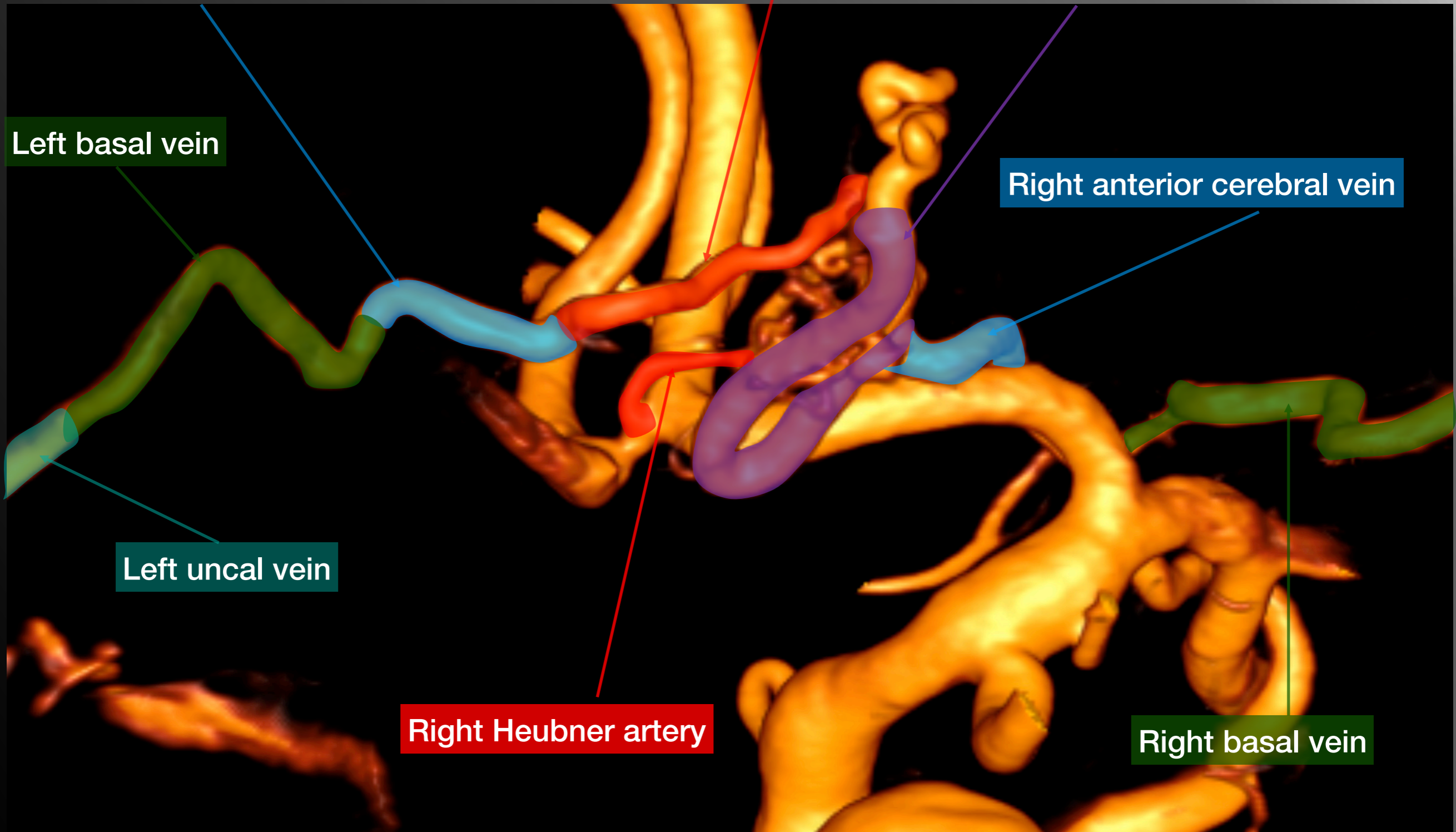
Left basal vein

Right anterior cerebral vein

Left uncal vein

Right Heubner artery

Right basal vein



Right basal vein

Right anterior cerebral vein

Left anterior cerebral vein



Anterior communicating vein

Left basal vein

Deep MC vein

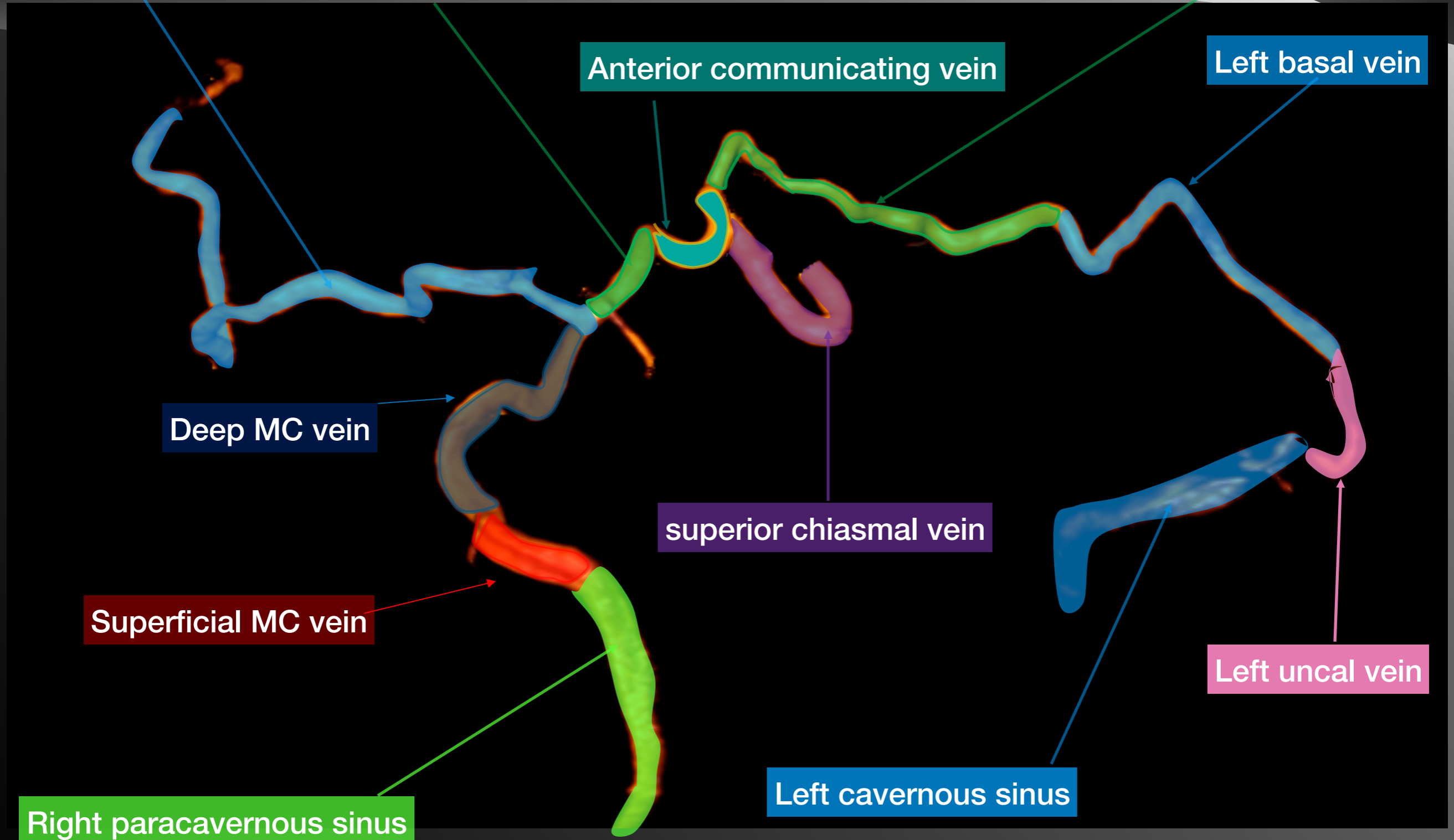
superior chiasmatal vein

Superficial MC vein

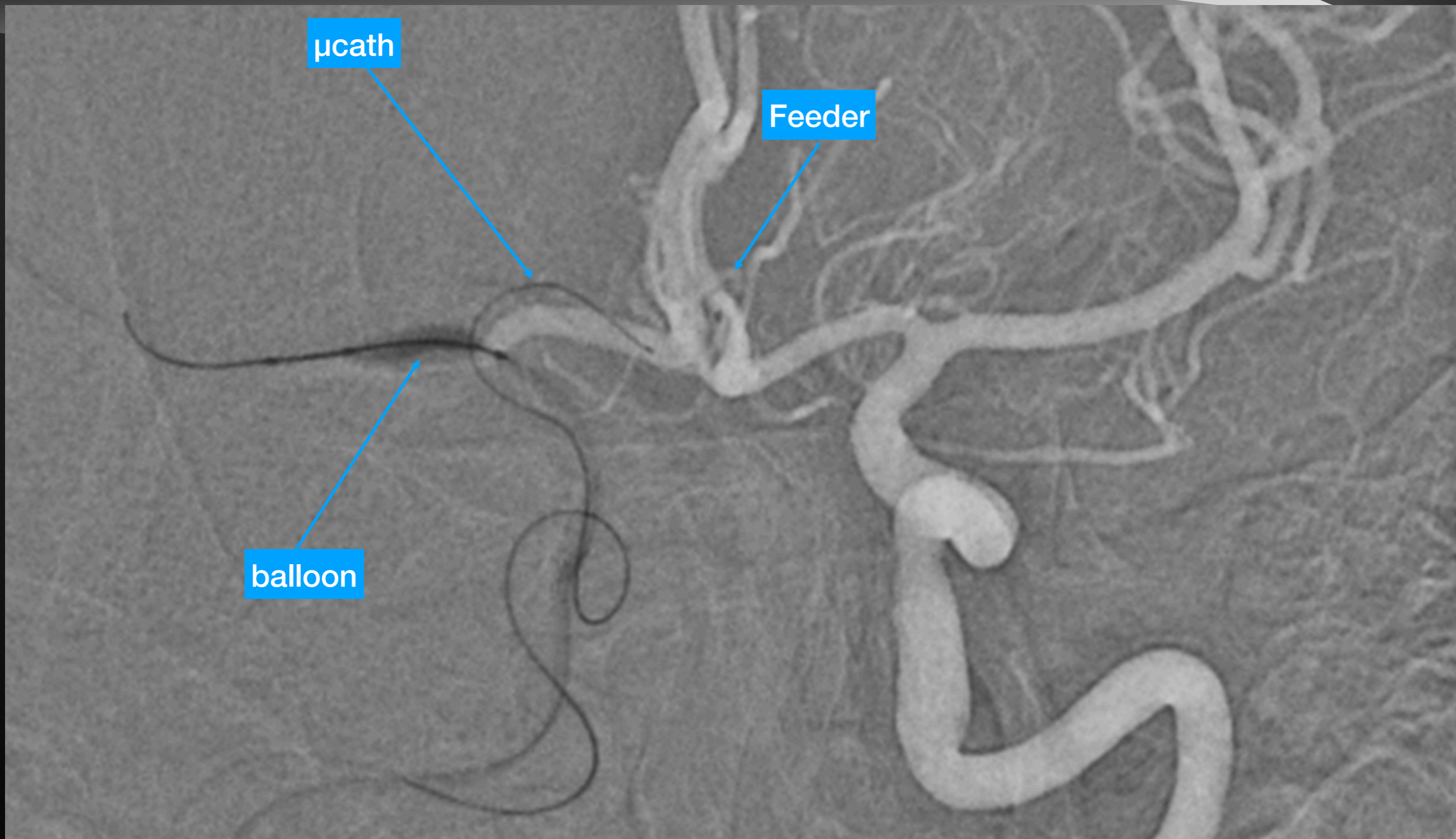
Left uncal vein

Right paracavernous sinus

Left cavernous sinus



Trans arterial Balloon assisted navigation technique

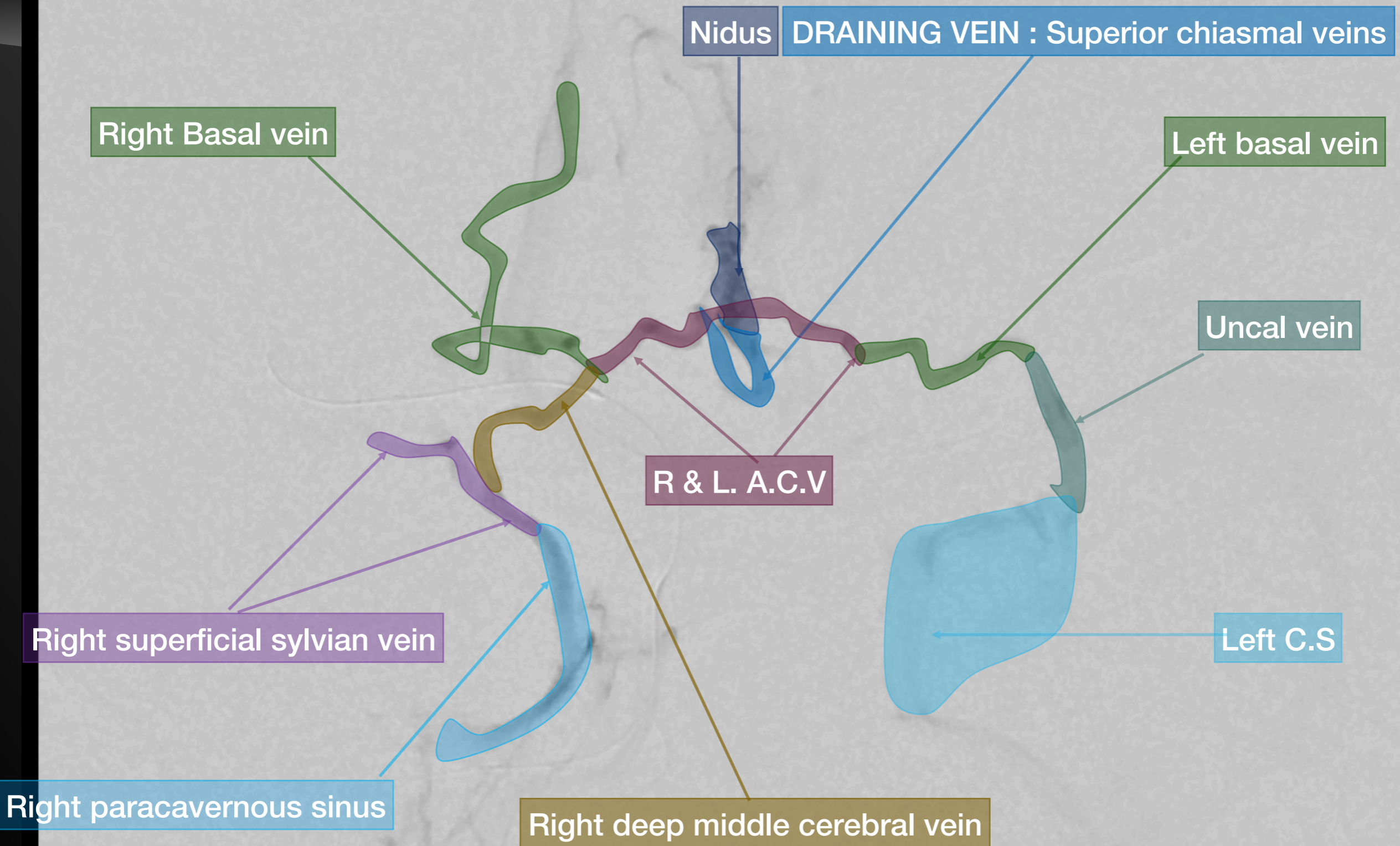
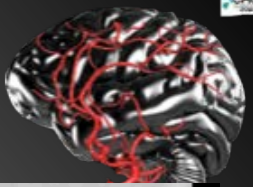


μcath

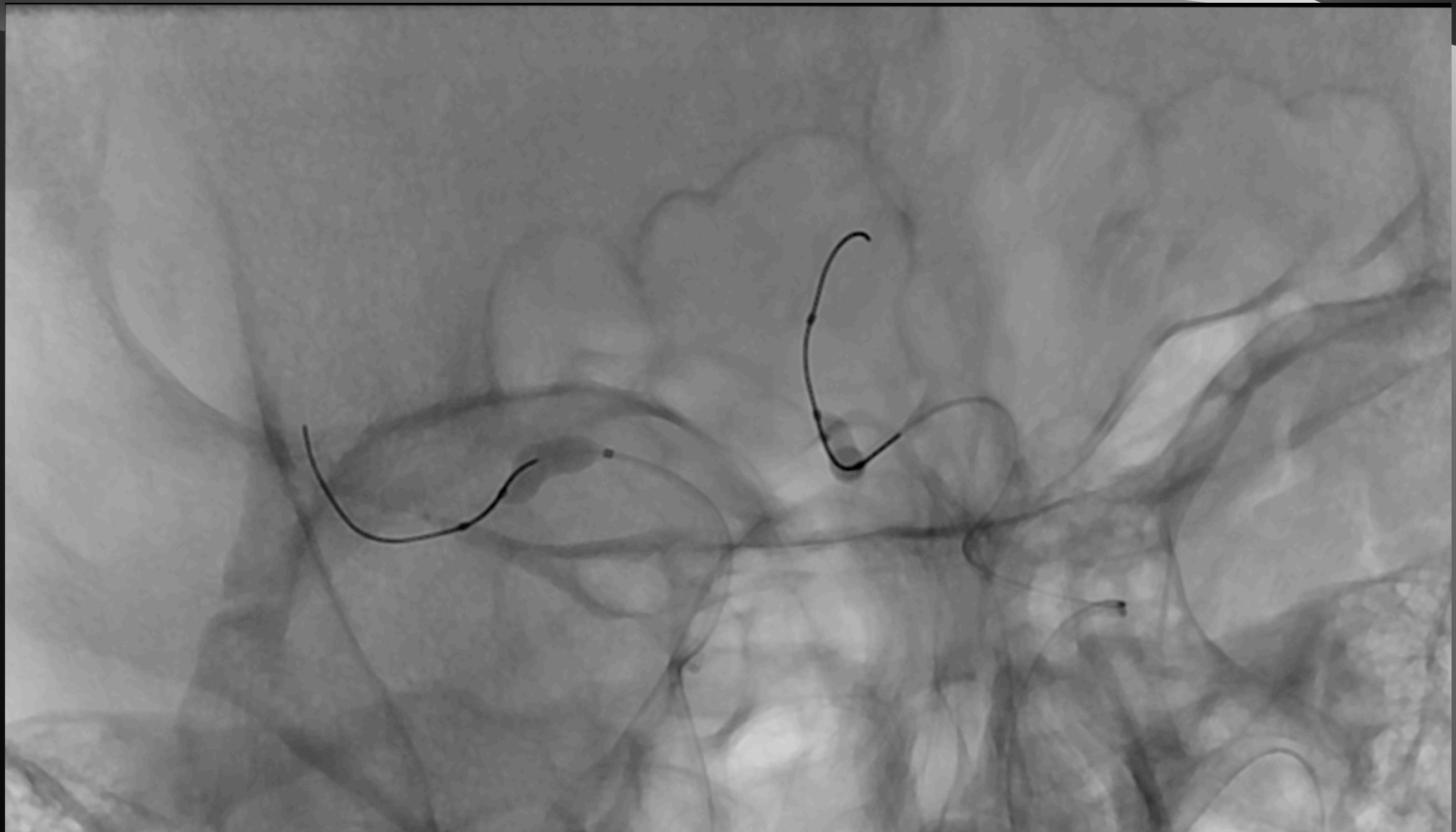
Feeder

balloon

Supper selective trans arterial injection

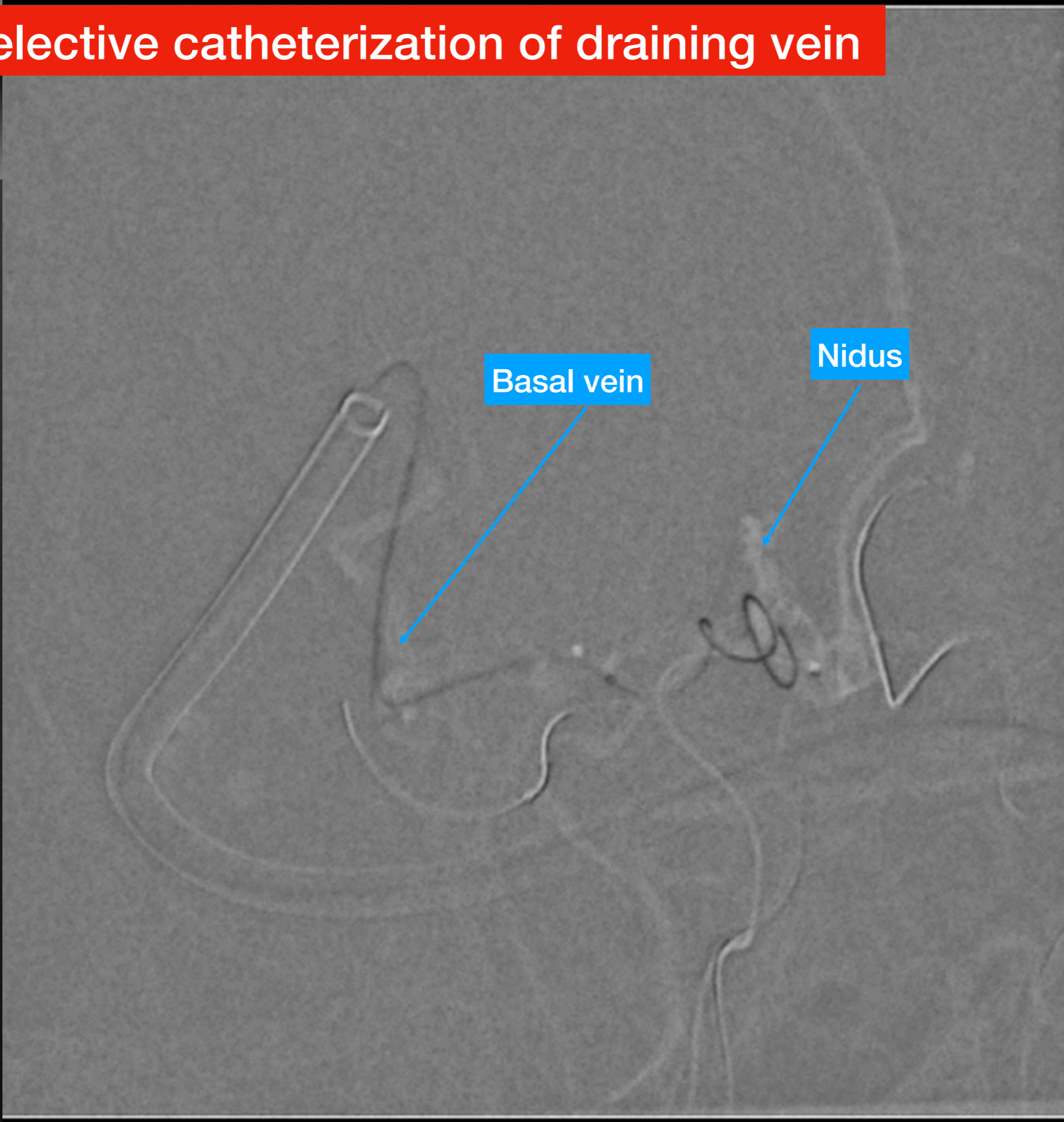








Selective catheterization of draining vein



Basal vein

Nidus

Trans venous injection



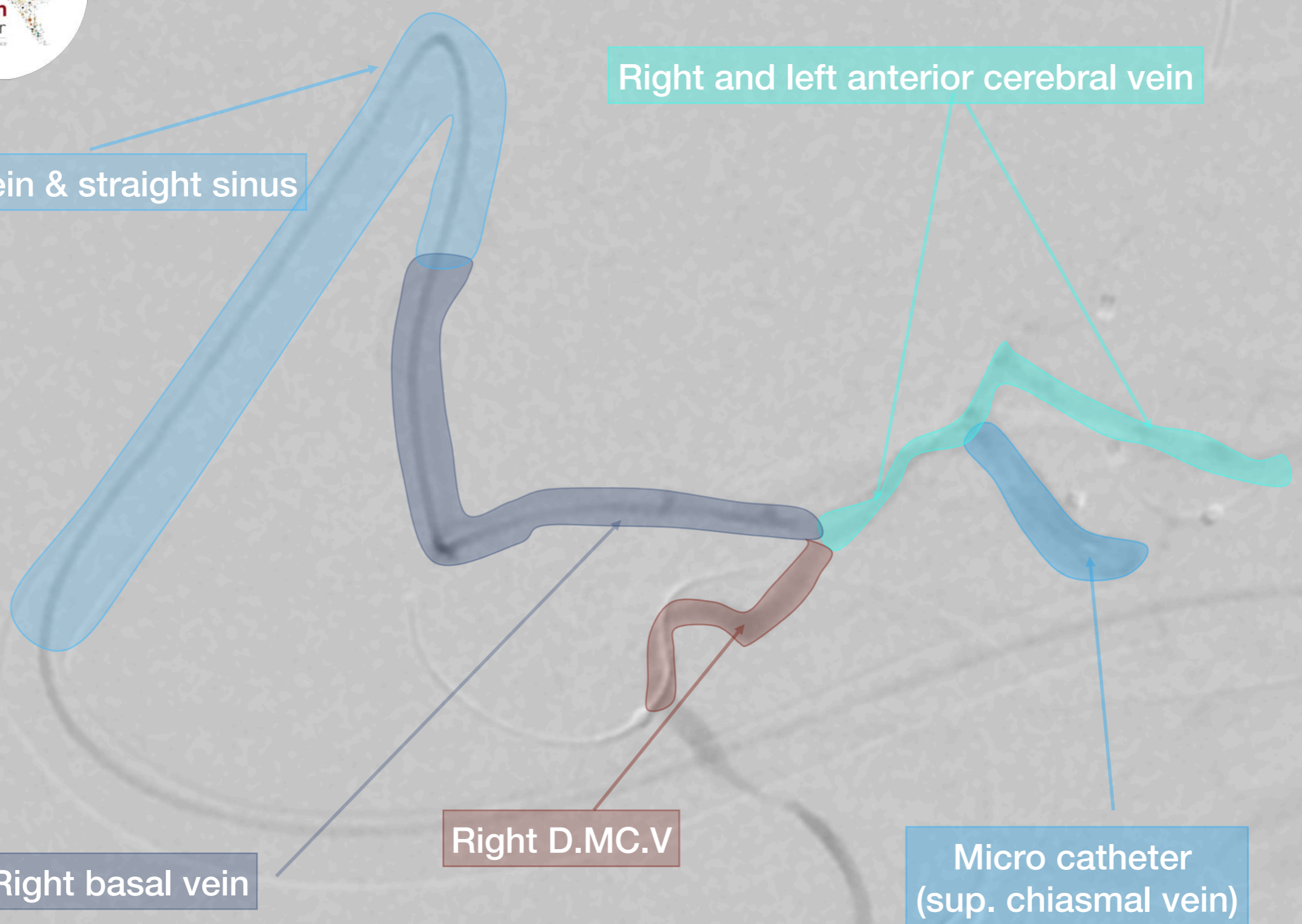
Galen vein & straight sinus

Right and left anterior cerebral vein

Right basal vein

Right D.MC.V

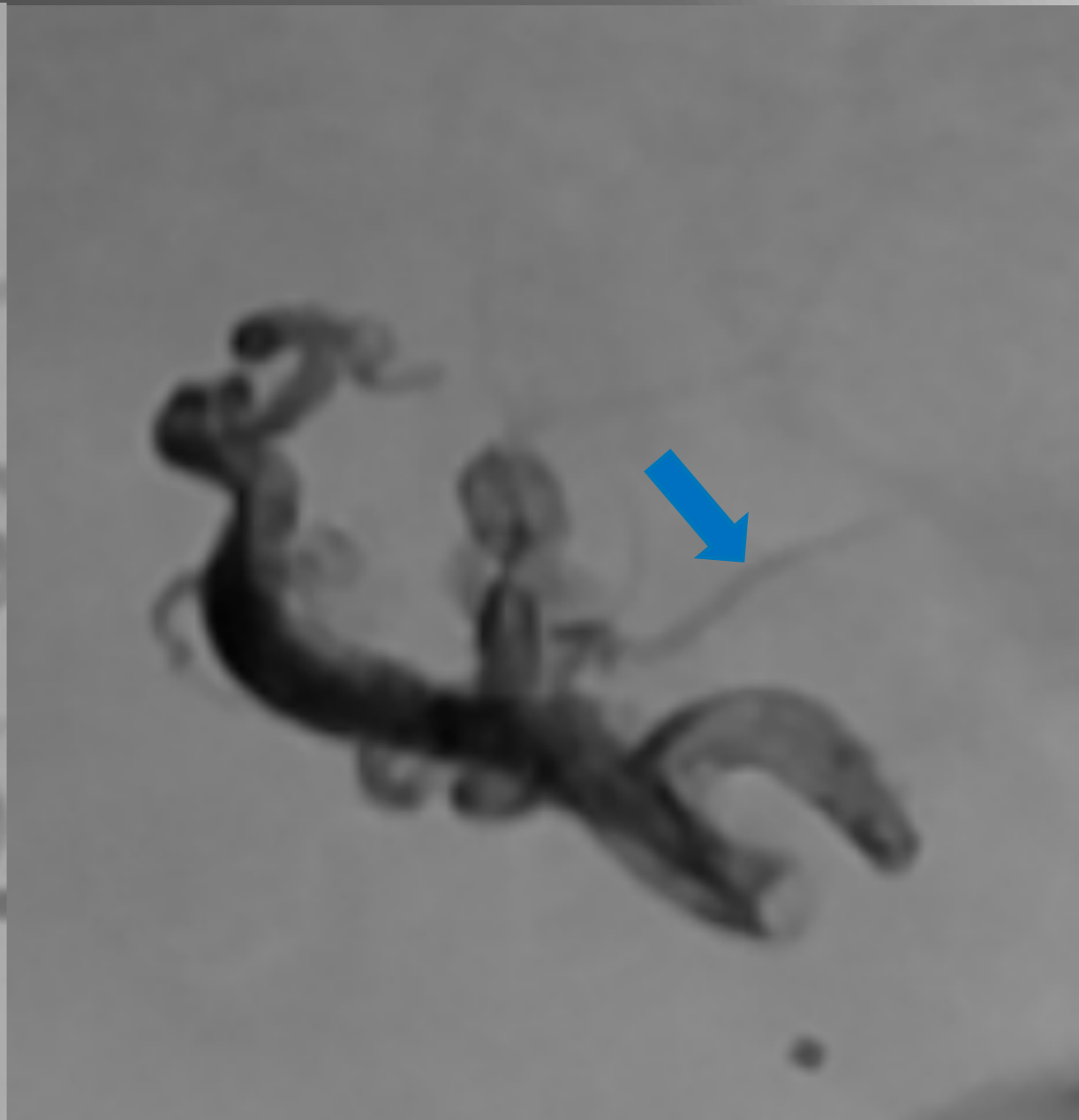
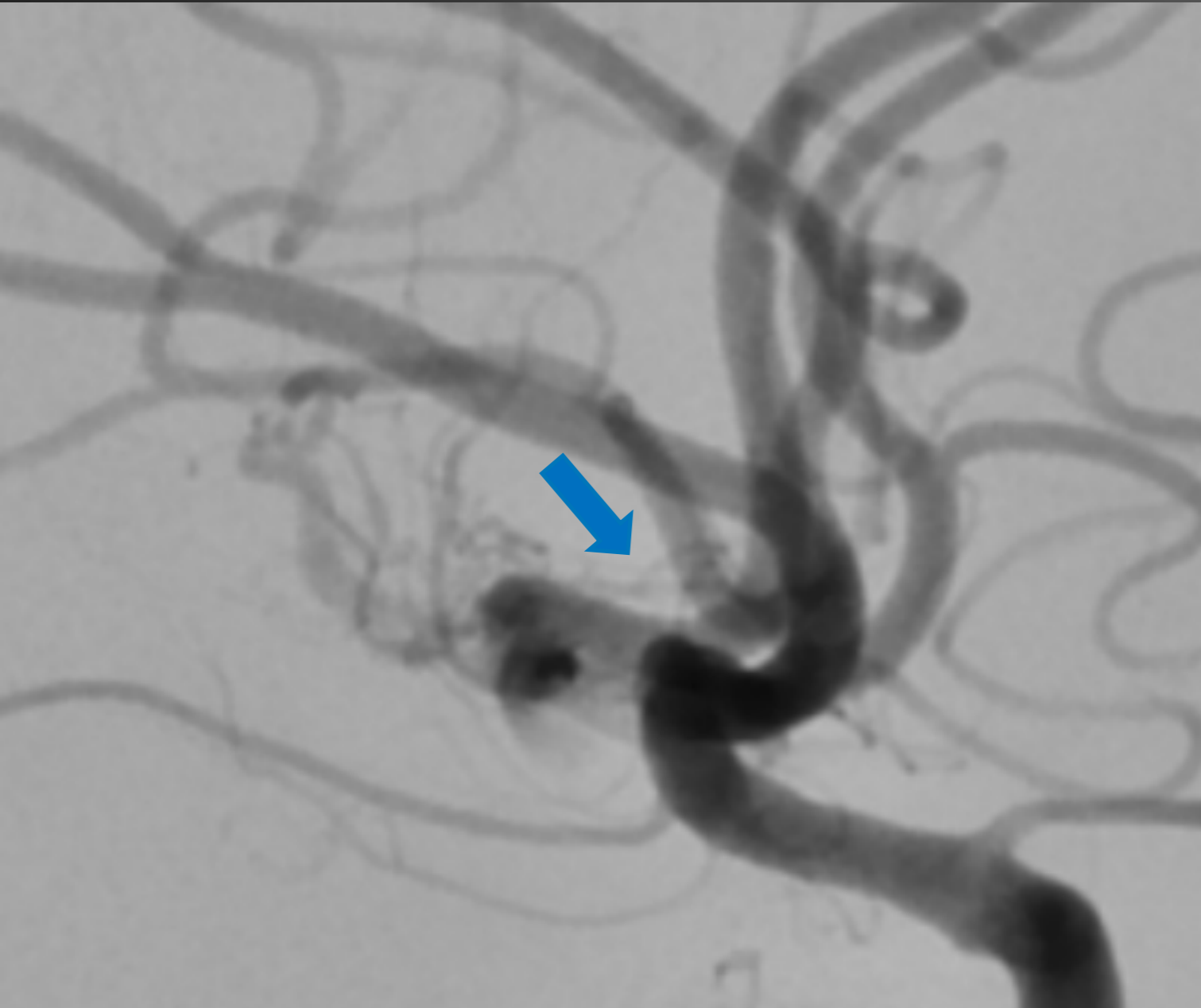
Micro catheter
(sup. chiasmal vein)



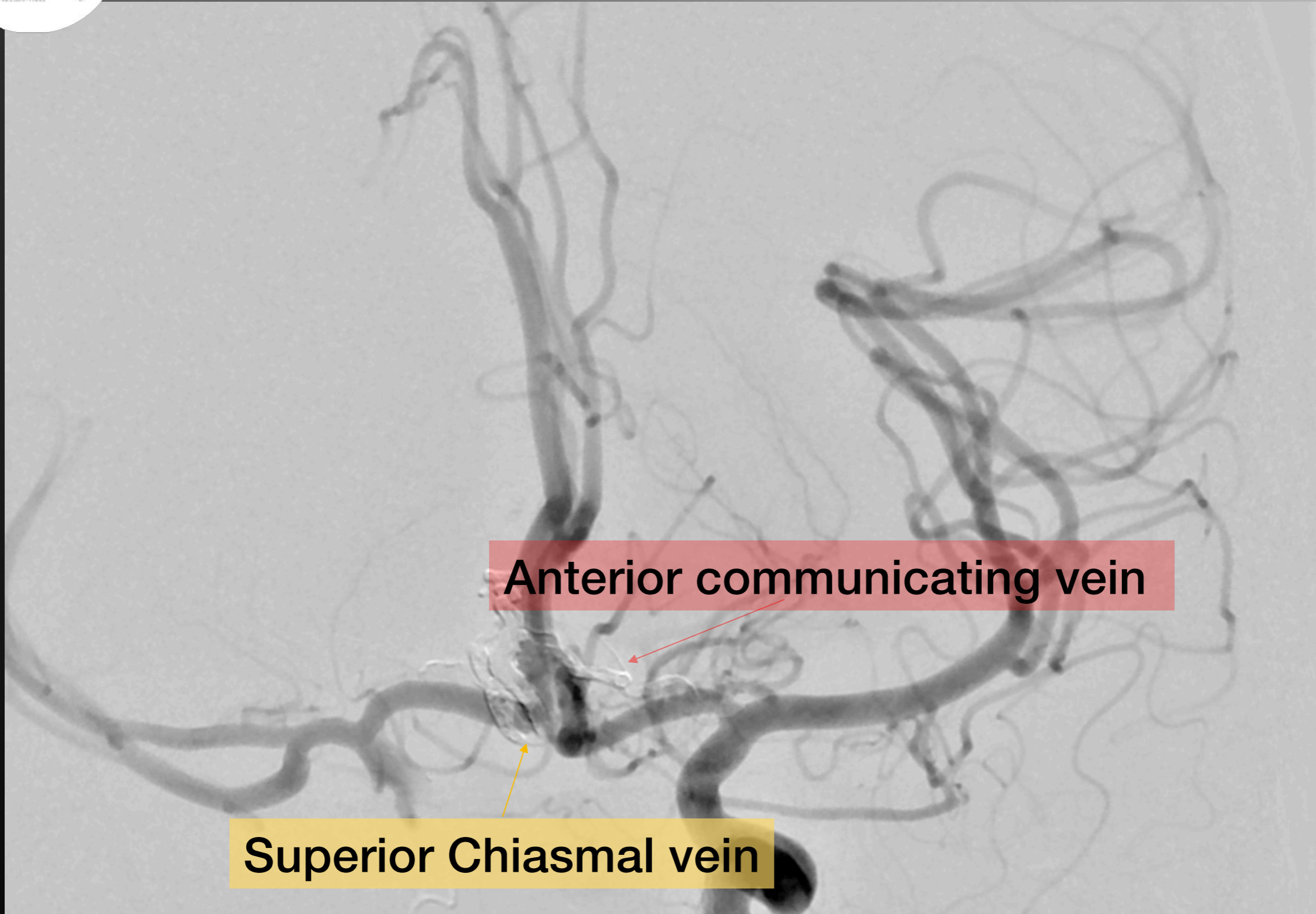


Balloons inflated





Final control

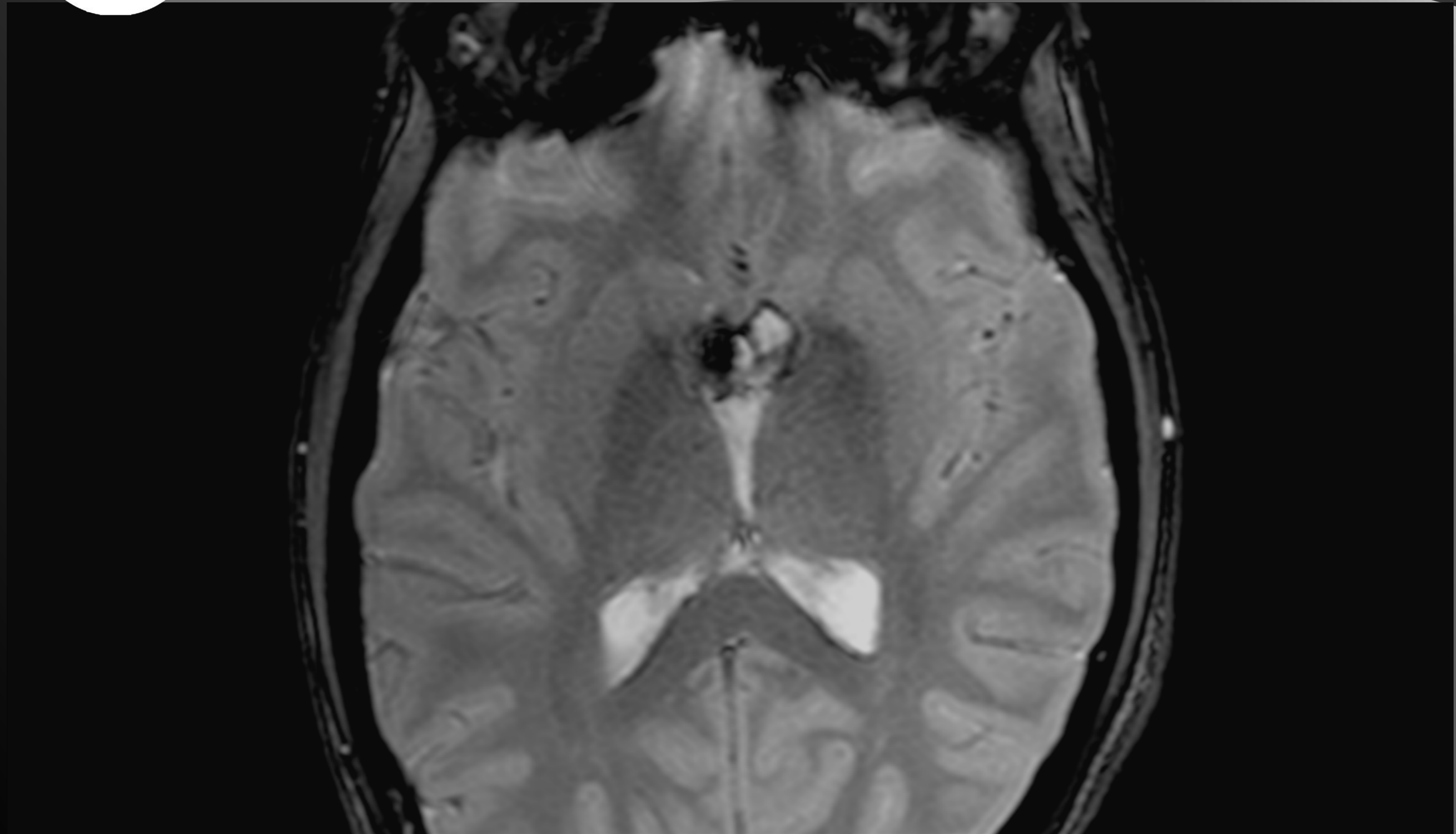


Anterior communicating vein

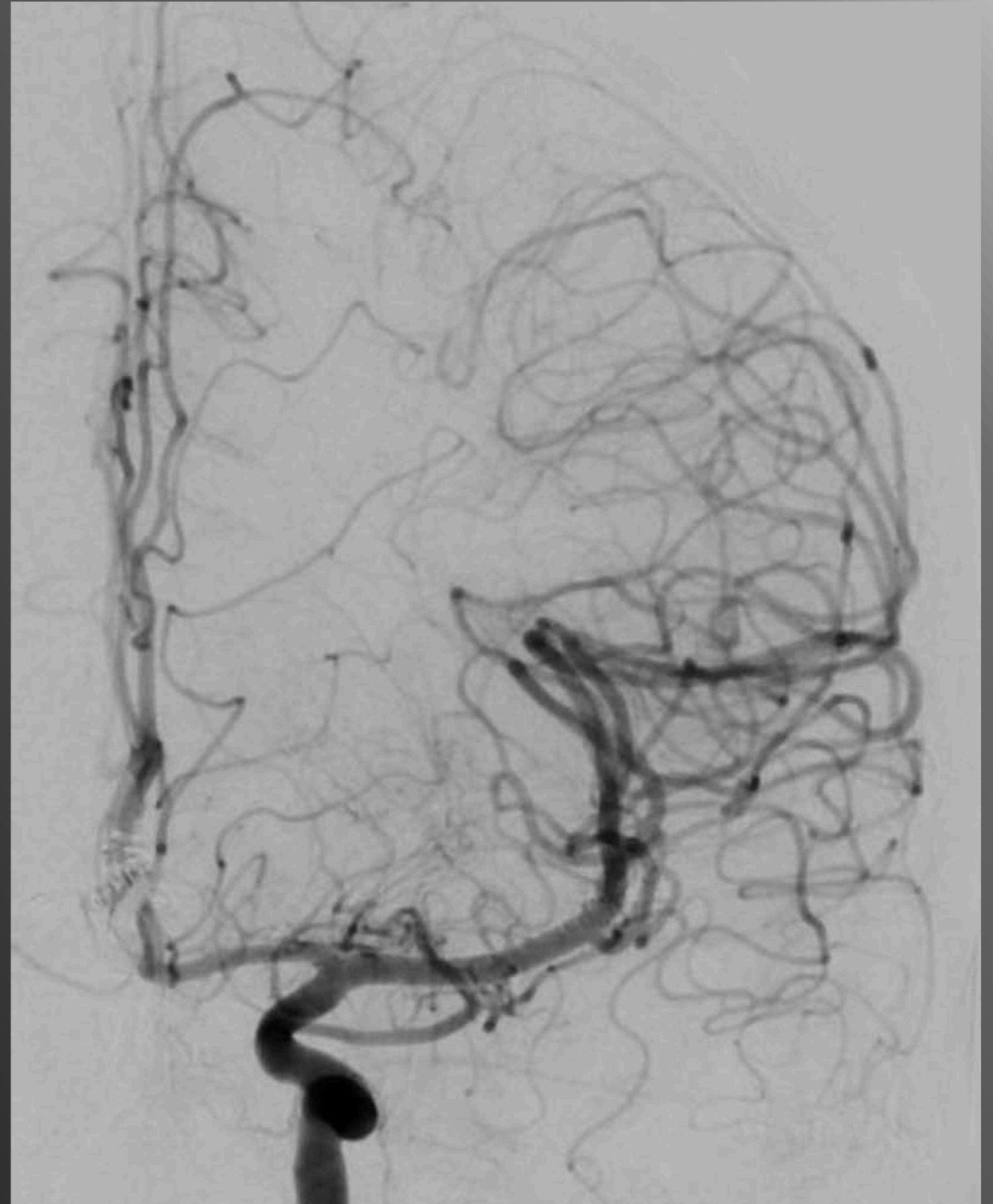
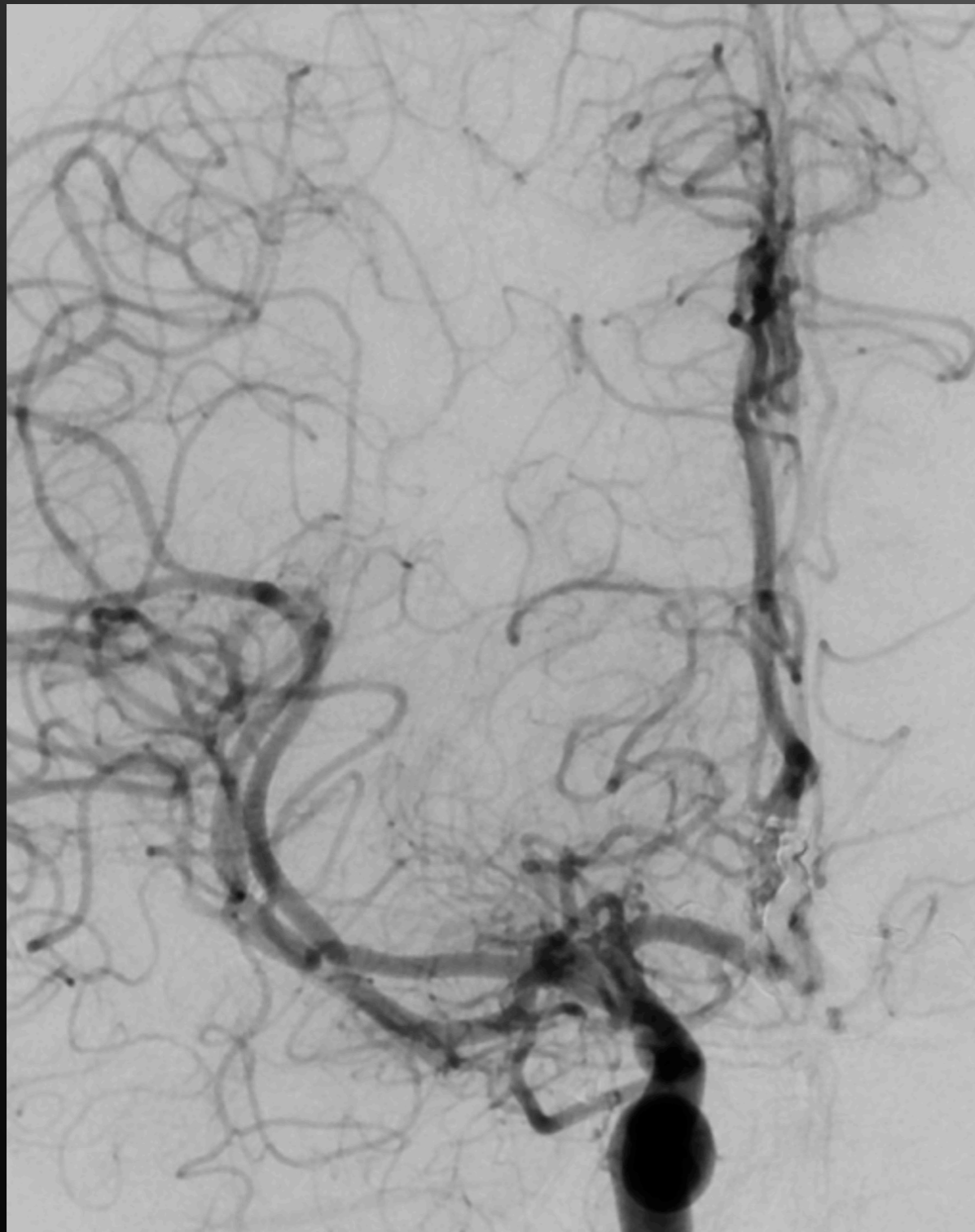
Superior Chiasmal vein



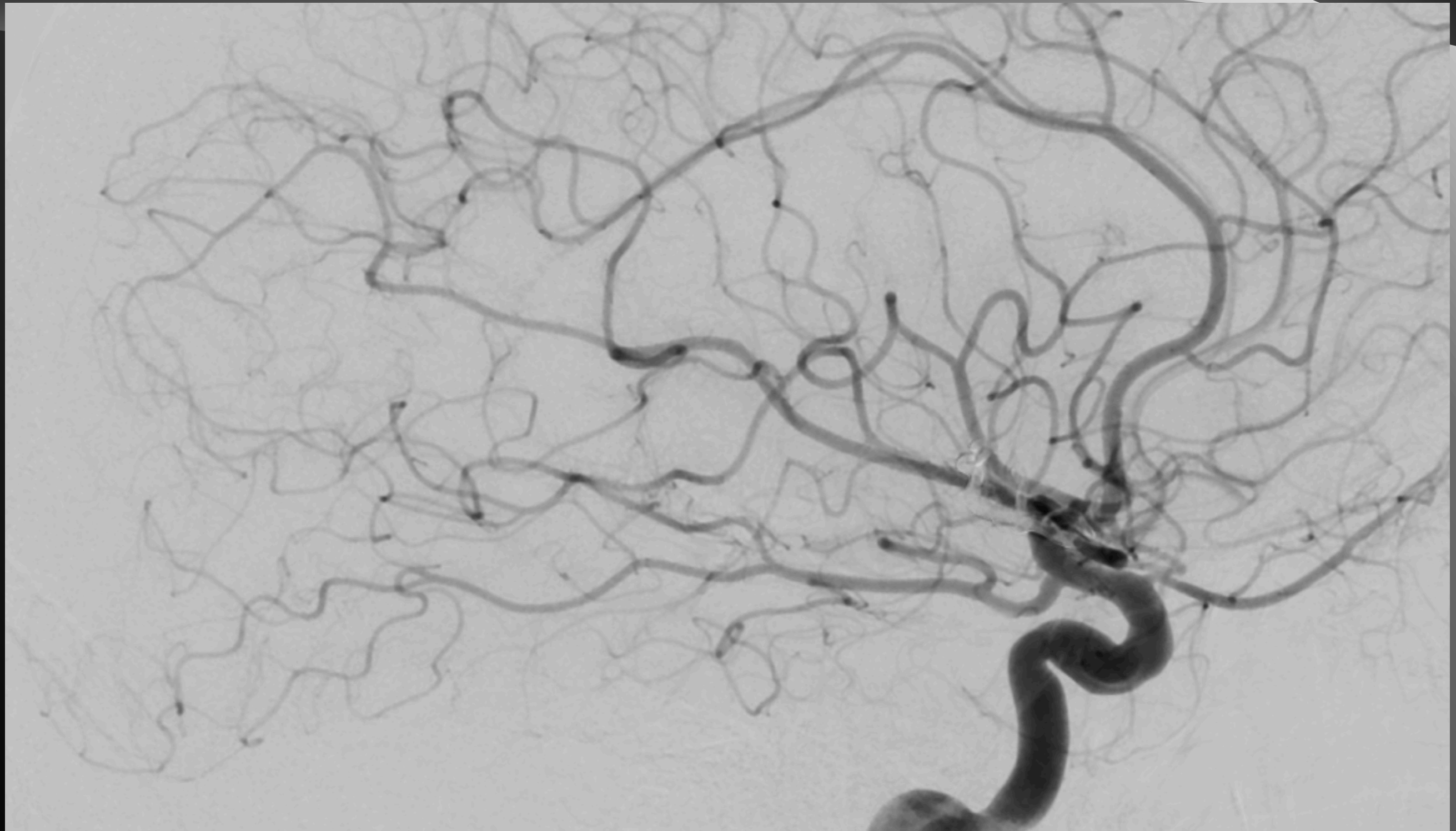
POST T2W MRI



six-month follow-up



six-month follow-up





Introduction

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Limitations

Introduction to the venous approach

➤ Venous approach for BG AVM

Engage in debate

Liquid agents

➤ Porcelain vein

Nidus size

Arterial Balloon

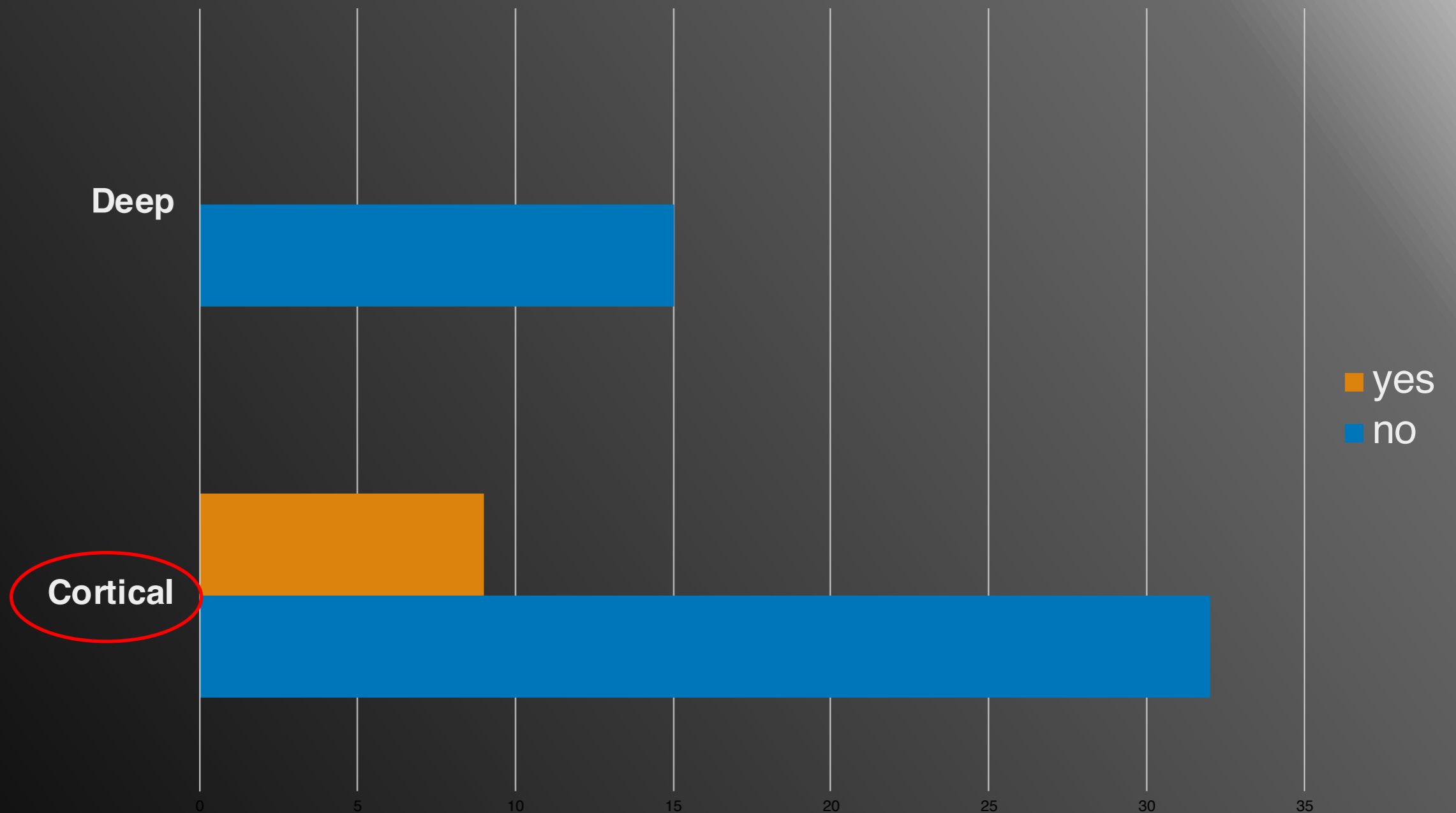
Could it be partial?

What about the venous ischemia?

Take home message

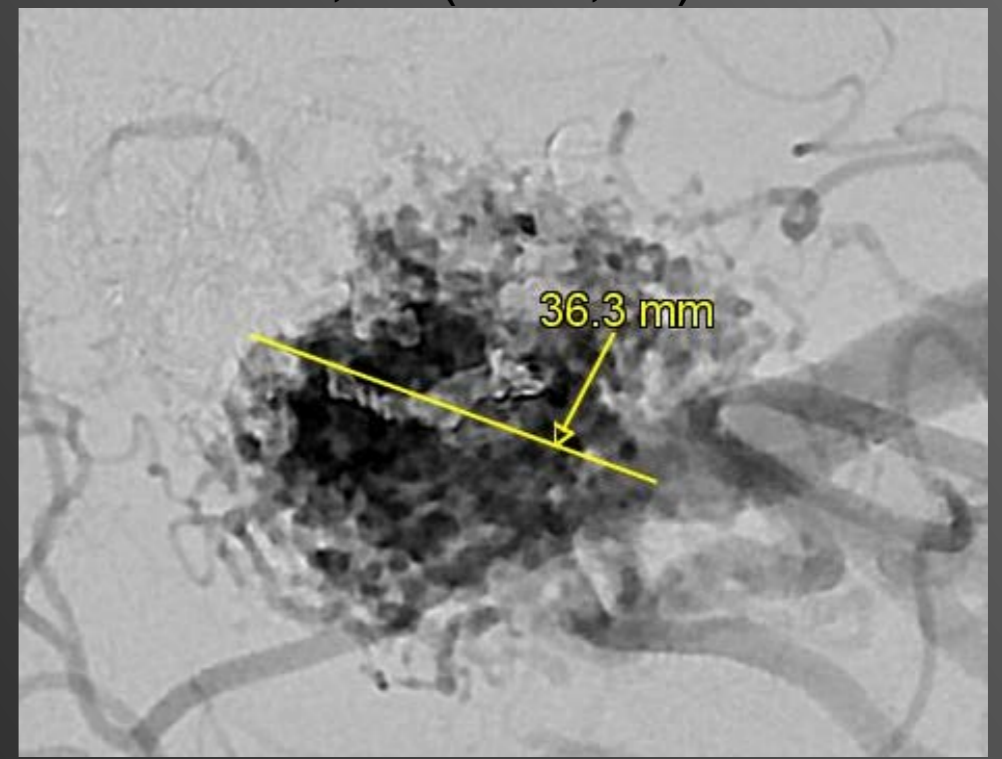
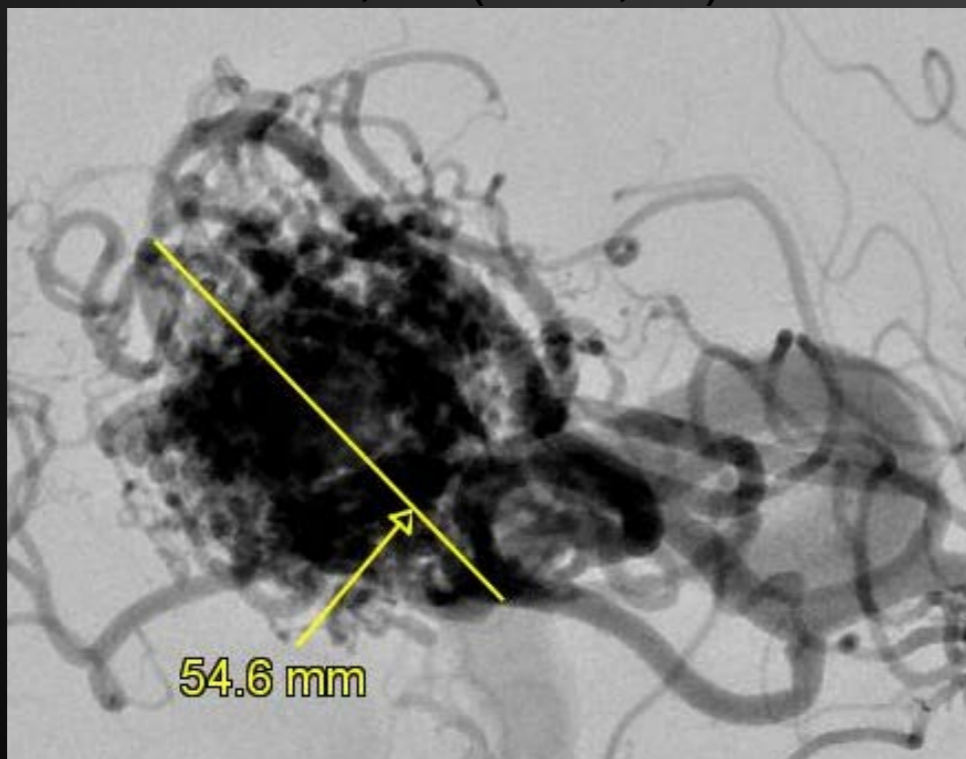
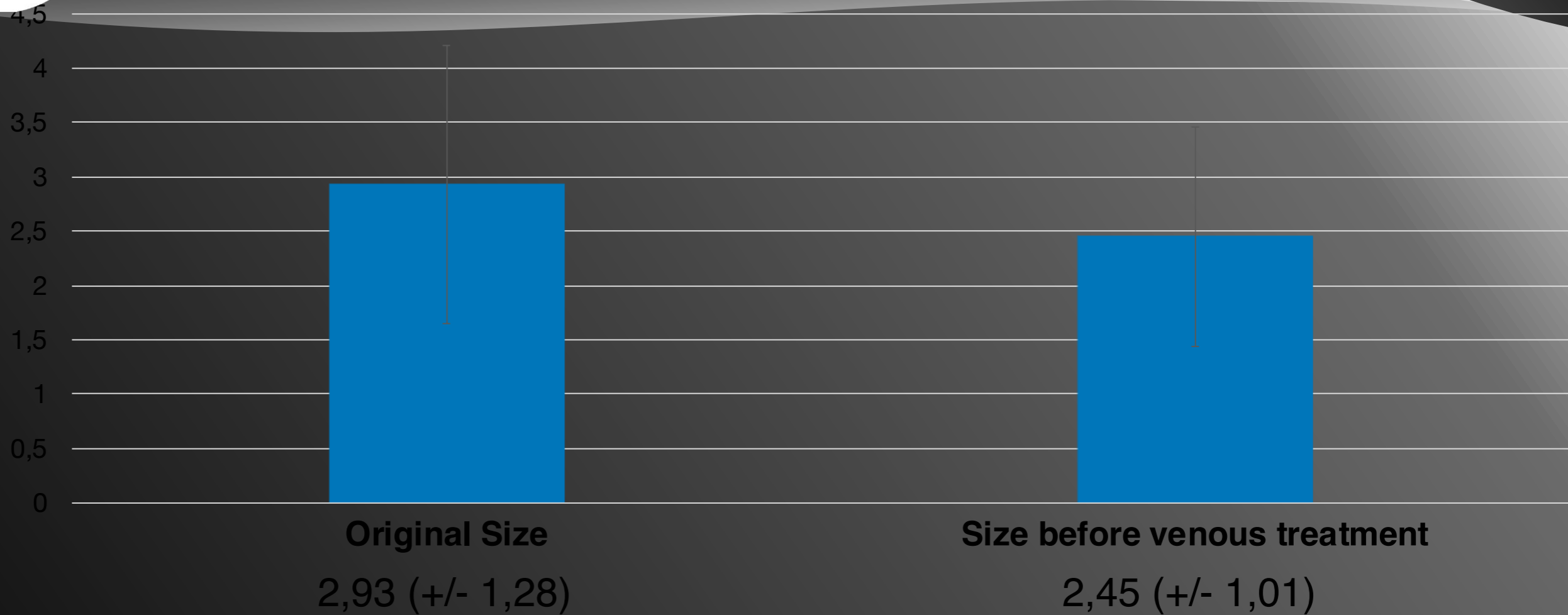


Nidus **location** vs. Hemorrhagic complication



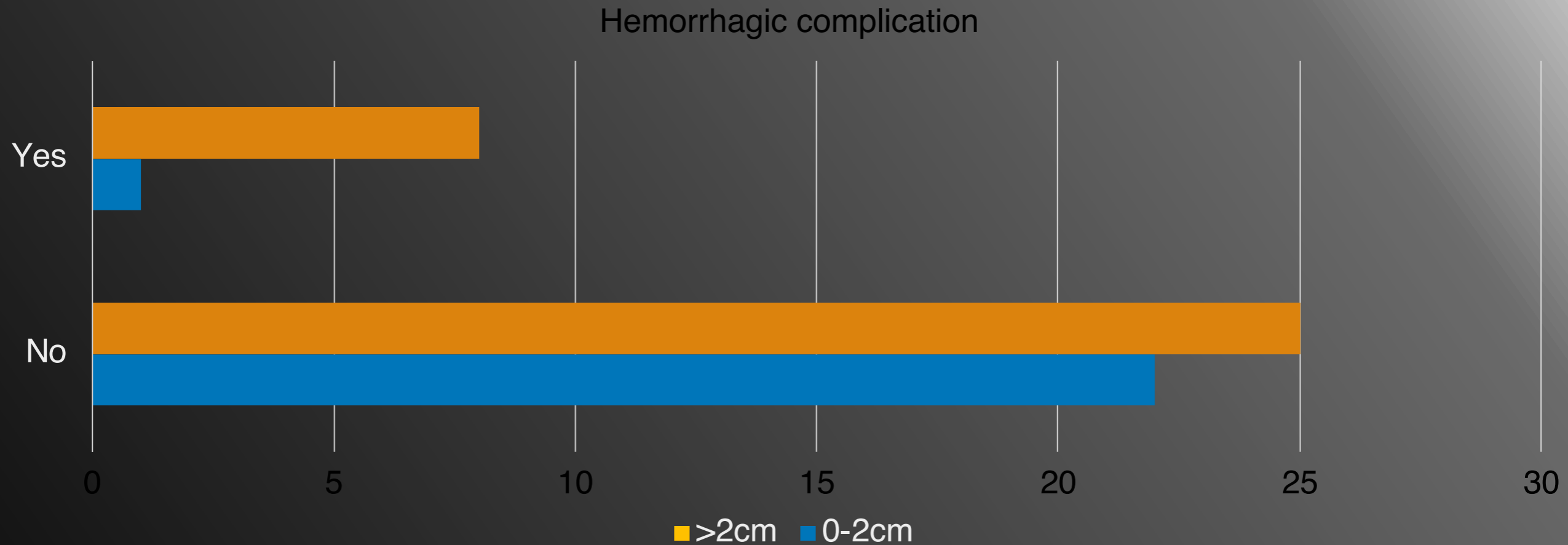
- All complications occurred in cortical AVMs
- $p=0,21$ (*chi square*)

Nidus Size





Nidus size before venous approach vs. hemorrhagic complication



p=0,04 (*chi-squared test*)

Hemorrhagic complication	No	Yes	Total N = 56
0-2 cm	39,3%	1,8%	41,1%
> 2 cm	44,7%	14,2%	58,9%
Total	84%	16%	100 %



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Porcelain vein

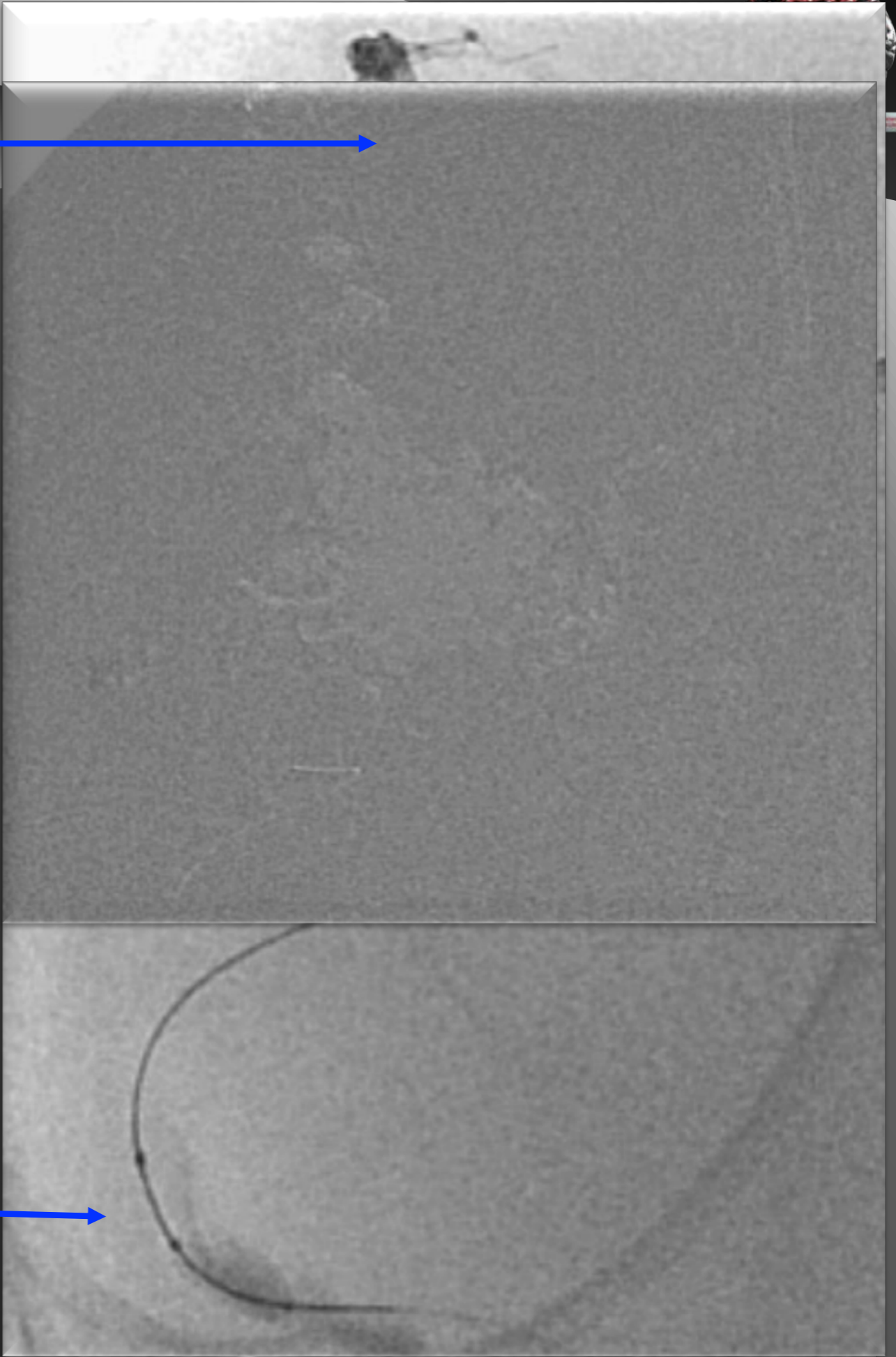
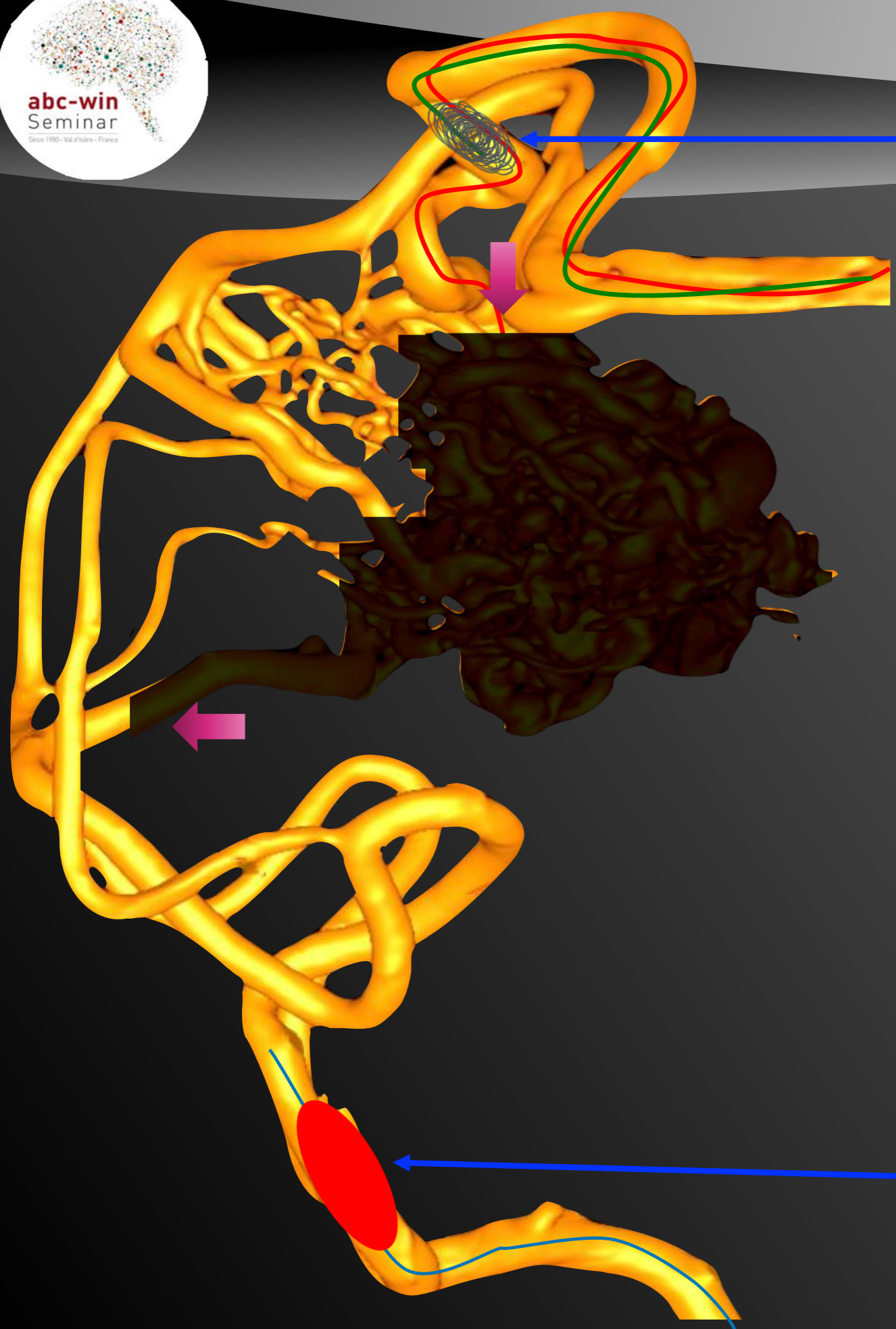
➤ Nidus size

Arterial Balloon

Could it be partial?

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Take home message





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Porcelain vein

Nidus size

➤ Arterial Balloon

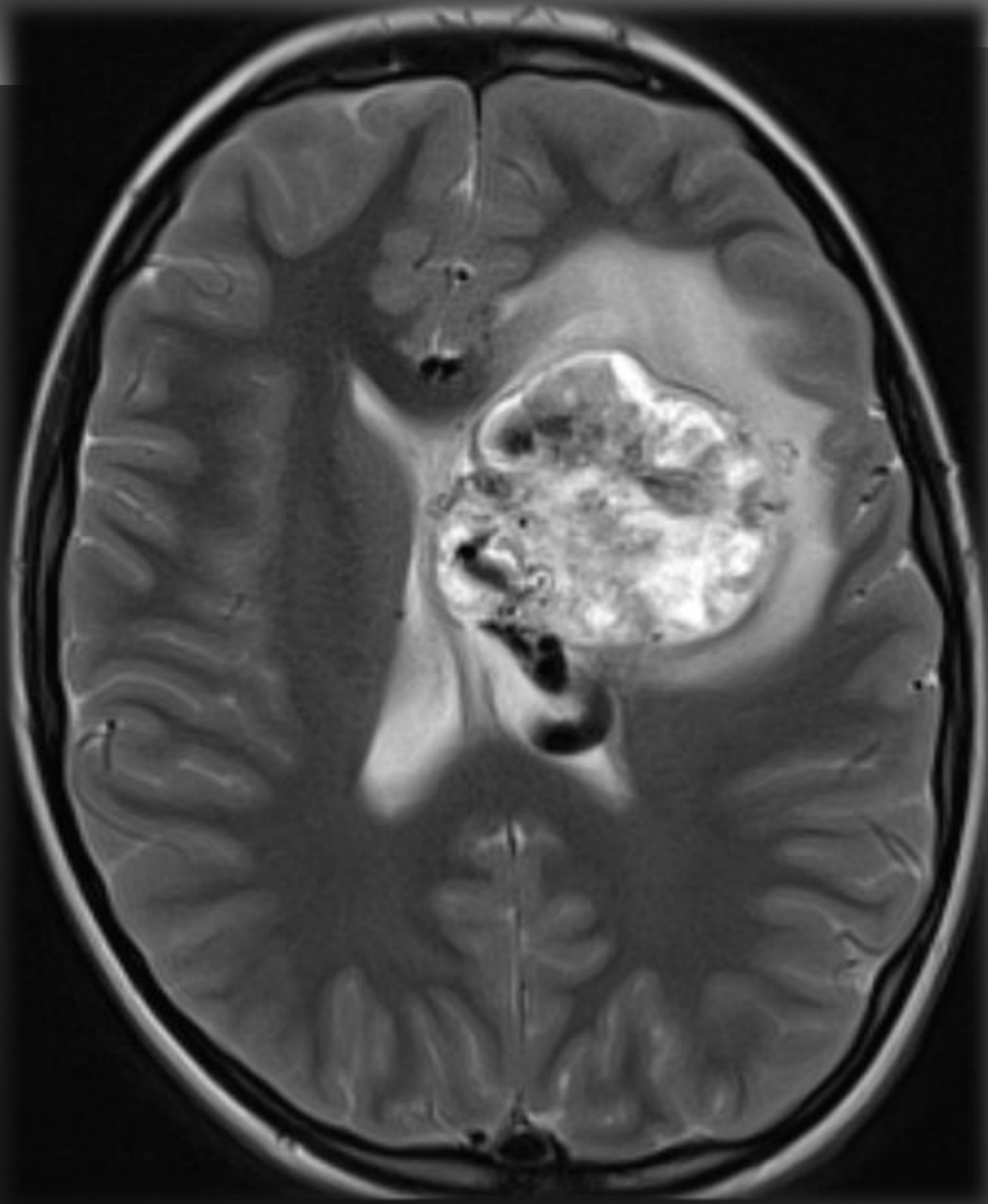
Could it be partial?

What about the venous ischemia?

Take home message

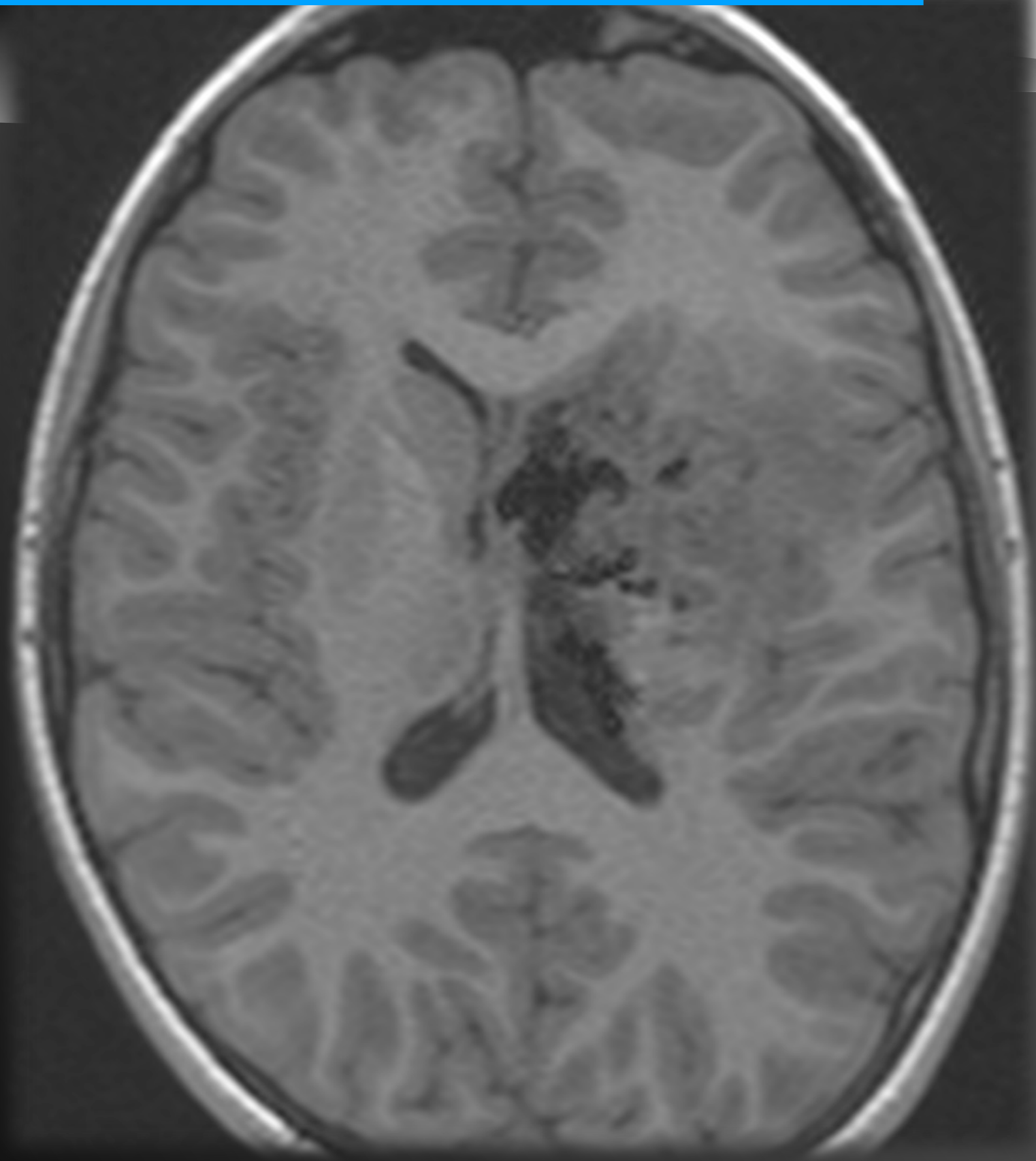


CAUDATE NUCLEUS & PUTAMEN



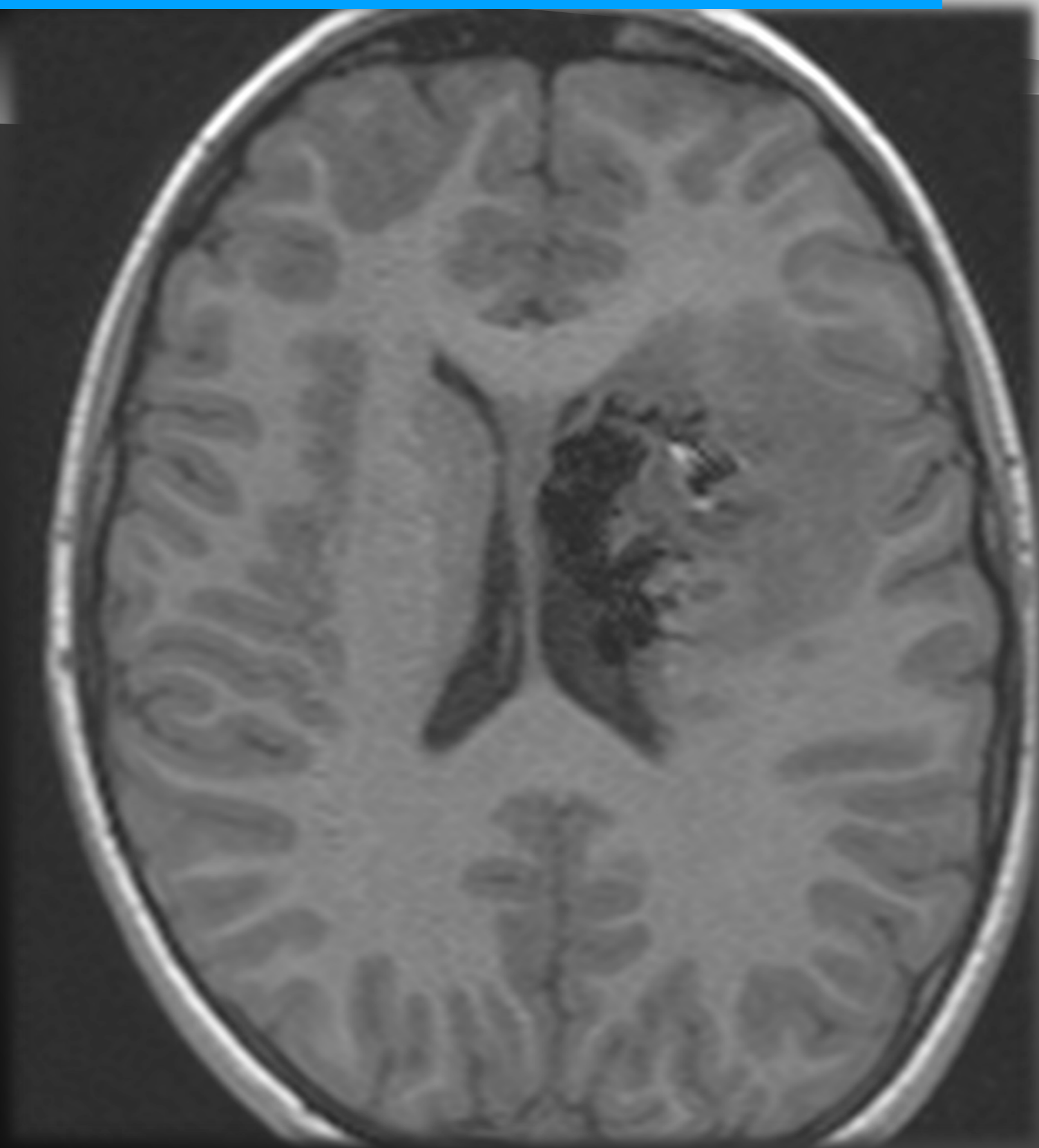


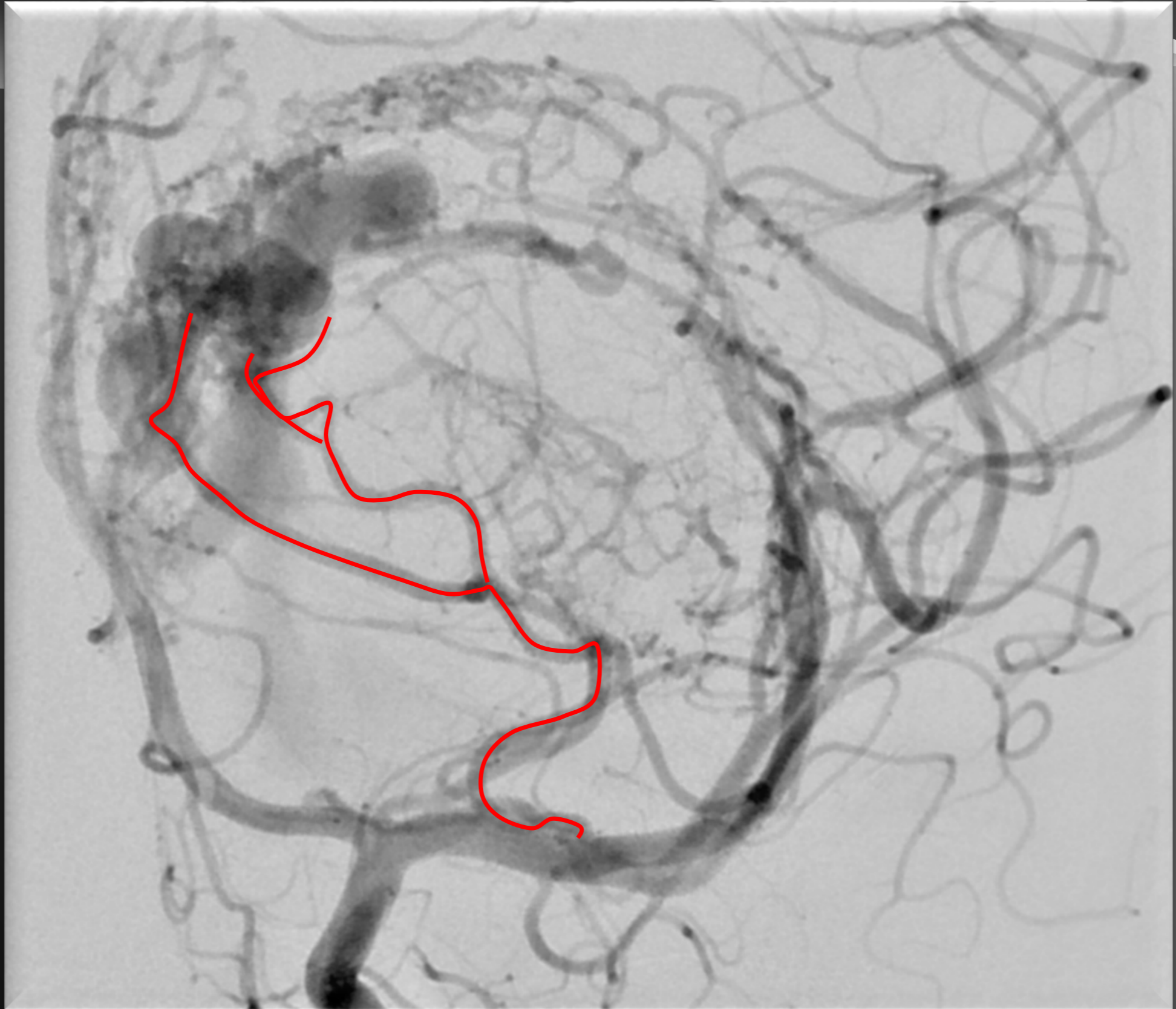
CAUDATE NUCLEUS & PUTAMEN

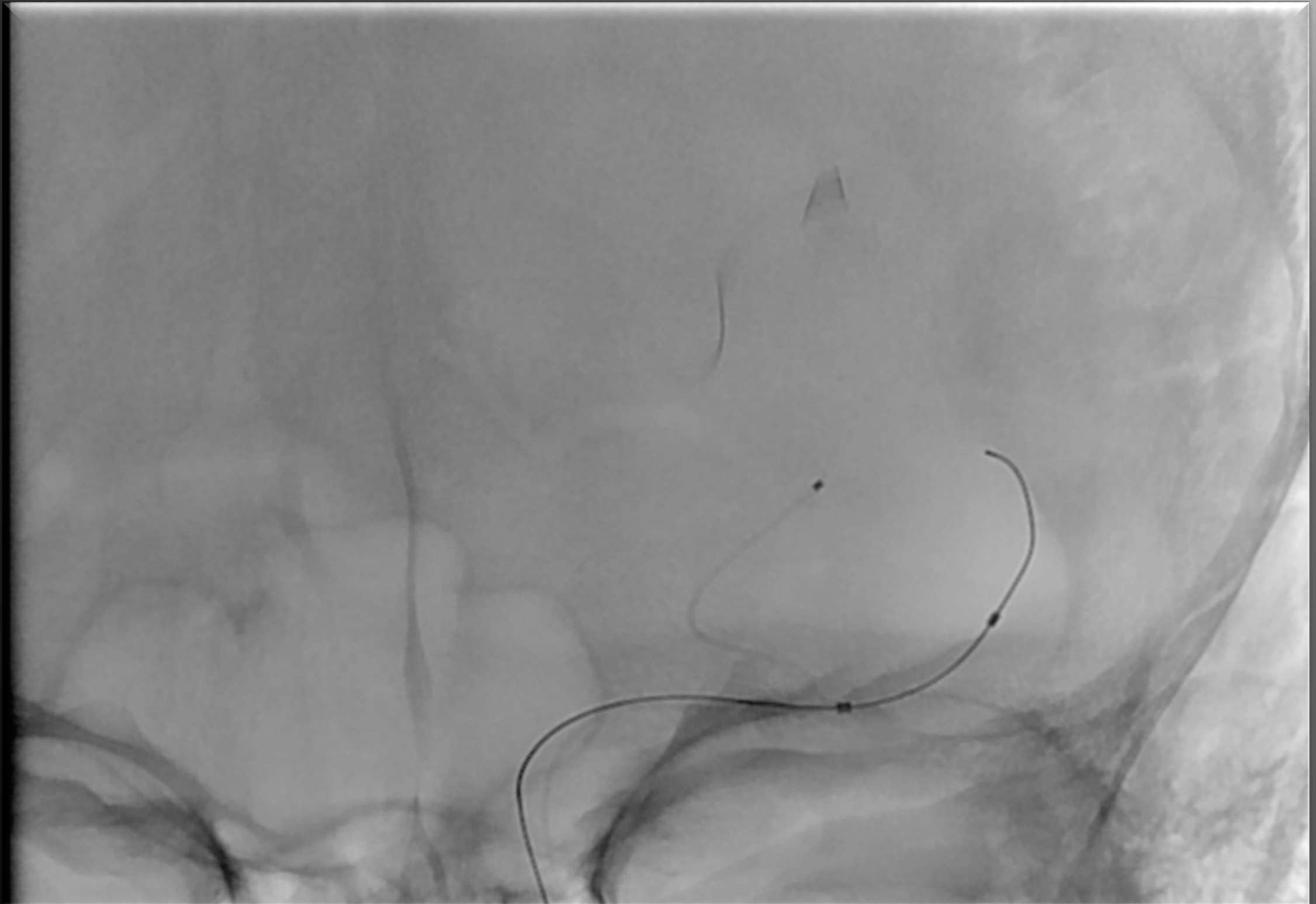


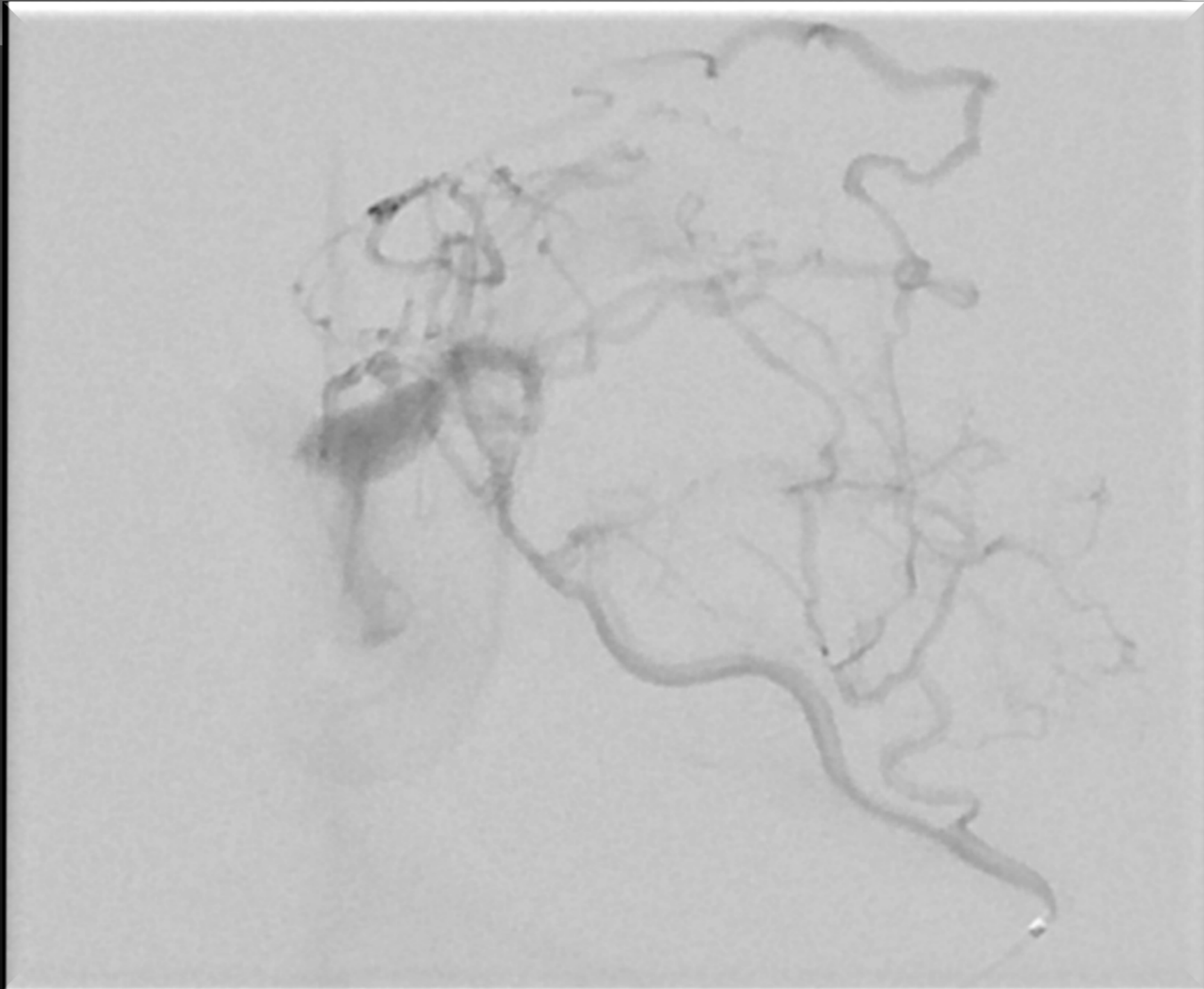
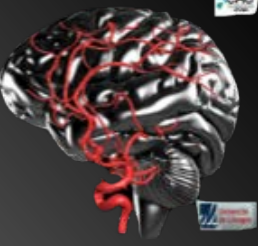


CAUDATE NUCLEUS & PUTAMEN











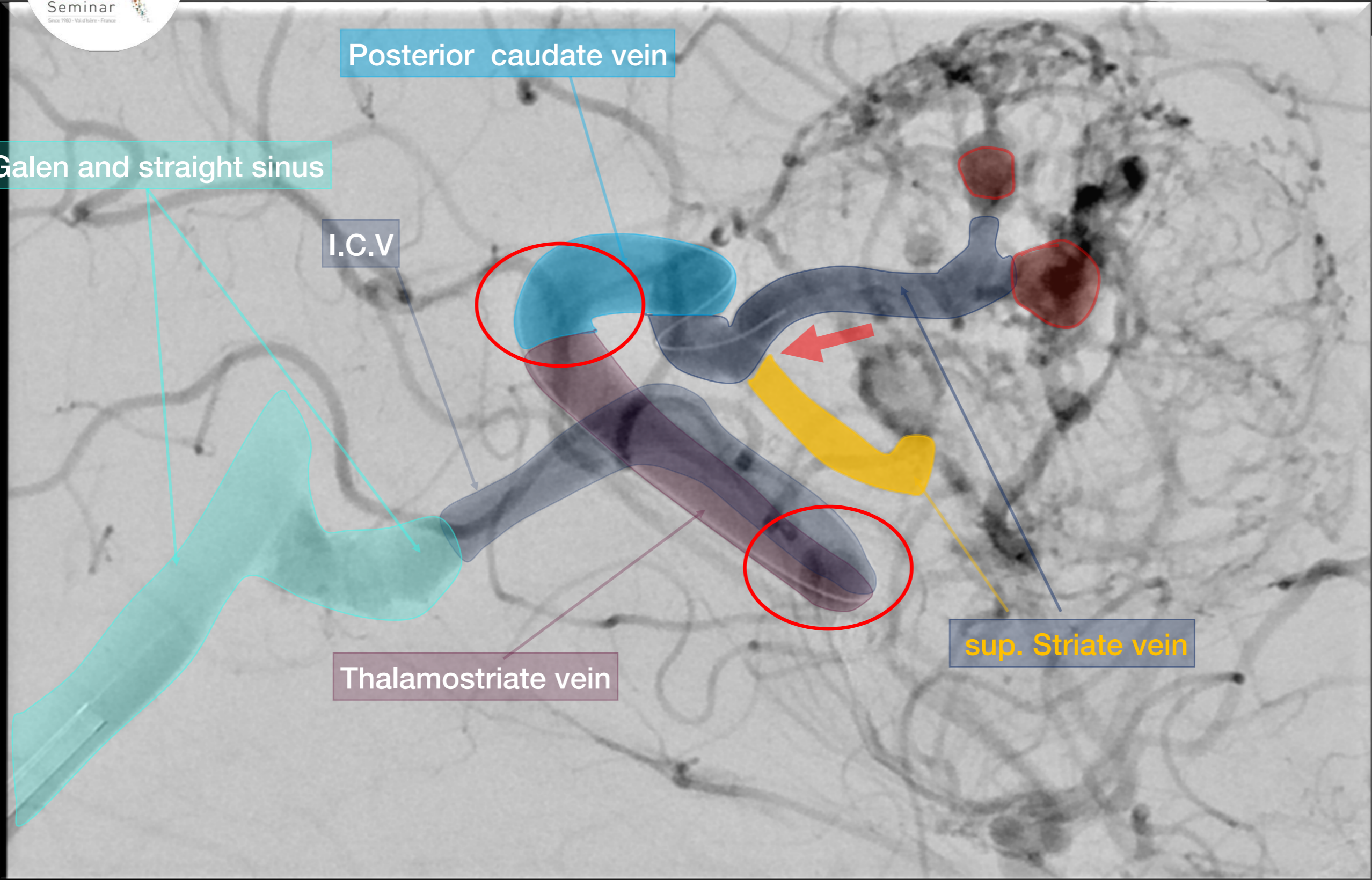
Posterior caudate vein

Galen and straight sinus

I.C.V

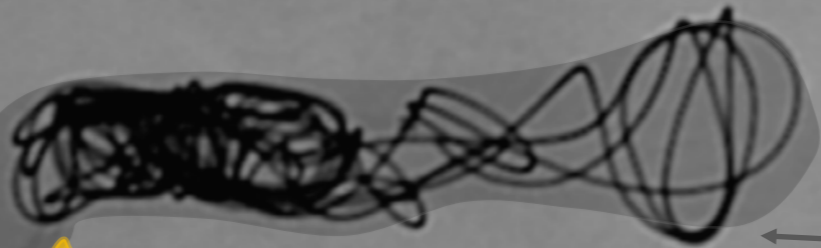
Thalamostriate vein

sup. Striate vein



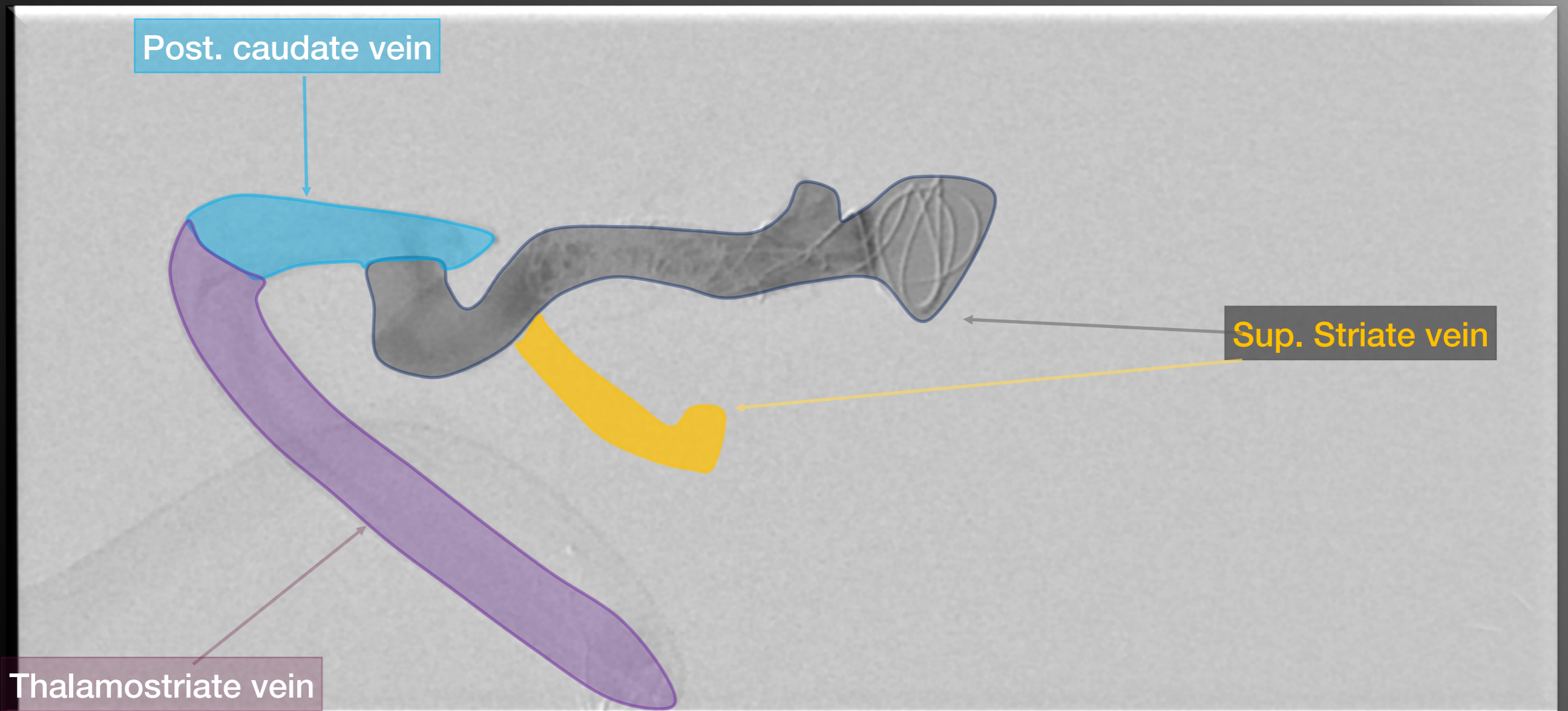


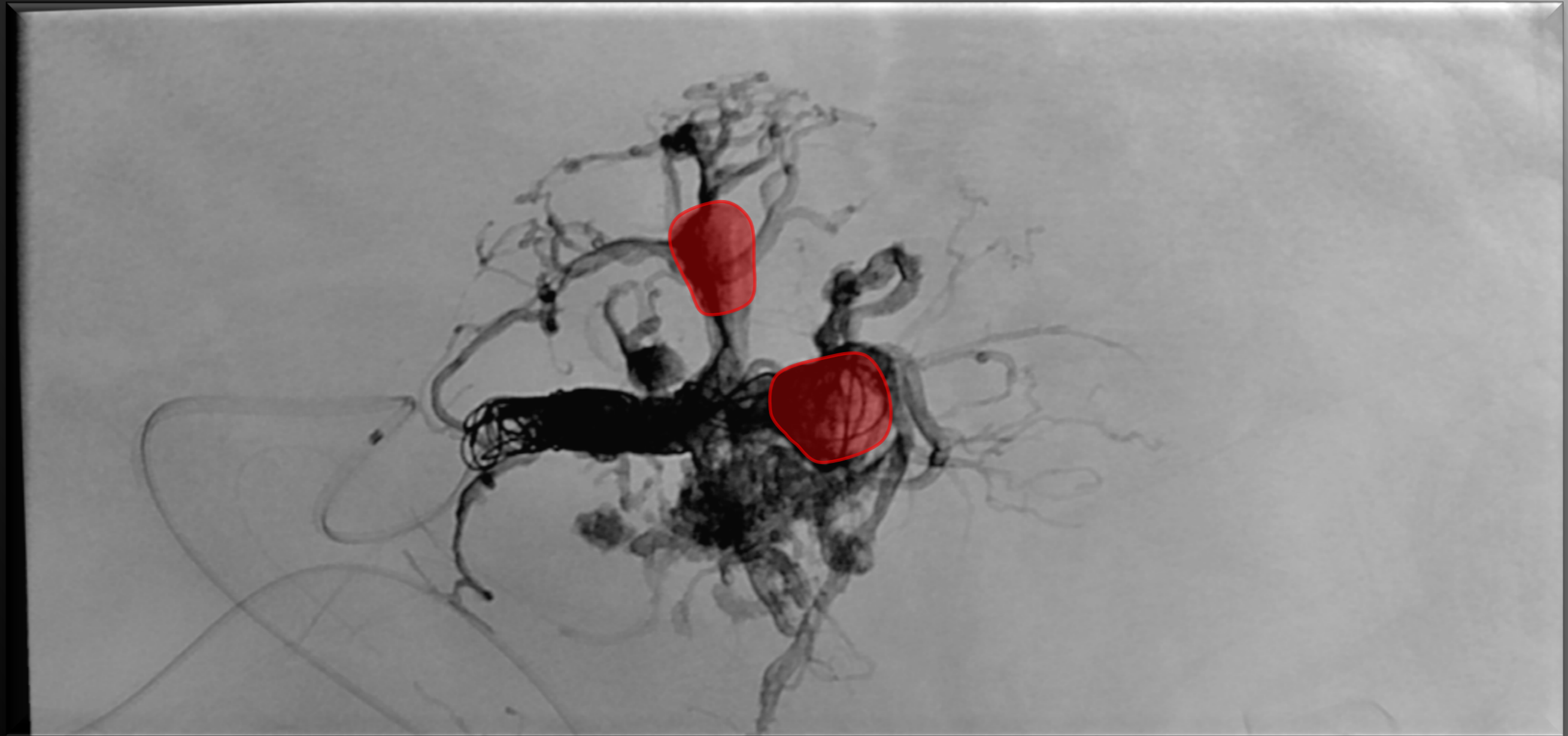
Post. caudate vein

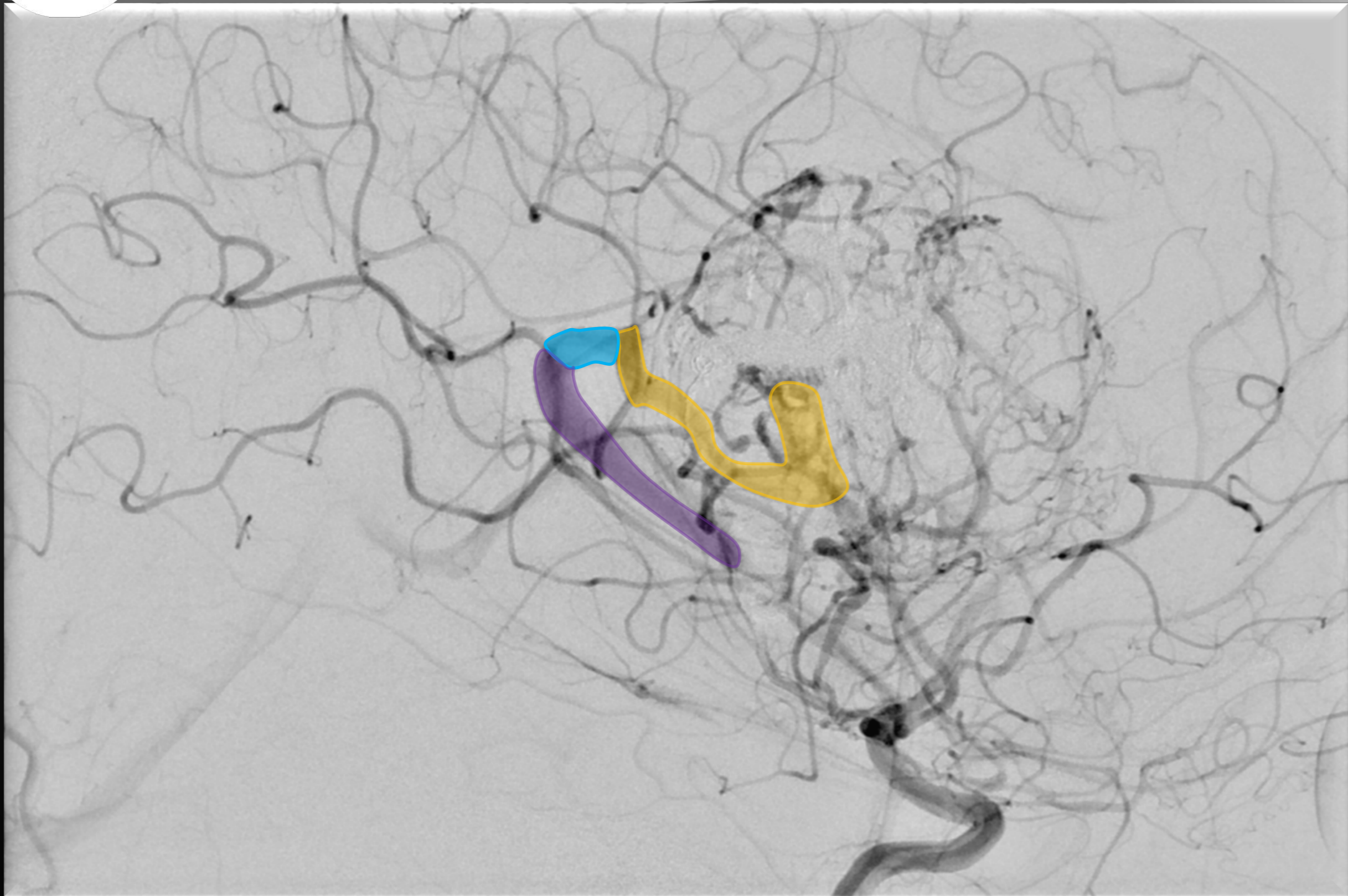


Sup. Striate vein







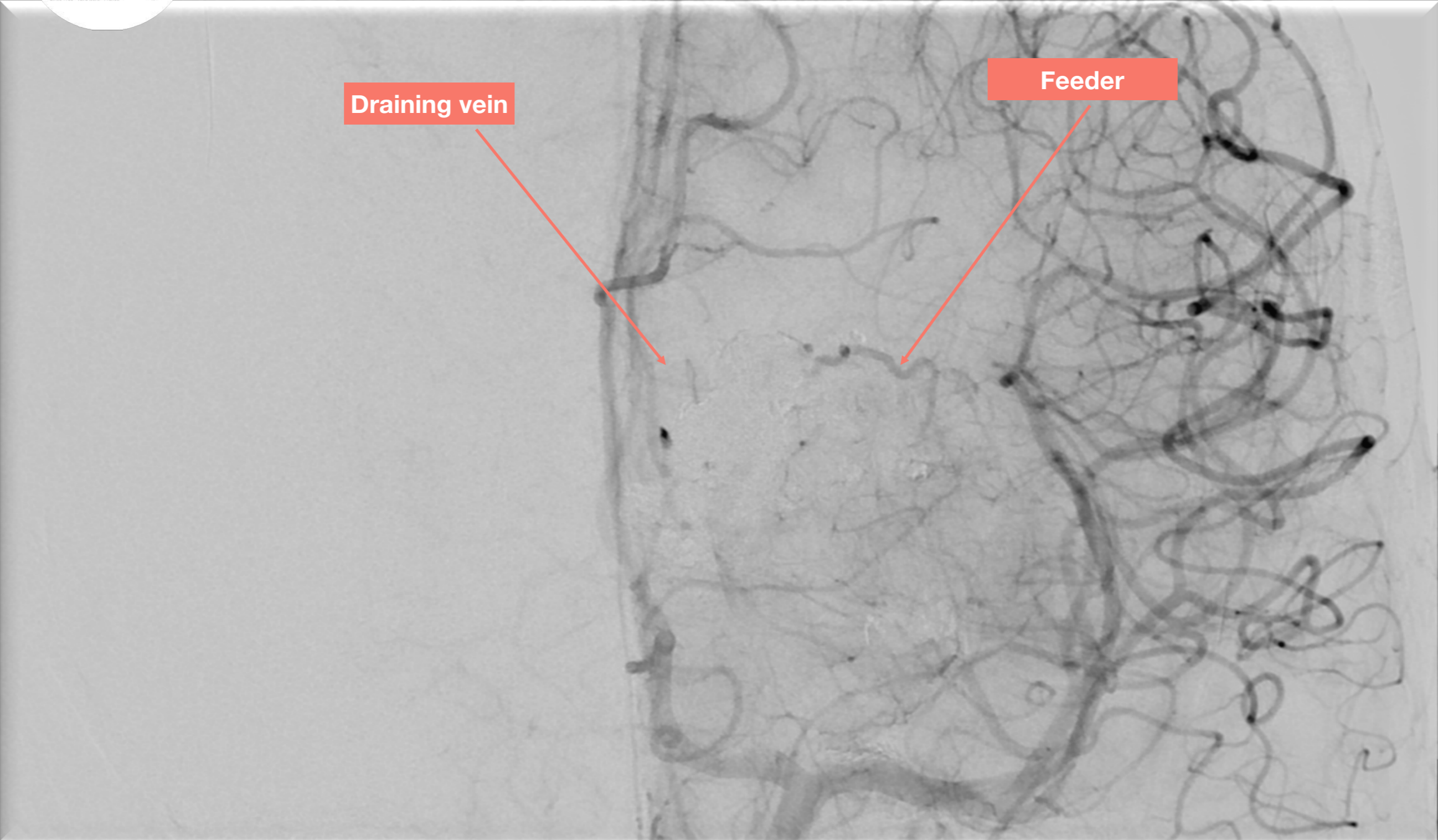


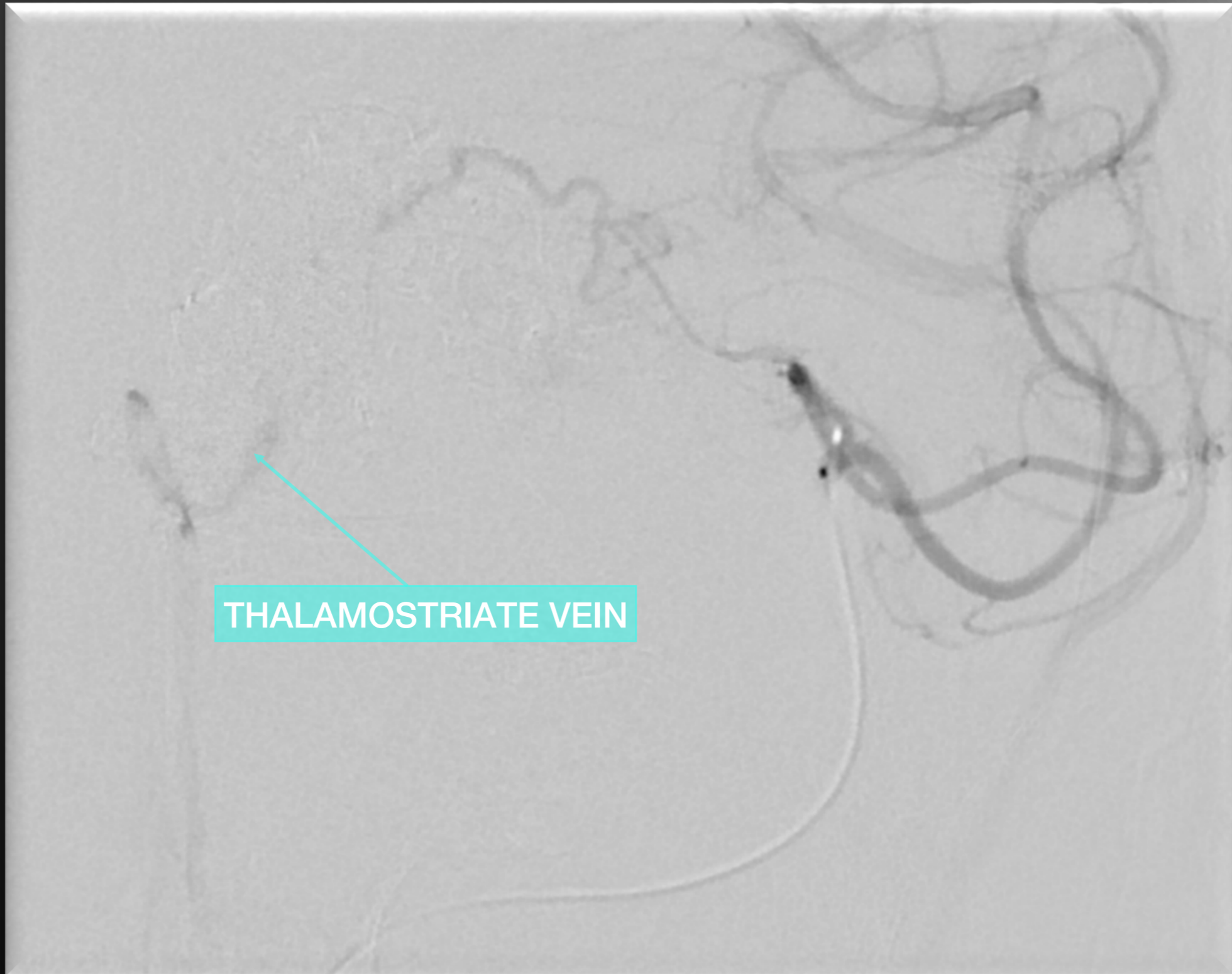
3 Months later



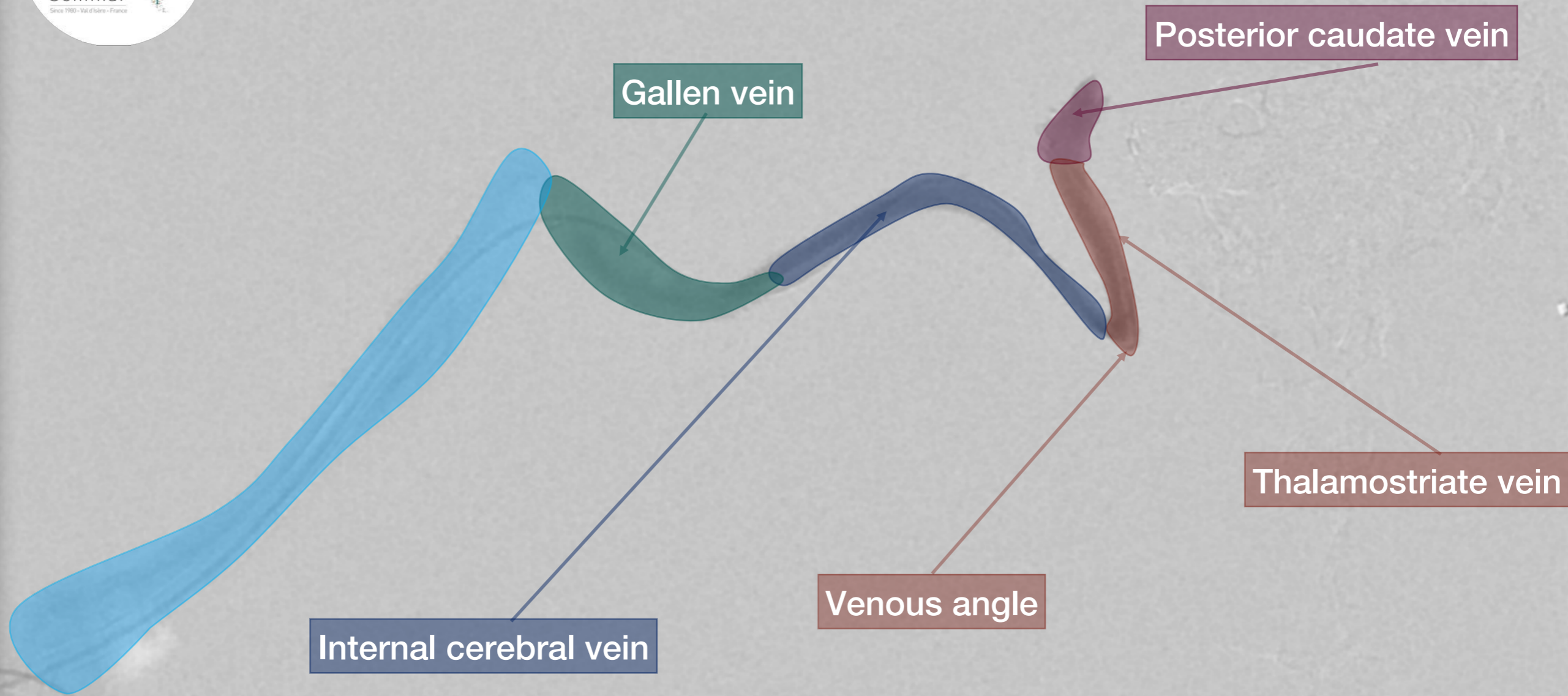
Draining vein

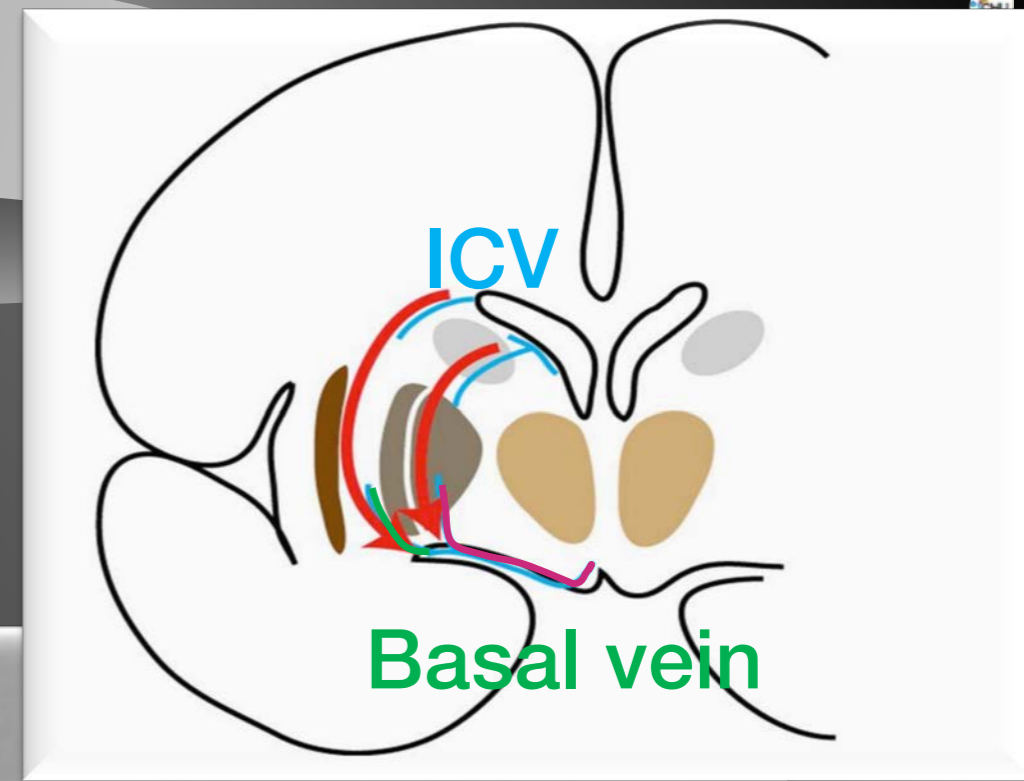
Feeder



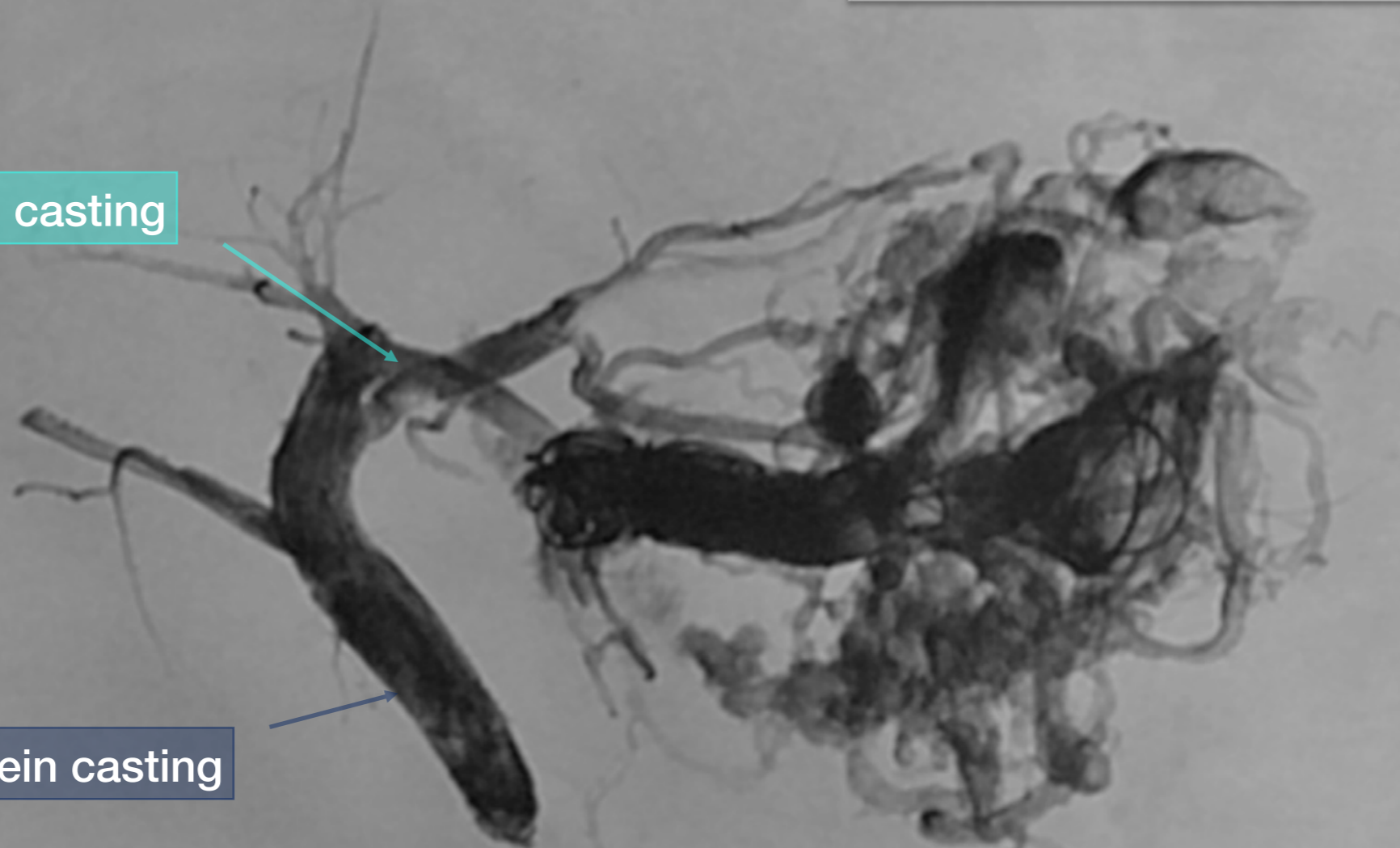


THALAMOSTRIATE VEIN



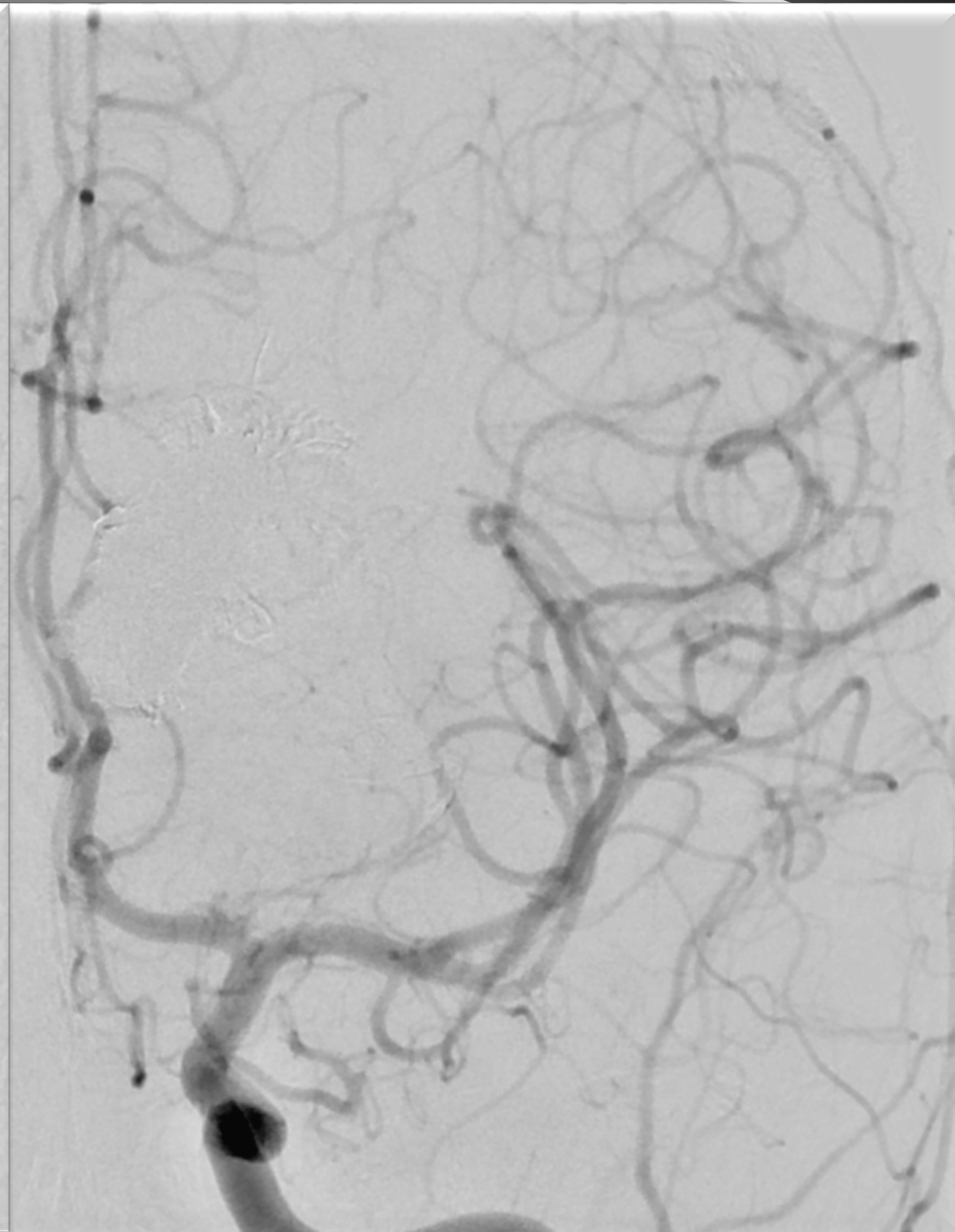
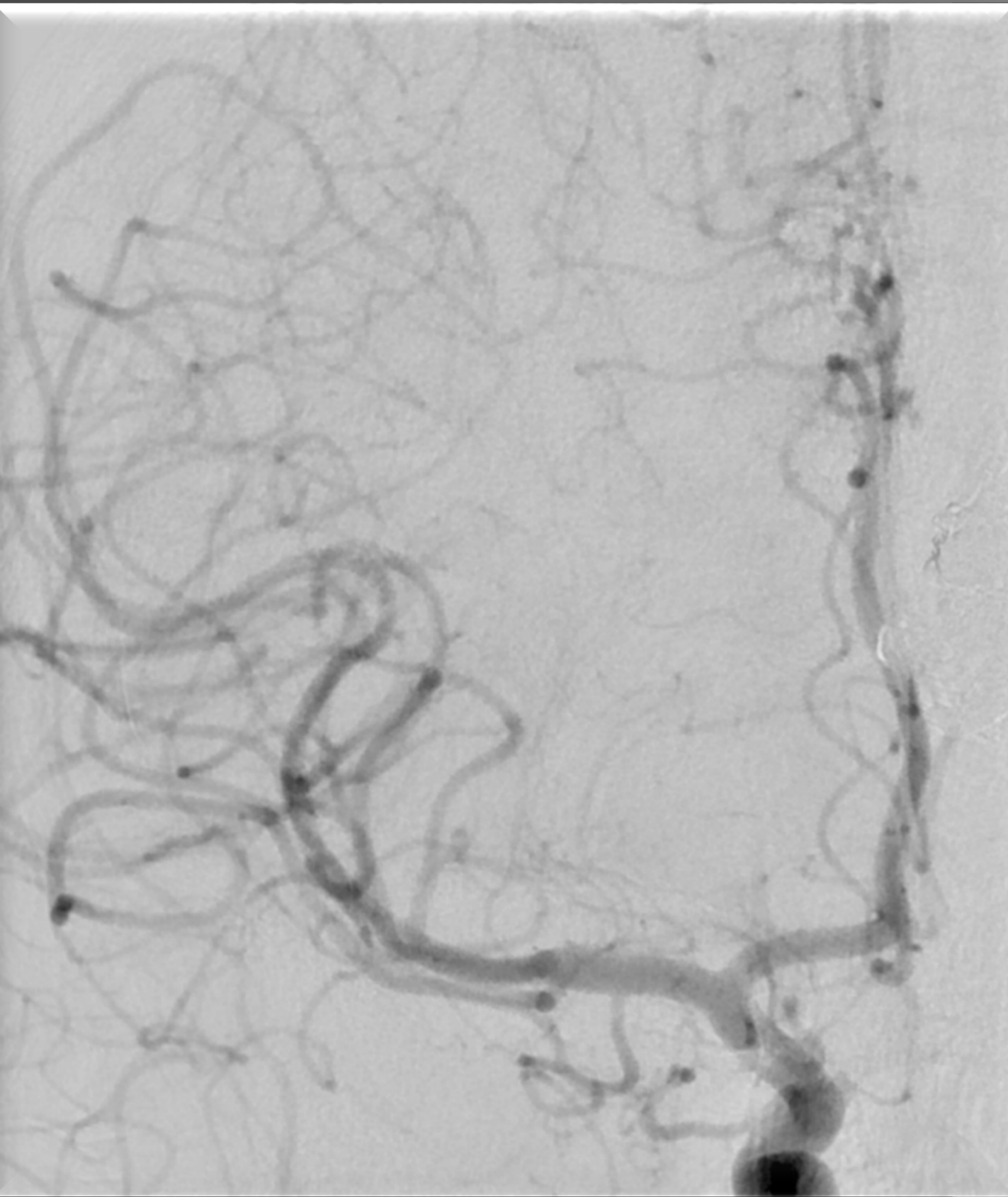


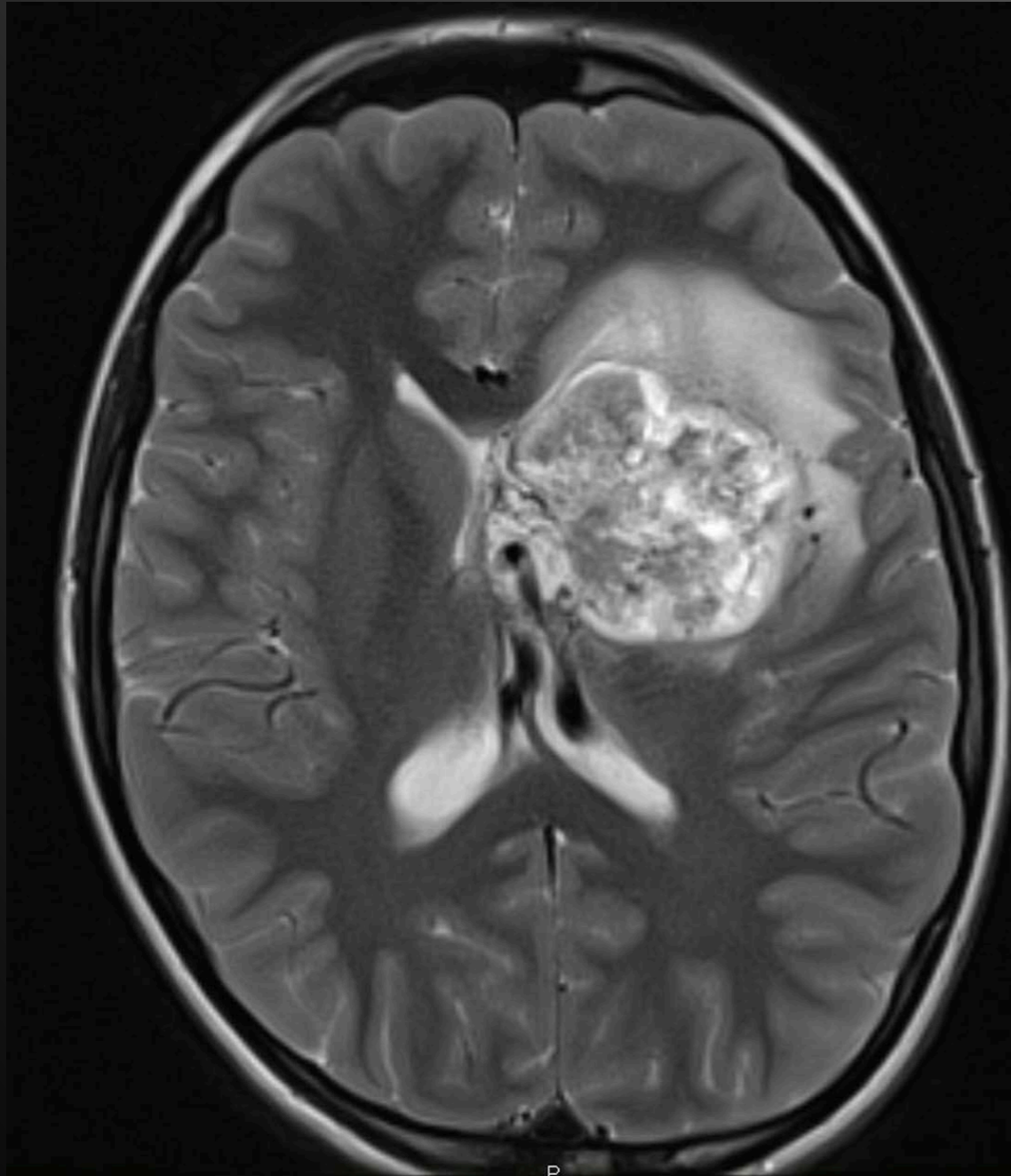
Posterior caudate vein casting



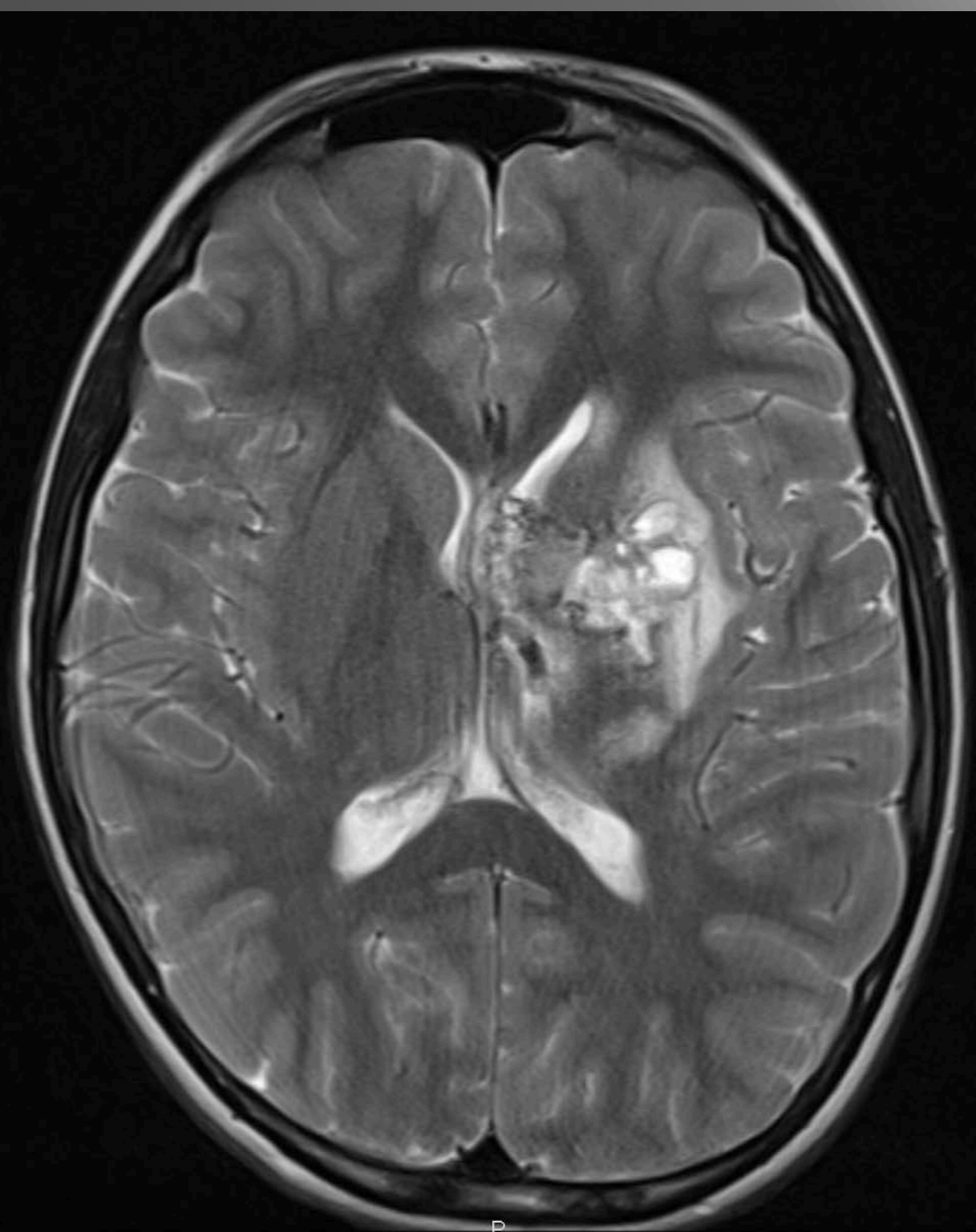
Thalamostriate vein casting

Final control





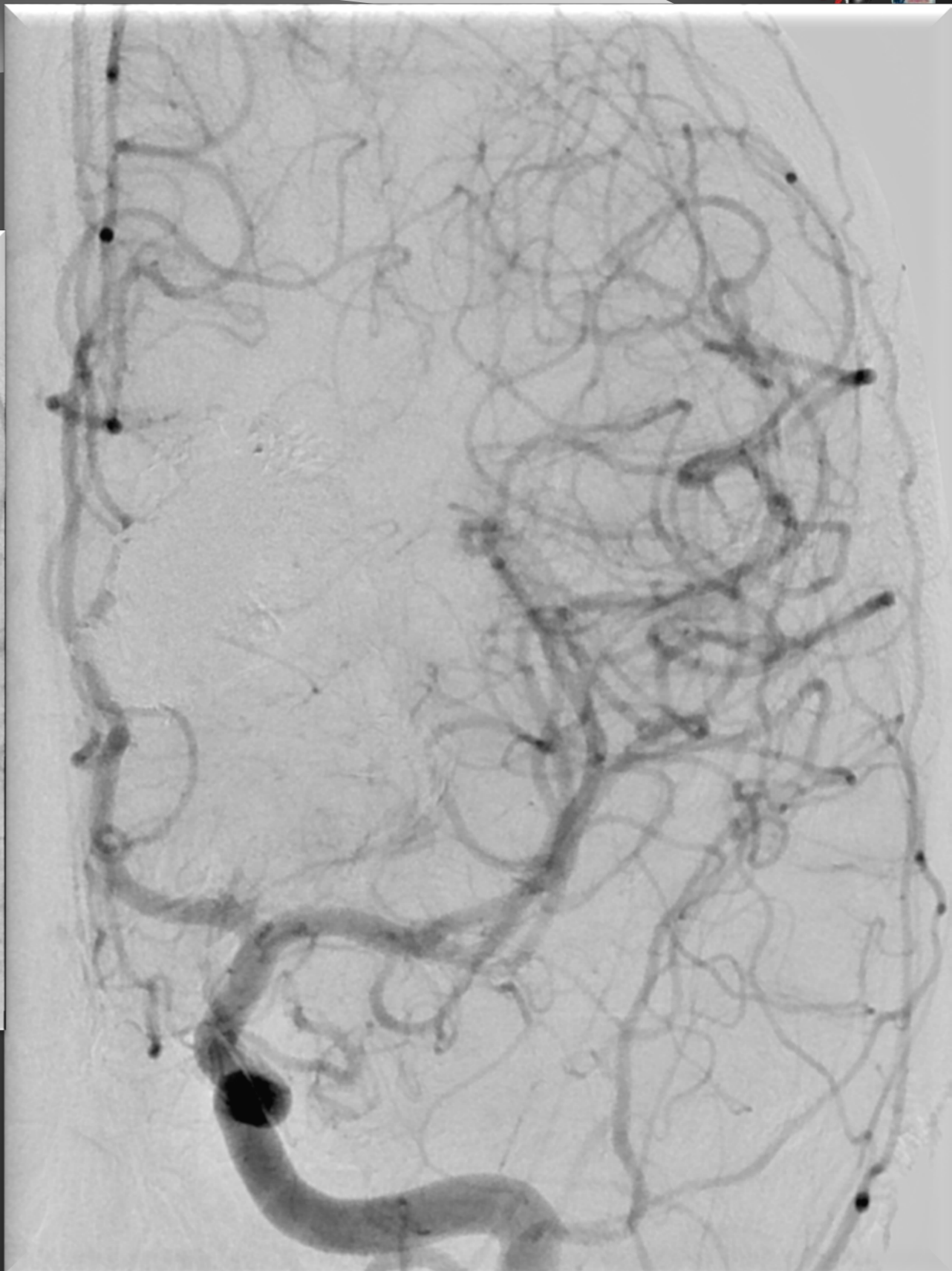
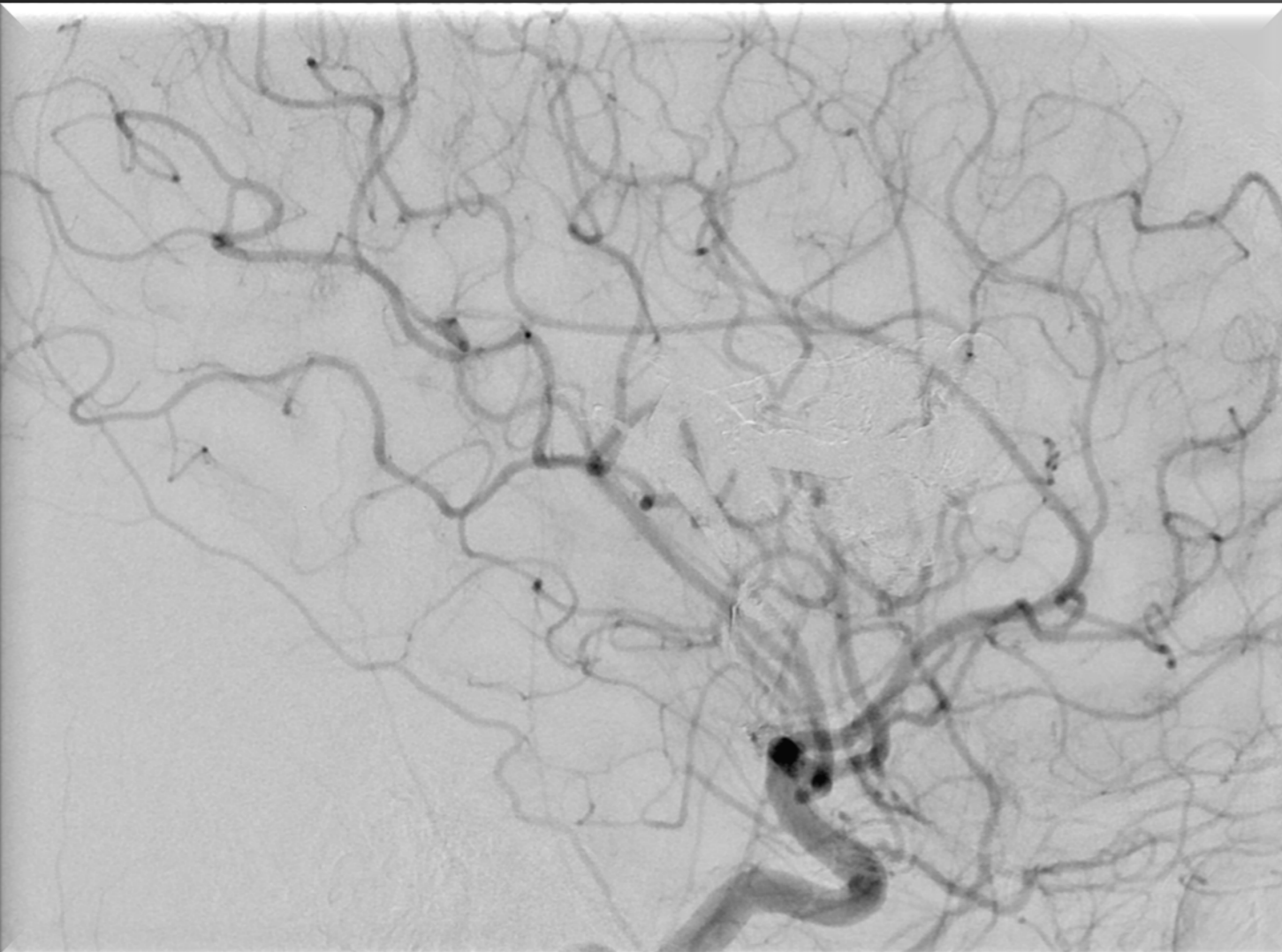
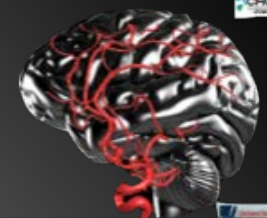
Before Treatment
26.7.2016



After Treatment
24.10.2016

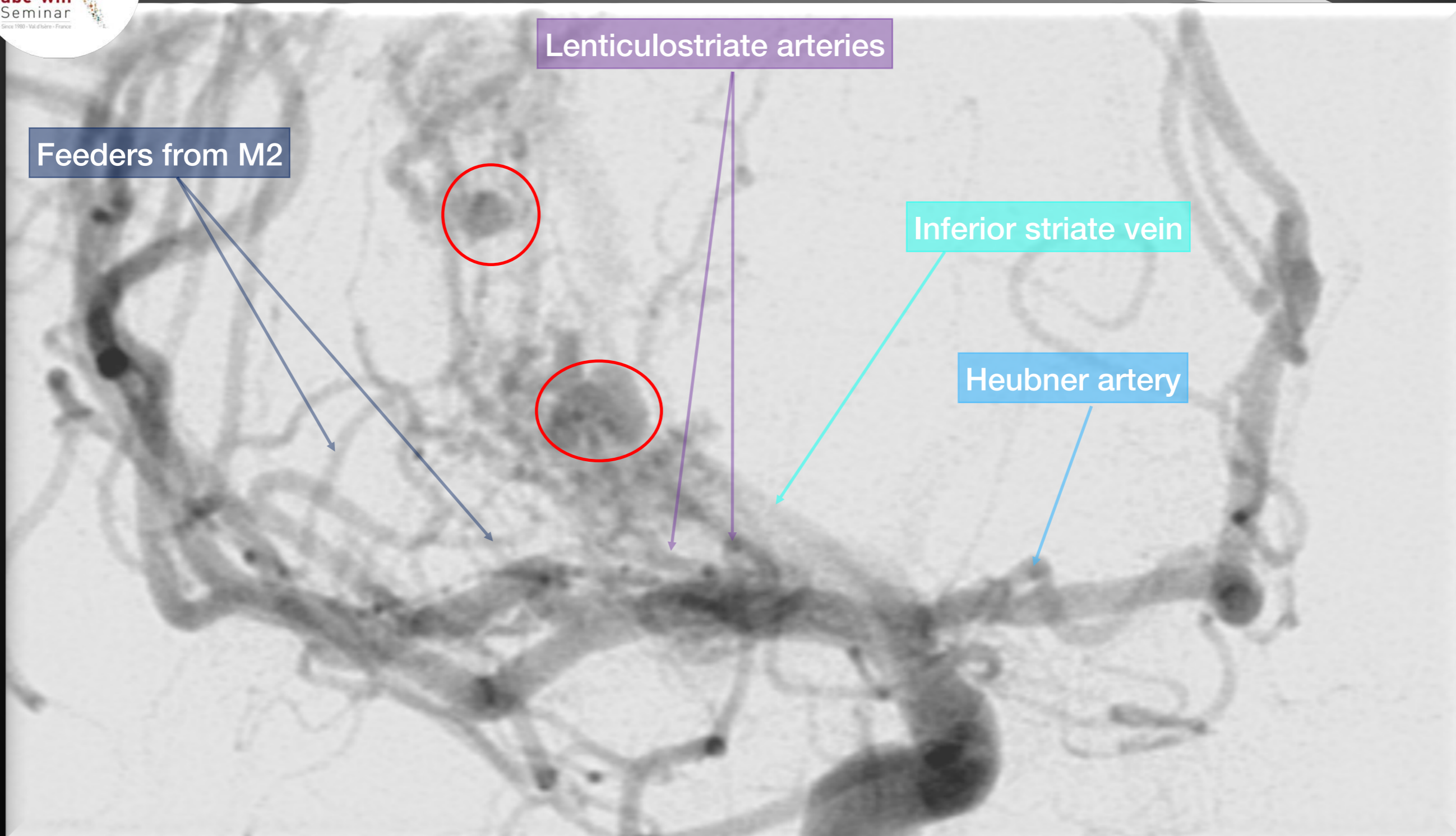


six-month follow-up



NEOSTRIATUM HAEMATOMA







View size: 2405 x 1524
WL: 39 WW: 280

Inferior External striate vein

Anterior caudate vein

Venous angle

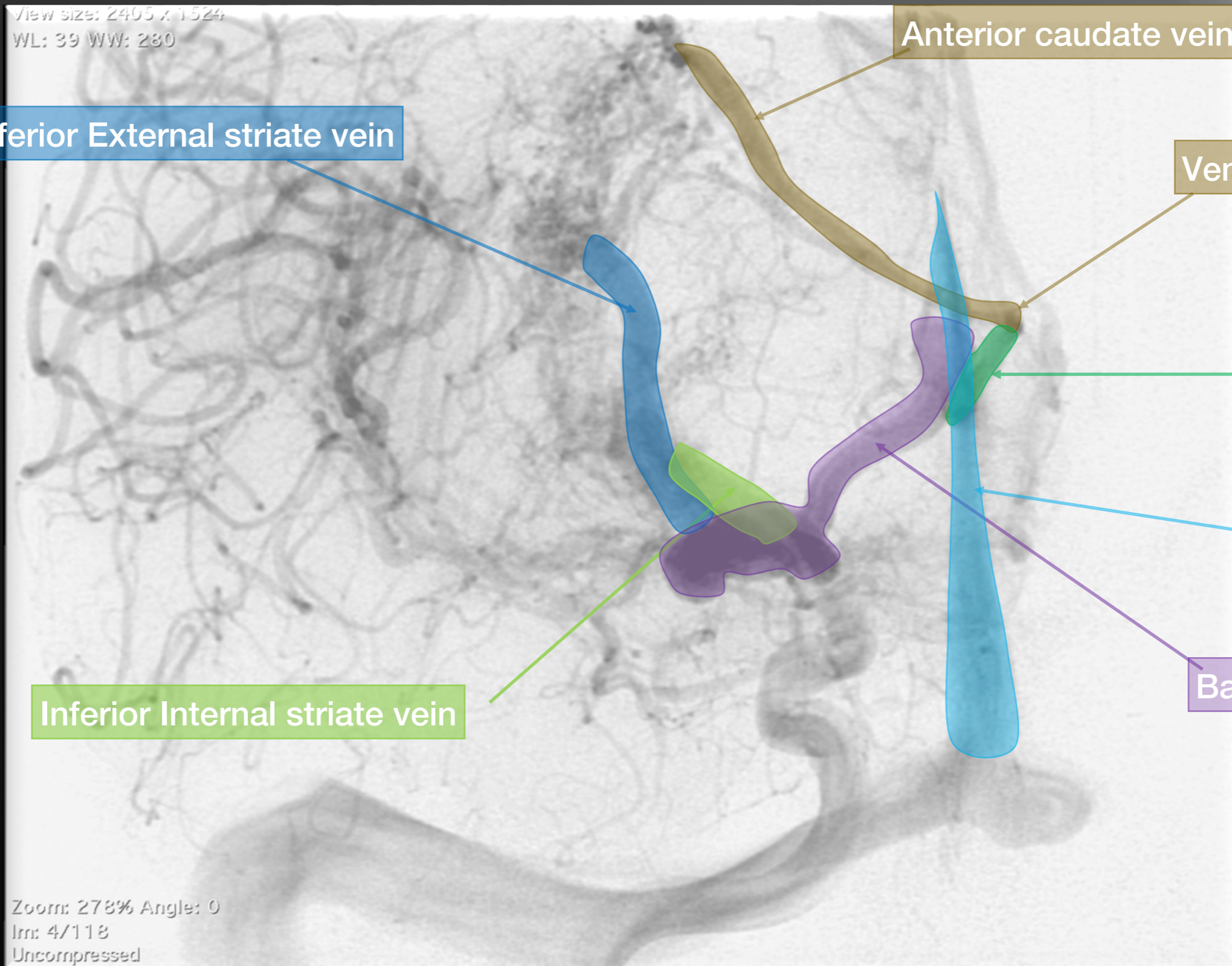
ICV

Straight sinus

Inferior Internal striate vein

Basal vein

Zoom: 278% Angle: 0
Im: 4/118
Uncompressed



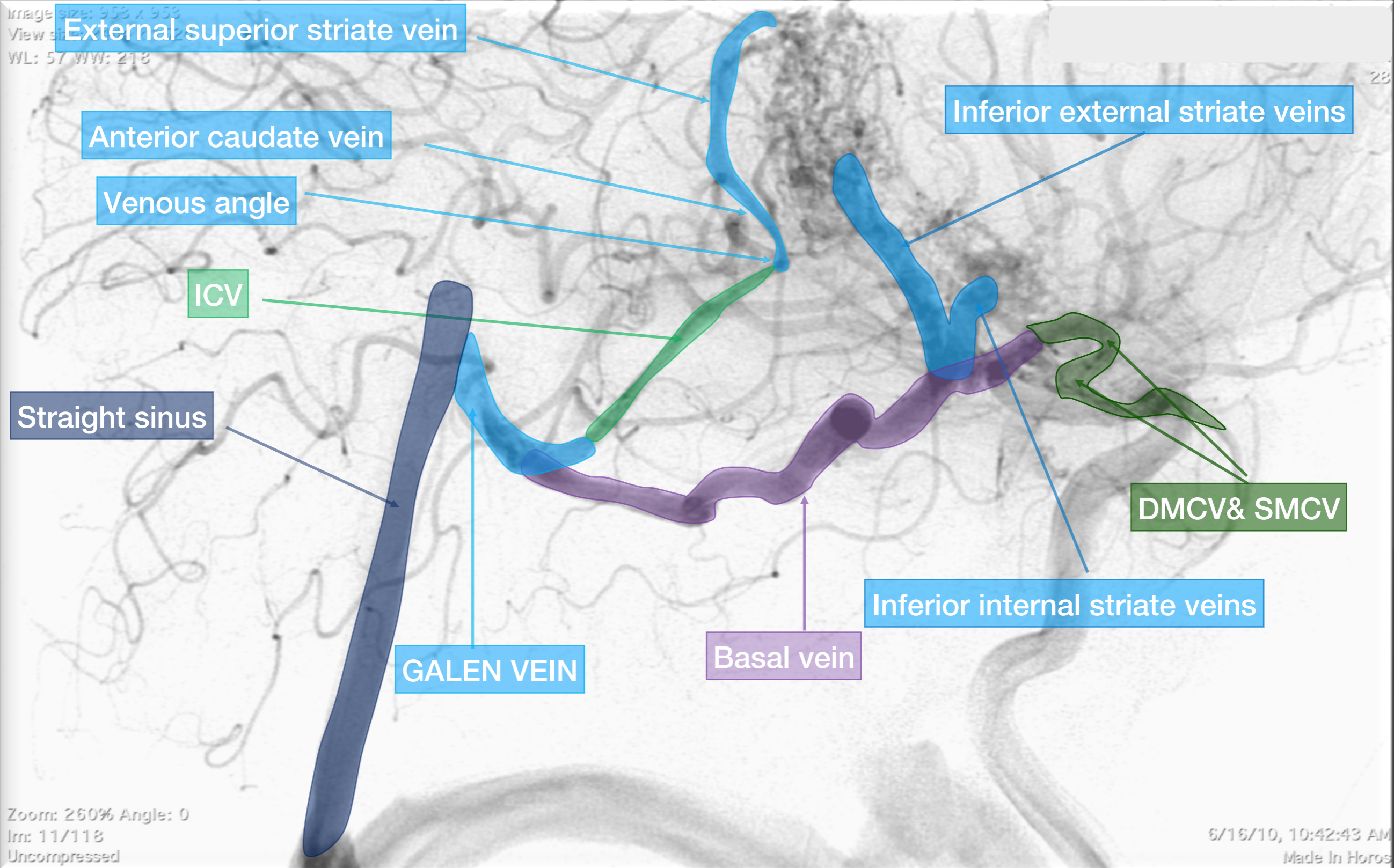


Image size: 953 x 953
View size: 1280 x 1280
WL: 57 WW: 218

External superior striate vein

Anterior caudate vein

Venous angle

ICV

Straight sinus

GALEN VEIN

Basal vein

Inferior external striate veins

DMCV & SMCV

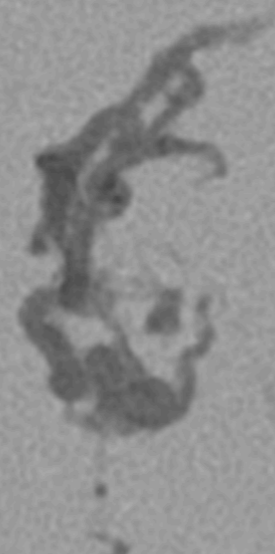
Inferior internal striate veins

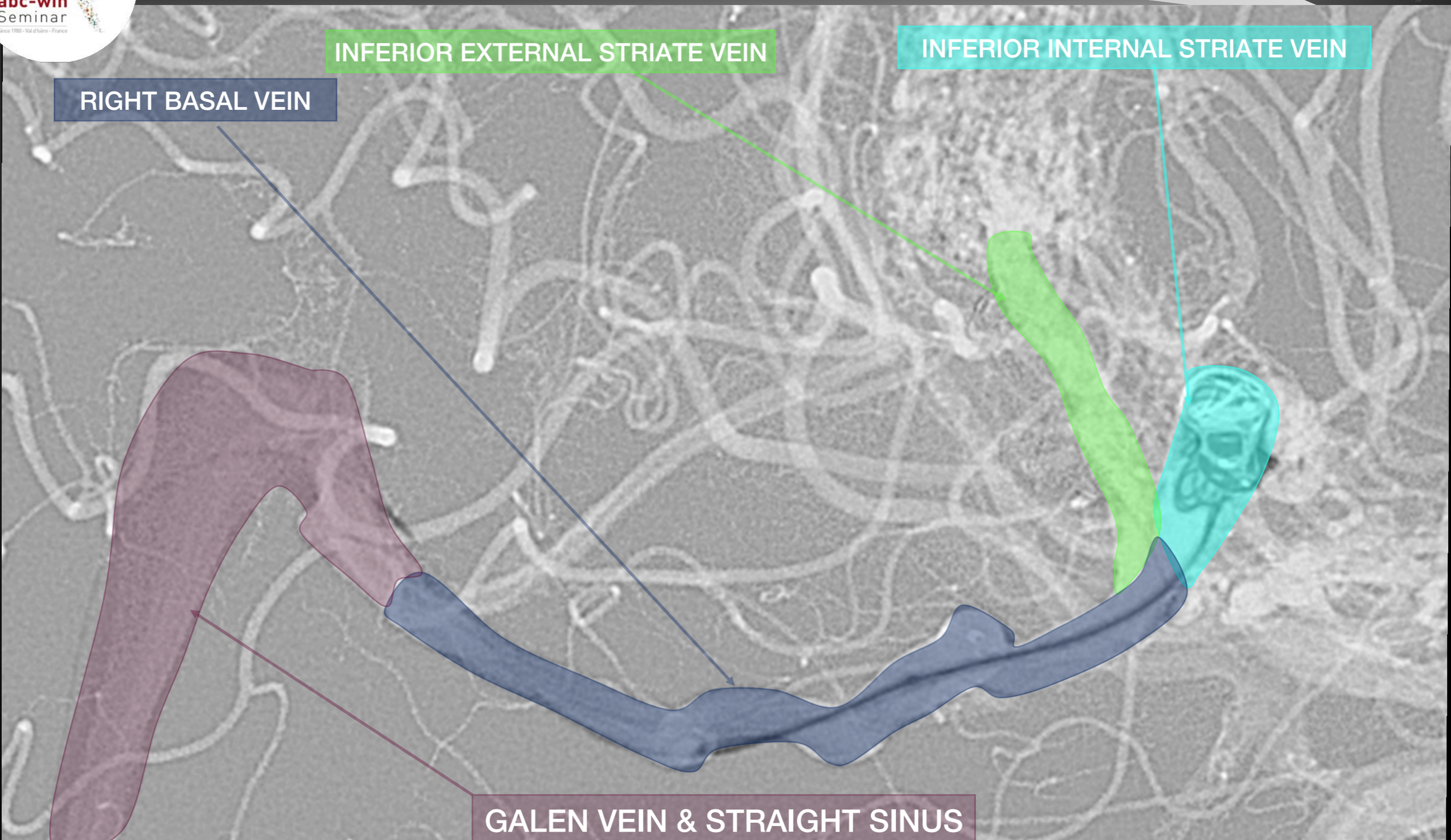
Zoom: 260% Angle: 0
Irr: 11/118
Uncompressed

6/16/10, 10:42:43 AM
Made In Horos



Lateral lenticulostriate arteries



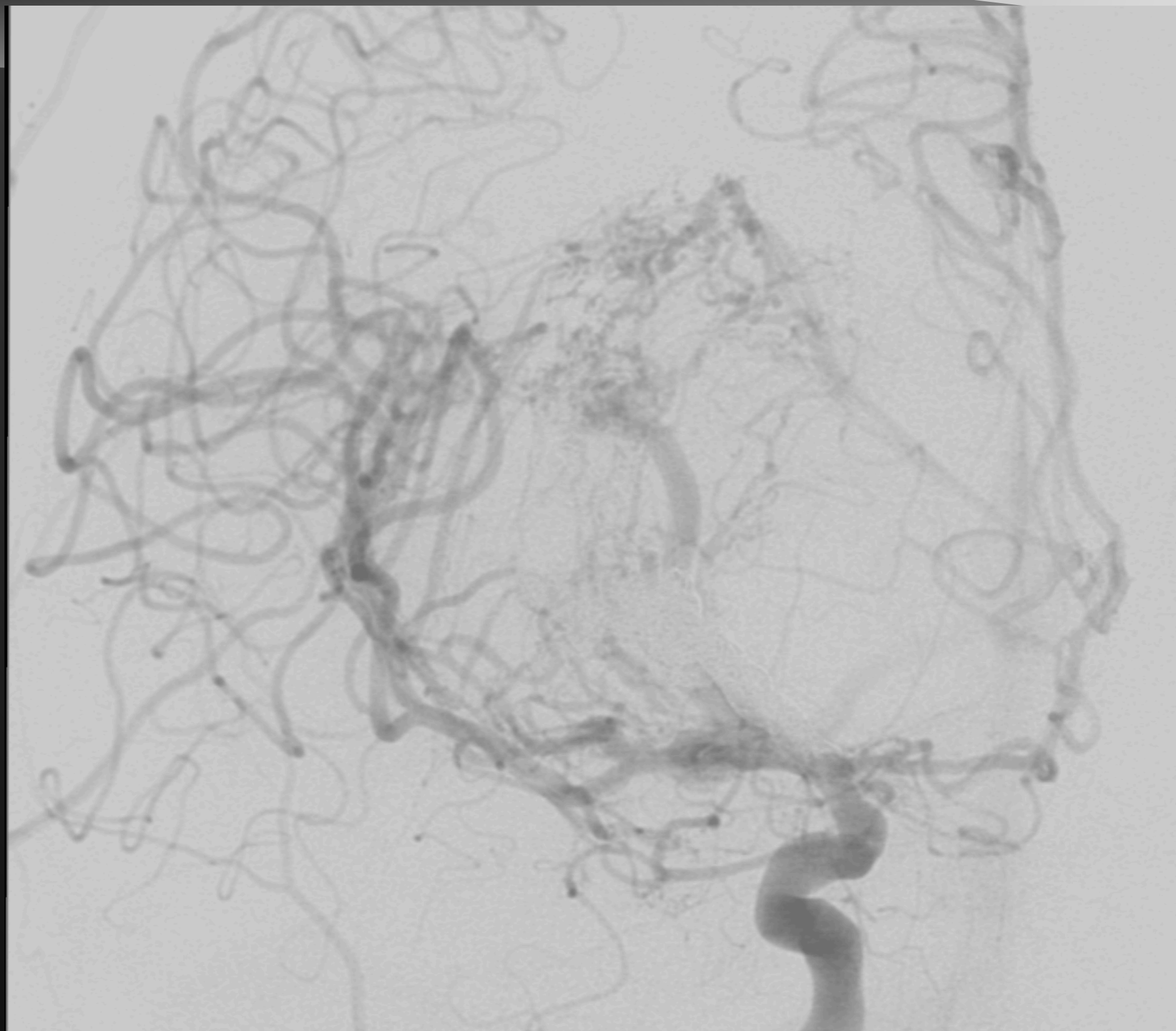


INFERIOR EXTERNAL STRIATE VEIN

INFERIOR INTERNAL STRIATE VEIN

RIGHT BASAL VEIN

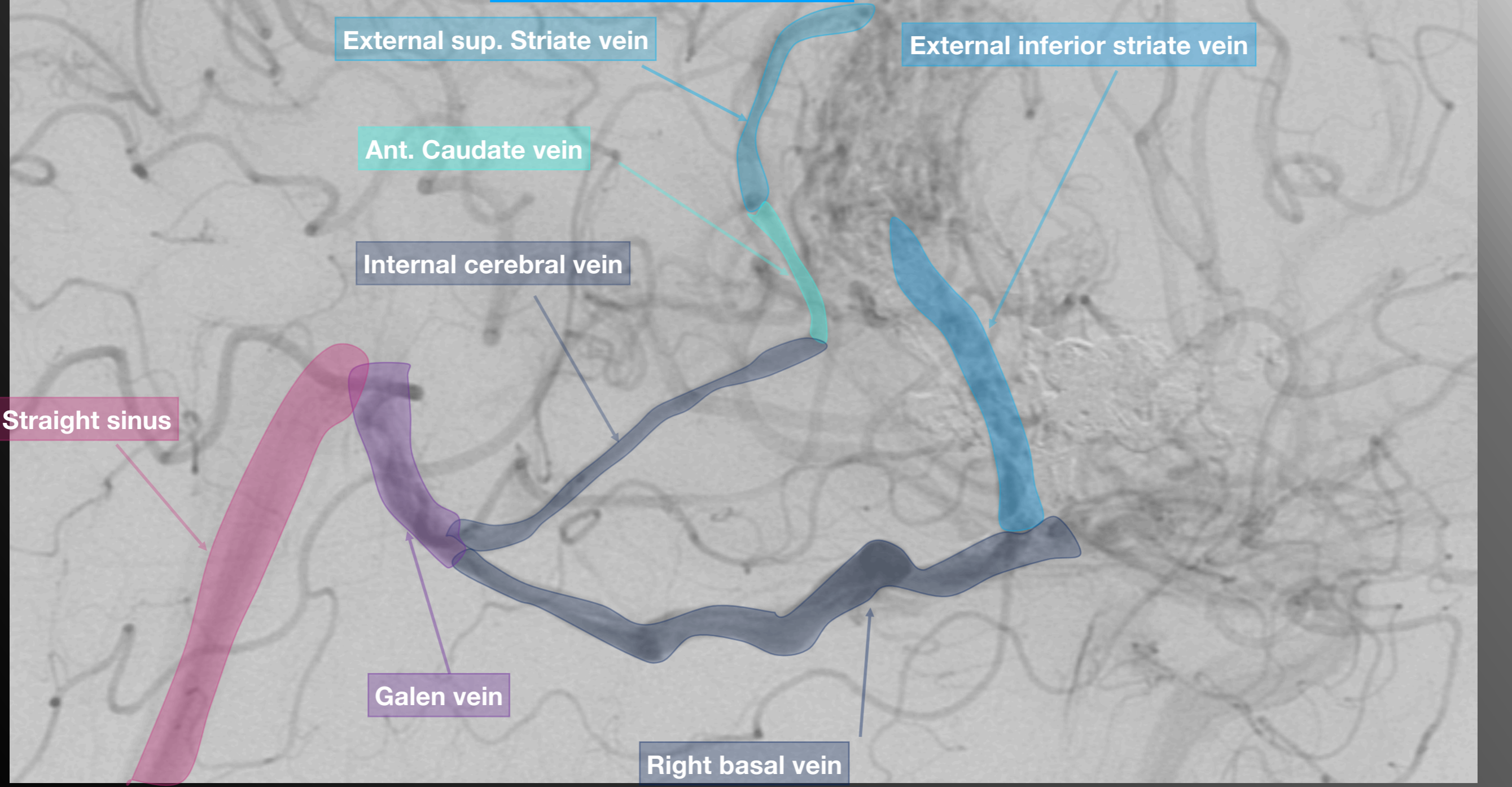
GALEN VEIN & STRAIGHT SINUS





FINAL CONTROL

PARTIAL OBLITERATION







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Engage in debate

Liquid agents

Porcelain vein

Nidus size

Arterial Balloon

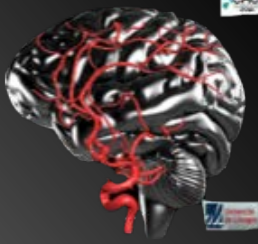
➤ Could it be partial?

What about the venous ischemia?

Take home message



Globus pallidus & anterior limb of internal capsule

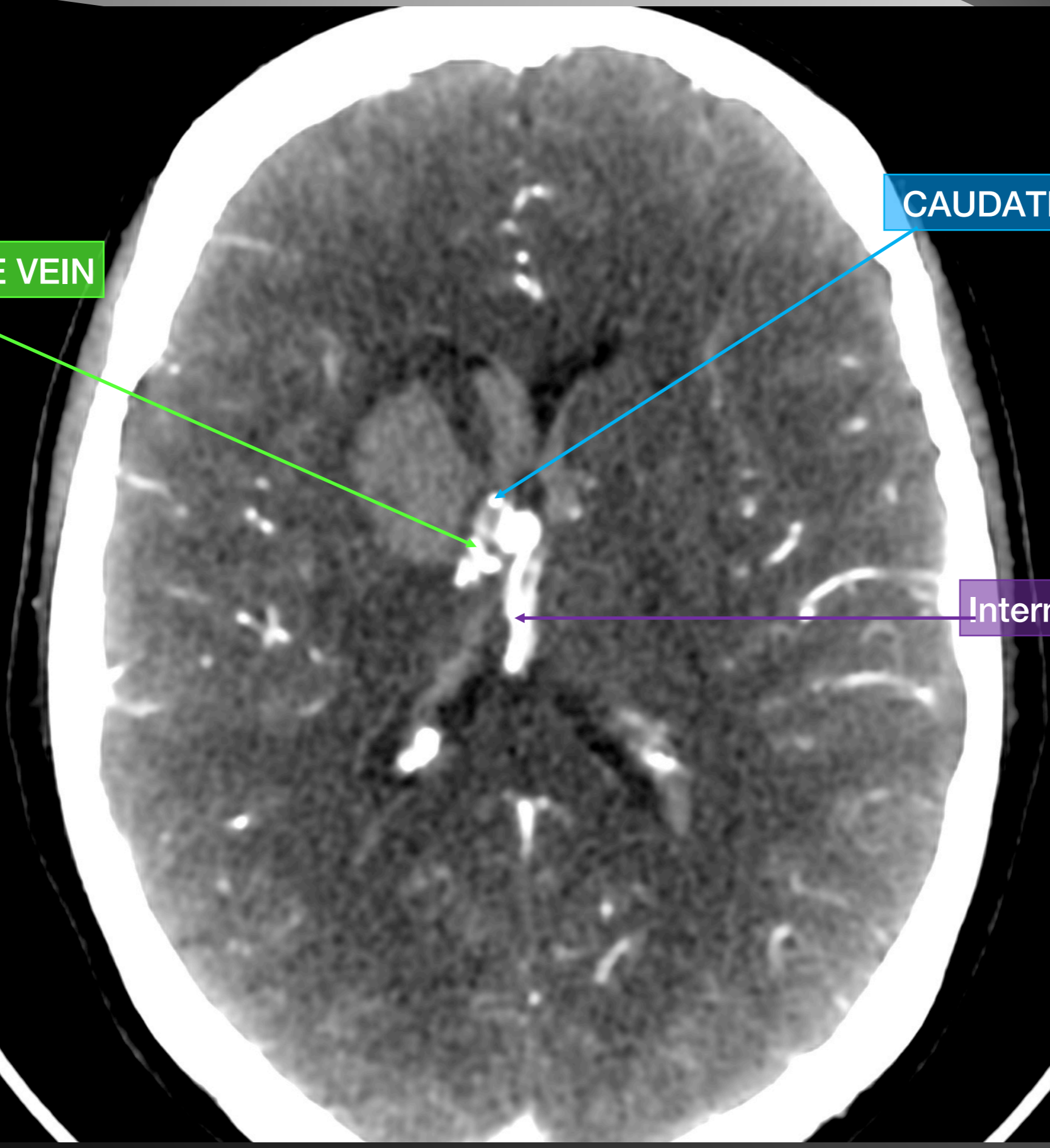




SUPERIOR STRIATE VEIN

CAUDATE HEAD VEIN

Internal cerebral vein



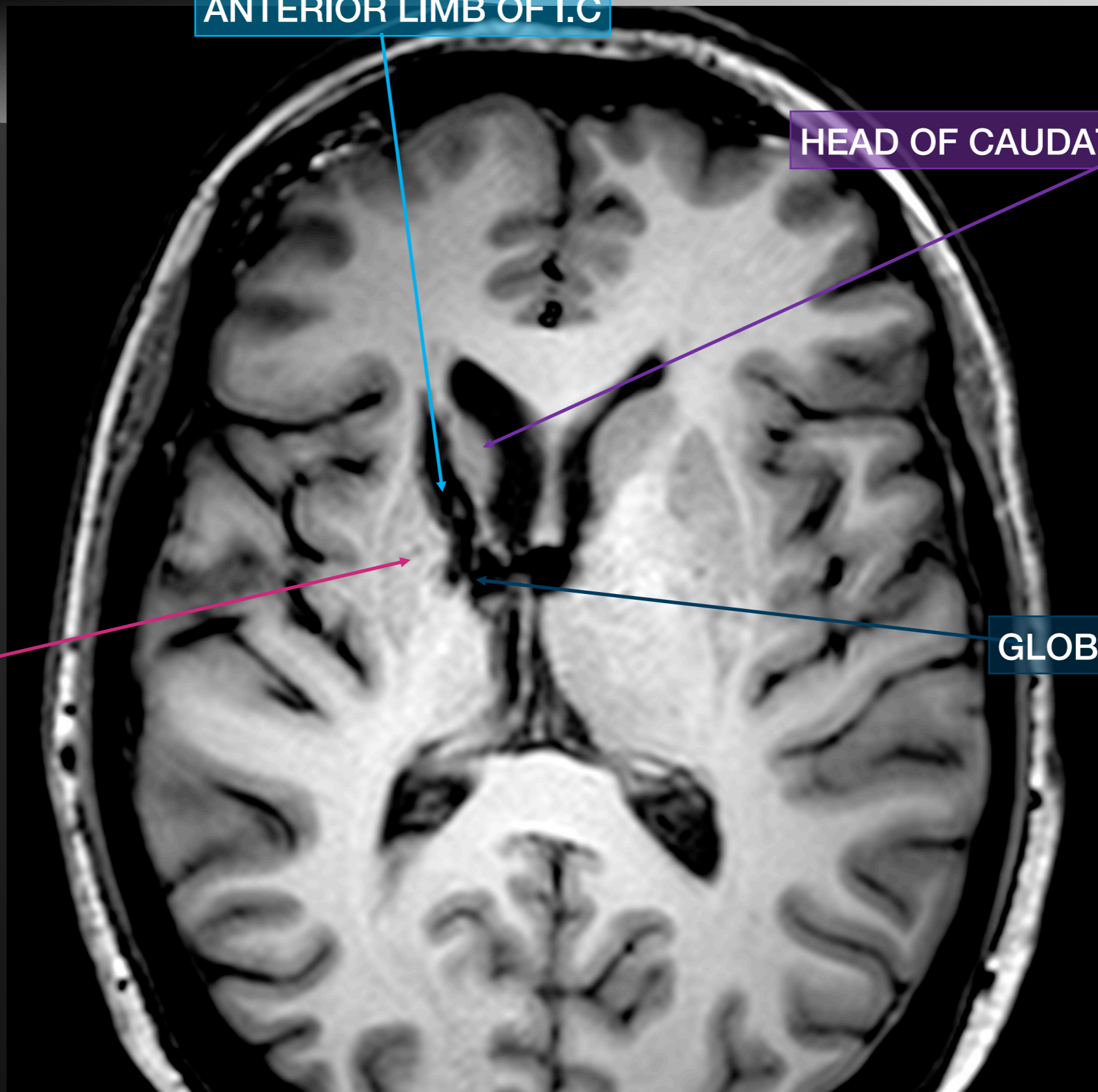


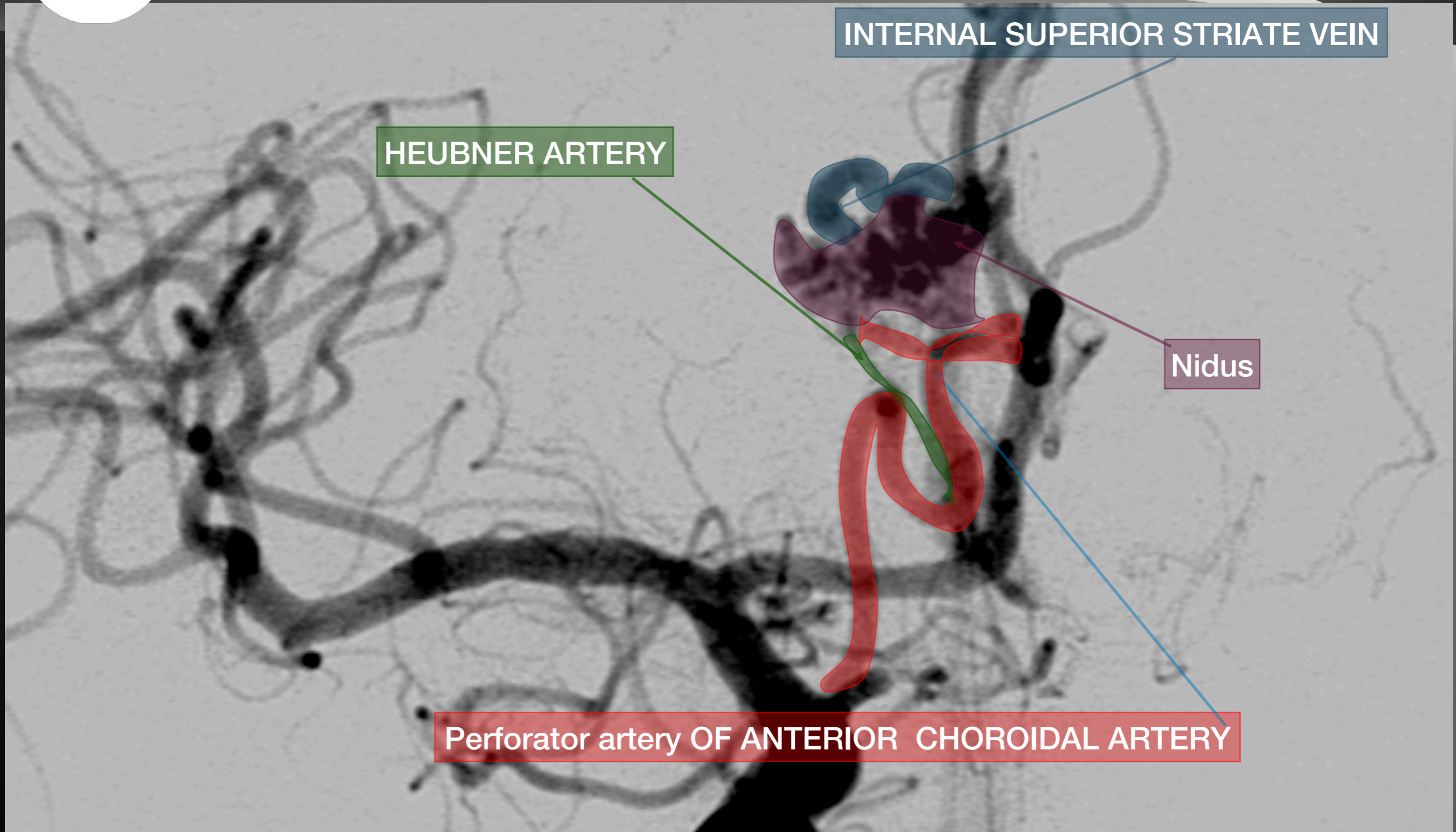
ANTERIOR LIMB OF I.C

HEAD OF CAUDATE NUCLEUS

PUTAMEN

GLOBUS PALLIDUS



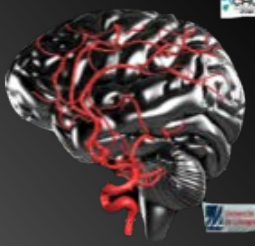


INTERNAL SUPERIOR STRIATE VEIN

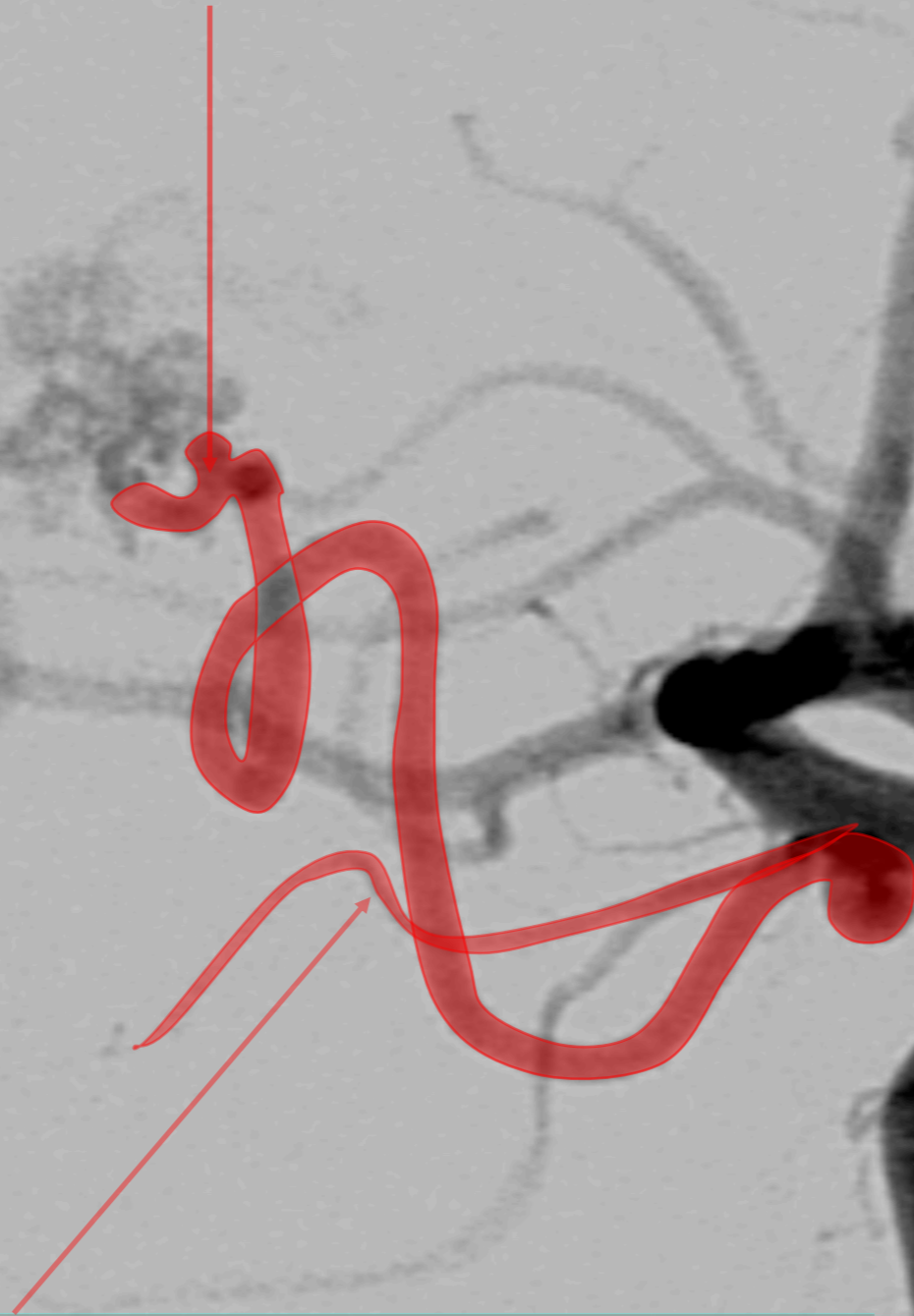
HEUBNER ARTERY

Nidus

Perforator artery OF ANTERIOR CHOROIDAL ARTERY



Perforator artery OF ANTERIOR CHOROIDAL ARTERY



CHOROIDAL BRANCH OF ANTERIOR CHOROIDAL ARTERY



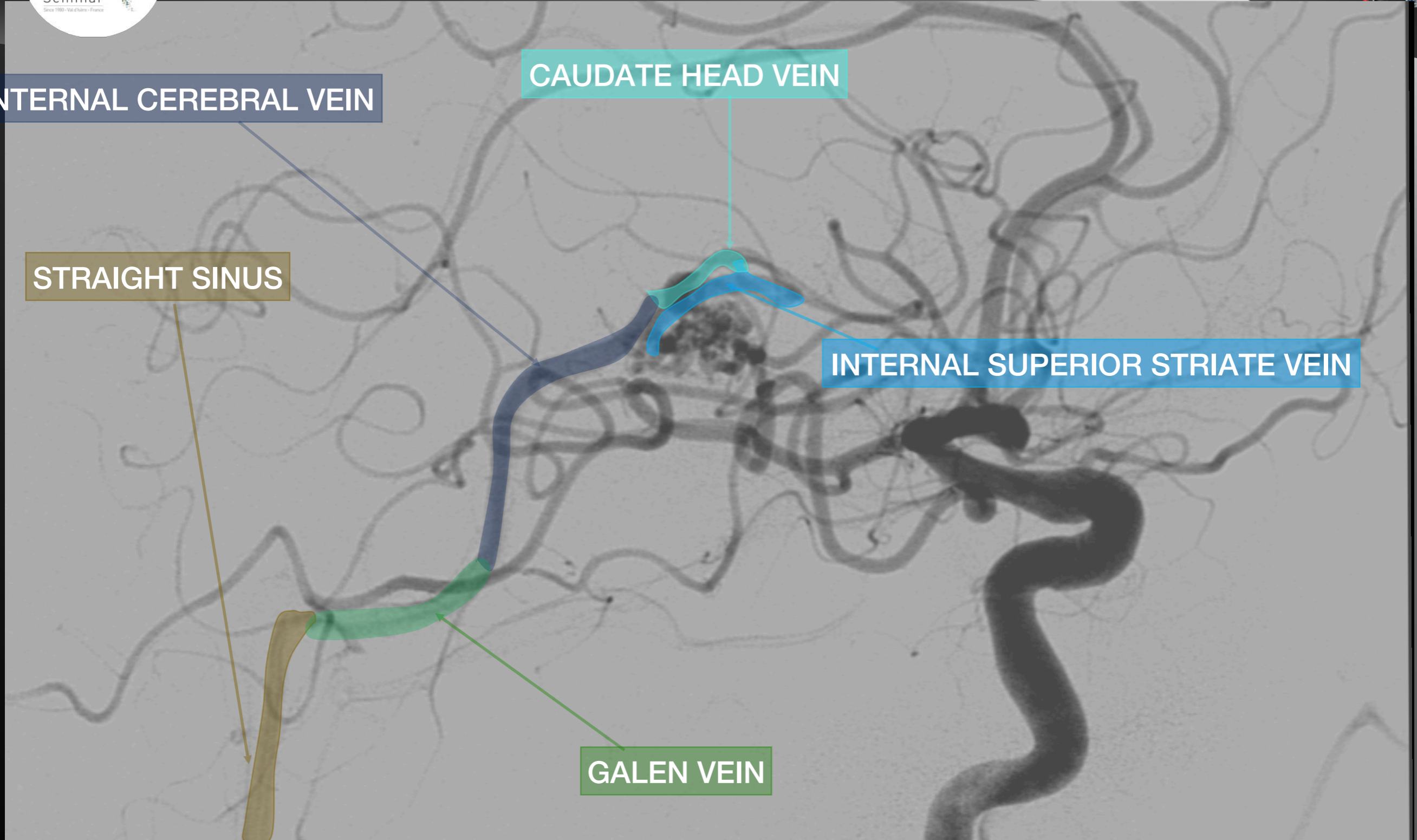
INTERNAL CEREBRAL VEIN

CAUDATE HEAD VEIN

STRAIGHT SINUS

INTERNAL SUPERIOR STRIATE VEIN

GALEN VEIN

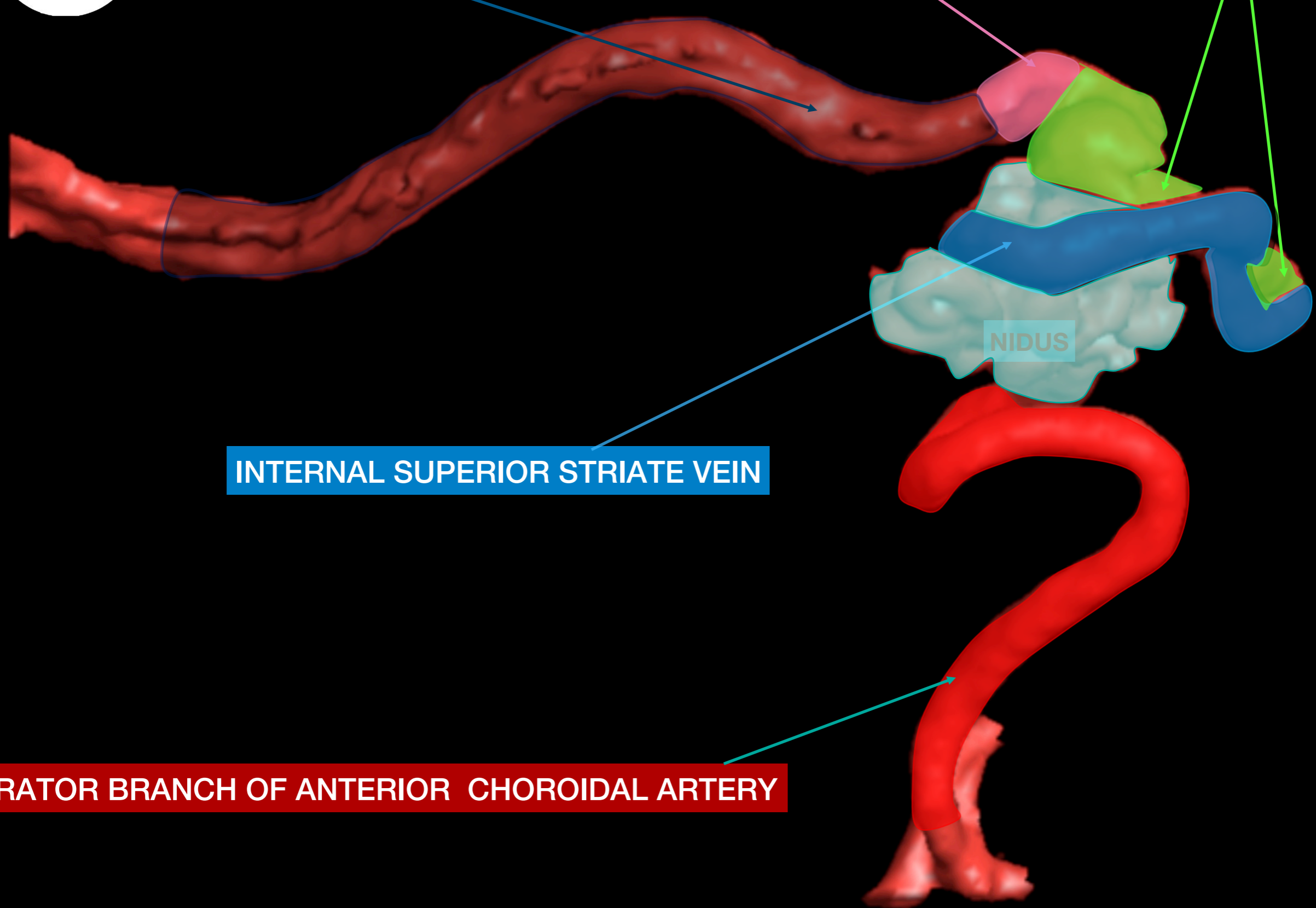




INTERNAL CEREBRAL VEIN

VENOUS ANGLE

CAUDATE HEAD VEIN

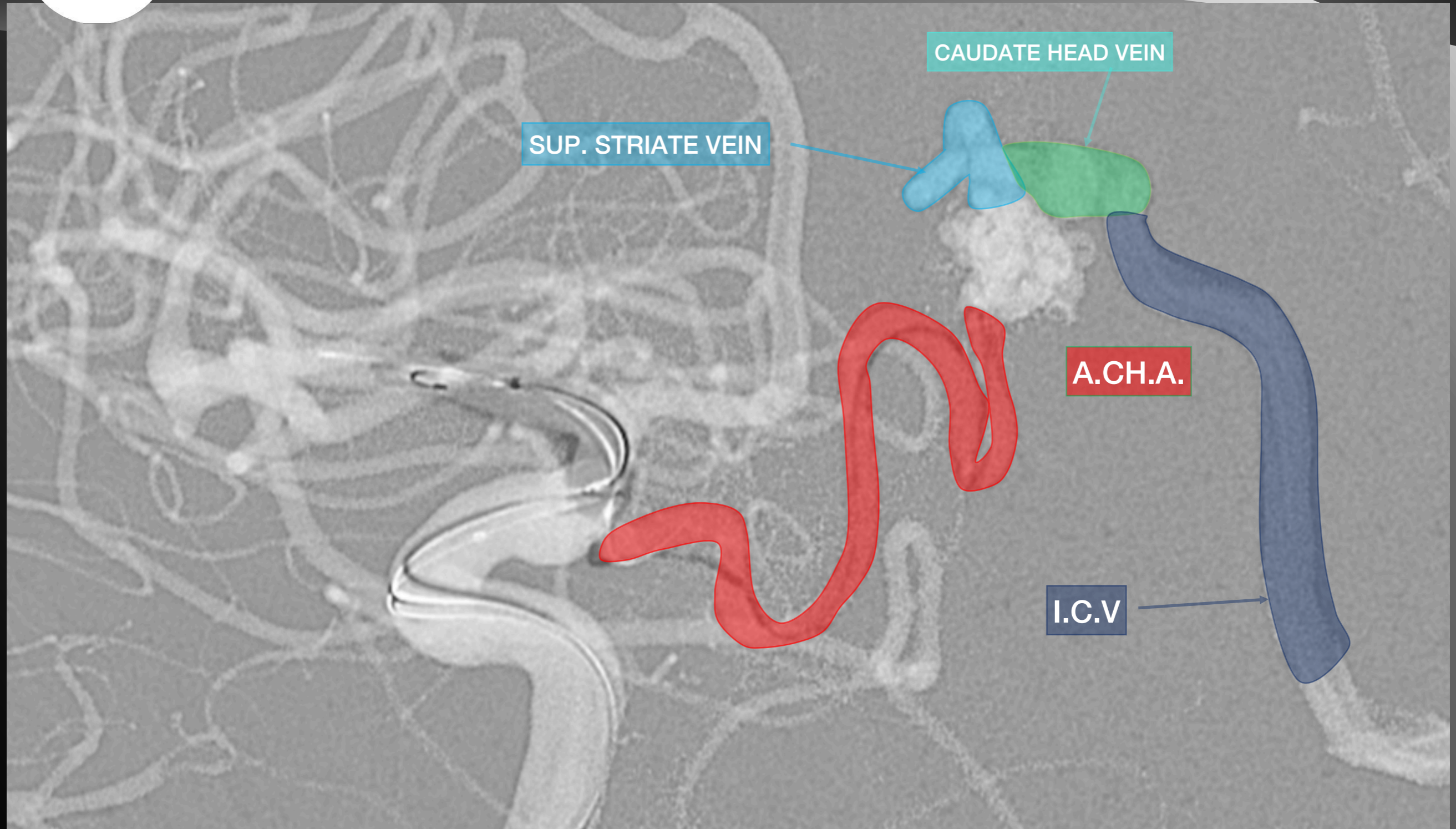
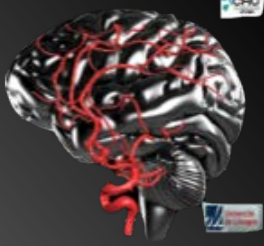


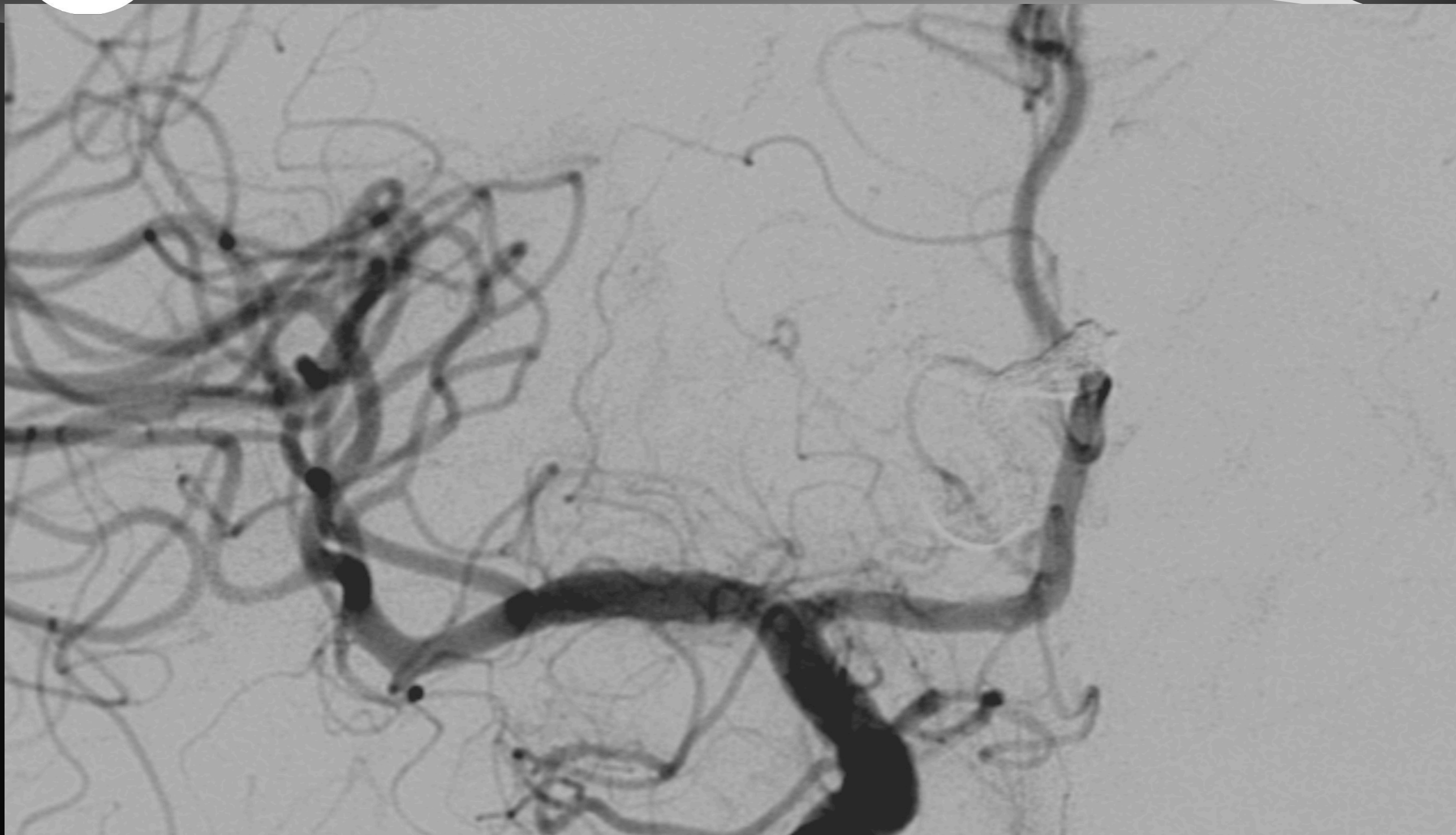
INTERNAL SUPERIOR STRIATE VEIN

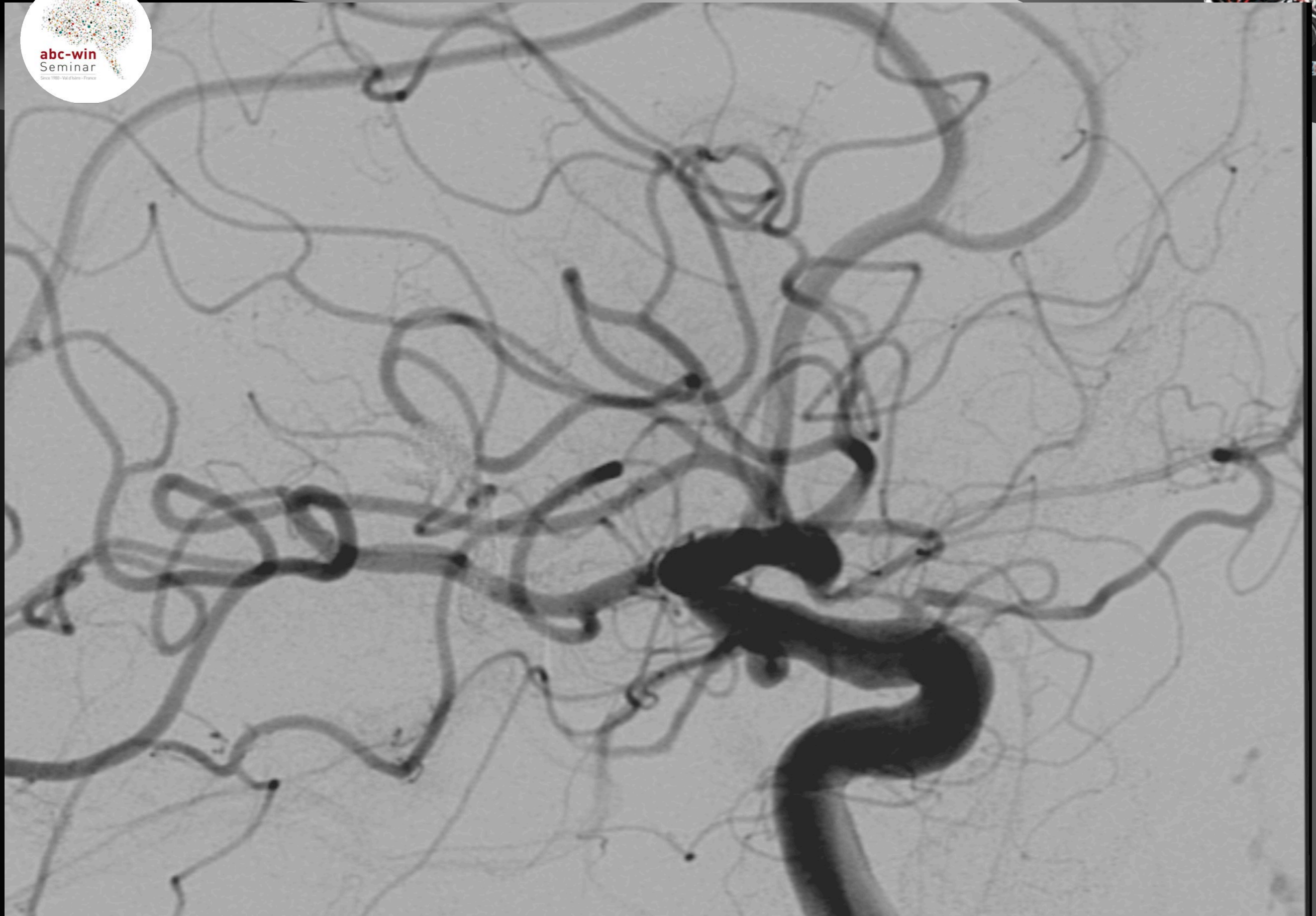
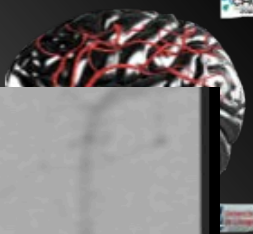
NIDUS

PERFORATOR BRANCH OF ANTERIOR CHOROIDAL ARTERY

First session

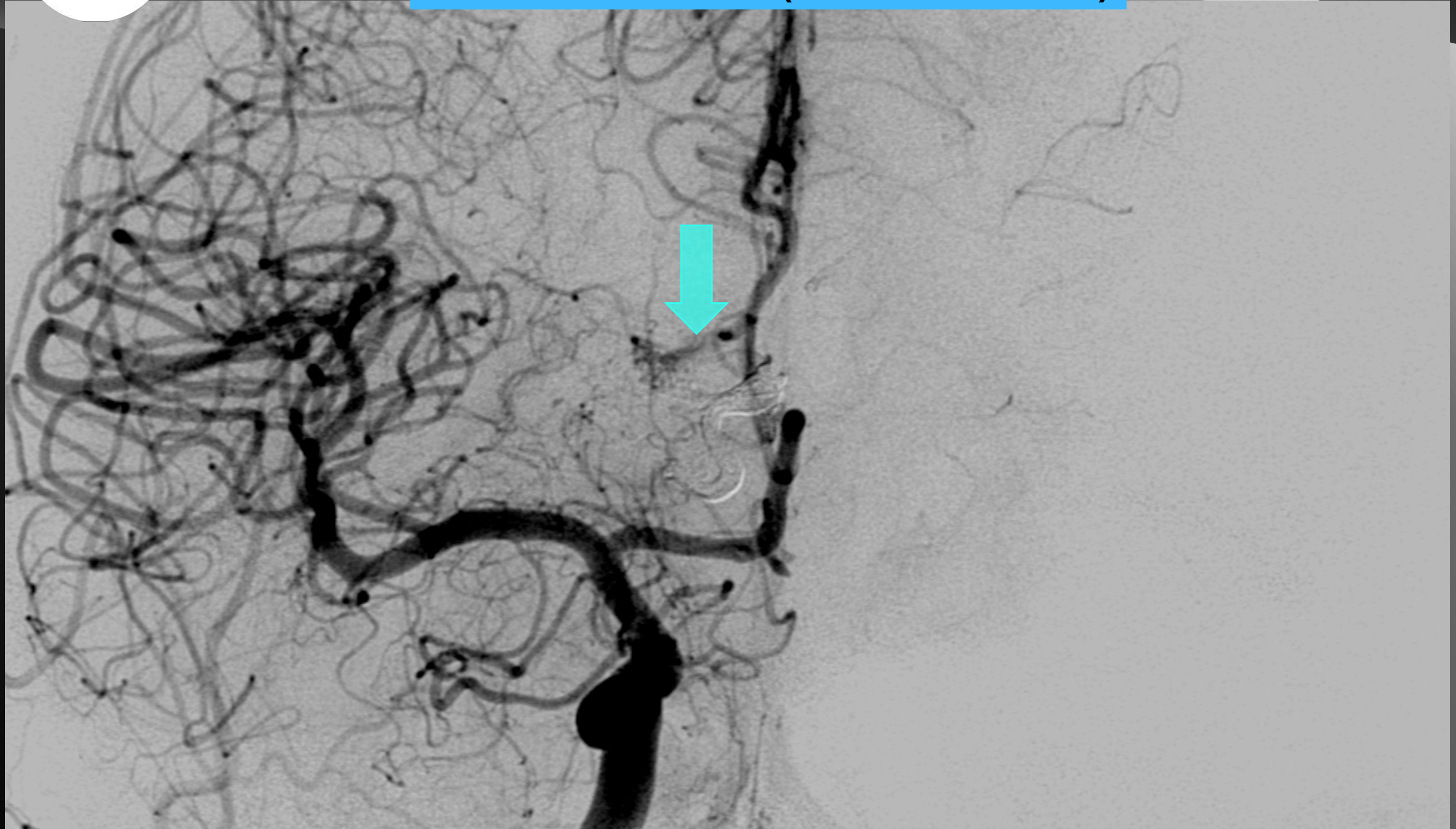


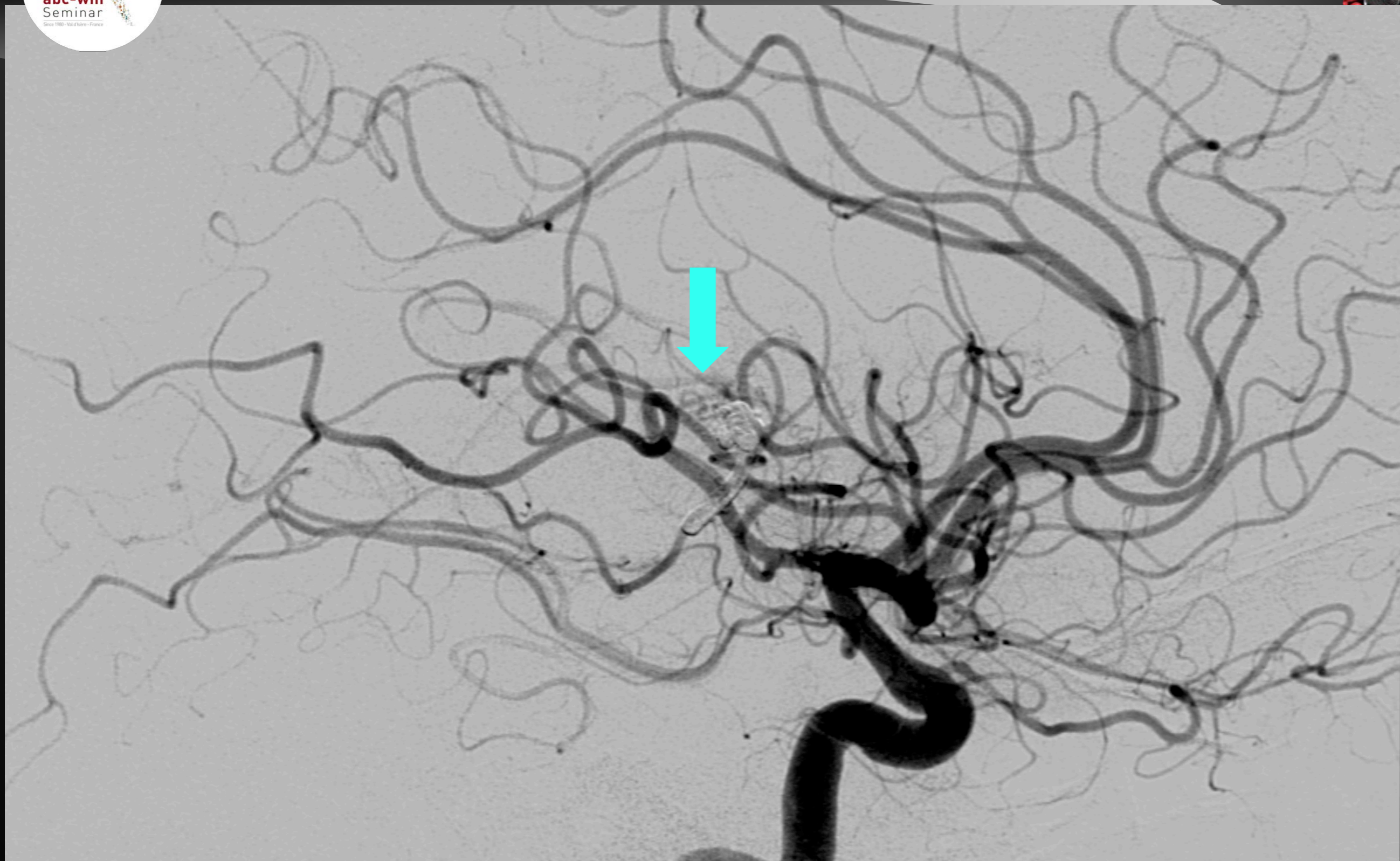


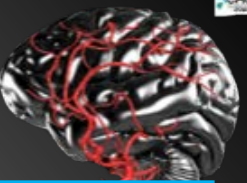




Second session (3 months later)





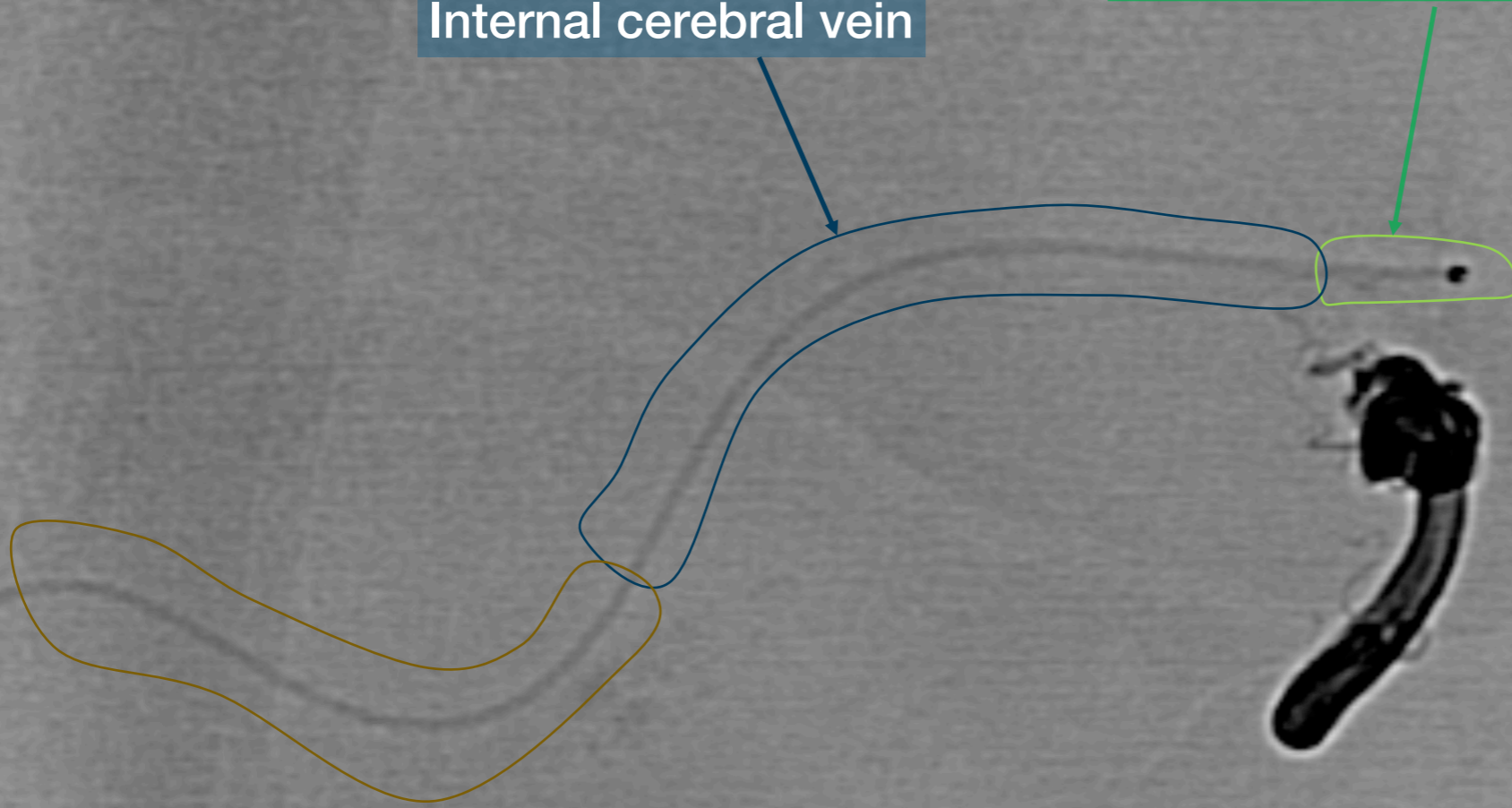


TRANS VENOUS APPROACH SIMPLE TECHNIQUE

Internal cerebral vein

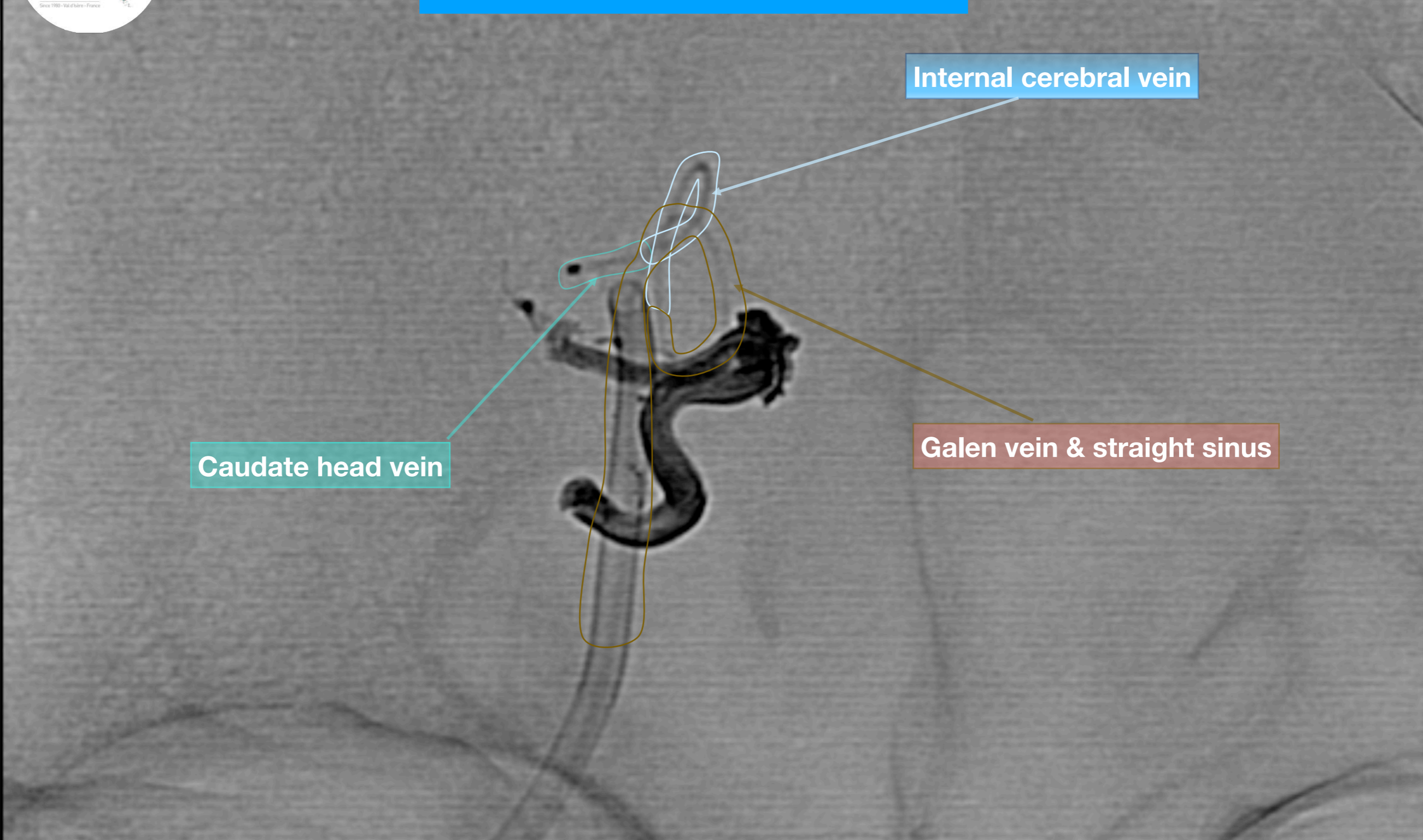
Caudate head vein

Galen vein





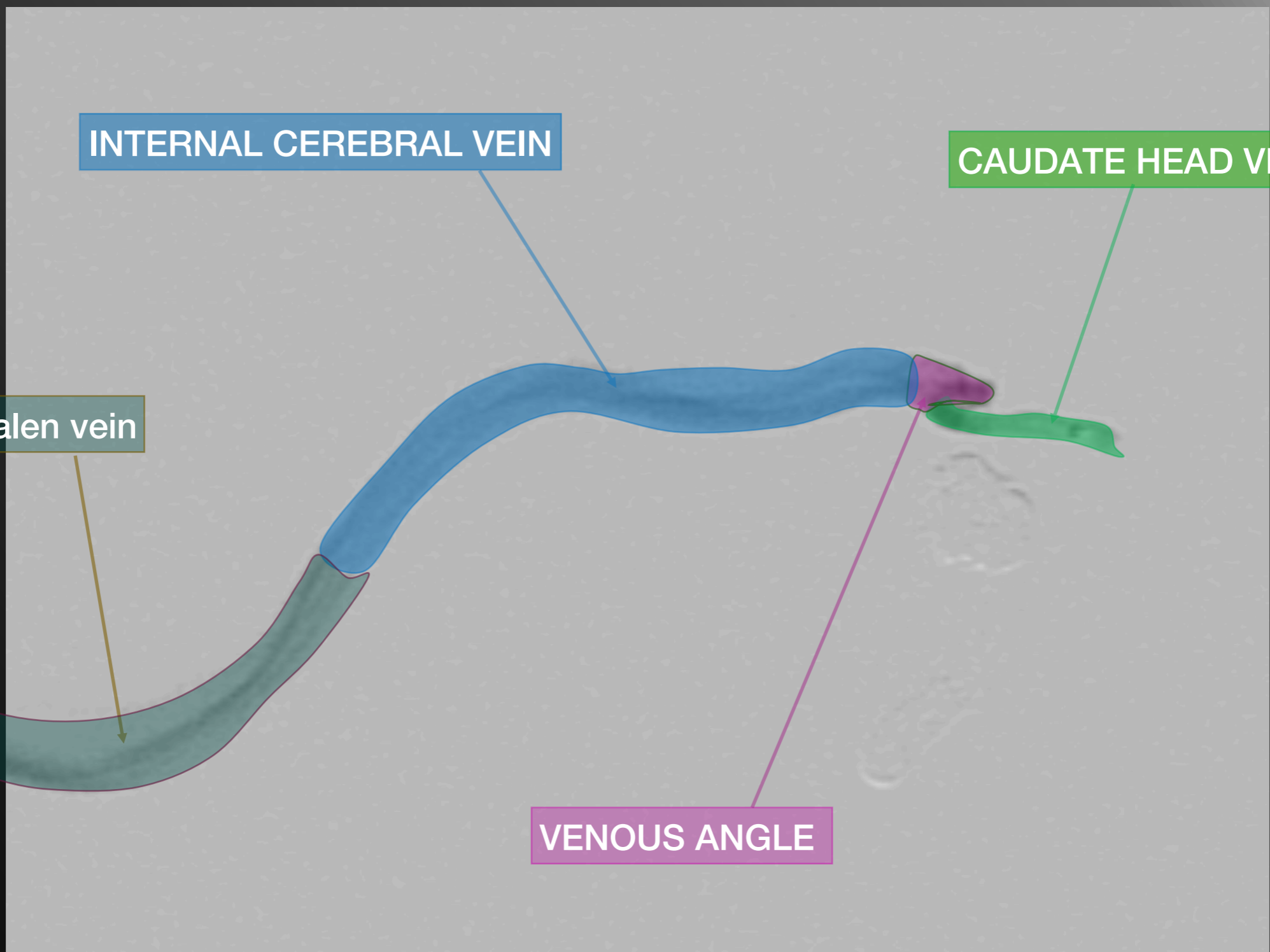
TRANS VENOUS APPROACH



Internal cerebral vein

Caudate head vein

Galen vein & straight sinus

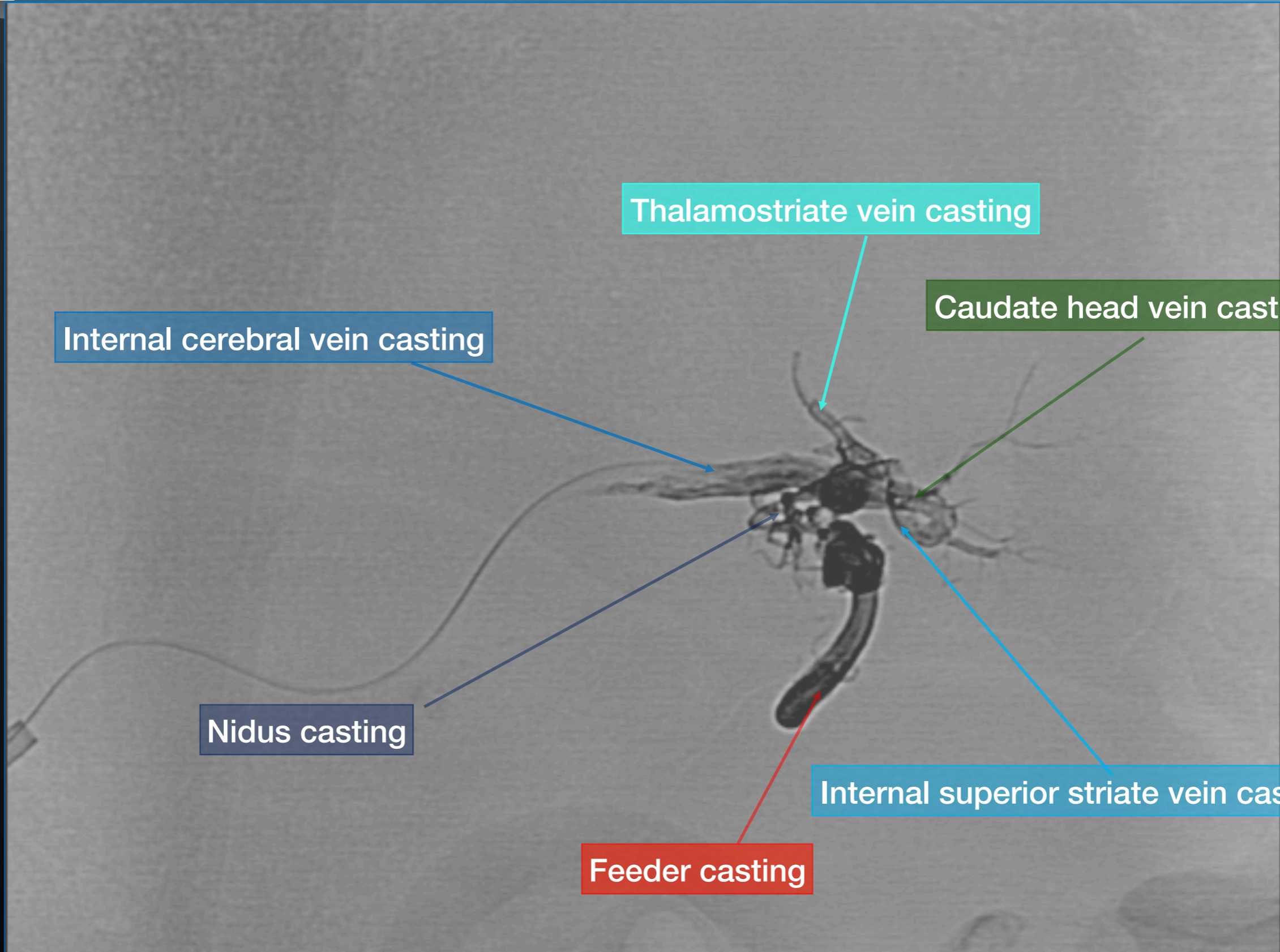
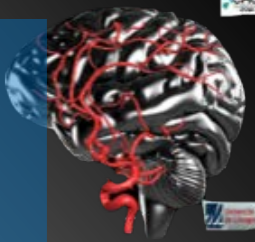


INTERNAL CEREBRAL VEIN

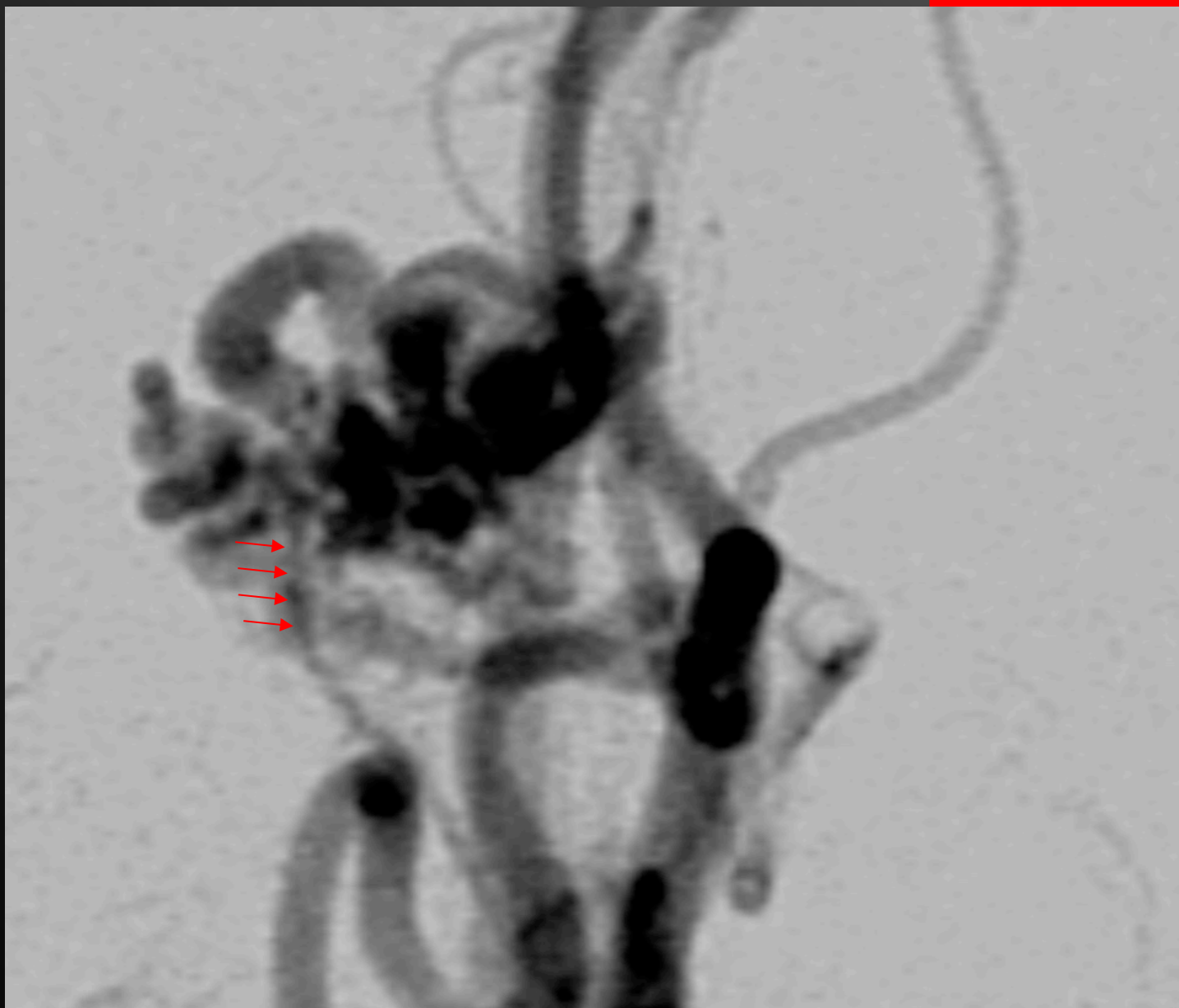
CAUDATE HEAD VEIN

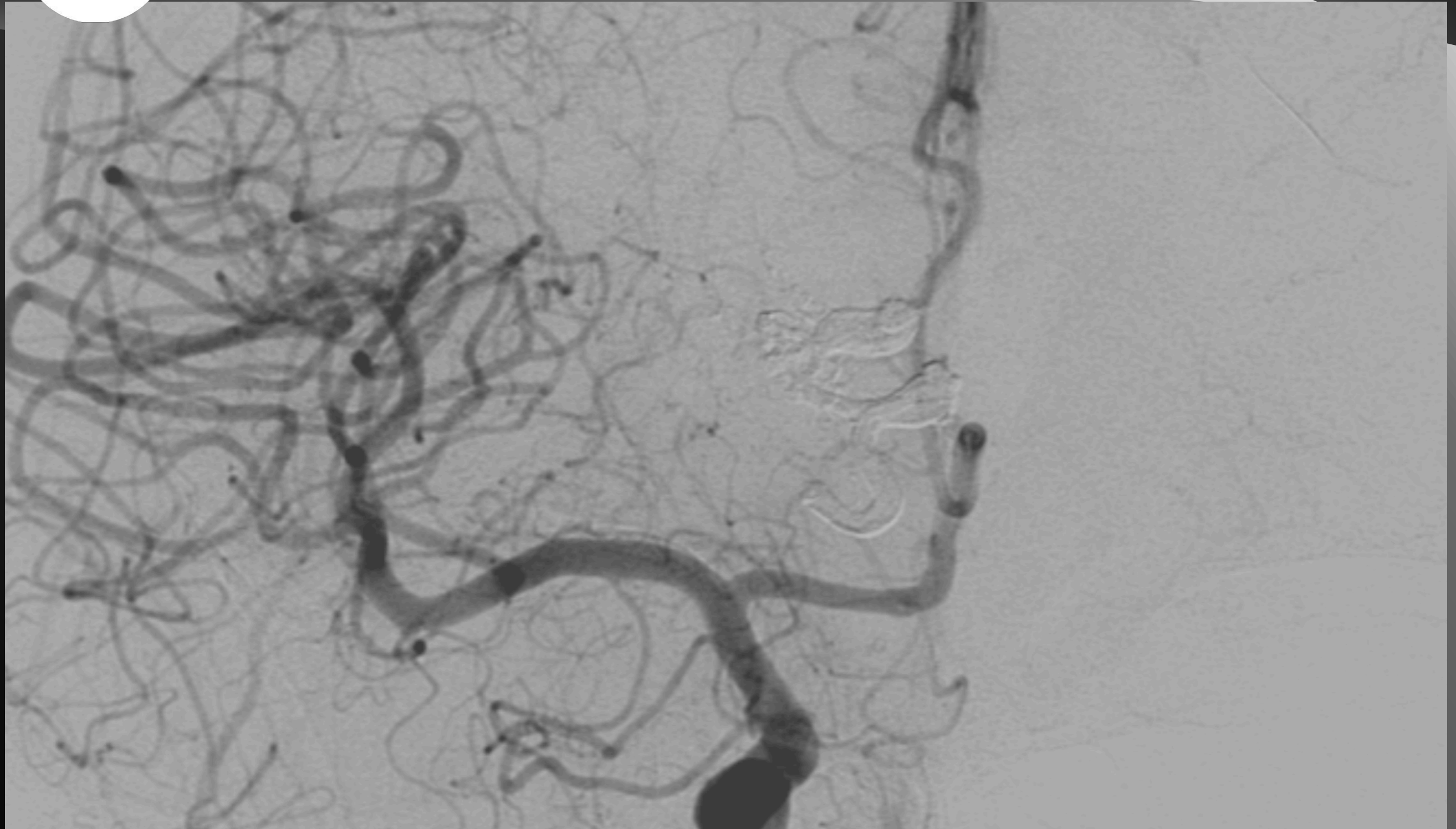
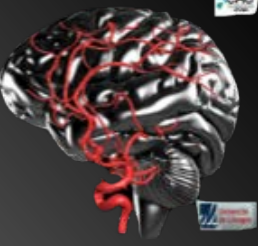
Galen vein

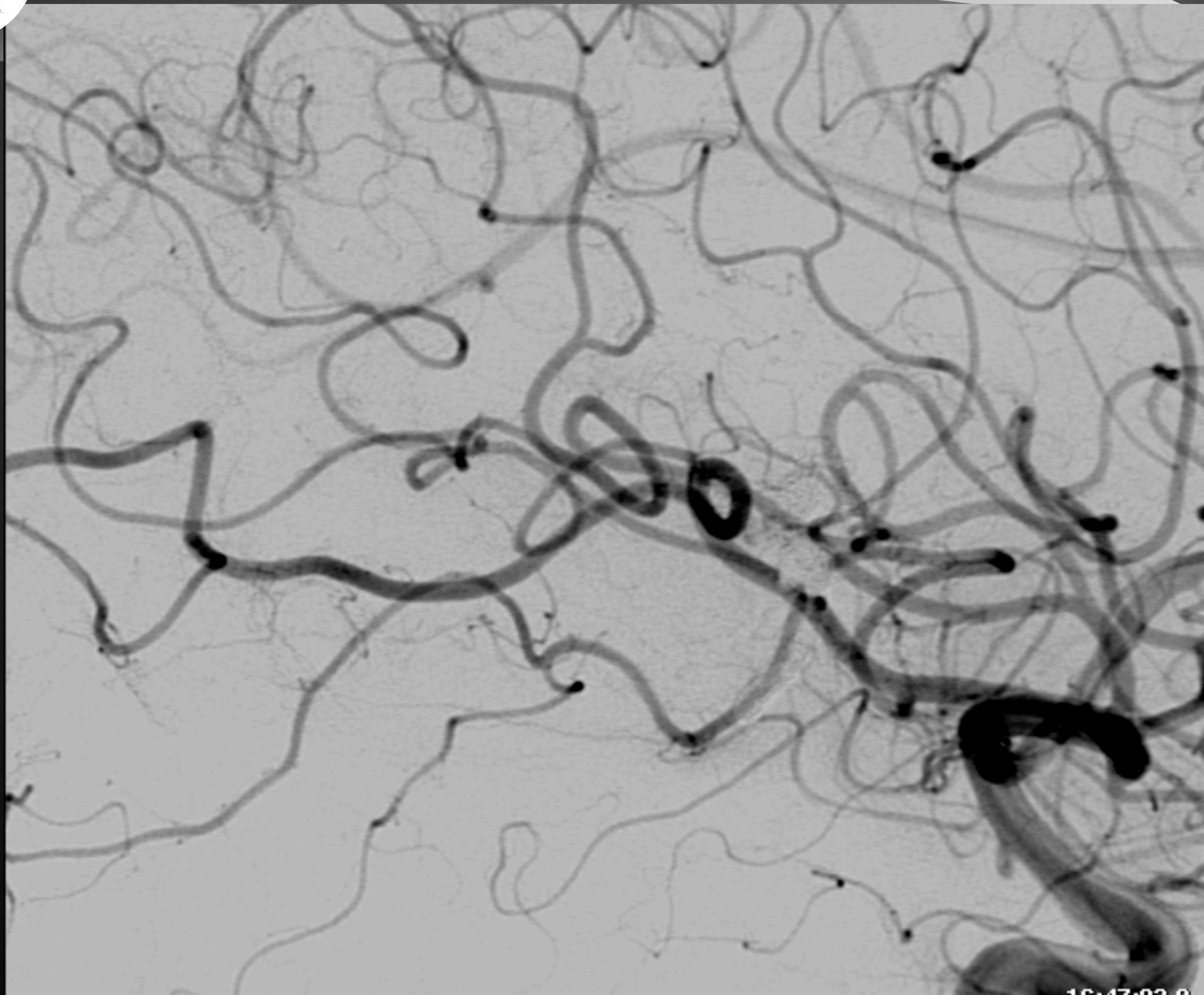
VENOUS ANGLE

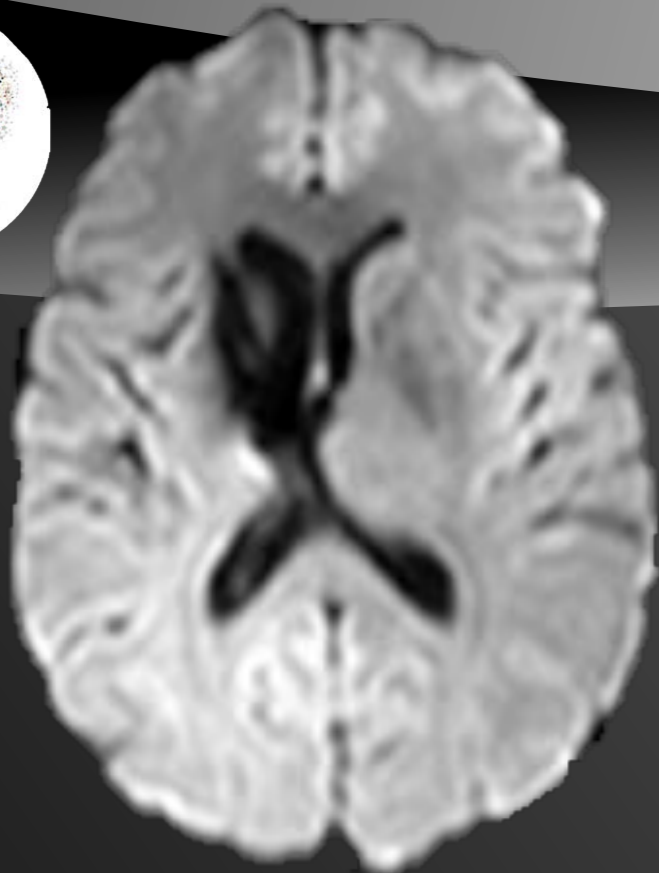


Heubner artery



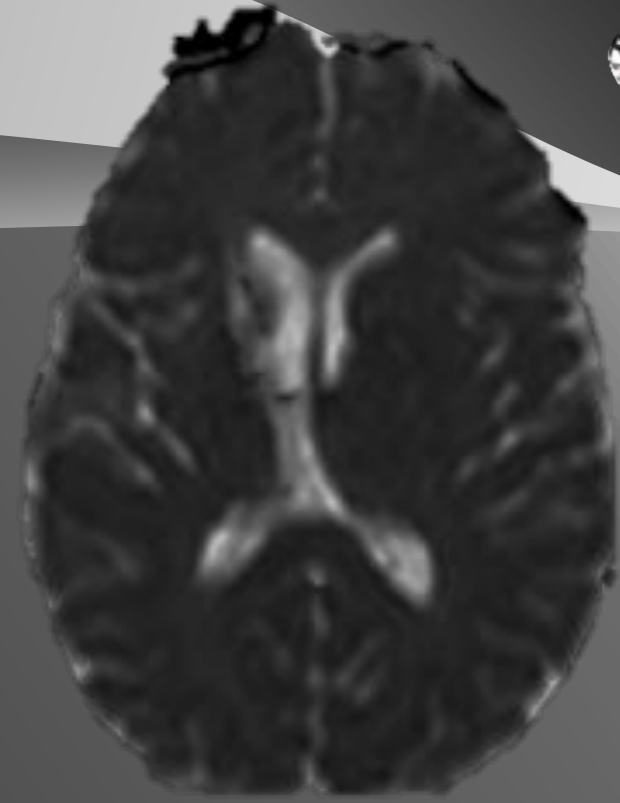




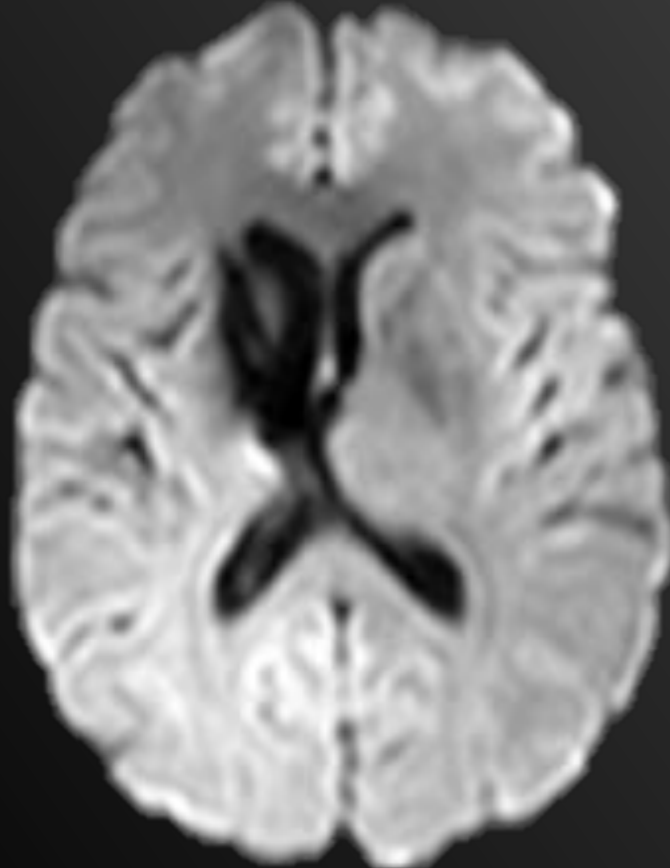
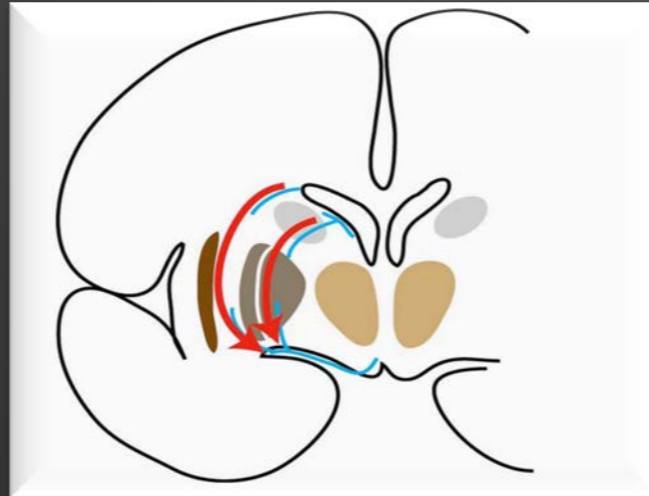


DWI

Before Treatment
2.4.2013

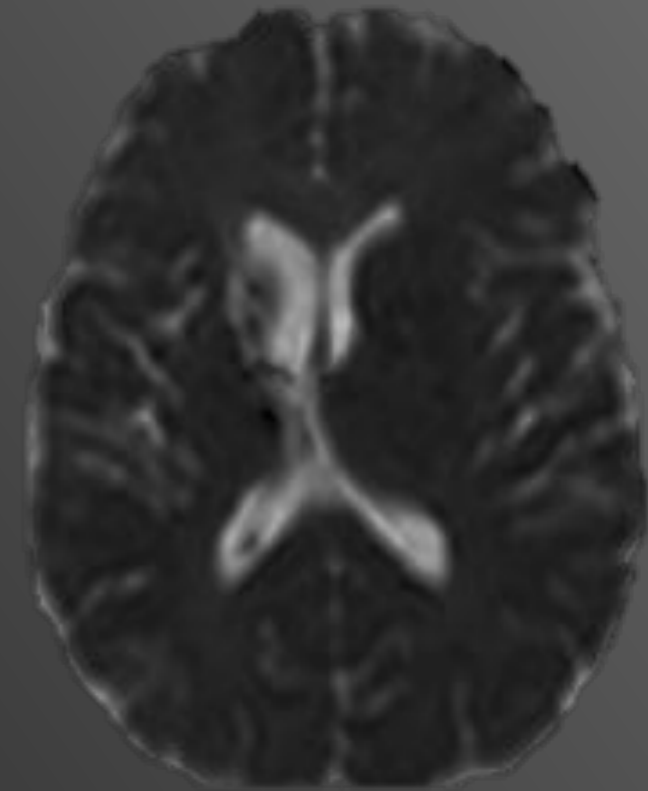


ADC



DWI

After Treatment
5.4.2013



ADC



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Porcelain vein

Nidus size

Arterial Balloon

Could it be partial?

What about the venous ischemia?

Take home message



- ✓ Combined EVT and SRS technique reduces the rate of BG AVM total occlusion
- ✓ SRS efficacy is limited by the high functionality of the treated area
- ✓ Arterial approach is limited by its tortuous access
- ✓ Venous approach offers an access to cure BG AVMs
- ✓ Arterial ischemia is one of venous approach major complications:
 - Nidus size as limited as possible (staged arterial procedures)
 - Porcelain vein technique
- ✓ Venous occlusion should be limited ---- Venous ischemia
- ✓ Multi-center randomized study

tatam

Transvenous Approach for the Treatment of cerebral
Arteriovenous Malformations (TATAM)

A Randomized Controlled Trial and Registry

Protocol V 1.0 – June 2018



Thanks for your attention