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Distal Posterior Cerebral Artery Aneurysms

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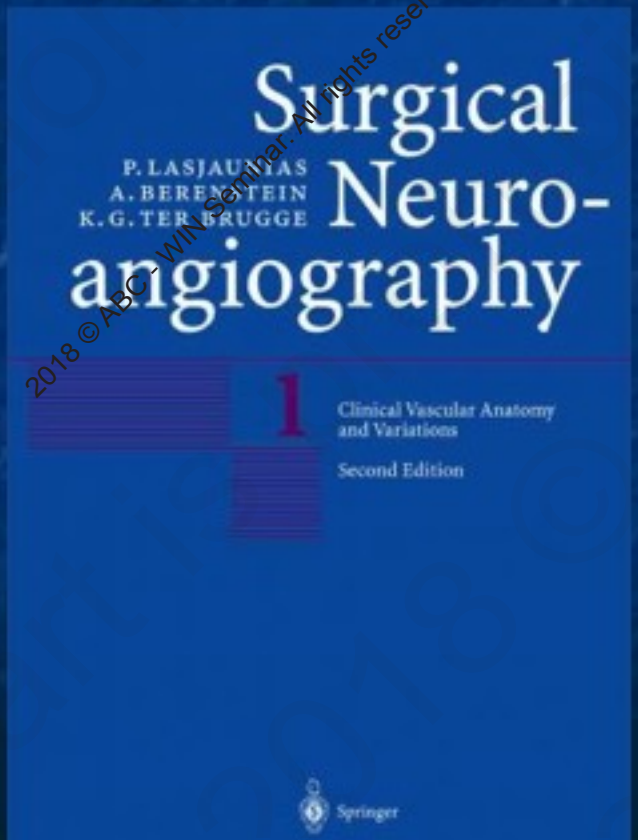
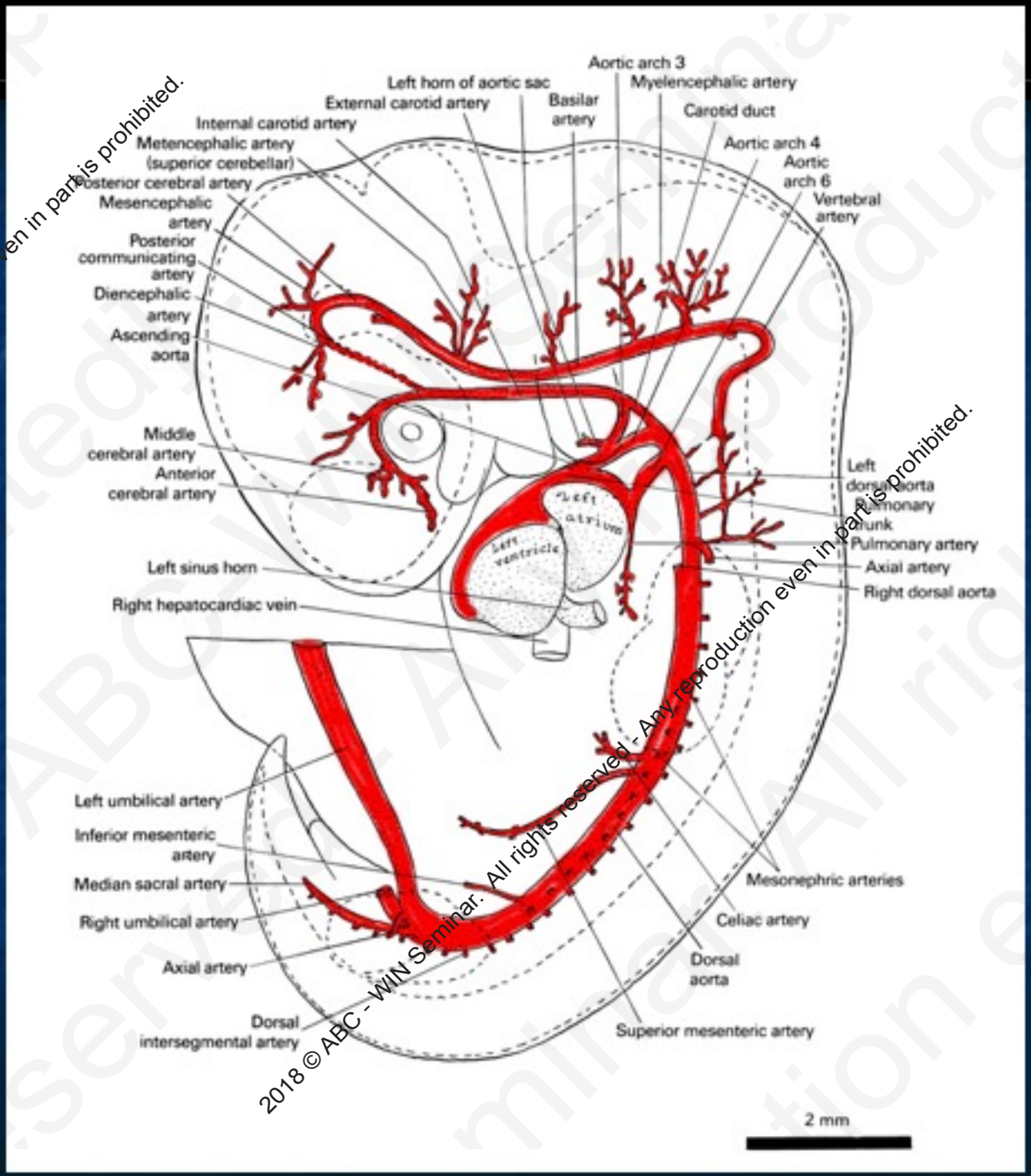
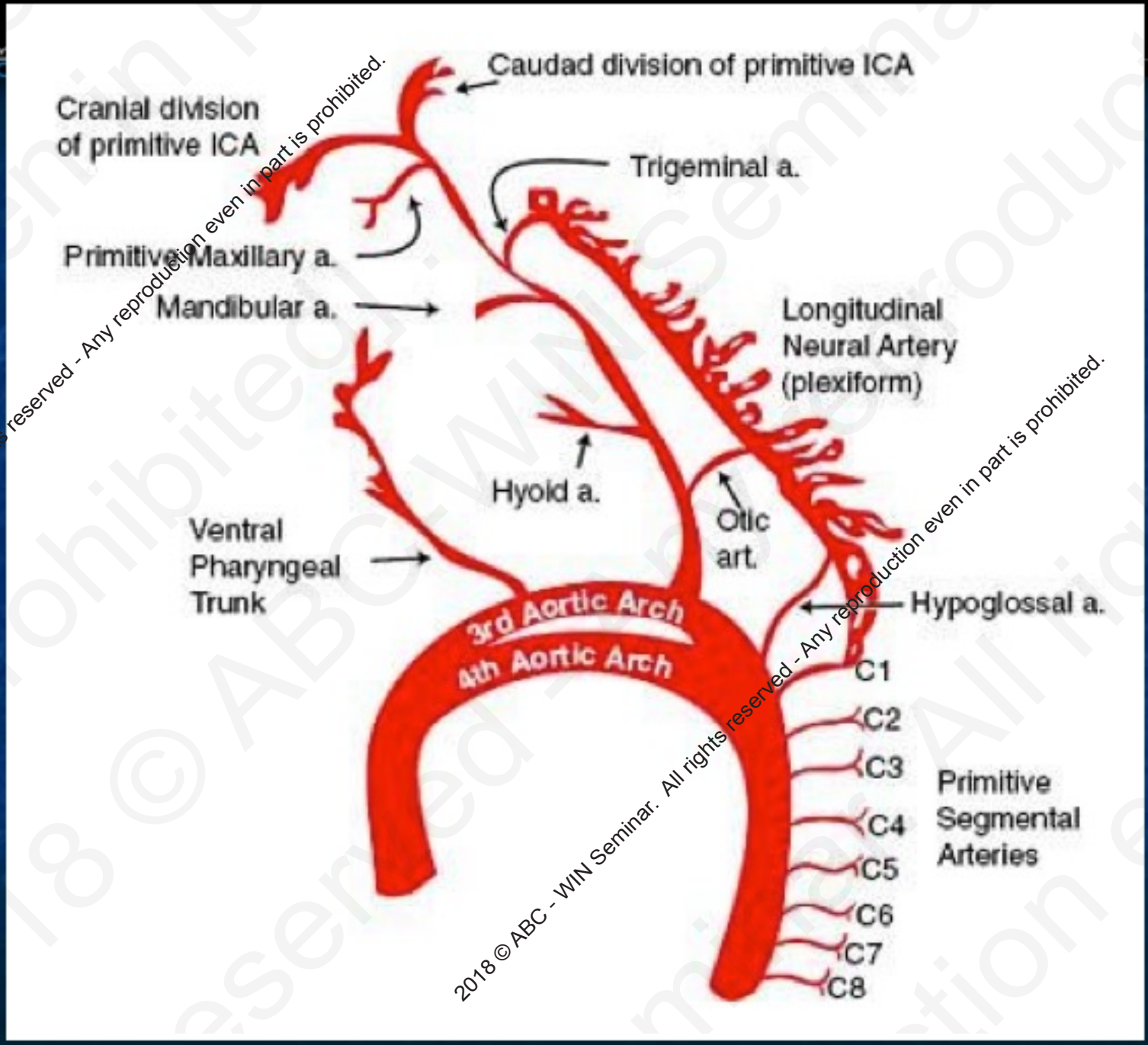
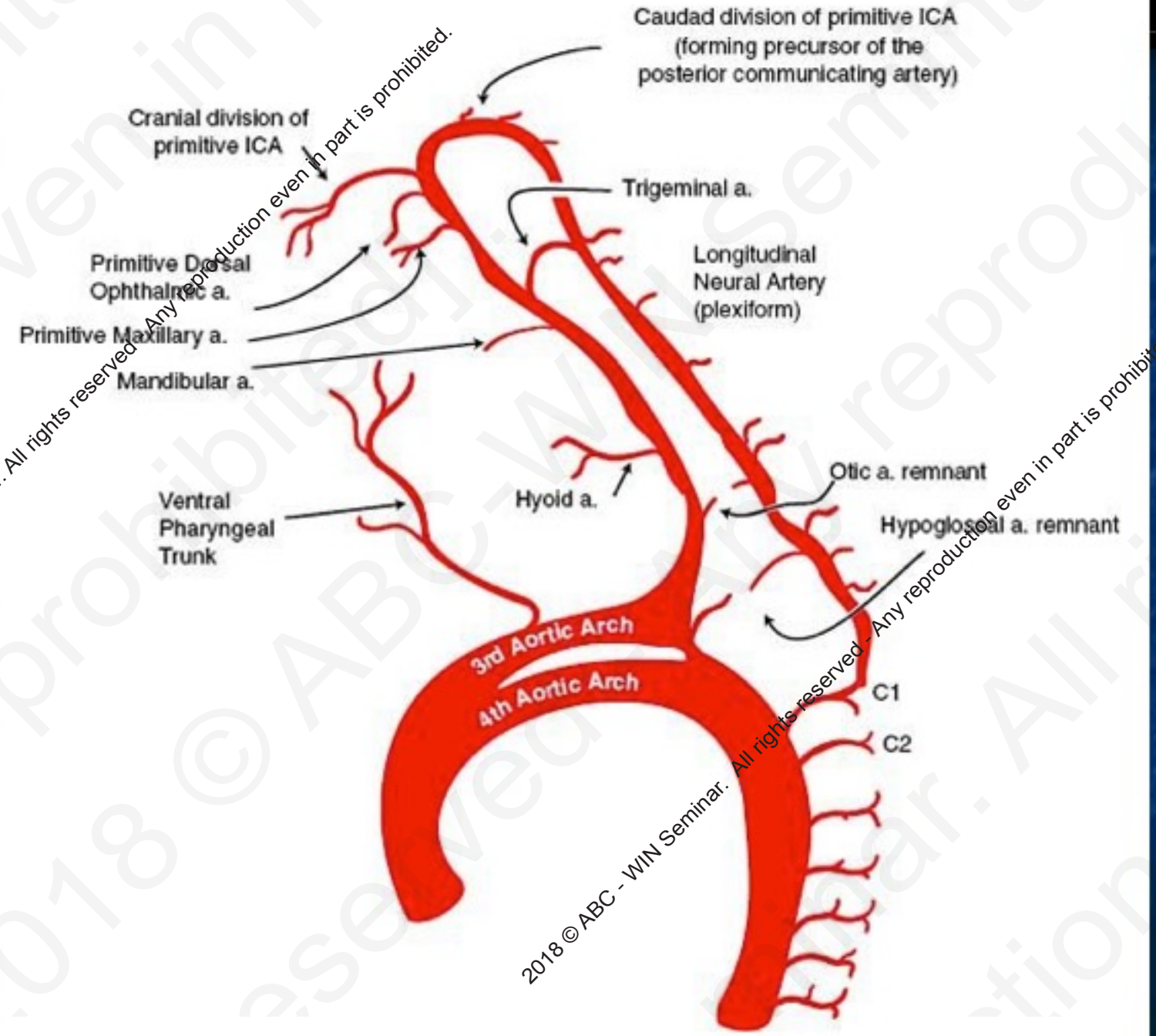
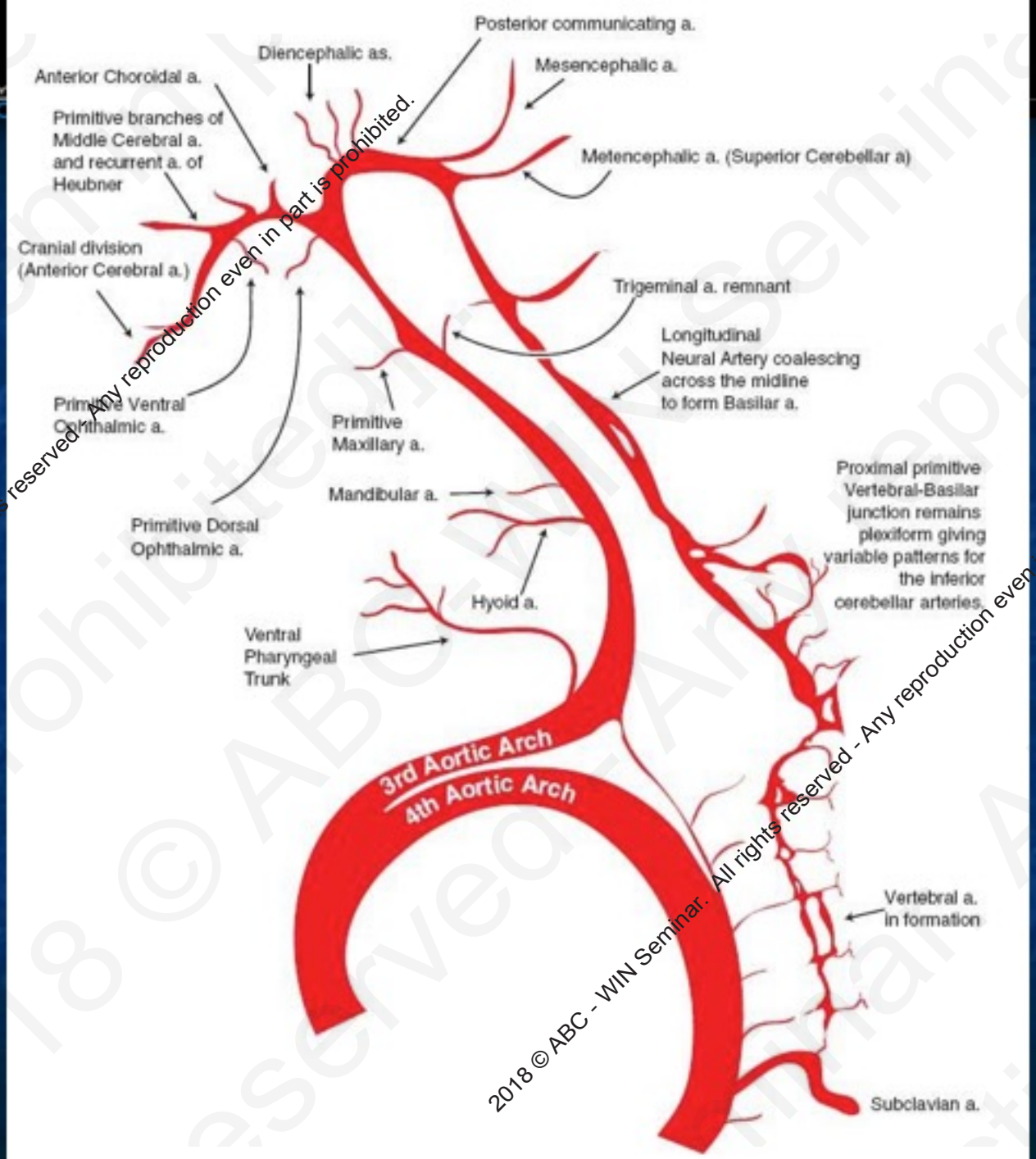
Lets start at the beginning…



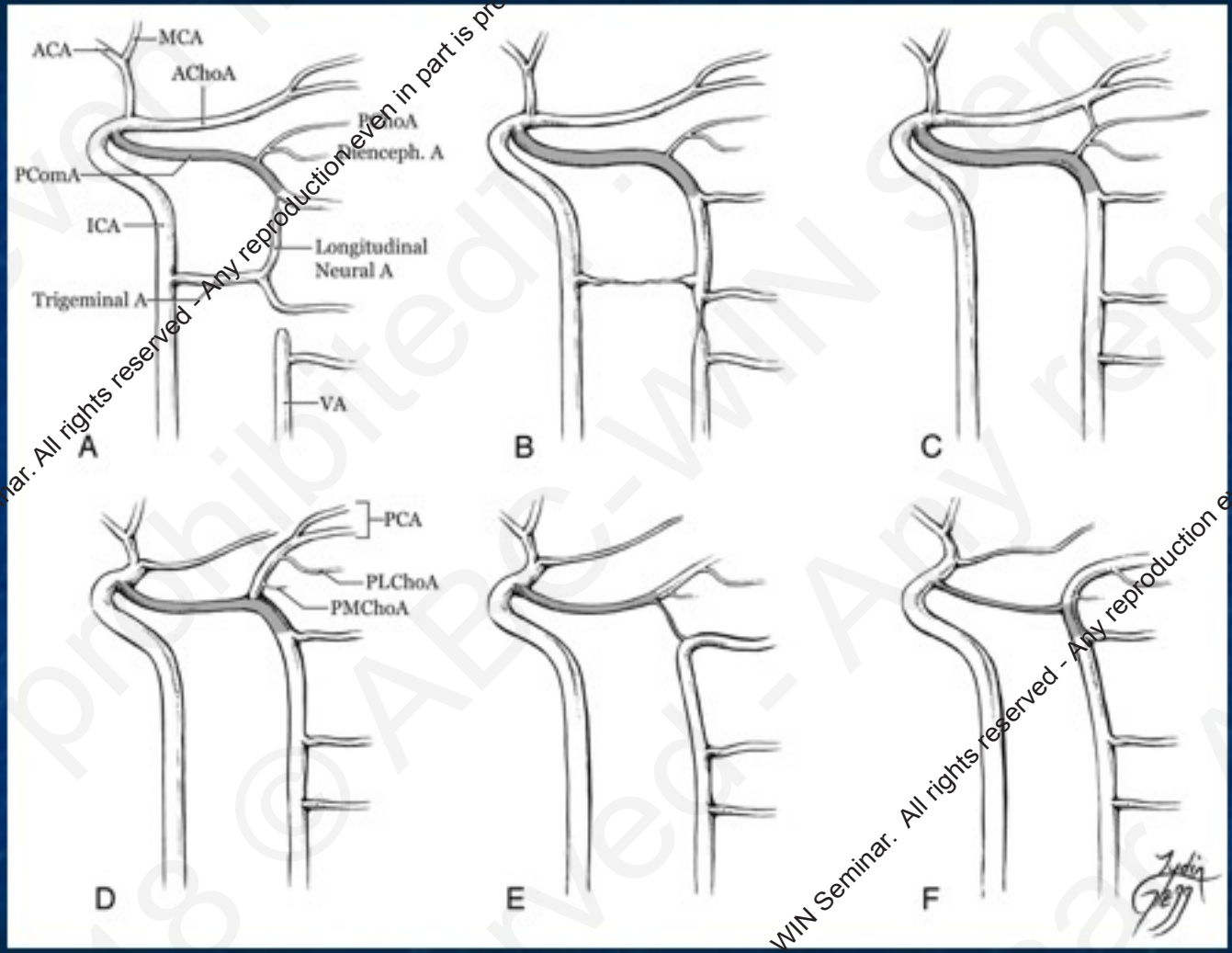








Developmental anatomy of the distal BA. A, The anterior circulation supplies the developing posterior circulation (ie, the parallel longitudinal neural arteries [LNA]) via the trigeminal and the posterior communicating arteries (PcomAs).



I.M. Burger et al. AJNR Am J Neuroradiol 2007;28:2017-2022

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Final Product

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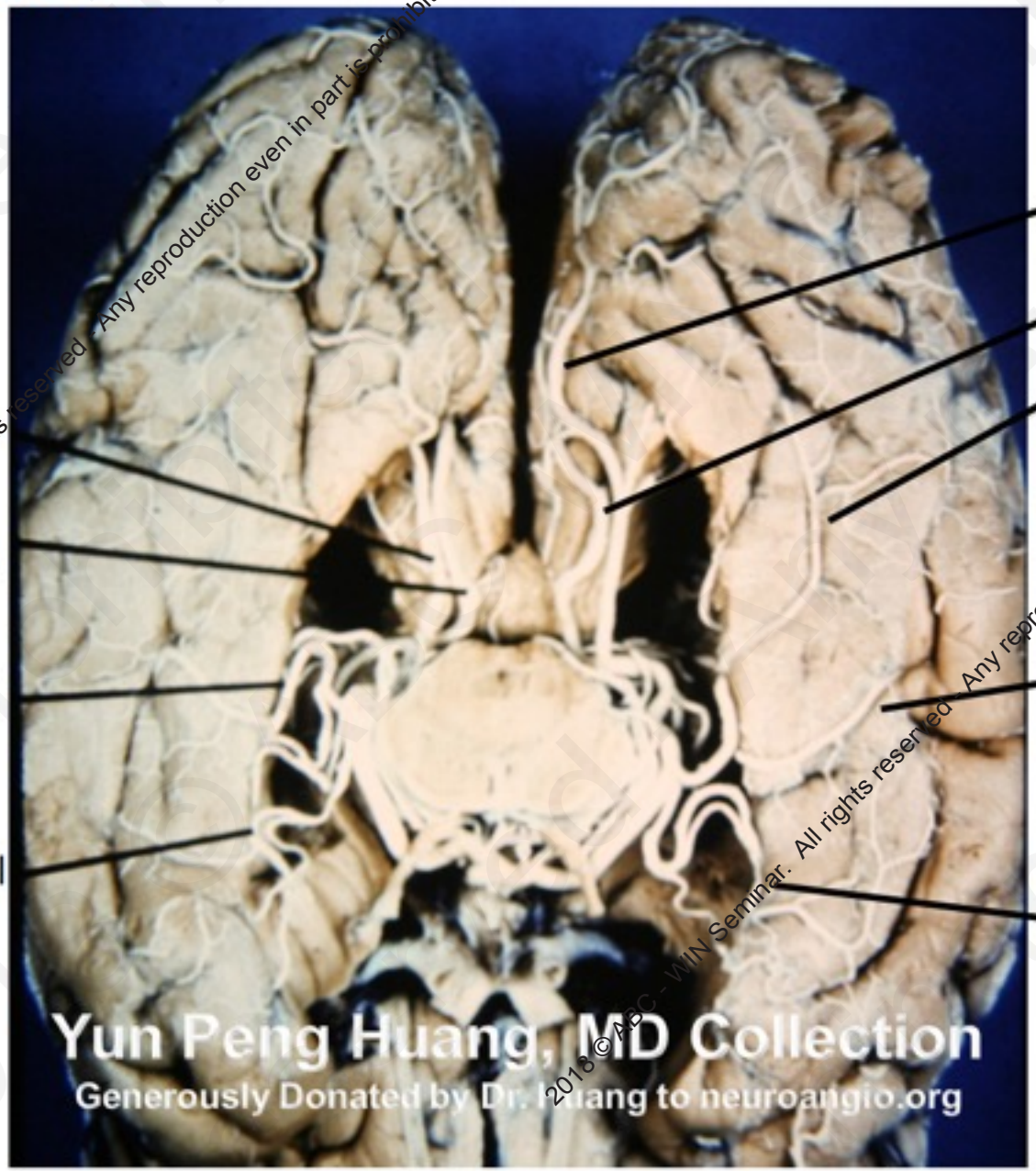

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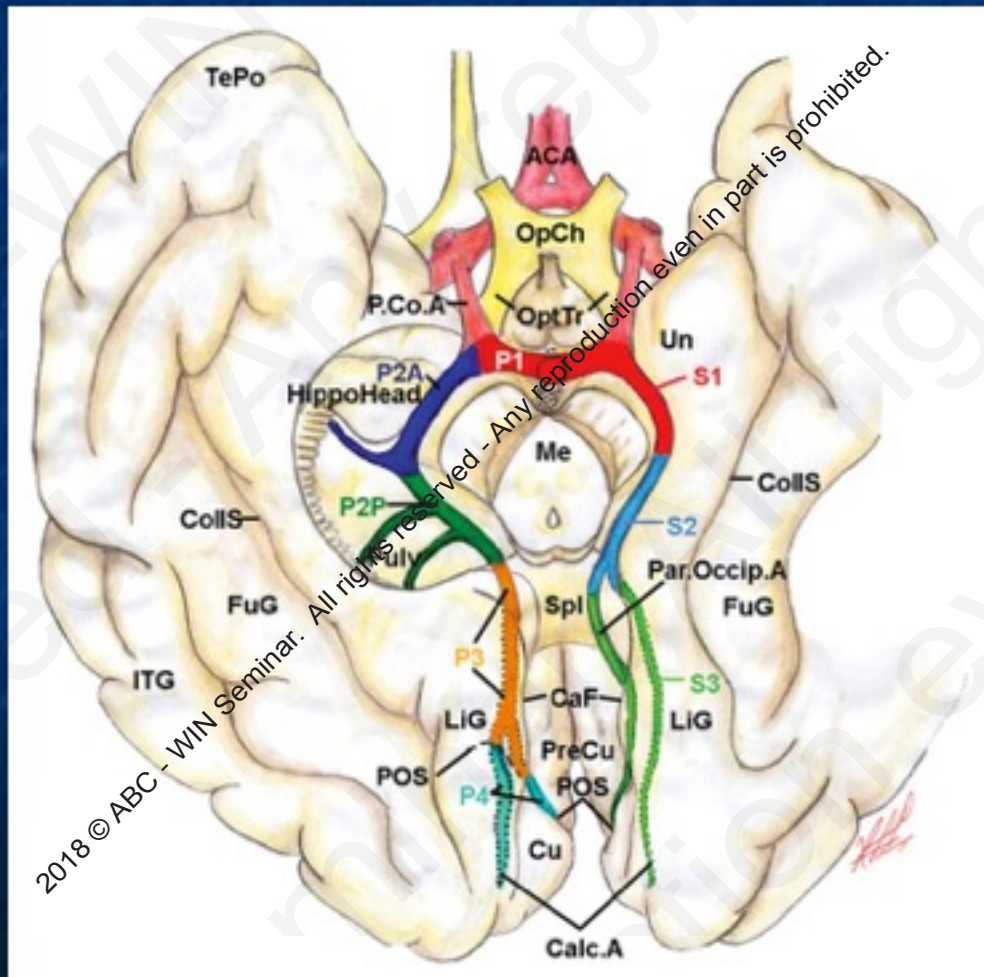
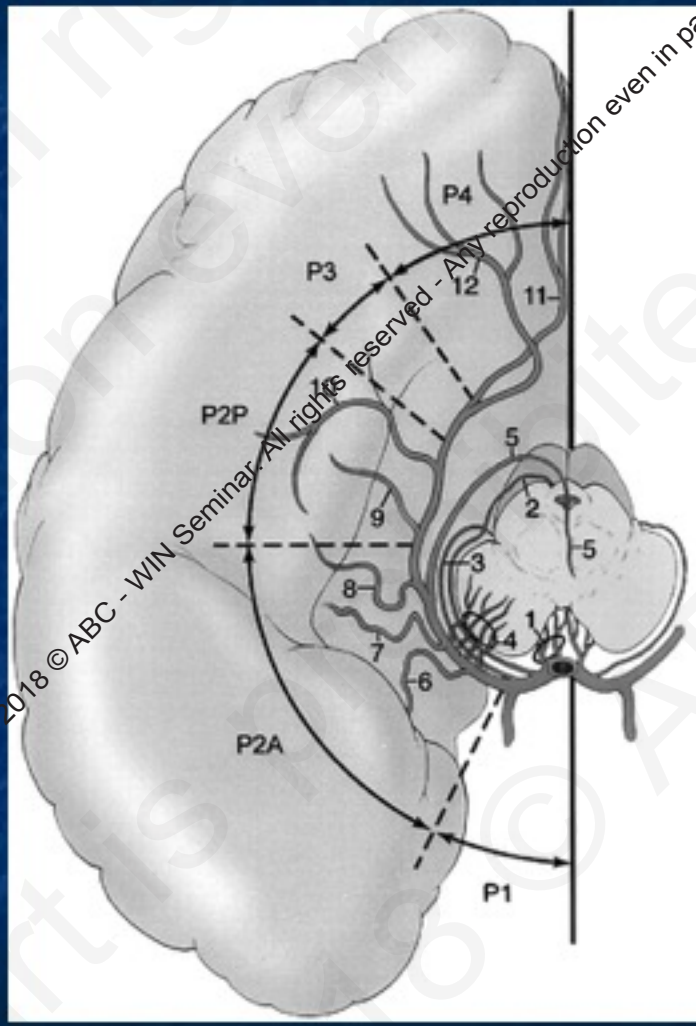
Anatomical Considerations of the Posterior Cerebral Artery

- Proximal PCA is considered to be the P1 segment – from the origin at basilar terminus to the attachment of the communicating artery
- P2 onwards is considered distal PCA
- Proximal and early distal PCA vessels have significant perforator anatomy
- PCA distribution has significant collaterals with the anterior circulation as well



Anatomical Considerations of the Posterior Cerebral Artery



P1 segment
1. Thalamo-perforating arteries
2. Long circumflex artery
3. Short circumflex artery

P2A segment
4. Direct peduncular perforating arteries
5. Medial posterior choroidal artery
6. Hippocampal artery
7. Anterior temporal artery
8. Middle temporal artery

P2P segment
9. Posterior temporal artery
10. Lateral posterior choroidal artery

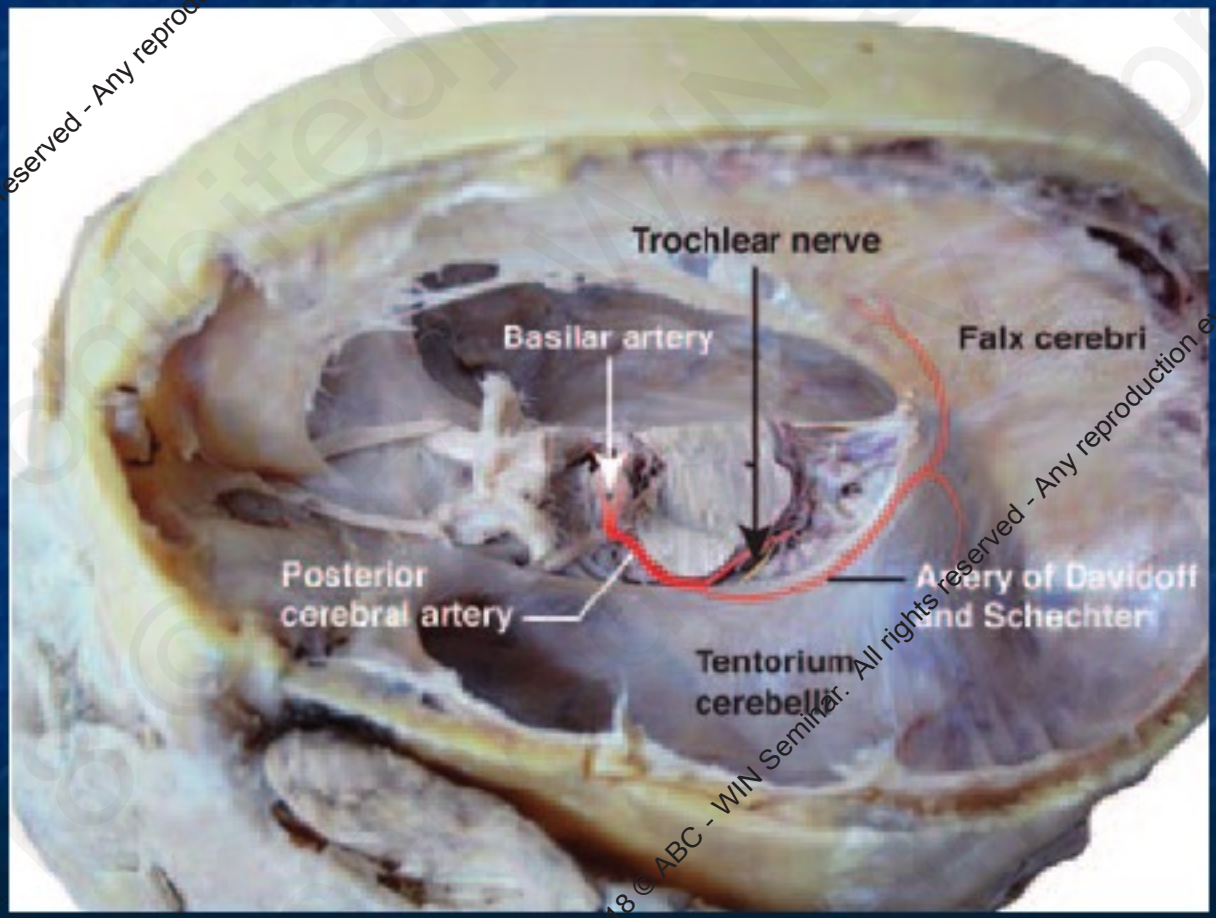
P3 and P4 segment
11. Calcarine artery
12. Parieto-occipital artery

t Am J Neuroradiol 22:27–34, January 2001

Aneurysms of the Posterior Cerebral Artery: Classification and Endovascular Treatment

Elisa F. Ciceri, Richard P. Klucznik, Robert G. Grossman, James E. Rose, and Michel E. Mawad

PCA also supplies adjacent tentorium – Artery of Davidoff and Schechter



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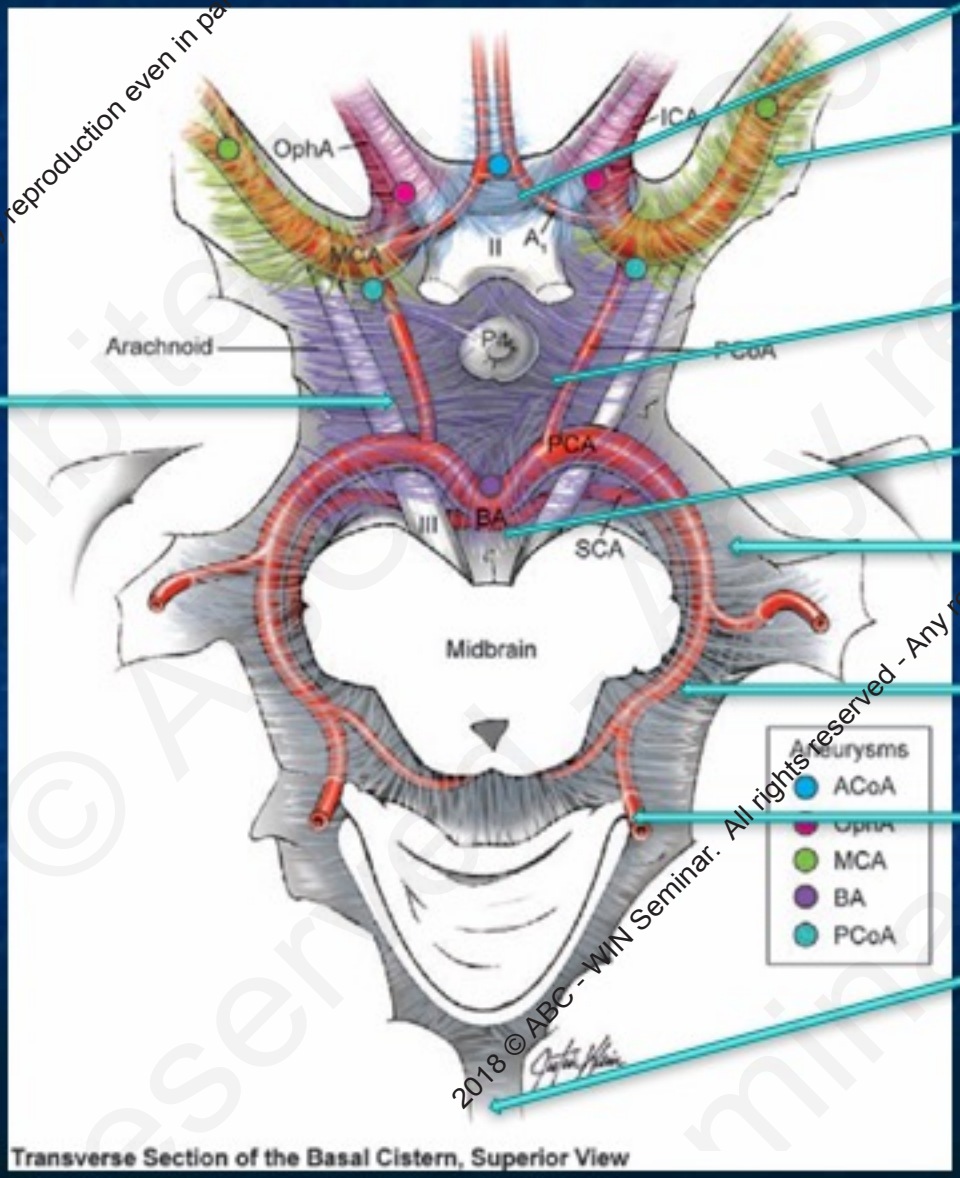
Cisterns around the midbrain



Transverse Section of the Basal Cistern, Superior View

Suprachiasmatic

Sylvian

Membrane of Liliquest

Suprasellar

Interpeduncular

Crural

Ambient

Quadrigeminal

Interhemispheric

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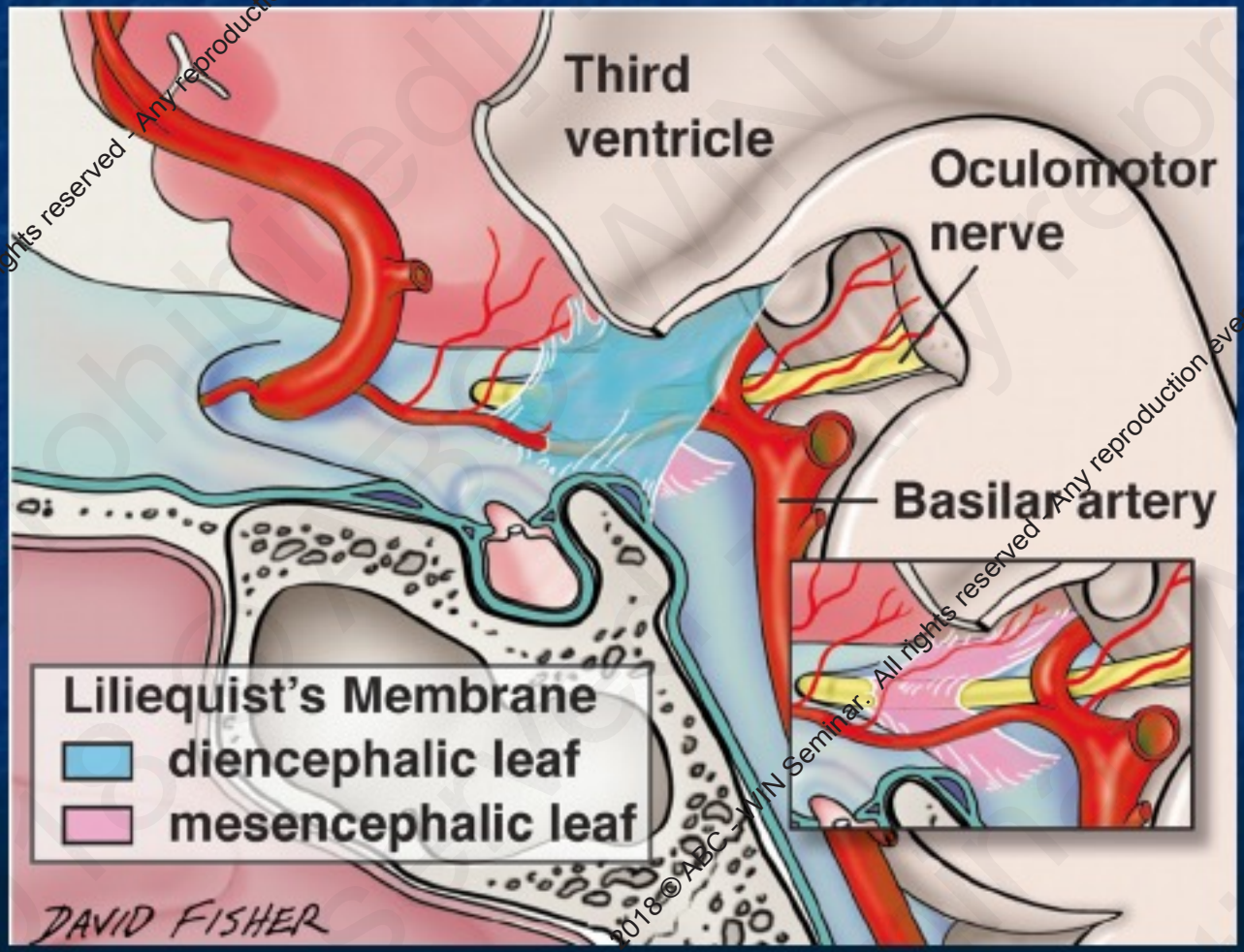
Membrane of Liliequist

The separator of anterior versus posterior circulation



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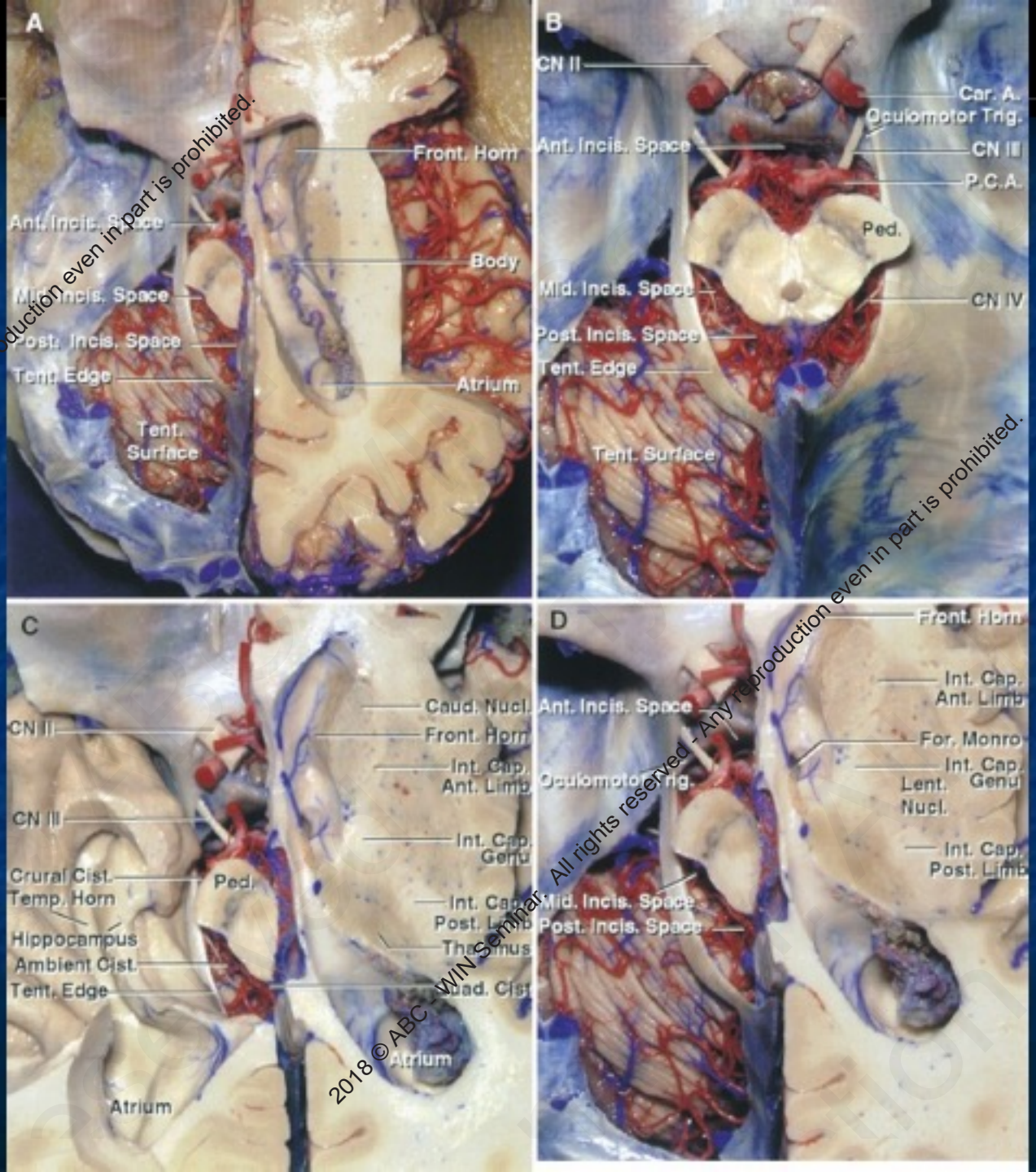

Albert Rhoton - Atlas of Neurosurgical anatomy

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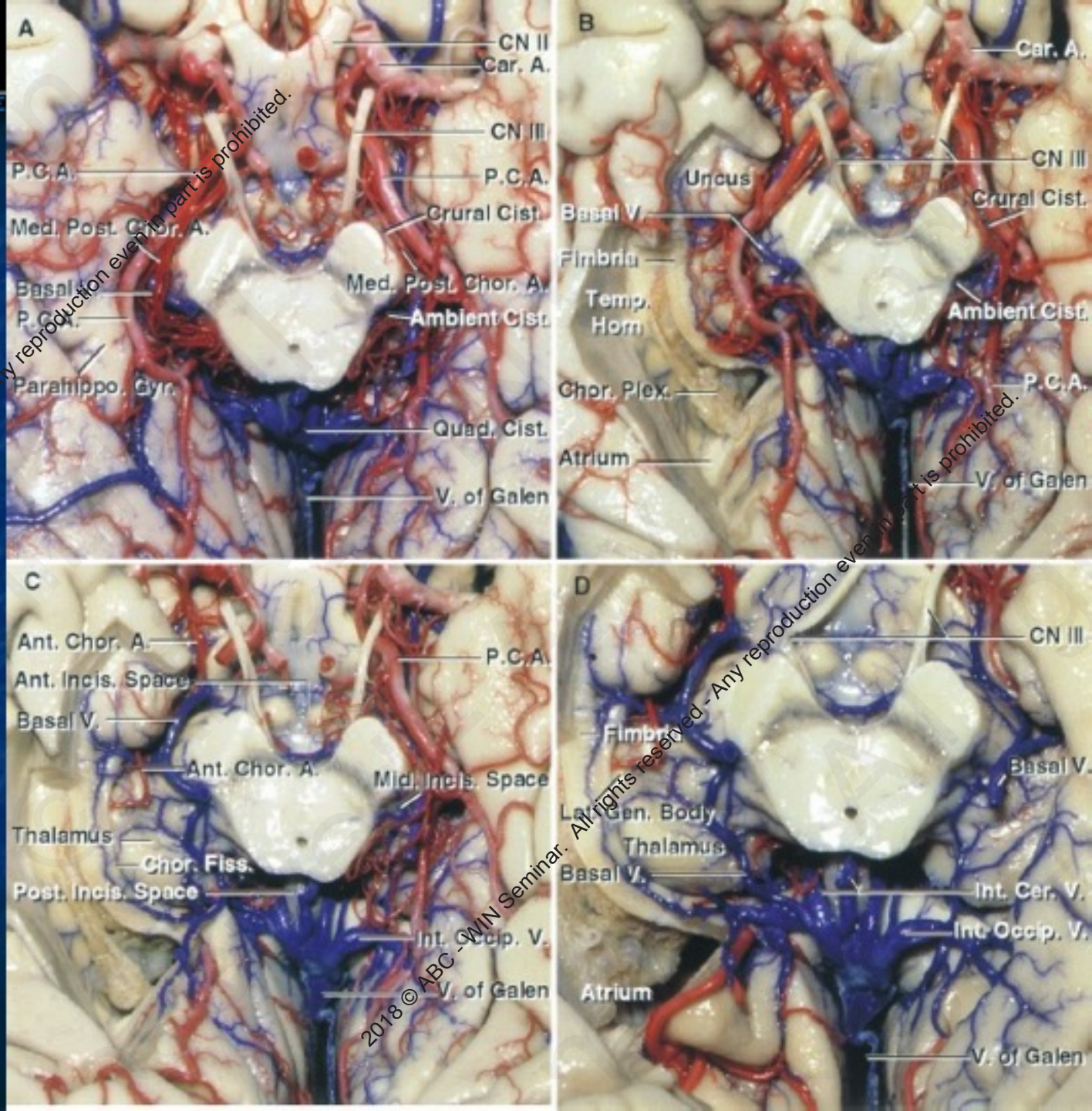

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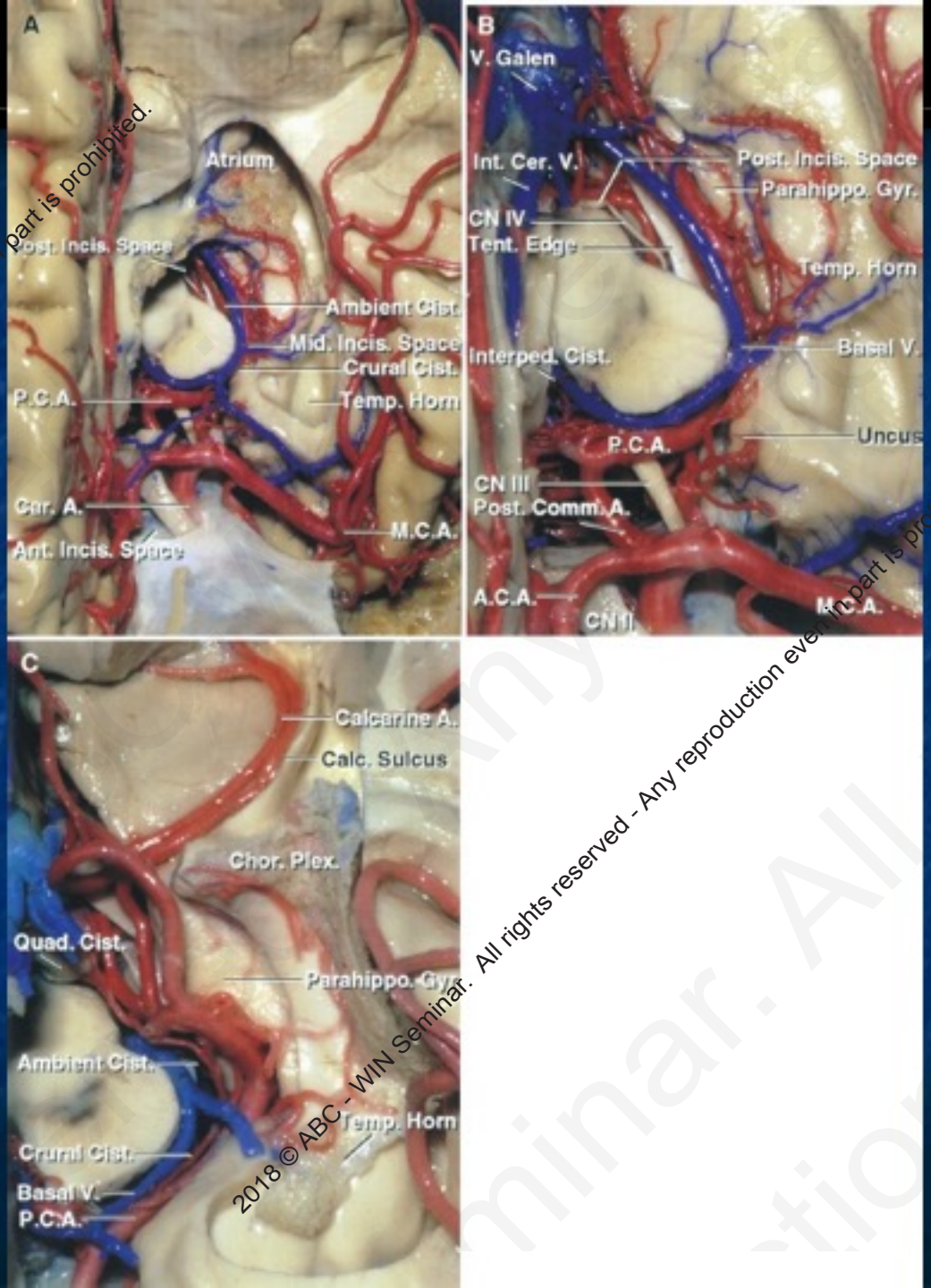

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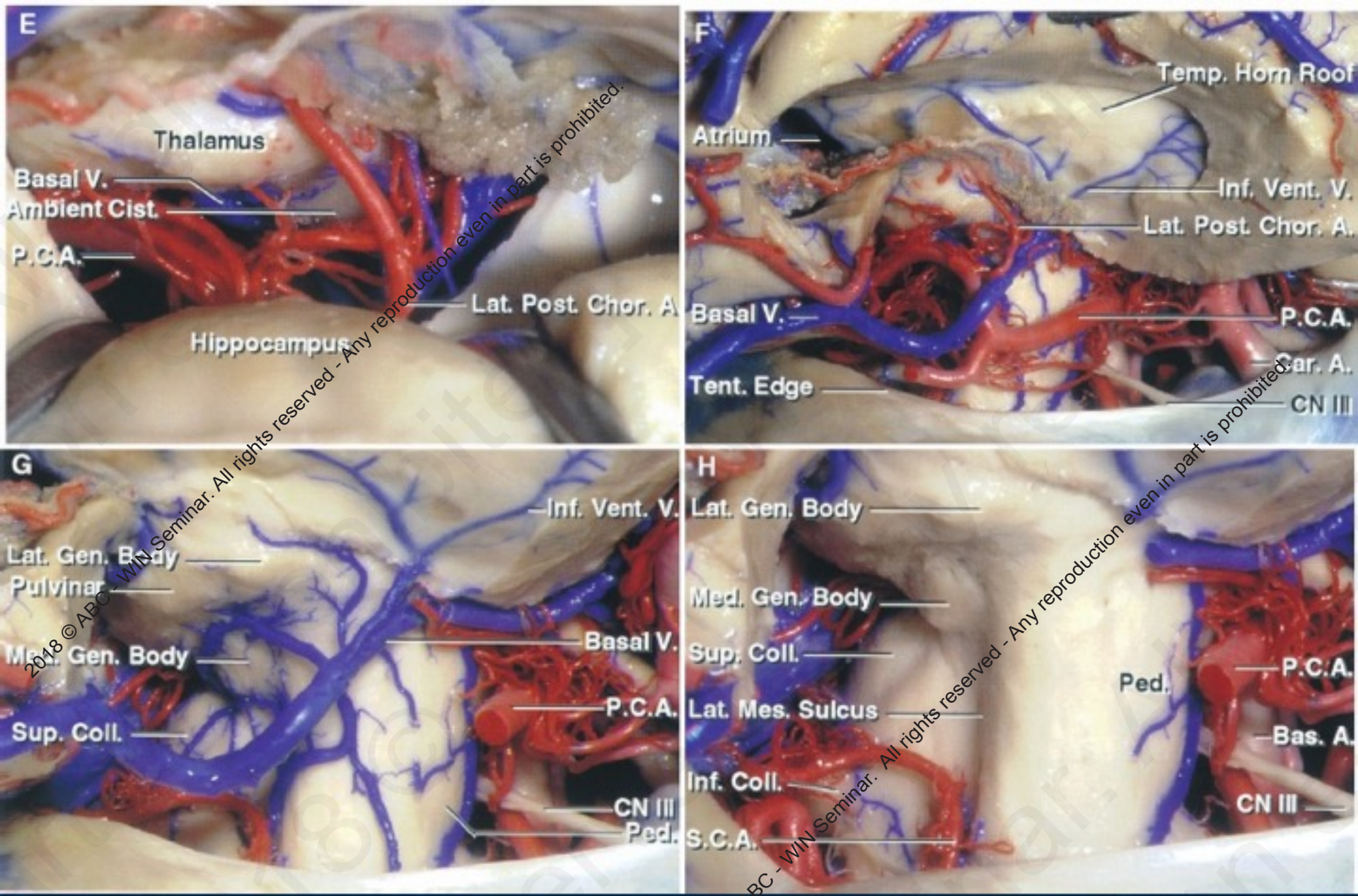

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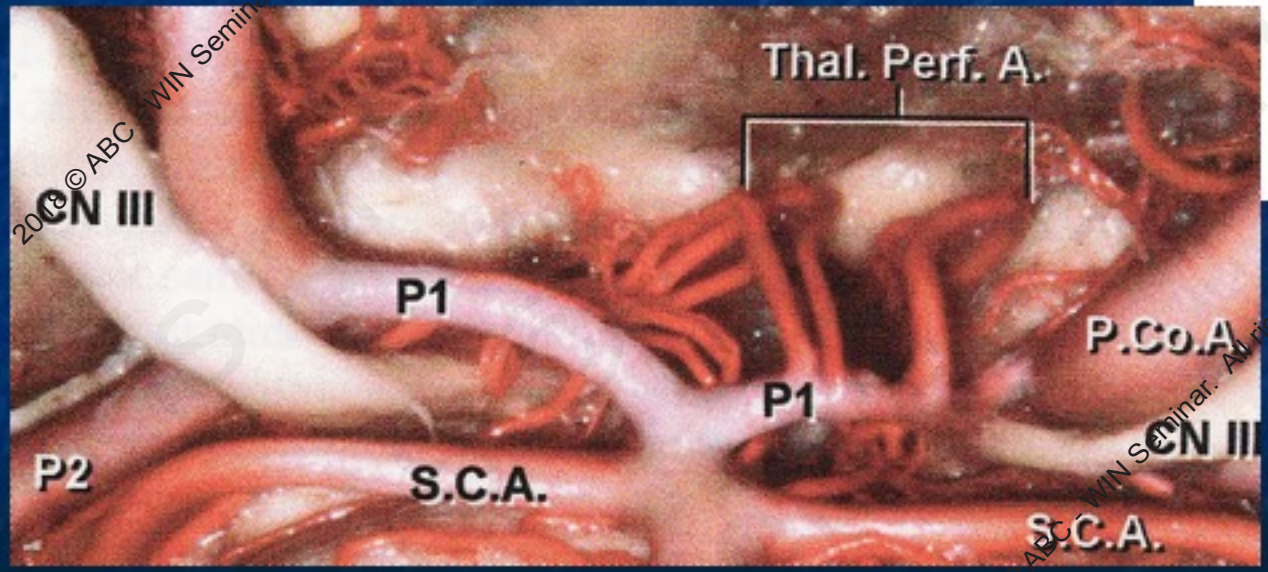
P1 SEGMENT OF POSTERIOR CEREBRAL ARTERY

- Posterior thalamoperforators
- Long circumflex
- Short Circumflex



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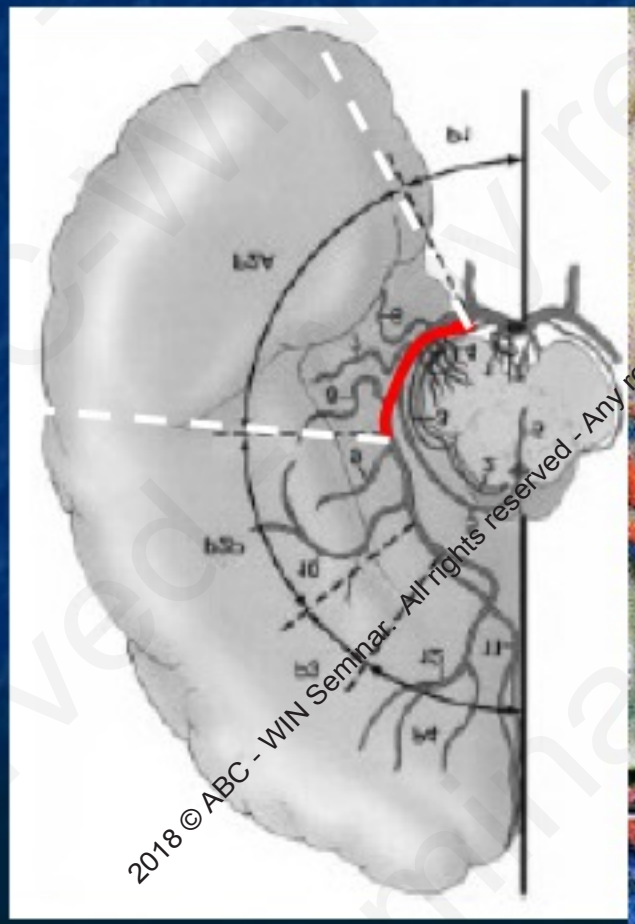
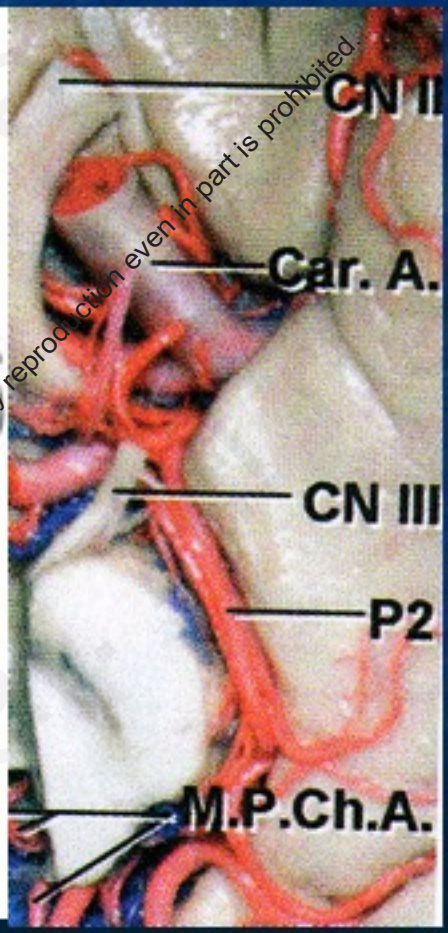
P2A SEGMENT OF POSTERIOR CEREBRAL ARTERY

- Courses in peduncular & ambient cisterns
  - Inferior to BVOR
  - Inferior to optic tract
  - Peduncular perforators
  - Short and long circumflex arteries
  - Posterior medial Choroidal artery





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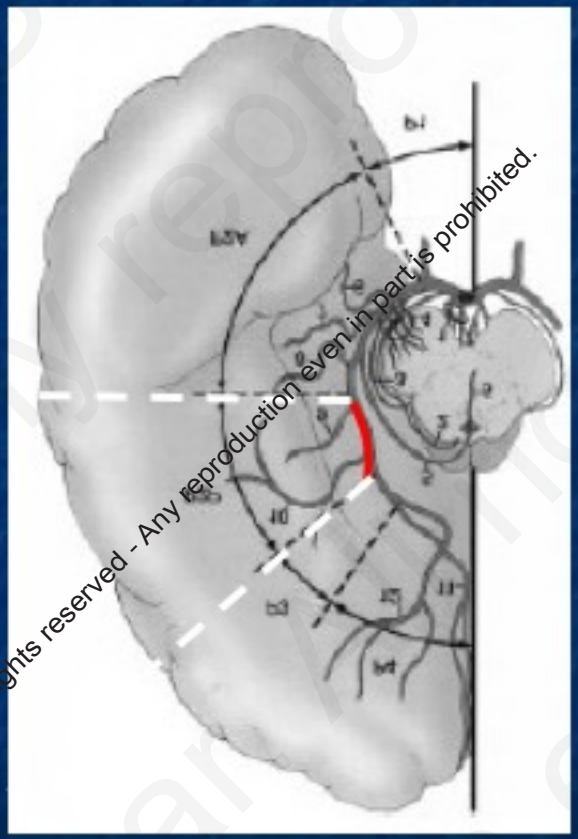
P2P SEGMENT OF POSTERIOR CEREBRAL ARTERY

- Begins at posterior margin of cerebral peduncle
  - Parallel & inferior to BVOR & optic tract
  - Inferolateral to geniculate bodies & pulvinar
  - Superomedial to trochlear nerve & tentorial edge
  - Thalamogeniculate perforators
  - Short and long Circumflex perforators
  - Posterior Lateral Choroidal artery



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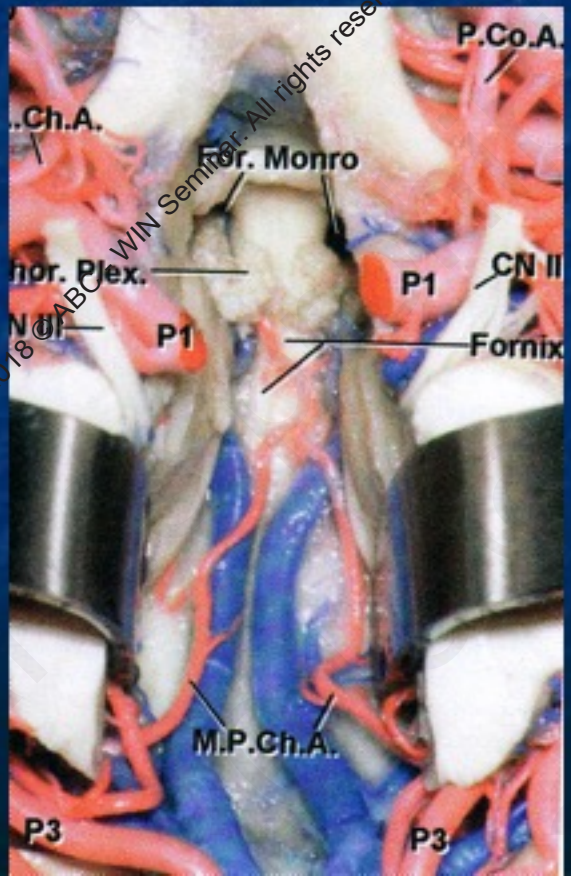
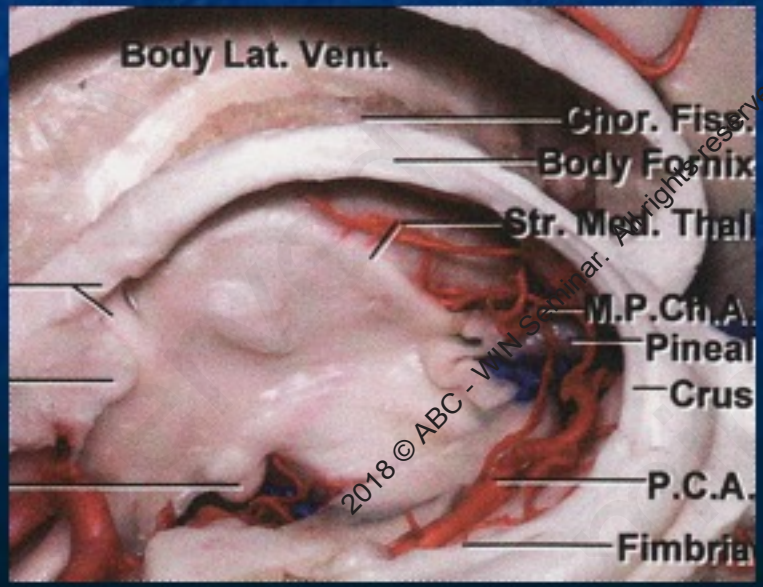
P2 Ventricular Branches

Medial posterior choroidal artery
Encircles midbrain

Runs anterior & lateral to pineal to enter Tela choroidea and course to foramen of Monro





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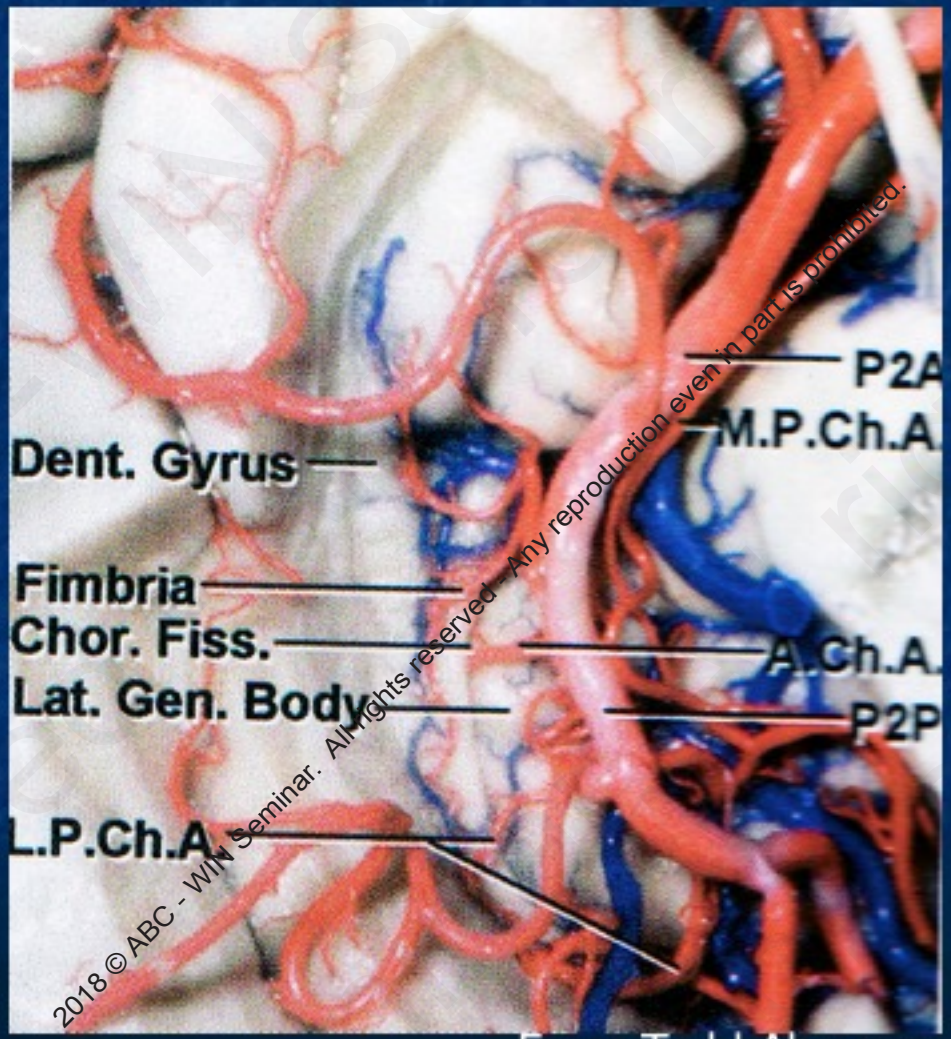
P2 Ventricular Branches

- Lateral posterior choroidal artery
- Passes over Pulvinar through choroidal fissure to enter lateral ventricle

Anastomoses with AChA near choroidal fissure



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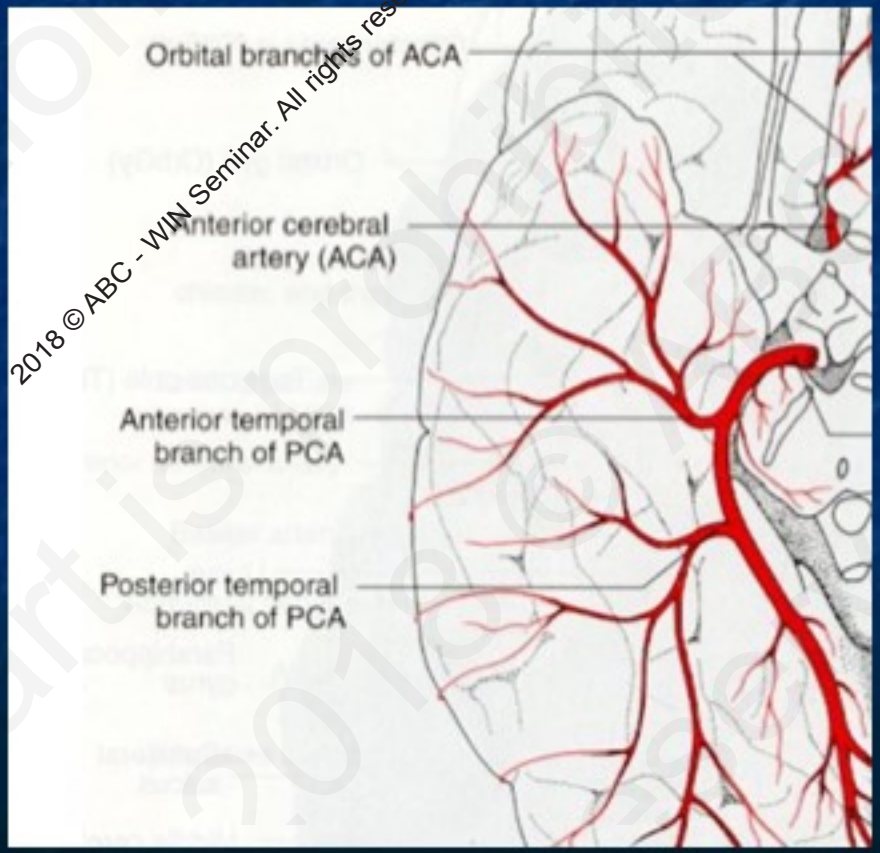
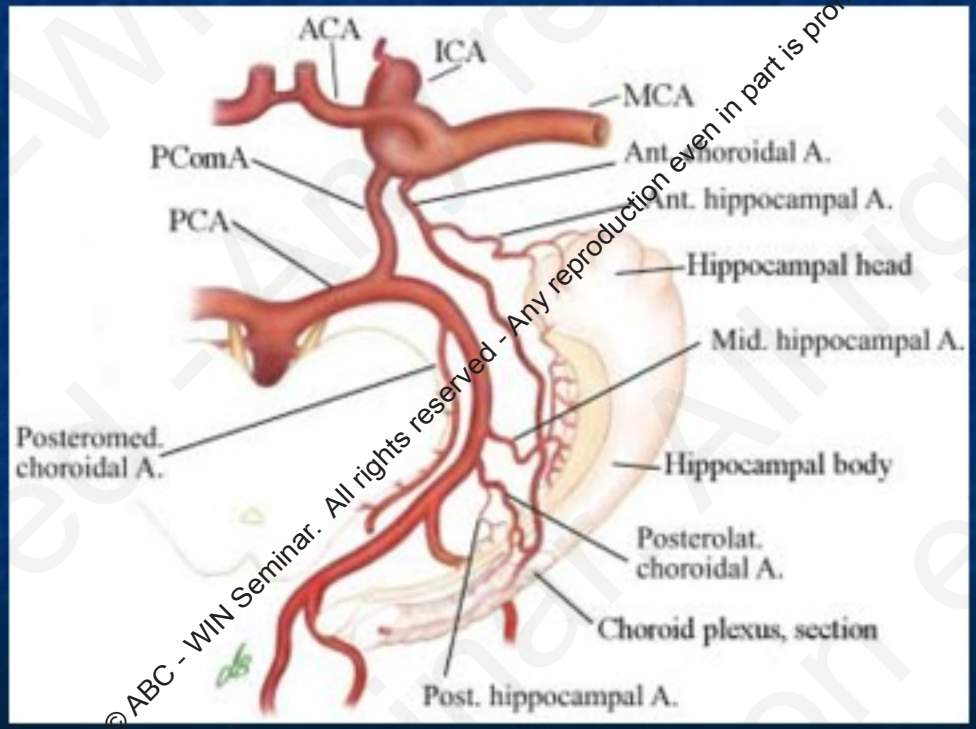
P2 Cortical Branches

1. Hippocampal artery (P2A)
2. Anterior temporal artery (P2A)
3. Middle temporal artery (P2A)
4. Posterior temporal artery (P2P)
5. Splenial or posterior pericallosal arteries





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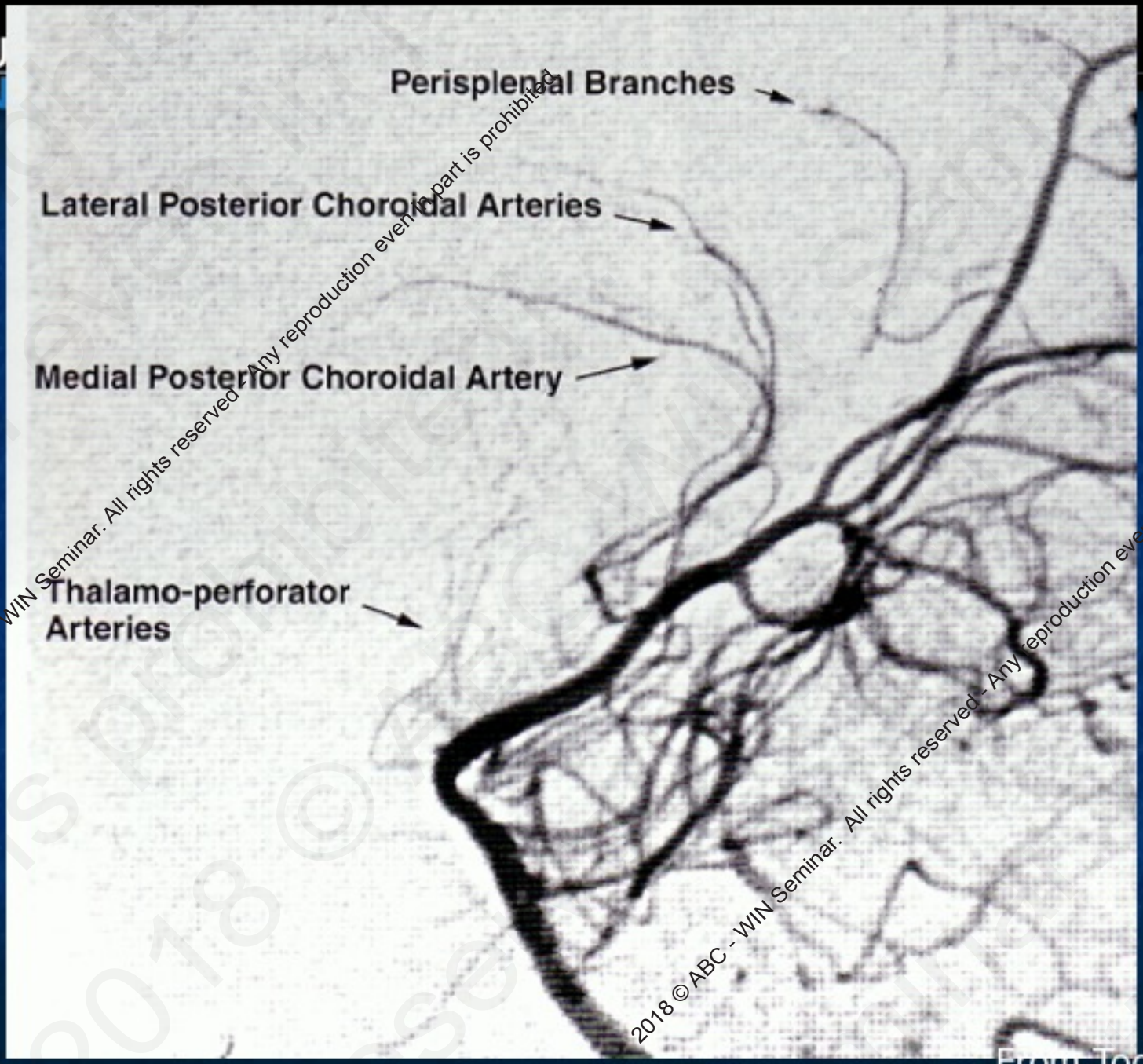

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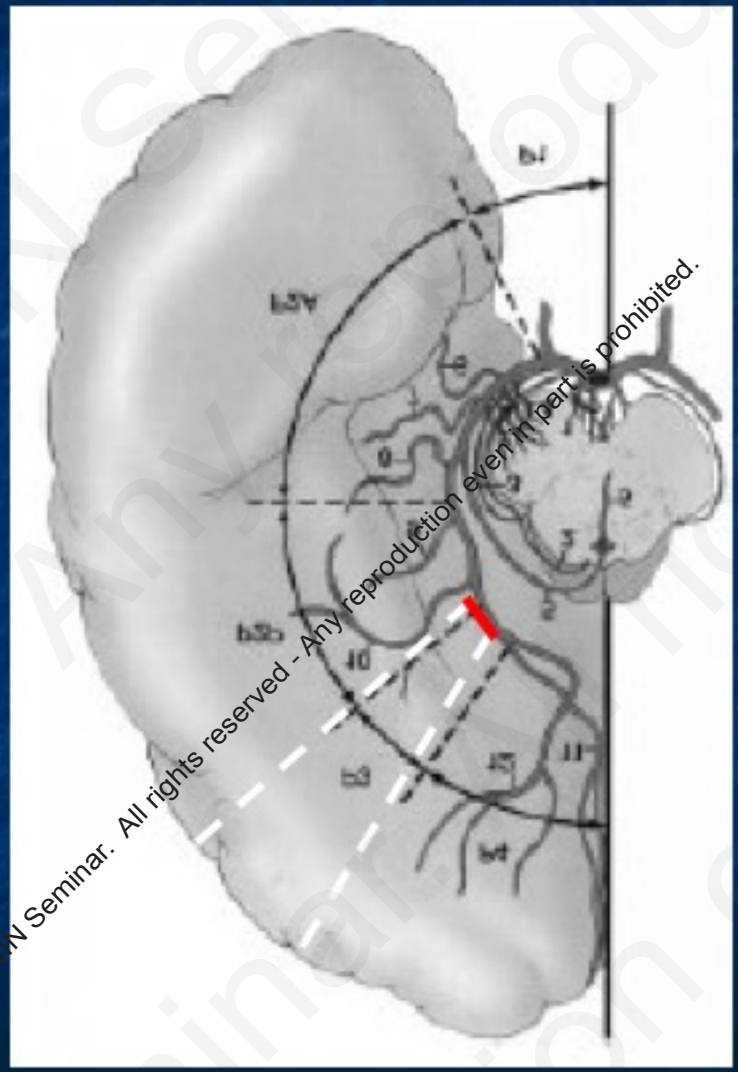
P3 SEGMENT OF POSTERIOR CEREBRAL ARTERY

- Originates in lateral aspect of Quadrigeminal cistern just distal to origin of Posterior temporal artery
- Terminates at anterior limit of Calcarine fissure



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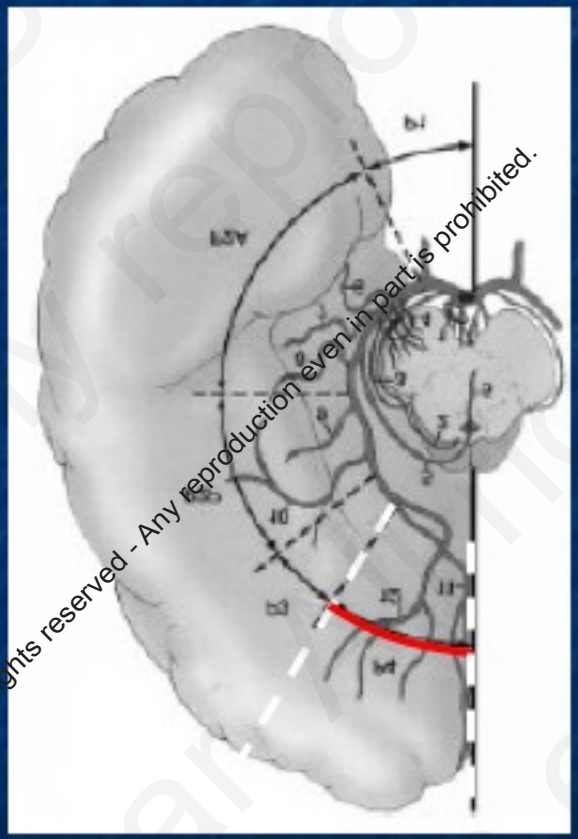
P4 SEGMENT OF POSTERIOR CEREBRAL ARTERY

- Consists of terminal cortical branches
  - Parieto-occipital artery
  - Calcarine artery



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PCA COLLATERALS

- Anterior Choroidal Artery
- Superior Cerebellar Artery
- Anterior cerebral artery
- Middle cerebral artery

Brain

The Independent Predictive Utility of Computed Tomography Angiographic Collateral Status in Acute Ischaemic Stroke

Ferdinand Miteff; Christopher R. Levi; Grant A. Bateman; Neil Spratt; Patrick McElduff; Mark W. Parsons

DISCLOSURES | Brain. 2009;132(8):2231-2238.

BRAIN

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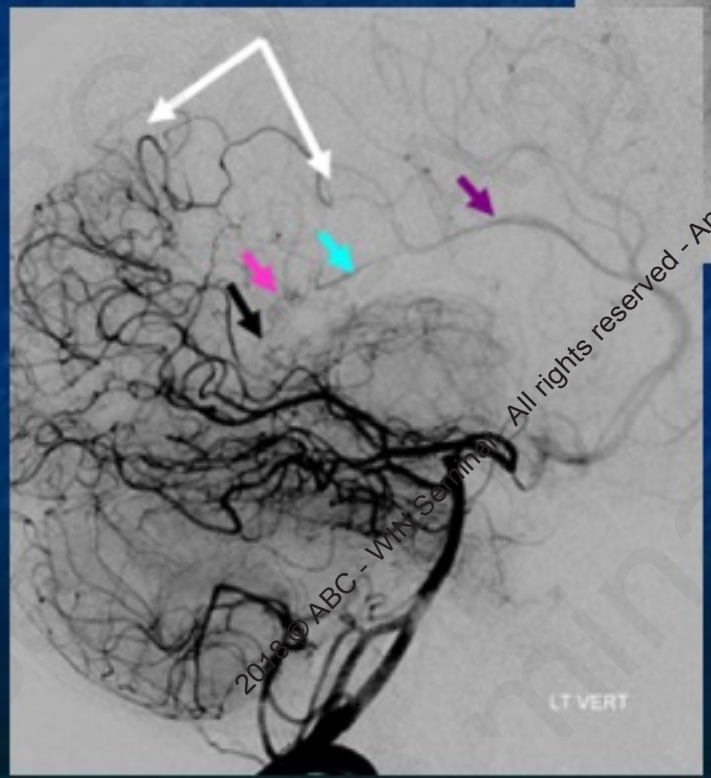
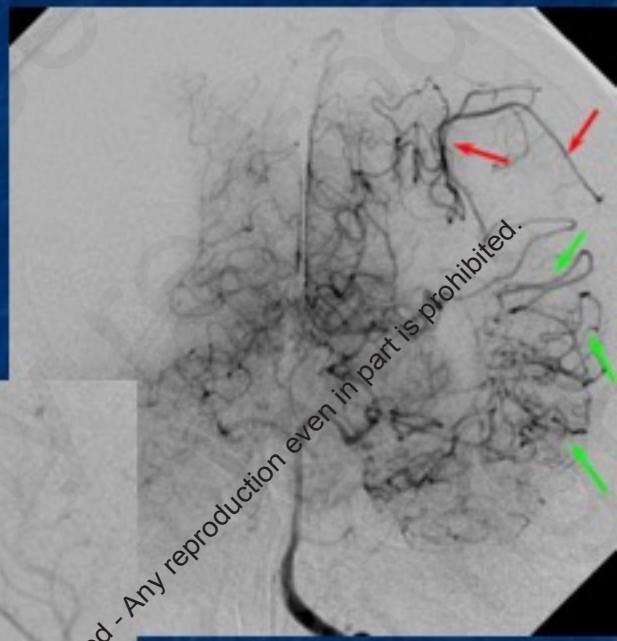
Collateral Supply

- Collaterals formed through the choroidal vessels become important in treating aneurysms of the P2 segment
- Long circumflex arteries of P1 segment and the superior cerebellar artery territory at quadrigeminal plate
- Splenial branches of ACA and PCA (at P3-4 segments) and leptomeningeal collaterals from ACA and MCA





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PCA ANEURYSMS

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Incidence and Prevalence

- Uncommon aneurysms with incidence < 1%
- Occur frequently in younger individuals with average age 38 yrs

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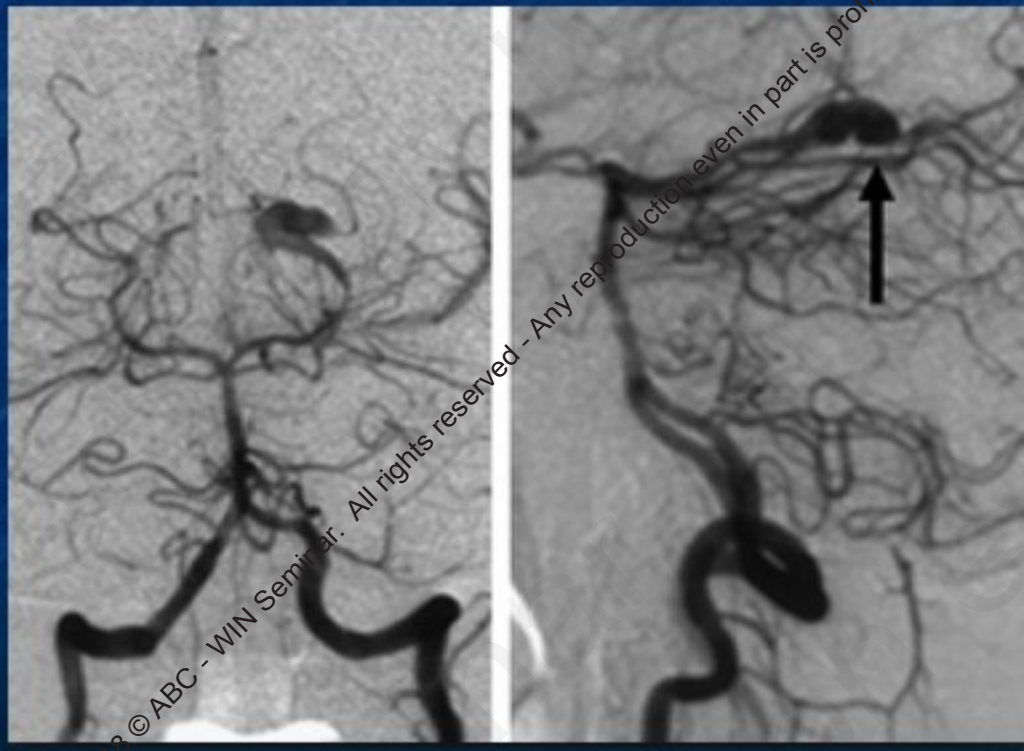
Types of Distal PCA Aneurysms

- Dissecting aneurysms 51%
  - Serpentine aneurysms 32
  - Fusiform aneurysms 9%
- Saccular aneurysms 8%



Aneurysms of the Posterior Cerebral Artery: Classification and Endovascular Treatment

Elisa F. Ciceri, Richard P. Klucznik, Robert G. Grossman, James E. Rose, and Michel E. Mawad

American Journal of Neuroradiology January 2001, 22 (1) 27-34;

TABLE: Summary of 20 patients with 21 PCA aneurysms

Case	Age (y)/Sex	PCA Segment	Nature	SAH	Treatment	Complications	Clinical Follow-up
1	21/F	P1	GSA	−	PAO	None	GOS 1
2	50/F	P1	Berry	+ from Pcom	GDC	None	GOS 1
3	43/M	P1	Berry	+	GDC	None	GOS 1
4	56/F	P1	Berry	−	GDC	None	GOS 1
5	49/F	P1	Berry	−	GDC	Perforation	GOS 1
6	78/F	P1	Berry	−	GDC	None	GOS 1
7	64/M	P1	Berry	+	GDC	None	GOS 1
8	56/F	P1-P2 junct.	Berry	+ from MCA	GDC	None	GOS 1
9	49/F	P1-P2 junct. P2 P	Berry				
10	41/F	P1-P2 junct.	Berry	−	GDC	None	GOS 1
11	17/M	P1-P2 junct.	Dissecting	−	GDC	None	GOS 1
12	64/M	P1-P2 junct.	Berry	+	GDC	None	GOS 3
13	13/M	P1-P2 junct.	Dissecting	+	GDC	None	GOS 1
14	12/M	P2 A	GSA	+	PAO	None	GOS 1
15	52/F	P2-P3 junct.	Berry	+	PAO	HHA	GOS 1
16	58/M	P2-P3	GSA	−	PAO	PCA stroke, HHA, CVA	GOS 1
17	52/F	P2-P3 junct.	Berry	+	PAO	None	GOS 1
18	56/F	P3	GSA	−	PAO	None	GOS 1
19	57/M	P3	GSA	−	PAO	None	GOS 1
20	52/F	P3-P4	Berry	+	GDC	None	GOS 1

Note.—SAH = subarachnoid hemorrhage; GDC = Guglielmi detachable coils; GOS = Glasgow Outcome Scale; GSA = giant serpentine aneurysm; MCA = middle cerebral artery; Pcom = posterior communicating artery; CVA = cerebrovascular accident; PAO = parent artery occlusion; HHA = homonymous hemianopsia.

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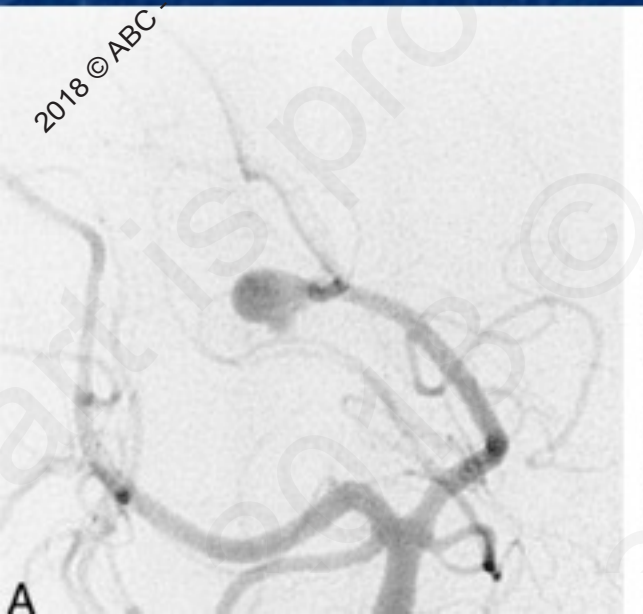
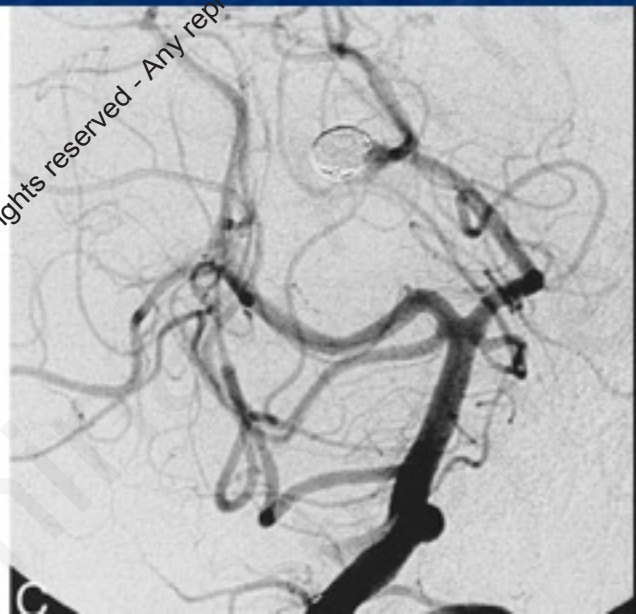
Dissecting Aneurysms

Most commonly found at the P2 segment likely caused by shear along the tentorium presenting at the P1-2 or P2-3 junctions





Saccular Aneurysms

- Saccular aneurysms
  - Largely found at bifurcations
  - Tend to have branching vessels in P2-3 segment aneurysms

Nakatomi et. al

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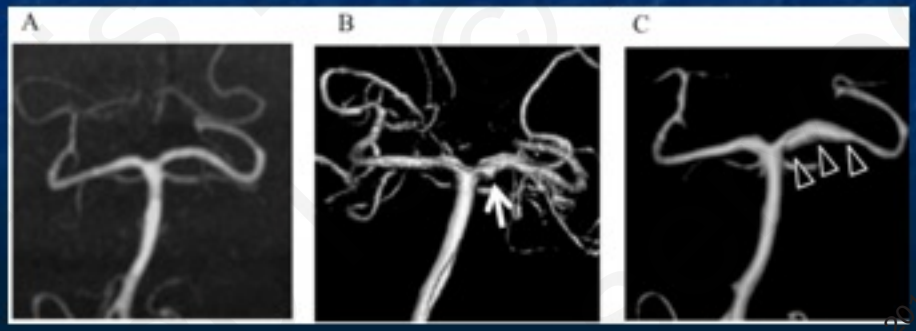
Fusiform Aneurysms

- Fusiform aneurysms: acute dissecting or chronic/dolichoectatic
- Fragmentation of internal elastic lamina and damage to the reticular network of the tunica media are involved in pathophysiology of aneurysm formation



Nakatomi et. al

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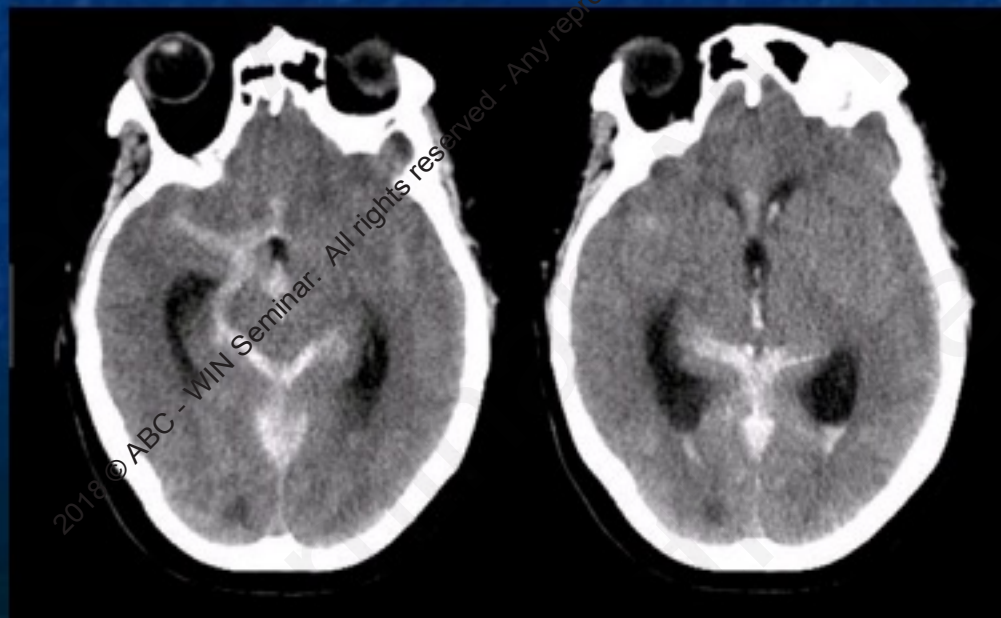
Clinical Presentation

- Most commonly present with subarachnoid hemorrhage (41%)
- Choroidal artery aneurysms can present with IVH only
- Large aneurysms tend to present with symptoms of brainstem compression and mass effect
- Pia and Fontana et all reported 27% incidence of visual disturbance on presentation



Li et al 2011

Characteristics of Posterior Cerebral Artery Aneurysms: An Angiographic Analysis of 93 Aneurysms in 81 Patients

Felix Goehre, MD*‡
Behnam Rezai Jahromi, MB‡
Juha Hernesniemi, MD, PhD‡
Ahmed Elsharkawy, MD§
Riku Kivisaari, MD, PhD‡
Mikael von und zu Fraunberg, MD, PhD¶
Juha Jääskeläinen, MD, PhD¶
Hanna Lehto, MD‡
Martin Lehecka, MD, PhD‡

TABLE 1. Characteristics and Distribution of 93 Aneurysms on the Posterior Cerebral Artery[a,b]

	P1 Aneurysms (n = 39)	P1/P2 Junction Aneurysms (n = 25)	P2 Aneurysms (n = 21)	P3 Aneurysms (n = 8)	Total (N = 93)
AVM association, no. (%)	9 (23)	2 (8)	3 (14)	0	14 (15)
Rupture state, no. (%)					
Ruptured	9 (23)	9 (36)	5 (24)	6 (75)	29 (31)
Unruptured	30 (77)	16 (64)	16 (76)	2 (25)	64 (69)
Saccular aneurysm size distribution, no. (%)	31 (79)	20 (80)	12 (57)	6 (75)	—
Small (<7 mm)	28 (90)	14 (70)	7 (58)	4 (67)	—
Medium (7-14 mm)	3 (10)	4 (25)	2 (17)	1 (17)	—
Large (15-24 mm)	0	2 (10)	1 (8)	0	—
Giant (>25 mm)	0	0	1 (8)	1 (17)	—
Saccular aneurysms unruptured, no. (%)	26 (67)	11 (44)	9 (43)	2 (25)	48 (52)
Length, mm, median (range)	5 (1-12)	5 (2-21)	4 (2-36)	3 and 35	3 (1-36)
Width, mm, median (range)	2 (2-8)	3 (2-18)	3 (2-36)	3 and 24	3 (2-36)
Neck, mm, median (range)	2 (1-10)	2 (2-14)	2 (2-9)	3 and 8	2 (1-14)
Saccular aneurysms ruptured, no. (%)	5 (13)	9 (36)	3 (14)	4 (50)	21 (23)
Length, mm, median (range)	5 (2-9)	6 (2-17)	15 (11-21)	6 (3-9)	6 (2-25)
Width, mm, median (range)	4 (2-4)	6 (2-14)	9 (8-15)	4 (3-6)	4 (2-15)
Neck, mm, median (range)	3 (2-3)	4 (3-10)	6 (4-8)	3 (3-4)	3 (2-10)
Fusiform aneurysms unruptured, no. (%)	4 (10)	5 (20)	7 (33)	0	16 (17)
Length, mm, median (range)	5 (3-8)	10 (2-16)	8 (5-40)	—	8 (2-40)
Diameter, mm, median (range)	3 (2-14)	10 (2-32)	5 (5-20)	—	5 (2-32)
Fusiform aneurysms ruptured, no. (%)	4 (10)	0	2 (10)	2 (25)	8 (9)
Length, mm, median (range)	8 (3-9)	—	7 and 37	12 and 13	8.5 (3-37)
Diameter, mm, median (range)	4 (2-6)	—	6 and 33	9 and 10	6 (2-33)

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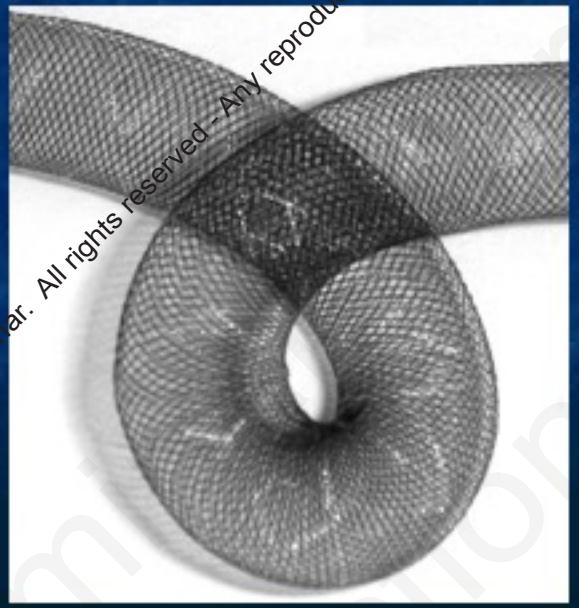
Treatment Modalities

- Endovascular
  - Coiling (balloon assisted and stent assisted)
  - Parent vessel sacrifice
  - Flow diversion
- Microsurgery
  - Clip reconstruction
  - Clip wrapping
  - Trapping and bypassing



Treatment Considerations

- Fetal versus adult circulation
- Location of aneurysm (P1-2/P2-3/P3-4)
- Type of Aneurysm
- Presentation
- Patient characteristics

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Dissecting Aneurysms

- Endovascular options
  - Flow diversion
  - Stent +/- coiling
  - Parent artery occlusion
- Microsurgical options
  - Primary clip reconstruction
  - Clip wrapping
  - Trapping and bypassing

Endovascular options

- Endovascular Considerations
  - Access
    - Type of arch
    - Dominance of the vertebral artery
    - Transradial versus transfemoral
  - Location of the aneurysm on PCA tree
  - Perforators
  - Distal access
  - Size of vessel

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Endovascular Treatment of the Posterior Cerebral Artery Aneurysms: Single-Center Experience and a Systematic Review

Carmelo Lucio Sturiale[1], Chiara De Waure[2], Giuseppe Maria Della Pepa[1], Giovanna Elisa Calabrò[2], Alessio Albanese[1], Francesco D'Argento[3], Eduardo Fernandez[1], Alessandro Olivi[1], Alfredo Puca[1], Alessandro Pedicelli[3], Enrico Marchese[1]

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Sturiale et al, 2016

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Table 1. Demographic, Angiographic, and Clinical Data of the Studies Included in the Systematic Review. A Pooled Analysis is Shown in the Last Row

Reference	Number of Patients/ Aneurysms	Male/ Female Ratio	Mean Age (Range)	Aneurysm Type	Segment Involved	Aneurysms Size	Number (%) of Ruptured Aneurysms	Number (%) of Patients Who Underwent PAO	Number (%) of Patients with GR
Arnou et al., 2007[1]	9/9	5/4	45.8 (23–76)	3 S; 6 F	2 P2; 7 n.r.	9 n.r.	4 (44.4)	6 (66.6)	6 (66.6)
Arat et al., 2002[7]	8/8	6/2	37.6 (17–61)	4 S; 4 F	6 P2; 2 P3	2 Sm; 4 Lg; 1 Gt; 1 n.r.	3 (37.5)	8 (100)	7 (87.5)
Ciceri et al., 2001[8]	20/21	8/12	44 (13–78)	13 S; 2 D; 5 Srp; 1 n.r.	7 P1; 8 P2; 5 P3; 1 P4	21 n.r.	8 (38.1)	7 (33.3)	19 (95)
Cui et al., 2009[9]	7/7	5/2	38.5 (4–58)	2 S; 5 D	1 P1; 6 P2;	2 Sm; 5 Lg	4 (57.1)	7 (100)	5 (71.4)
Guglielmi et al., 1992[6]	5/5	1/4	42.6 (34–46)	5 S	4 P1; 1 P2	2 Sm; 1 Lg; 2 Gt	2 (40)	0	5 (100)
Hallacq et al., 2002[7]	10/10	5/5	43 (18–70)	5 S; 4 F; 1 Srp	10 P2	5 Lg; 5 Gt	2 (20)	9 (90)	9 (90)
Kashiwazaki et al., 2011[5]	21/21	7/14	60.9 (33–68)	16 S; 1 F; 1 D; 3 Srp	3 P1; 9 P2; 6 P3; 3 P4	14 Sm; 6 Lg; 1 Gt	15 (71.4)	9 (42.8)	12 (57.1)
Kim et al., 2013[9]	10/10	4/6	53.2 (11–75)	9 S; 1 F	2 P1; 5 P2; 3 P4	8 Sm; 2 Lg	4 (40)	2 (20)	8 (80)
Li et al., 2008[10]	18/18	12/6	39 (4–65)	10 S; 4 F; 4 Srp	5 P1; 11 P2; 2 P3	18 n.r.	9 (50)	5 (27.7)	11 (61.1)
Limaye et al., 2012[11]	9/9	5/4	40.2 (18–55)	9 n.r.	4 P1; 5 P2	9 n.r.	0	8 (88.8)	6 (66.6)
Liu et al., 2001[12]	12/12	7/5	44 (16–73)	1 F; 7 D; 4 Srp	9 P2; 3 P3	5 Sm; 7 Lg	5 (41.6)	12 (100)	11 (91.6)
Luo et al., 2011[13]	10/10	3/7	47.1 (18–66)	2 S; 2 F; 6 D	6 P2; 4 P3	4 Sm; 5 Lg; 1 Gt	7 (70)	6 (60)	6 (60)
Lv et al., 2012[14]	19/20	10/9	40.1 (5–71)	4 S; 16 D	18 P2; 2 P3	3 Sm; 15 Lg; 2 n.r.	4 (20)	20 (100)	16 (84.2)
Onan et al., 2009[15]	7/7	2/5	46 (36–58)	4 F; 3 D	7 n.r.	7 n.r.	7 (100)	4 (57.1)	5 (71.4)
Roh et al., 2008[16]	13/17	5/8	44 (20–67)	8 S; 7 F; 2 D	3 P1; 1 [illegible]; 2 [illegible]; 7 P4	11 Sm; 6 Lg	10 (58.8)	10 (58.8)	11 (84.6)
Taqi et al., 2011[17]	7/7	2/5	37 (5–62)	7 D	P2; 3 P3	2 Sm; 4 Lg; 1 Gt	6 (85.7)	3 (42.8)	0 (0)
van Rooij et al., 2006[18]	22/22	8/14	49.4 (27–72)	17 S; [illegible] 2 F	1 P1; 17 P2; 1 P3; 3 P4	19 Sm; 2 Lg; 1 Gt	10 (45.4)	5 (22.7)	18 (81.8)
Wang et al., 2011[19]	24/24	14/10	n.r. (4–65)	S; 13 F	5 P1; 17 P2; 2 P3	9 Sm; 15 Lg + Gt	13 (54.1)	12 (50)	18 (75)
Zhao et al., 2008[20]	8/8	6/2	n.r. ([illegible])	4 S; 3 D; 1 Srp	7 P2; 1 P3	3 Sm; 2 Lg; 3 Gt	3 (37.5)	3 (37.5)	8 (100)
Zhao et al., 2012[21]	7/7	6/1	[illegible] (53–72)	4 S; 3 D	5 P1; 2 P2	5 Sm; 2 Lg	4 (57.1)	0	6 (85.7)
Institutional series	7/7	1/6	53.7 (16–75)	3 S; 2 F; 2 D	5 P2; 2 P3	4 Sm; 3 Lg	4 (57.1)	6 (85.7)	3 (42.8)
Pooled analysis	253/259	122/131	45.2±6.4 (4–78)	120 S; 39 F; 60 D; 18 Srp; 15 n.r.	40 P1; 159 P2; 35 P3; 11 P4; 14 n.r.	93 Sm; 69 Lg; 15 Lg + Gt; 15 Gt; 67 n.r.	124 (47.8)	142 (56.1)	190 (75.1)

GR, good recovery according to the Glasgow Outcome Scale; S, saccular; F, fusiform; n.r., not reported; Sm, small; Lg, large; Gt, giant; D, dissecting; Srp, serpentine.

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Table 2. Pooled Analysis of the Main Outcomes Reported in the 21 Included Studies, Grouped as Reported in the First Column

Outcome Measured	Cumulative		
	Raw Number	Percentage (95% Confidence Interval)	I^2 (%)
Bleeding			
Subarachnoid hemorrhage	124/253	49 (38–60)	61.26
Treatment			
Selective coiling	95/256	27 (13–44)	84.29
Spontaneous thrombosis	3/256	0 (0–2)	0.00
Stenting	2/256	0 (0–1)	0.00
Stent-assisted coiling	13/256	2 (0–8)	63.51
Parent artery occlusion	143/256	62 (44–78)	85.74
Aneurysm morphology			
Saccular	120/249	44 (30–58)	77.52
Fusiform	51/249	15 (6–27)	74.22
Dissecting	60/249	21 (8–38)	85.61
Serpentine	18/249	3 (0–8)	39.46
Angiographic outcome			
Immediate complete/near-complete occlusion	239/256	96 (91–1[illegible])	44.47
Complete/near-complete occlusion at follow-up	154/179	90 (82–97)	43.65
Complications			
Overall intraoperative complications	43/252	15 (9–21)	25.82
Thrombosis/transient hemiparesis	3/252	0 (0–1)	0.00
Stroke/permanent hemiparesis	14/252	2 (0–6)	18.99
Intraoperative rupture	[illegible]/252	0 (0–2)	0.00
Hemianopsia	23/252	7 (3–11)	0.00
Clinical outcome (Glasgow Outcome Scale)			
Mortality at follow-up	7/244	1 (0–4)	0.00
Vegetative state	1/244	0 (0–1)	0.00
Severe disability	10/244	1 (0–4)	1.51
Moderate disability	36/244	12 (7–18)	28.46
Good recovery	190/244	80 (73–86)	23.87

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Table 3. Outcomes Comparison Between Ruptured Versus Unruptured Aneurysms

Outcome	Ruptured			Unruptured			*P* Value
	Raw Number	Percentage (95% Confidence Interval)	I^2 (%)	Raw Number	Percentage (95% Confidence Interval)	I^2 (%)	Ruptured Versus Unruptured
Treatment							
Selective coiling	47/124	29 (13–46)	66.43	43/131	28 (12–47)	70.87	0.40
Spontaneous thrombosis	1/124	0 (0–2)	0.00	2/131	0 (0–2)	0.00	0.59
Stenting	2/124	0 (0–2)	0.00	0/131	0 (0–1)	0.00	0.14
Stent-assisted coiling	6/124	1 (0–6)	33.67	7/131	1 (0–6)	21.31	0.85
Parent artery occlusion	68/124	59 (42–75)	61.36	75/131	60 (37–81)	79.68	0.70
Aneurysm morphology							
Saccular	57/115	46 (29–63)	60.46	56/104	52 (34–71)	60.79	0.53
Fusiform	23/115	15 (6–25)	19.97	22/104	12 (2–27)	59.26	0.83
Dissecting	27/115	21 (8–38)	64.18	18/104	14 (1–32)	69.70	1.26
Serpentine	7/115	2 (0–7)	0.00	11/104	4 (0–12)	0.00	0.23
Angiographic outcome							
Immediate complete/near-complete occlusion	117/123	99 (95–100)	0.00	121/132	97 (91–100)	0.00	0.27
Complete/near-complete occlusion at follow-up	59/71	91 (74–100)	47.48	51/68	82 (66–95)	29.01	0.33
Complications							
Overall intraoperative complications	22/107	17 (9–27)	0.00	16/102	10 (3–19)	0.00	0.36
Thrombosis/transient hemiparesis	2/107	0 (0–3)	0.00	1/102	0 (0–2)	0.00	0.59
Stroke/permanent hemiparesis	9/107	3 (0–9)	0.00	6/102	2 (0–7)	0.00	0.48
Intraoperative rupture	0/107	0 (0–1)	0.00	2/102	0 (0–3)	0.00	0.14
Hemianopsia	12/107	7 (2–15)	0.00	1/102	1 (0–7)	0.00	0.27
Clinical outcome (Glasgow Outcome Scale)							
Mortality at follow-up	5/114	1 (0–6)	0.00	2/111	0 (0–3)	0.00	0.26
Vegetative state	1/114	0 (0–2)	0.00	0/111	0 (0–1)	0.00	0.32
Severe disability	9/114	2 (0–8)	2.79	1/111	0 (0–2)	0.00	**0.01**
Moderate disability	21/114	14 (6–22)	0.00	12/111	6 (1–13)	0.00	0.11
Good recovery	78/114	71 (59–82)	23.86	96/111	91 (83–97)	0.00	**< 0.01**

Differences that were considered significant at *P* values are listed in bold type.

Table 4. Outcomes Comparison According to Selective and Nonselective Treatment

Outcome	Parent Artery Occlusion			Nonparent Artery Occlusion			*P* Value
	Raw Number	Percentage (95% Confidence Interval)	I^2 (%)	Raw Number	Percentage (95% Confidence Interval)	I^2 (%)	Parent Artery Occlusion Versus Nonparent Artery Occlusion
Treatment							
Saccular	31/117	30 (12–50)	73.34	86/117	70 (50–88)	73.34	**< 0.01**
Fusiform	44/51	96 (82–100)	7.81	7/51	4 (0–18)	7.81	**< 0.01**
Dissecting	51/60	87 (62–100)	65.12	8/60	10 (0–34)	64.02	**< 0.01**
Serpentine	18/18	100 (91–100)	0.00	0/18	0 (0–9)	0.00	**< 0.01**
Angiographic outcome							
Immediate complete/near-complete occlusion	158/239	74 (56–89)	84.97	81/239	26 (11–44)	84.97	**< 0.01**
Complete/near-complete occlusion at follow-up	97/136	78 (59–93)	74.91	41/136	25 (8–46)	79.71	**< 0.01**
Complications							
Overall intraoperative complications	31/43	79 (55–97)	43.14	12/43	21 (3–45)	43.14	**< 0.01**
Thrombosis/transient hemiparesis	2/3	72 (0–100)	18.94	1/3	28 (0–100)	18.94	1
Stroke/permanent hemiparesis	10/14	81 (42–100)	23.11	4/14	19 (0–58)	23.11	0.06
Intraoperative rupture	0/3	0 (0–62)	0.00	3/3	100 (38–100)	0.00	0.10
Hemianopsia	19/23	95 (73–100)	0.00	4/23	8 (0–32)	0.00	**< 0.01**
Clinical outcome (Glasgow Outcome Scale)							
Mortality at follow-up	3/7	38 (0–87)	0.00	4/7	62 (13–100)	0.00	1
Severe disability	8/10	86 (40–100)	28.49	2/10	14 (0–60)	28.49	0.02
Moderate disability	26/36	81 (60–96)	0.00	10/36	19 (4–40)	0.00	**< 0.01**
Good recovery	103/190	60 (38–80)	86.38	87/190	40 (20–62)	86.38	0.10

Differences that were considered significant at *P* values are listed in bold type.

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Endovascular treatment of posterior cerebral artery aneurysms: a single center's experience of 55 cases

*Xuanfeng Qin, MD, PhD, Feng Xu, MD, PhD, Yashengjiang Maimaiti, MD, Yongtao Zheng, MD, Bin Xu, MD, PhD, Bing Leng, MD, PhD, and Gong Chen, MD, PhD

TABLE 3. Endovascular treatment and angiographic results of PCA aneurysms*

Characteristic	Total	PCA Aneurysms	
		Saccular	Fusiform/ Dissecting
No. of patients	55	23 (41.8)	32 (58.2)
Treatment	55		
Selective embolization		21	1
Aneurysm & PA occlusion		2	18
PA occlusion		0	6
Aneurysm sac occlusion		0	2
Partial coiling of the aneurysm & PA		0	5
Initial angiographic results	55		
Complete occlusion		21 (91.3)	24 (75)
Nearly complete occlusion		2 (8.7)	0
Incomplete occlusion		0	8 (25)
Follow-up angiography	46	20	26
Complete occlusion		18 (90)	23 (88)
Nearly complete occlusion		2 (10)	0
Incomplete occlusion		0	3 (12)

TABLE 5. Clinical outcomes of patients with PCA aneurysms

GOS Score	No. of Patients	
	At Discharge	At Long-Term Follow-Up*
Saccular aneurysms		
5	18	21
4	4	0
1	1	0
Fusiform/dissecting aneurysms		
5	22	26
4	8	2
1	2	1

Qin et al, 2017

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Primary Coiling

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Factors Favoring Primary Coiling

- Saccular Etiology
- Straight access to allow for easier deployment
- Size
- Narrow neck

Aneurysms of the Posterior Cerebral Artery: Classification and Endovascular Treatment

Elisa F. Ciceri, Richard P. Klucznik, Robert G. Grossman, James E. Rose, and Michel E. Mawad

American Journal of Neuroradiology January 2001, 22 (1) 27-34;

FIG 3. Successful obliteration of a ruptured saccular aneurysm of the PCA with preservation of the parent artery.

A, The oblique subtracted view of a vertebral angiogram shows an irregular bilobed saccular aneurysm arising from the origin of the P3/P4 segments. The patient is a 52-year-old woman presenting with acute SAH.

B, The oblique nonsubtracted view of the posttreatment vertebral angiogram shows the cast of the GDC obliterating the aneurysm with preservation of the parent artery.

C, The oblique subtracted view of the follow-up vertebral angiogram, obtained 2 years after the treatment, shows persistent obliteration of the aneurysm.

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Primary Coiling
Case Presentation

- 68 year old female with no past medical history.
- Presented with HH 2 and worst headache of life with double vision.

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Key points:

- Primary coiling when possible is ideal
- Access is a determining factor in decision making

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Patient remained in ICU for 14 days monitored according to SAH protocol.

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Case

- 36 yo woman presents to remote outside hospital with SAH – Comatose
- Upon transfer, exam was dismal but not brain dead
- Ventriculostomy performed and patient improved somewhat
- Angiography and coiling the next day

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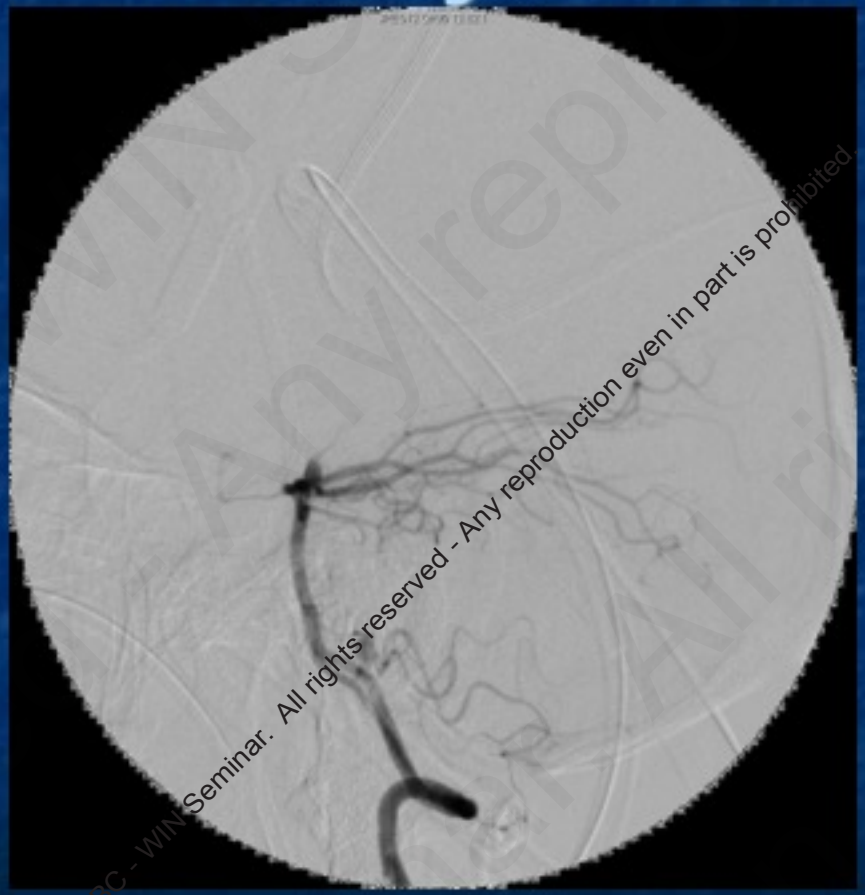
R PCA and L PICA Aneurysms



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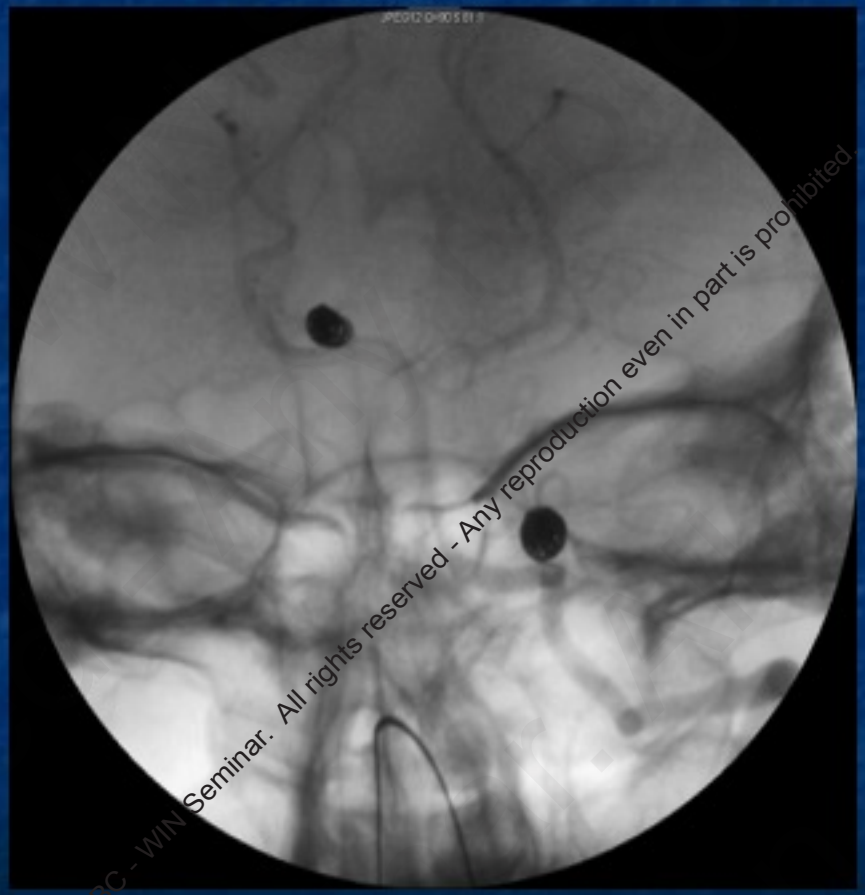
Coiling of Aneurysms



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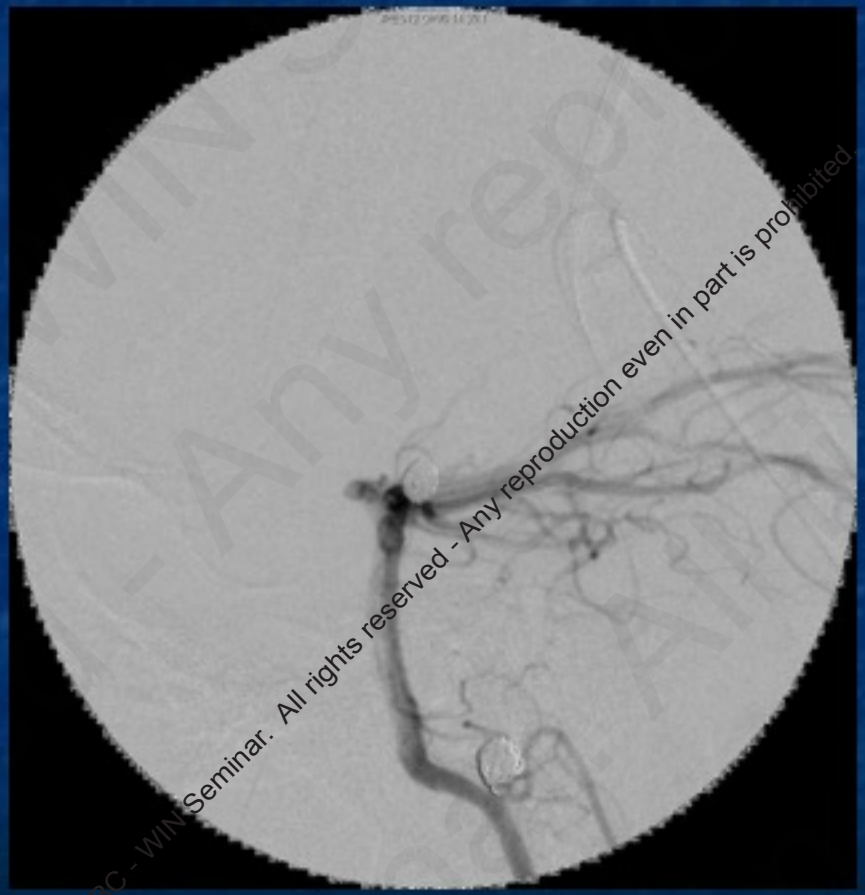
Coiling of Aneurysms



Flow related aneurysm - AVM

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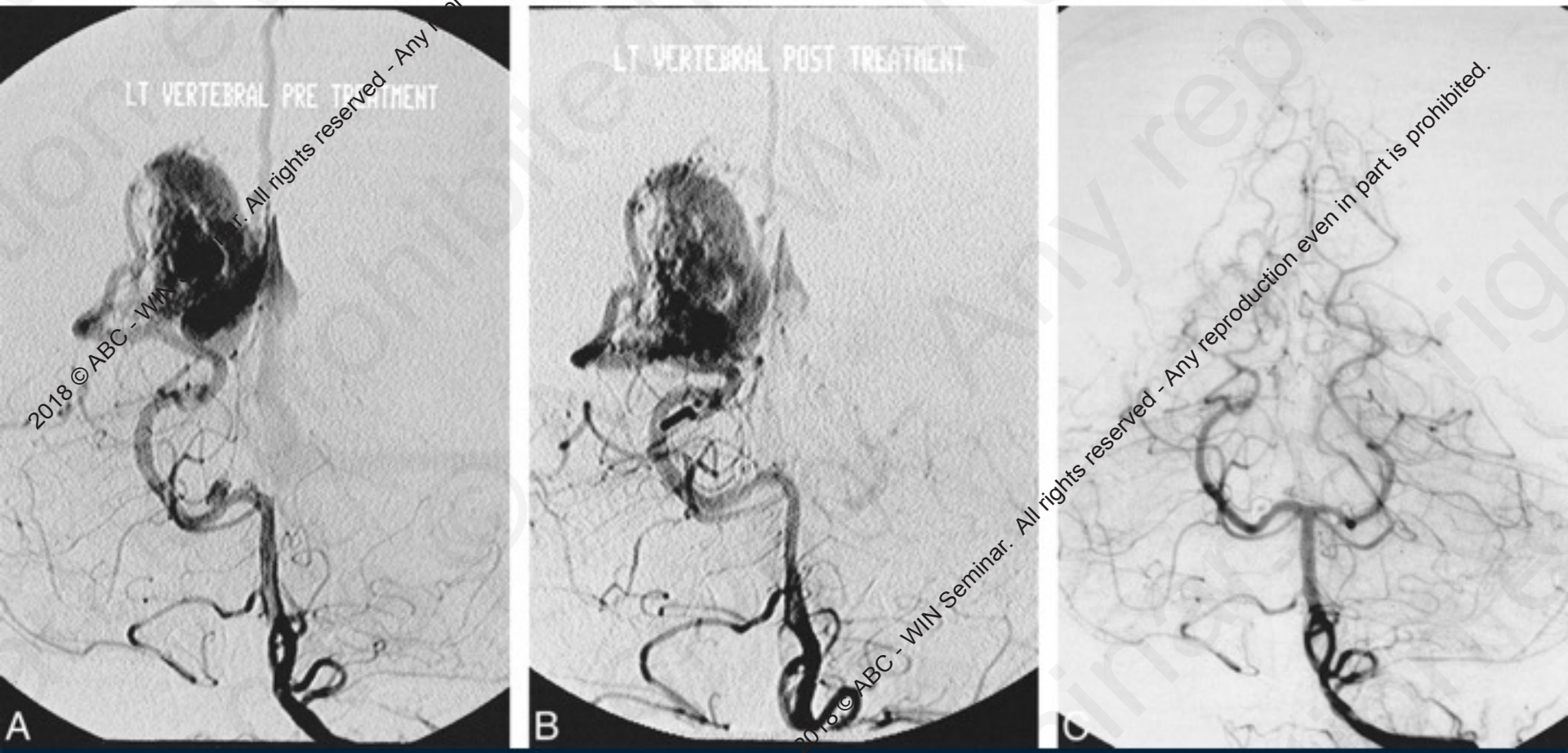

Flow related aneurysm – Moya Moya

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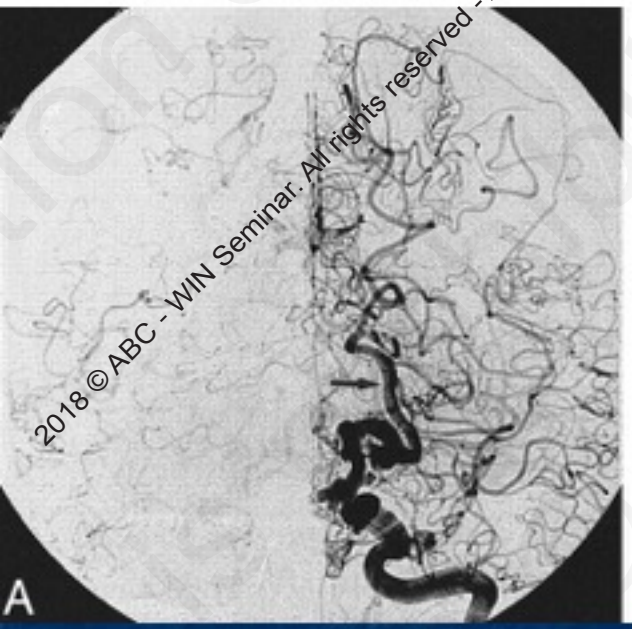

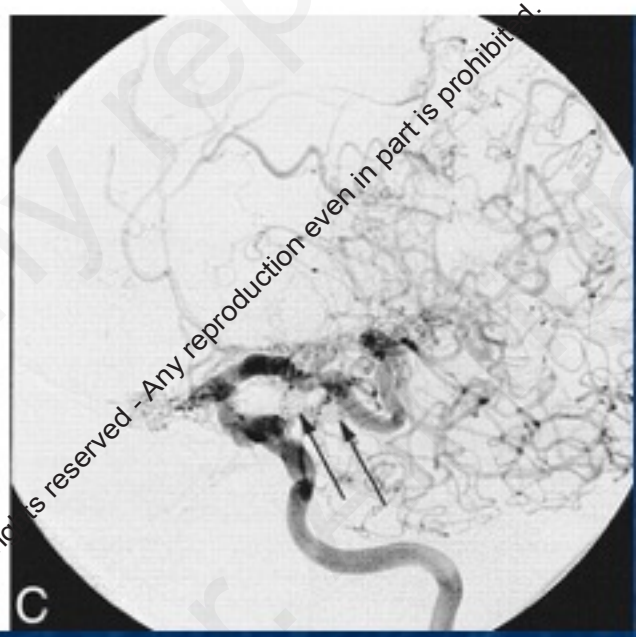

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Parent Artery Occlusion

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Factors Favoring Parent Vessel Sacrifice

- Distal vessels not serving eloquent tissue
  - Awake WADA
- Good means to treat distal flow related aneurysms and mycotic aneurysms
- Ease of use of NBCA and onyx
- Dissecting aneurysms with large vessel segment that is diseased

Research Article | INTERVENTIONAL

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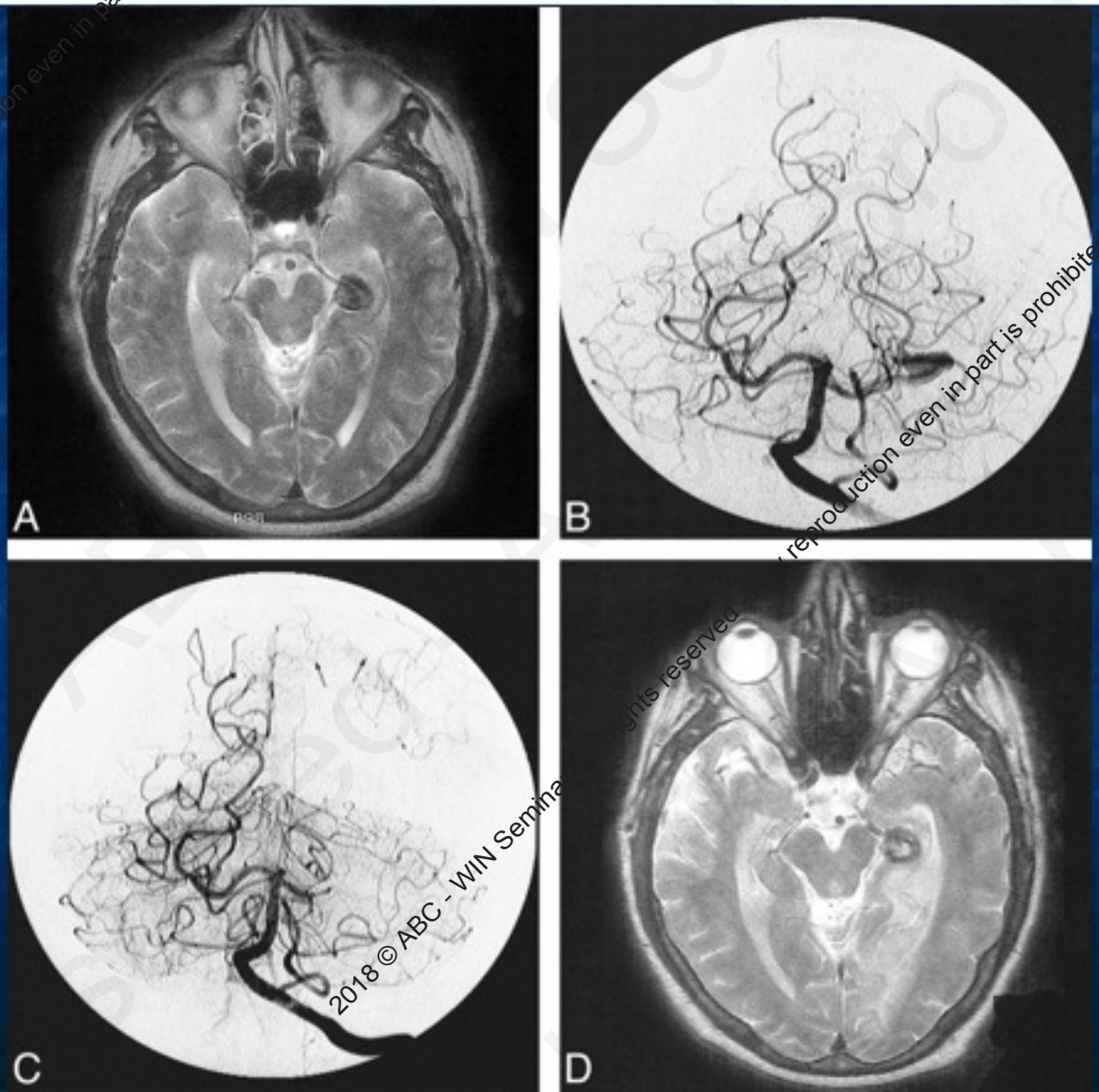
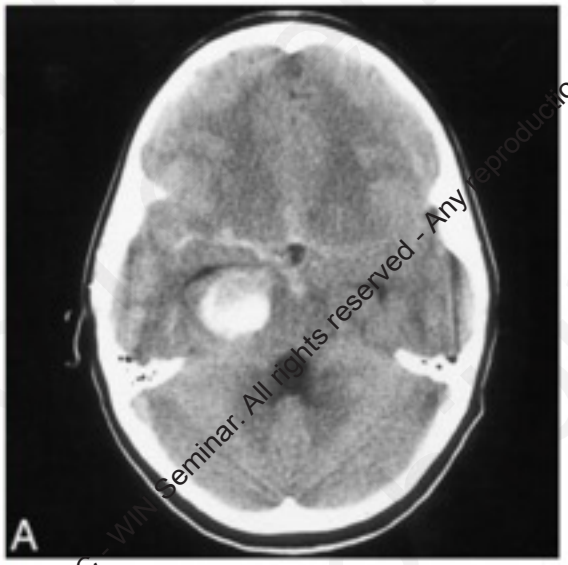


Aneurysms of the Posterior Cerebral Artery: Classification and Endovascular Treatment

Elisa F. Ciceri, Richard P. Klucznik, Robert G. Grossman, James E. Rose, and Michel E. Mawad

American Journal of Neuroradiology January 2001, 22 (1) 27-34;



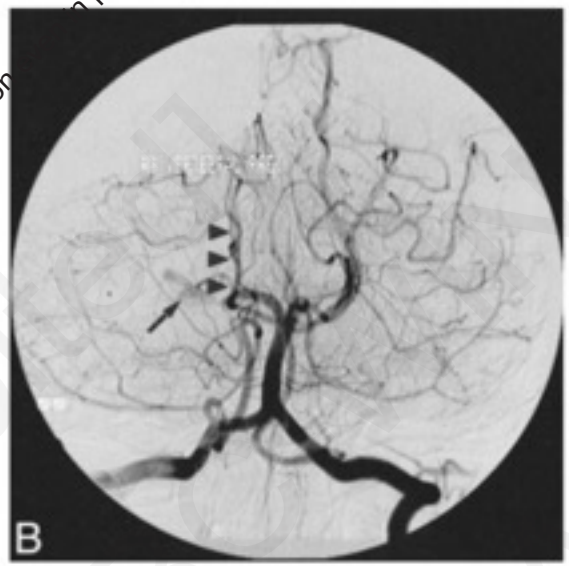


FIG 2. Giant serpentine aneurysm of the P2A segment of the PCA presenting with intracerebral and subarachnoid hemorrhage in a 12-year-old boy.

A, Noncontrast CT scan of the head shows the large partially clotted aneurysm in the perimesencephalic cistern, associated with SAH.

B, Towne's view of the vertebral angiogram shows the residual lumen of the partially clotted aneurysm (*arrow*), non-filling of the distal branches of the ipsilateral PCA, and avascular mass effect on the brain stem structures (*arrowheads*).

C, The lumen of the aneurysm and the parent artery were permanently occluded with GDC. The nonsubtracted Towne's view shows the metallic cast of the coils.

D, The corresponding subtracted image of the posttreatment vertebral angiogram shows complete obliteration of the aneurysm.

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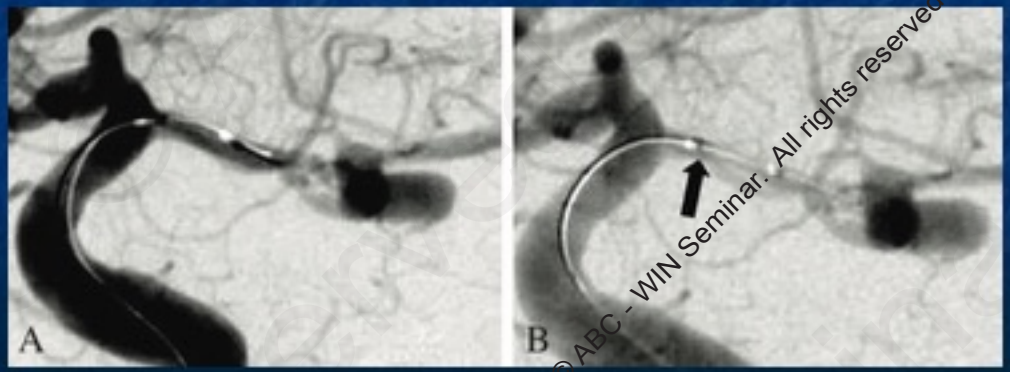
Super-selective Balloon Test Occlusion of the Posterior Communicating Artery in the Treatment of a Posterior Cerebral Artery Fusiform Aneurysm: a Case Report

Makoto Isozaki, Hiroshi Arai, Hiroyuki Neishi, Ryuhei Kitai, and Ken-ichiro Kikuta

- Super selective balloon test occlusions can be helpful to determine eloquence of territory
- Use of 4x7mm hyperform or similar device can be used in distal vessels
- Can confirm collateral supply of temporal lobes, especially left PCA aneurysms



Isozaki 2016

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Deliberate Parent Artery Occlusion for Non-Saccular Posterior Cerebral Artery Aneurysms

L. LIU, H. HE, C. JIANG, X. LV, Y. LI

Beijing Neurosurgical Institute, Beijing Tiantan Hospital, Capital Medical University; Beijing, China

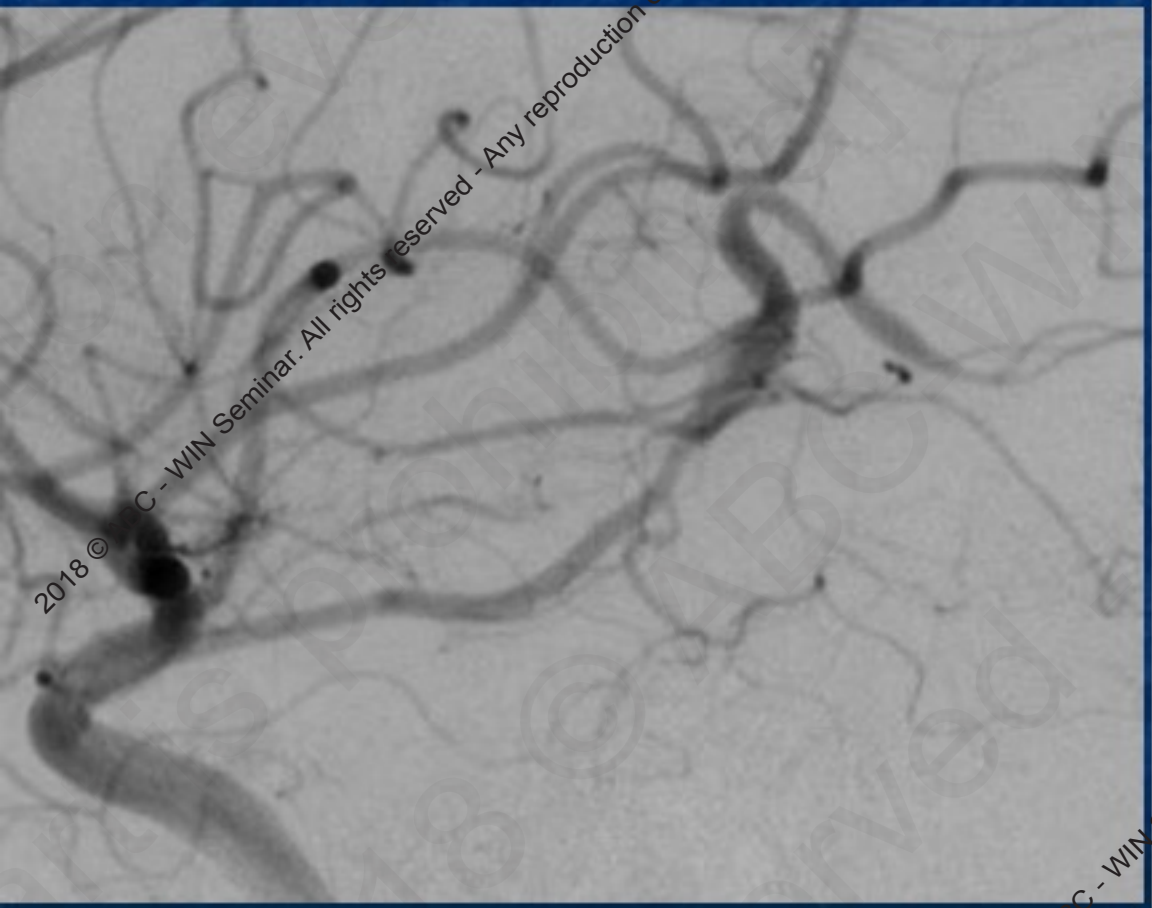
- 12 patients were treated with PAO with coils
- 0% of patients demonstrated recanalization at 25 months
- 1/12 patients presented with partial hemianopsia after occlusion that resolved in 1 month

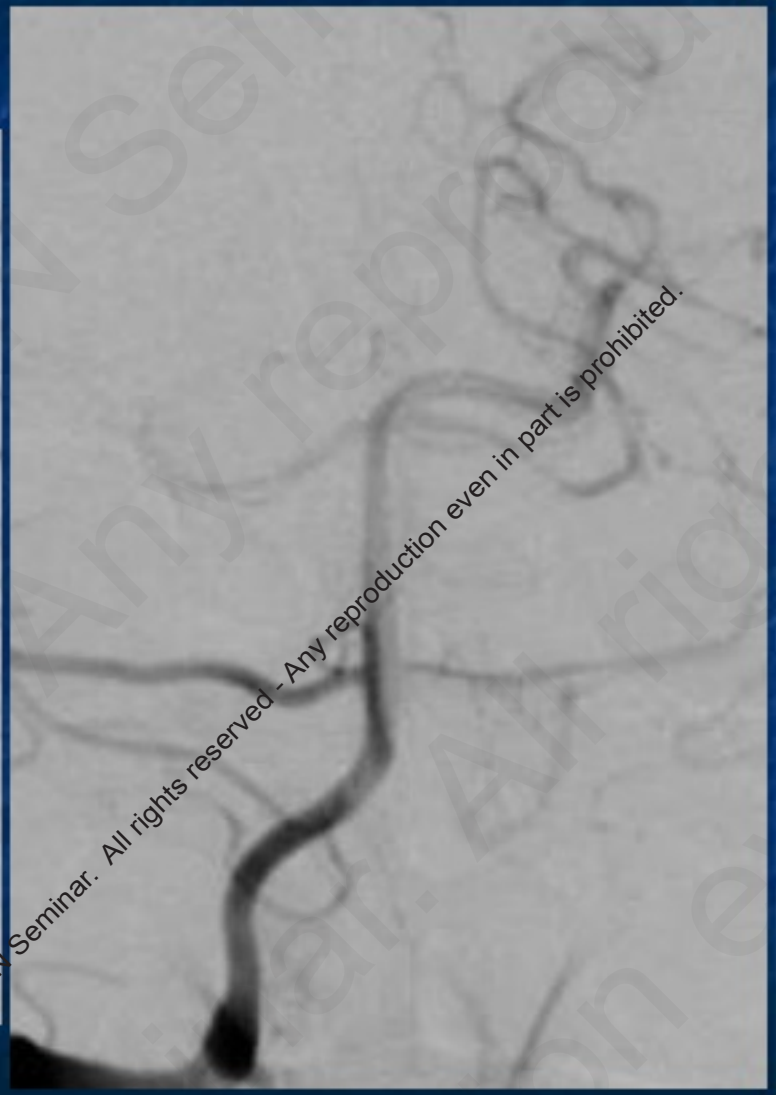
Liu 2011

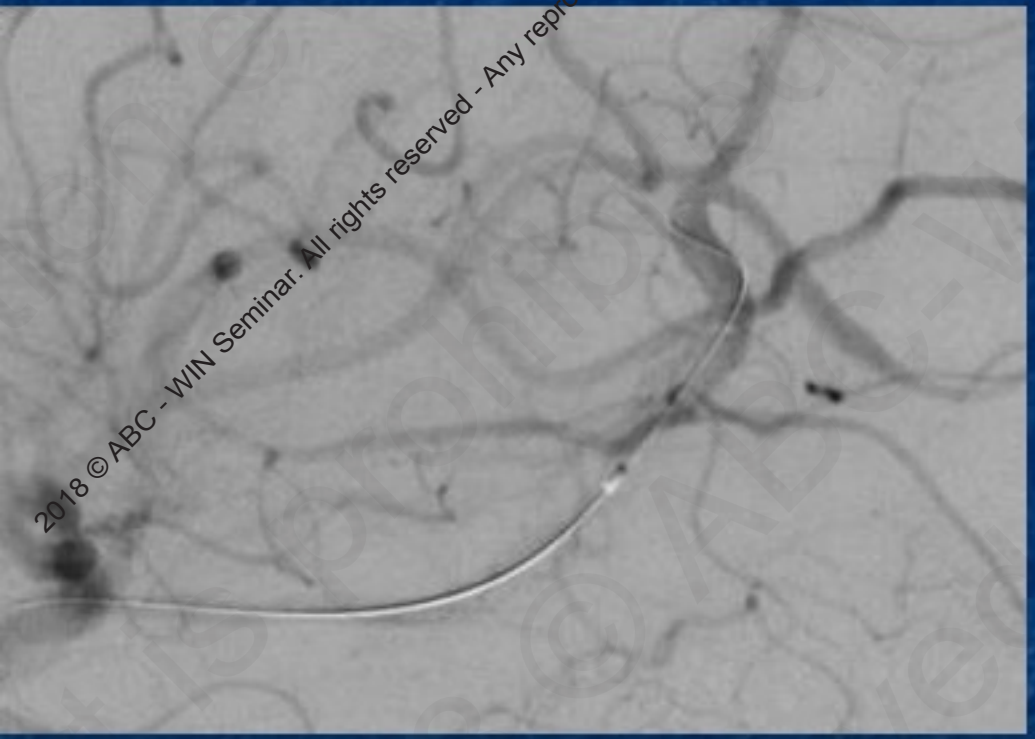
UB NS University at Buffalo Neurosurgery

Presentation

- 54 year old male with no past medical history.
- Presented with posterior fossa strokes in the right PCA distribution and diplopia.
- Neuro intact with diplopia.







DEVICES USED:

1. A 6-French sheath.
2. A 0.035-inch Glidewire.
3. Angled 5-French catheter and Envoy 6-French catheter.
4. Heparin 5000 for ACT 253 and 1000 units.
5. Balloon test occlusion with Synchro-2 standard microwire.
6. Voyager balloon 1.5 x 12 mm Prowler LP ES.
7. Microcatheter with Synchro-2 standard microwire.
8. Axiom coil 6 x 20, 5 x 15, 4 x 12, 3 x 8, 2 x 4.
9. Angio-Seal 6-French device for closure.

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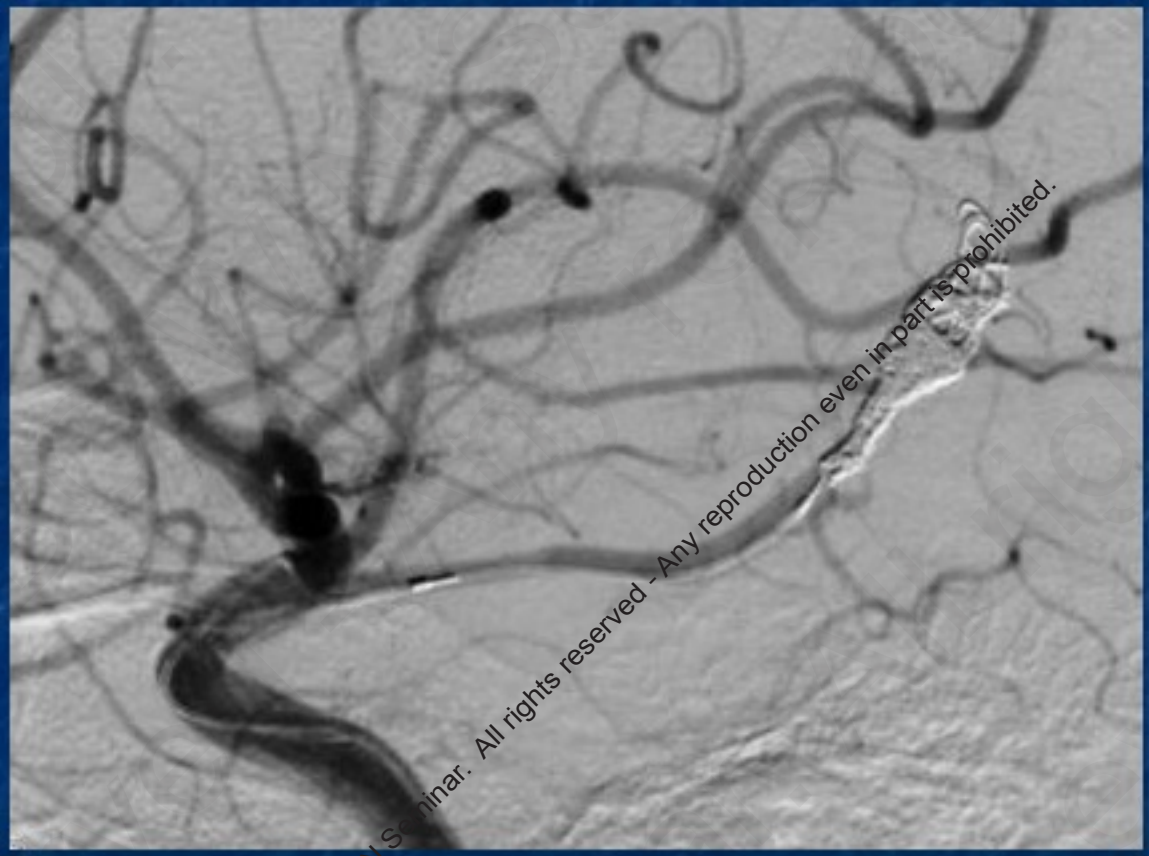
- Parent artery occlusion from P2b segment distally with coil occlusion



Discharged home on POD 2 with unchanged diplopia.

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Presentation

- 54 year old female with no past medical history.
- Presented with GCS 8 and found to have IVH.
- Was intubated and taken emergently for evaluation.

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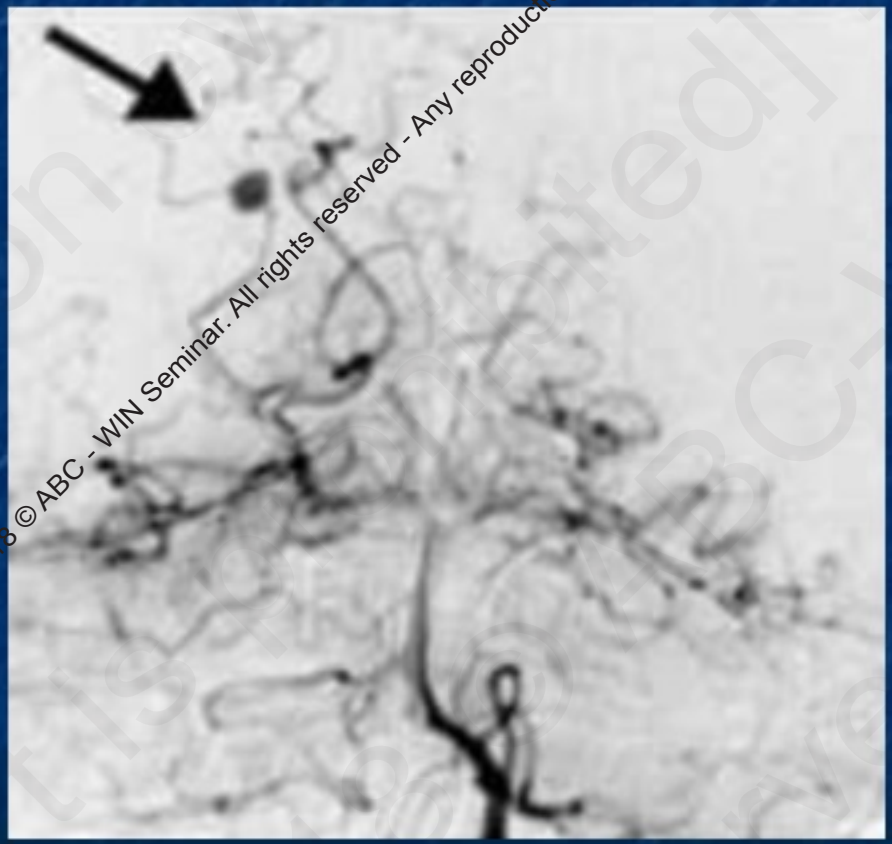

- Diagnostic imaging and left vertebral injection demonstrated right lateral posterior choroidal artery aneurysm
-

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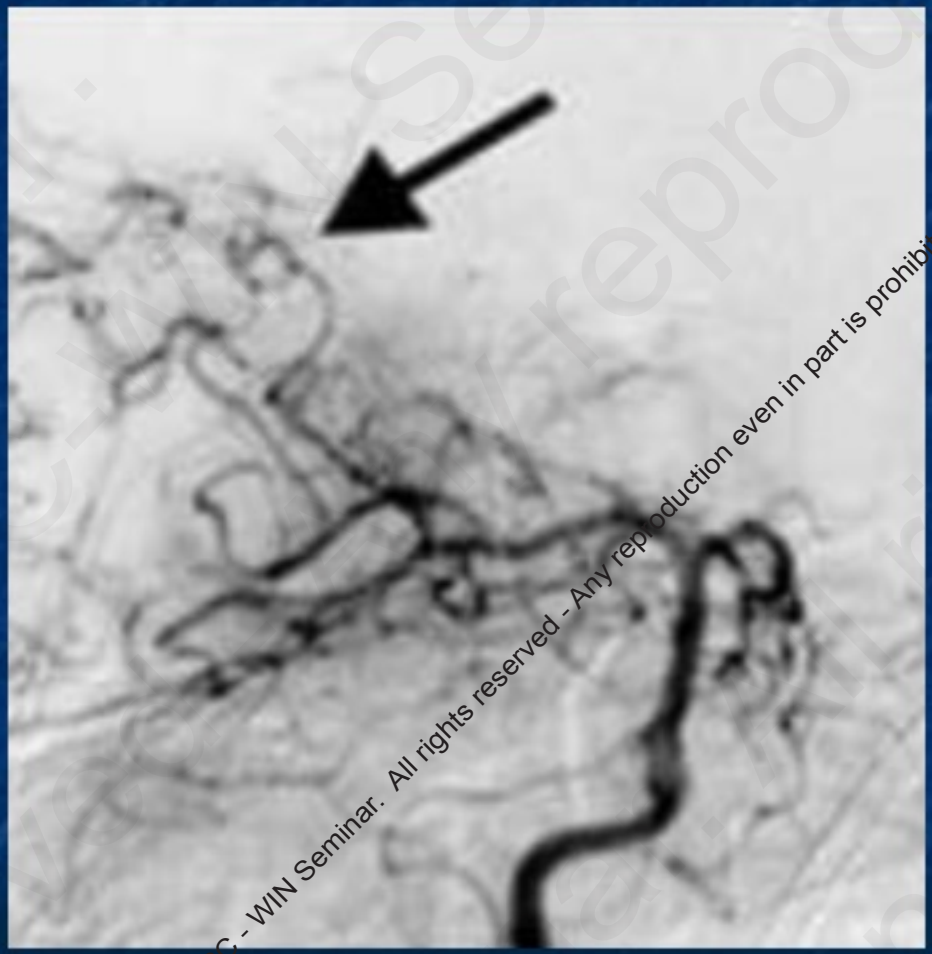
- Given location and distance to access the aneurysm, PAO was selected
- NBCA was used to control embolization of distal portion of vessel demonstrating excellent occlusion of aneurysm



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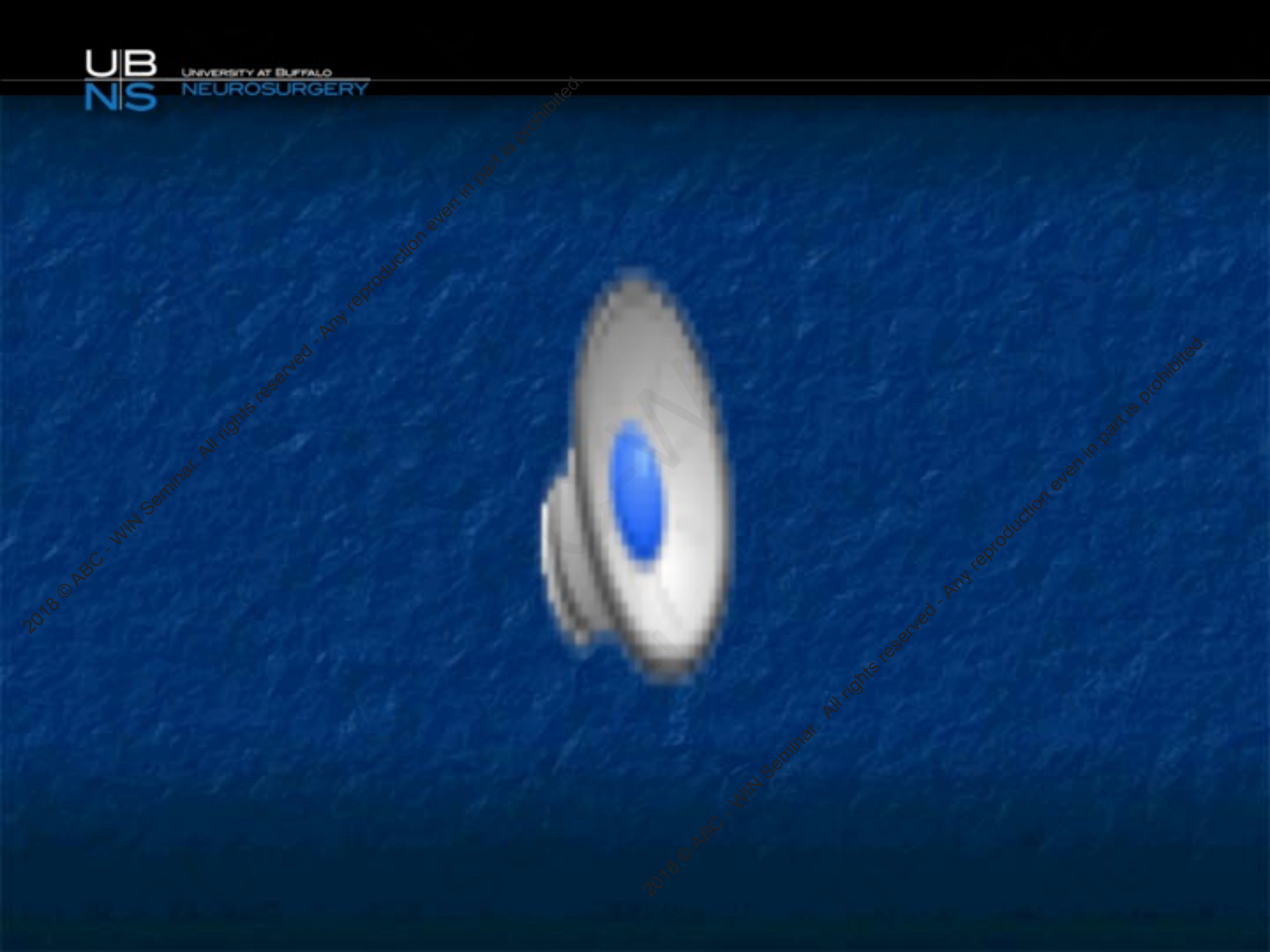
Presentation

- 44 year old female with no significant medical history.
- Presented intermittent pounding headaches for 1 month in the back of her head. She denied any visual disturbances.
- Neurologically intact.



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DEVICES USED:

1. A 6-French sheath.
2. Angled catheter.
3. A 0.035-inch exchange wire.
4. Neuron 070-guide catheter.
5. V18-wire.
6. Heparin 6000 units for a final ACT of 328.
7. Prowler Select LPES microcatheter.
8. Synchro-2 microwire.
9. GDC coils, 16 x 40, 14 x 30, 13 x 30, 13 x 30, 11 x 30, 10 x 30, 9 x 20, SL-10 microcatheter.
10. GDC coils, 2.5 x 6, HyperSoft coils, 2 x 6, 2 x 6, 2 x 4, 2 x 4 and 2 x 4 and DeltaPlush coils, 2 x 6, 2 x 6, 2 x 4, 2 x 4 and HyperSoft coil, 2 x 4.

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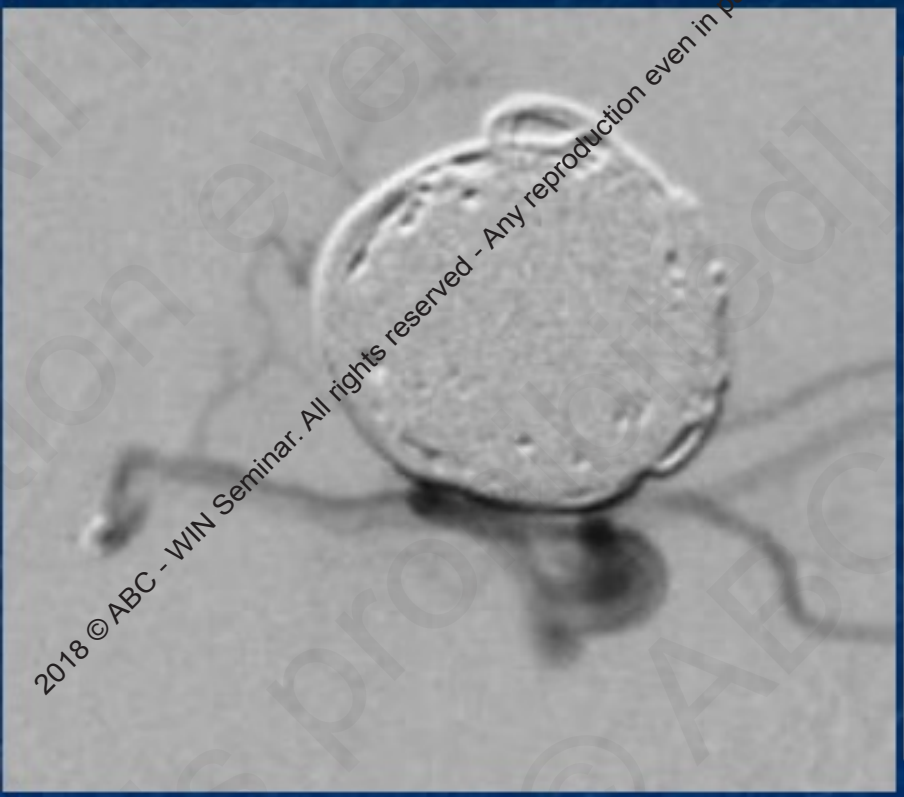

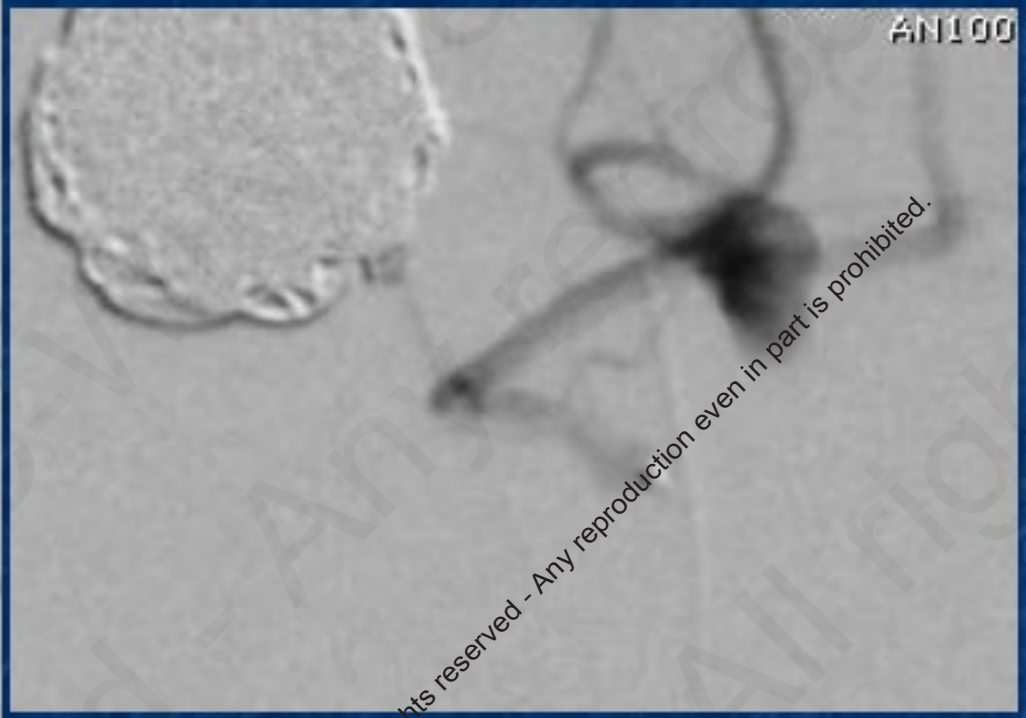

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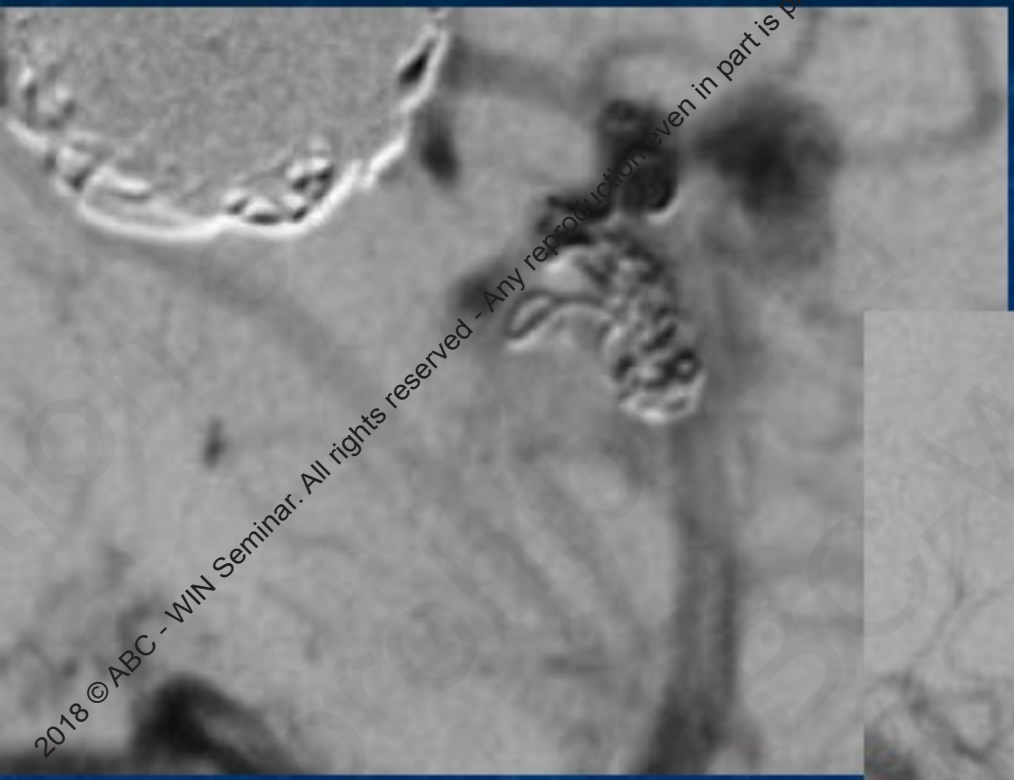
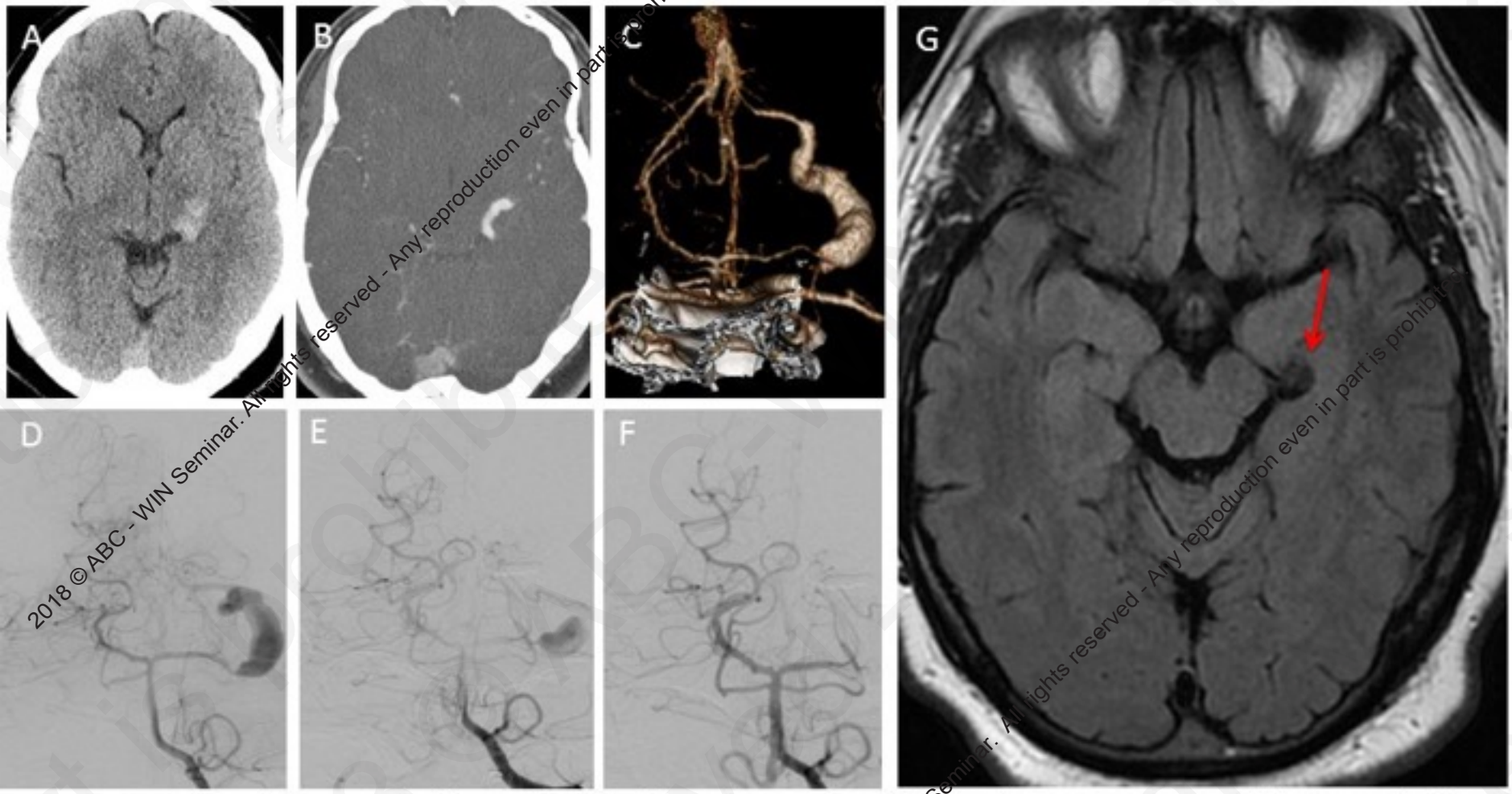


Plan to sacrifice the parent vessel, patient remained neurological unchanged and intact.

Case 4: PCA Aneurysm



A 34 year old male presented with transient hemiparesis. Unenhanced (A) and contrast enhanced (B) CT examination shows a large dissecting aneurysm in the right P2-P3 junction. Panel C shows the 3D reconstruction from the contrast enhanced study. (D-E) Intraoperative DSA images show coiling of the distal and proximal portion of the aneurysm. Brain stem perforators were identified in the proximal portion of the aneurysm and were spared during the sacrifice. (F) T2 FLAIR MRI images 1 year after treatment show signal void in the left PCA territory from the platinum coils. No ischemic changes are seen. The patient had no residual symptoms on follow up examination.

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Endovascular treatments for posterior cerebral artery aneurysms and vascular insufficiency of fetal-type circulation after parent artery occlusion

Hideaki Matsumura [a,b,*], Norifuki Kato [a], Yusuke Fujiwara [a], Hisayuki Hosoo [a], Tomosato Yamazaki [a], Susumu Yasuda [a], Akira Matsumura [b]

[a] Department of Neurosurgery, National Hospital Organization, Mito Medical Center, 280 Sakuranosato, Ibaraki-machi, Higashiibaraki, Ibaraki 311-3193, Japan
[b] Department of Neurosurgery, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8575, Japan

Summary of data in 10 patients with posterior cerebral artery aneurysms

No.	Age (y)	Sex	Presenting symptom	H & K	Fisher grade	Side	Location	Shape	Size (mm)	PCA type	Treatment type	Result[#]
1	51	M	SAH	1	2	Left	P2	Saccular	2.7 × 3.6	Adult	Selective coil occlusion	II
2	49	F	Incidental	0	0	Left	P1	Saccular	2.5 × 2.5	Fetal	Selective coil occlusion	III
3	64	F	SAH	2	3	Left	P2	Fusiform	4.9 × 7.4	Adult	PAO	I
4	43	F	Incidental, AVM	0	0	Left	P1	Saccular	7.0 × 6.0	Adult	Selective coil occlusion	I
5*	53	F	Hemiparesis	0	0	Right	P1/P2	Saccular	24.5 × 20.0	Fetal	PAO	I
6	65	F	SAH	2	3	Right	P4	Saccular	6.5 × 4.1	Adult	Selective coil occlusion	I
7	50	F	Incidental	0	0	Left	P3	Fusiform	12.7 × 10.7	Adult	PAO	I
8*	58	F	SAH	2	2	Left	P2	Saccular	6.1 × 5.3	Fetal	PAO	I
9	62	F	SAH	4	3	Left	P1/2	Saccular	5.6 × 5.0	Adult	Selective coil occlusion	I
10	12	M	Incidental	0	0	Right	P2	Fusiform	6.9 × 7.3	Adult	PAO	I

Matsumura et al, 2016

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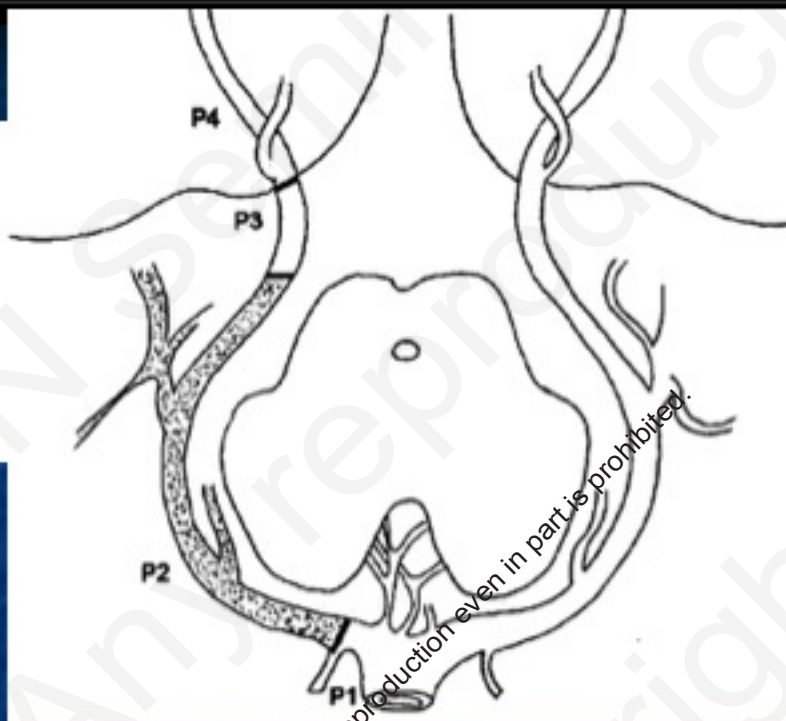
Endovascular Occlusion of the Posterior Cerebral Artery for the Treatment of P2 Segment Aneurysms: Retrospective Review of a 10-Year Series

Paul Hallacq, Michel Piotin, and Jacques Moret



Summary of data in 10 patients with P2 segment aneurysms

Patient No./Sex/ Age (y)	Aneurysm Type, Side, and Size	Presenting Symptom	Test	Treatment Type and Year	Clinical Outcome and Follow-Up Findings
1/43/M	Saccular, R, giant thrombosis	Headaches, phosphenes	Balloon occlusion	Balloon, 1990	Excellent, no headaches, phosphenes gone; at 11-mo angiography, no recanalization; MR imaging at 6 y, two-thirds reduction in aneurysmal mass
2/53/F	Saccular, R, giant thrombosis	Headaches, LHH	Balloon occlusion, clinical examination	Balloon, 1994	LHH, no headaches; at 6-mo angiography, no recanalization
3/20/M	Fusiform, L, large	Headaches	Angiography	GDC, 1996	Excellent, no headaches; at 1-y angiography, no recanalization
4/60/M	Fusiform, L, large	Headaches	Balloon occlusion	GDC, 1998	Excellent, no headaches; at 1-y angiography, no recanalization
5/49/F	Fusiform, L, giant thrombosis	Gertsmann syndrome	Angiography	GDC, 1998	Excellent, no deficit; at 1-y angiography, no recanalization
6/18/F	Saccular, L, large	SAH, hematoma	Angiography	Histoacryl, 1998	Excellent, no deficit; at 1-y angiography, no recanalization
7/49/F	Saccular, L, large	Headaches	Balloon occlusion	GDC, 1999	Excellent, no headaches; at 1-y angiography, no recanalization
8/47/M	Fusiform, L, giant thrombosis	SAH, diplopia	Balloon occlusion	GDC, 1999	Excellent, no deficit; at 1-y angiography, no recanalization
9/26/M	Serpentine, R, giant thrombosis	Headaches	Angiography	GDC, 1999	Excellent, no headaches; at 1-y angiography, no recanalization
10/70/F	Saccular, R, large	Headaches	None	None	Well 3 y after attempt

Hallacq et al, 2002

Microsurgical Occlusion

UB University at Buffalo NEUROSURGERY

Posterior Cerebral Artery Aneurysms: Treatment and Outcome Analysis in 121 Patients

Felix Goehre[1,2], Behnam Rezai Jahromi[1], Martin Lehecka[1], Hanna Lehto[1], Riku Kivisaari[1], Hugo Andrade-Barazarte[1], Tarik F. Ibrahim[1], Richard Gonzalo Párraga[4], Christopher Ludtka[2], Hans Jörg Meisel[2], Timo Koivisto[3], Mikael von und zu Fraunberg[3], Mika Niemelä[1], Juha E. Jääskeläinen[3], Juha A. Hernesniemi[1]

Table 4. Treatment of 121 Patients with 135 Posterior Cerebral Artery Aneurysms Treated Between 1980 and 2012

	Number of Patients with Unruptured Saccular PCA Aneurysms (n = 9)	Number of Patients with Unruptured Fusiform PCA Aneurysms (n = 10)	Number of Patients with Unruptured Giant PCA Aneurysms (n = 7)	Number of Patients with Unruptured PCA Aneurysms with Associated Unruptured Aneurysms (n = 21)	Number of Patients with Unruptured PCA Aneurysm and Ruptured Associated Aneurysm (n = 17)	Number of Patients with Ruptured Saccular PCA Aneurysms (n = 20)	Number of Patients with Ruptured Fusiform PCA Aneurysms (n = 7)	Number of Patients with Ruptured PCA Aneurysms with Associated Unruptured Aneurysms (n = 18)	Number of Patients with an Associated AVM (n = 12)
Treatment									
Microsurgical treatment	3	9	5	10	4	13	1	10	2
Endovascular treatment	0	0	1	3	3	3	2	5	0
Conservative	6	1	1	8	10	4	3	3	10
One-year outcome									
mRS 0–1 (good)	7	5	1	13	7	8	2	5	3
mRS 2–4 (moderate)	1	5	5	7	4	6	3	9	8
mRS 5–6 (poor)	1	0	1	1	6	6	2	4	1

AVM, arteriovenous malformation; mRS, modified Ranking Scale; PCA, posterior cerebral artery.

Goehre et al, 2016

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Table 5. PCA Infarction After Parent Vessel Occlusion

Patient	Treatment	Occluded Segment	Aneurysm Shape	Infarction
1	Microsurgical trapping	P2	Fusiform	Infarction
2	Microsurgical trapping	P2	Saccular	—
3	Microsurgical proximal occlusion	P3	Fusiform	—
4	Microsurgical proximal occlusion	P2	Fusiform	Infarction
5	Microsurgical proximal occlusion	P2	Fusiform	—
6	Microsurgical proximal occlusion	P3	Fusiform	Infarction
7	Microsurgical proximal occlusion	P2	Fusiform	Infarction
8	Microsurgical proximal occlusion	P1/2	Fusiform	—
9	Microsurgical proximal occlusion	P2	Fusiform	Infarction
10	Endovascular aneurysm and parent vessel occlusion	P3	Fusiform	—
11	Endovascular aneurysm and parent vessel occlusion	P3	Fusiform	Infarction

Table 6. Characteristics of 12 Patients with Ruptured Posterior Cerebral Artery Aneurysms Treated Between 1954 and 2012

Variables	Number of Patients
Patients	12
Posterior cerebral artery aneurysms	12
Gender	
Male	5
Female	7
Age at diagnosis (years), mean (range)	43 (23–63)
Aneurysm size	
Small (<7 mm)	8
Medium (7–14 mm)	3
Large (15–24 mm)	1
Hunt and Hess Grade	
Unruptured	4
Grade 1	0
Grade 2	2
Grade 3	3
Grade 4	0
Grade 5	3
Treatment	
Conservative	12
Outcome (latest follow-up)	
mRS 0–1 (good)	1
mRS 2–4 (moderate)	5
mRS 5–6 (poor)	6

mRS, modified Ranking Scale.

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Fetal-type posterior cerebral artery: the pitfall of parent artery occlusion for ruptured P_2 segment and distal aneurysms

*Jing Xu, MD,[1] Liang Xu, MD,[1] Ziheng Wu, MD,[2] Xianyi Chen, MD,[1] Jun Yu, MD,[1] and Jianmin Zhang, MD, PhD[1]

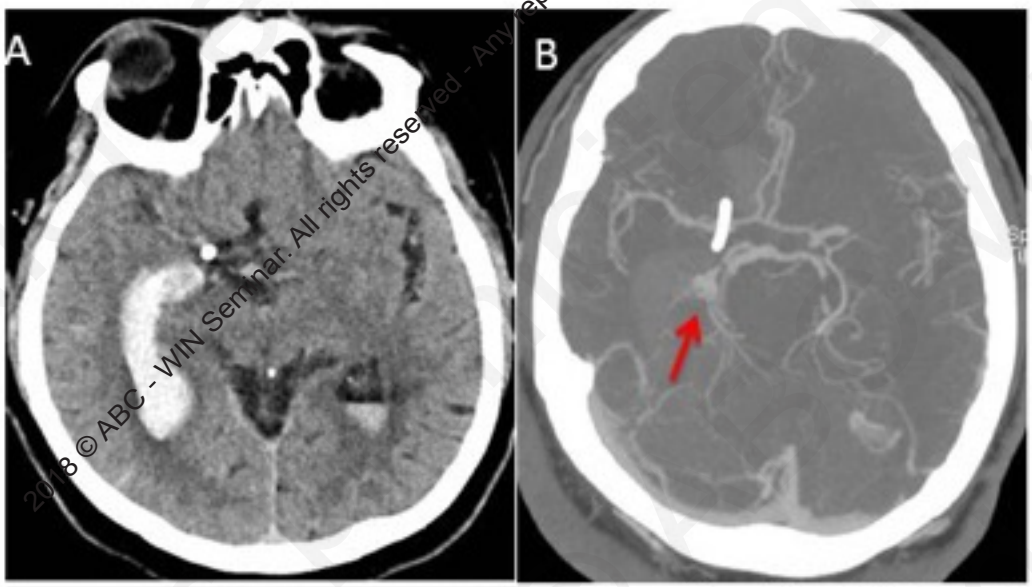
[1]Department of Neurosurgery, The Second Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou, Zhejiang Province; [2]Department of Vascular and Endovascular Surgery, The First Affiliated Hospital, School of Medicine, Zhejiang University, Hangzhou, Zhejiang Province, People's Republic of China

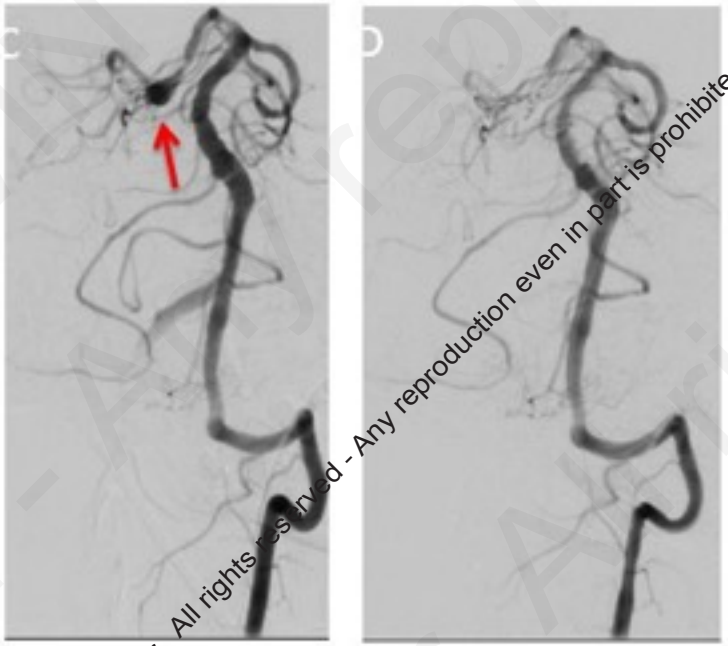
- 11 patients presented and were treated with distal PCA aneurysms
- 6/11 had adult type PCAs and had PAO without significant neurological sequelae
- 4/11 had fetal type PCAs and had PAO, all having resulting hemianopsia and hemiparesis
- 1/11 had a fetal type PCA aneurysm that was selectively coiled, neurologically intact

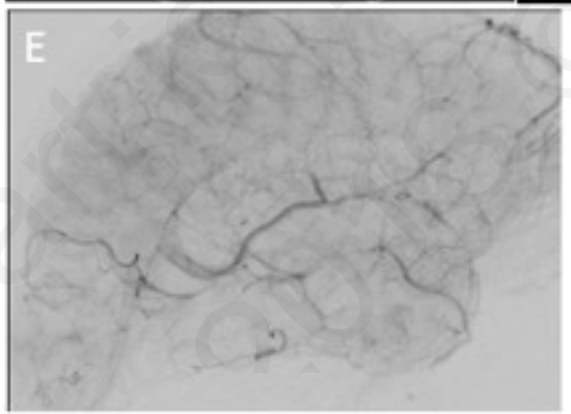
Xu et al, 2015

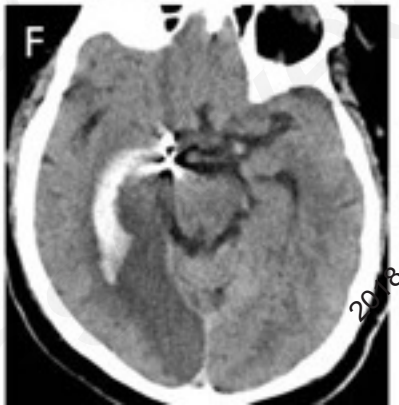
Case 1: Fusiform PCA Aneurysm

A 45 year old female presented with acute headache and decreased level of consciousness. CT examination showed intraventricular hemorrhage (A) and a fusiform aneurysm of the right PCA (B). (C) DSA images from the vessel sacrifice procedure redemonstrate the PCA aneurysm (D) Post treatment DSA shows complete occlusion of the aneurysm with no residual filling and delayed filling of the distal PCA via collaterals (E). Repeat CT examination 2 days post procedure shows hypoattenuation and loss of grey white differentiation in the right PCA territory (F) which was not appreciated on the pre-procedural study.









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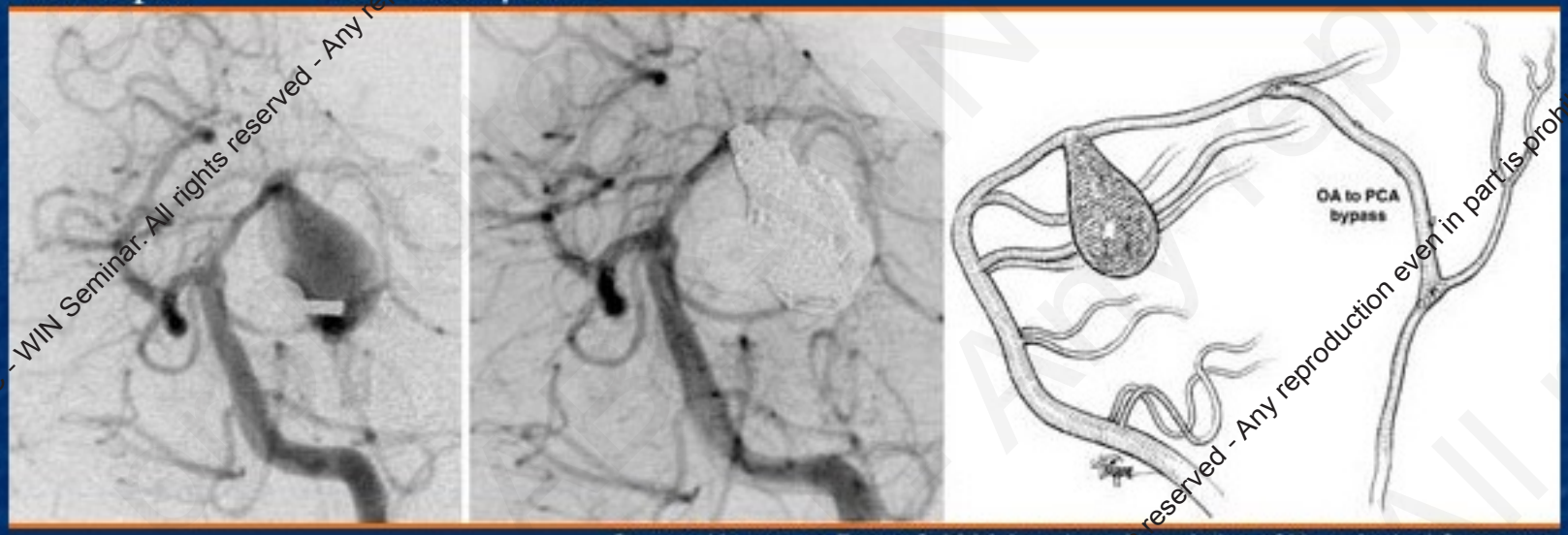
One solution is to bypass distal to occluded segment

Medscape® www.medscape.com



Source: Neurosurg Focus © 2004 American Association of Neurological Surgeons

Combined Endovascular and Microsurgical Management of Giant and Complex Unruptured Aneurysms

[Neurosurg Focus 17(5), 2004. © 2004 American Association of Neurological Surgeons]

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One additional problem with coiling…

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54yo female presents with WHOL

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Left distal PCA aneurysm

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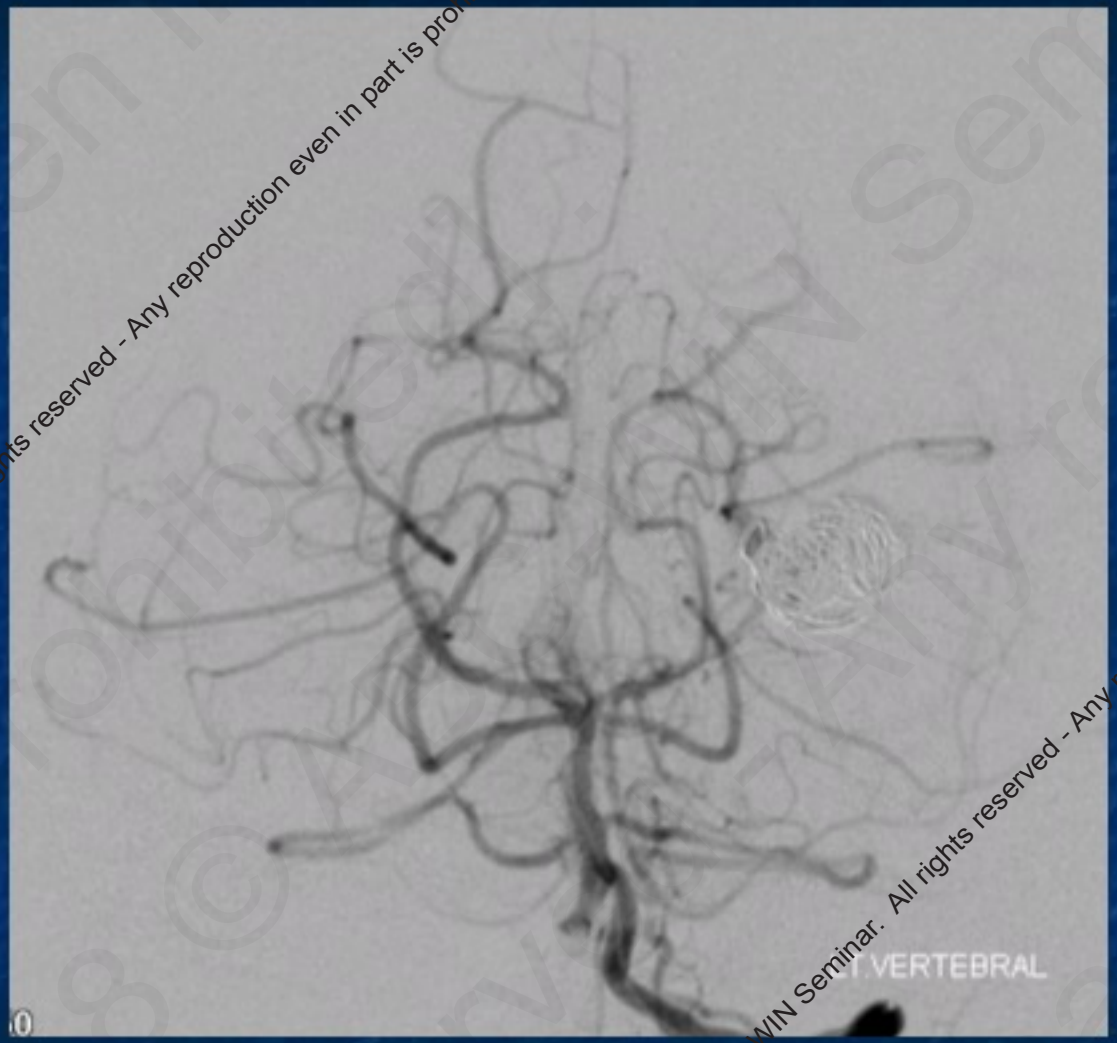

Post coiling

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3 months later - recurrence

Perhaps BTO and PAO or if she fails stent assisted coiling

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Stent-assisted Coiling

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Factors Favoring Assisted Coiling

- Wide necked aneurysms that require support from balloon assisted or stent assisted techniques
- Small vessel caliber < 1.5mm but large enough for small open cell stents

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Case 2

- 43/F presented with severe H/A.
- Giant thrombosed aneurysm (+).
- Transferred for management.
- PMH: Unremarkable.
- Smoker.

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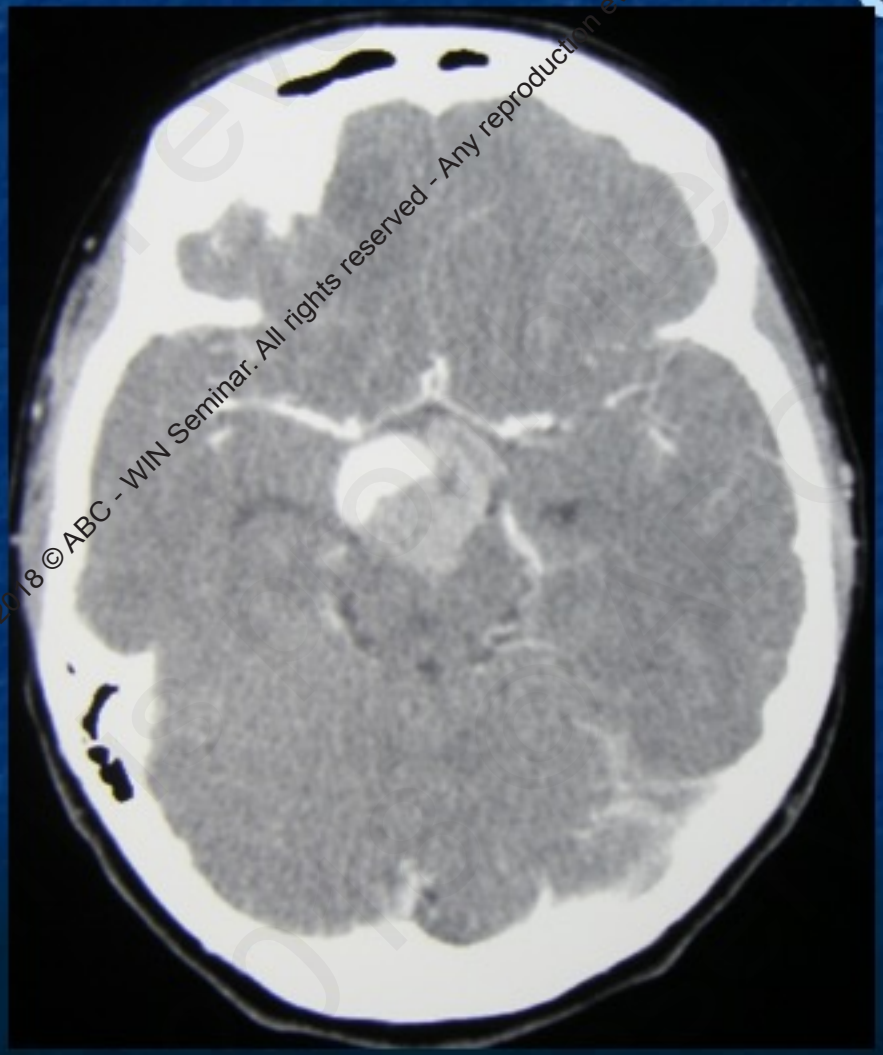
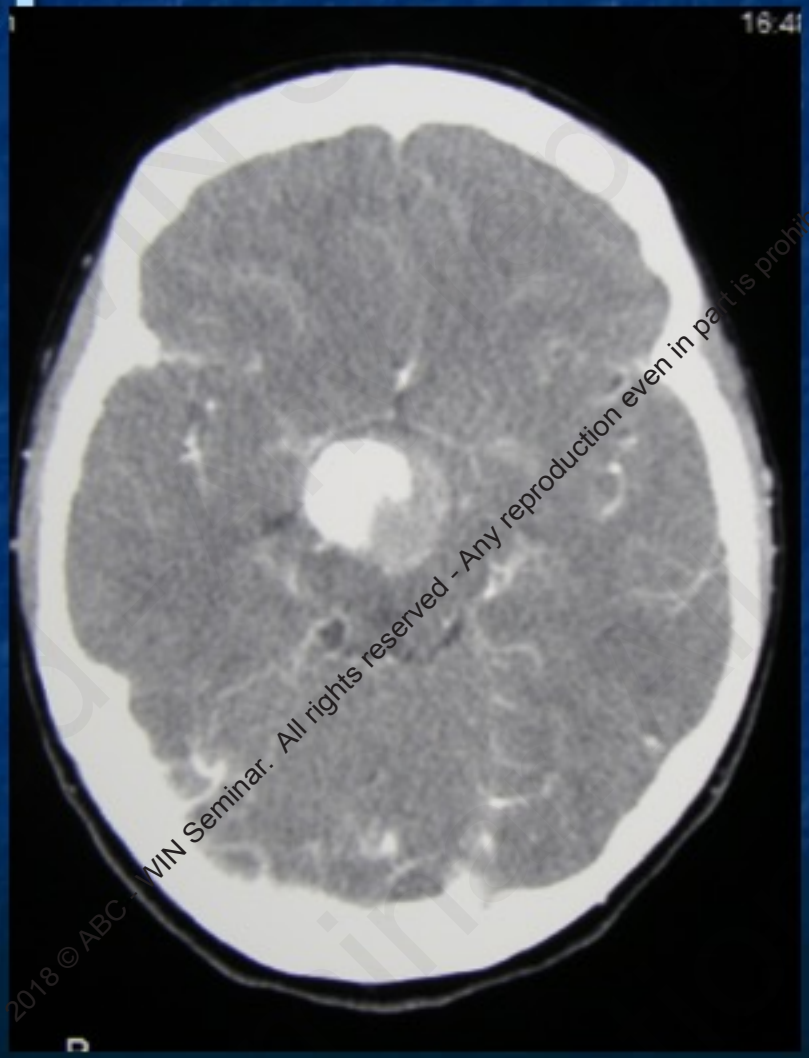
CT





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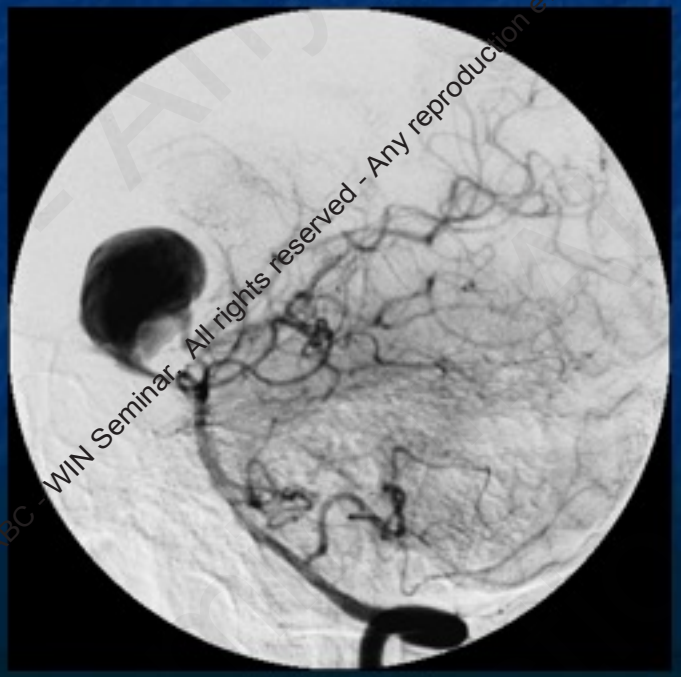
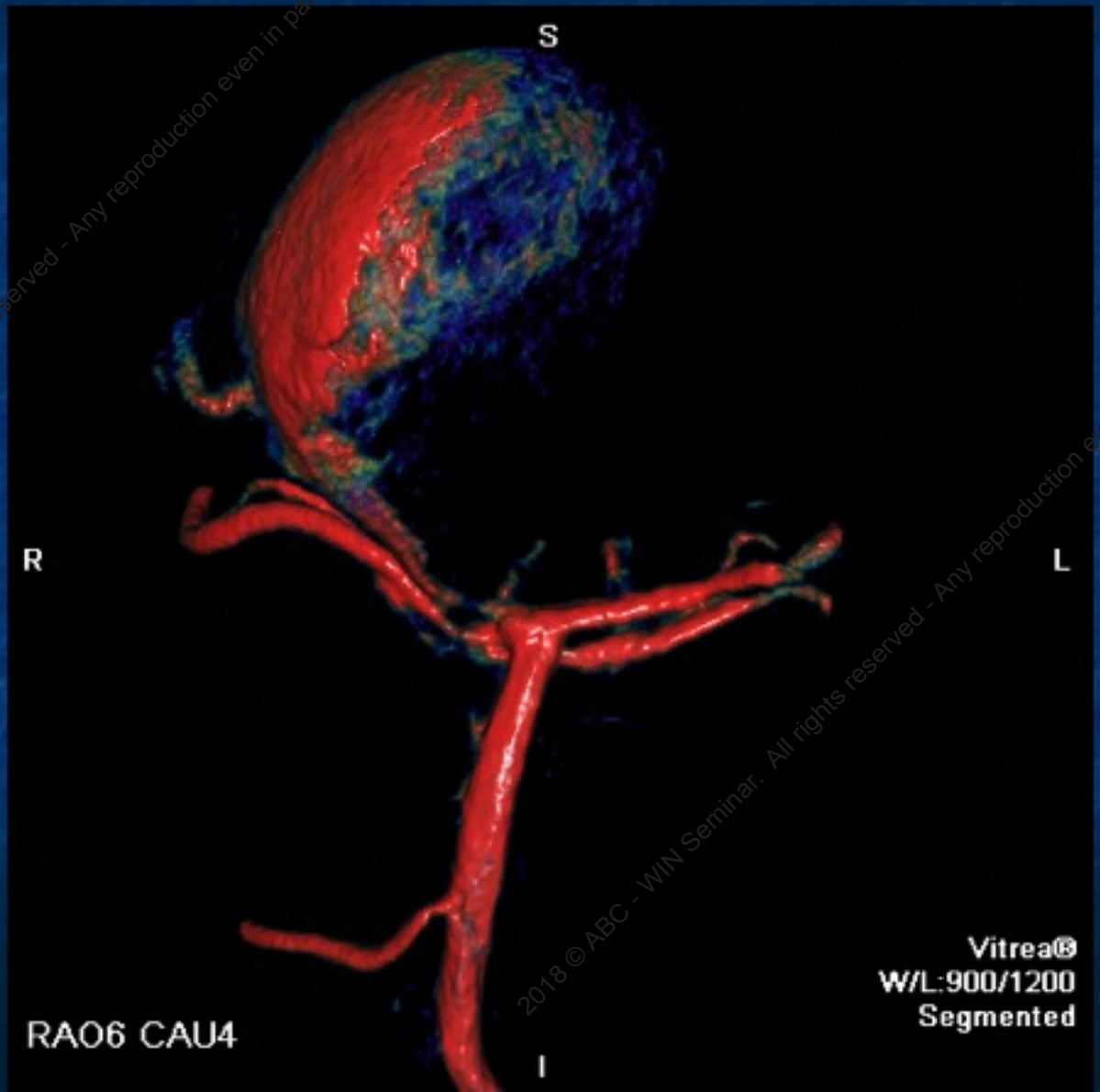
MRI





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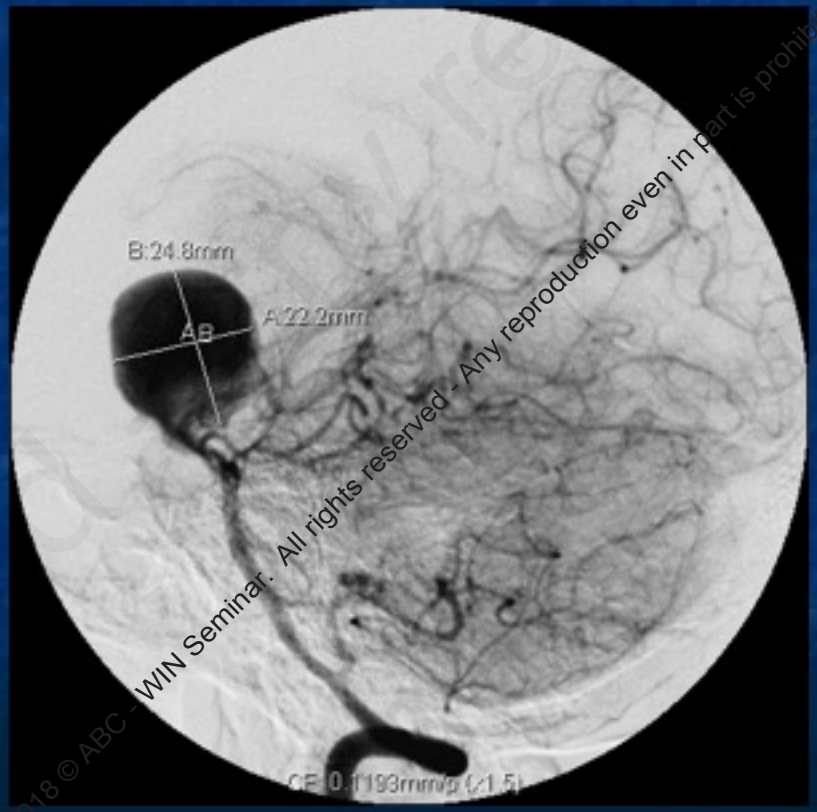

Microwire

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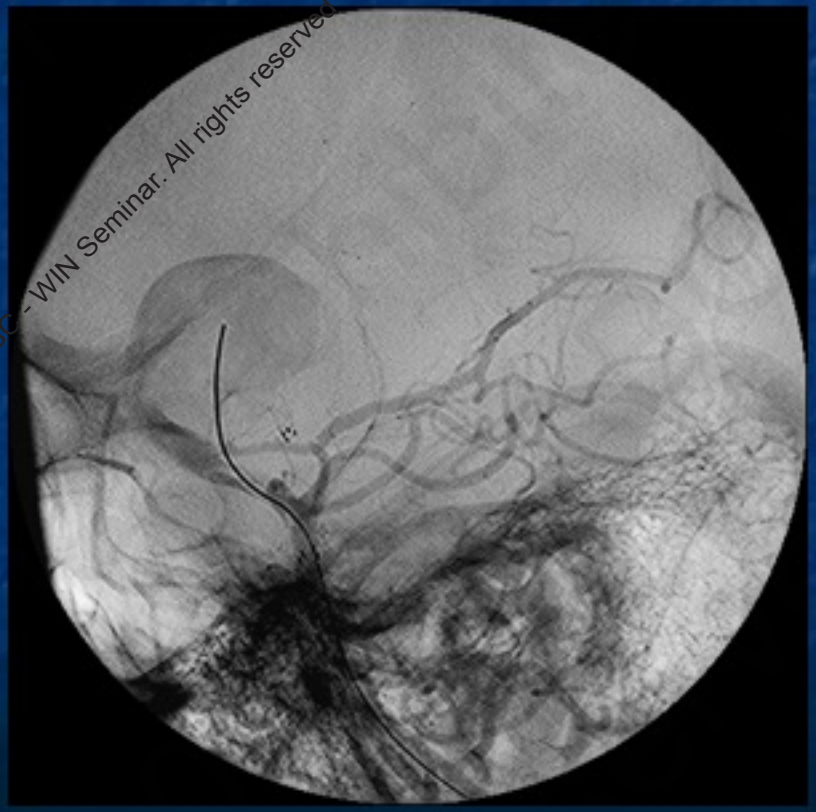
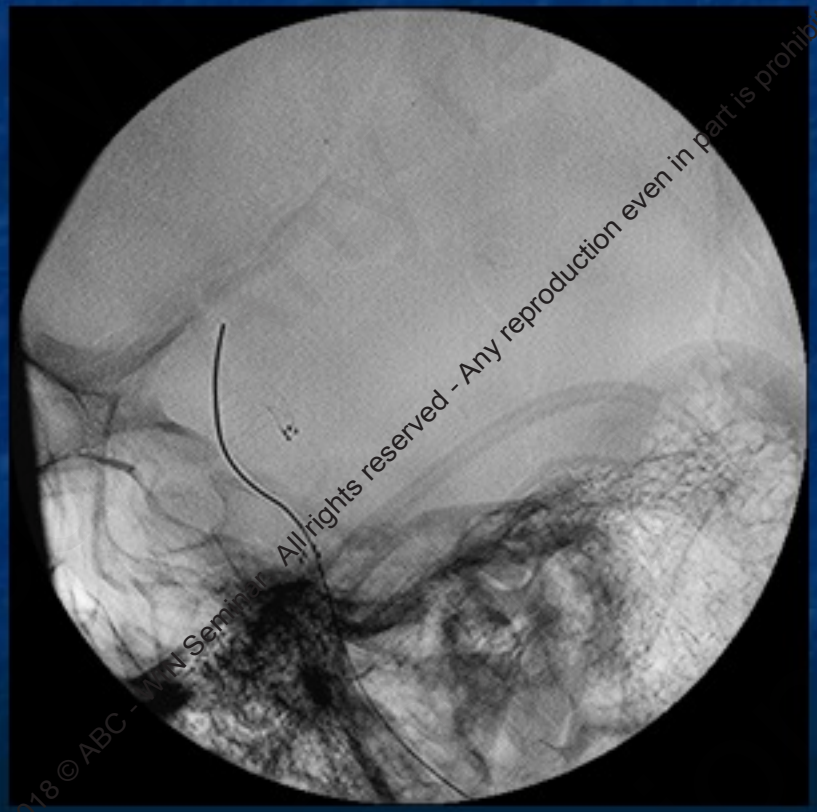
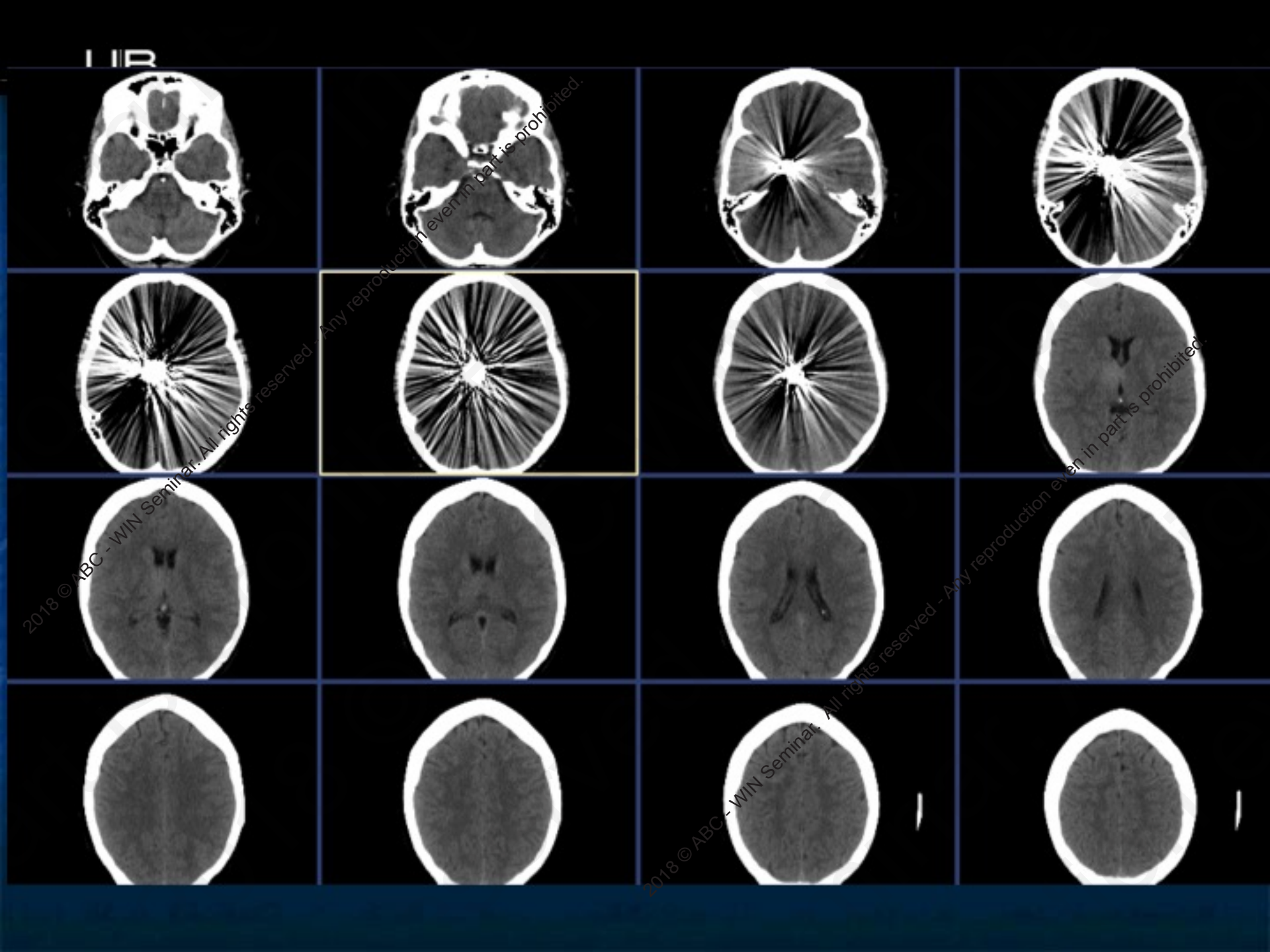
Neuroform 4x30





Post-coil



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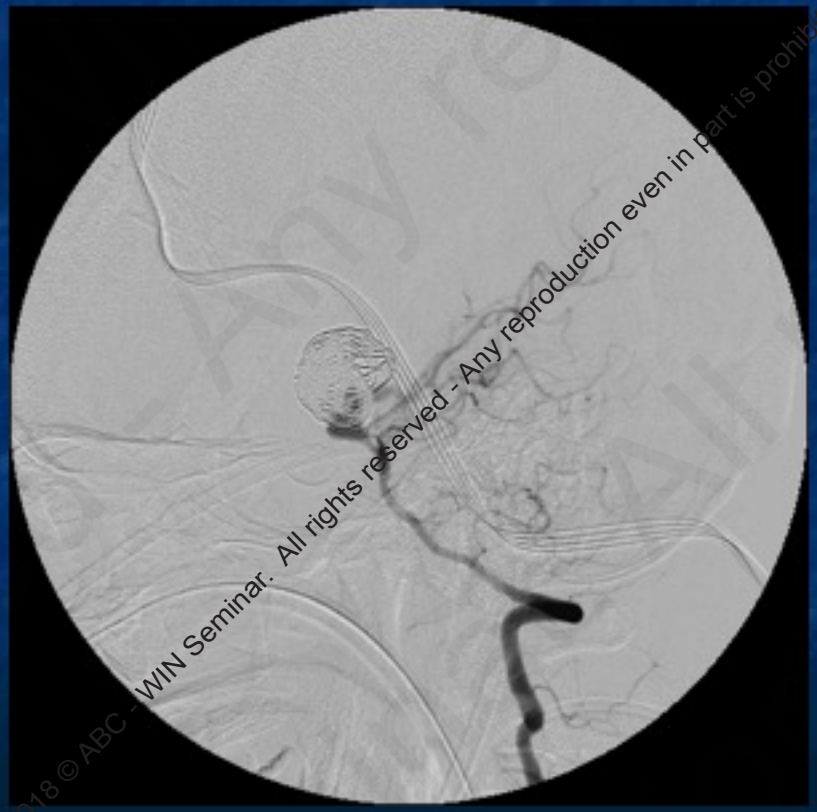
f/u angio 3 days later



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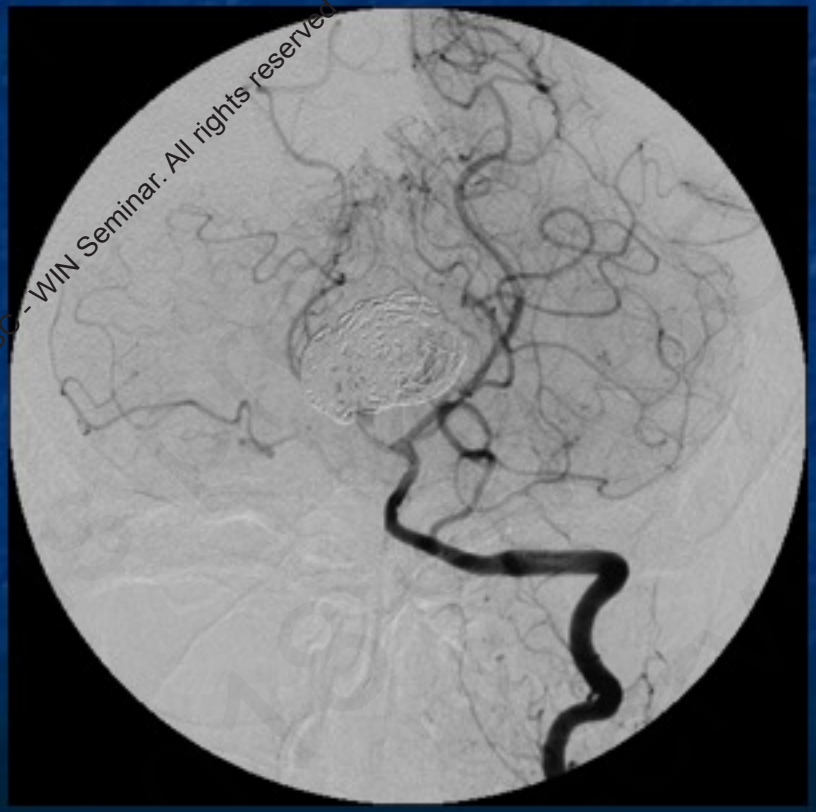
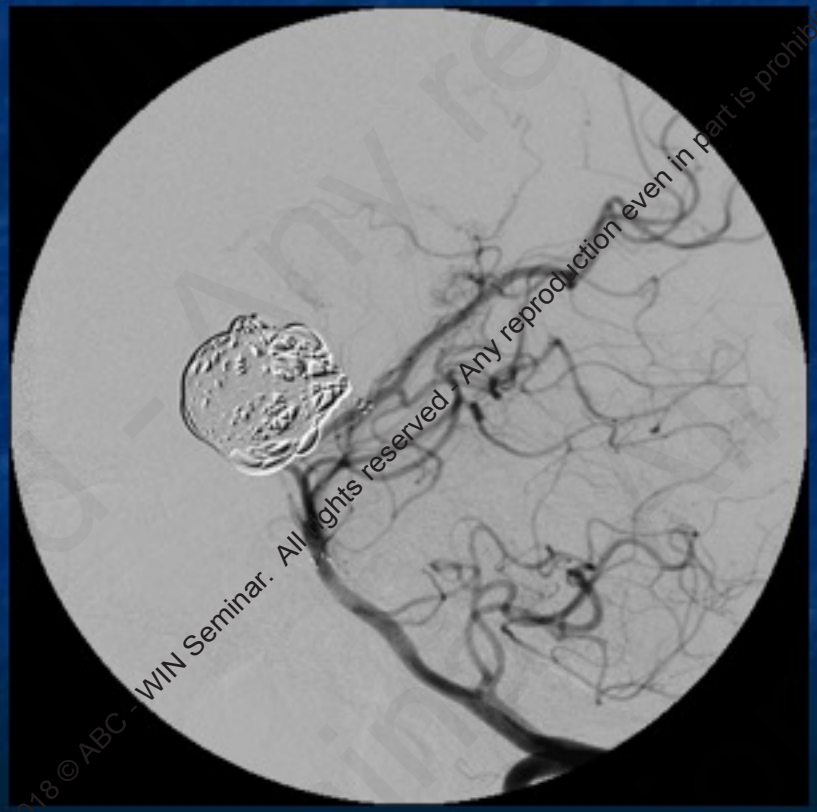
f/u @ 1 year





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Case

- 54 year old woman presented with new onset occipital headaches
- Negative CT and LP

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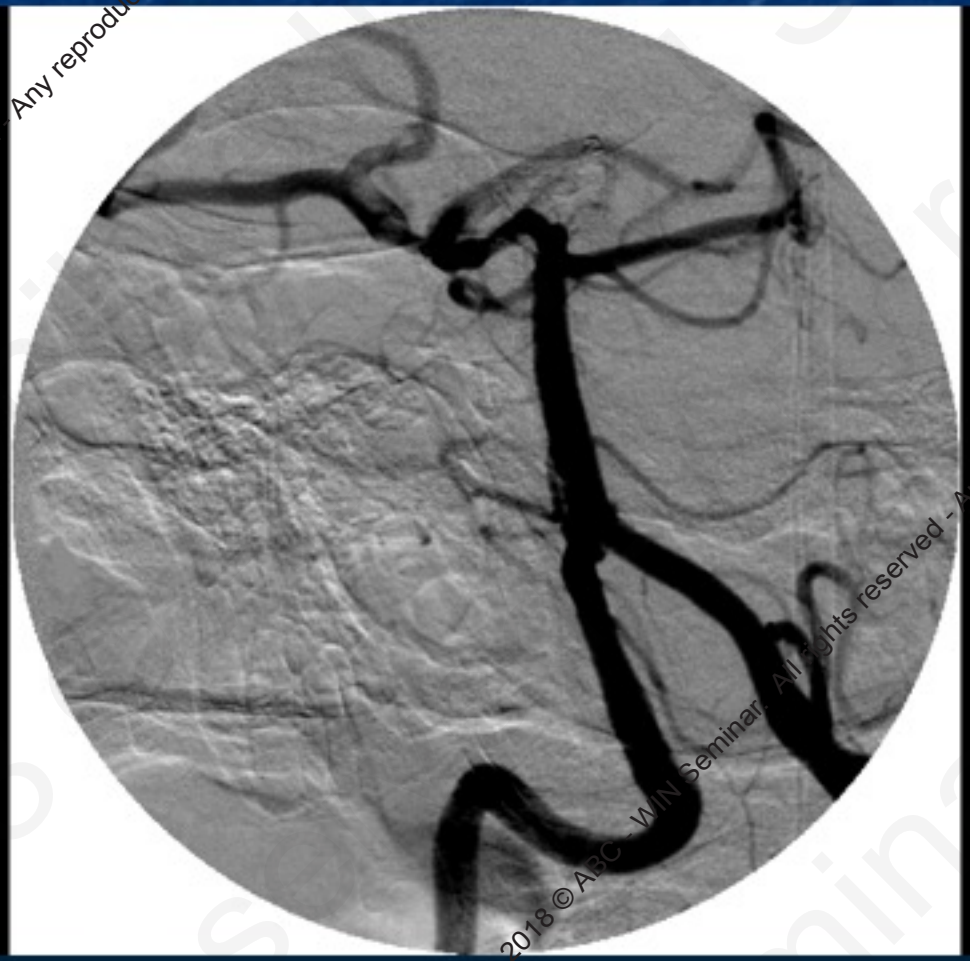
2 Enterprise stents placed in series

Obliteration of aneurysm without coils



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Flow Diversion

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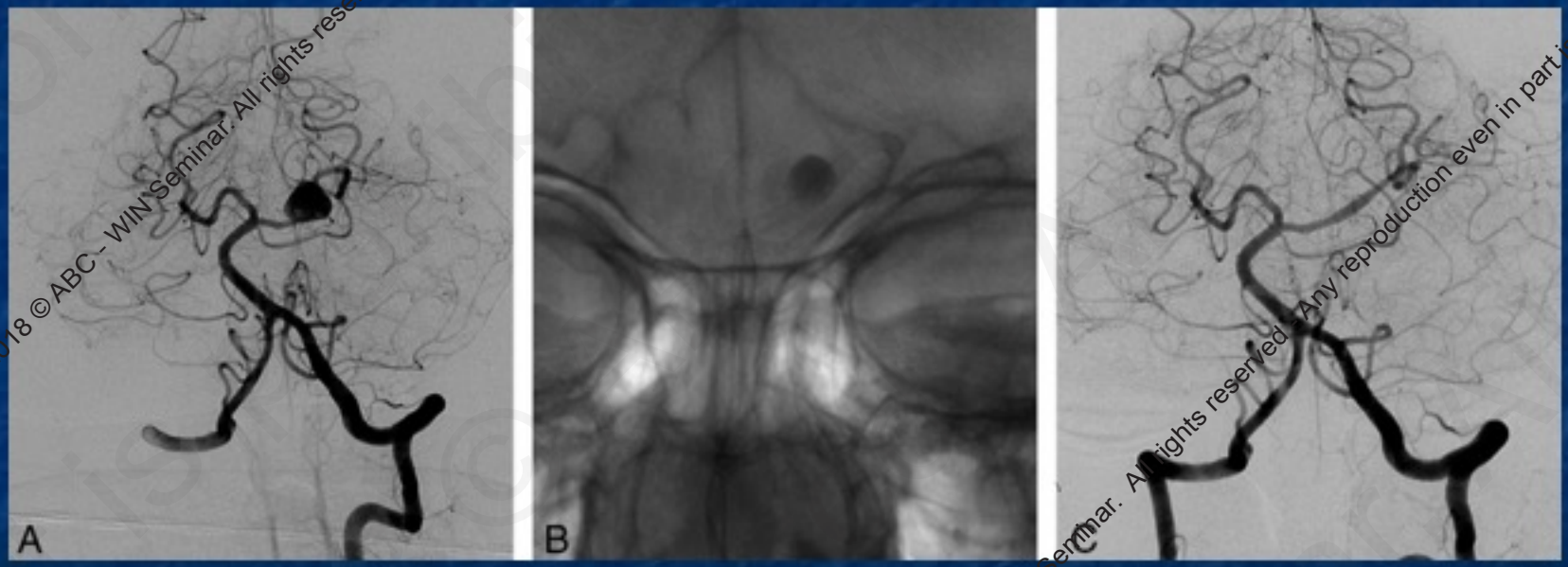
Left vertebral angiogram (A) demonstrates the left PCA aneurysm, which presented with left thalamic infarct (not shown).

Left vertebral angiogram (*A*) demonstrates the left PCA aneurysm, which presented with left thalamic infarct (not shown). Immediate postoperative view (*B*) shows the single PED (2.5 × 20 mm) placed in the left PCA, resulting in contrast stasis within the sac. Control angiography (*C*) after 6 months confirms total occlusion of the aneurysm with the PCA preserved.



I. Saatci et al. AJNR Am J Neuroradiol 2012;33:1436-1446

AJNR
AMERICAN JOURNAL OF NEURORADIOLOGY

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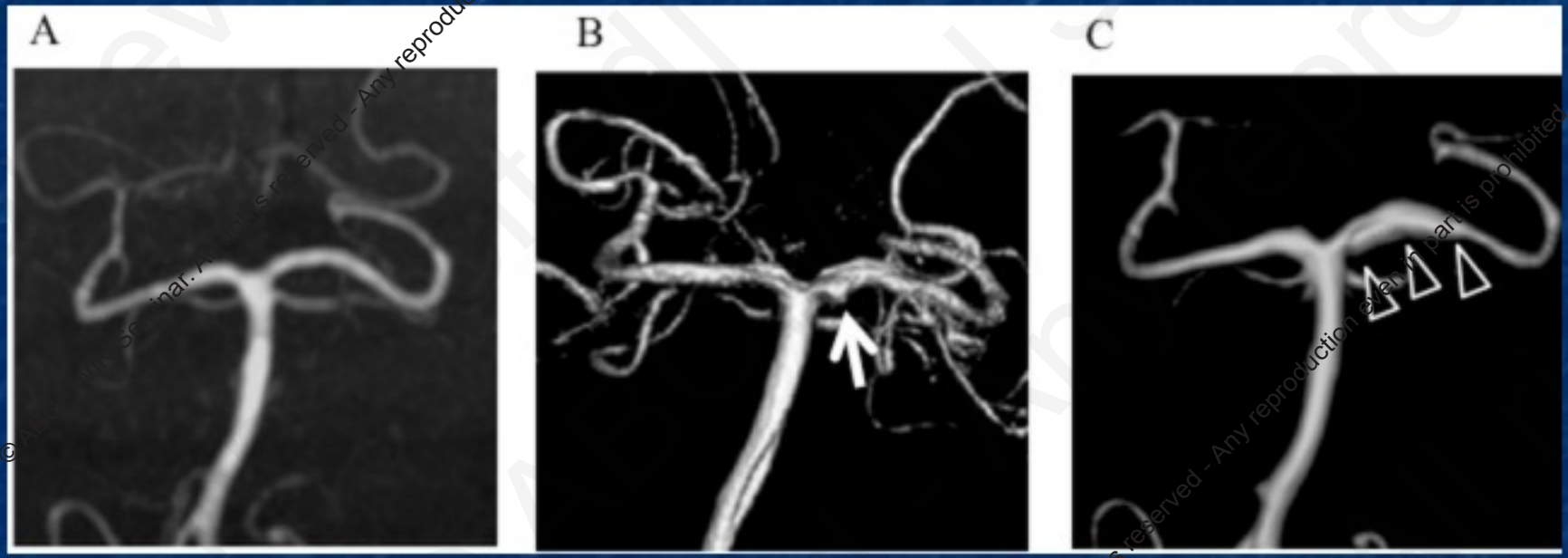
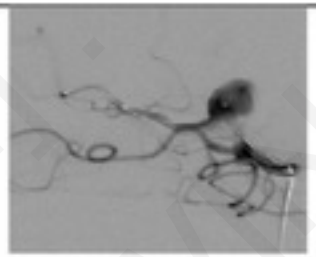
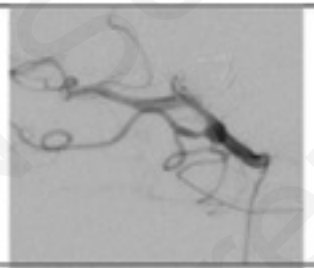
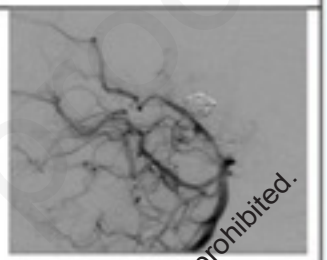
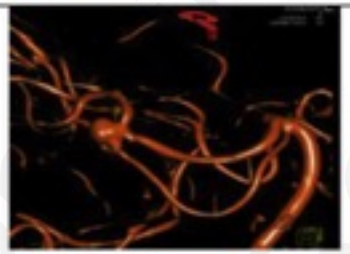
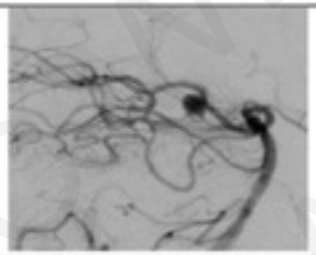
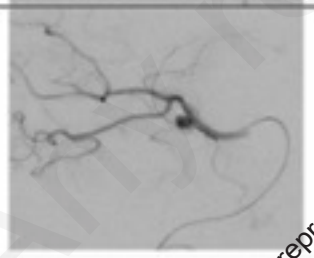
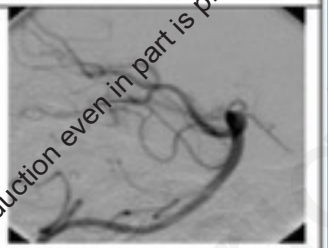
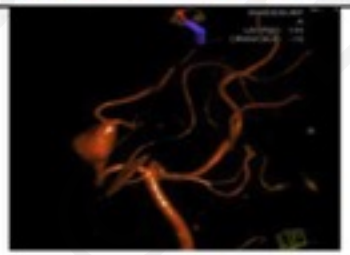
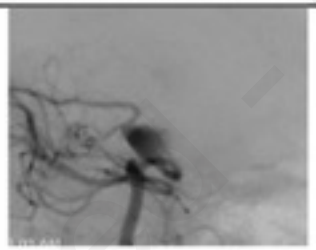
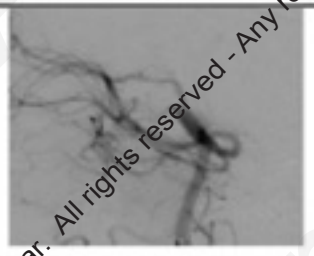
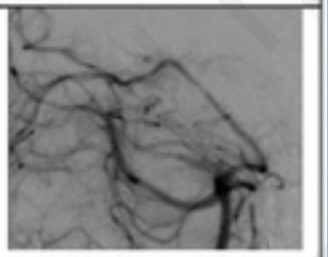
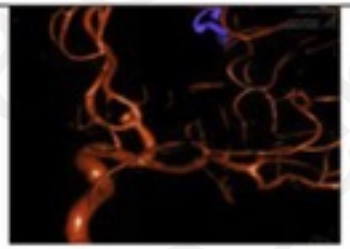
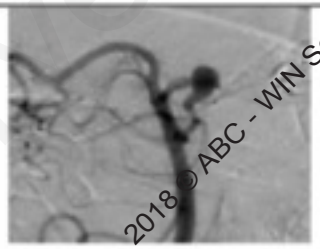
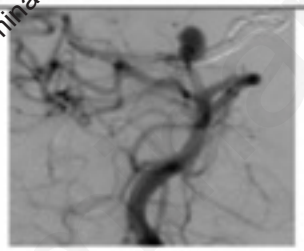
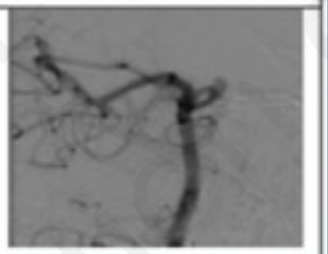
Flow Diversion



Han et al 2008

Endovascular Treatment of Complex Distal Posterior Cerebral Artery Aneurysms with the Pipeline Embolization Device

Paul Mazaris[1], Tapan Mehta[1], Mohammed Hussaini[1], Violiza Inoa[1], Justin Singer[2], Gary Spiegel[1], Inam Kureshi[1], Martin Ollenschleger[1]

	Pre-PED (volume rendered technique)	Pre-PED	Post-PED	12 month f/u
Case 1				
Case 2				
Case 3				
Case 4				

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Mazaris et al, 2017

TABLE 6. Summary of experiences with flow diverters for PCA aneurysms

Authors & Year	No. of Cases	Treatment Device	No. of Procedure-Related Complications	No. of Deaths	No. of Angiographic Obliterations
de Barros et al., 2011	1	Pipeline	0	0	1
McAuliffe & Wenderoth, 2012	2	Pipeline	0	0	1
Phillips et al., 2012	5	Pipeline	1	0	4
Wagner et al., 2012	1	Silk	1	0	0
Ding et al., 2014	1	Pipeline	1	0	0
Colby et al., 2015	1	Pipeline Flex	1	0	0
Wakhloo et al., 2015	3	Surpass	0	0	3
Roth et al., 2015	1	Pipeline	1	0	0

Qin et al, 2017

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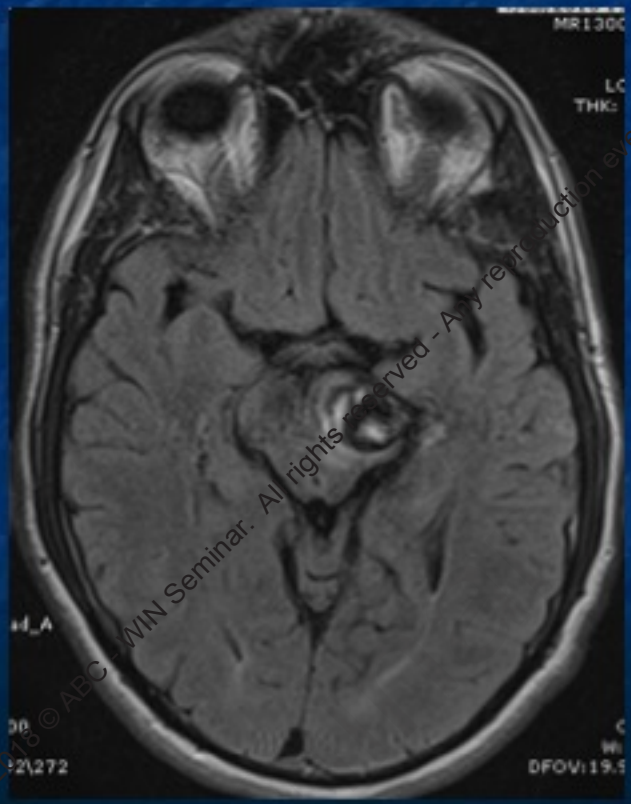
Large PCA aneurysm

- 36 yo male with progressive hx of headache and hemiparesis for several months



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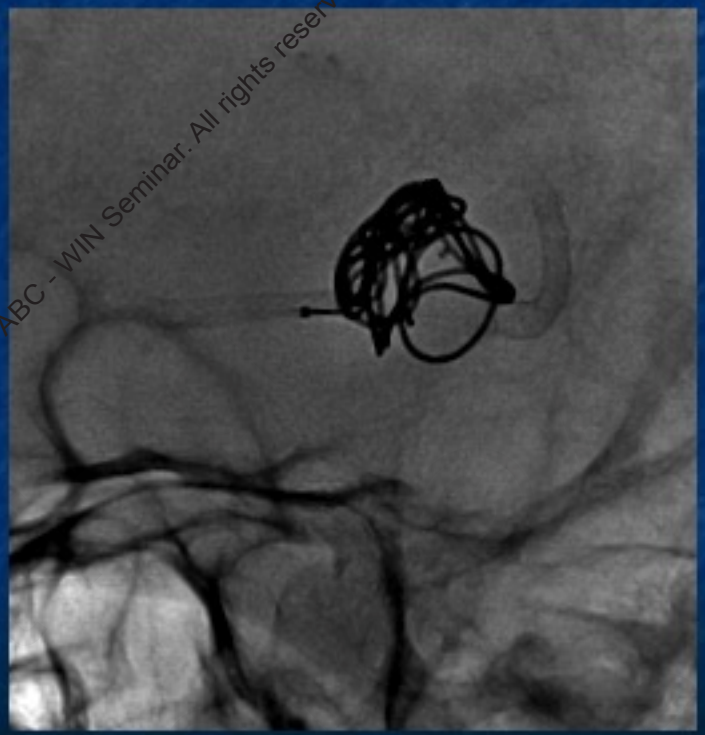
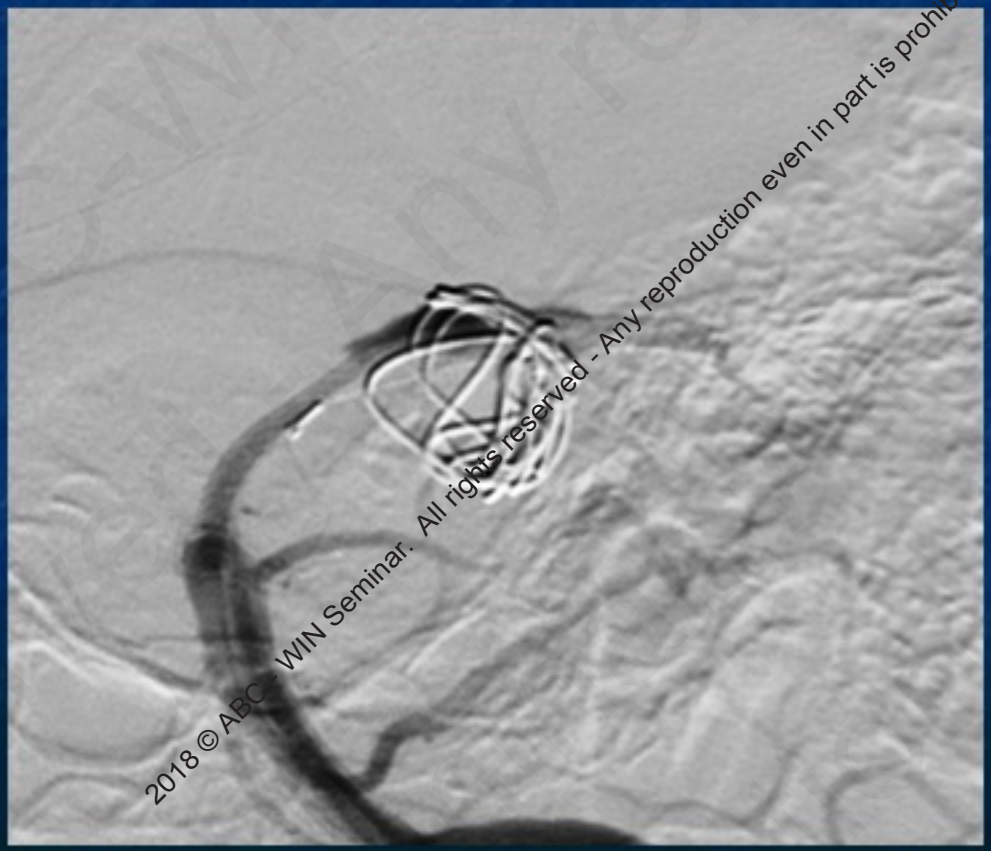
Plan

- Combination of single long Pipeline + Penumbra 400 coils into left PCA





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2 year follow up neurologically intact

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How to prevent complications?

4 strategies:

- Anti-platelet therapy
- Beware of perforator-rich territories
- Avoid using multiple PEDs
- Significant coiling in addition to PED placement for support and thrombosis
- Recognizing intra-op signs of trouble

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Pipeline Embolization Device with or without Adjunctive Coil Embolization: Analysis of Complications from the IntrePED Registry

M.S. Park, C. Kilburg, P. Taussky, F.C. Albuquerque, D.F. Kallmes, E.I. Levy, P. Jabbour, I. Szikora, E. Boccardi, R.A. Hanel, A. Bonafé, and C.G. McDougall

- Patients in the International Retrospective Study of Pipeline Embolization Device registry were divided into those treated with the Pipeline Embolization Device alone (*n* 689 patients; *n* 797 aneurysms; mean aneurysm size, 10.3 7.6 mm) versus those treated with the Pipeline Embolization Device and concurrent coil embolization (*n* 104 patients; *n* 109 aneurysms; mean aneurysm size, 13.6 7.8 mm).
- The Pipeline Embolization Device with versus without coiling required a significantly longer procedure time (135.8 63.9 versus 96.7 46.2 min; *P* .0001) and resulted in higher neurological morbidity (12.5% versus 7.8%; *P* .13).

Park et al, 2016

Table 2: Aneurysm characteristics

Aneurysm Characteristics	PED/Coils	PED Alone	*P* Value[a]
No. of aneurysms	109	797	
No. of patients	104	689	
Aneurysm size (mm)[b]			<.0001
Mean	13.6 ± 7.8	10.3 ± 7.6	
Median, range	12; 1.6–45.0	8; 1.0–55.0	
Aneurysm neck (mm)			.017
Mean	6.4 ± 3.0	6.2 ± 5.1	
Median, range	6; 0.8–16.0	5; 1.9–53.0	
Aneurysm shape (No., %)			.3366
Fusiform	13 (11.9%)	103 (12.9%)	
Saccular	85 (78.0%)	604 (75.8%)	
Dissecting	3 (2.8%)	51 (6.4%)	
Other	8 (7.3%)	39 (4.9%)	
Aneurysm location (No., %)			<.0001
Internal carotid artery	70 (64.2%)	614 (77.0%)	
Middle cerebral artery	8 (7.3%)	35 (4.4%)	
Posterior cerebral artery	0 (0%)	15 (1.9%)	
Basilar artery	16 (14.7%)	28 (3.5%)	
Other	15 (13.8%)	105 (13.2%)	
Aneurysm ruptured at initial presentation (No., %)	13 (11.9%)	63 (7.9%)	.155
Multiple PEDs used[c] (No., %)	34 (31.2%)	274 (34.5%)	.499

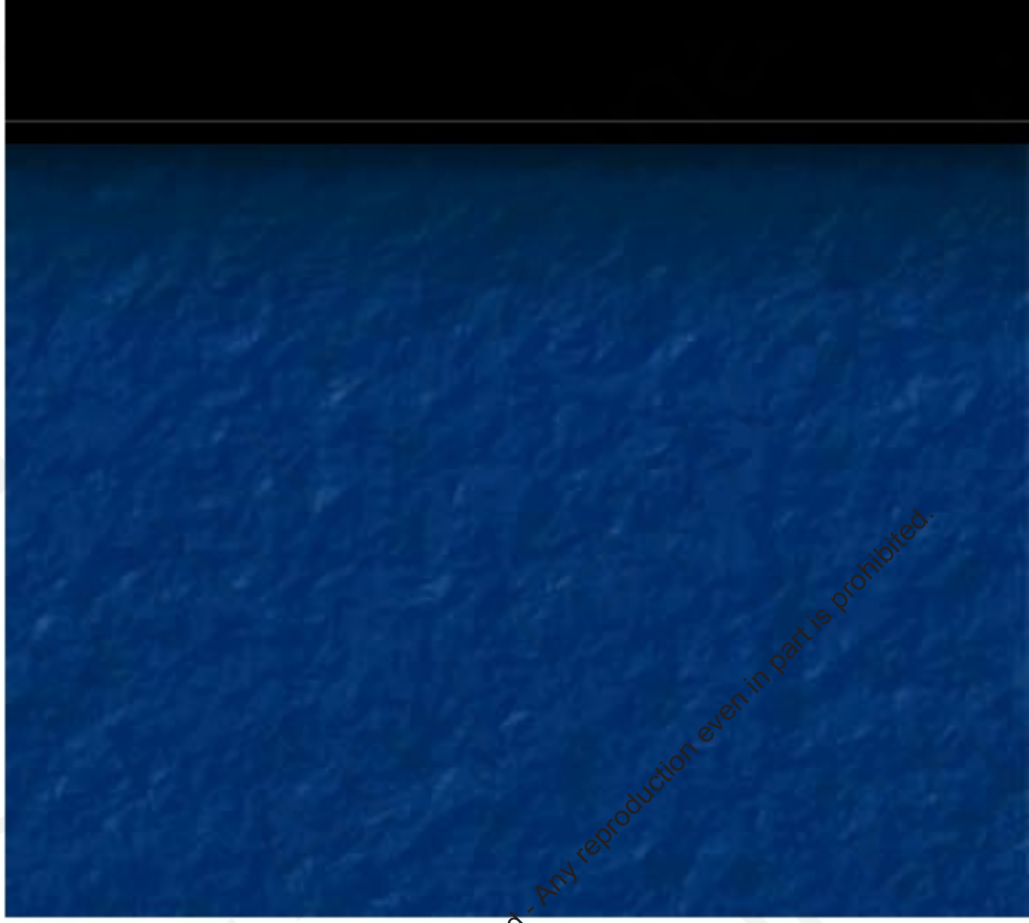

Table 4: Patient outcomes

Major Complications	PED/Coils (*n*, %) (Patients = 104; Aneurysms = 109)	PED Alone (*n*, %) (Patients = 689; Aneurysms = 797)	*P* Value[a]
Neurologic morbidity	11 (10.6%)	48 (7.0%)	.226
Spontaneous rupture	0 (0%)	5 (0.7%)	>.99
Ipsilateral intracranial hemorrhage	3 (2.9%)	17 (2.5%)	.738
Ischemic stroke	7 (6.7%)	29 (4.2%)	.307
Parent artery stenosis	0 (0%)	2 (0.3%)	>.99
Cranial neuropathy	1 (1.0%)	1 (0.1%)	.245
Neurologic mortality	7 (6.7%)	23 (3.3%)	.099
Neurologic morbidity and mortality	13 (12.5%)	54 (7.8%)	.128

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PED in ruptured aneurysms: Buffalo Experience

Journal of NeuroInterventional Surgery

The Journal of the Society of NeuroInterventional Surgery

Utilization of Pipeline embolization device for treatment of ruptured intracranial aneurysms: US multicenter experience.

Lin N[1], Brouillard AM[1], Keigher KM[2], Lopes DK[2], Binning MJ[3], Liebman KM[3], Veznedaroglu E[3], Magarik AA[4], Mocco J[4], Duckworth EA[5], Arthur AS[6], Ringer AJ[7], Snyder KV[8], Levy EI[9], Siddiqui AH[10].

Conclusion: The PED can be utilized for ruptured aneurysms and is a good option for blister-type aneurysms. However, due to periprocedural complications, it should be reserved for lesions that are difficult to treat by conventional clipping or coiling.

Presentation

- 70 year old male who presented previously stent coiled many years prior presented with growth at the aneurysm neck.
- Neurologically intact.

- Able to get microwire and microcatheter through stent tines into the residual neck of the aneurysm

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Microsurgical Clip Ligation

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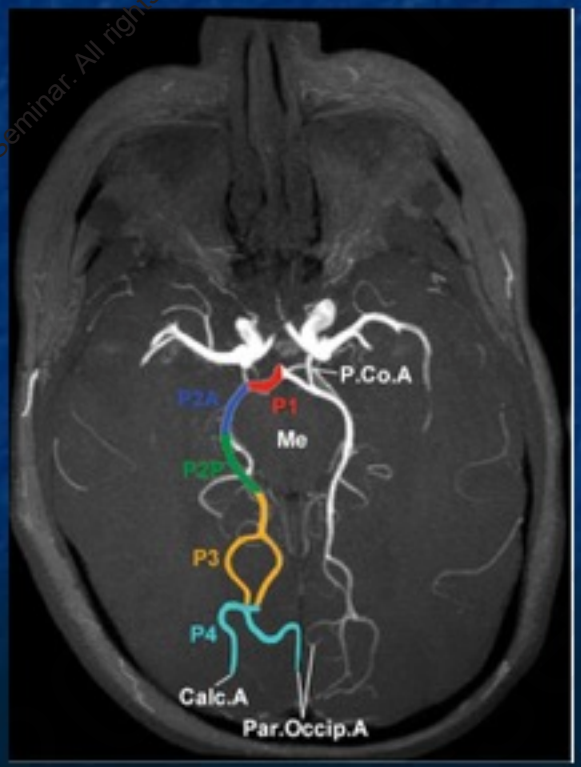
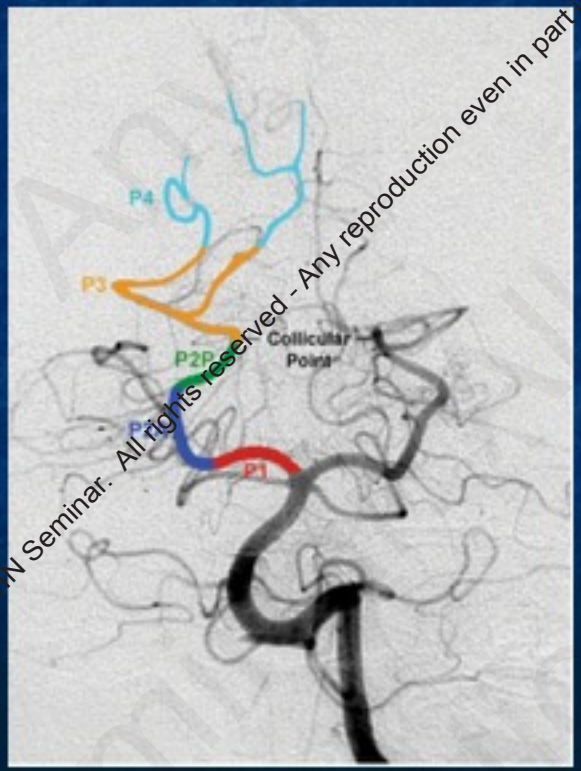
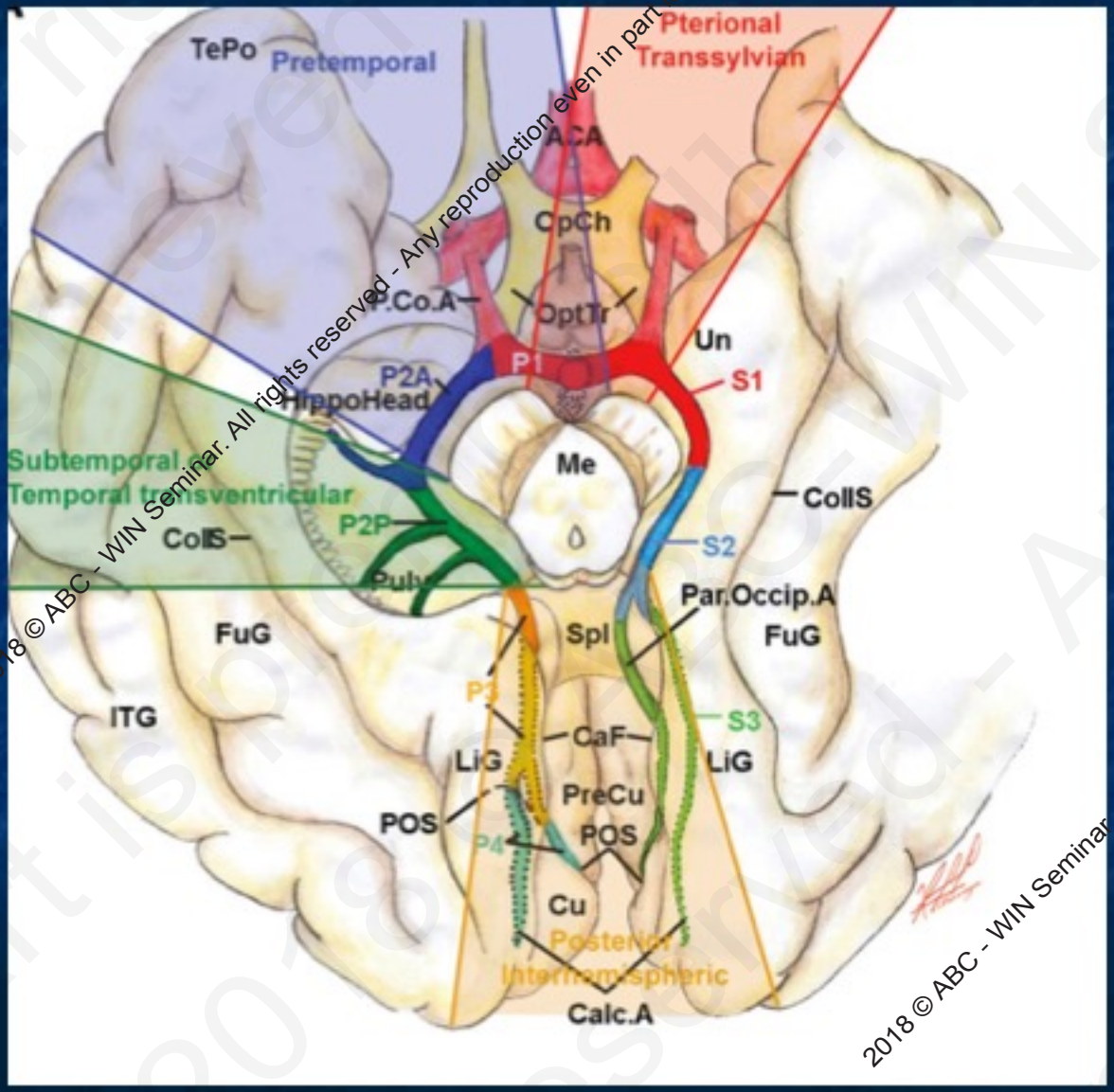
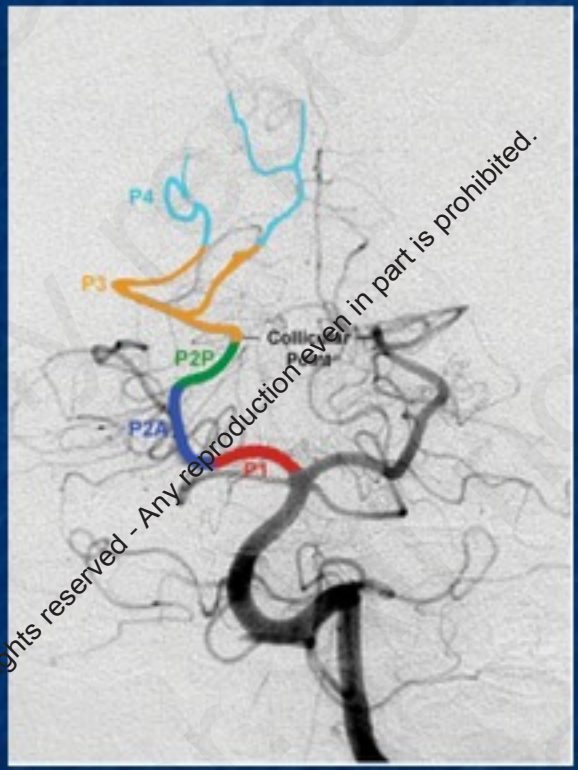
Factors favoring Clipping

- If vessels are less than 1.5mm likely hood of patency with stenting is poor
- Very distal aneurysms serving eloquent matter









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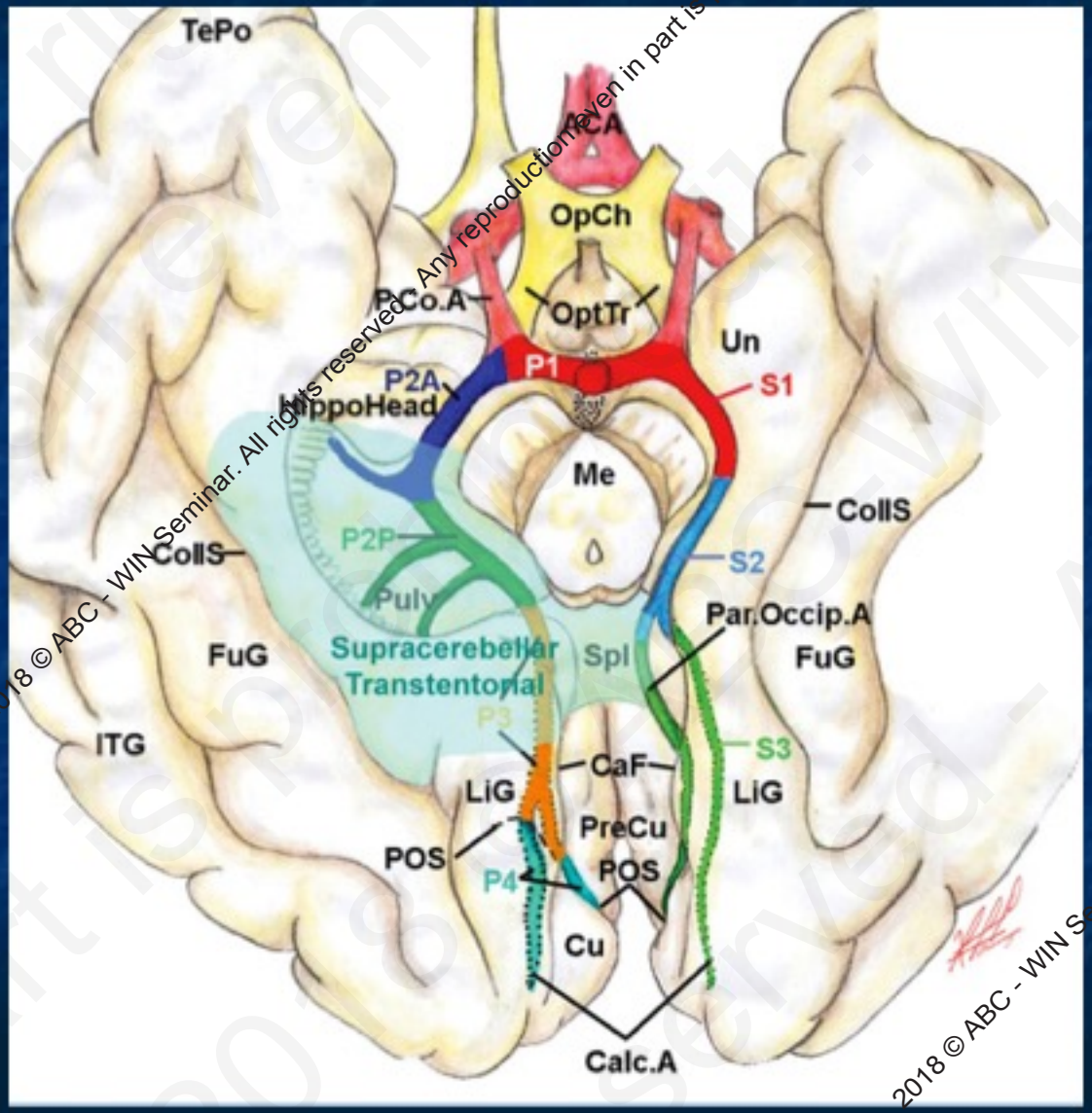

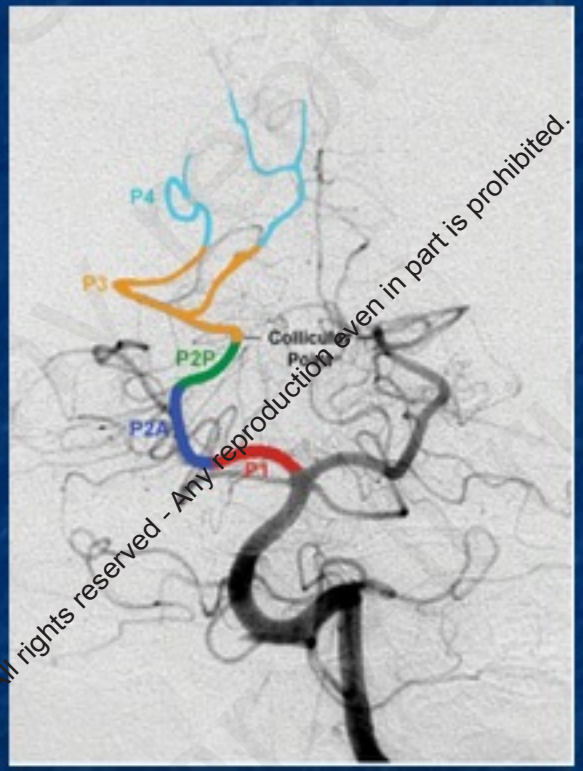

Factors favoring Clipping
Severe access tortuosity

- If intracranial access cannot be obtained satisfactorily then open surgery provides excellent direct access
- Difficult for distal flow diversion or assisted coiling techniques

Factors favoring Clipping

Recurrence after coiling for a rupture

- Aneurysm should be ideally treated if they can following a rupture with coil embolization with or without balloon assistance
- However, once patient has recovered from the acute phase AND the aneurysm demonstrates recurrence then definitive therapy should be considered
- If patient anatomy is not amenable to available stent techniques then clipping remains an excellent choice

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Results of surgical management for posterior cerebral artery aneurysms: 7-year experience in the endovascular era

Hasan Kocaeli · Chiraz Chaalala · Todd A. Abruzzo · Mario Zuccarello

Table 1 Summary of 15 consecutive patients who underwent treatment of PCA aneurysms. (*F* female, *M* male, *HH* Hunt and Hess SAH scale, *ICA* internal carotid artery, *ICH* intracerebral hemorrhage, *PVO* parent vessel occlusion) (Printed with permission of Mayfield Clinic)

Patient no.	Age, sex	Symptoms	Segment affected	Type of aneurysm (size)	Treatment	Complications	Bypass	Outcome[a]
1	57, F	SAH(HH II)	Left P1	Saccular (7 mm)	Endovascular (coiling)	Intraoperative bleeding	No	GOS 5
2	45, F	Headache, first presentation SAH (HH IV) second presentation	Right P1-P2, recurrent right P1-P2	Saccular (10 mm), recurrent Saccular (16 mm)	Endovascular (coiling) and clipping at recurrence	PCA dissection	No	GOS 5
3	40, F	Seizures	Right P2	Saccular partially thrombosed (40 mm)	Surgery (clipping)	Postoperative temporal lobe swelling	Occipital-P4	GOS 5
4	54, F	SAH (HH I)	Right P1-P2	Saccular (6 mm)	Surgery (clipping)	-	No	GOS 5
5	48, F	Unruptured	Left P1-P2	Saccular (3 mm)	Conservative (observation)	-	No	GOS 5
6	45, F	Unruptured	Left P1-P2	Saccular (3 mm)	Conservative (observation)	-	No	GOS 5
7	59, F	Stroke	Right P1-P2	Fusiform, spontaneous thrombosis (14 mm)	Conservative (aspirin)	-	No	GOS 5
8	77, F	SAH (HH I)	Right P1-P2	Saccular (5 mm)	Surgery (clipping)	-	No	GOS 4
9	48, F	Headache	Left P1	Saccular (4 mm)	Surgery (clipping)	Partial CN III palsy	No	GOS 5
10	76, F	SAH (HH III)	Right P1-P2	Saccular (6 mm)	Surgery (clipping)	-	No	GOS 5
11	21, M	Headache	Right P2, left ICA occlusion	Fusiform (22 mm)	Endovascular (coiling)	-	Occipital-P4	GOS 4 (baseline)
12	50, M	ICH	Right P4	Saccular (7 mm)	Surgery (clipping)	-	No	GOS 3 at discharge, lost to follow up
13	28, M	Headache	Right P2	Fusiform, partially thrombosed (22 mm)	Endovascular (PVO by coiling)	-	No	GOS 5
14	30, M	Stroke	Right P2	Saccular partially thrombosed (47 mm)	Endovascular (PVO by coiling)	Left hemianopsia	No	GOS 4
15	47, M	Headache	Left P2	Saccular partially thrombosed (22 mm)	Endovascular (PVO by coiling)	Right hemianopsia	Occipital-P4	GOS 4

[a]Glasgow Outcome Scores (GOS): 1 = death, 2 = persistent vegetative state, 3 = severe disability, 4 = moderate disability, 5 = good recovery

Table 2 Summary of clinical studies of patients with aneurysms of the PCA where the parent vessel was occluded during treatment. (Printed with permission of Mayfield Clinic)

Site of occlusion	Authors, year [ref.]	No. of patients	Collateral flow testing	Revascularization procedure	Deficit
P1	Chang et al., 1986 [2]	1		Yes	
	Ciceri et al., 2001 [3]	1			
	Yonekawa et al., 1999 [26]	2			2 deaths[a]
	Seoane et al., 1997 [21]	3			1 death[a]
	Roh et al., 2007 [19				No deficit despite hippocampus, thalamus, midbrain infarcts
P1-P2	Ponce et al., 2004 [1	1		Yes	1 hemianopsia (resolved)
	Chang et al., 1986 [2]	1			1 hemianopsia and hemiparesis/hemiplagia
	Terasaka et al., 2000 [23]	1			1 hemianopsia and hemiparesis/ hemiplagia
P2	Ponce et al., 2004 [17]	3		Yes	2 hemianopsia 1 hemiparesis/hemiplagia
	Drake et al., 1969 [6]	1			1 death[a]
	Chang et al., 1986 [2]	1			1 transient hemianopsia and hemiparesis/hemiplagia
	Ferrante et al., 1996 [7]	3	Back-bleeding		1 hemianopsia (preoperative)
	Ciceri et al., 2001 [3]	1			
	Hallacq et al., 2002 [10]	4 proximal5 distal	Balloon test occlusion		1 hemianopsia (preoperative)
	Gerber et al., 1992 [8]	5			hemianopsia for 1 year
	Yamashita et al., 1992 [25]	3	Angio collaterals		1 hemianopsia resolved after raised blood pressure
	Kitazawa et al., 2001 [15]	3			
	Van Rooij et al., 2006 [24]	2			
	Arat et al., 2002 [1]	6	Angio collaterals		1 hemianopsia, 1 asymptomatic thalamic infarction
	Hamada et al., 2005 [11]	3			1 hemianopsia
	Sakata et al., 1993 [16]	2			
	Roh et al., 2007 [19]	4			1 asymptomatic medial temporal lobe infarction

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P2-P3	Ciceri et al., 2001 [3]	3			1 hemianopsia, 1 hemianopsia and hemiparesis /hemiplegia
	Van Rooij et al., 2006 [24]	1			1 death[a]
	Yonekawa et al., 1999 [26]	1			1 death[a]
	Arat et al., 2002 [1]	1			1 hemiparesis/hemiplegia and hemianesthesia transient (1 year)
	Jayakumar et al., 2004 [14]	4	Balloon test occlusion		1 death, 2 superior quadrantanopia due to occipital infarct, 1 asymptomatic distal embolism
	Roh et al., 2007 [19]	1			1 asymptomatic thalamus and splenium infarct
P3	Drake et al., 1969 [6]	1			Hemianesthesia transient
	Ciceri et al., 2001 [3]	2			
	Gerber et al., 1992 [8]	1			
	Arat et al., 2002 [1]	1			
	Honda et al., 2004 [13]	1			1 hemianopsia

Site of occlusion	Authors, year [ref.]	No. of patients	Collateral flow testing	Revascularization procedure	Deficit
	Roh et al., 2007 [19]	1			
P3-P4	Ponce et al., 2004 [17]	1		Yes	
P4	Van Rooij et al., 2006 [24]	2			1 death[a], 1 hemianopsia (preoperative)
	Taylor et al., 2003 [22]	1			1 hemianopsia
Unknown	Ponce et al., 2004 [17]	1			
	Higadisha et al., 1989 [12]	3			
	Taylor et al., 2003 [22]	8			2 hemianopsia (preoperative)
Total		91			20 (death or permanent deficit)

Table 1 Review of patients with P_4 aneurysms of the posterior cerebral artery

Case No.	Author (Year)	Age (yrs)/ Sex	Clinical presentation	H&K grade	Aneurysm (side/size/type)	Surgery (approach/procedure)	Outcome
1	Burton et al. (1968)[3]	14/M	ICH, trauma	NA	rt/small/NA	occipital craniotomy/ proximal electrocautery	MD, quadrantic hemianopia
2	Ishikawa et al. (1974)[11]	40/M	ICH, mycotic infection	NA	lt/small/NA	transhematoma/ resection	MD, hemianopia
3	Pia and Fontana (1977)[15]	43/F	ICH, IVH, congenital aneurysm	4	lt/small/saccular	occipital lobectomy	NA, hemianopia
4	Tanaka et al. (1980)[23]	40/M	SAH, moyamoya disease	2	lt/small/saccular	transventricle/ resection	MD, hemianopia
5	Ishibashi and Onuma (1989)[10]	6?/F	ICH, IVH, congenital aneurysm	2	lt/small/saccular	OIHA/ clipping	MD, hemianopia
6	Statham et al. (1990)[22]	45/F	incidental, SAH (ruptured P_2)	3	lt/giant/fusiform	subtemporal approach/ proximal clipping	MD, hemianopia
7	Barker (1992)[2]	42/M	ICH, IVH, tumor	4	rt/small/saccular	transhematoma/ clipping	NA
8	Orita et al. (1994)[13]	63/M	ICH, lt ICA occlusion	4	lt/small/saccular	OIHA/ coating	NA
9		73/F	ICH, IVH, SLE	4	lt/small/saccular	transhematoma/ clipping	D
10	Ito et al. (1998)[12]	57/M	SAH, ICH	2	lt/small/saccular	OIHA/ clipping	MD, hemianopia
11	Ramakrishnamurthy et al. (1999)[16]	50/F	SAH, ICH	1	lt/small/fusiform	OIHA/ clipping	NA
12	Eckard et al. (2000)[7]	NA/NA	SAH	NA	rt/NA/NA	coil PAO	MD, hemianopia
13	Hashimoto et al. (2000)[9]	73/M	ICH, SAH, rt ICA occlusion	2	rt/small/saccular	OIHA/ clipping	MD, hemianopia
14	van Rooij et al. (2006)[24]	27/M	SAH, endocarditis	4	NA/small/NA	coil PAO	D
15		64/F	SAH, congenital aneurysm	2	NA/small/NA	coil PAO	MD, hemianopia
16	Present case	75/F	SAH, congenital aneurysm	2	lt/small/saccular	OIHA/ clipping	GR

Yamahata et al, 2010

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Long-term Clinical and Angiographic Follow-up of Unclippable Wrapped Intracranial Aneurysms

22	47/F	Incidental	R PI segment	Giant with perforators	Wrapped	Cotton	5	None	24	5	12	Cath	Stable
32	30/M	Traumatic	R PCA	Fusiform dissecting	Wrapping	Cotton	5	None	48	5	10	Cath	Stable
33	68/M	Incidental	L P1-2 Jx	Unknown	Wrapped	Cotton	5	None	48	5	48	Cath	Stable
38	27/M	SAH	R PCA P2-3	Fusiform/	Clip-wrap	Cotton	5	None	48	5	48	Cath	Stable
43	68/F	SAH	L PCA P1	Fusiform dissecting	Wrapped	Cotton	5	L CN III palsy	60	5	60	MRA	Stable
56	29/M	Stroke/emboli from aneurysm	L PCA	Fusiform	Wrapped	Cotton	5	None	108	5			

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Deshmukh et al, 2005

Presentation

- 54 year old female with no past medical history.
- Underwent workup for gait difficulty and found to have right carotid dissection.
- Neurologically intact.

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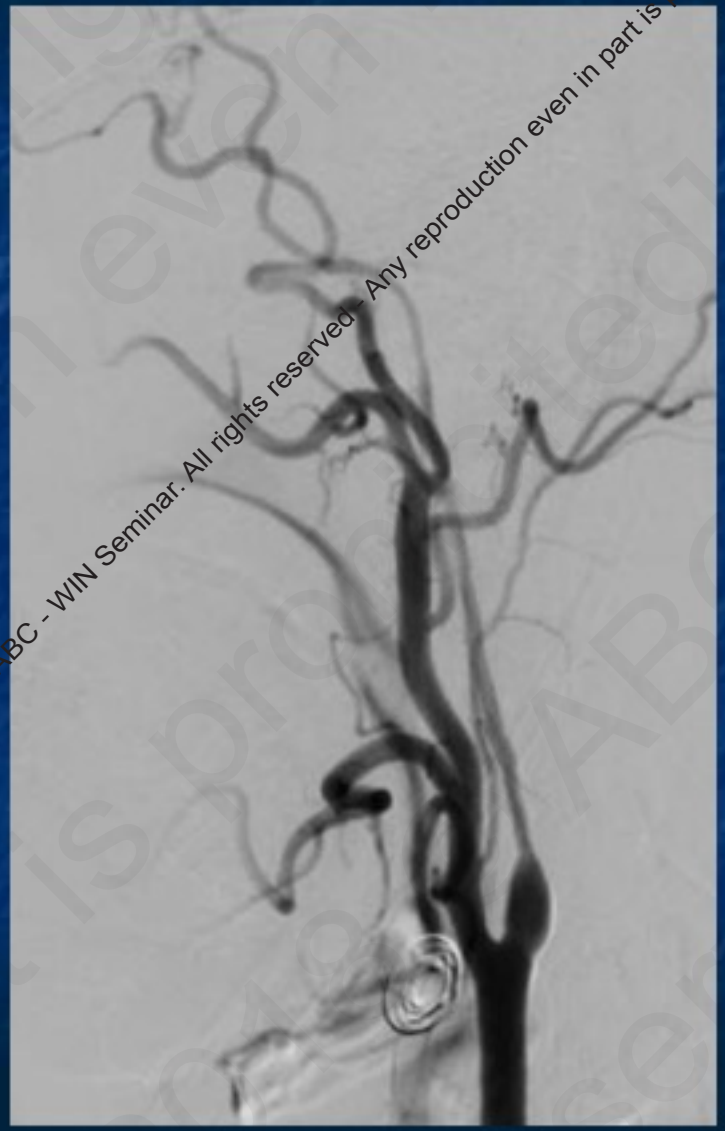
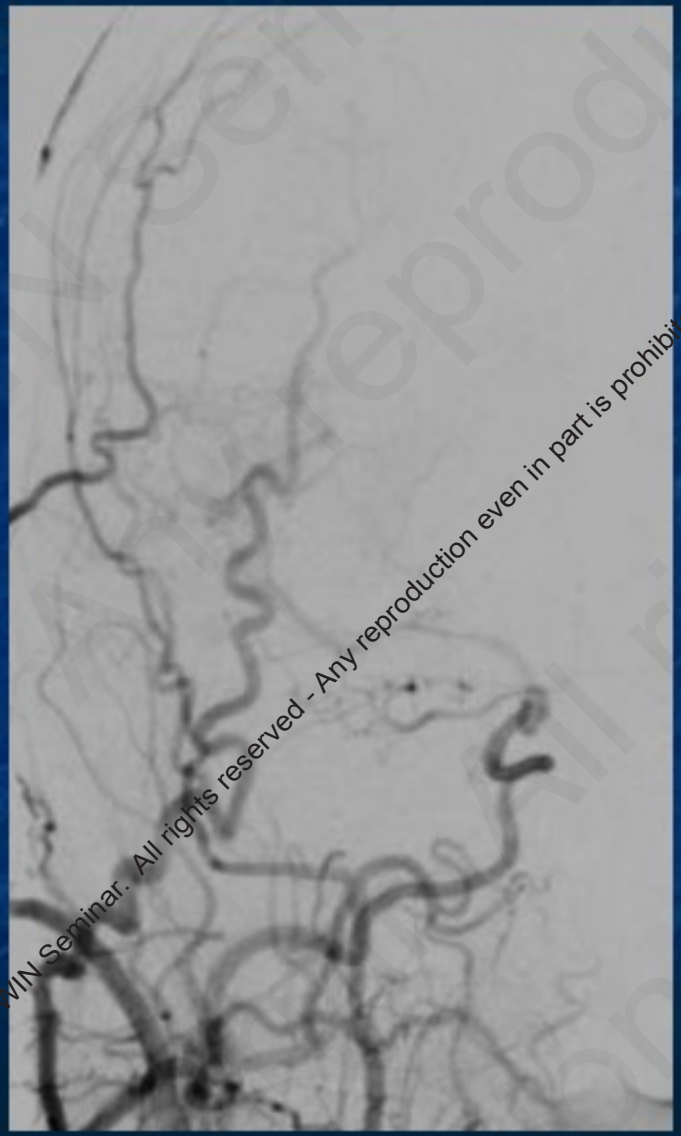
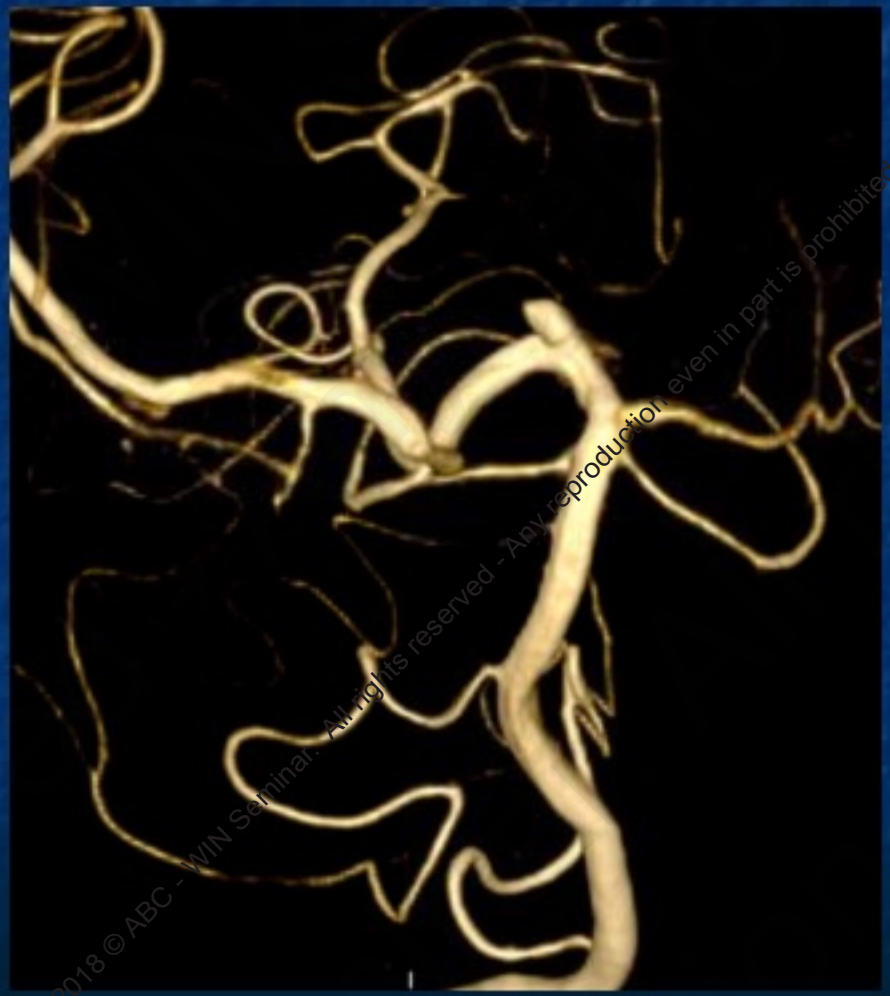
RIGHT CCA INJECTION







- Given that aneurysm was likely flow related and need for protection of flow to right MCA and diminutive inflow from the ICA
- Concern for jailing contralateral PCA and SCA
- Flow diversion difficult with difficult to navigate neck for coiling

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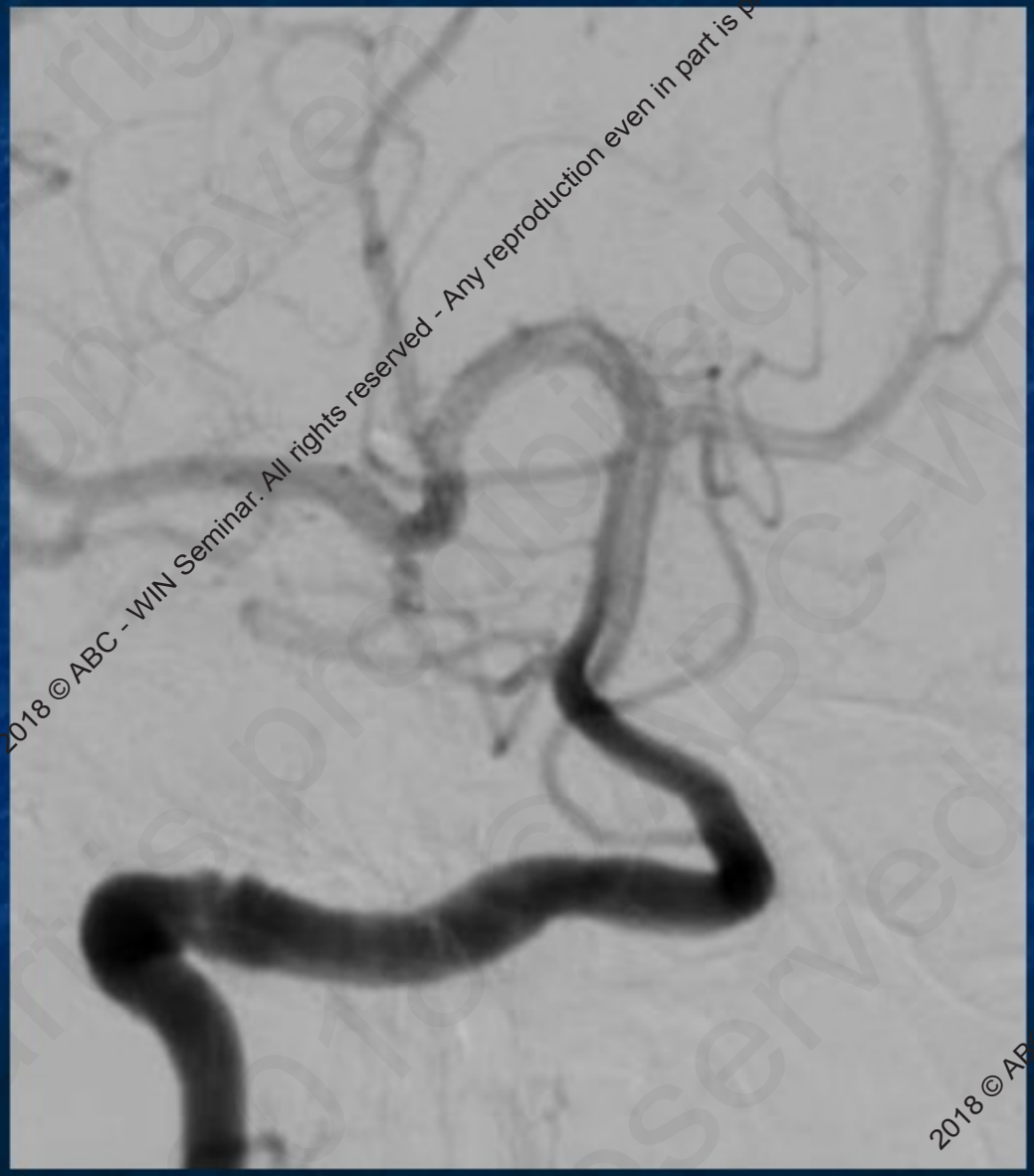

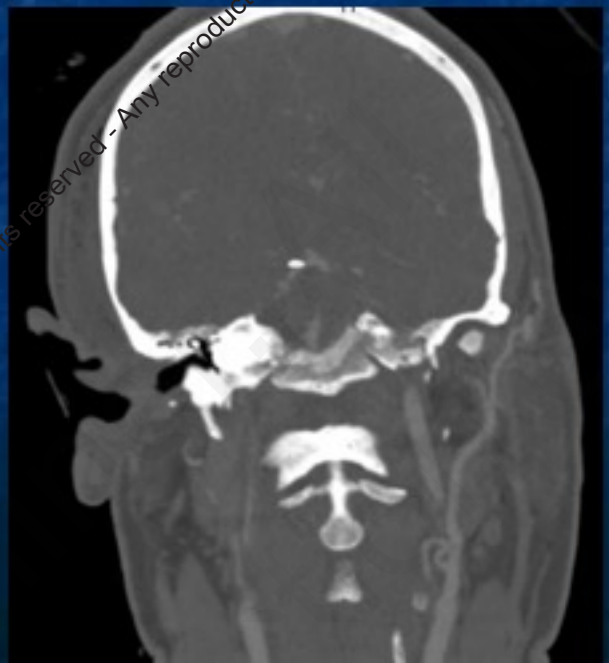

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And then there are these cases....

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15 yo F

- Presented with worsening of H/A and R 3rd nerve palsy over the past few days
- h/o mild R 3rd nerve palsy & mild headache since last September
- Head CT @ CHOB; LP – (no SAH)
- Transferred to MFGH on 03/18/2007
- O/E: only R 3rd nerve palsy; markedly improved after 10mg decadron

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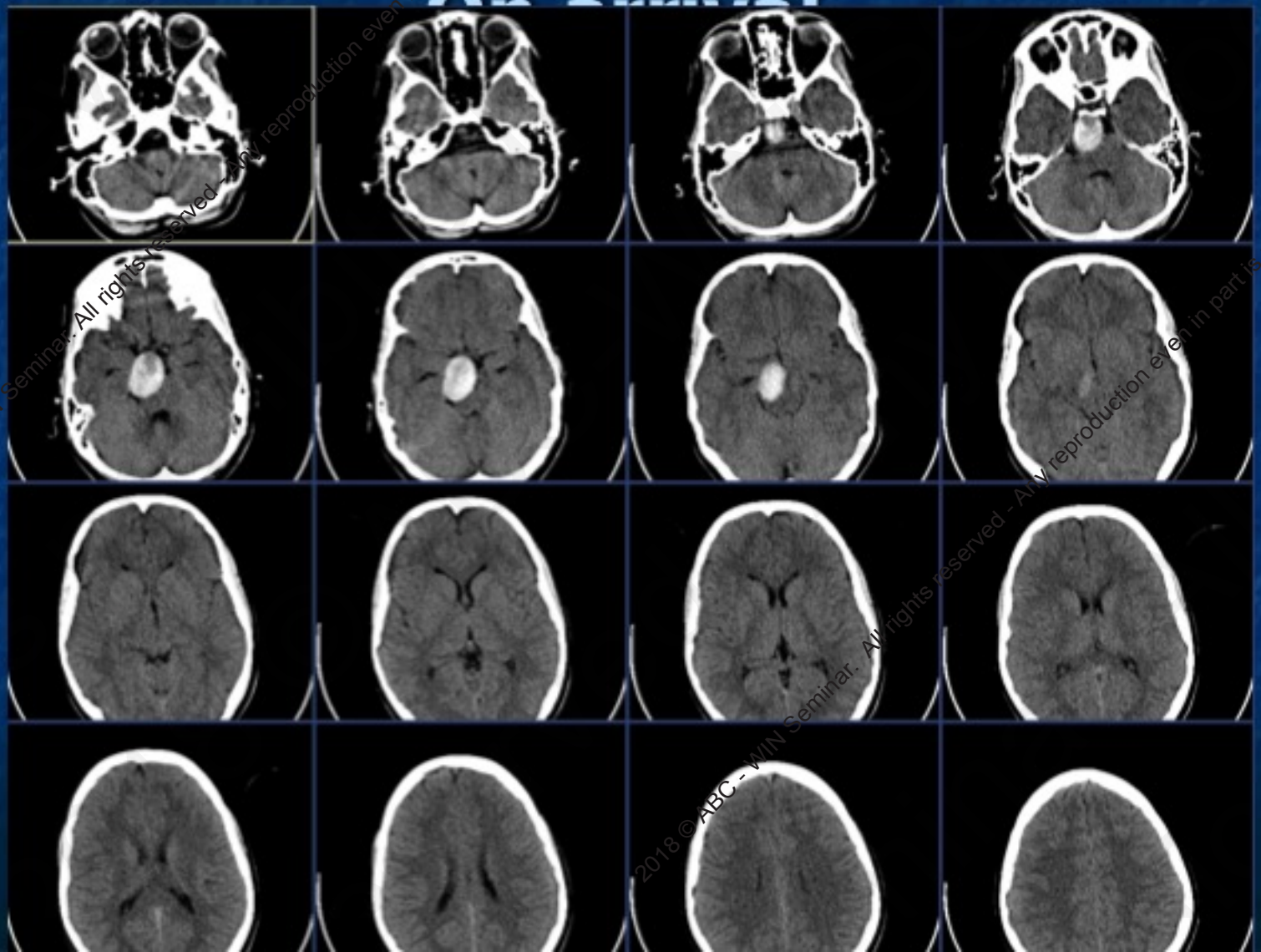
On arrival



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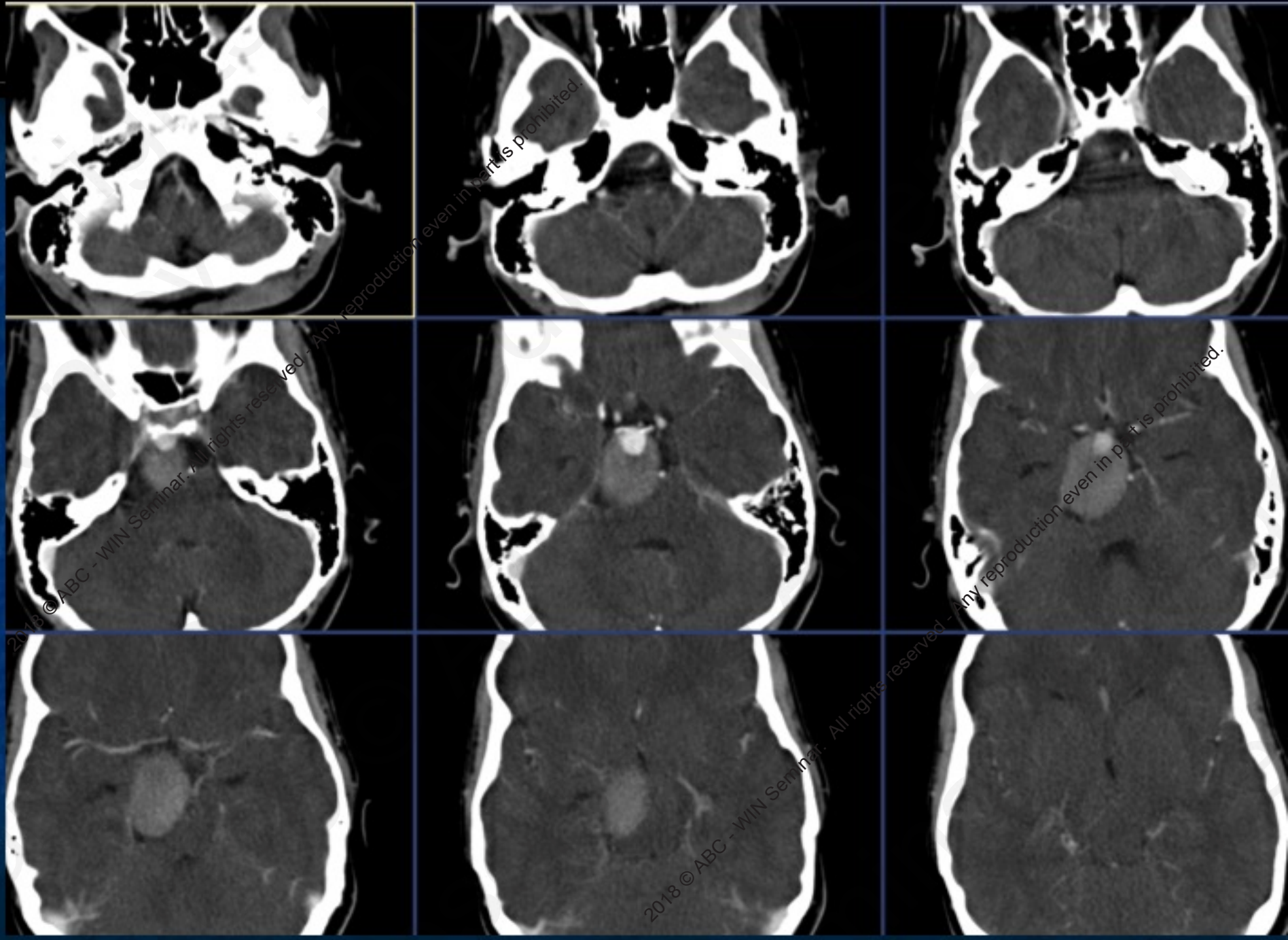

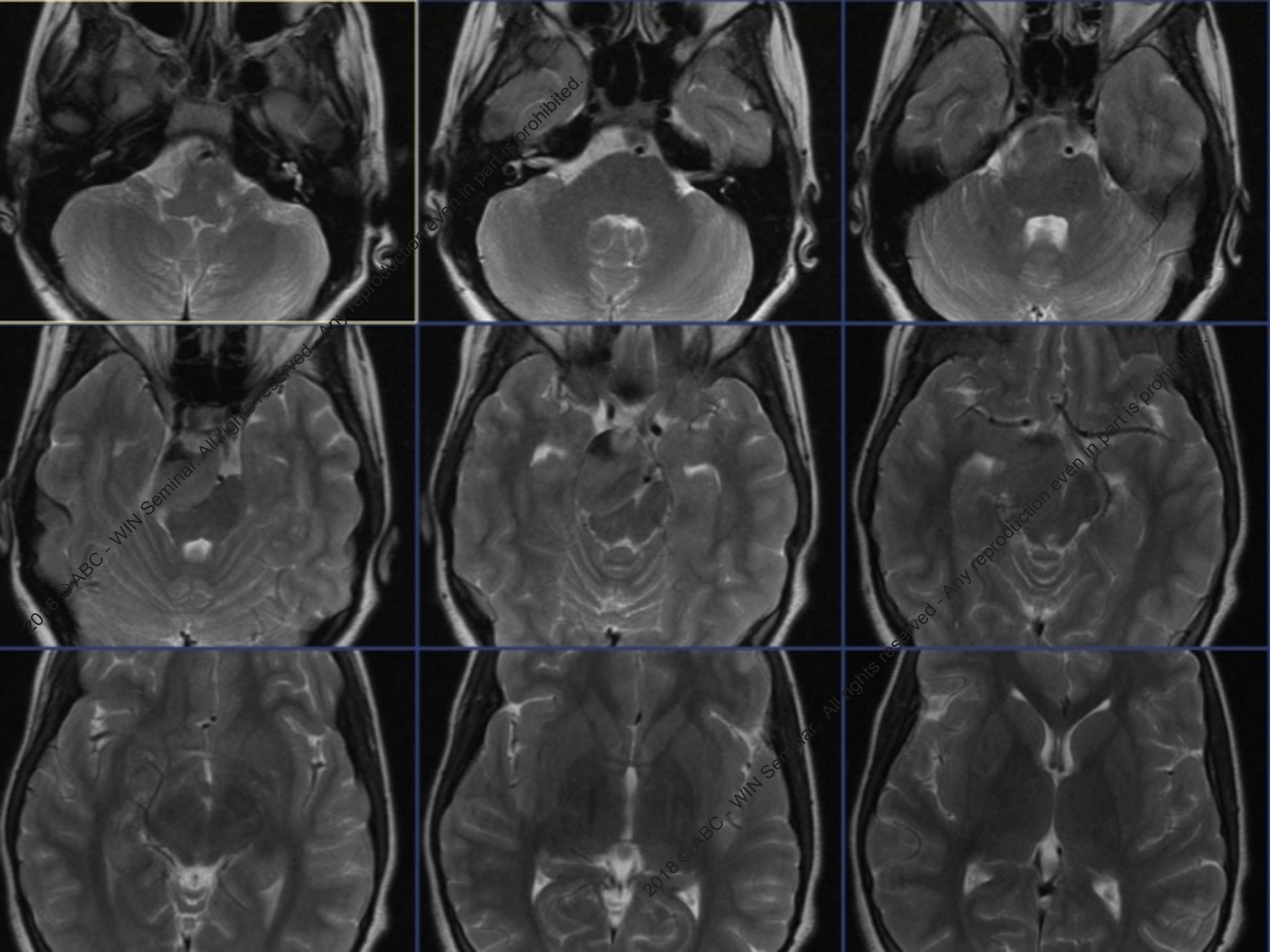

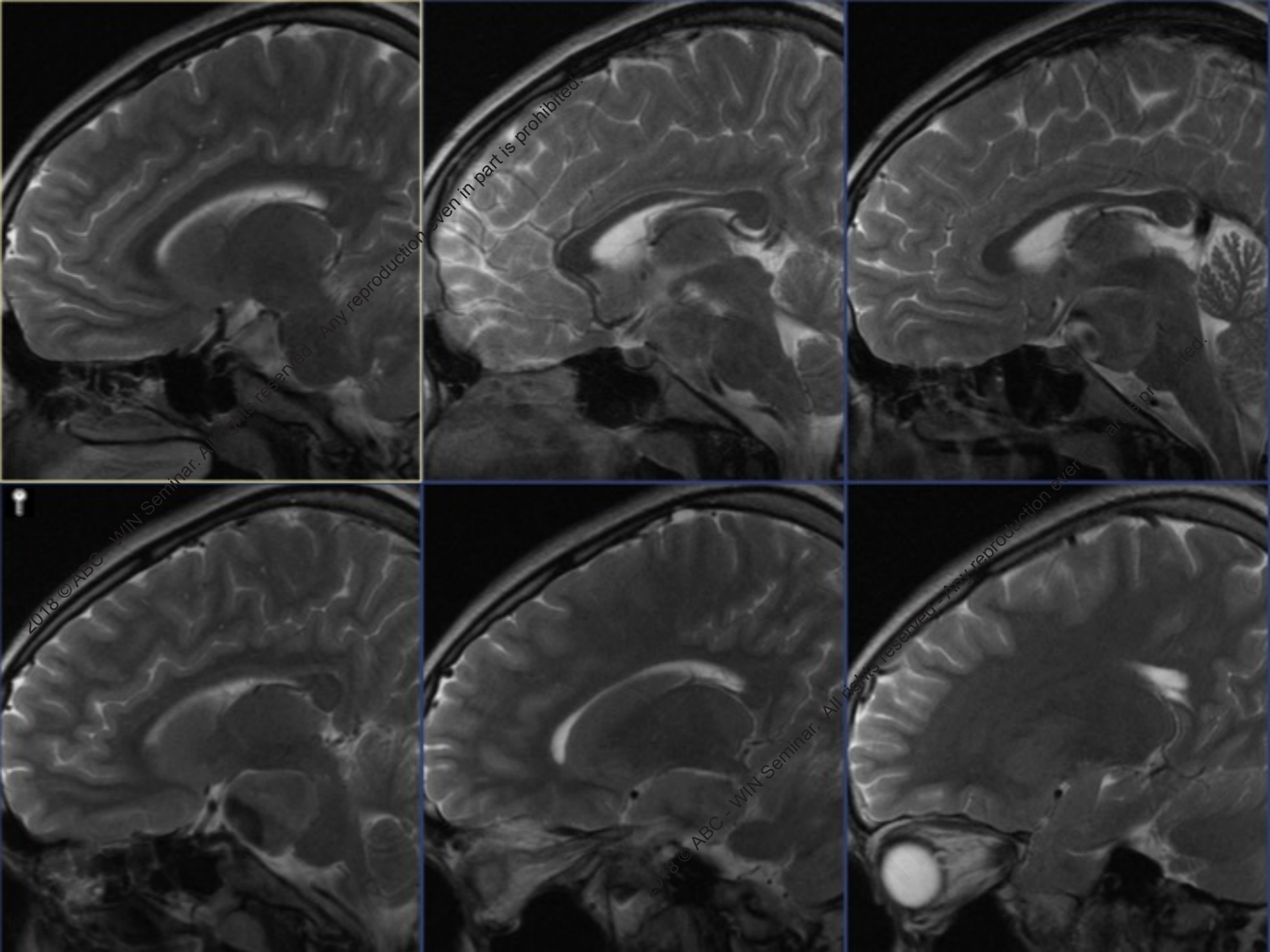

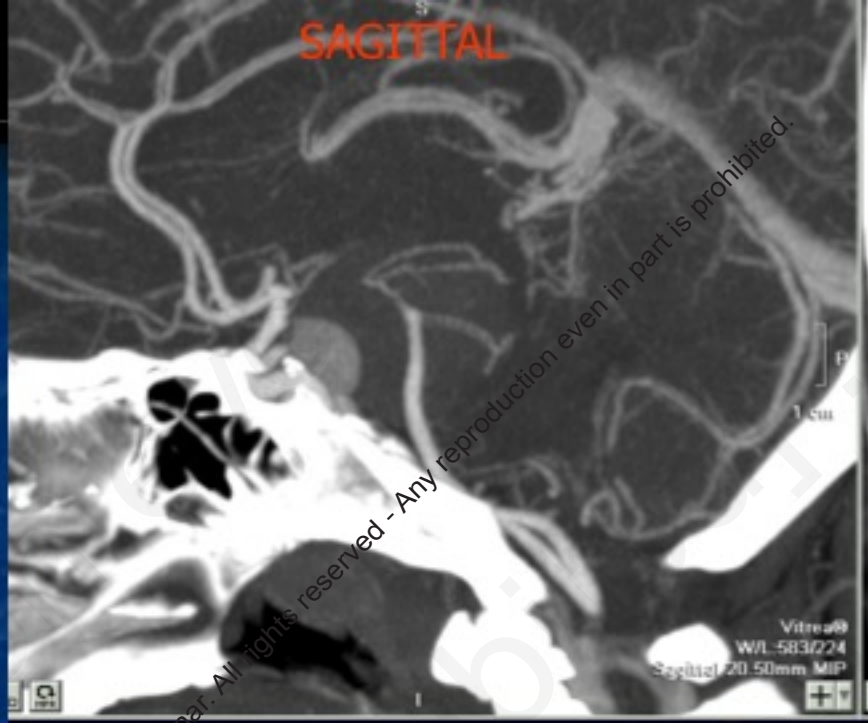

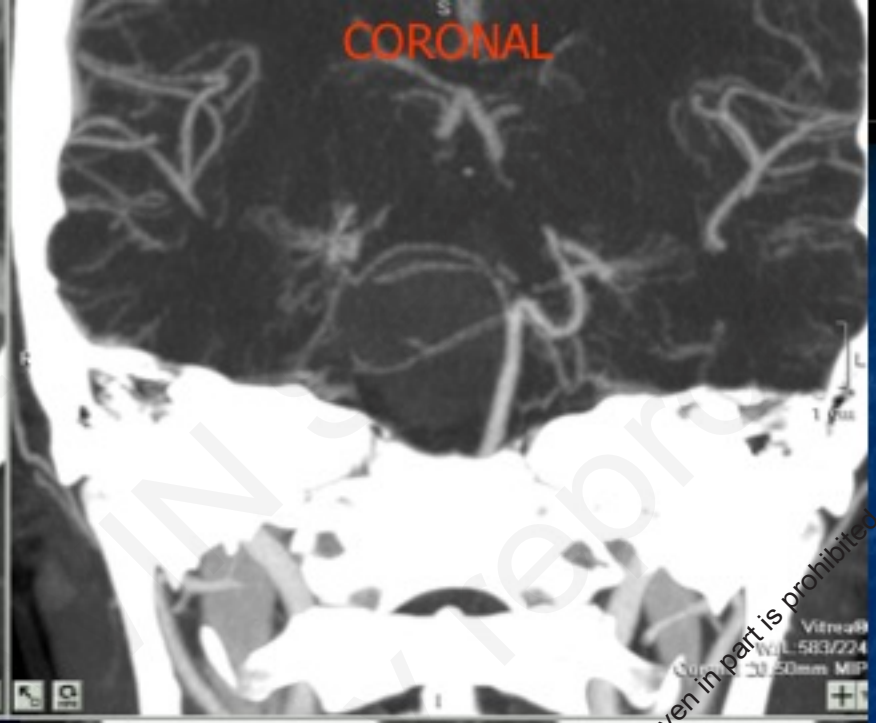

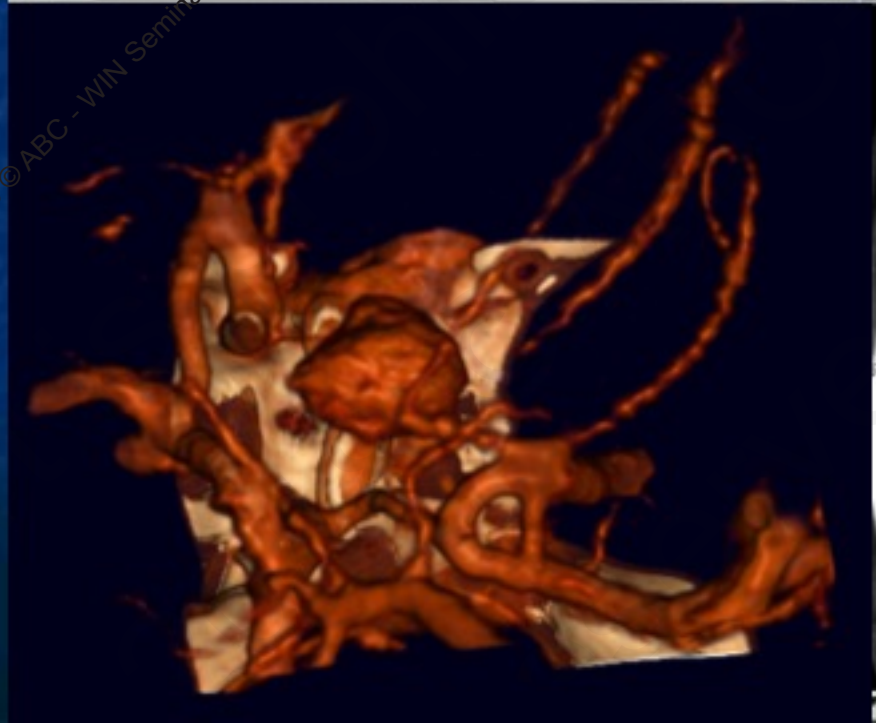

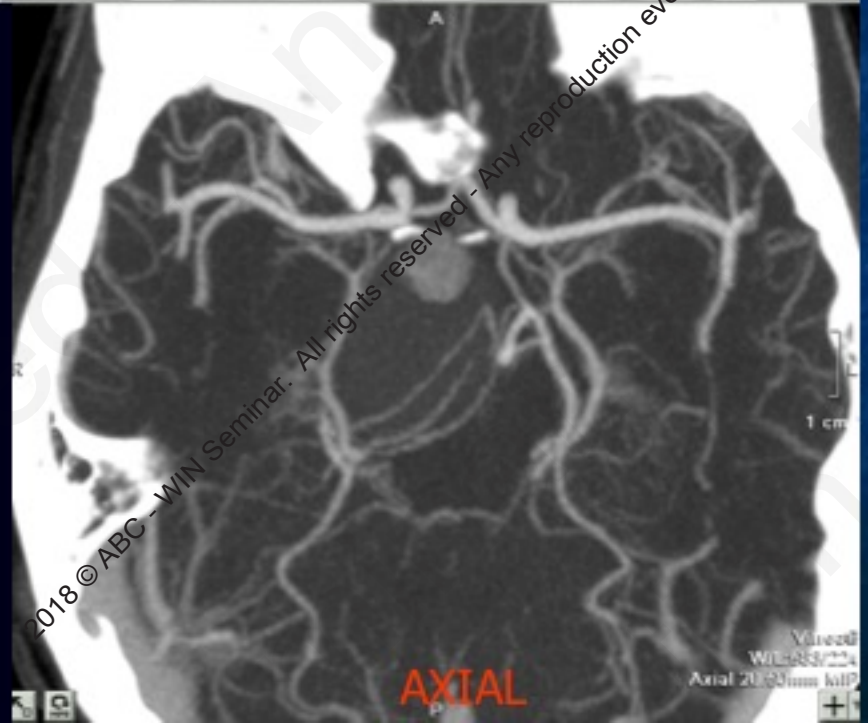

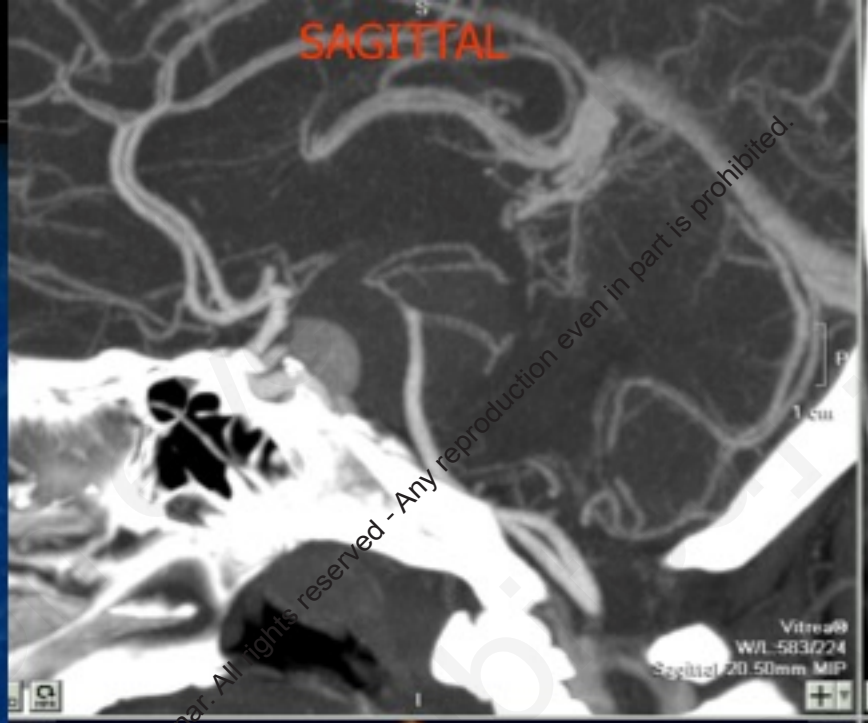

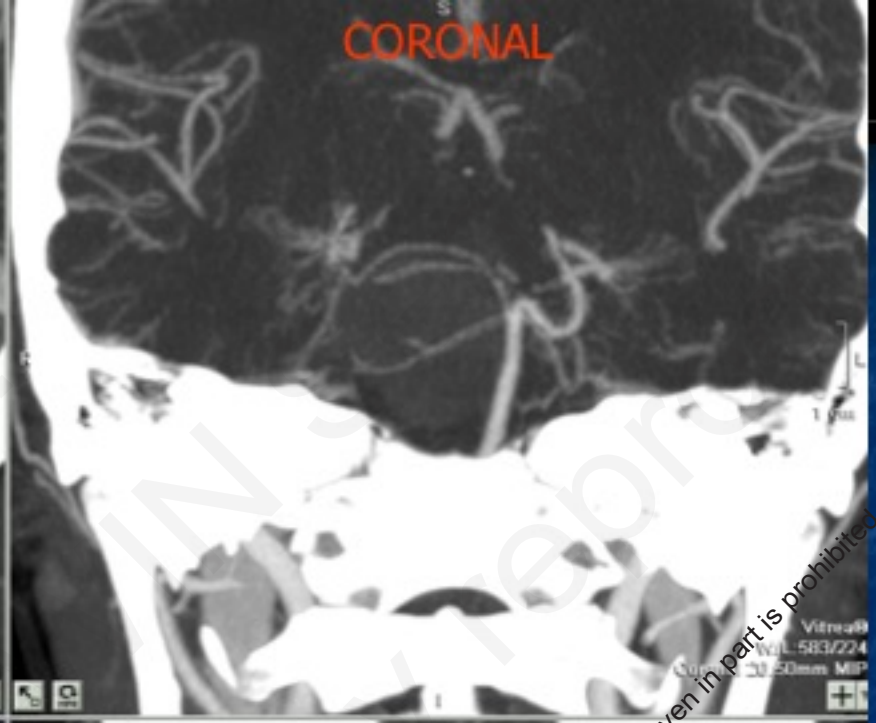

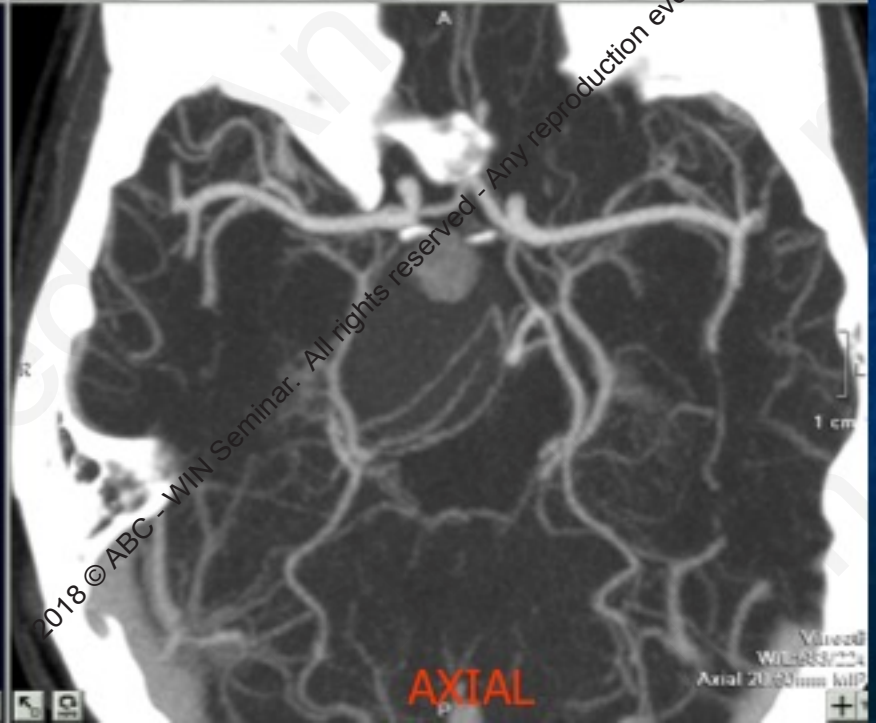

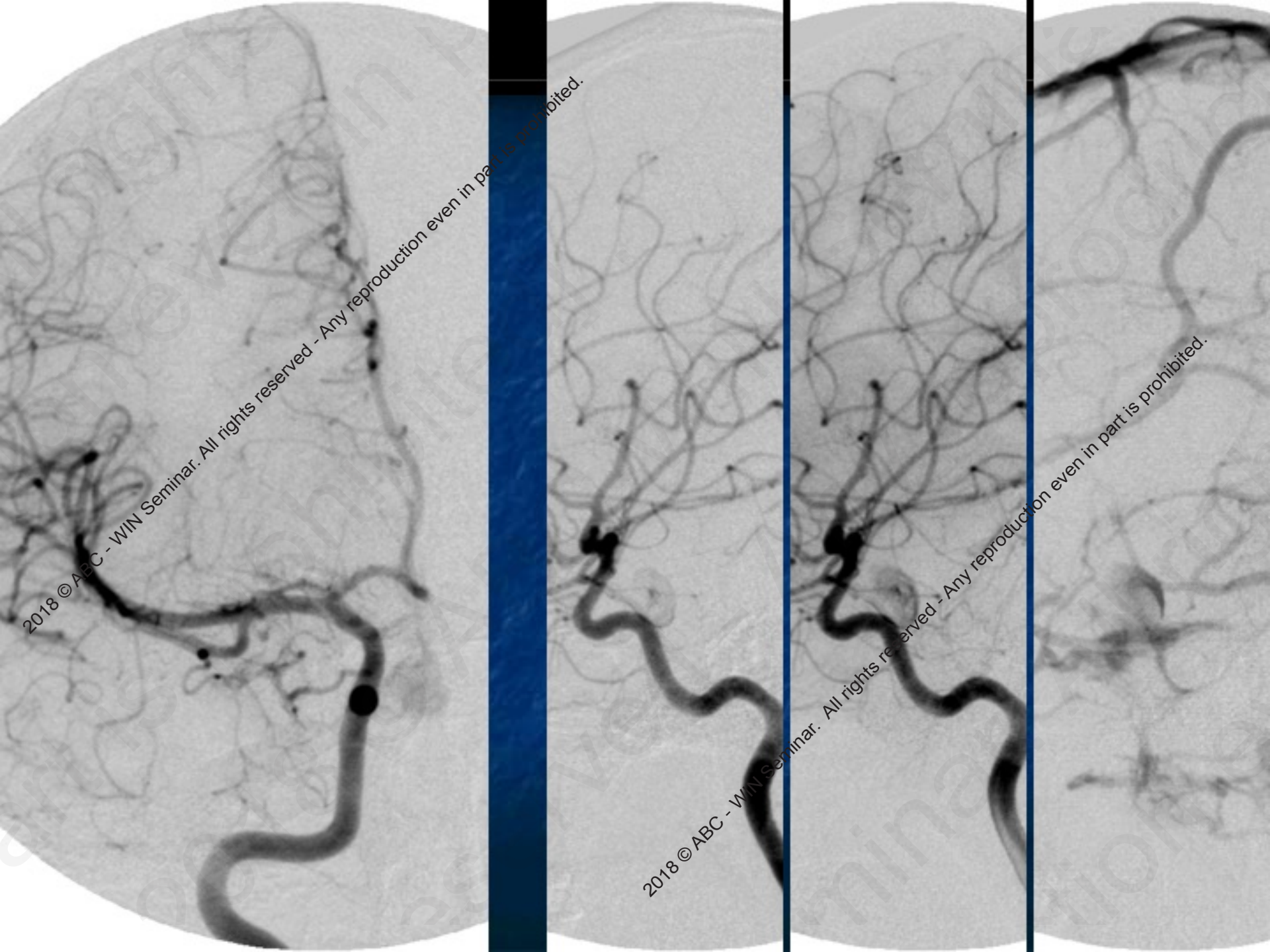

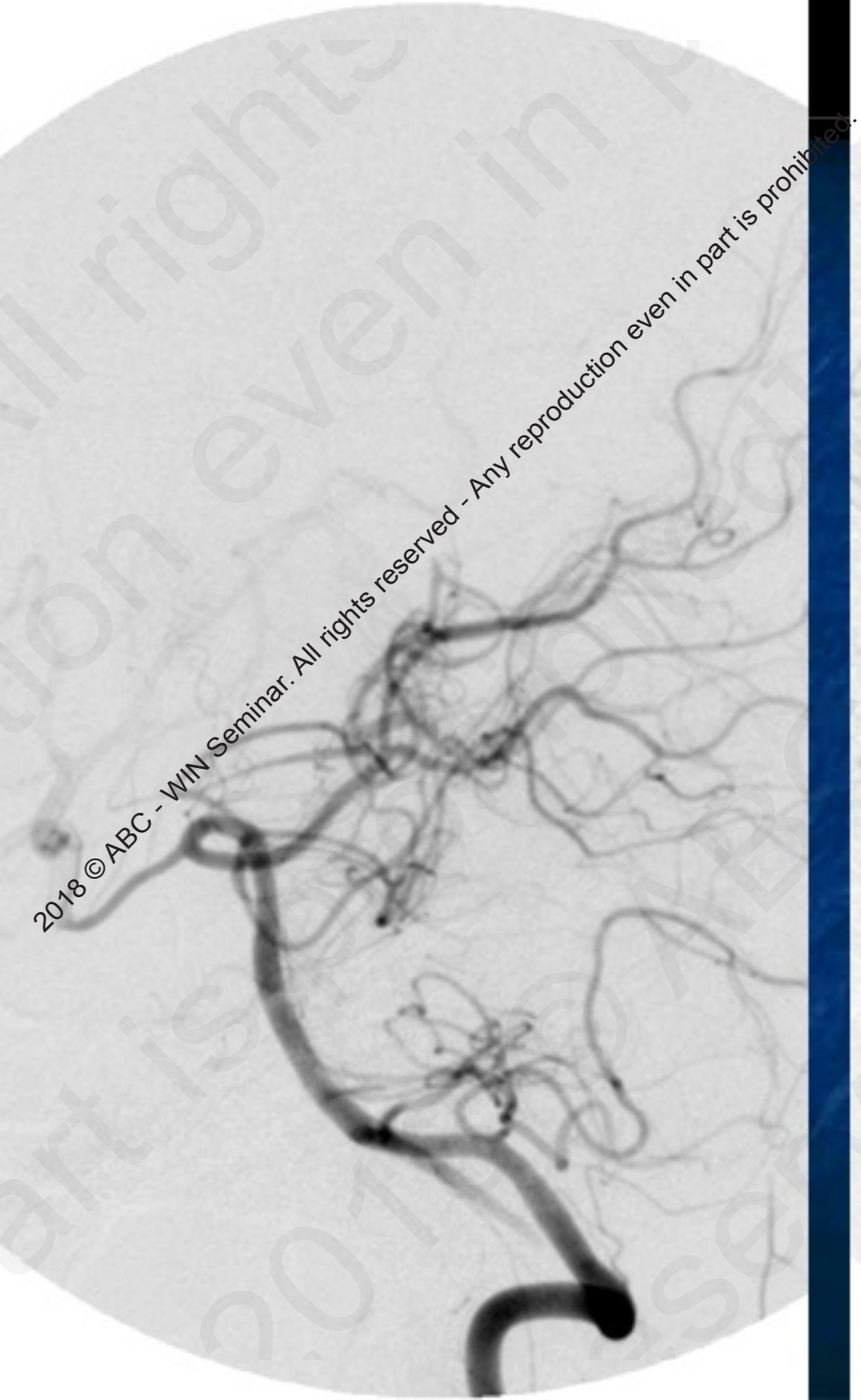

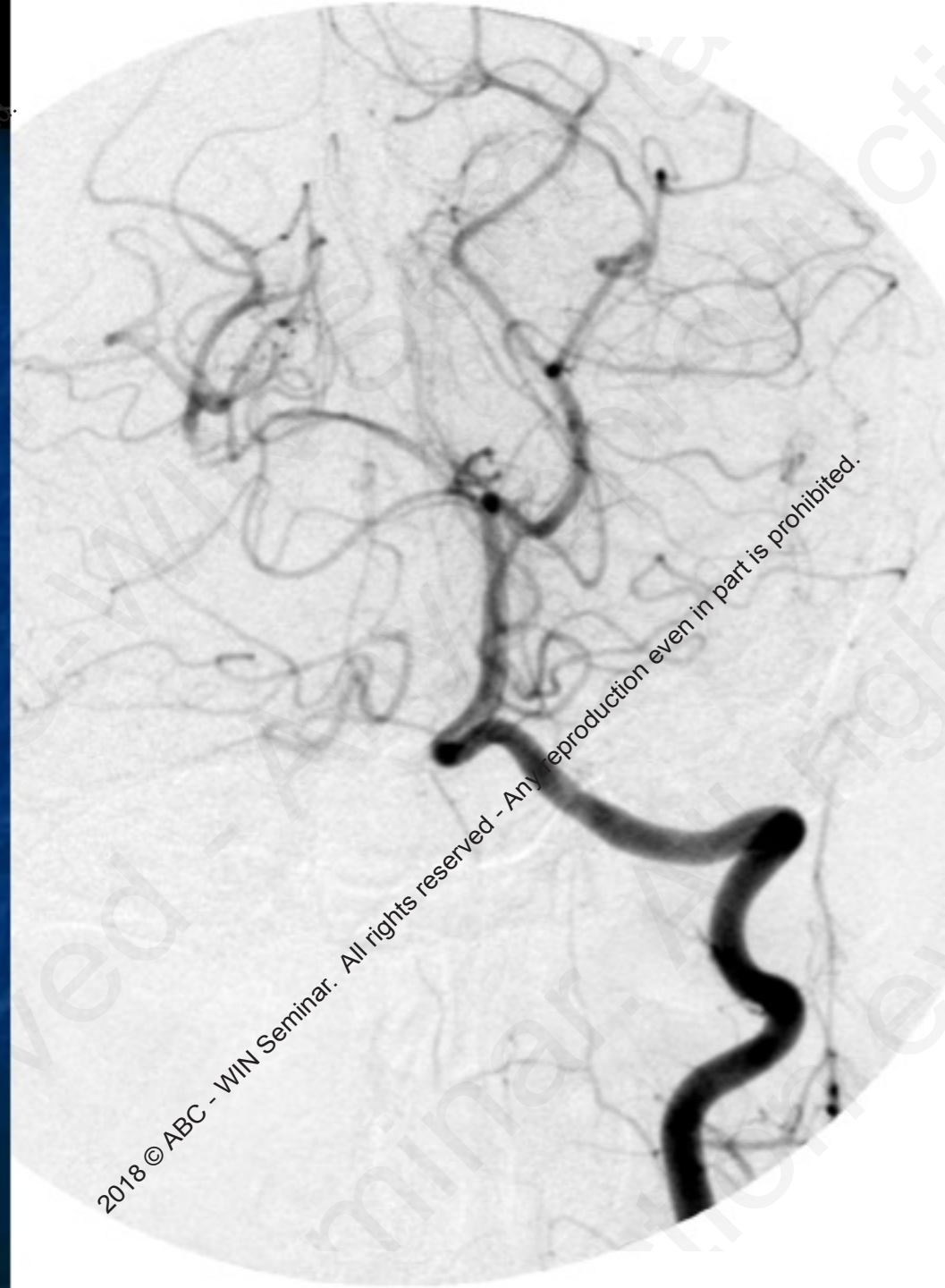

Bilateral carotid cross-compression

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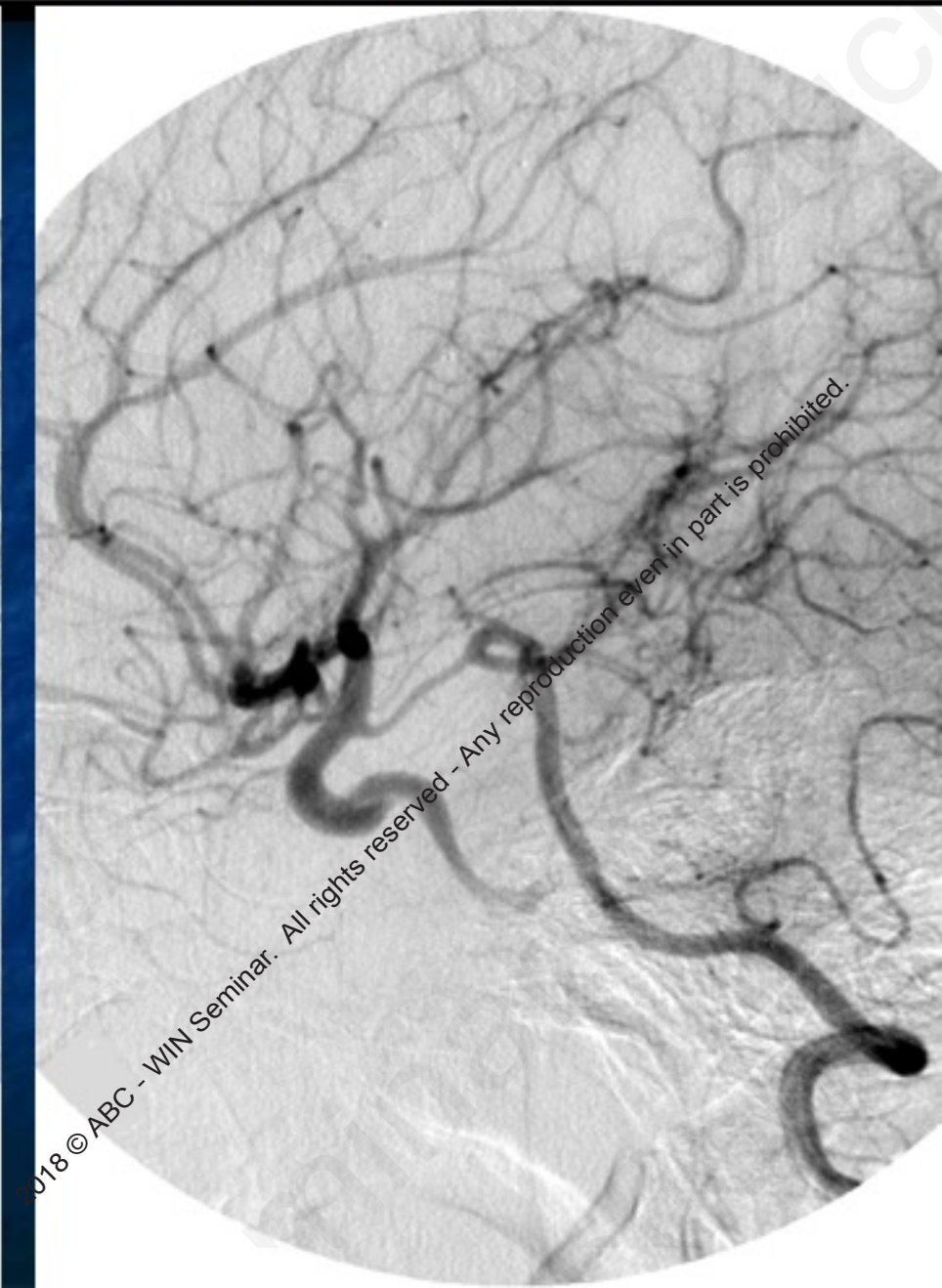

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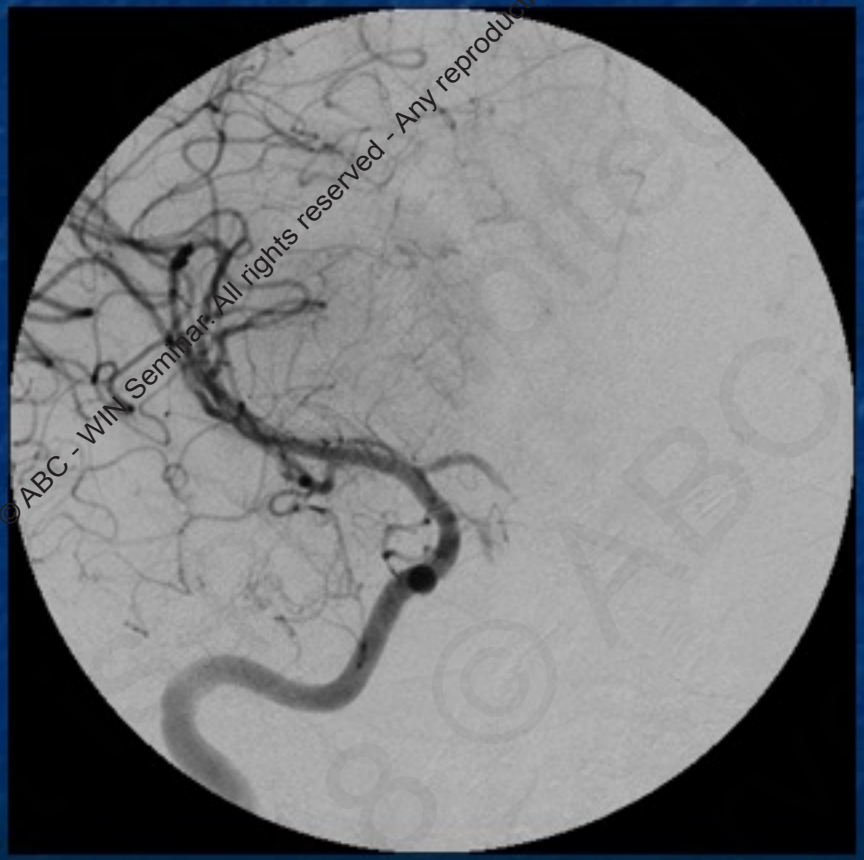
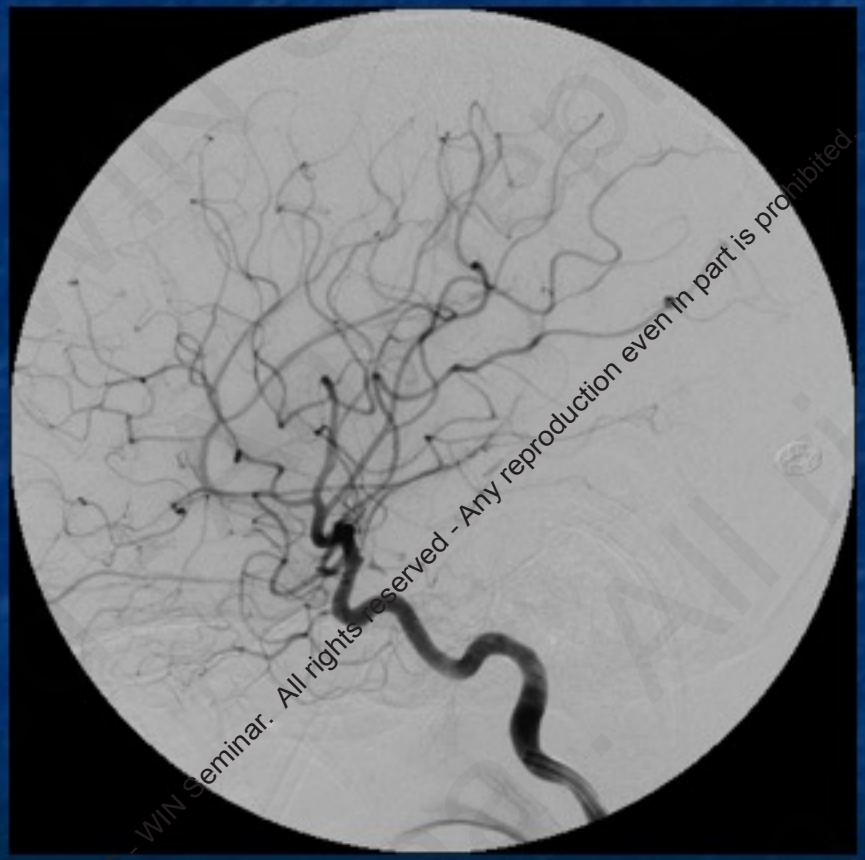
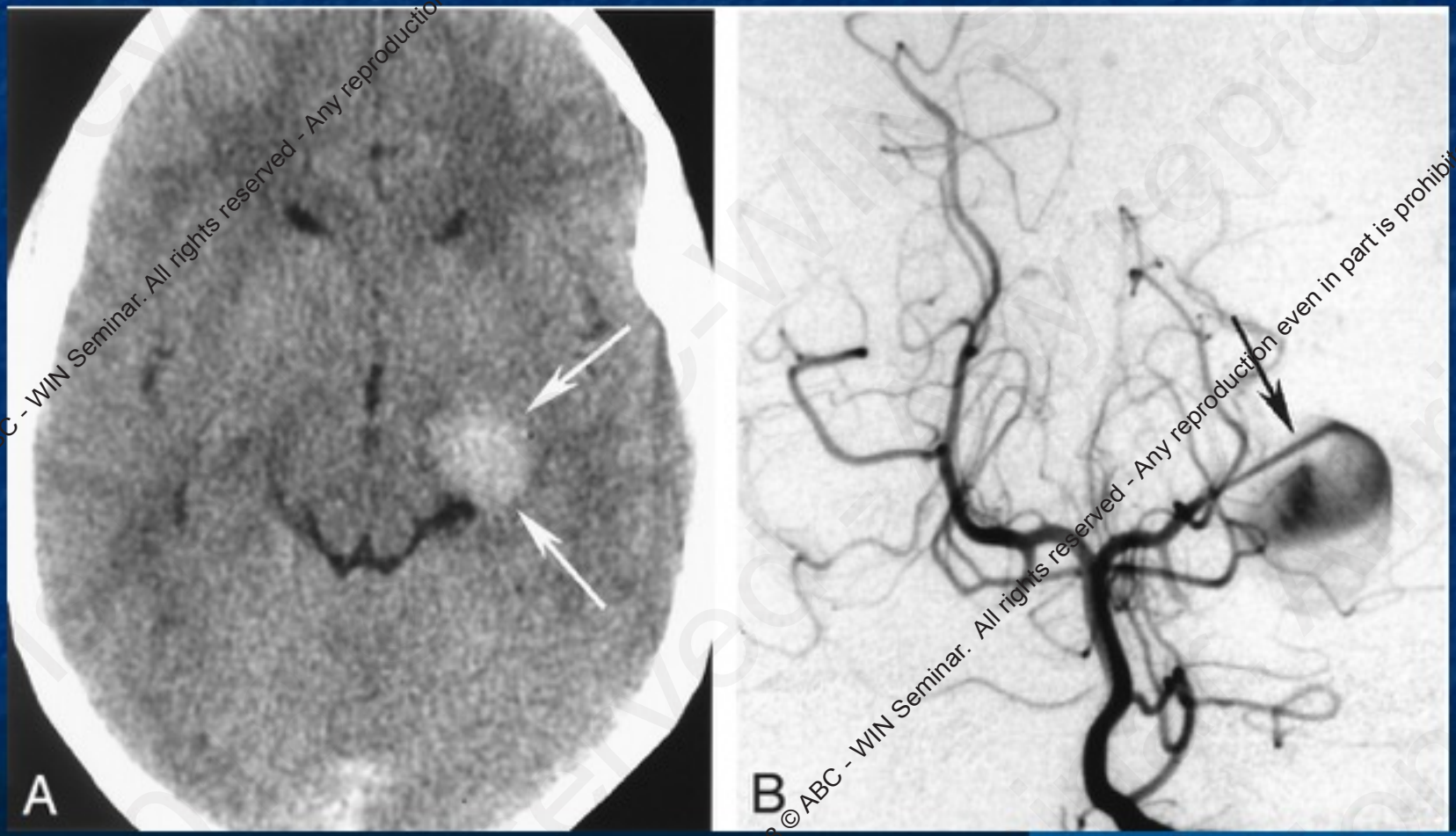
4 days later





4 year old boy after a fall

A, Initial CT scan. Axial CT scan shows hyperattenuated round lesion (arrows) adjacent to the left ambient cistern with slight compression of the brain stem. B, Initial arteriogram. Left vertebral arteriogram, anteroposterior view, shows a contrast medium "jet" filling (arrow) of a large aneurysm arising from the left P2 segment.



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Follow-up CT scan.

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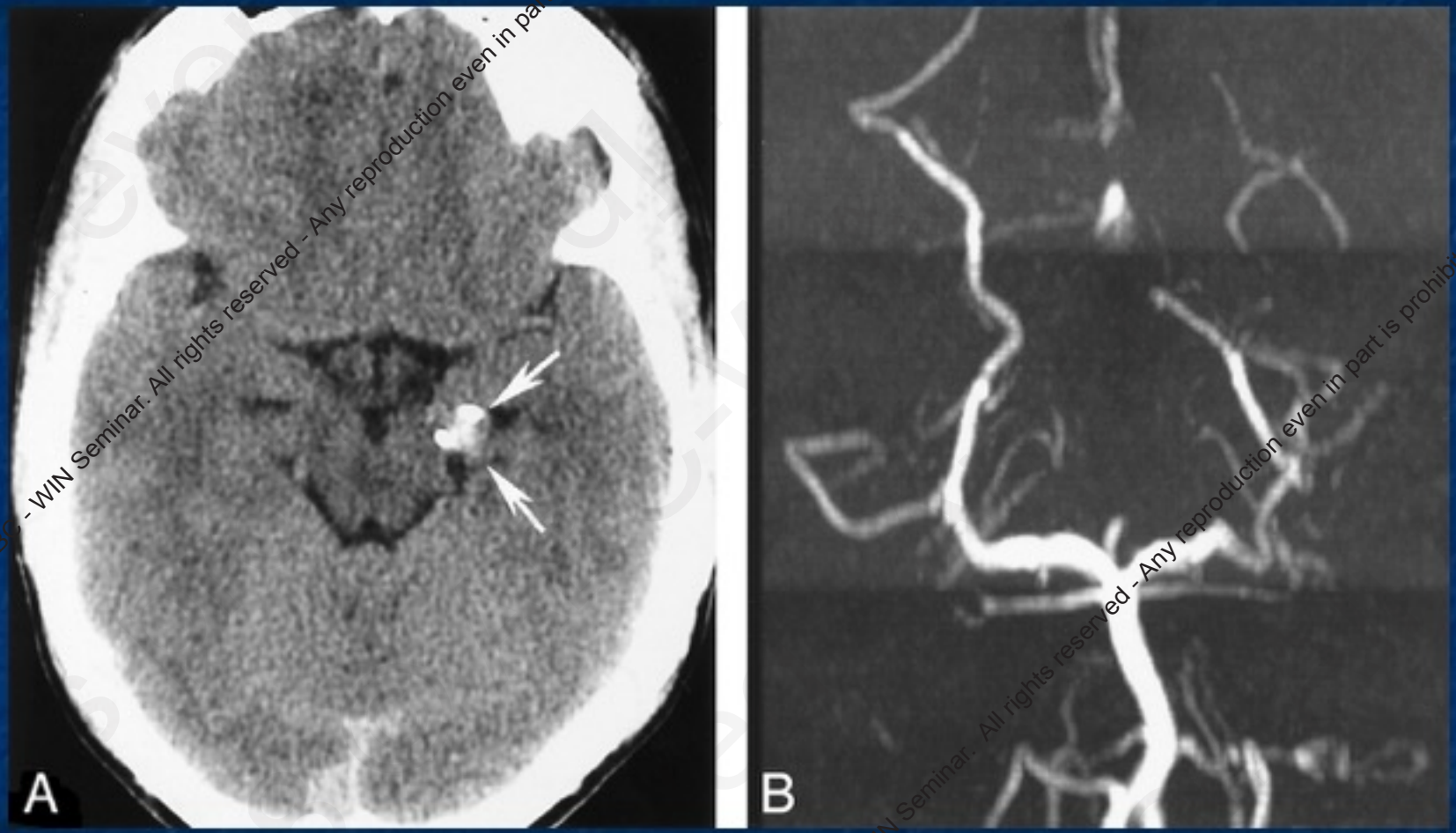
AJNR American Journal of Neuroradiology

A, Follow-up axial CT scan, obtained 5 years later, demonstrating the shrinkage of the lesion associated with some calcifications.



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Conclusions

- Developmental Considerations
  - The long tentorial edge proximity sandwiched between the medial temporal lobe or midbrain and tentorial edge exposes the distal PCA to particularly high risk of injury
  - Natural Choroidal anastamoses with AChrA and
  - Pial collaterals with ACA, MCA and SCA
    - Makes the likelihood of passing a Balloon test occlusion much higher than in other similar distal locations

Conclusions

- Classification
  - Saccular / Berry Aneurysms – a minority of cases
    - Flow Related
    - Naturally Occurring
      - Amenable to primary coiling or if wide necked to balloon or stent assisted coiling
      - Primary Clip ligation
      - Giant Aneurysms
        - Parent artery occlusion after passing a balloon test occlusion
        - Flow Diversion with or without coiling if vessel large enough (I prefer adjunctive coiling for large and giant aneurysms)
        - If BTO fails PAO with bypass or Flow Diversion

Conclusions

- Classification continued
  - Dissecting
    - Acute ruptured or unruptured
    - Chronic (Fusiform, Serpentine)
      - Parent artery occlusion after passing a balloon test occlusion
      - For ruptured prefer to avoid dual antiplatelets
      - Flow Diversion with either a FD or with single or multiple stents with or without coiling if vessel large enough (I prefer adjunctive coiling for large and giant aneurysms)
      - If BTO fails PAO with bypass or Flow Diversion as above
  - Atherosclerotic Fusiform
    - As above

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Thank you!
Questions?