

Treatment planning for neurosurgical approach (Planning di intervento chirurgico)



Giuseppe Esposito, MD, PhD

Clinical Neurocenter, Department of Neurosurgery
University Hospital Zurich, University of Zurich
Switzerland



M. Sebök, MD

B. V. Niftrik, MD

Prof. L. Regli, MD

Disclosure

Consultant for Aesculap B Braun



Approaching the aneurysm.... aneurysm location and decision making I

Paraclinoidal:

- Proximal control with preparation of the carotid at neck
- Craniotomy: pterional vs lateral-supraorbital

Pcom, Acho, ICA-Terminus:

- Craniotomy: pterional vs lateral-supraorbital

Acom:

- Choice of the site: orientation of the Acom complex, dominant A1, orientation of the aneurysm
- Craniotomy: pterional vs lateral-supraorbital



Approaching the aneurysm.... aneurysm location and decision making II

MCA proximal

- Craniotomy: pterional vs lateral-supraorbital vs mini-pterional
- Opening of the fissure: distal-to-proximal vs proximal-to-distal

MCA distal:

- Distal craniotomy
- Neuronavigation

Distal ACA:

- Craniotomy: parasagittal interhemispheric
- Neuronavigation



Approaching the aneurysm.... aneurysm location and decision making III

Basilar tip:

- Orientation, perforators, high of the basilar tip (related to dorsum sellae)
- Craniotomy/approach: fronto-orbital-(zygomatic) (right or left) vs pterional (right or left) vs subtemporal (right or left)

Posterior fossa:

- positioning: prone vs lateral vs park-bench
- Craniotomy: suboccipital vs lateral-suboccipital vs far-lateral vs retrosigmoidal



Approaching the aneurysm.... Influence of clinical conditions

Treatment planning is strongly influenced by:

- Clinical conditions: emergency vs elective

- Lumbar drain?
- Ventricular drain?
- Hematoma removal? ...if big hematoma...hematoma removal plus decompressive craniectomy?



Choice of the clip

Trying to decide the temporary and definitive clip (as well as the clip applicator to be used) before the operation starts means:

- Knowledge of the instrumentation
- Understanding the angioanatomy
- OP-team is ready and knows what to do during delicate steps (clipping moment, intra-op aneurysm rupture, etc)



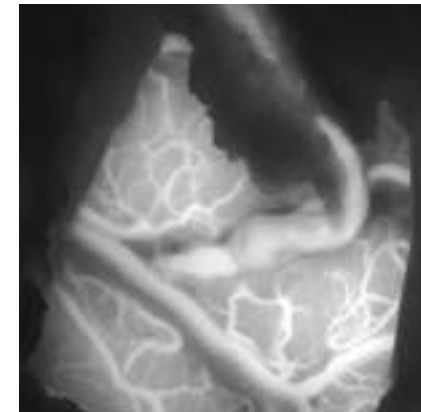
	TEMPORARY					PERMANENT						
	Item No.		Blade length (mm)	Blade opening (mm)	Clipping force (N)	Item No.		Blade length (mm)	Blade opening (mm)	Clipping force (N)		
			mm	mm	g			mm	mm	g		
TITANIUM MINI	FT180T		3.0	3.3	0.80	90	FT680T		3.0	3.3	1.00	110
	FT190T		3.0	4.0	0.80	70	FT690T		5.0	4.0	1.00	110
	FT200T		3.0	3.3	0.80	90	FT700T		3.0	3.3	1.00	110
	FT210T		5.0	4.0	0.80	70	FT710T		5.0	4.0	1.00	110
	FT220T		7.0	4.6	0.80	70	FT720T		7.0	4.6	1.00	110
	FT182T		3.8	3.3	0.80	90	FT682T		3.8	3.3	1.00	110
	FT194T		4.0	3.6	0.75	80	FT694T		4.0	3.6	1.00	110
	FT192T		4.7	3.8	0.80	70	FT692T		4.7	3.8	1.00	110
	FT211T		4.0	3.6	0.75	80	FT711T		4.0	3.6	1.00	110
	FT212T		4.7	3.8	0.80	70	FT712T		4.7	3.8	1.00	110
	FT213T		4.0	3.6	0.75	80	FT713T		4.0	3.6	1.00	110

	TEMPORARY					PERMANENT						
	Item No.		Blade length (mm)	Blade opening (mm)	Clipping force (N)	Item No.		Blade length (mm)	Blade opening (mm)	Clipping force (N)		
			mm	mm	g			mm	mm	g		
TITANIUM STANDARD	FT240T		7.0	6.2	1.00	110	FT740T		7.0	6.2	1.4T	150
	FT250T		9.0	7.0	0.80	90	FT750T		9.0	7.0	1.7T	180
	FT260T		11.0	7.8	0.80	90	FT760T		11.0	7.8	1.7T	180
	FT280T		15.0	9.2	0.80	90	FT780T		15.0	9.2	1.96	200
	FT292T		17.5	10.6	0.80	90	FT792T		17.5	10.6	1.96	200
	FT290T		20.0	11.4	1.00	110	FT790T		20.0	11.4	1.96	200
	FT242T		5.5	6.0	1.00	110	FT742T		6.5	6.0	1.4T	150
	FT252T		8.2	6.8	0.80	90	FT752T		8.2	6.8	1.7T	180
	FT262T		10.2	7.5	0.80	90	FT762T		10.2	7.5	1.7T	180
	FT282T		13.7	8.7	1.00	110	FT782T		13.7	8.7	1.96	200
	FT291T		15.3	9.8	1.00	110	FT791T		15.3	9.8	1.7T	180

Intera-operative verification of the efficacy of the treatment

- Clip inspection at 360° (→ cave perforators!): in ruptured and unruptured aneurysms
- Flowmetry (matching the flow pre and post-clipping): in ruptured and unruptured aneurysms
- ICG videoangiography → FLOW800: in ruptured and unruptured aneurysms
- Neuromonitoring (in unruptured ones): most of the time in unruptured aneurysms
- Puncture of the aneurysm after clipping (in ruptured and unruptured aneurysms)

Intra-operative ICG-Videoangiography (ICGVA)



Goals of every treatment planning

- I. Understanding of the anatomy (CTA/MRA → DSA)
- II. Choice of the most efficient and less risky surgical strategy (DECISION-MAKING)
- III. Application of the strategy → goal is to exclude the aneurysm and to preserve the flow
- IV. Allows intra-operative verification of efficacy of the treatment strategy
 - I. Aneurysm is excluded
 - II. Flow is preserved

Treatment planning and choice of the treatment are influenced by:

- Clinical conditions: emergency vs elective
- Anatomical conditions: non-complex vs complex aneurysm

Today's talk

Goals of every treatment planing

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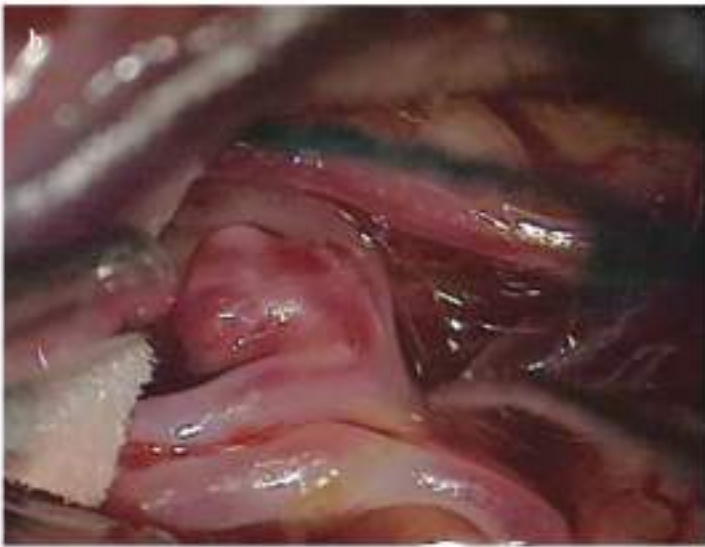
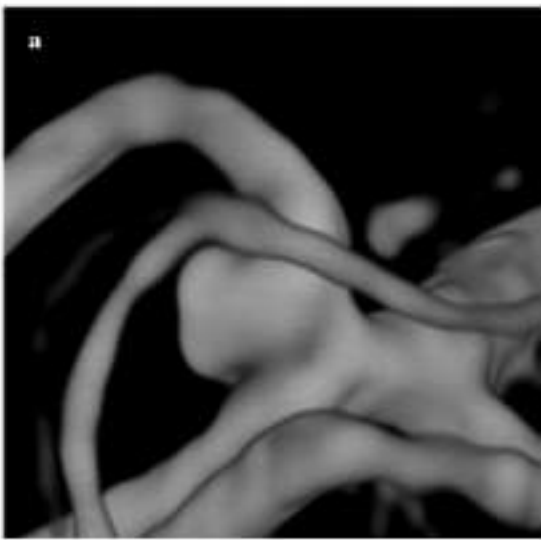
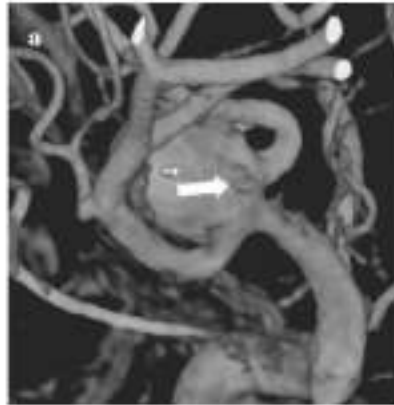


Fig. 2a,b Case 2. A 72-year-old woman with subarachnoid haemorrhage treated as an urgent case. The 3D angiography well depicts site, orientation, morphology and relationship with the parent arteries of an aneurysm of the middle cerebral artery, allowing a virtual view of the surgical field (a). The image is identical to the surgical findings (b).



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NEURORADIOLOGY
NEURORADIOLOGIA

Three-dimensional rotational angiography for craniotomy planning and postintervention evaluation of intracranial aneurysms

A. Pedicelli¹ • F. Desiderio¹ • G. Esposito² • M. Rollo¹ • A. Albanese² • T. Verdolotti¹
F. D'Argento¹ • L. Bonomo¹ • G. Maira² • C. Colosimo¹

3DRA multiple projections with a **preview of the surgical field** and study of lesion characteristics
→ faster and safer surgery



UniversitätsSpital
Zürich

Our strategy regarding pre-op DSA

We operate patients with non-complex “ruptured” aneurysms on the basis of good quality CT-Angio including tridimensional reconstruction.

For what concerns patients with unruptured aneurysms, we operate them as a rule on the basis of the information provided by 3-Tesla MR-Angio including tridimensional reconstruction.

Usually CT- or MR-Angio are able to correctly show the aneurysmal angioanatomy.

A digital subtraction angiography is done in case the aneurysmal morphology is unclear (or in case of dissecting origin, if BTO is needed, etc)



Goals of every treatment planing

- I. Understanding of the anatomy (CTA/MRA → DSA)
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Treatment planing and choice of the treatment are influenced by:

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Today's talk

Goals of every treatment planing

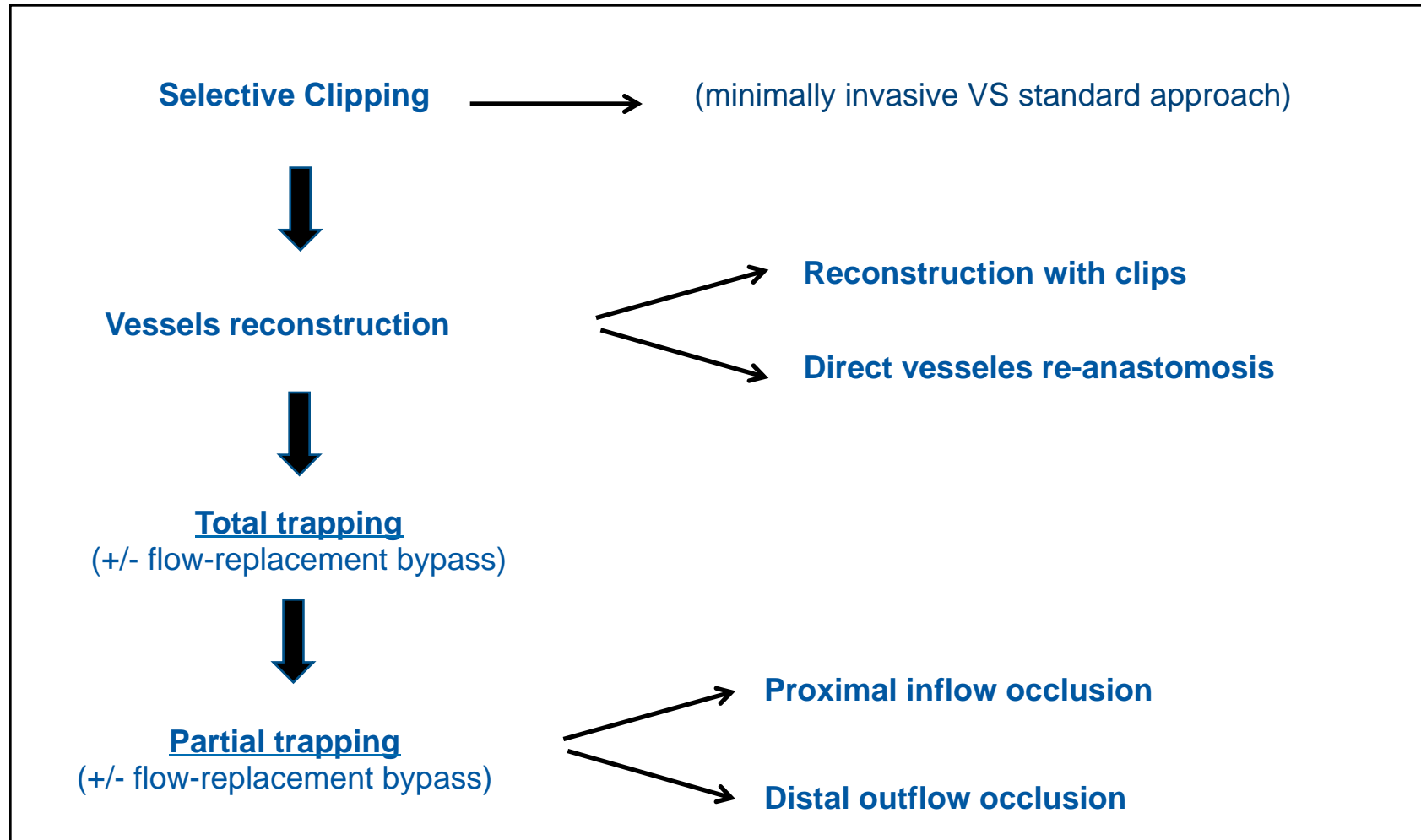
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Treatment planing and choice of the treatment are influenced by:

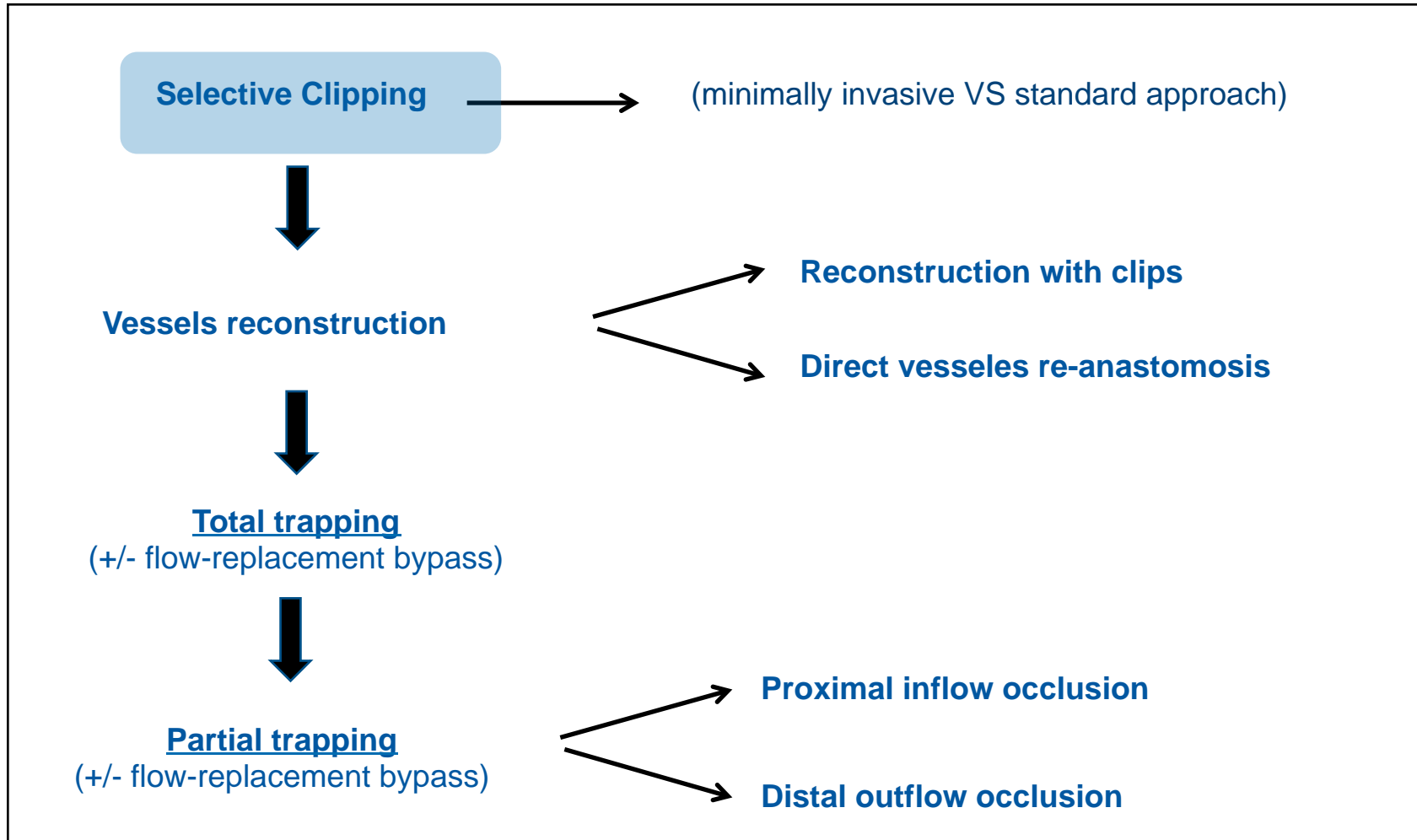
- Clinical conditions: emergency vs elective
- Anatomical conditions: non-complex vs complex aneurysm



SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS

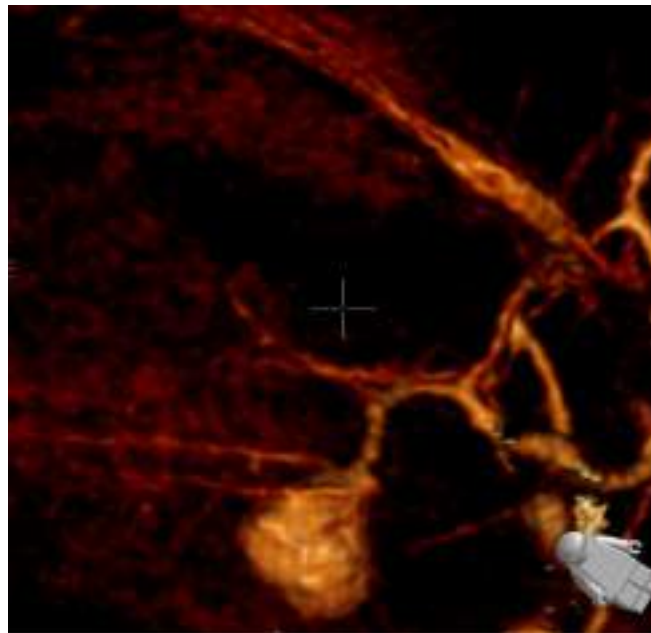
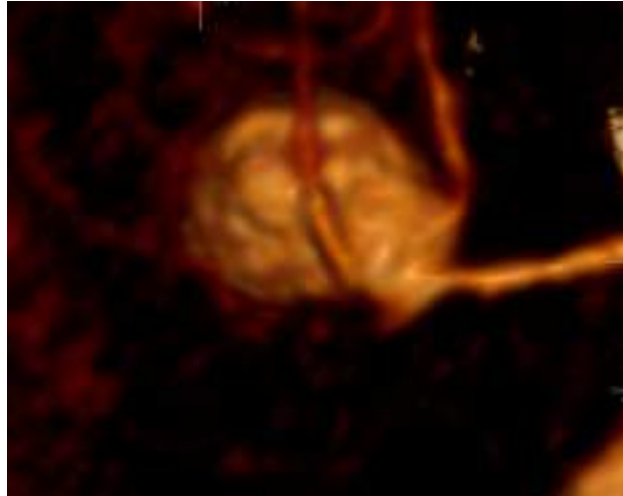
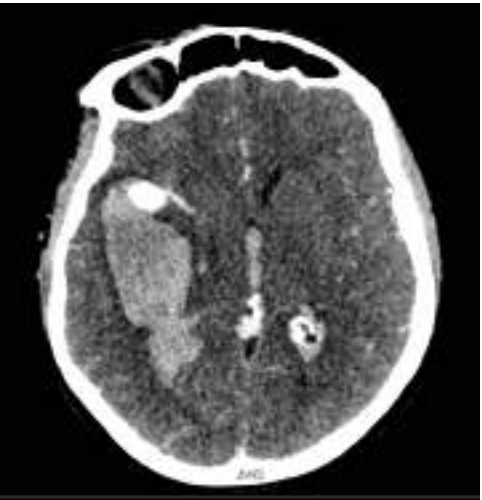


SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS

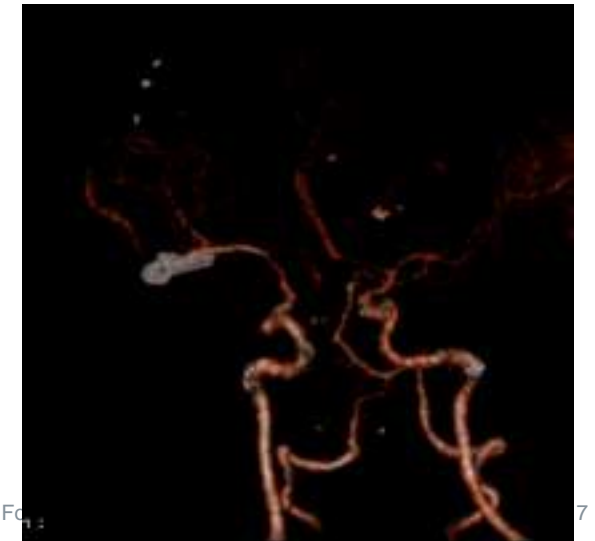
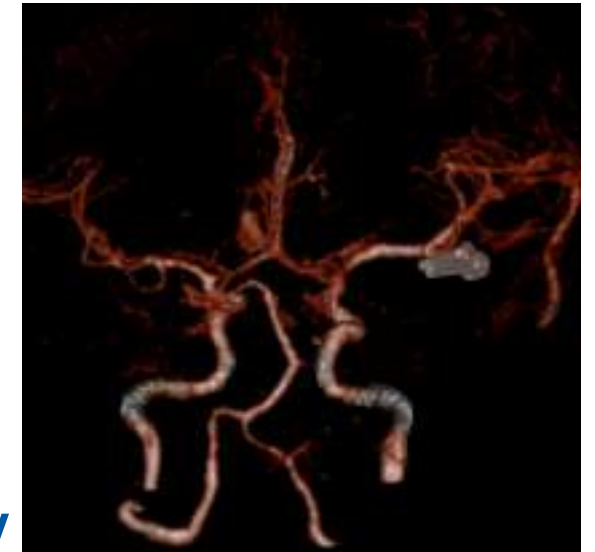


CASE 1 (in emergency)
Selective clipping, clear anatomy, life-threatening
hematoma.
No DSA despite aneurysm size.

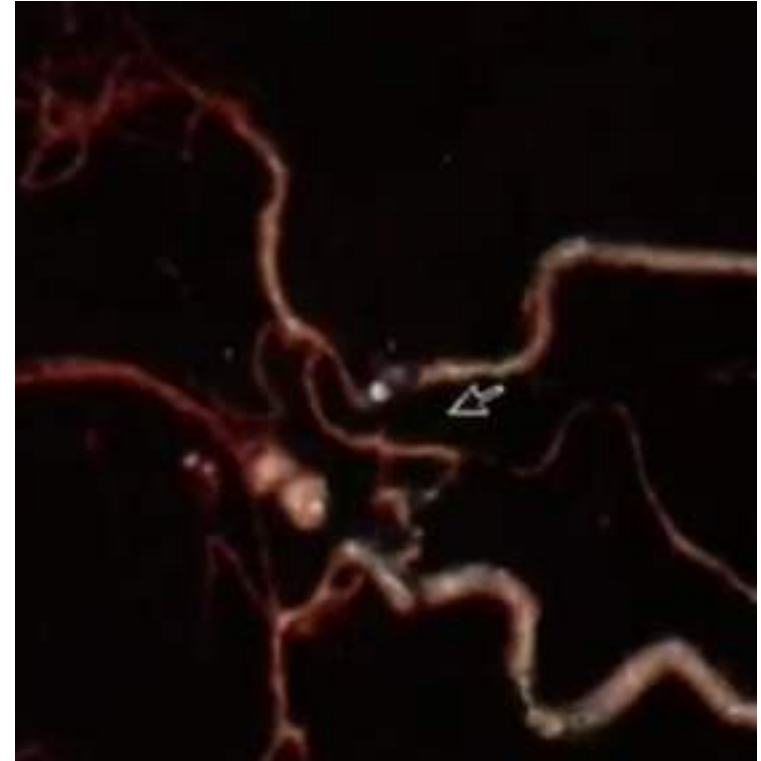
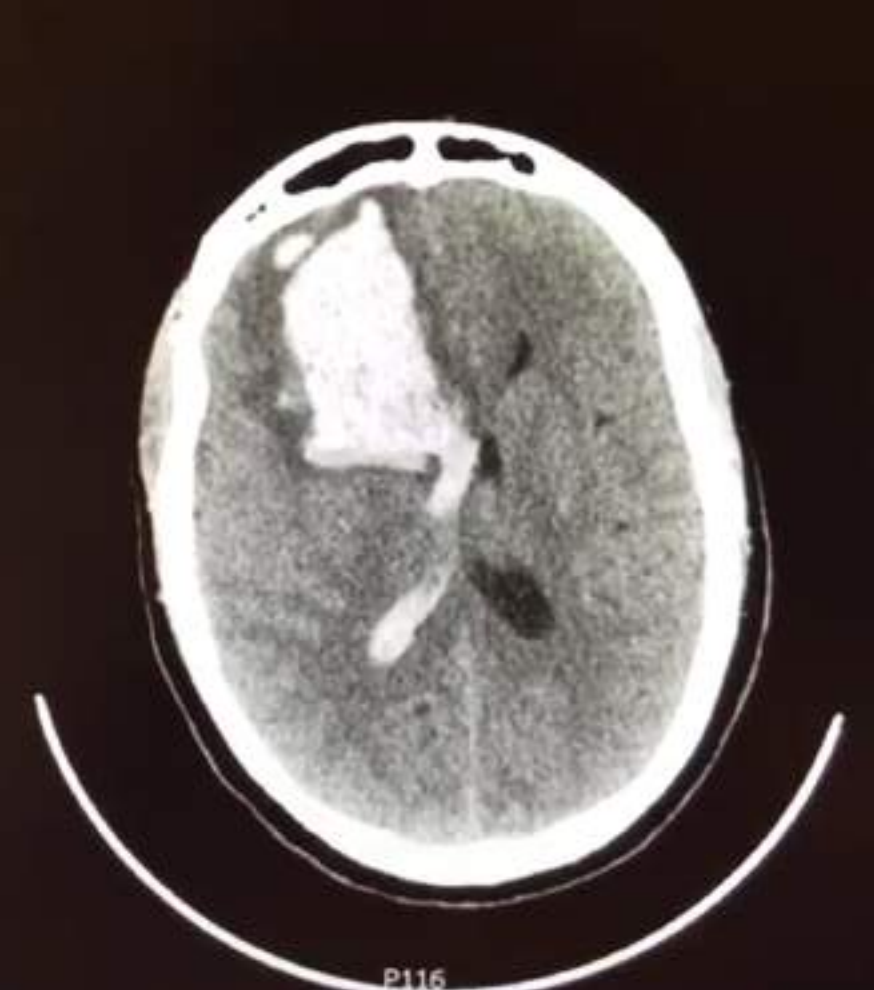
Ruptured right MCA bifurcation aneurysm
(50 yo, female, WFNS4, HH4, BNI5)



Decompressive craniectomy
hematoma removal
selective clipping



CASE 2 (in emergency)
Selective clipping, clear anatomy (no DSA), life-threatening hematoma.

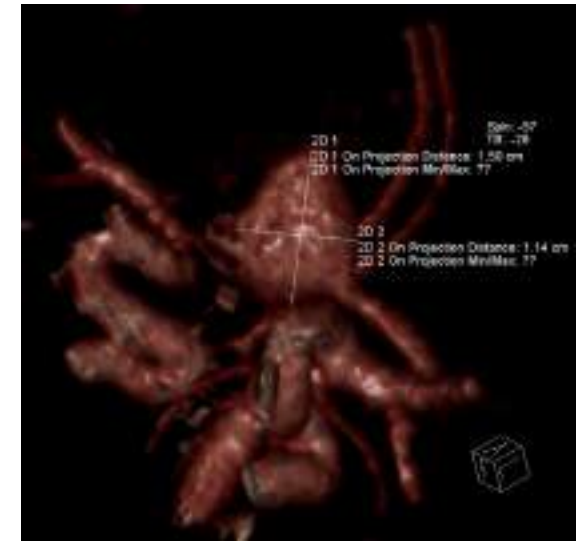


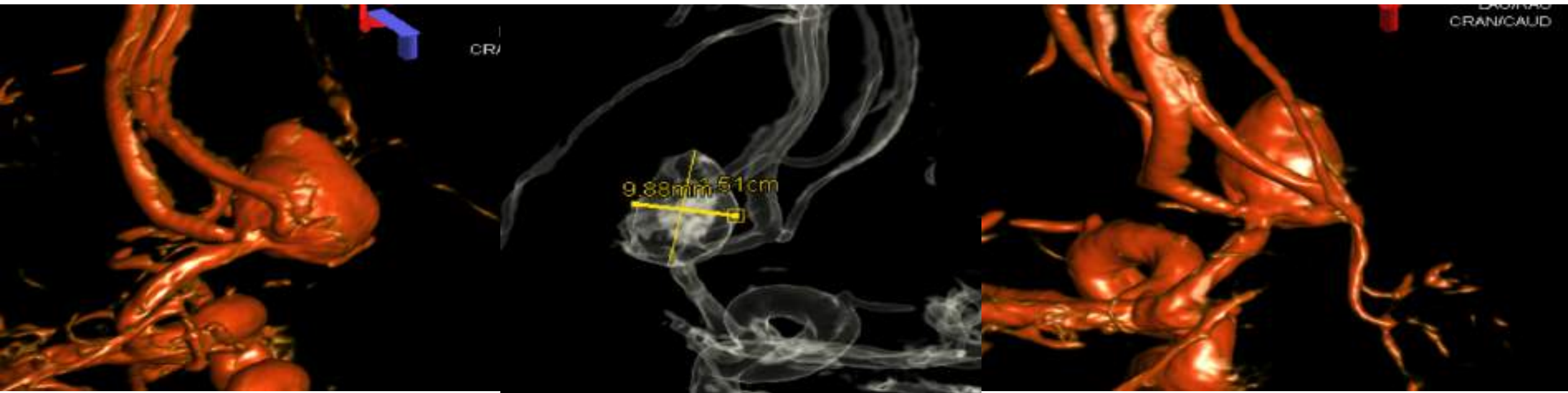
CASE 3 (in emergency)

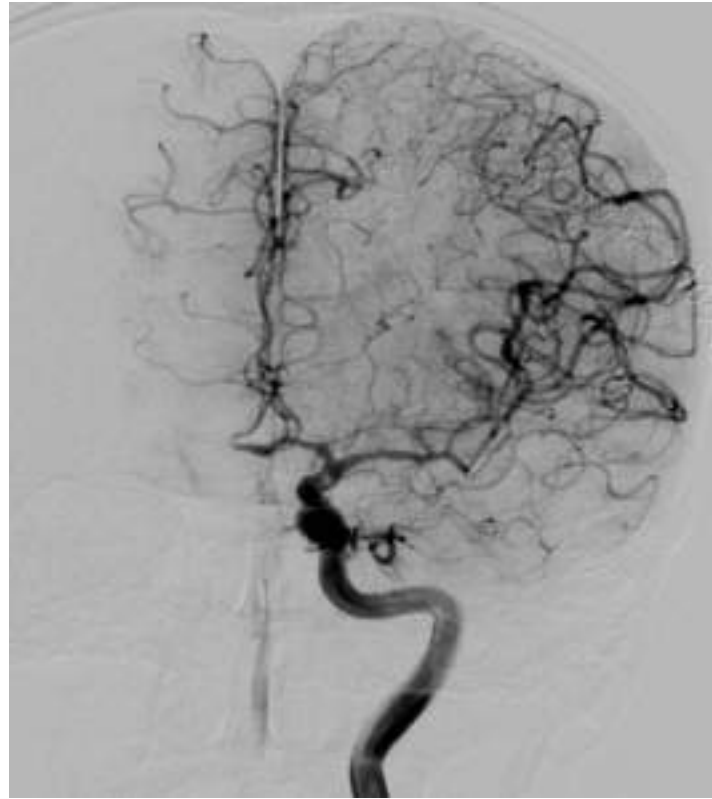
Selective clipping, pre-op DSA

58 years old male patient

Ruptured Acom aneurysm (WFNS I, HH1, BNI 5, Fisher III)



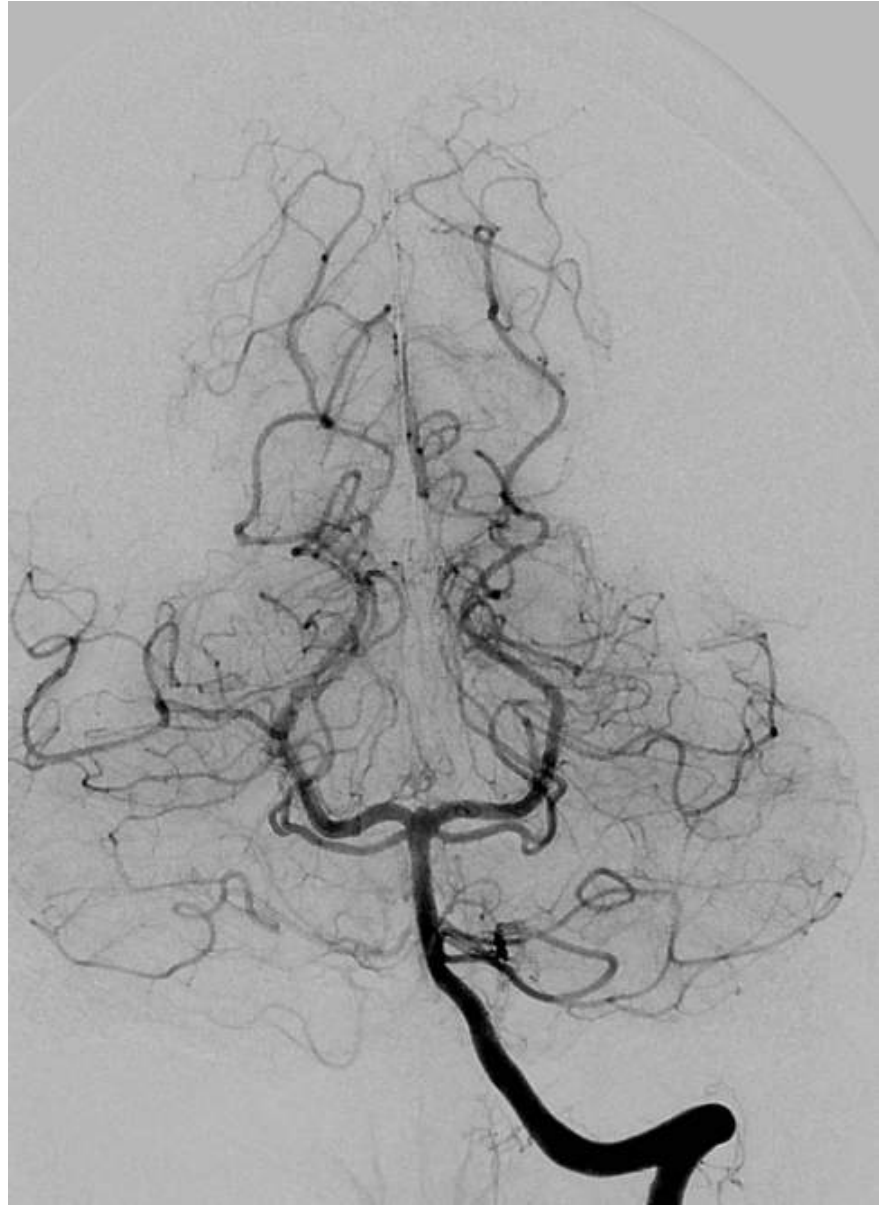
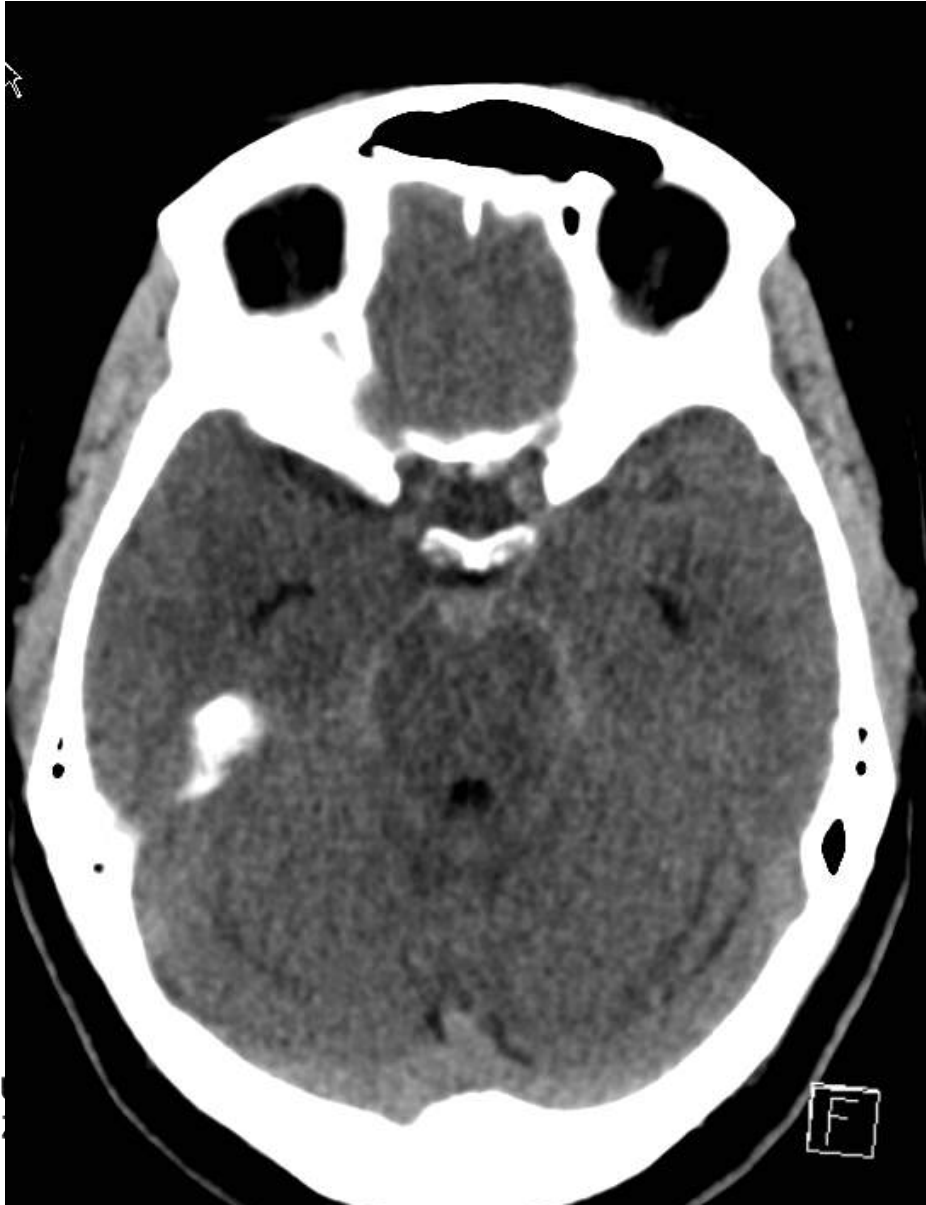


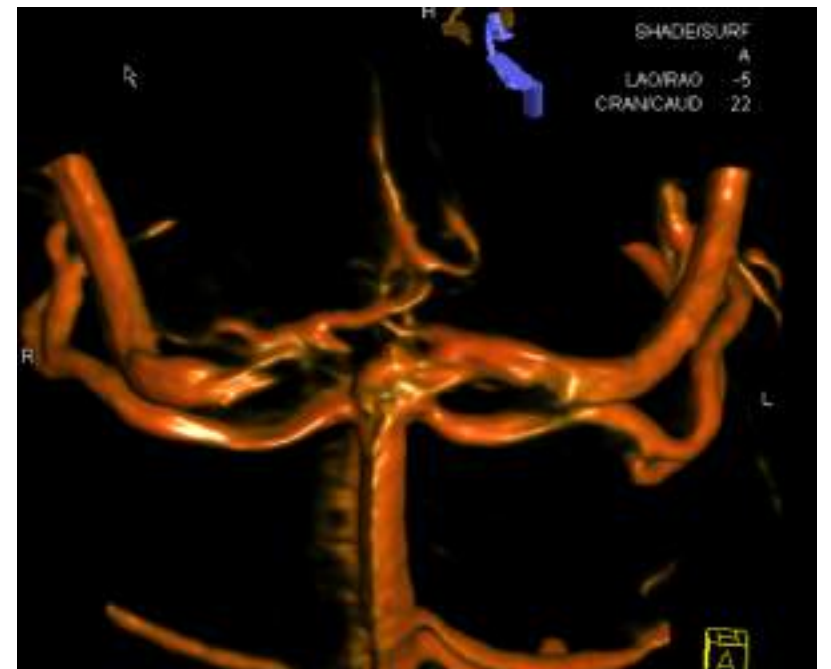
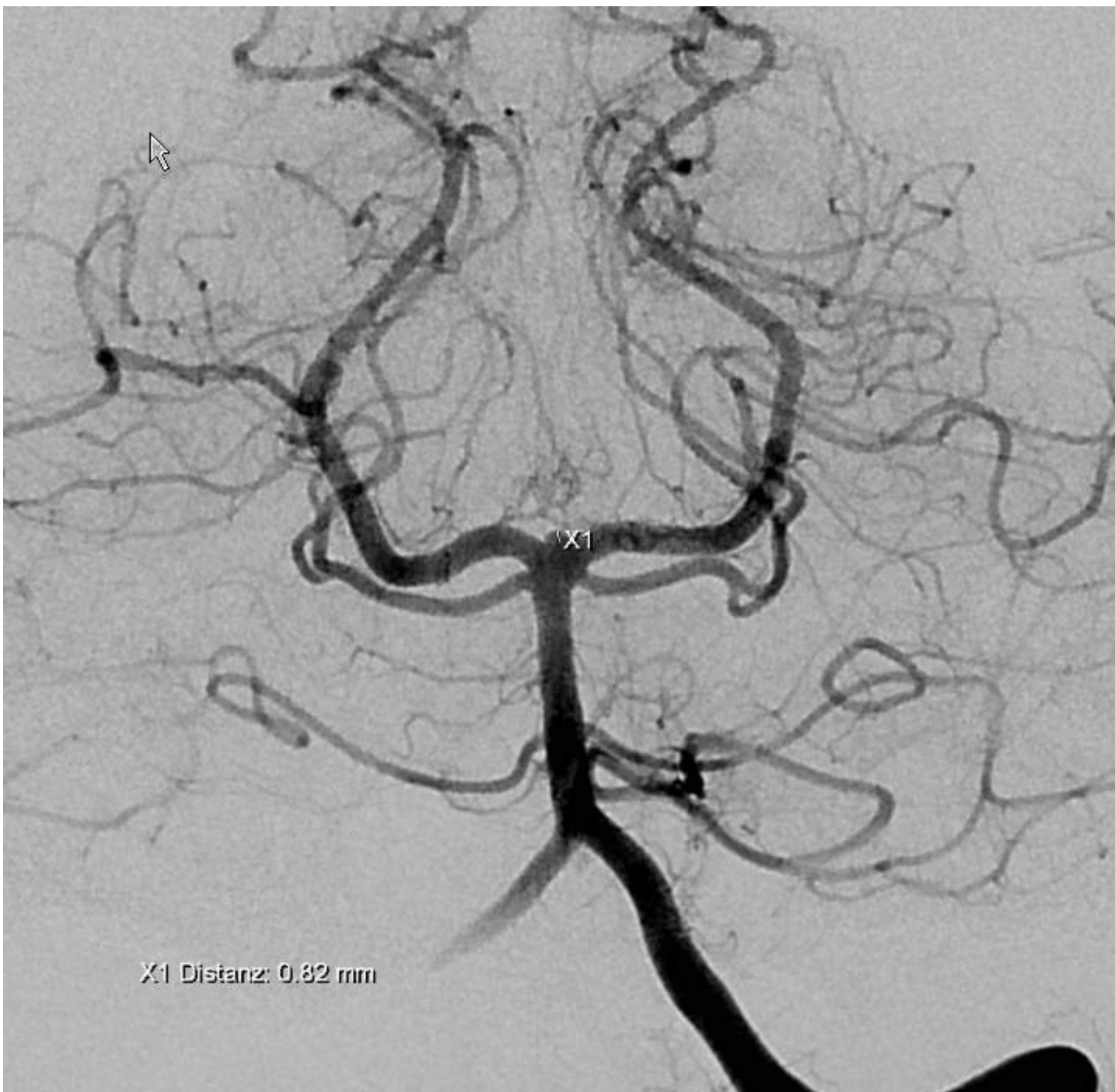


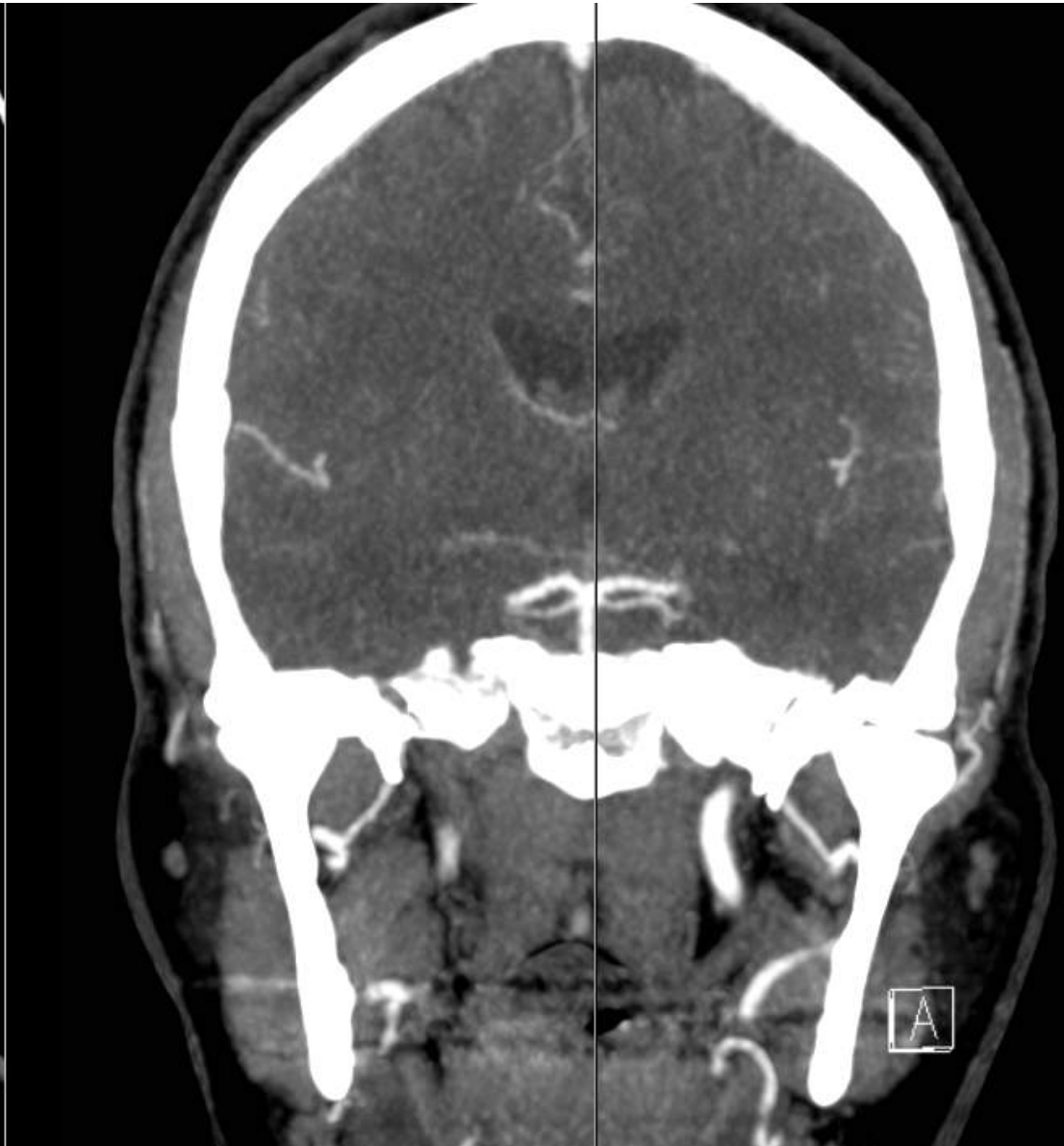
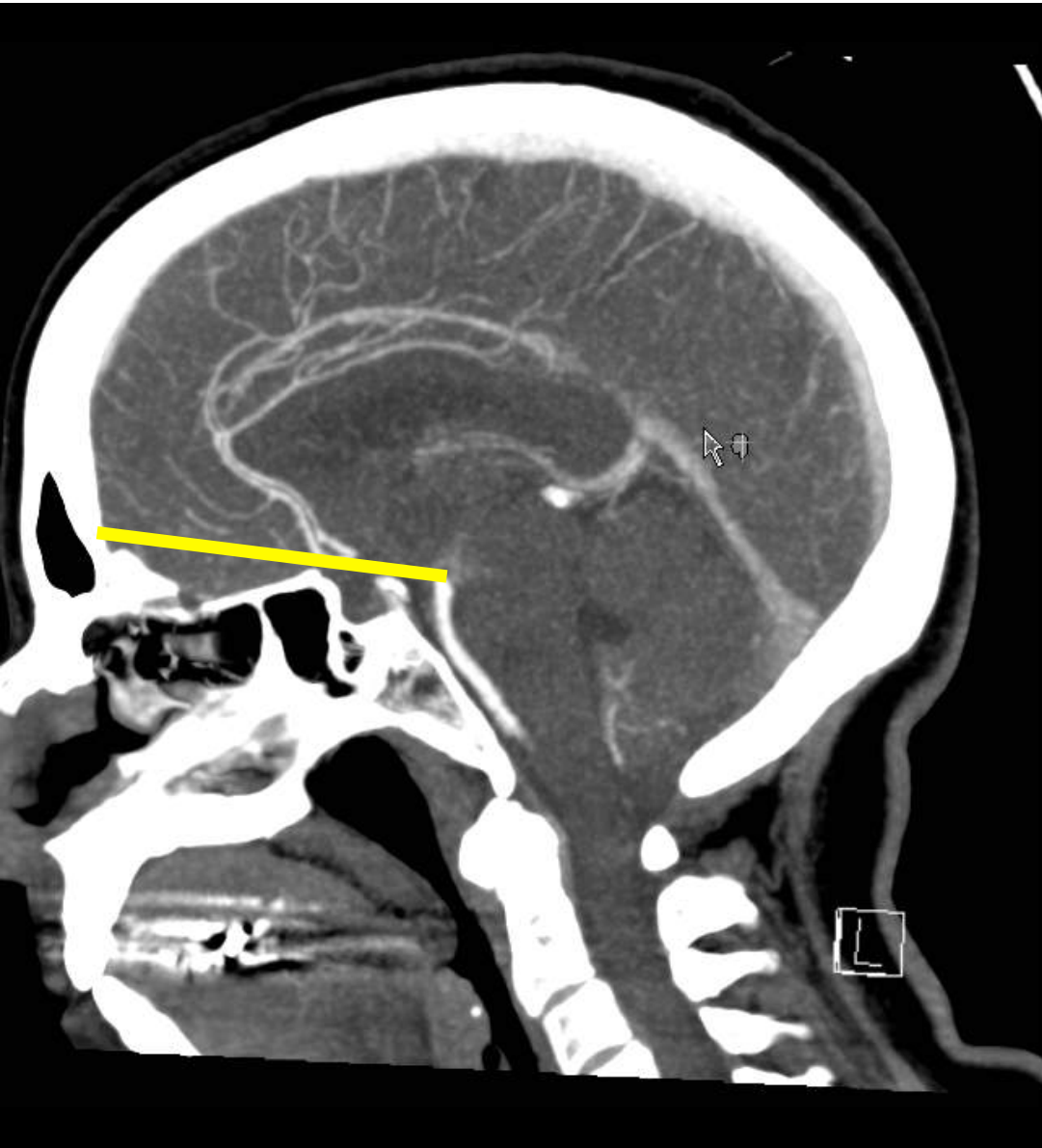
56 years old female patient

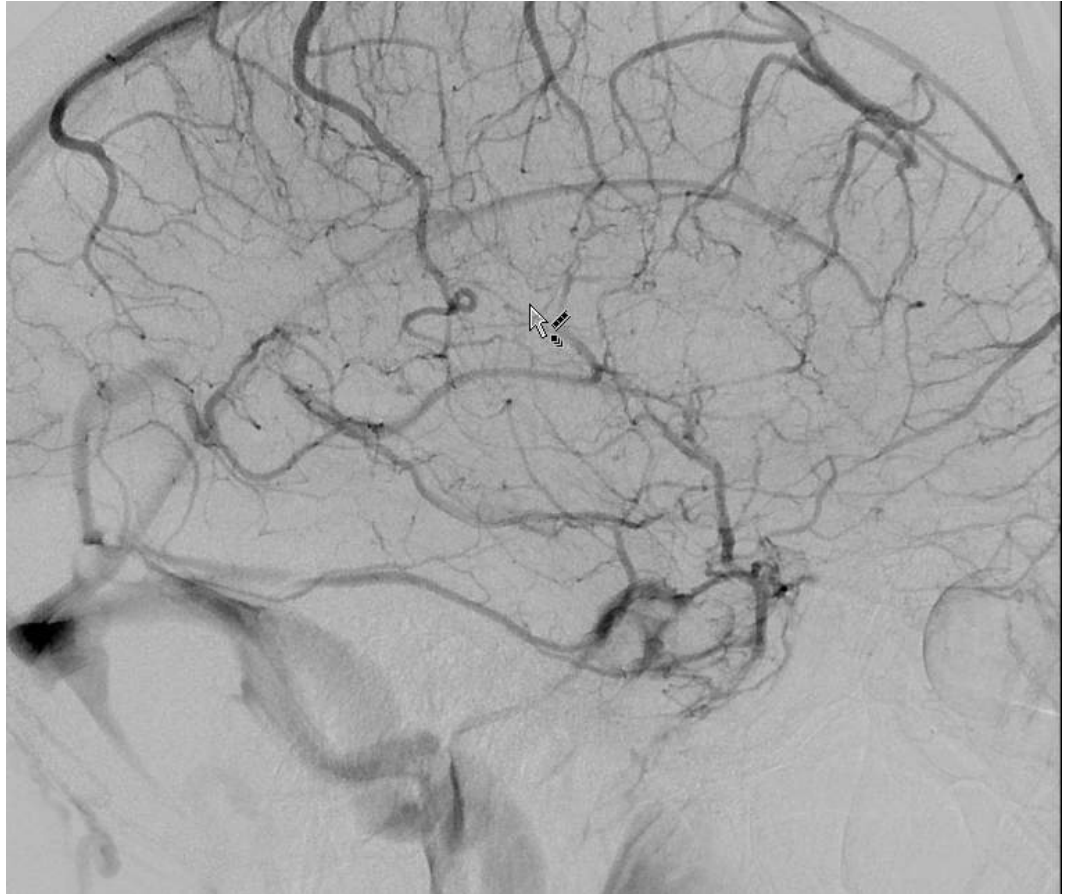
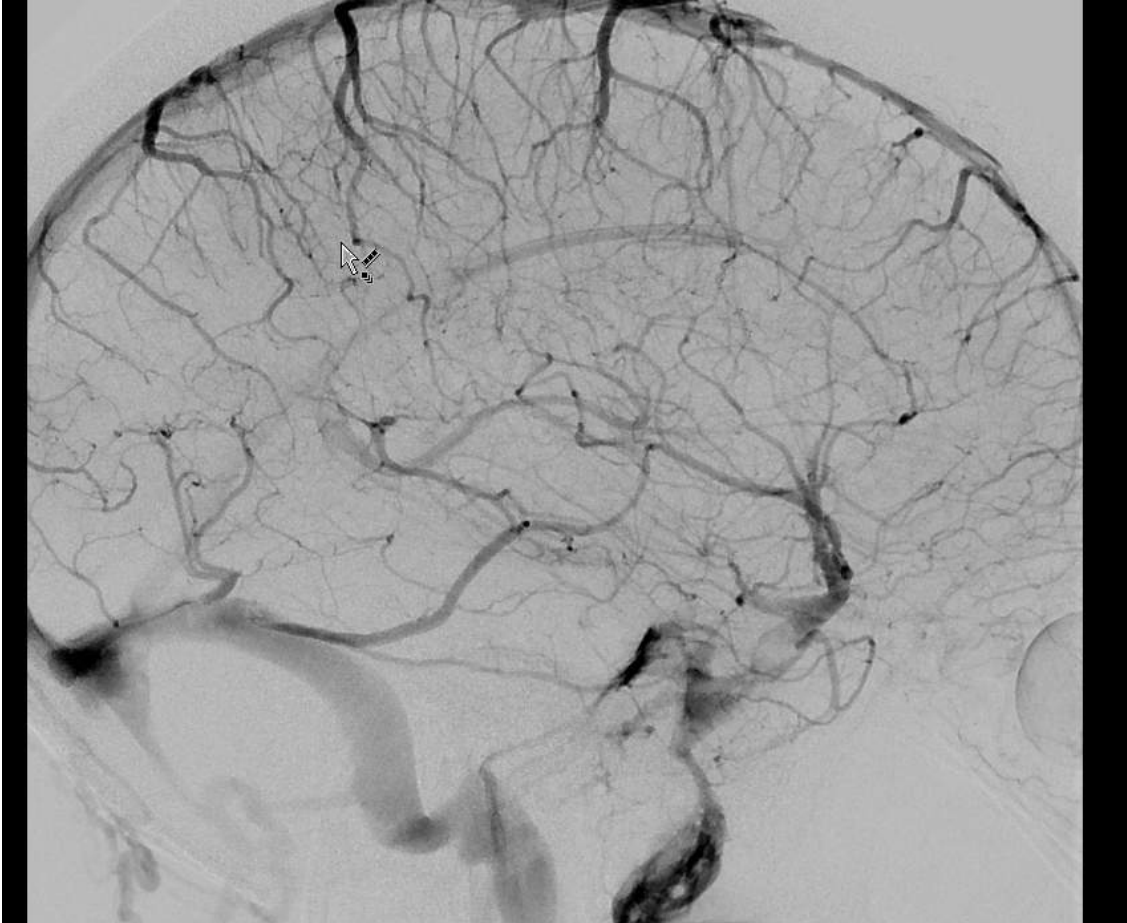
Suspect of ruptured basilar tip microaneurysms VS. Spontaneous perimesencephalic SAB (WFNS I, HH1, Fisher IV)



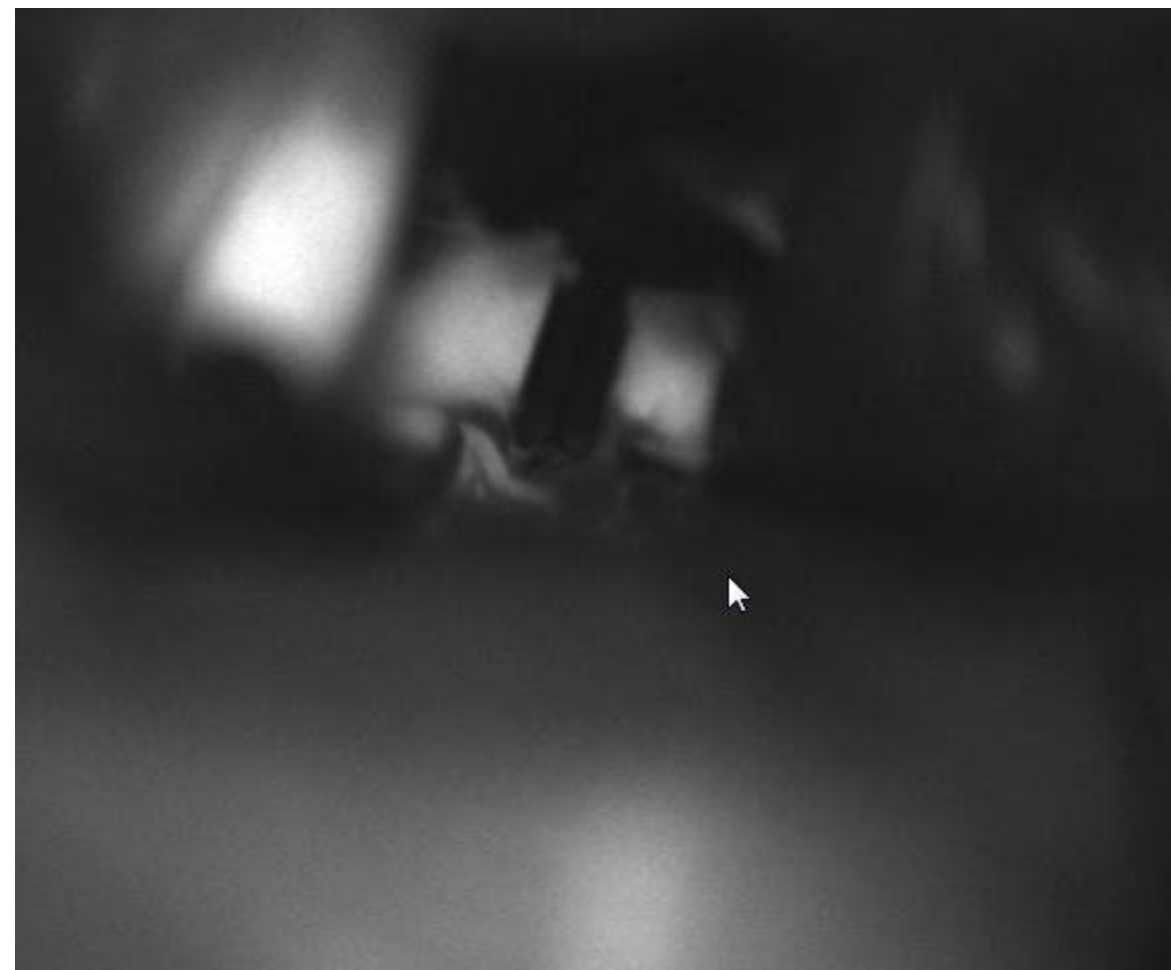


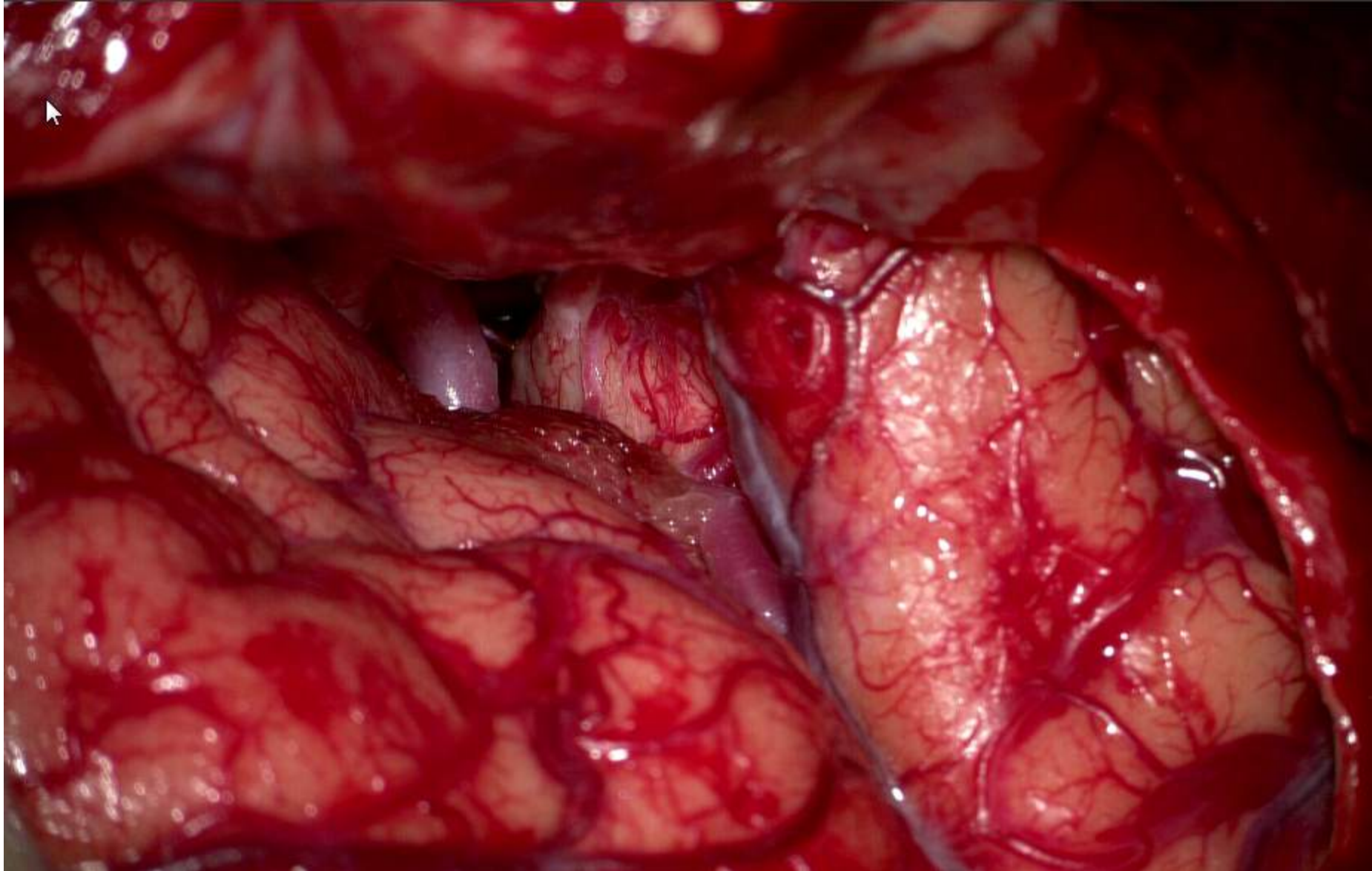






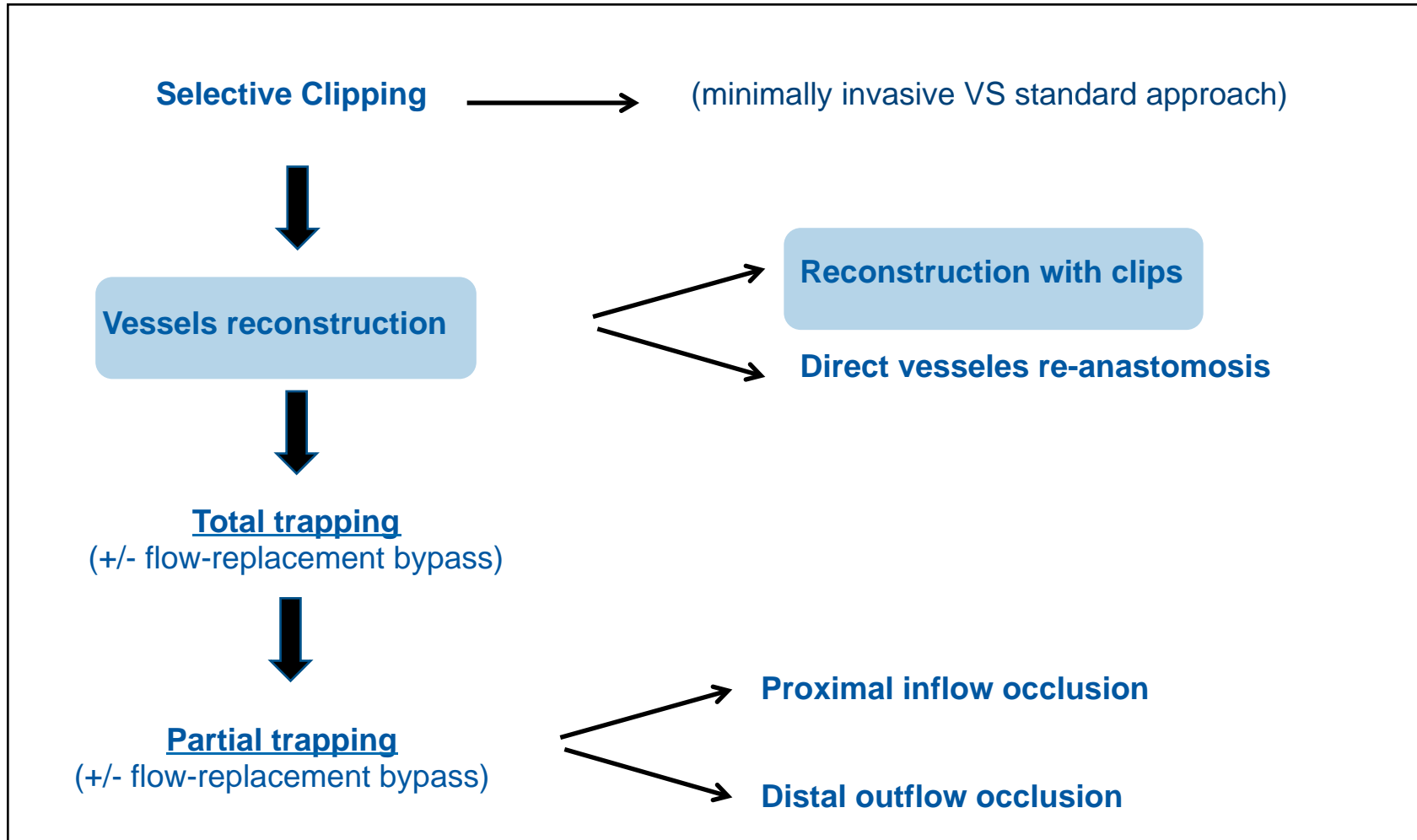








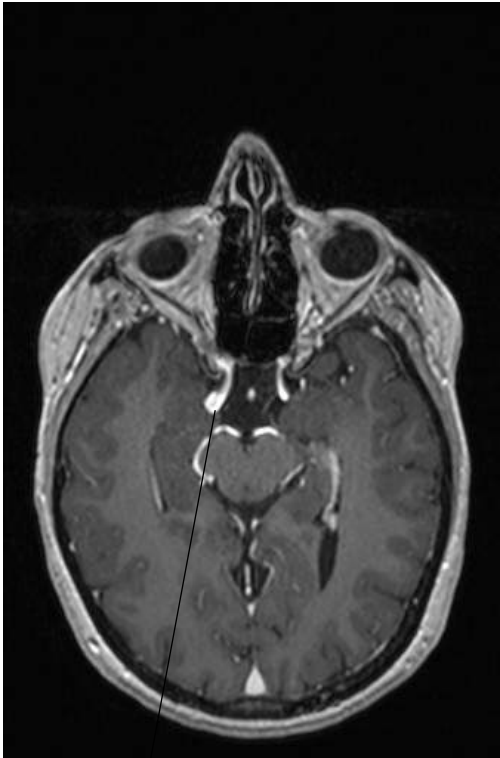
SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS



Clinical presentation - preoperative

- Intermittend, pulsating headache (VAS 8/10), 3-4 times per week
 - Migraine
 - Tension-headache
- Photophobia, phonophobia
- Nausea and vomiting

Neuroradiological findings – preoperative Angio

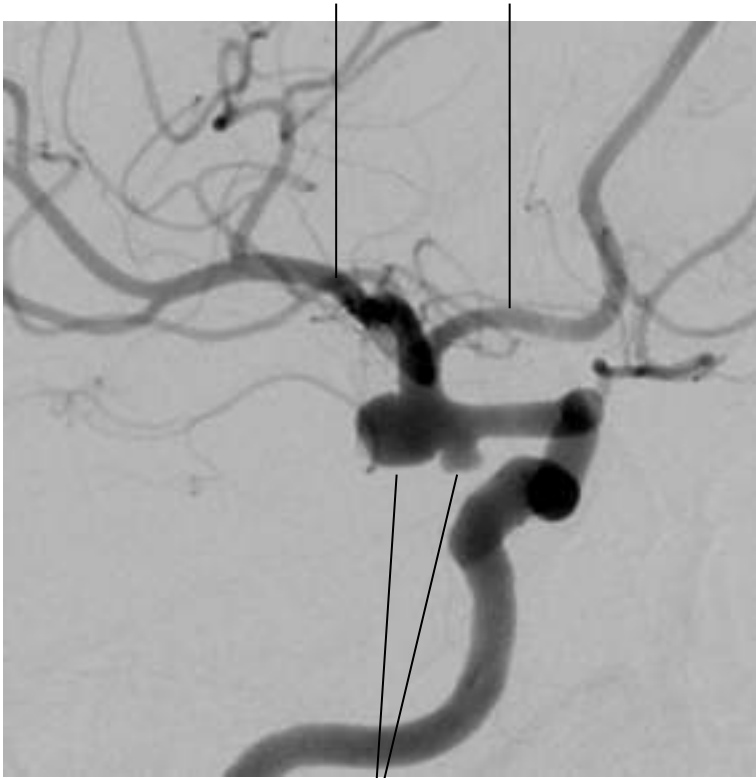


ICA aneurysms right side

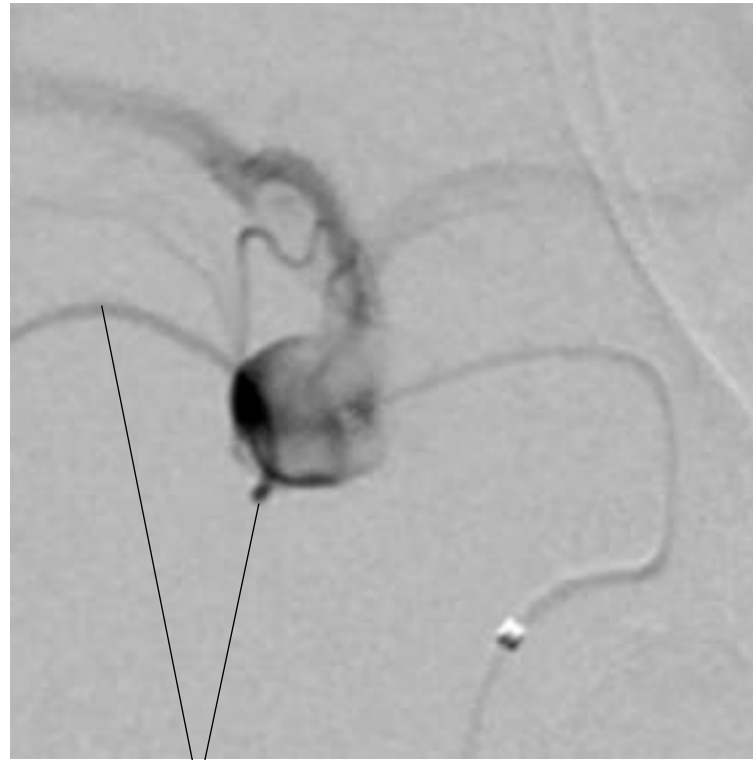


ICA aneurysms right side

Neuroradiological findings – preoperative Angio

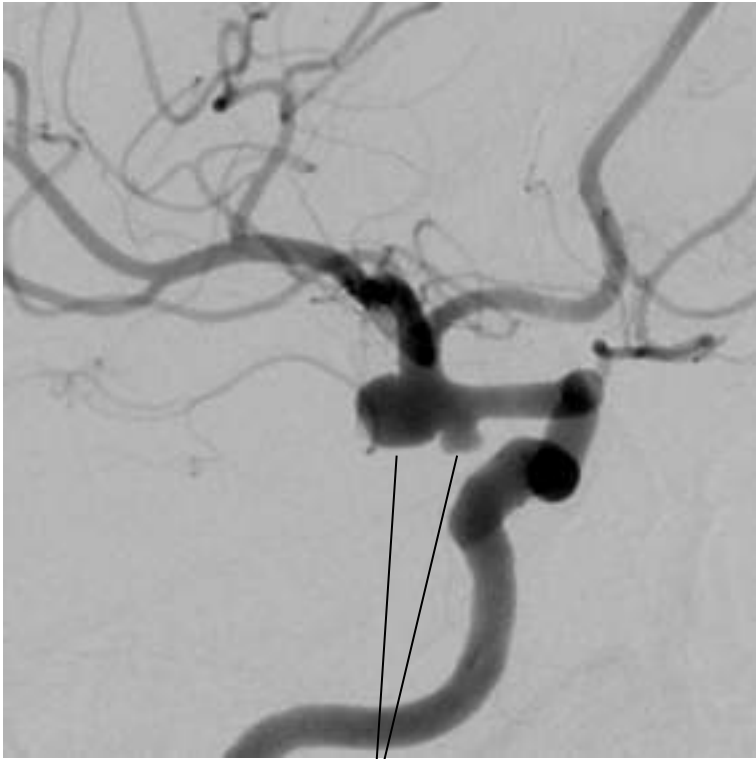


ICA aneurysms



Anterior Choroideal Artery

Neuroradiological findings – preoperative Angio

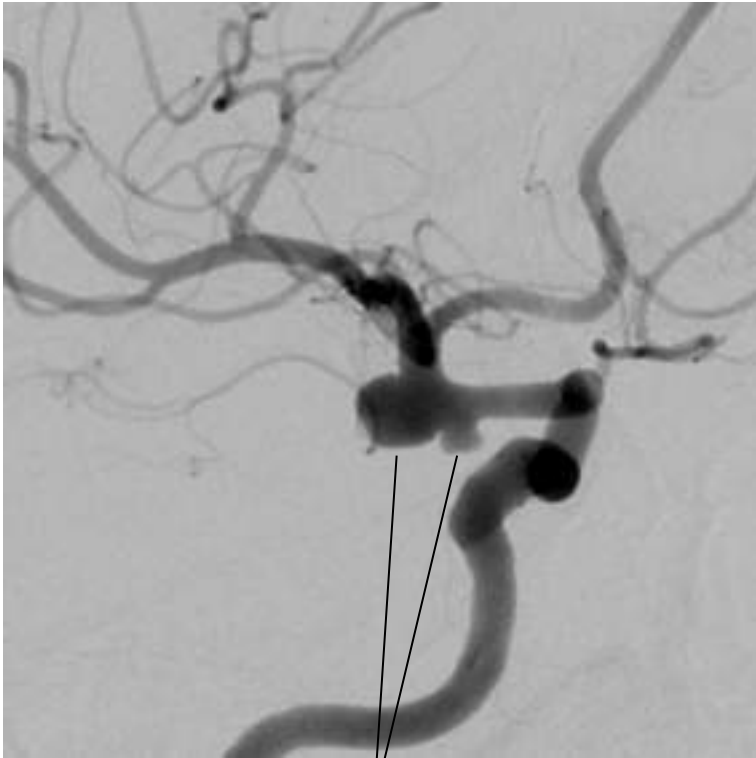


ICA aneurysms



Anterior Choroideal Artery

Neuroradiological findings – preoperative Angio



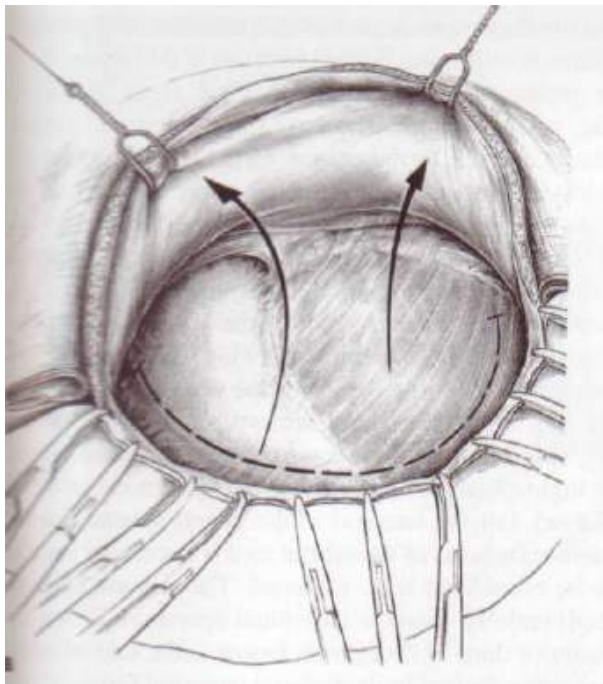
ICA aneurysms



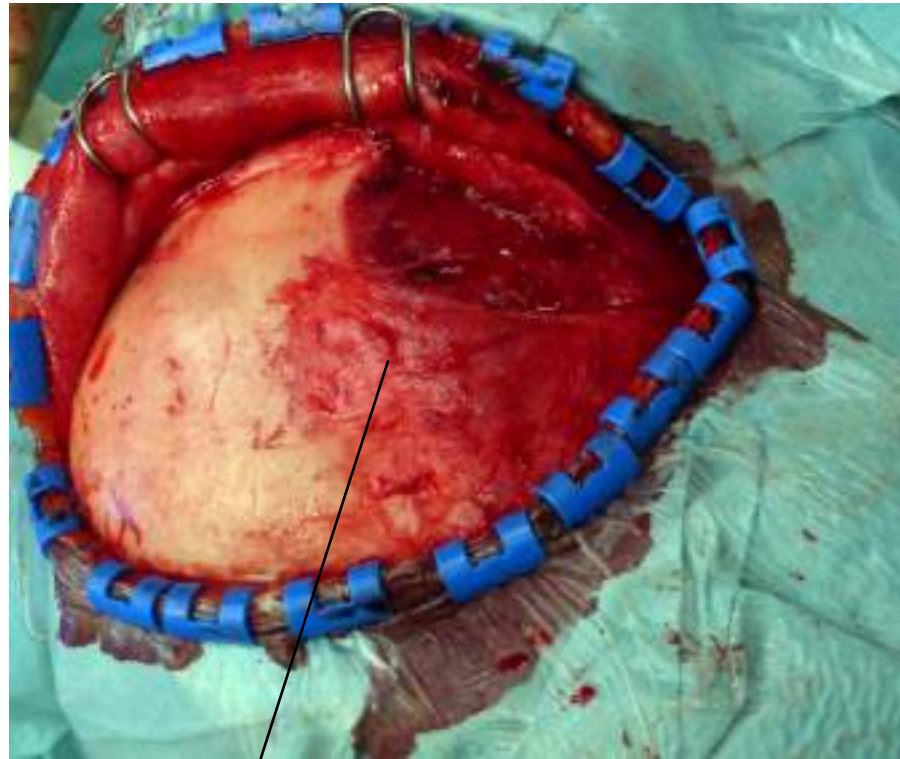
Anterior Choroideal Artery

Surgery - positioning

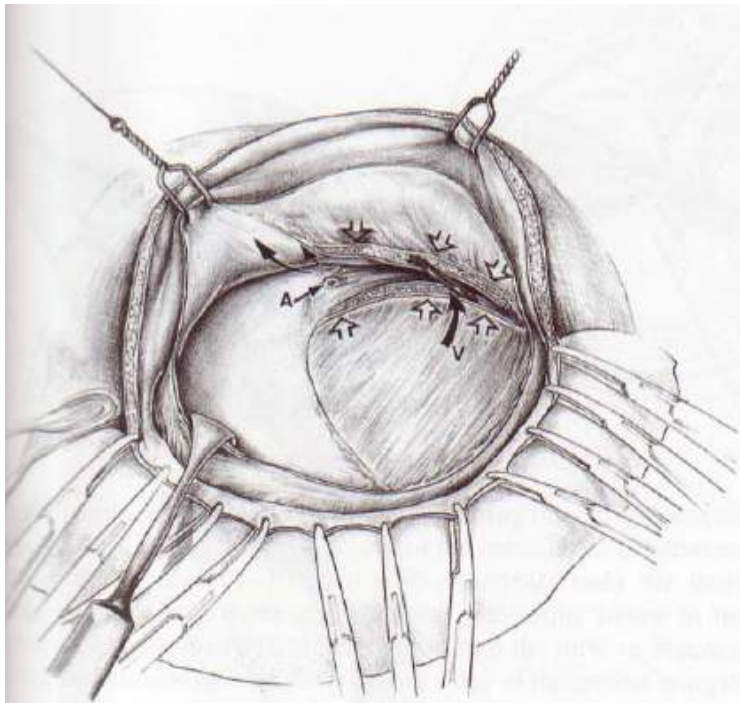


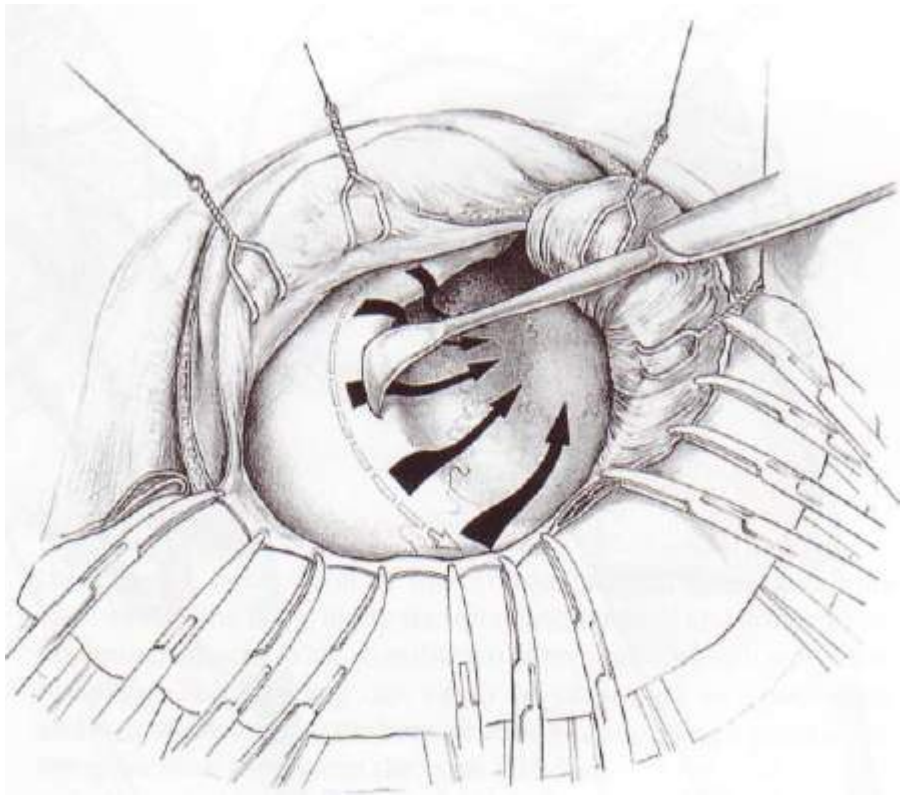


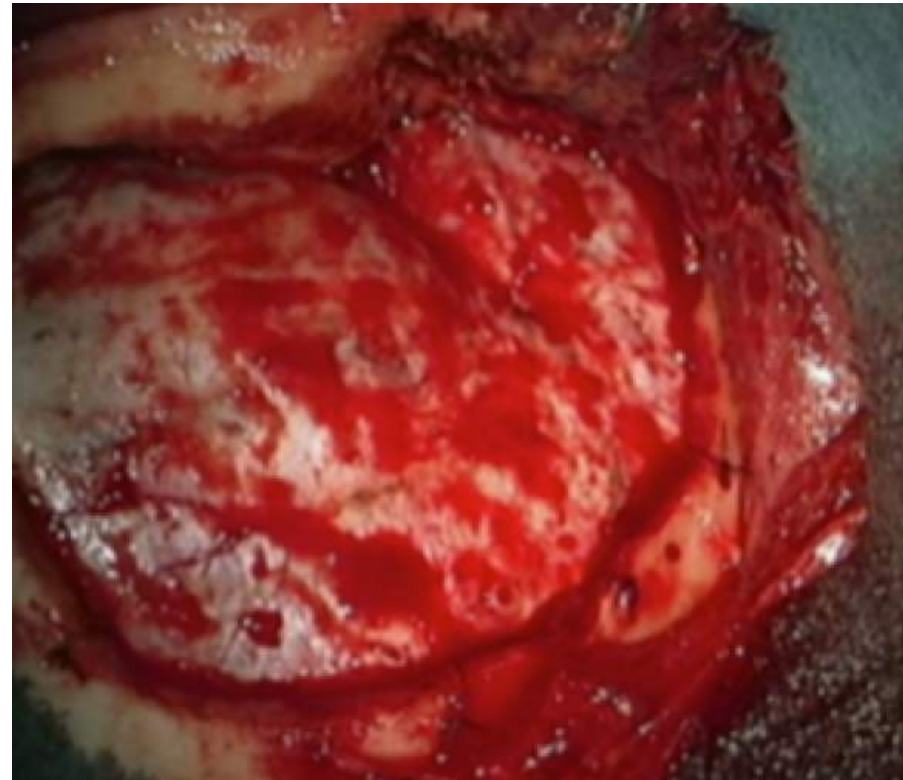
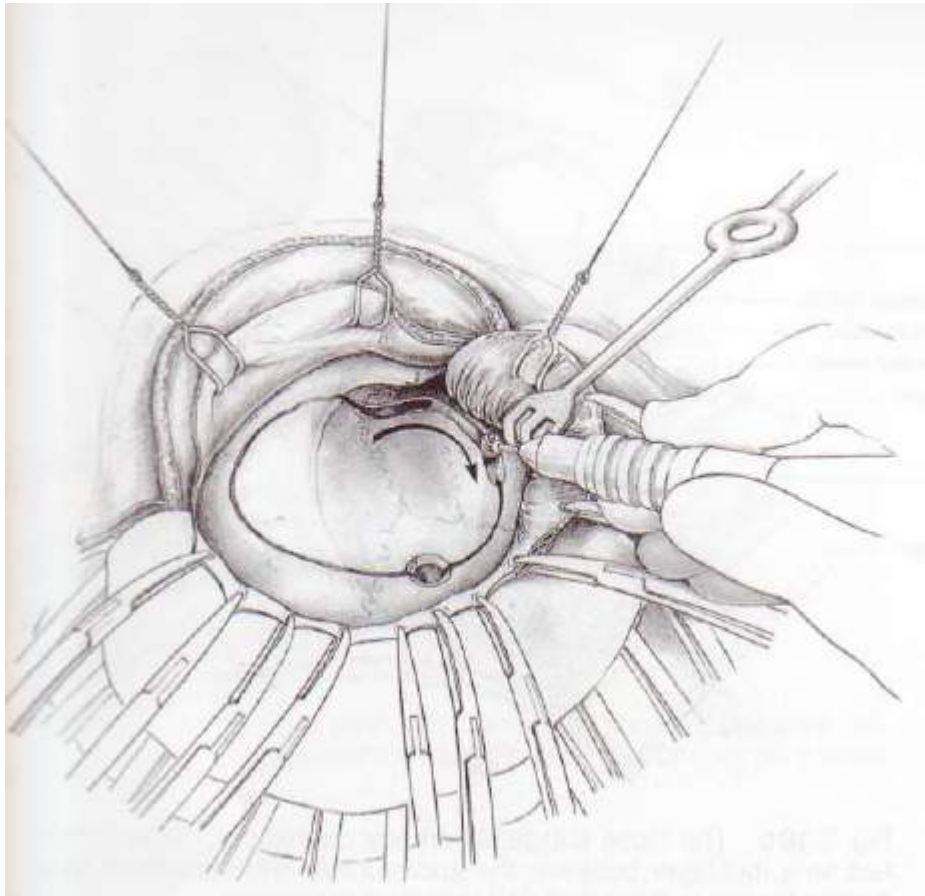
Skin flap

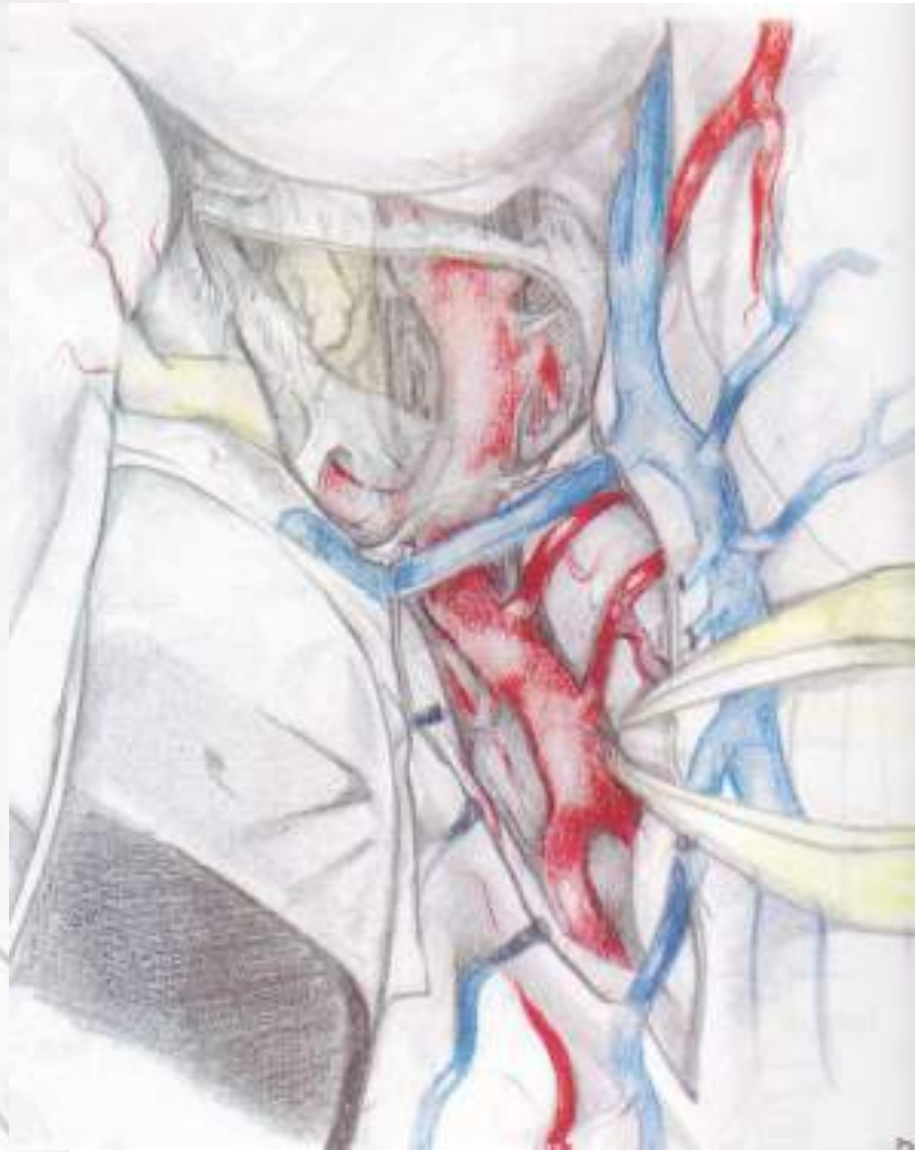
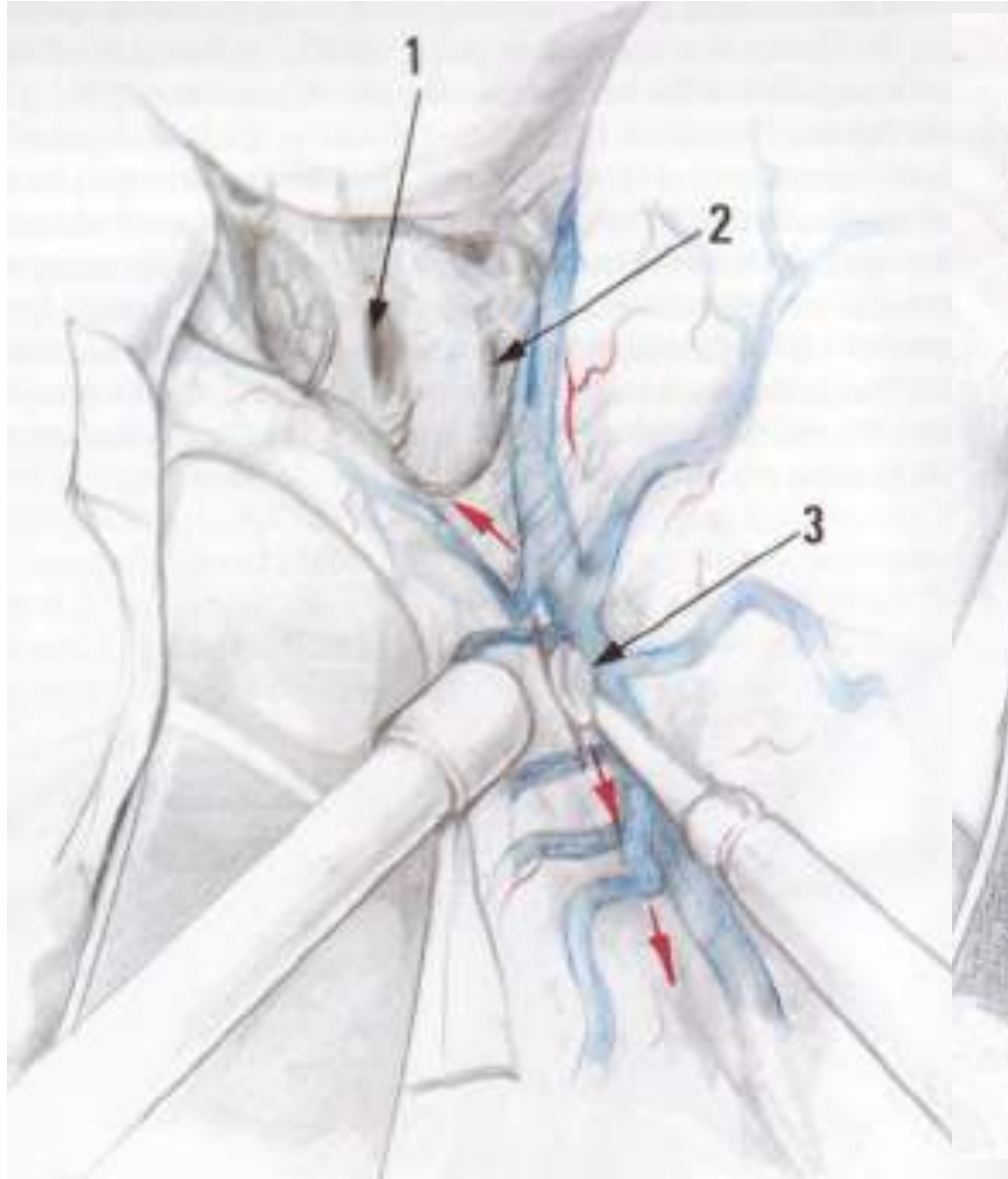


Superior temporal line



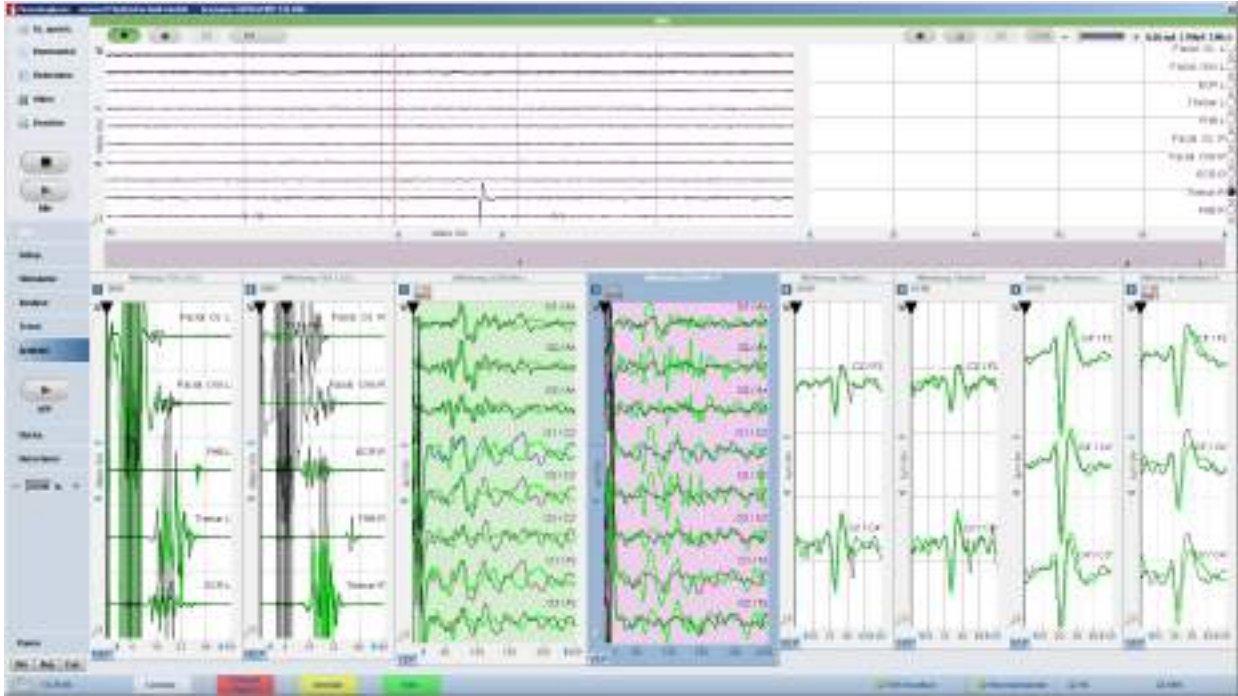








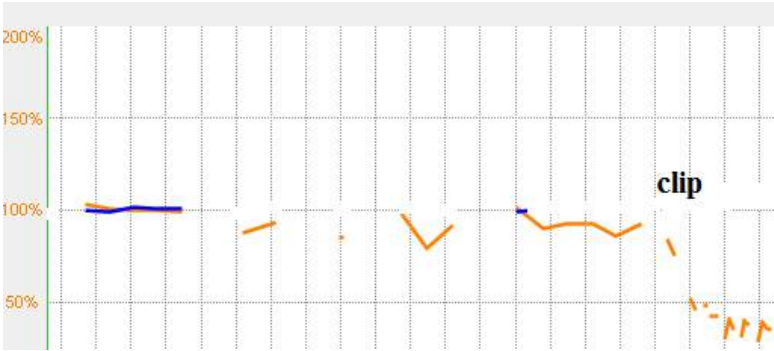
Surgery – intraoperative
neuromonitoring → in all UIAs



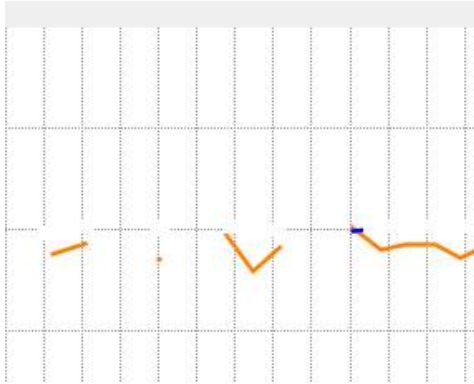
Surgery – intraoperative neuromonitoring → in all UIAs



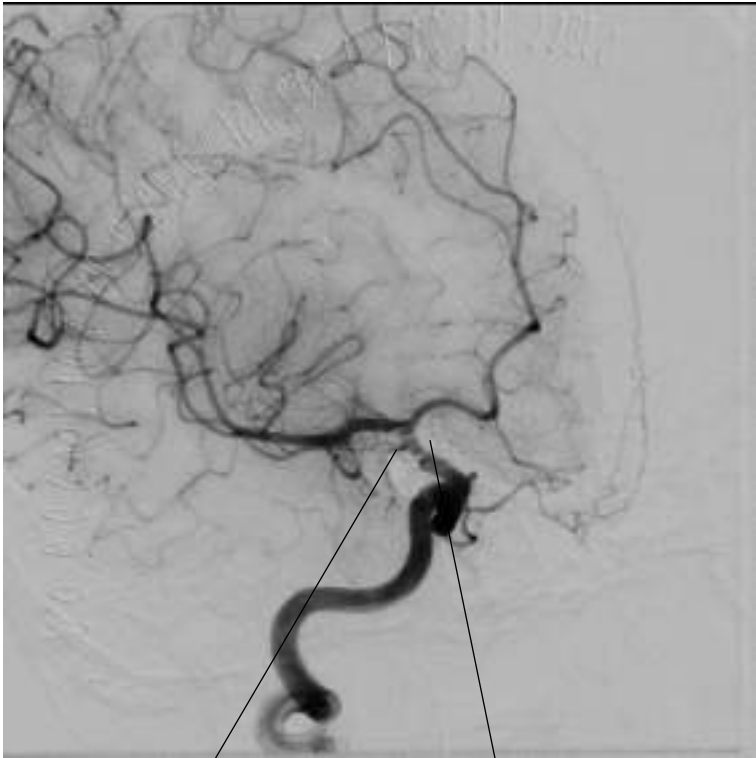
If neuromonitoring is not stable (did not happen in this case)



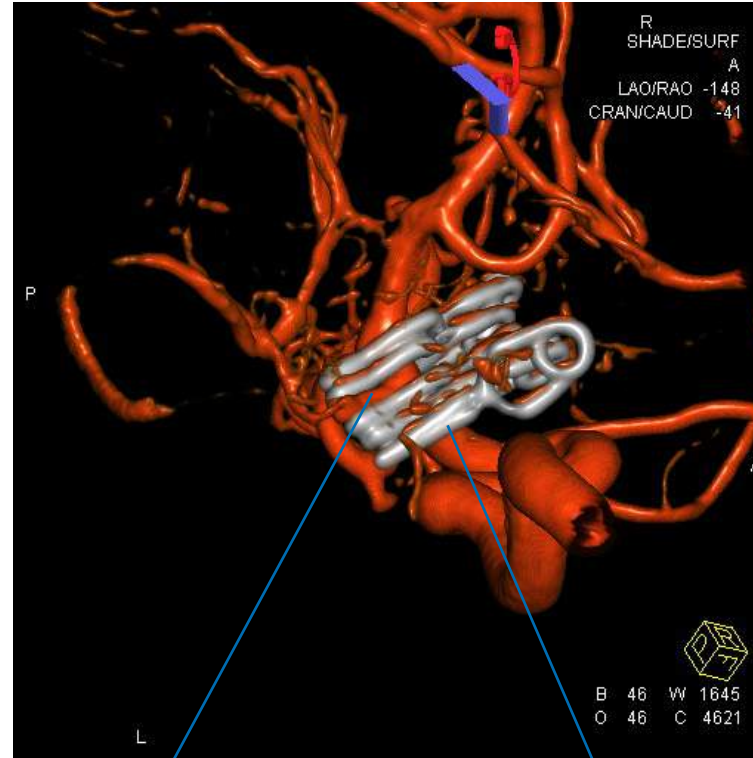
Repositioning of the clip



Neuroradiological findings – postoperative Angio



Anterior Choroidal Artery Fenestrated and straight clips



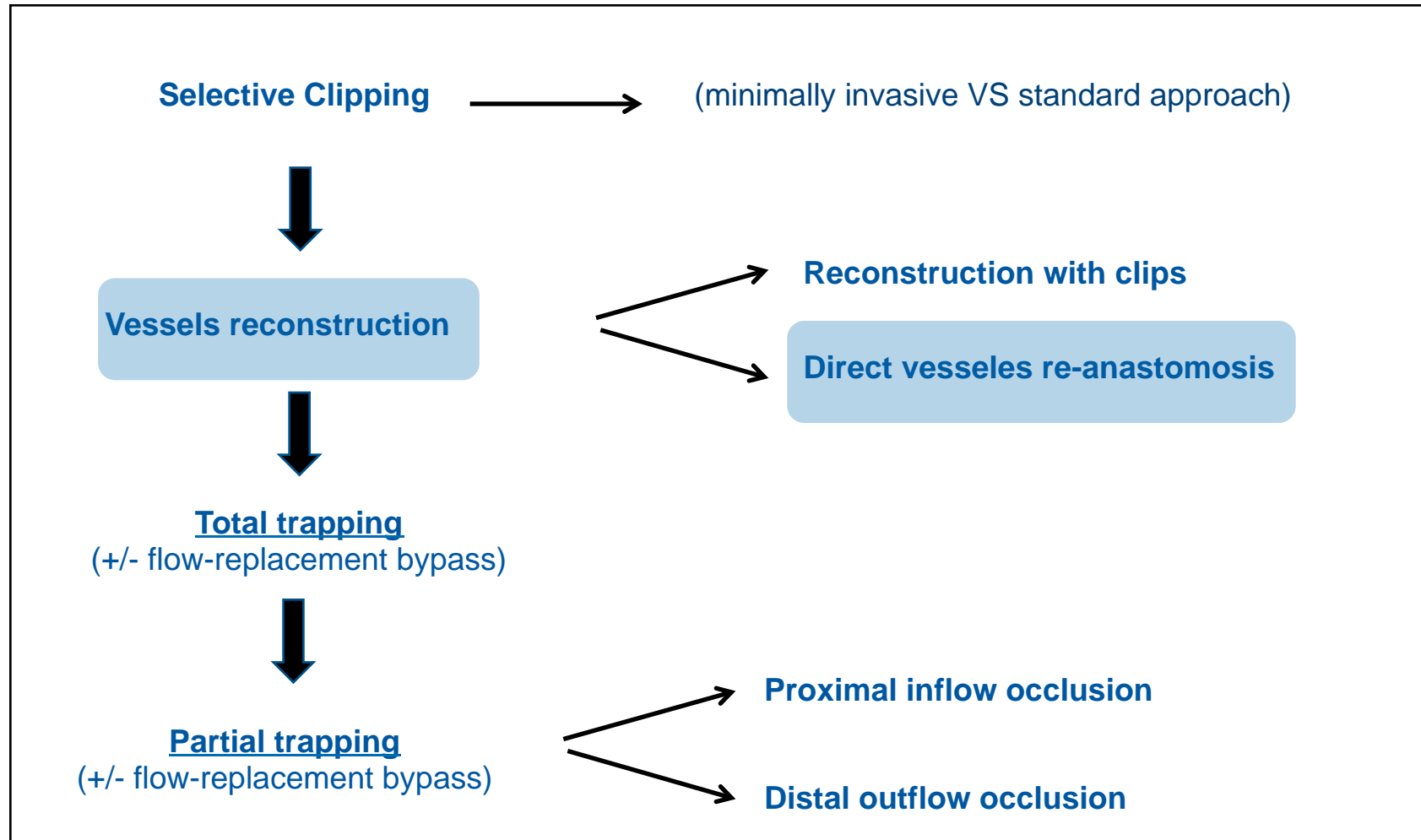
Remodelled Ant.chor. A and ICA with 4 fenestrated clips

Straight clip for 2nd aneurysm

Clinical presentation - postoperative

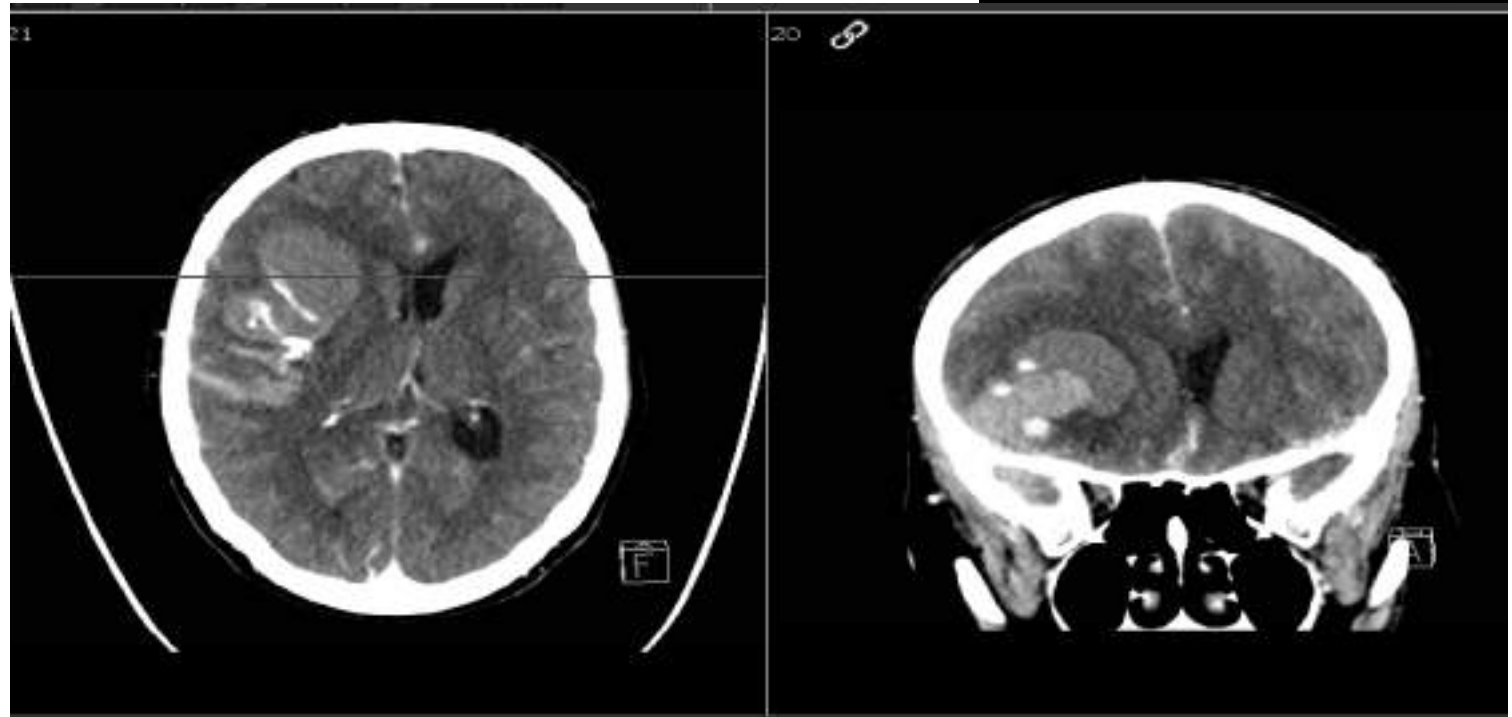
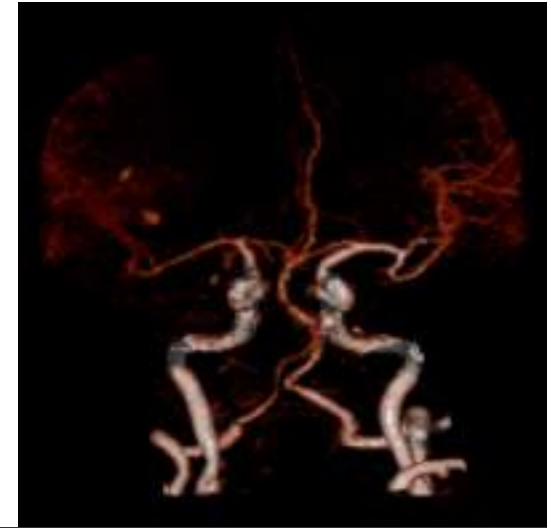
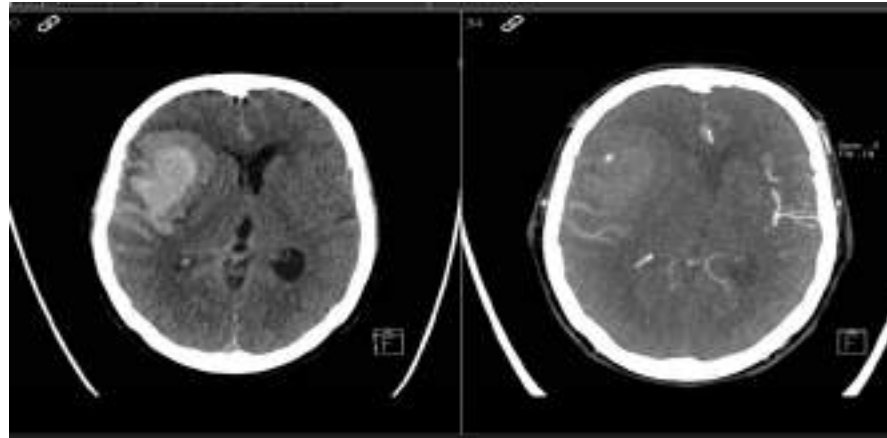
- No new focal neurological deficits
- Uneventful postoperative course, discharge on postoperative day six

SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS



CASE 6 (in emergency)
Direct vessel re-anastomosis, no DSA

F, 70 y - SAH (WFNS 3, HH3): GCS 14



Treatment planning (Plan A):

- DSA
- thereafter hematoma removal with eventual treatment of source of the bleeding

Clinical deterioration:

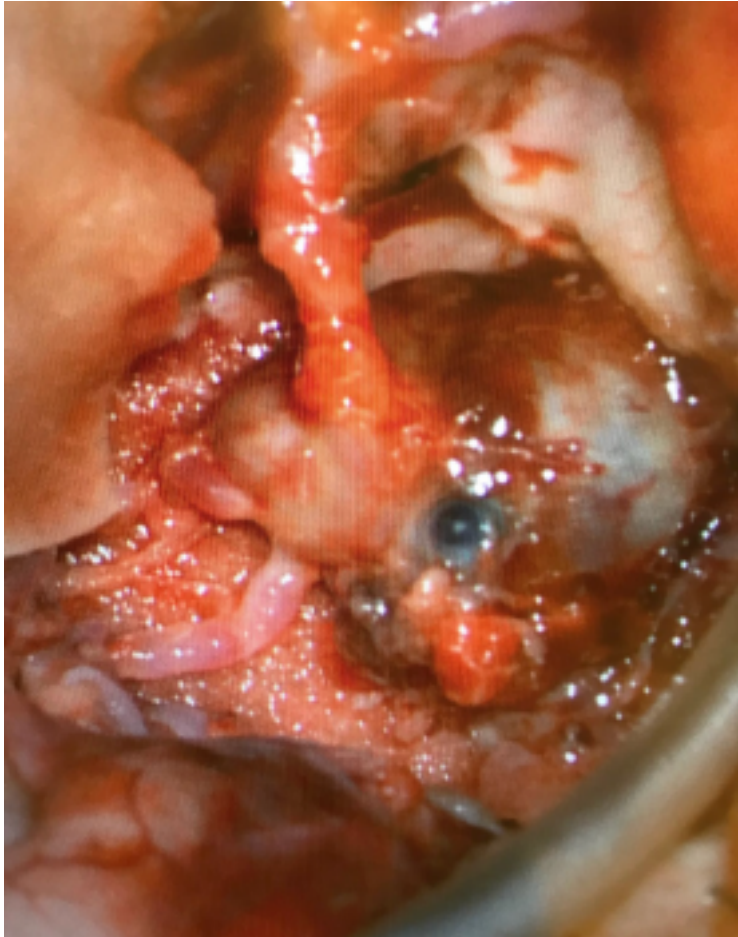
- GCS 14 → GCS 4 (anysocoric onm the right side)

Plan B → Therefore directly in the operative room (risky but doable)



Opening the fissure, removal of the hematoma → intra-op finding

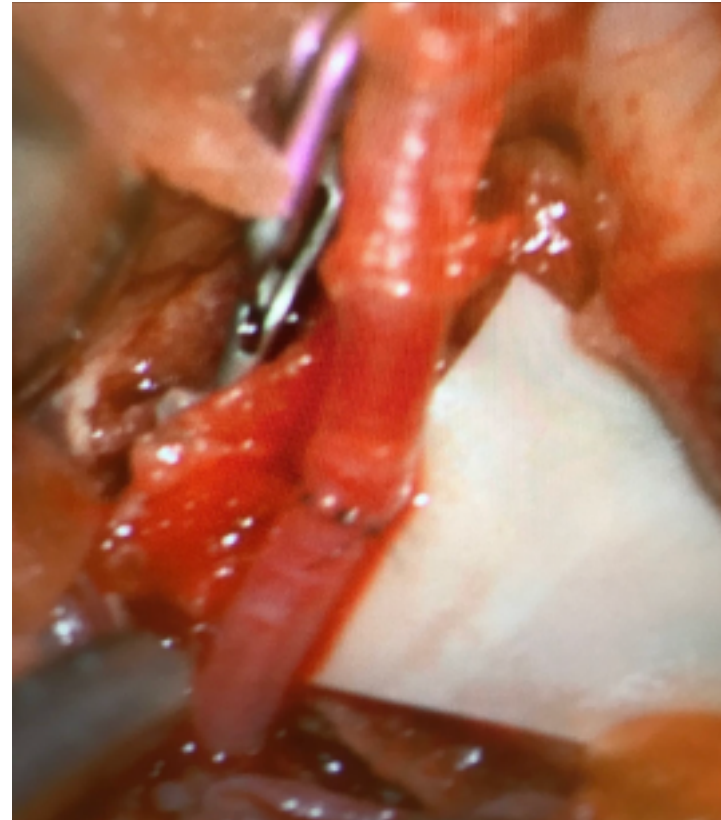
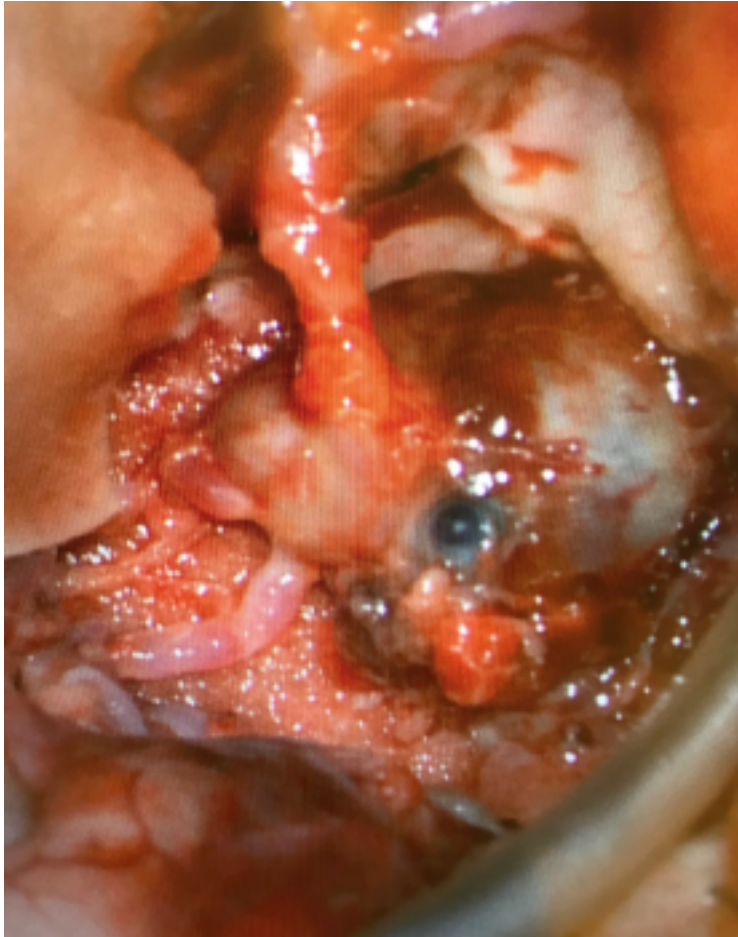




Opening the fissure, removal of the hematoma → intra-op finding

TREATMENT: aneurysm excision + in situ bypass (end-to-end anastomosis), IC-IC, MCA-MCA
- simple, occlusion time 14 minutes

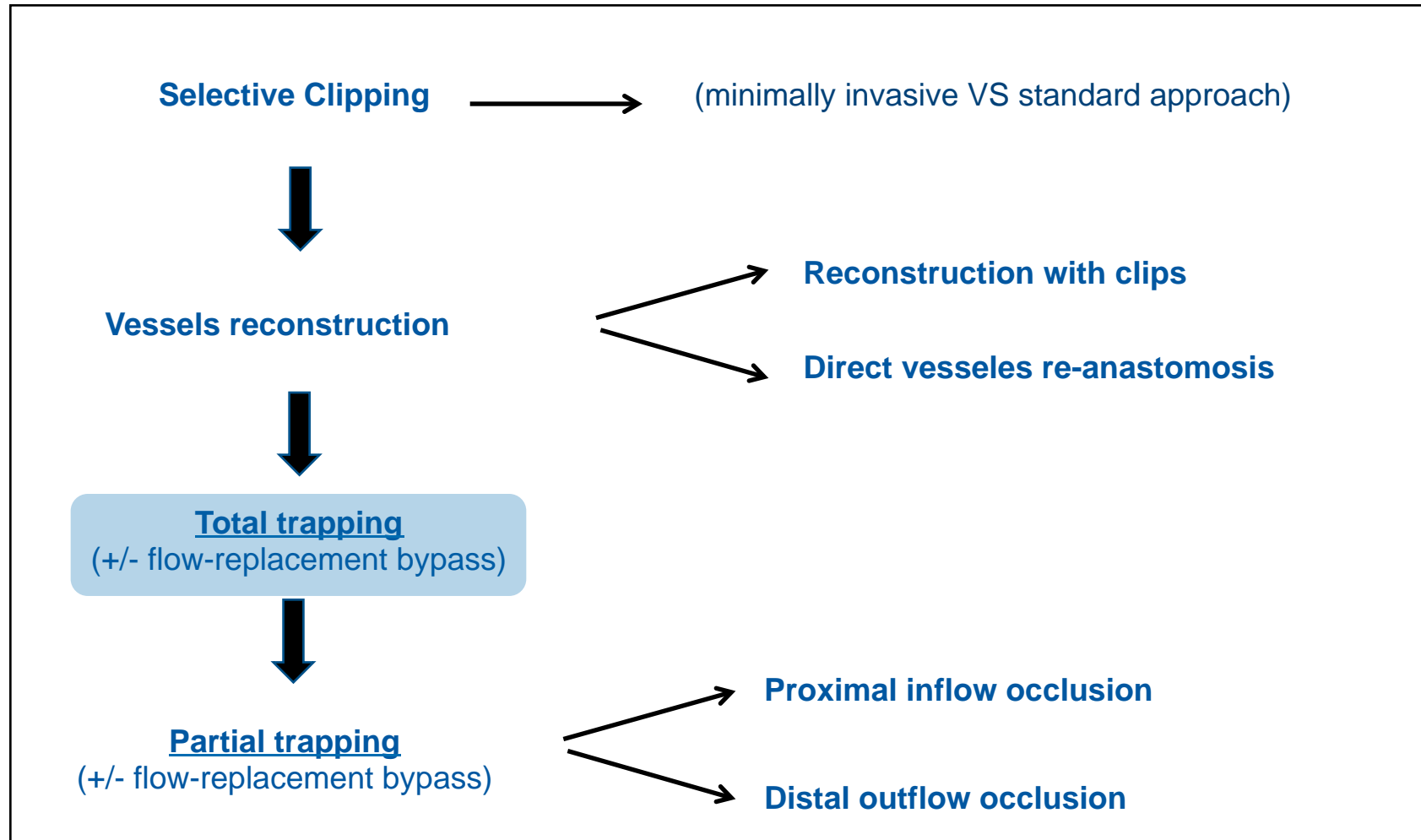
Bypass was initially not contemplated → bypass in the surgical armamentarium simplifies the intra-op management



TREATMENT: aneurysm excision + in situ bypass (end-to-end)
- simple, occlusion time 14 minutes



SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS



Management of a aneurysm:

- Aneurysm exclusion
- Flow-preservation

When selective clipping/endovascular treatment is not feasible or is considered too risky, one should considerate trapping strategies.



Trapping = sacrifice of a vessel



Contemplate a bypass



Trapping = sacrifice of a vessel

**Do we always need a flow preservation
(replacement) bypass after trapping?**

Need for Bypass?
(MAY DEPEND ON THE COLLATERAL CIRCULATION)

<10%

>90%

NO
(bypass may not be necessary)

- Aneurysm is too proximal:
 - i.e. cavernous ICA (→ **collaterals via circle of Willis**)**
 - i.e. VA: collaterals via contralateral VA
- Aneurysm is too distal: i.e. M4-MCA, telovelotonsillar or cortical dissecting PICA (→ **pial collaterals**)**

** : SAB-ICB situations

YES
(bypass is indicated)

- No adequate collaterals
- Collaterals not predictable → in doubt, it is our belief to bypass

Need for Bypass?
(MAY DEPEND ON THE COLLATERAL CIRCULATION)

<10%

>90%

NO
(bypass may not be necessary)

- Aneurysm is too proximal:
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** : SAB-ICB situations

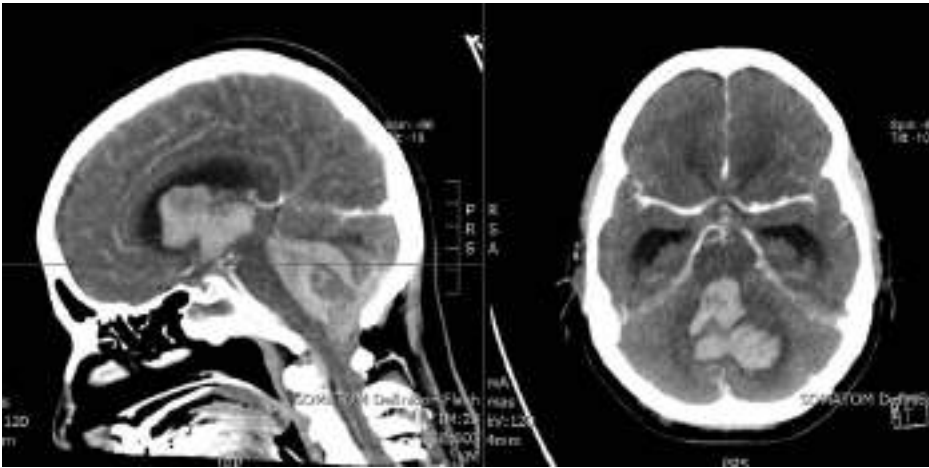
YES
(bypass is indicated)

- No adequate collaterals
- Collaterals not predictable → in doubt, it is our belief to bypass

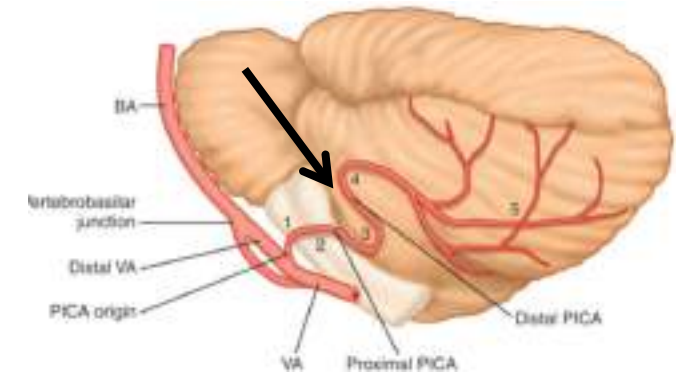
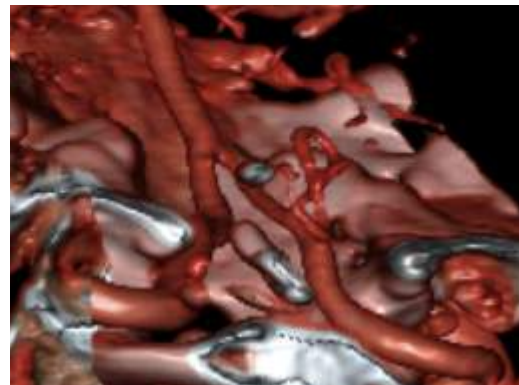
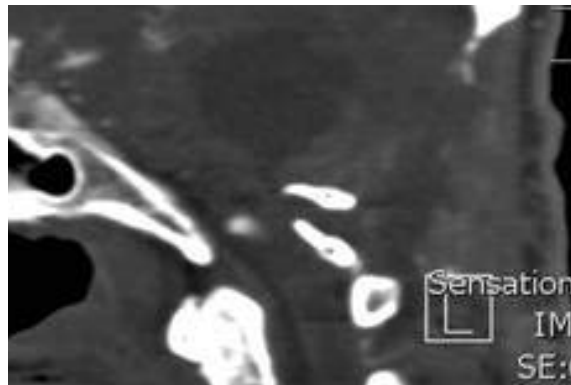
CASE 7 (in emergency)

Total trapping, no DSA, no bypass

F, 70 yo, SAH, IVH, ICB, WFNS 4
Trapping of a ruptured **distal PICA (telovelotonsillar)**
dissecting aneurysm and removal of the cerebellar and
intraventricular (IV) hemorrhage



**No bypass necessary after
total trapping**



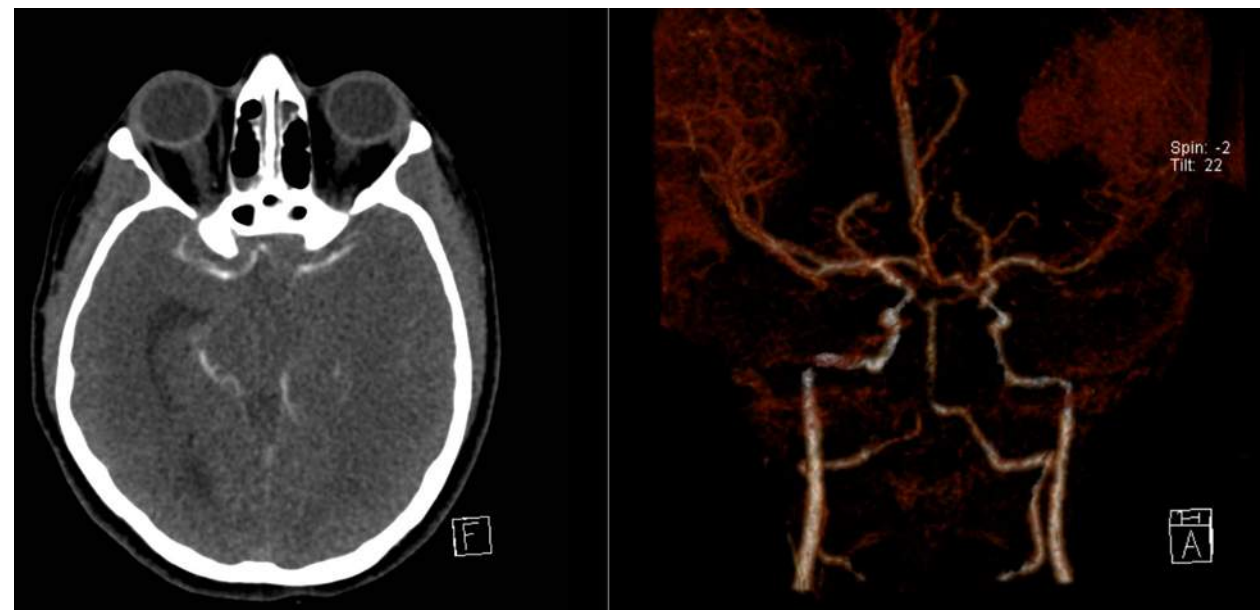
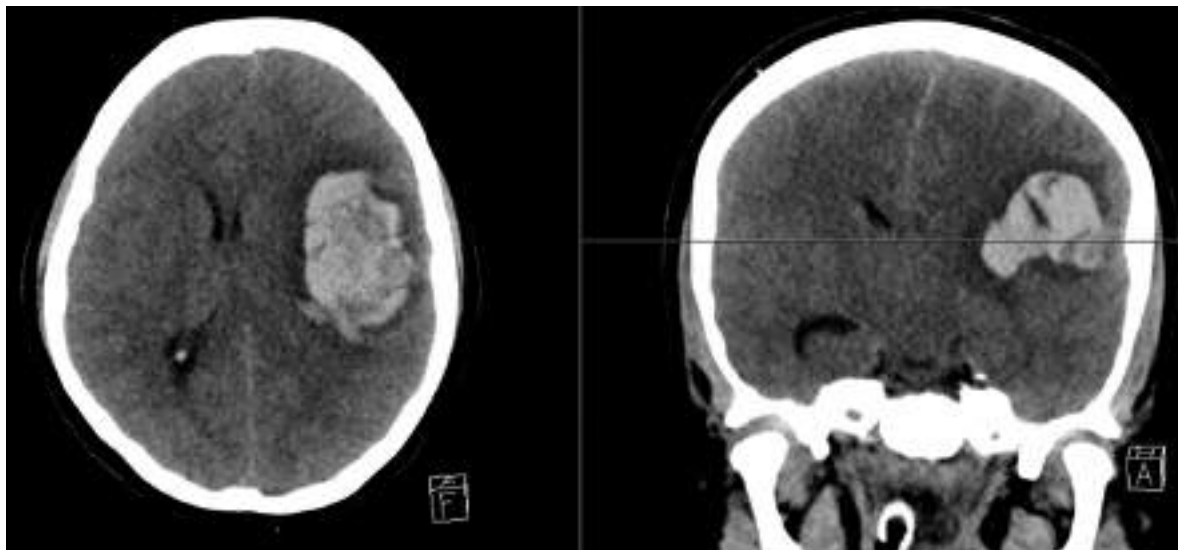
CASE 8 (in emergency)

Total trapping, no DSA, no bypass

34-years old patient with intracerebral hemorrhage frontal left by ruptured distal dissection aneurysm of the left cerebral artery (M3)

Initial Presentation at 08.12.2017

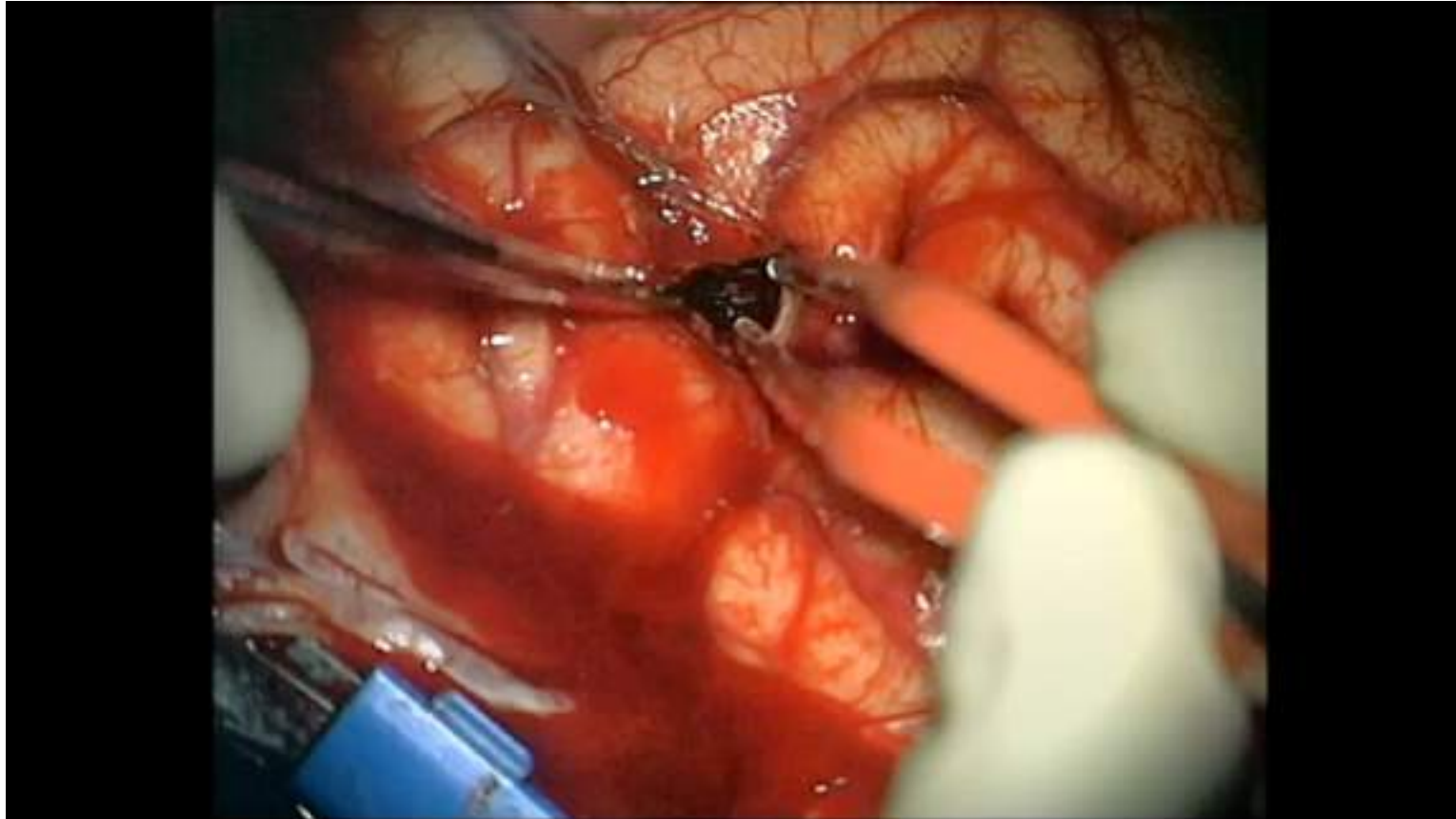
- Loss of consciousness, at arrival of emergency service GCS of 6 with consecutive intubation
- Shock room USZ: GCS 3 (intubated), both pupils 1.5mm
- Emergency CT/CTA:



Emergency left fronto-parieto-temporal craniectomy

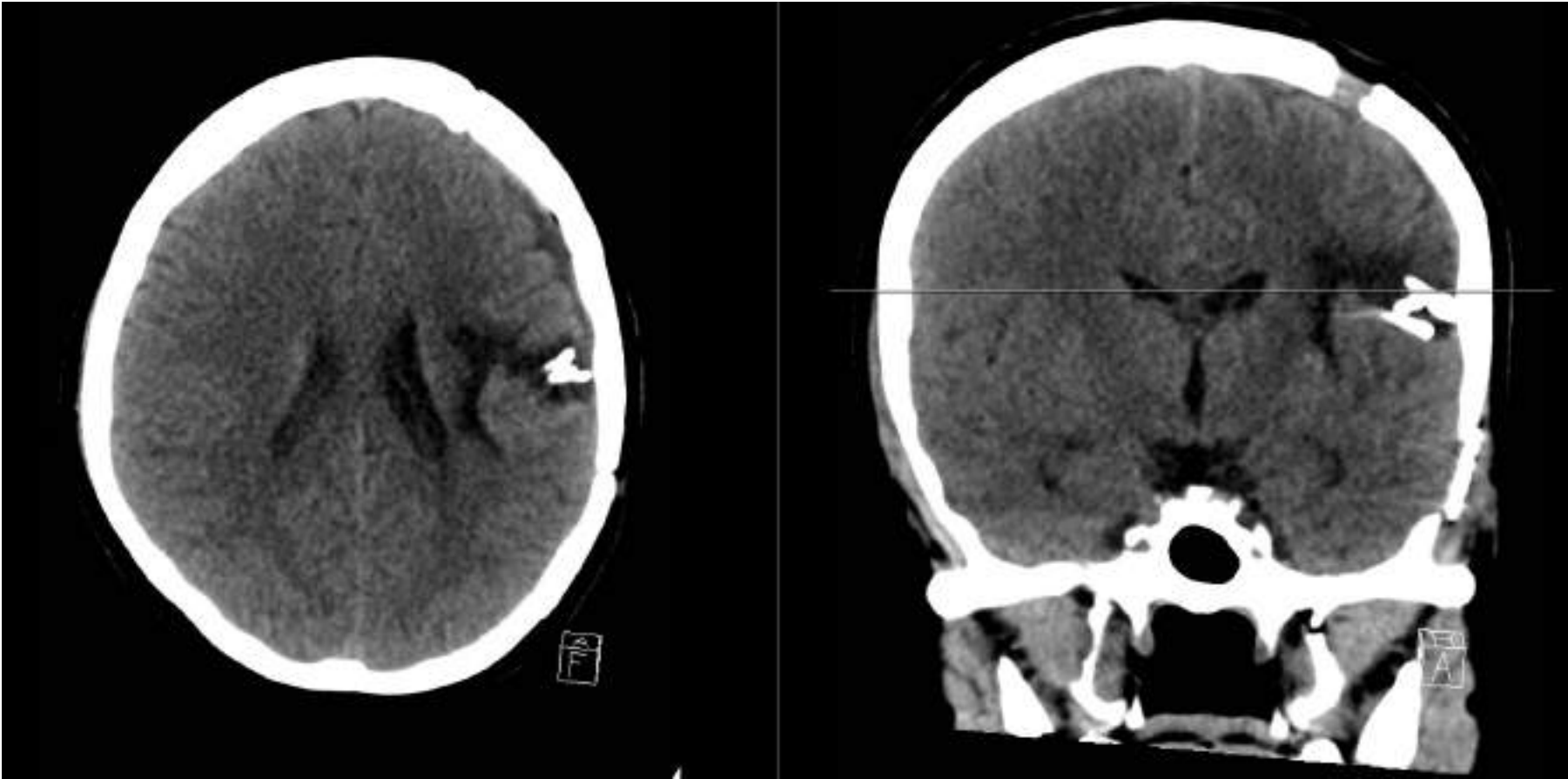
Distal transylvian approach for hematoma evacuation

Total trapping and excision of a distal dissection aneurysm of the left MCA (M3)



Follow-up on 27.4.2018

Clear improvement of right sided hemiparesis, motor dysphasia



Need for Bypass?
(MAY DEPEND ON THE COLLATERAL CIRCULATION)

<10%

>90%

NO
(bypass may not be necessary)


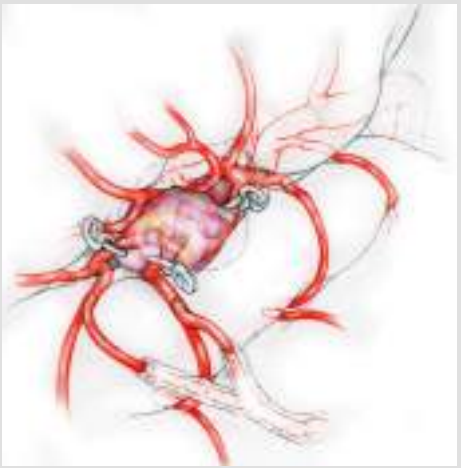


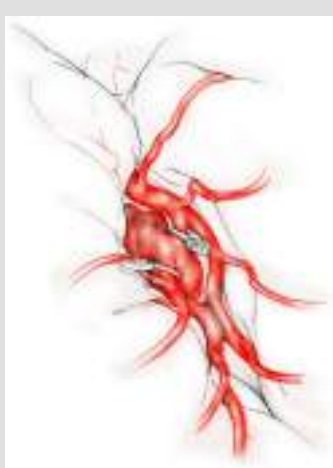
- Aneurysm is too proximal:
 - i.e. cavernous ICA (→ **collaterals via circle of Willis**)**
 - i.e. VA: collaterals via contralateral VA
- Aneurysm is too distal: i.e. M4-MCA, telovelotonsillar or cortical dissecting PICA (→ **pials collaterals**)**

** : SAB-ICB situations

YES
(bypass is indicated)

- No adequate collaterals
- Collaterals not predictable → in doubt, it is our belief to bypass

→ **to replace the flow** provided by a major intracranial vessel, the occlusion of which is necessary for treating an aneurysm or a tumor (trapping=sacrifice of a vessel)

FLOW-PRESERVATION				
EC-IC bypass			IC-IC bypass	
No graft interposition		Graft interposition (long graft)	Graft interposition (short graft)	No graft interposition ("in situ" bypass)
				
Single-bypass	Double-bypass	Single-bypass (Occlusive VS Non-Occlusive-ELANA)		

Characteristics of the anastomosis:

- End-to-side VS. side-to-side VS. end-to-end
- Occlusive VS. non-occlusive (ELANA)

Capacity of the bypass:

- **low** (<50 mL/min)
- **intermediate** (50-100 mL/min)
- **high** (> 100 mL/min)

Training in bypass surgery

Keep the bypass simple

Match the flow demand

Recipient:

superficial * > deep

Donor:

artery > vein > other

Microanastomosis:

end to side > end to end > latero-lateral

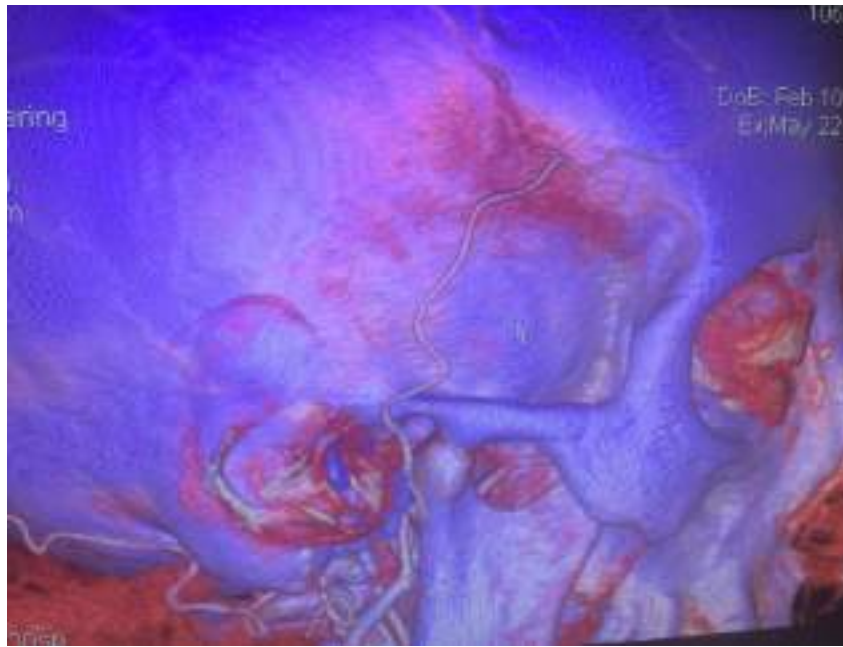
Type:

IC-IC > EC-IC

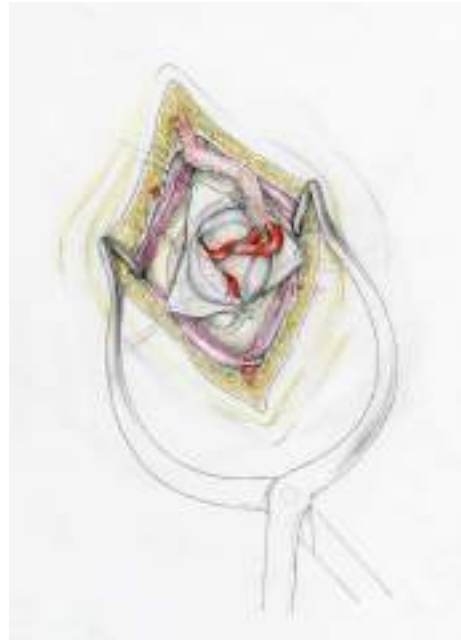
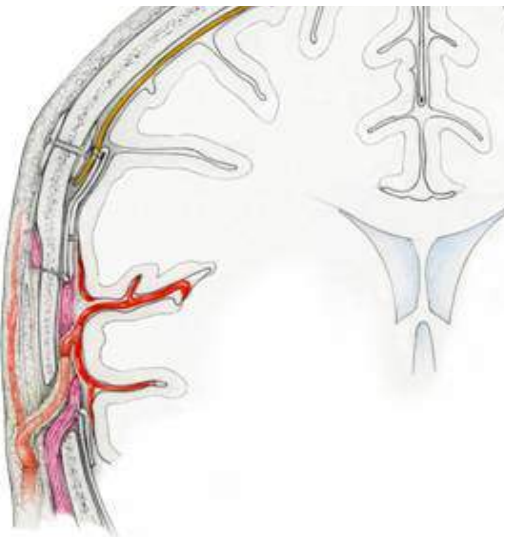
In situ > donor artery > interposition jump graft

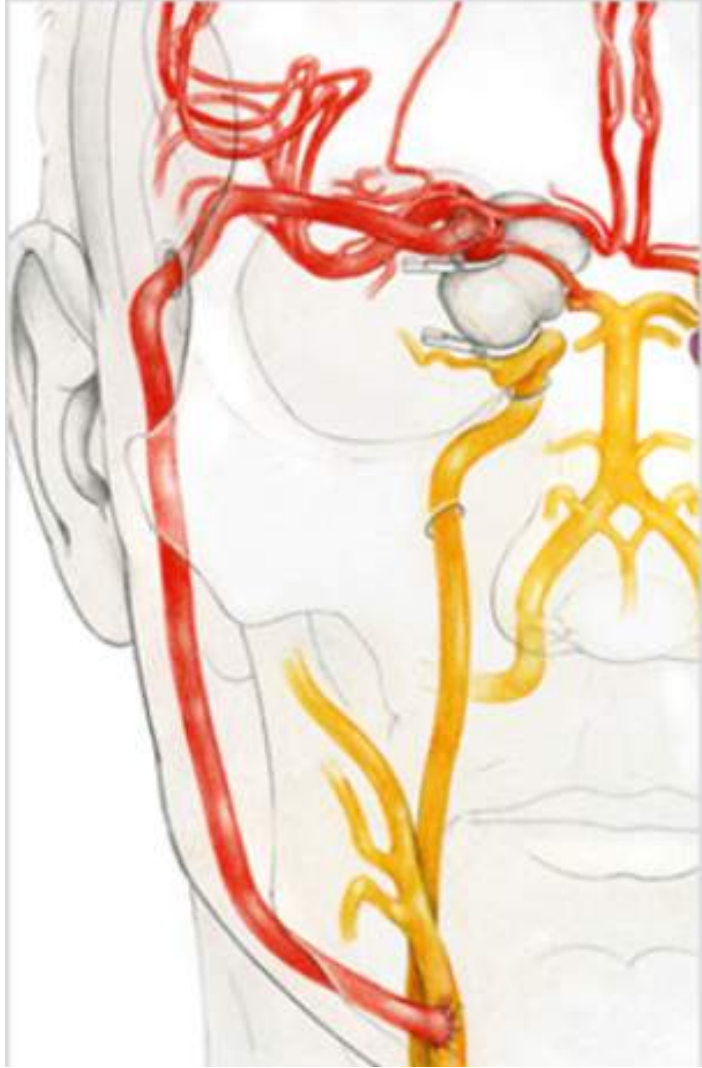
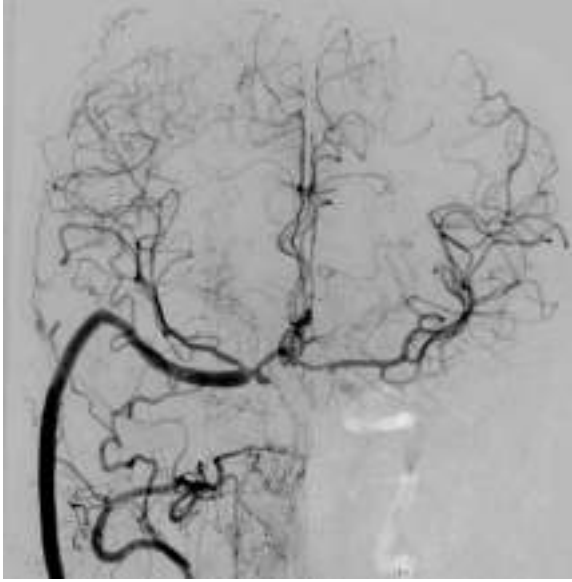
Non occlusive > occlusive





The STA-MCA bypass is still the most used bypass technique in neurosurgery







When performing a bypass operation, the surgeon should be able to:

1. map and dissect high quality donor vessel (**Doppler, ICG-VA-special use**)
2. identify the correct recipient vessel (**ICG-VA-special use**)
3. verify the patency of the anastomosis (**Doppler, ICG-VA, Flowmetry**)
4. verify the appropriateness of the direction of the flow in the bypass and in the recipient artery (**Doppler, ICG-VA, Flowmetry**)
5. quantify the flow in the bypass, allowing to verify that the bypass match the flow demand (**Flowmetry**)

Acta Neurochirurgica (2018) 160:775–778
<https://doi.org/10.1007/s00701-017-3455-y>

EDITORIAL (BY INVITATION)

Intraoperative tools for cerebral bypass surgery

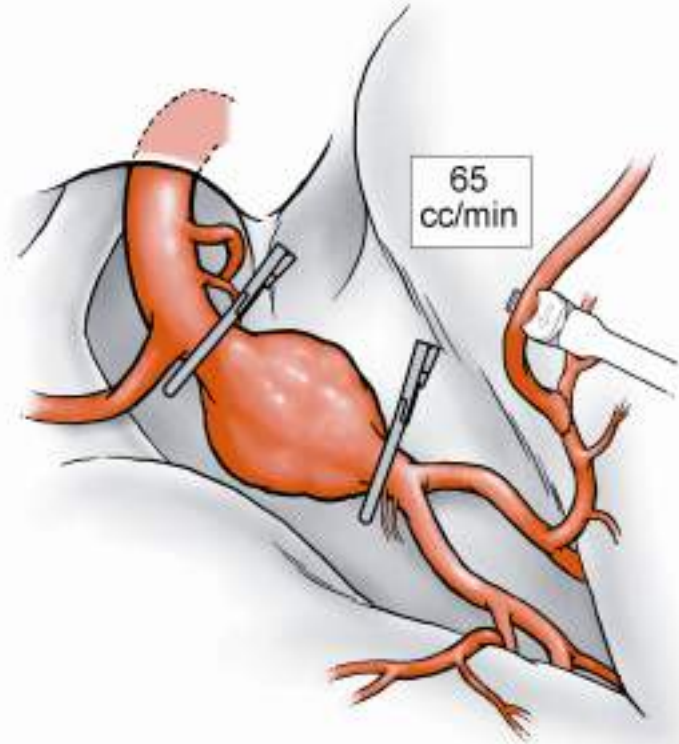
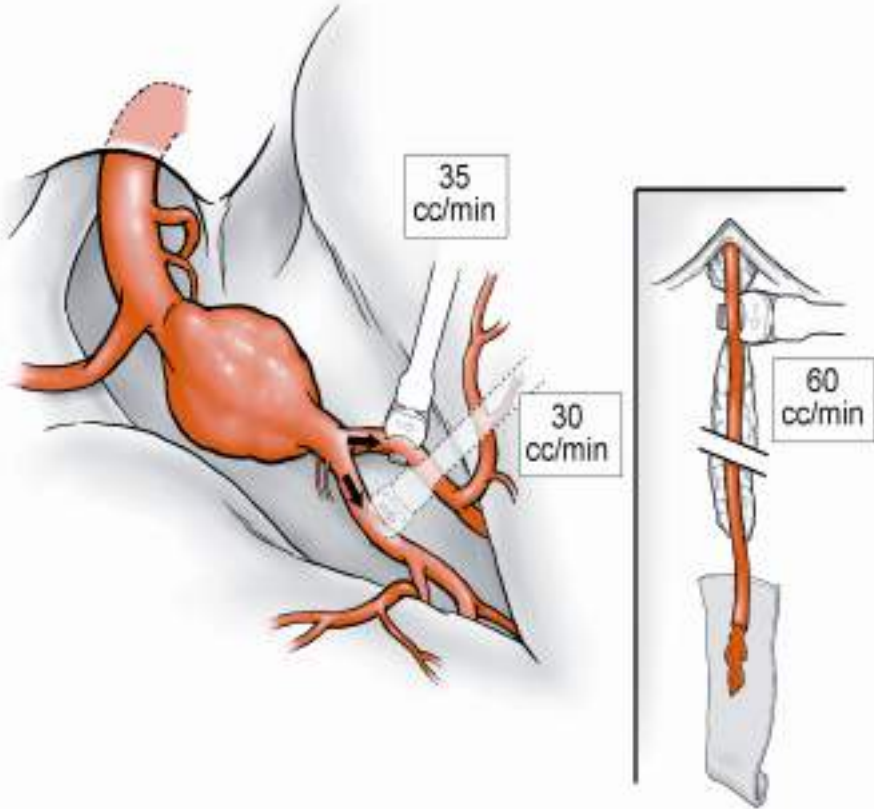
Giuseppe Esposito¹ · Luca Regli¹ 



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Intra-operative tool

Intra-operative quantitative Flowmetry (ml/min)

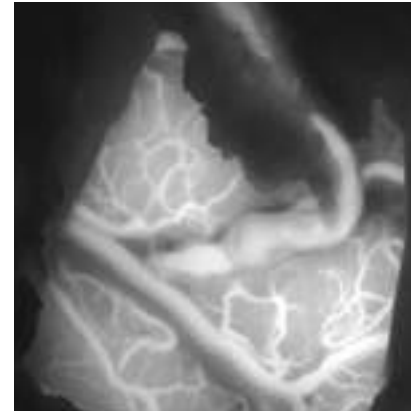


- **Patency of anastomosis**
- **Direction of blood flow**
- **Matching of the flow**



Intra-operative tool

Intra-operative ICG-Videoangiography (ICGVA)

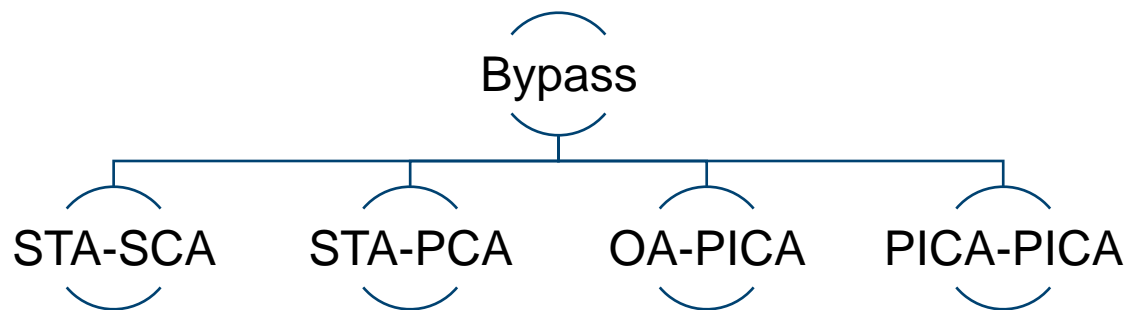
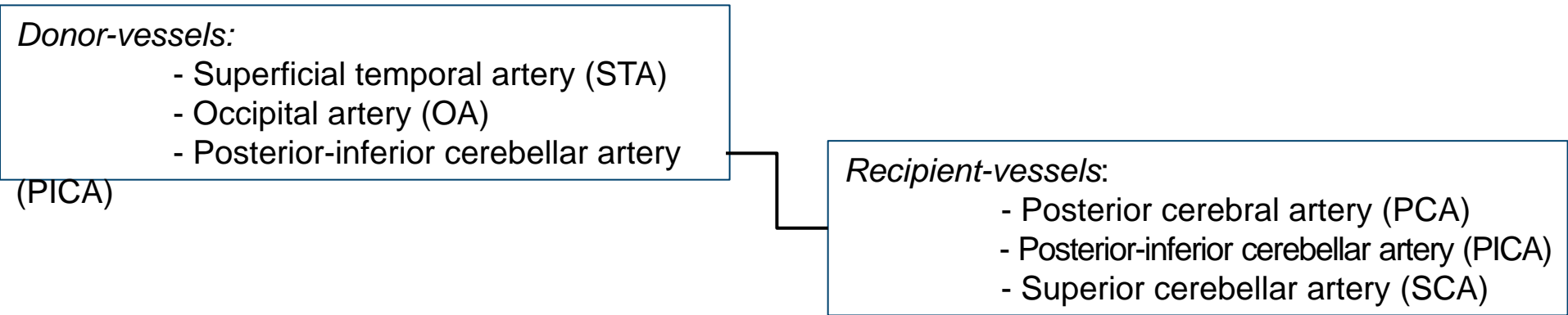


- Bypass and anastomosis patency
- Correct direction of blood flow

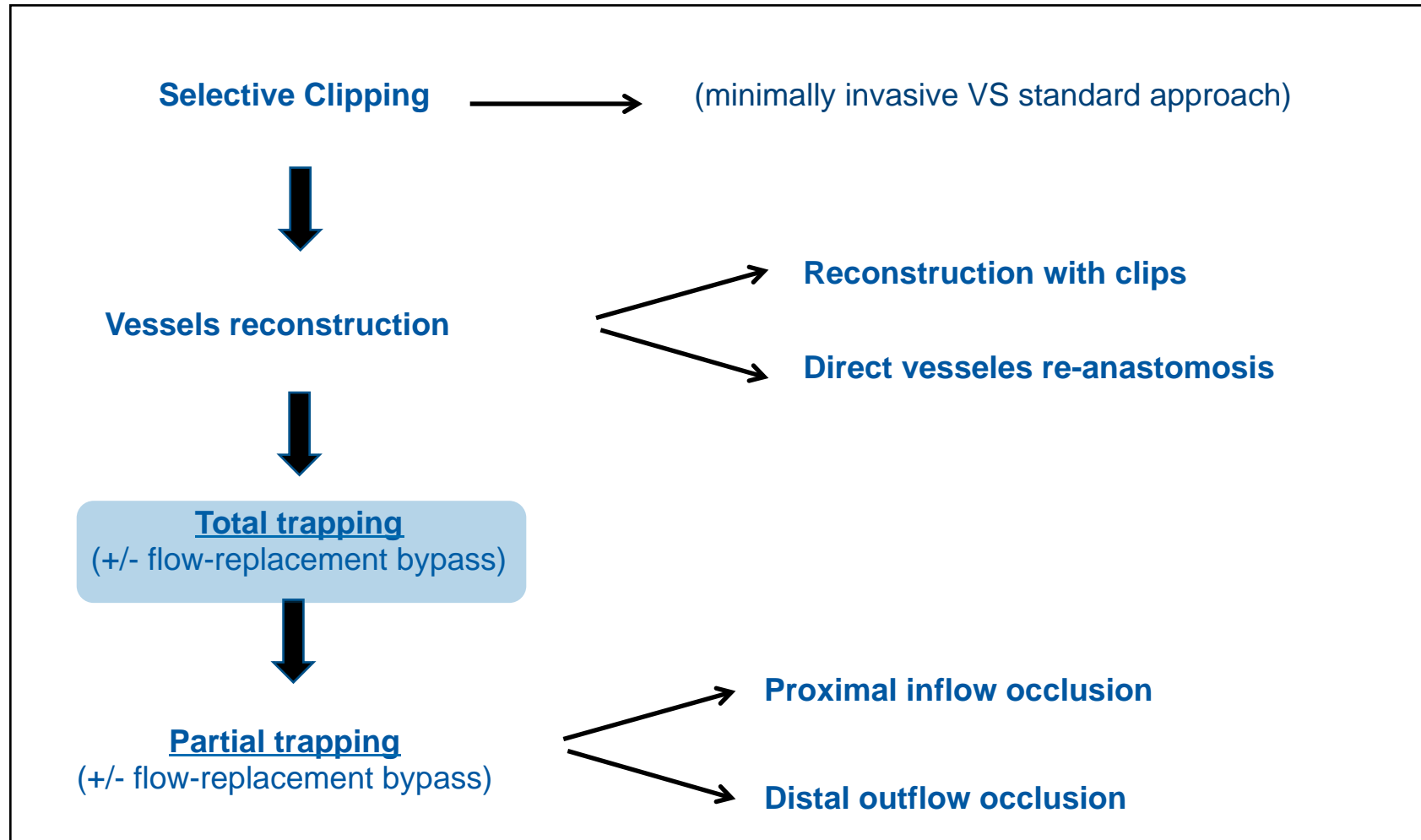
Further use of ICGVA:

- Technique for identification of donor (STA) → Esposito et al, Acta NCH 2016
- Technique for selective targeted bypass surgery (identification of recipient vessel in flow-replacement bypass surgery) → Esposito et al, Neurosurgery 2012

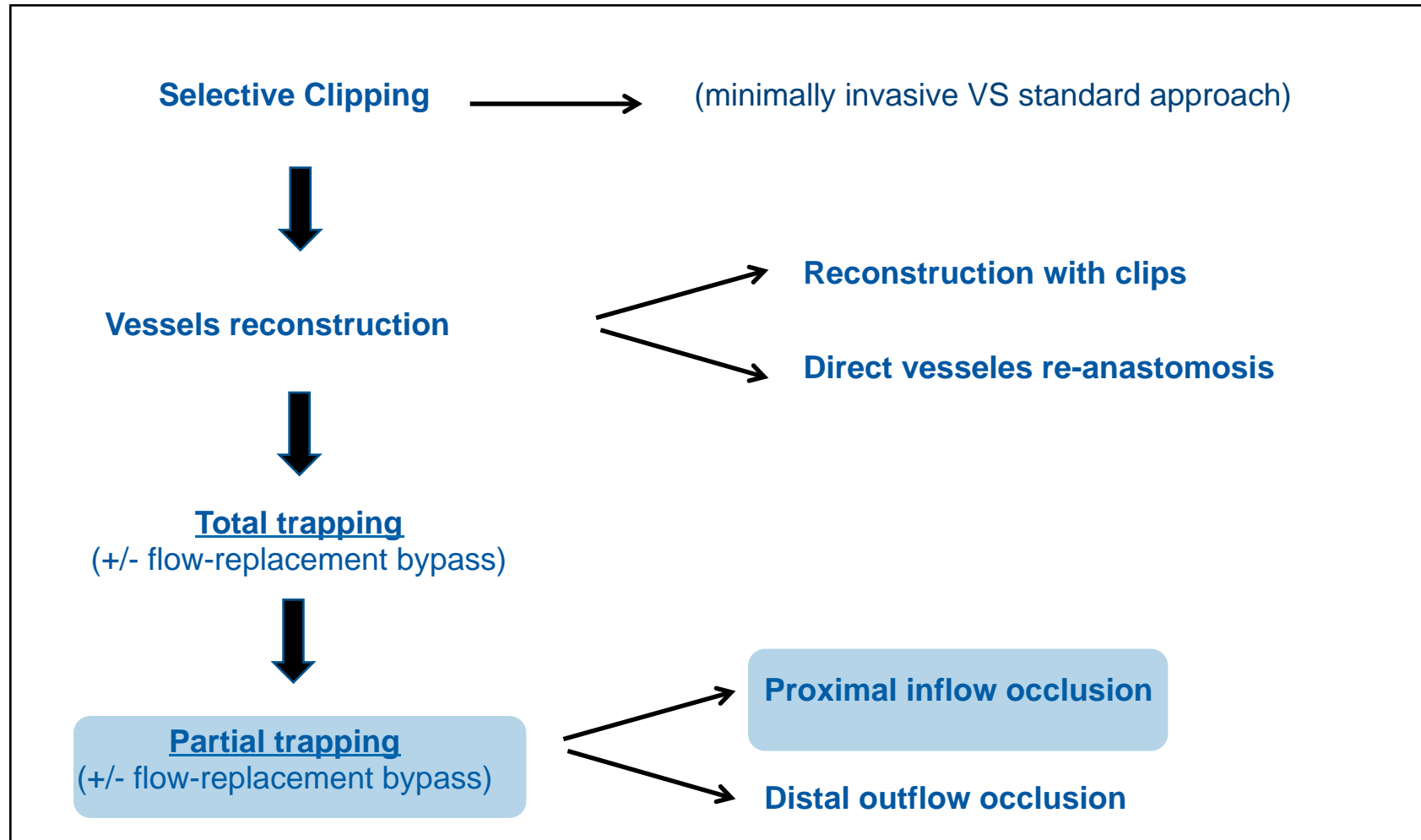
Flow-preservation bypass for posterior fossa



SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS



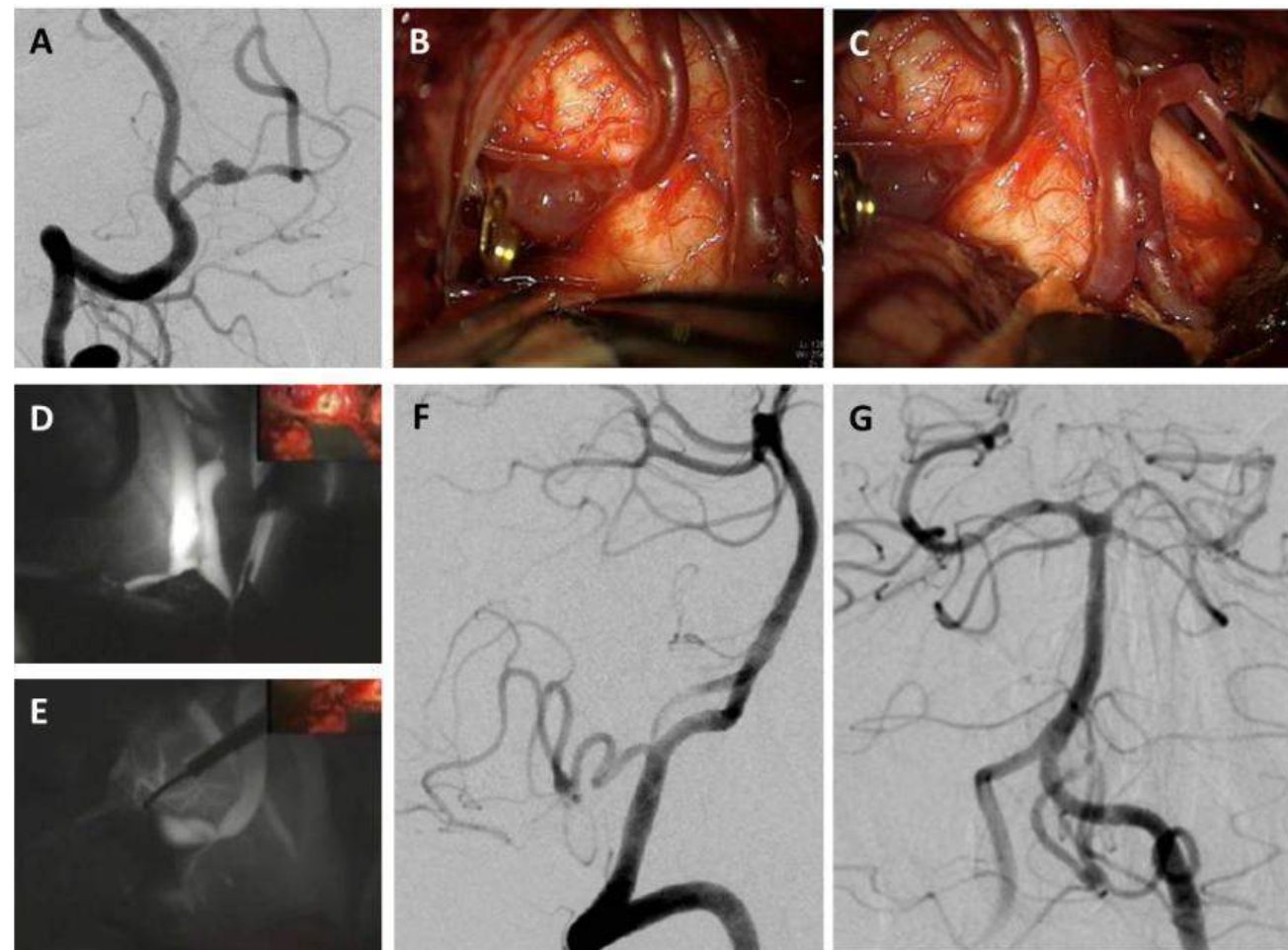
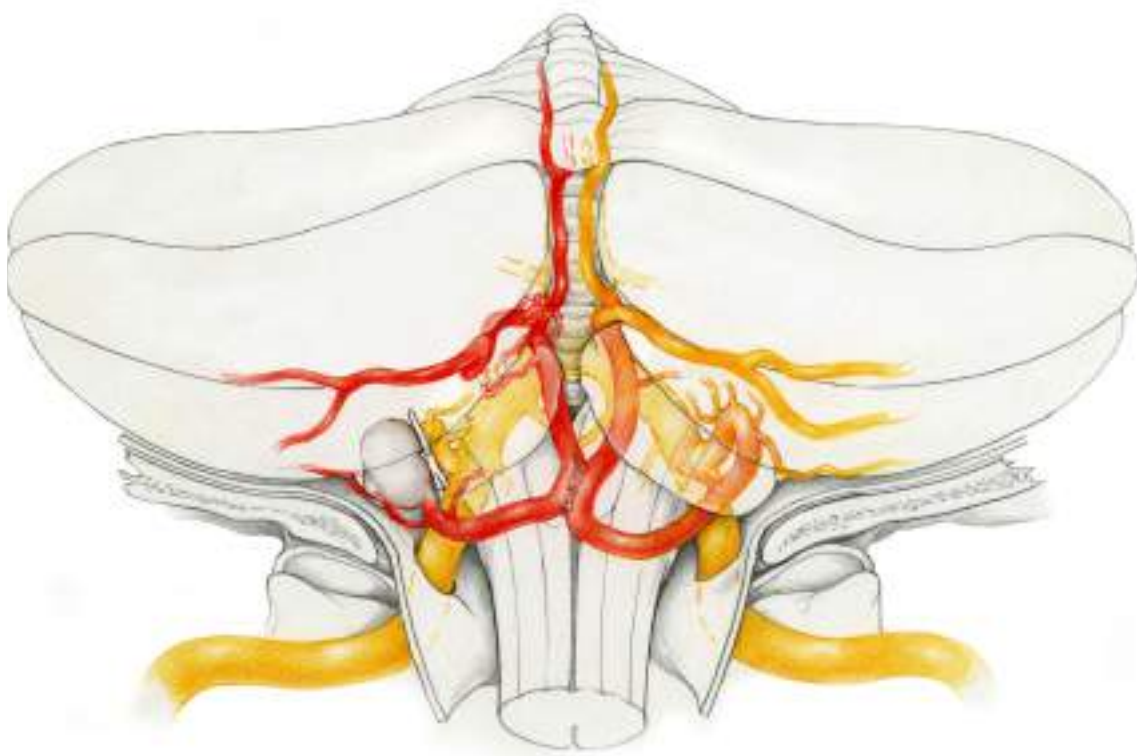
SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS



CASE 9 (elective)

Partial trapping (inflow occlusion), DSA, bypass

In situ: Single IC-IC PICA-PICA
bypass (1 x side-to-side
anastomosis)



**64, F, left PICA dissecting aneurysm - SAH-
Partial trapping (proximal inflow occlusion) + PICA-PICA bypass**



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Esposito G, Regli L. Surgical decision-making in the treatment of complex intracranial aneurysms. Acta Neuroch Suppl 2014 (Vol. 119). DOI 10.1007/978-3-319-02411-0_1: pagg. 3-11.

SURGICAL DECISION-MAKING FOR INTRACRANIAL ANEURYSMS

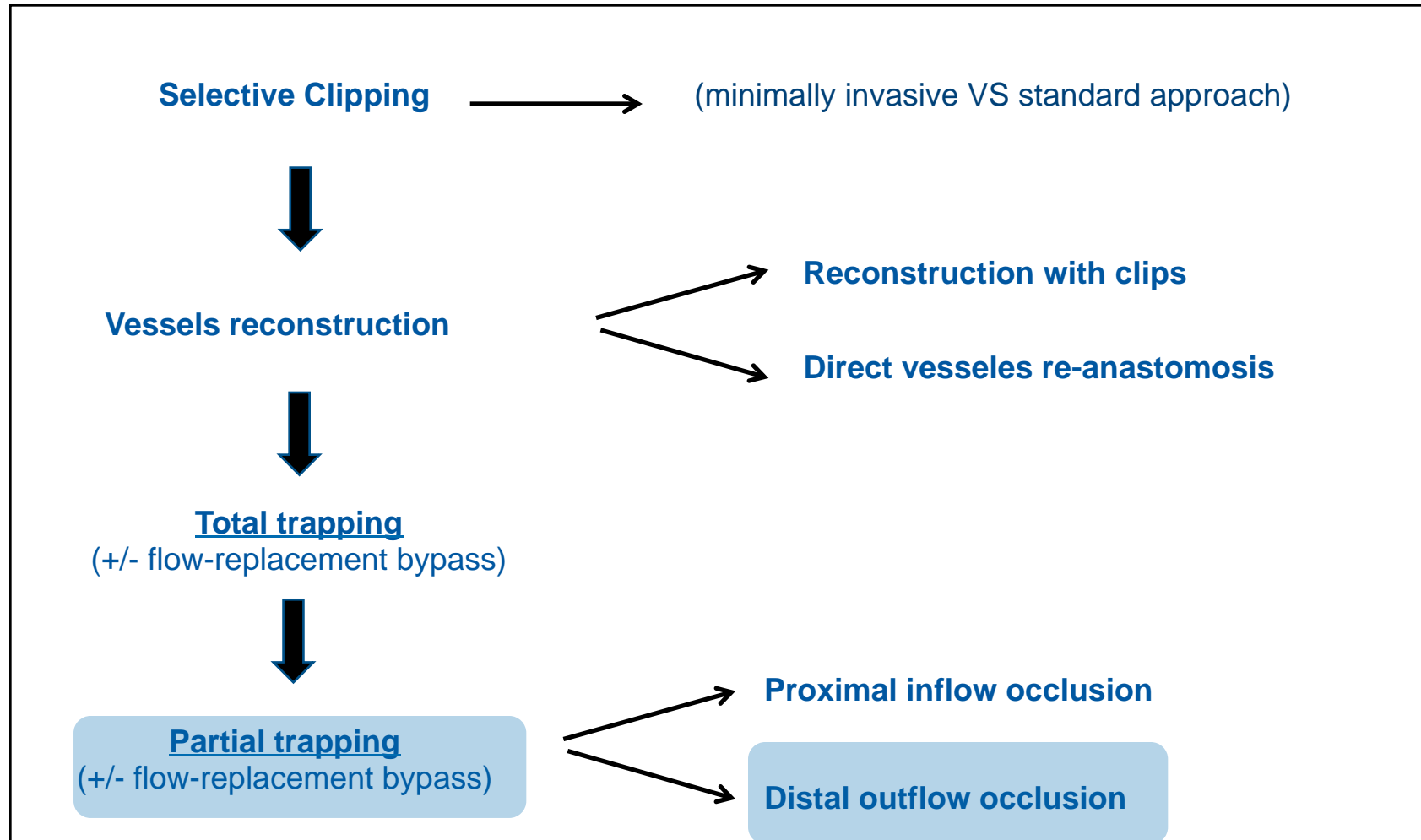
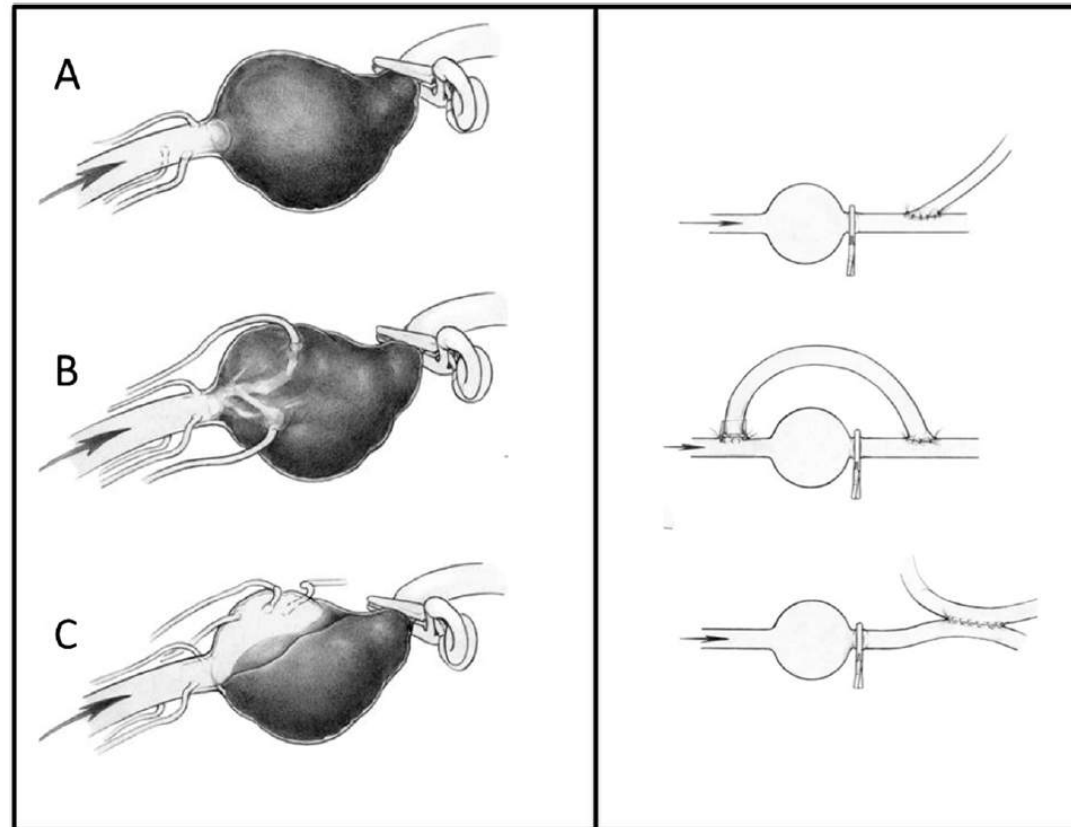

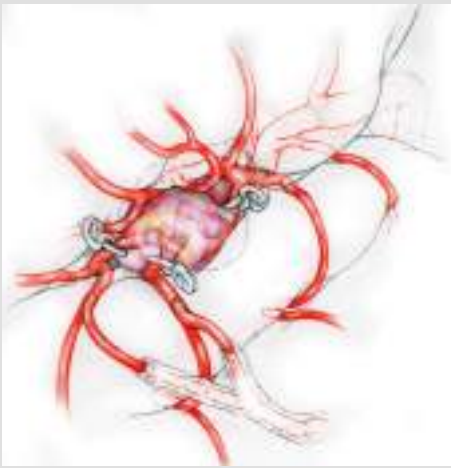


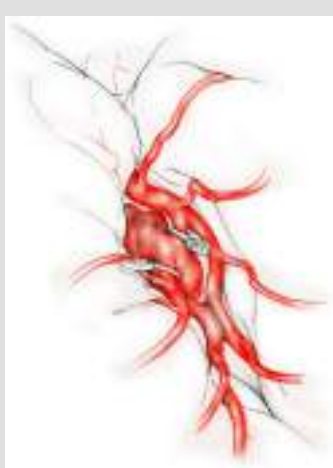


Fig. 3 On the *left side*, a drawing of possible aneurysmal changes (**a, b, c**) after distal outflow occlusion. On the *right side*, various associated revascularization strategies



FLOW-PRESERVATION				
EC-IC bypass			IC-IC bypass	
No graft interposition		Graft interposition (long graft)	Graft interposition (short graft)	No graft interposition ("in situ" bypass)
				
Single-bypass		Double-bypass	Single-bypass (Occlusive VS Non-Occlusive-ELANA)	

Characteristics of the anastomosis:

- End-to-side VS. side-to-side VS. end-to-end
- Occlusive VS. non-occlusive (ELANA)

Capacity of the bypass:

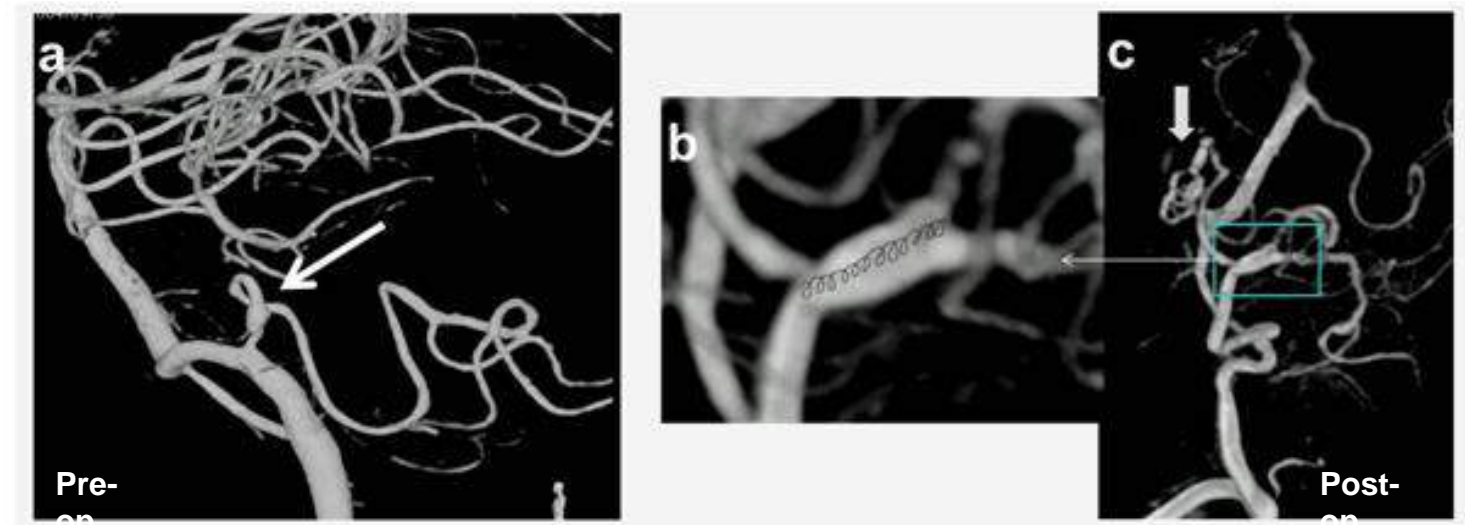
- **low** (<50 mL/min)
- **intermediate** (50-100 mL/min)
- **high** (> 100 mL/min)



CASE 10 (emergency)

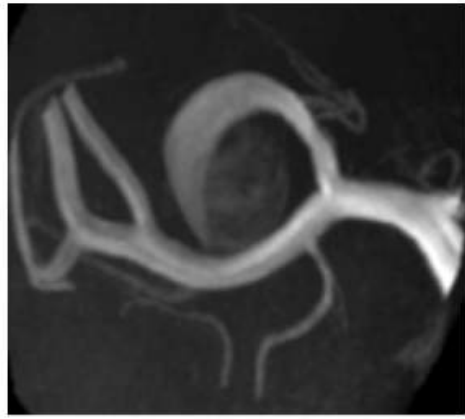
Partial trapping (outflow occlusion), DSA, bypass

Pt.	Aneurysms		SAH	Surgical strategies		Outcome			
	Site	Characterist.		Aneurysms' Treatment	Bypass	Radiological			
						Aneurysms exclusion	Bypass patency	Ischemie	Clinical
6	PICA r	Dissecting	Yes	Partial trapping (distal outflow occlusion)	PICA-PICA (side-to-side)	complete	Yes	No	

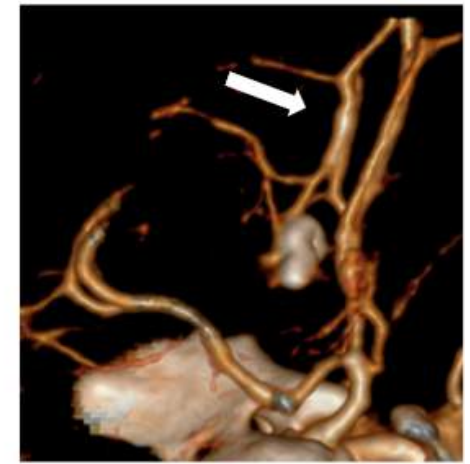
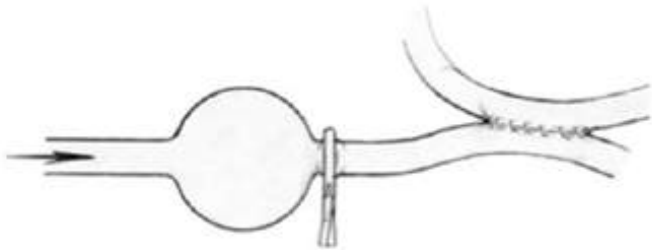


CASE 11 (elective)

In situ: Bypass: Single IC-IC M3-M3 bypass (1 x side-to-side anastomosis)



Pt	Aneurysm and treatment details						
	Size (mm)	Type	Location		Site of distal occlusion	Bypass	Anastomosis
			Artery	Segment			
6	13	Dissecting	MCA r	M2	M2	M3-M3	Side-to-side



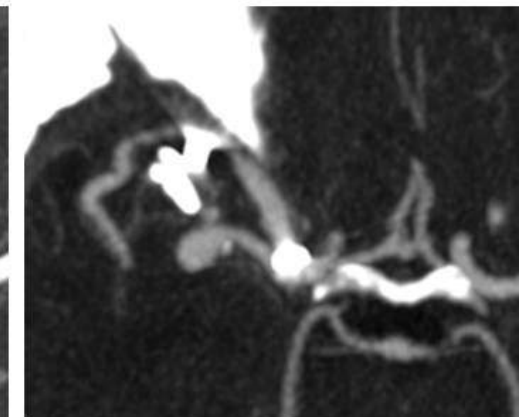
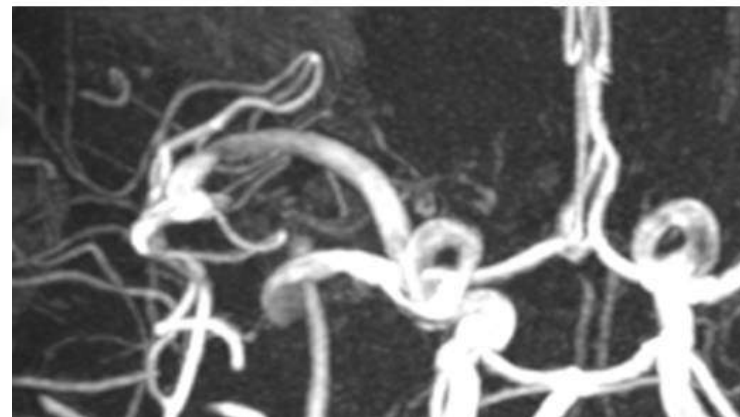
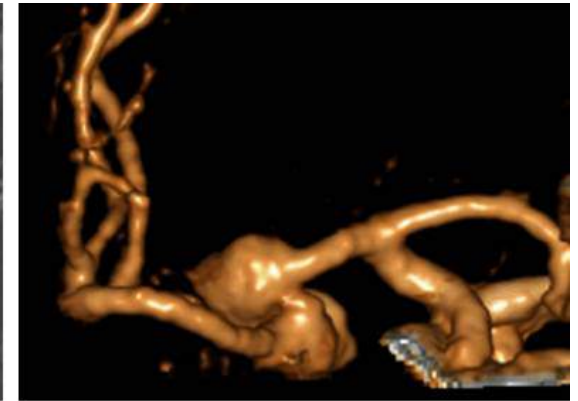
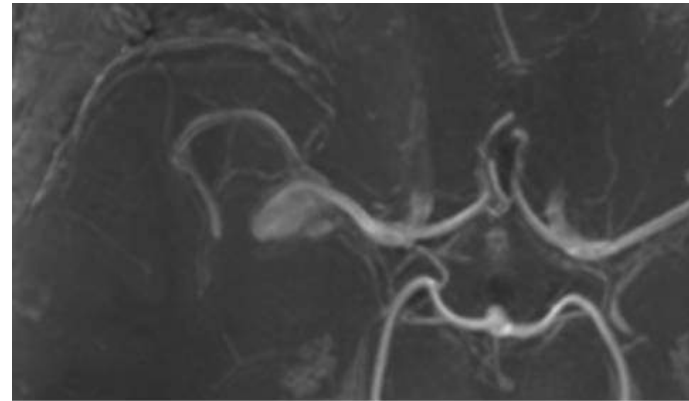
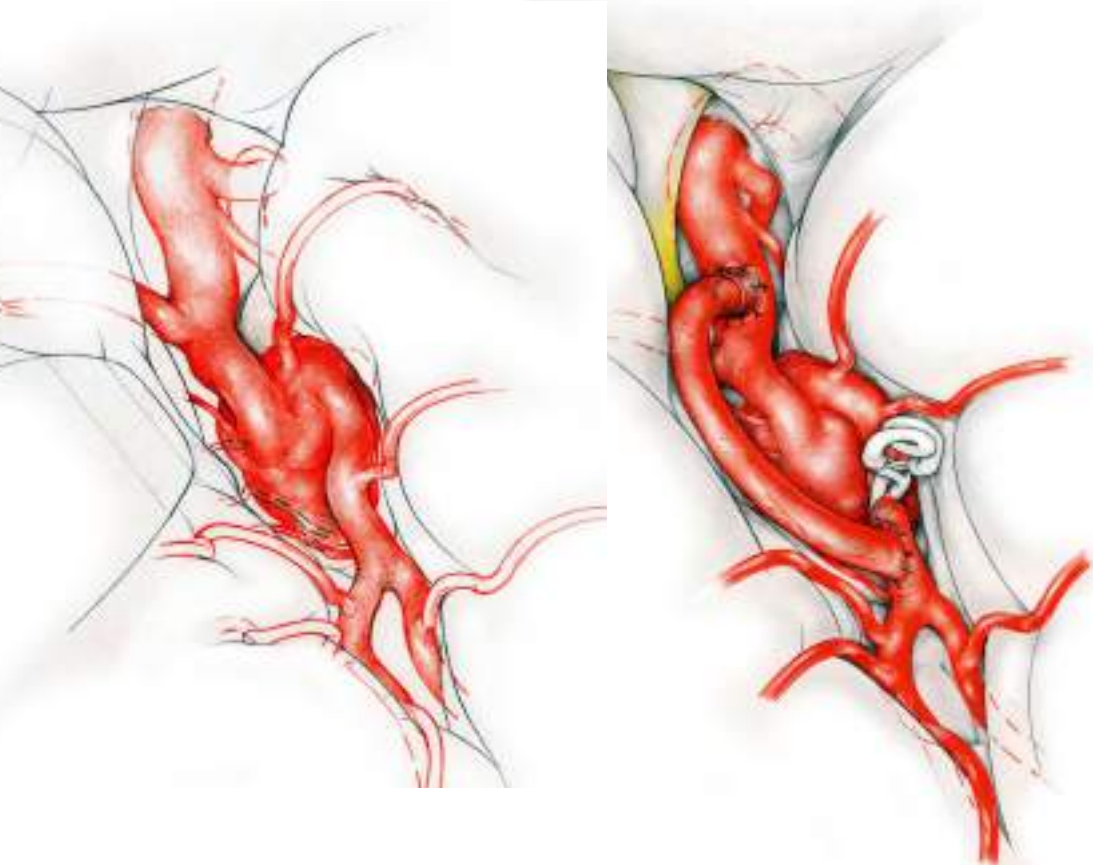
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Esposito G, Fierstra J, Regli L (2016) Distal outflow occlusion with bypass revascularization: last resort measure in managing complex MCA and PICA aneurysms. *Acta Neurochir* 2016 Aug;

CASE 12 (elective)

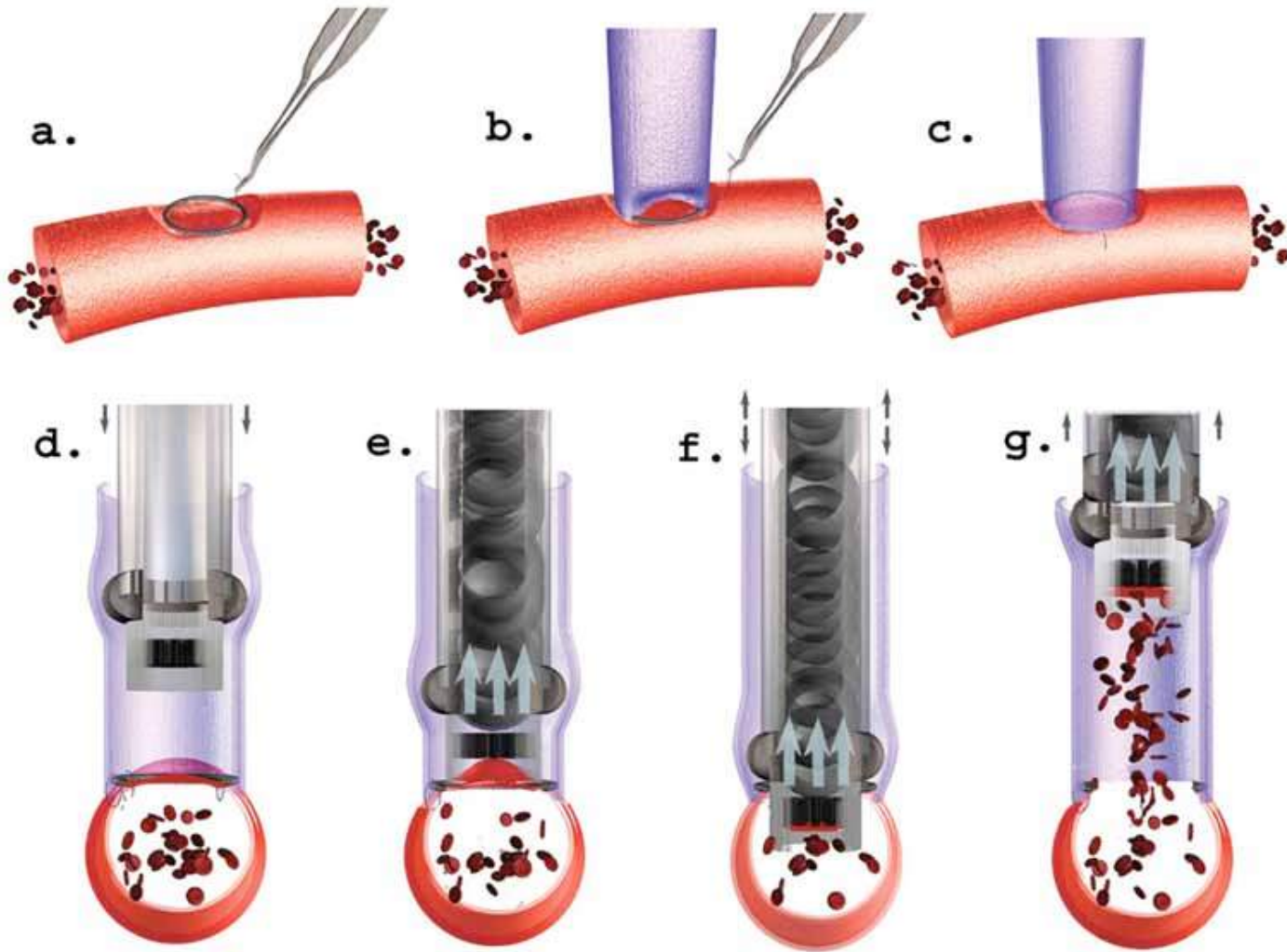
Partial trapping (outflow occlusion),
DSA, bypass

**IC-IC ICA-MCA bypass with arterial graft (2 x end-to-side
anastomosis, one of which was a non-occlusive ELANA
anastomosis)**



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Esposito G, Fierstra J, Regli L (2016) Distal outflow occlusion with bypass revascularization: last resort measure in managing complex MCA and PICA aneurysms. *Acta Neurochir* 2016 Aug;



ELANA (Excimer Laser-Assisted Non Occlusive Anastomosis)





CAMPO BASE NEUROVASCOLARE

Campo Base NeuroVascolare

10 - 13 OTTOBRE 2018

A.O.U. - Azienda Ospedaliero-Universitaria Careggi
Nuovo Ingresso Careggi - NIC
Padiglione 3 piano terra, Largo Brambilla 3, 50134
Firenze

Sono stati relatori e partner di:

Spazio del Servizio:
Neurologia e
Neurochirurgia

Thank you for your attention



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Giuseppe.Esposito@usz.ch⁸³