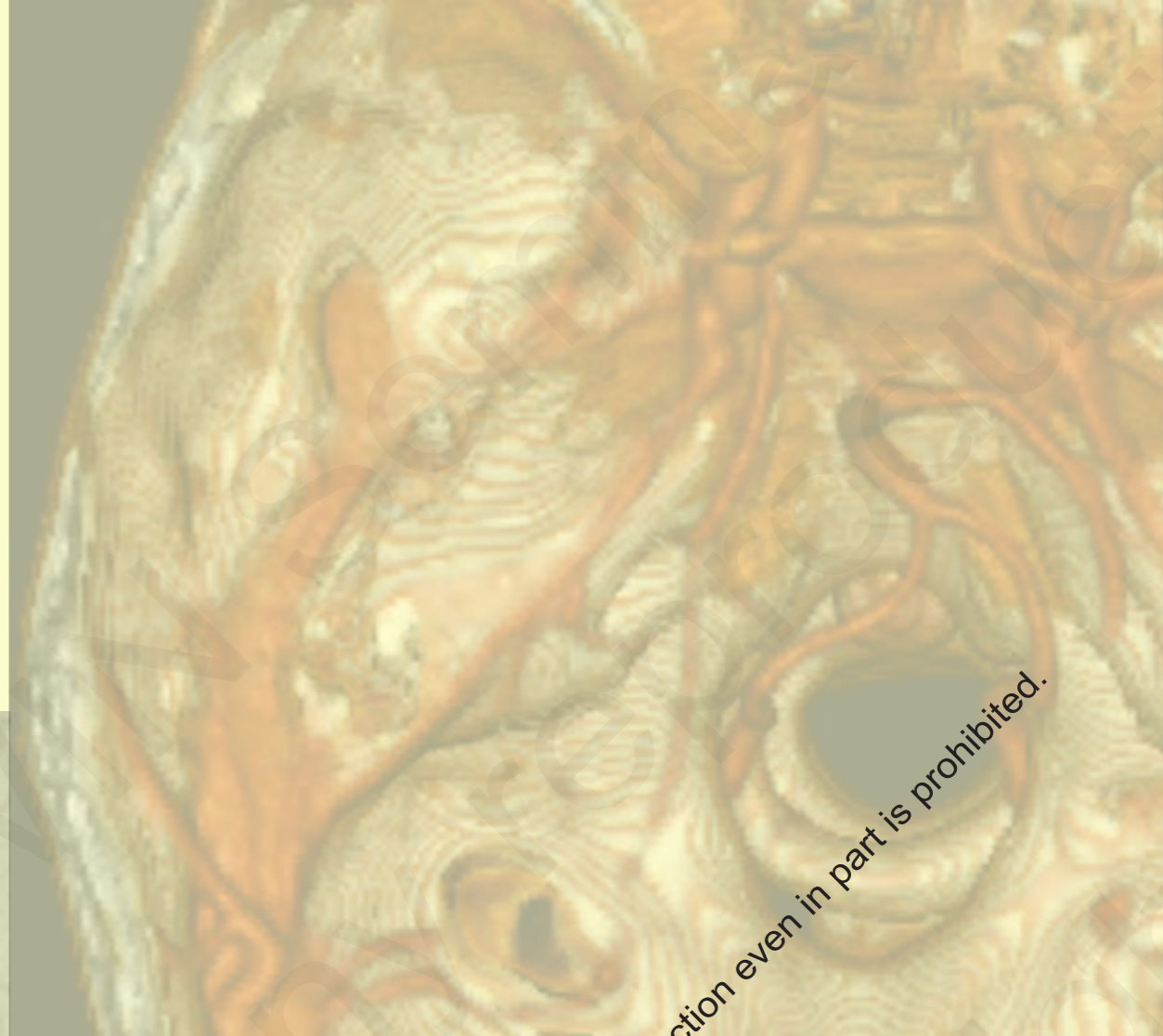


The veins of the anterior and middle skull base

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

Diego San Millán, MD

ABC course
Val d'Isère
13.01.2019



2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

Neuroradiology Unit
Service of Diagnostic and Interventional
Radiology
Hospital of Sion, Valais
Switzerland

Neuroradiology, SwissNeuroInstitute
Hirslanden Klinik Zurich
Zurich, Switzerland

general organization

the cranial venous system

cerebral venous system

- supratentorial and infratentorial superficial and deep veins
- dural venous sinuses

neurocranial venous system

- meningeal veins (sinuses)
- diploic veins

emissary veins

general organization

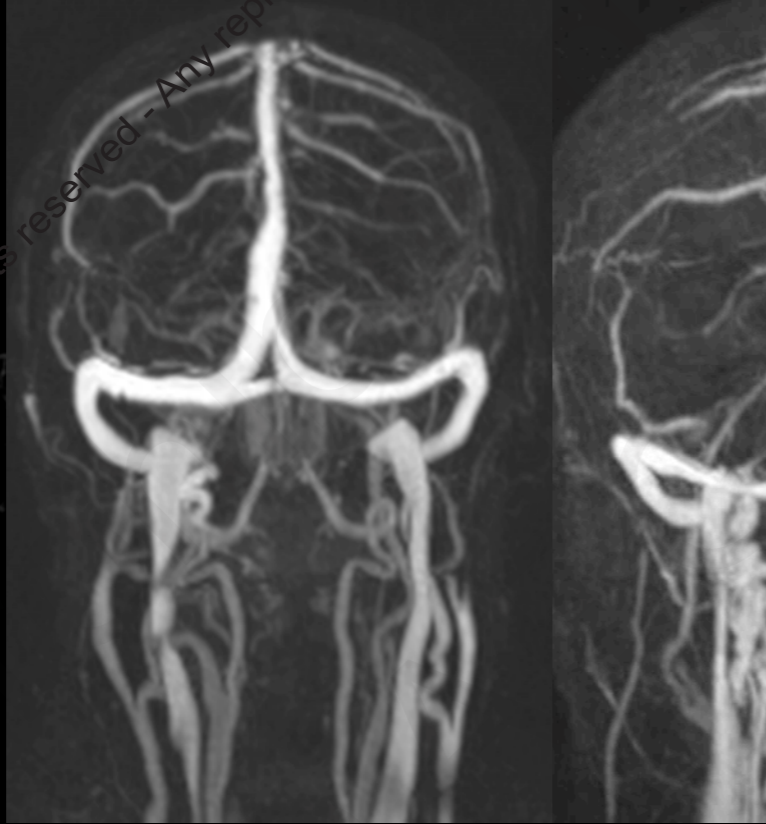
the bulk of the cerebral venous outflow reaches the internal jugular veins (IJV) and the vertebral venous system (VVS) by way of the dural venous sinuses of the posterior fossa

cranio-encephalic drainage

TWIST



IJV



IJV > VVS



IJV



VVS

cranio-cervical venous drainage

- internal jugular vein (IJV)
- vertebral venous system (VVS)

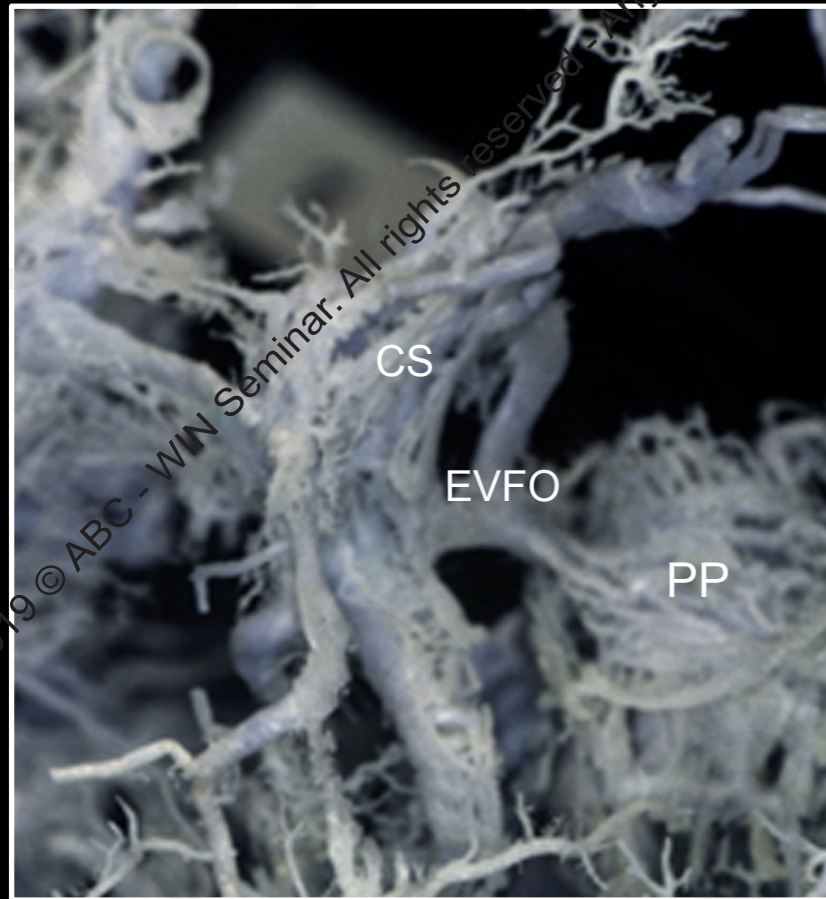
TWIST

general organization

the bulk of the cerebral venous outflow reaches the internal jugular veins (IJV) and the vertebral venous system (VVS) by way of the dural venous sinuses of the posterior fossa

a small proportion of the cerebral venous outflow often reaches the external jugular vein (EJV) by way of the cavernous sinus (CS) and its venous derivation pathways mainly through the emissary vein of the foramen ovale (MCF) then to the pterygoid plexus (PP)

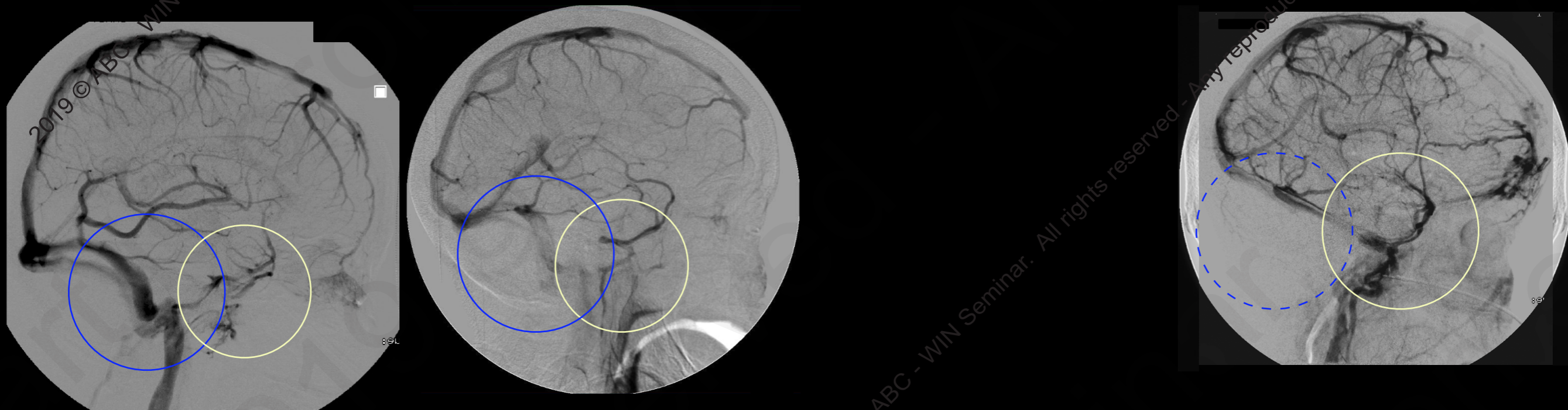
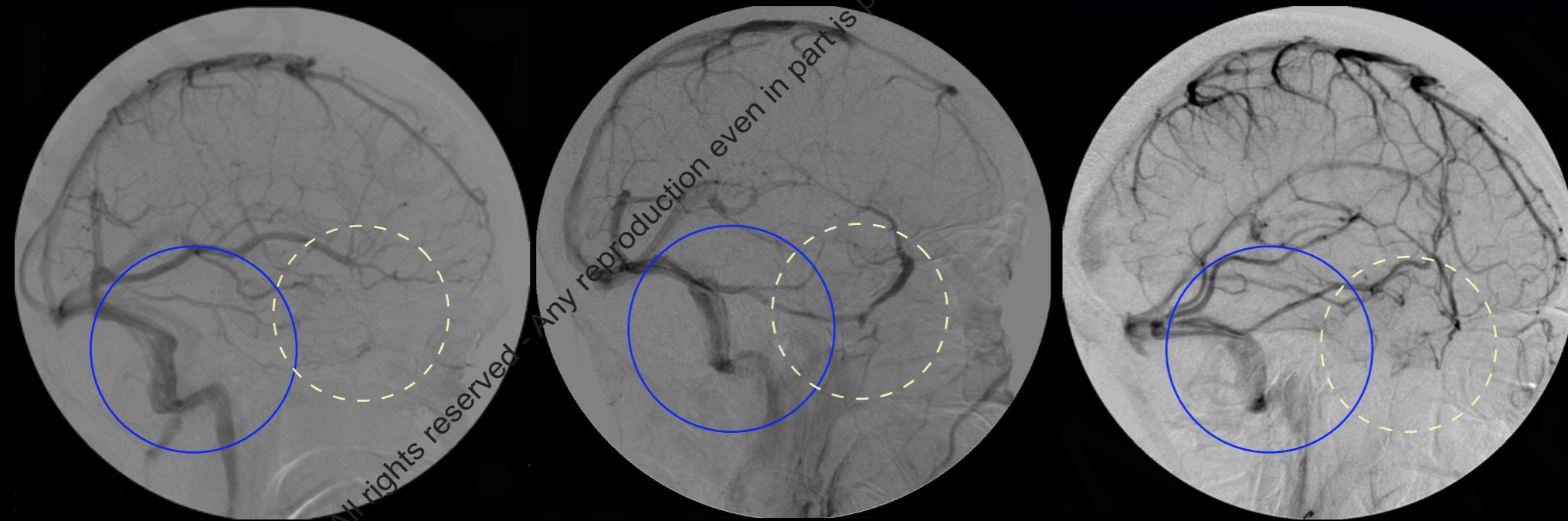
external jugular pathway



indirect route:

superficial middle cerebral vein (SMCV) → cavernous sinus (CS) → pterygoid plexus (PP)
→ internal maxillary vein → external jugular vein (EJV)

variable encephalic drainage into the EJV



2019 © ABC - WIN Seminar. All rights reserved.

2019 © ABC - WIN Seminar. All rights reserved. Any reproduction even in part is prohibited.

general organization

the bulk of the cerebral venous outflow reaches the internal jugular veins (IJV) and the vertebral venous system (VVS) by way of the dural venous sinuses of the posterior fossa

a small proportion of the cerebral venous outflow often reaches the external jugular vein (EJV) by way of the cavernous sinus (CS) and its venous derivation pathways mainly through the emissary vein of the foramen ovale (MCF) then to the pterygoid plexus (PP)

on rare occasions, the bulk of the cerebral venous outflow is directed from the posterior fossa venous sinuses to the external jugular system by way of a petrosquamosal sinus

the veins of the anterior and middle cranial fossa

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

general organization

venous systems of the anterior and middle cranial fossa

anterior cranial fossa

- diploic veins
- meningeal veins (sinuses)
- emissary veins
- ¿vein of the foramen caecum?
 - controversial, anatomically observed in intrauterine life and neonates (Thiele 1847, Luschka 1867, Zuckerkandl 1885, Hédon 1888)
 - described as connecting the nasal cavity to SSS

middle cranial fossa

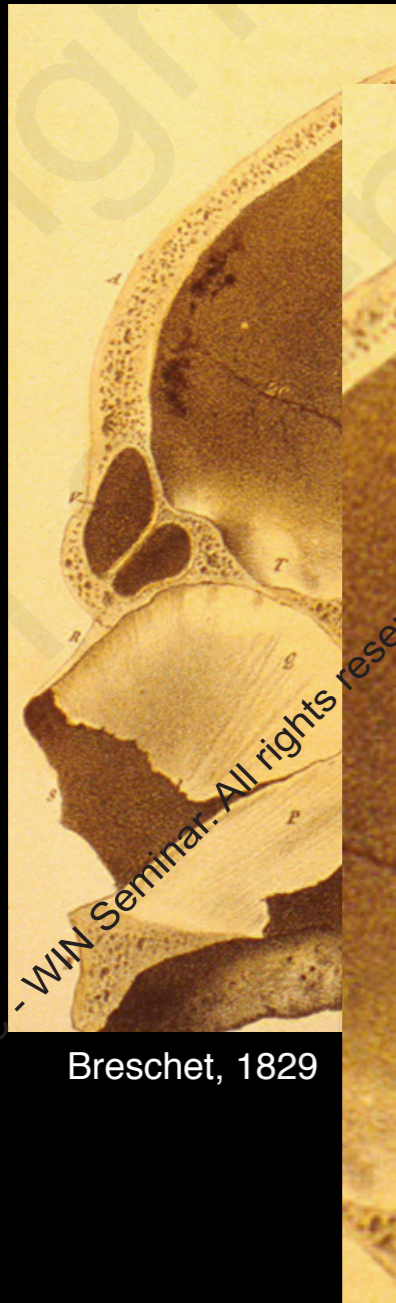
- diploic veins
- meningeal veins
- laterosellar space : cavernous sinus and derivation pathways
- termination of the SMCV / DMCV
- emissary veins

diploic and meningeal veins

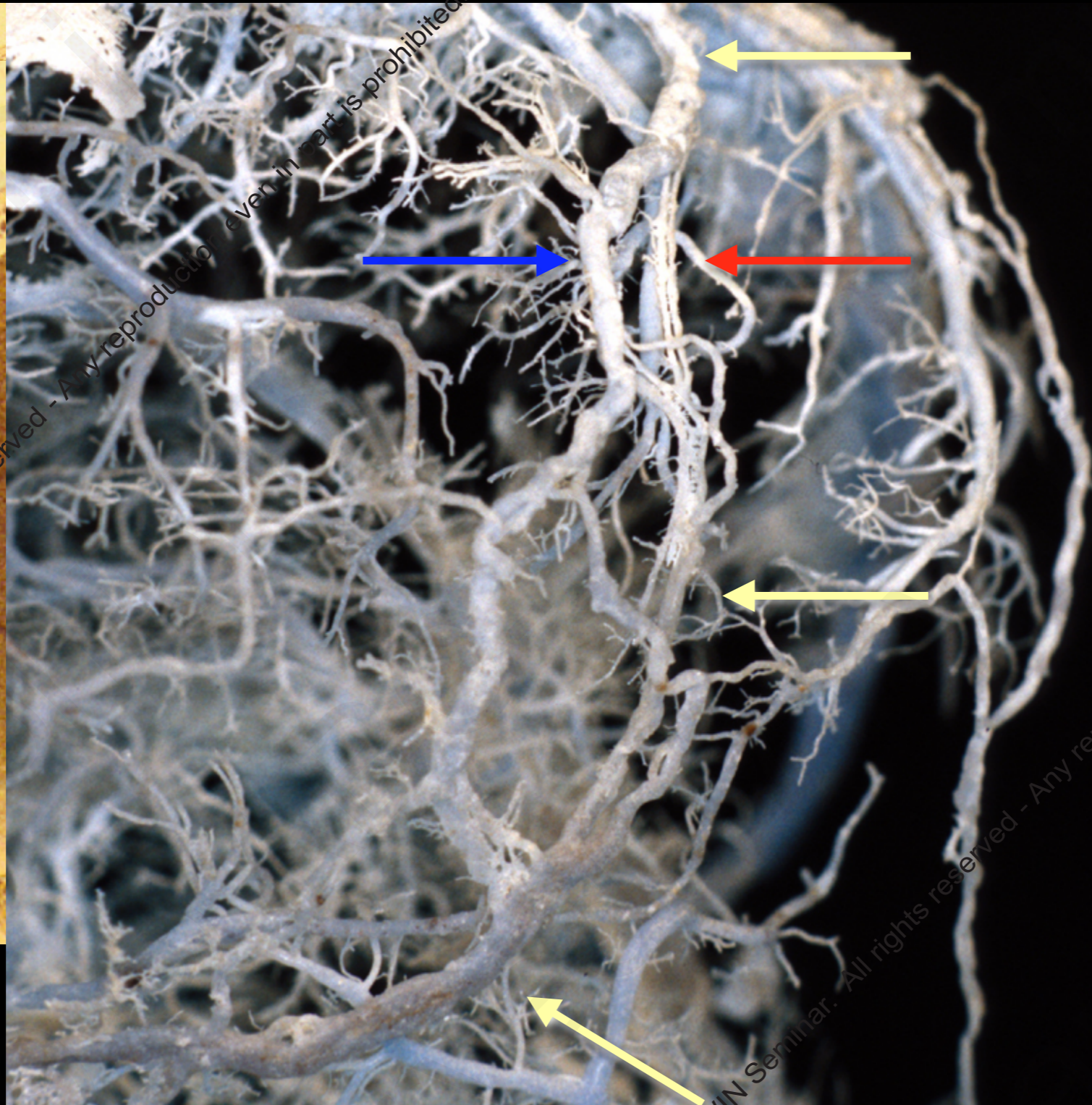
2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

diploic and meningeal veins

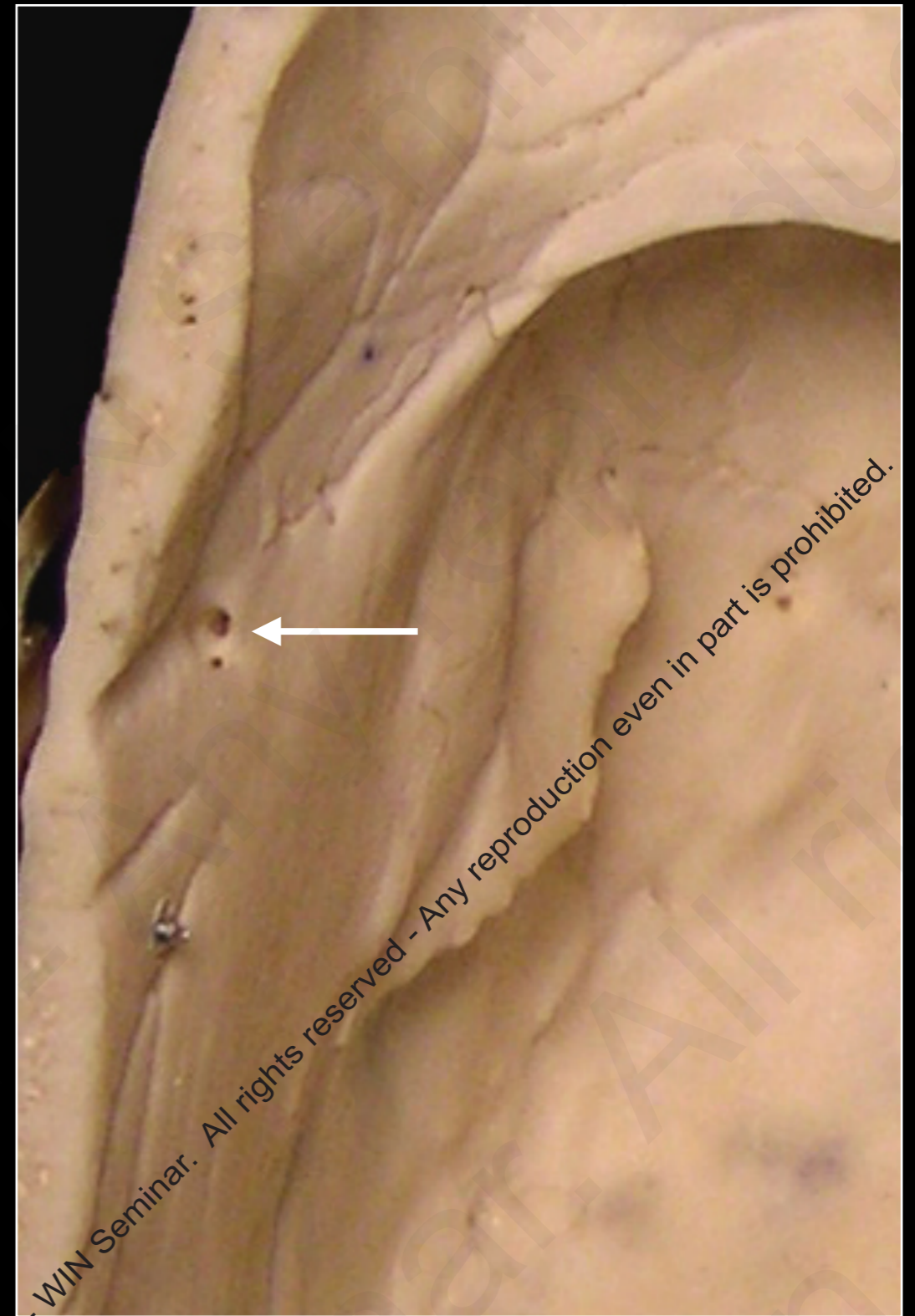
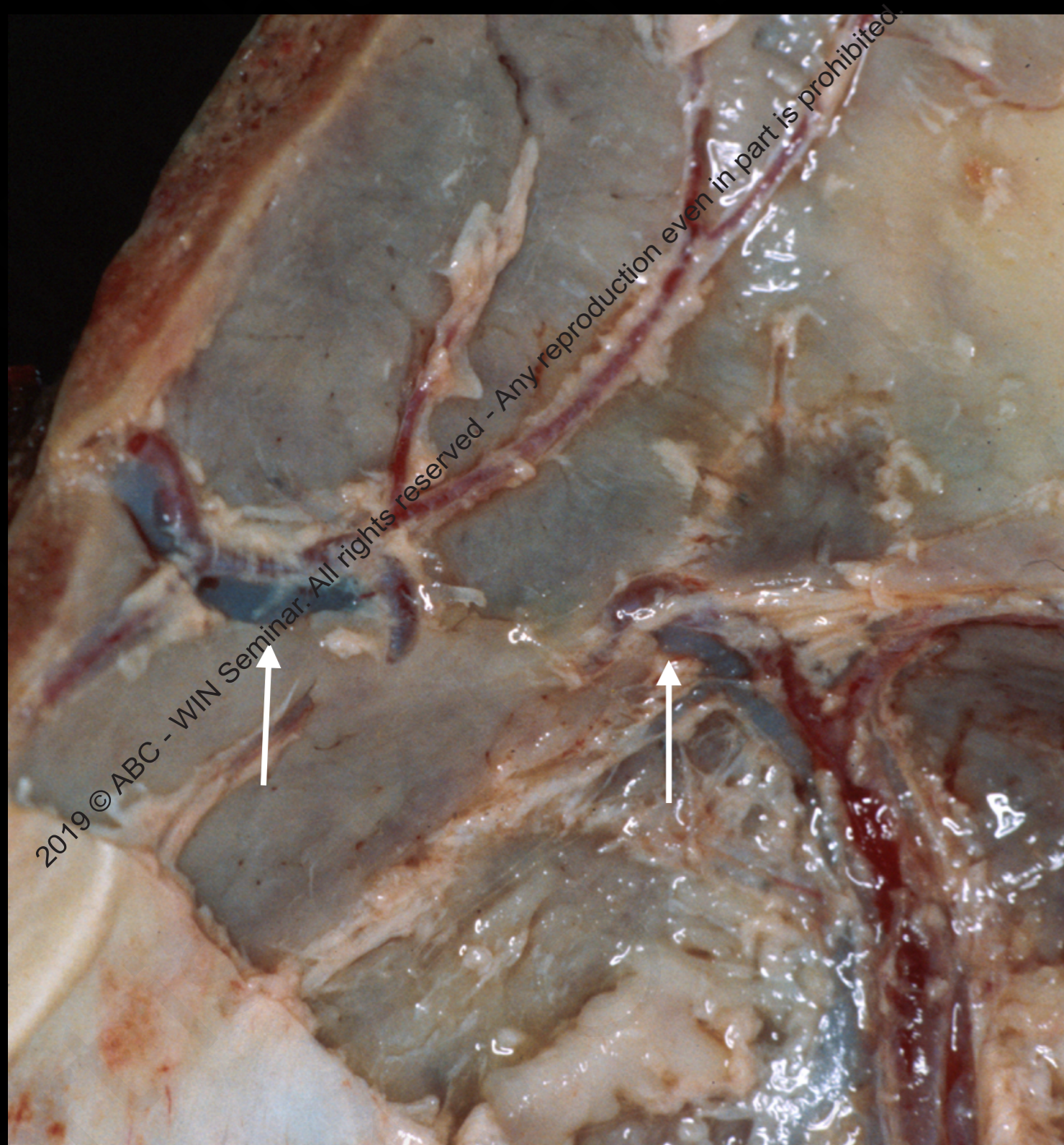


Breschet, 1829



- meningeal are meningeal sinuses, embedded in the superficial (outer) dura mater
- connections between MMV and DV exist
- with age, MMV impressions become deeper and merge with DV where their courses overlap
- → dual diploic and meningeal nature (Trolard 1868, Padgett 1956, Saban 1984, San Millán 2004)

diploic and meningeal veins



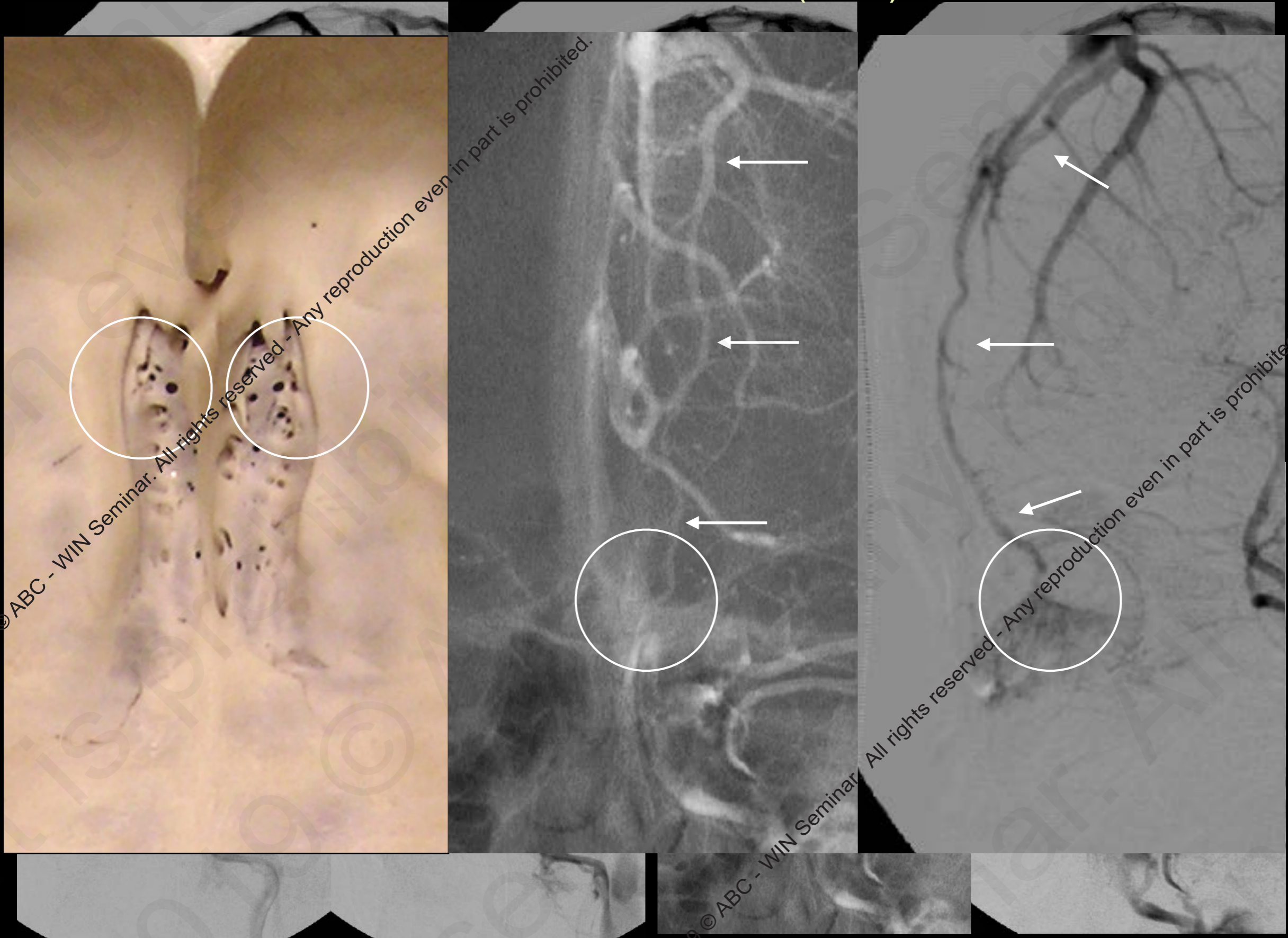
- meningeal veins are sinuses, coursing within the dura, superficial to the meningeal artery (Wood Jones, 1912, Padgett 1956)

anterior cranial fossa

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

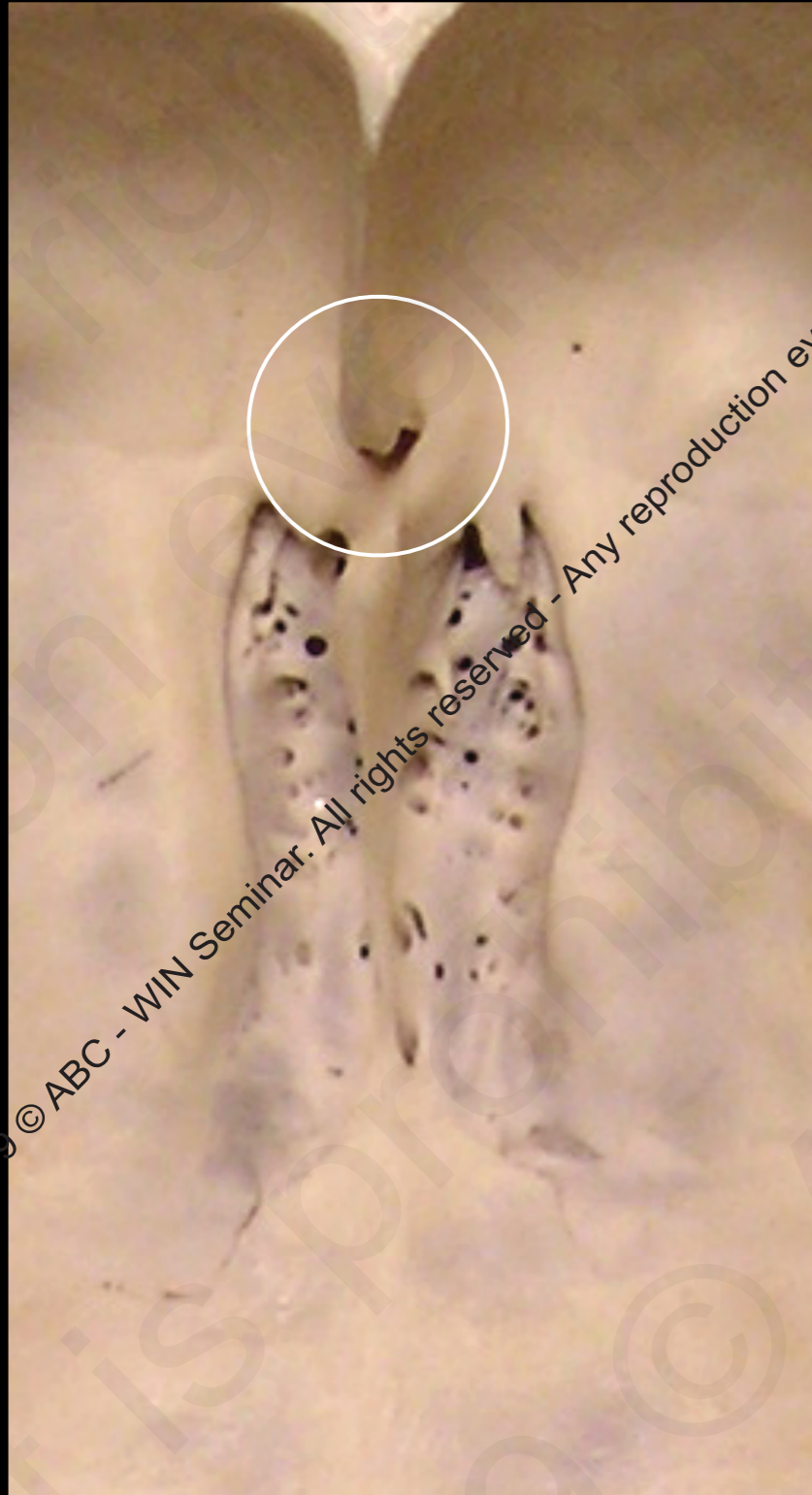
2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

anterior cranial fossa (ACF)

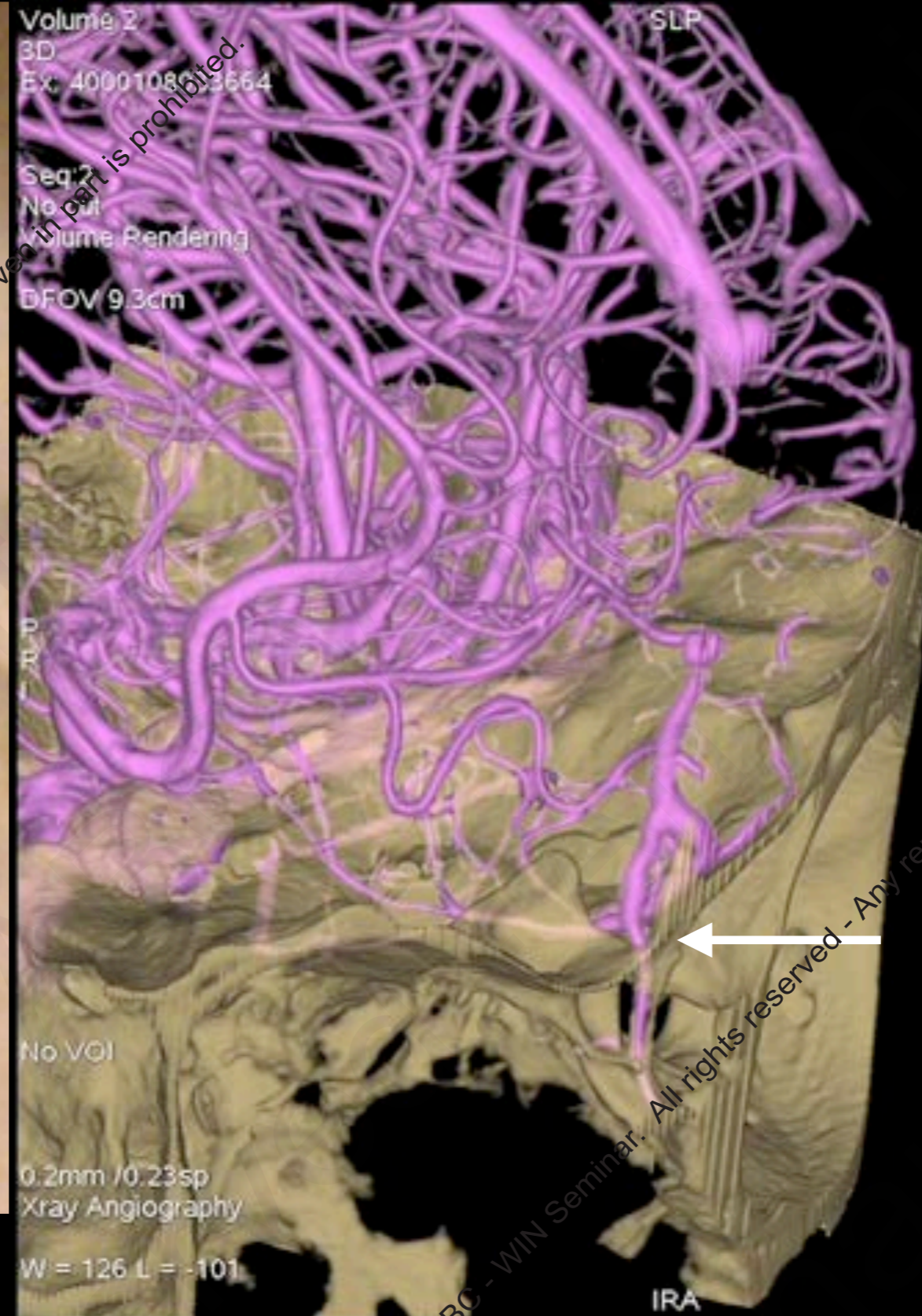


vein of the cribriform plate

ACF



W = 126 L =



courtesy of Pr Kittipong Srivatanakul, Tokai University
Aoki R et al. Eur. J. Anat. 2017

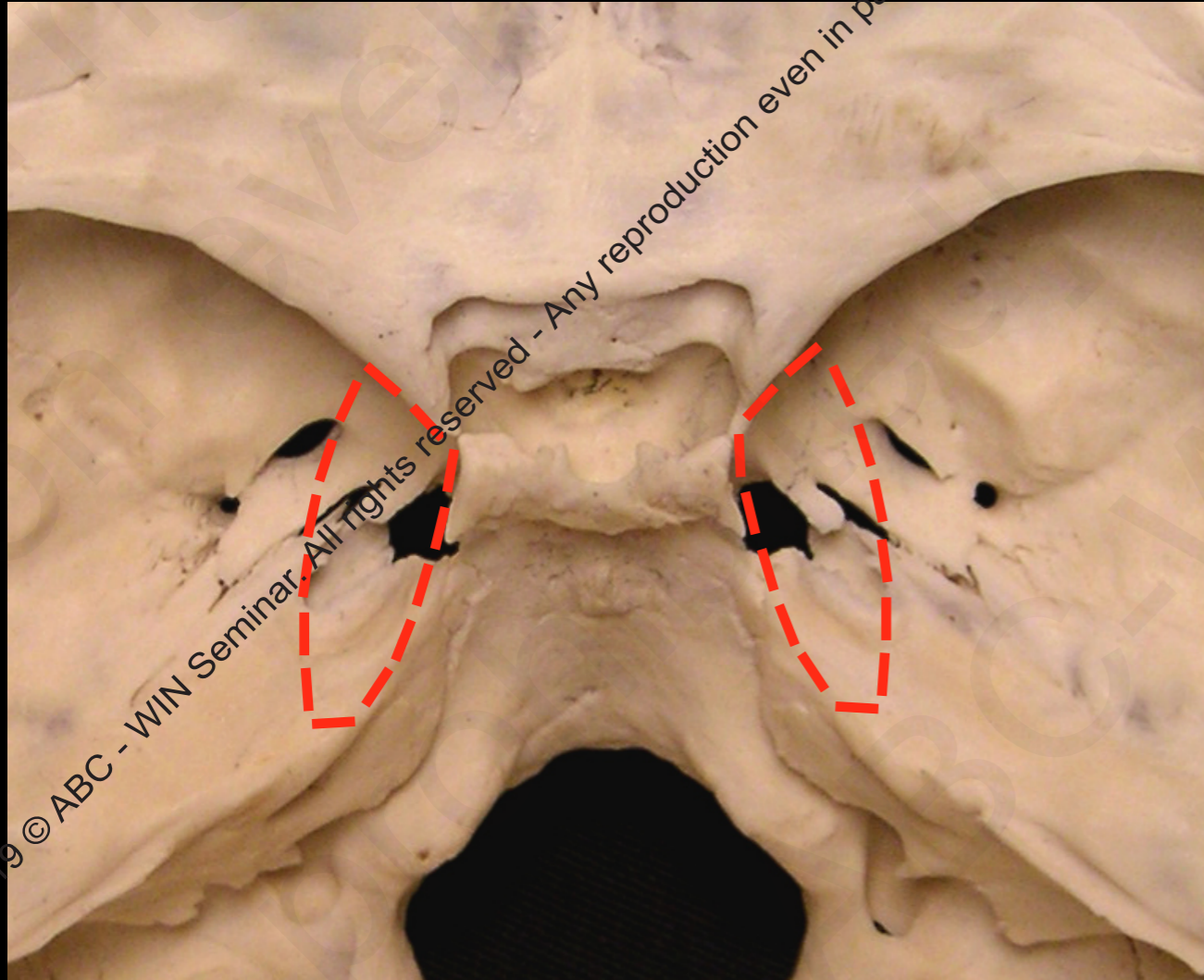
vein of the foramen caecum

middle cranial fossa

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

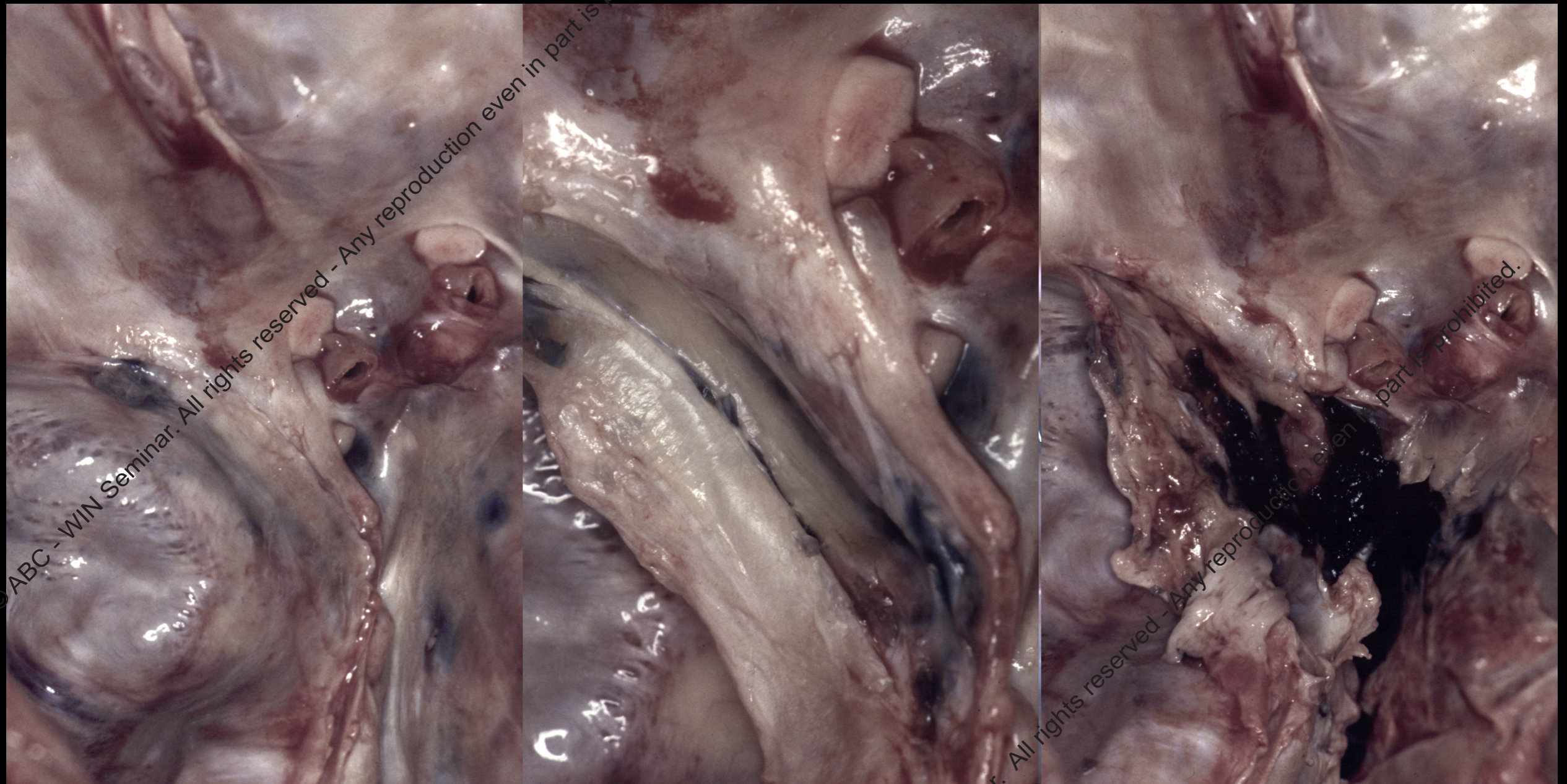
middle cranial fossa - laterosellar space



2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

laterosellar space - lateral wall



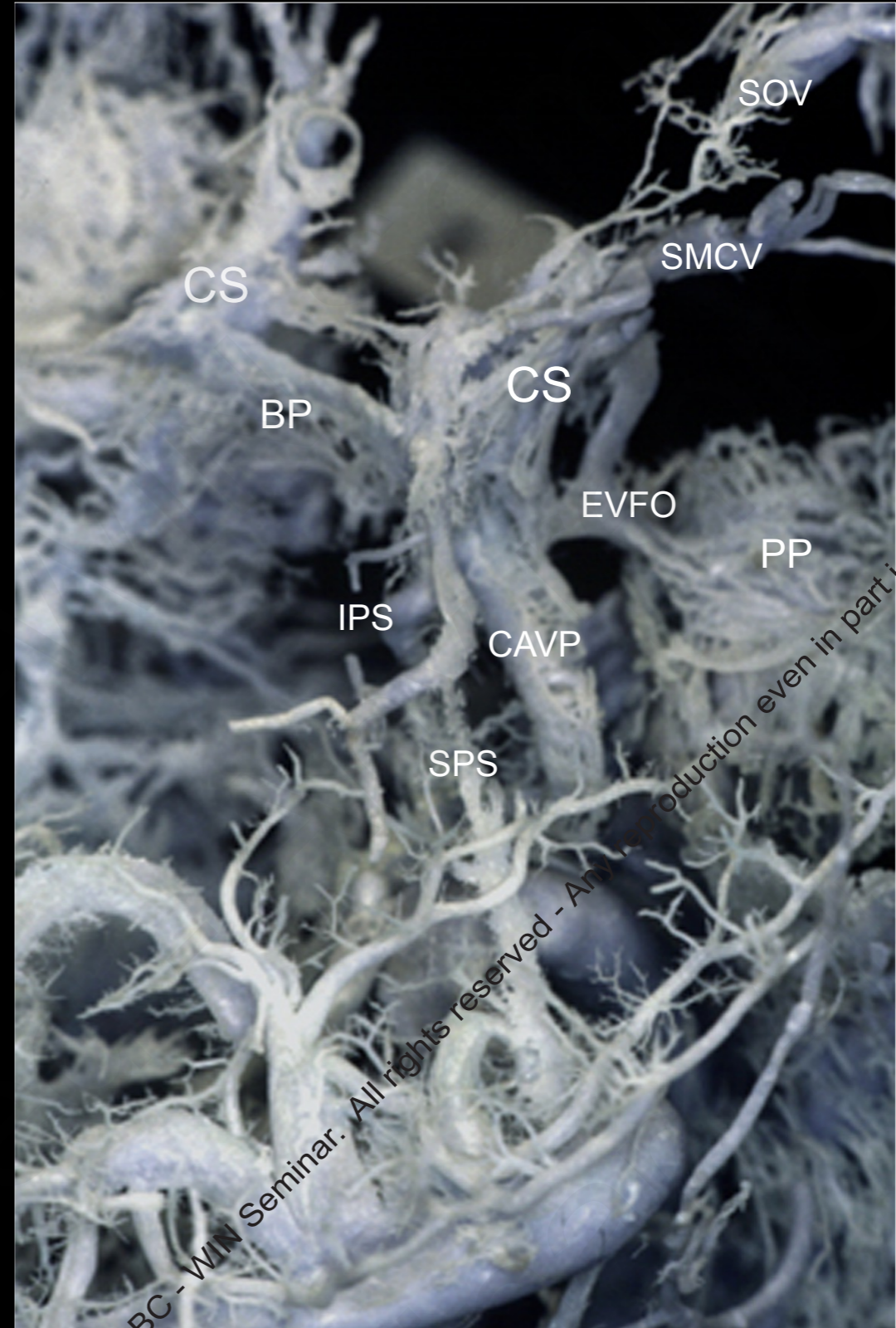
cavernous sinus

into the CS :

1. superior ophthalmic vein (SOV) → CS
2. sphenoparietal sinus (SphpS) → CS
3. {superficial middle cerebral vein (SMCV)} → CS

out of the CS:

1. CS → emissary vein foramen ovale (EVFO)
2. CS → carotid artery venous plexus (CAVP)
3. CS → inferior petrosal sinus (IPS)
4. CS → {superior petrosal sinus (SPS)}

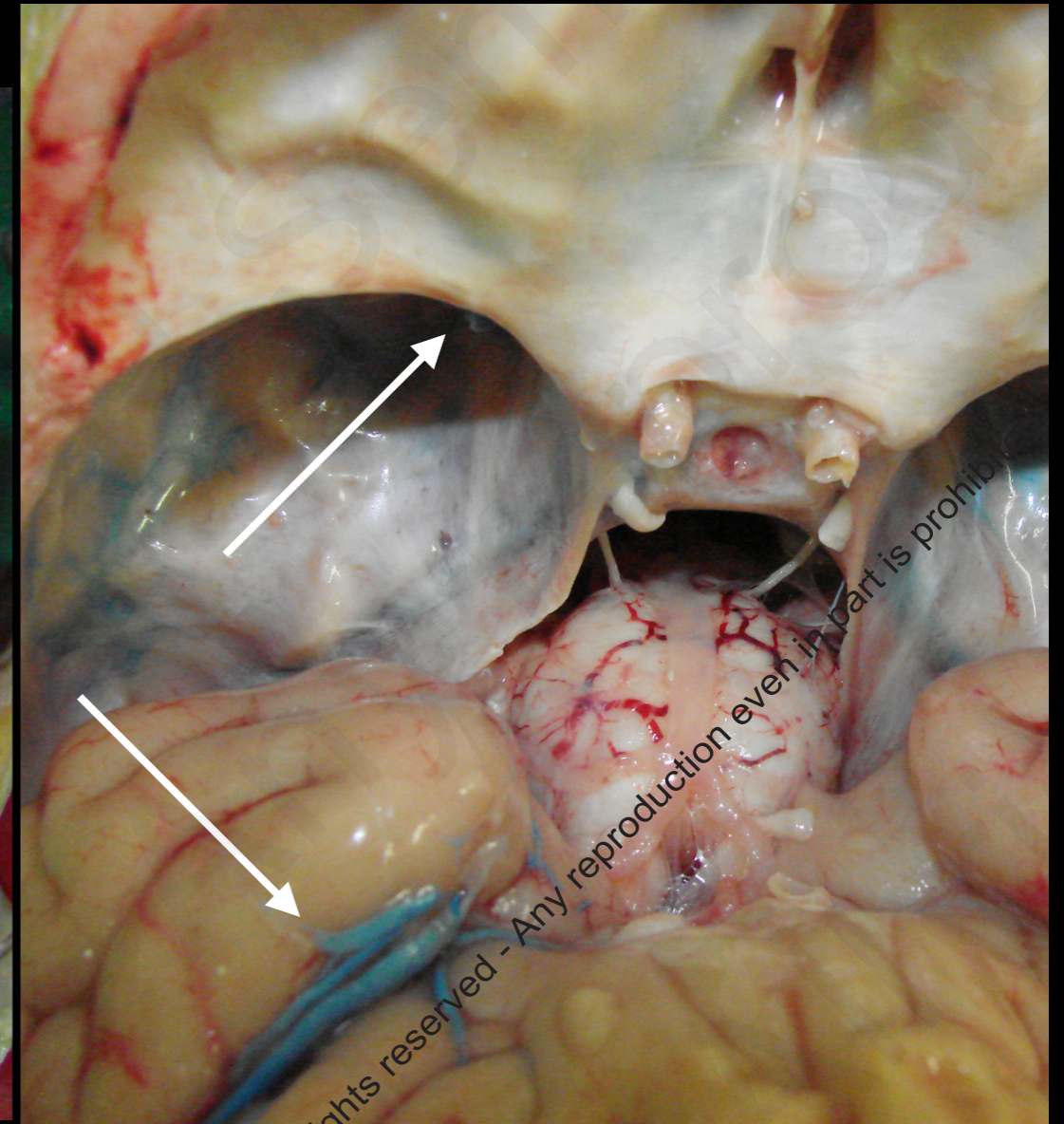
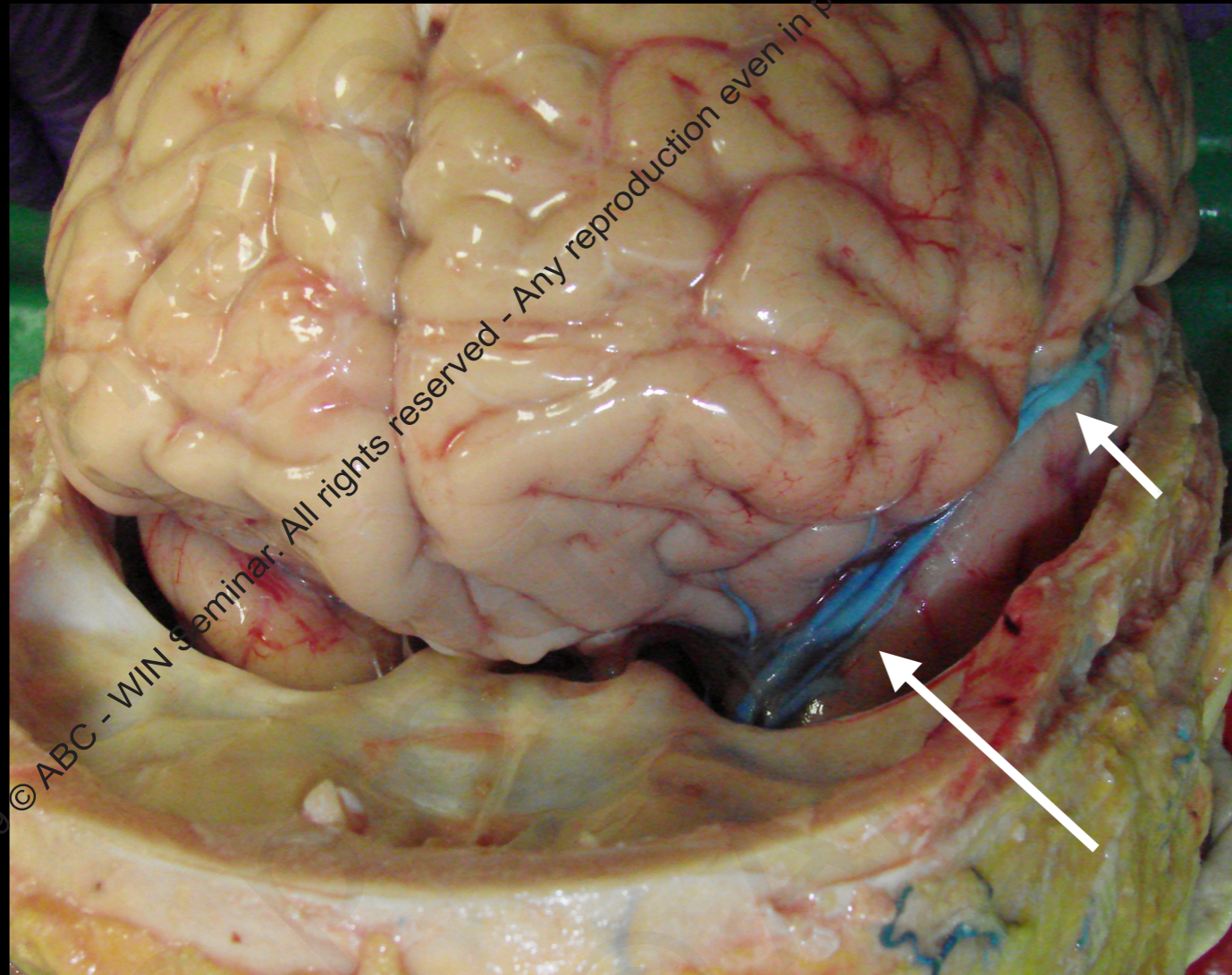


superficial middle cerebral vein (SMCV)

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

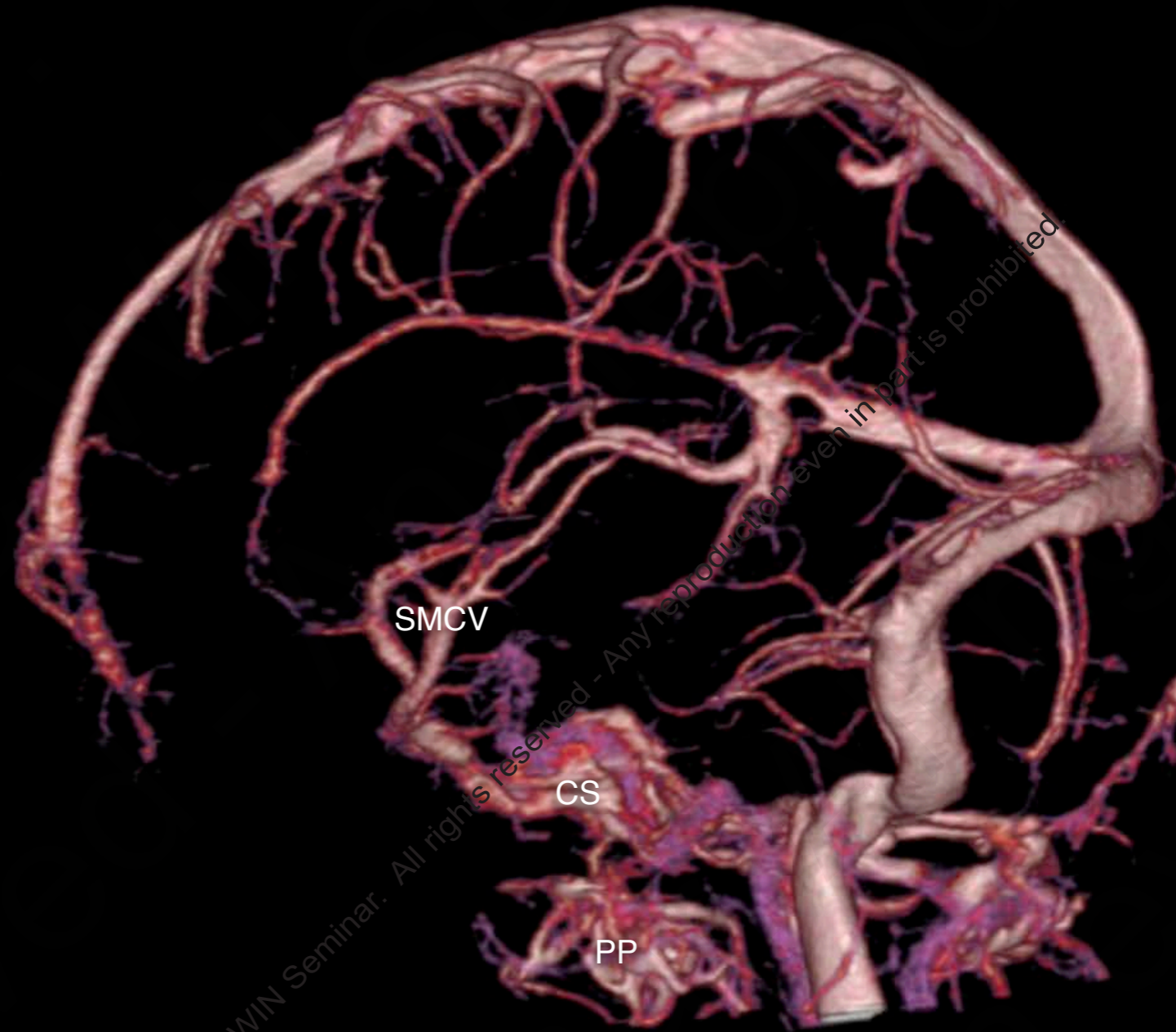
2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

the superficial middle cerebral vein



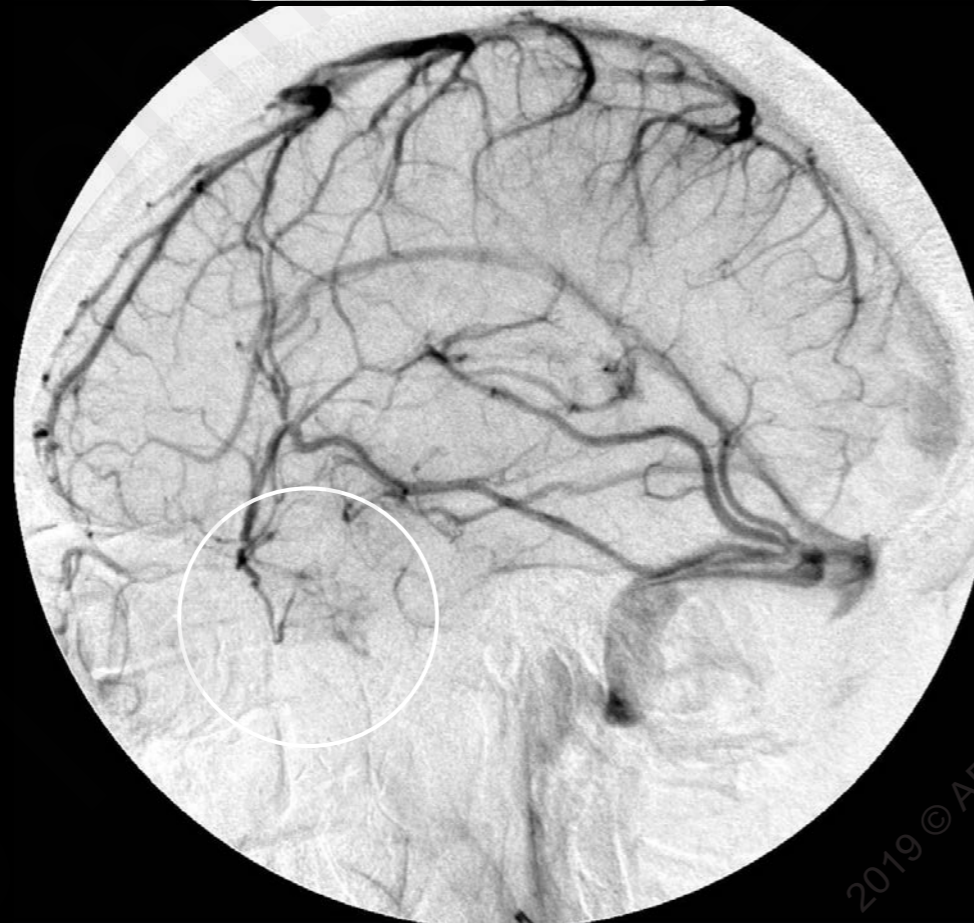
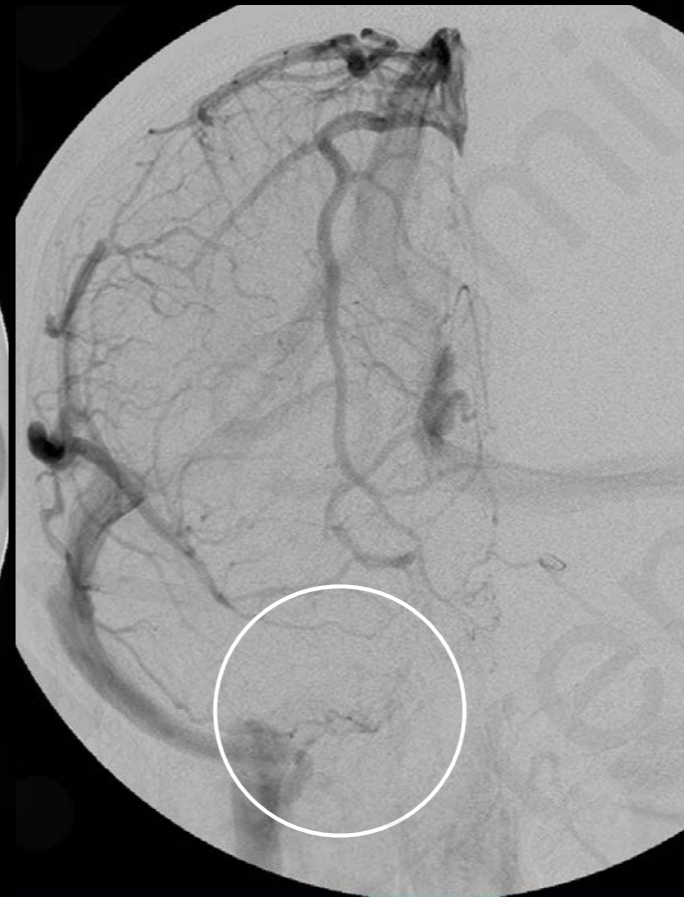
- courses along the lateral sulcus, drains the brain around the sylvian fissure
- classic anatomy where the SMCV drains anteriorly into the cavernous sinus the SMCV

the superficial middle cerebral vein



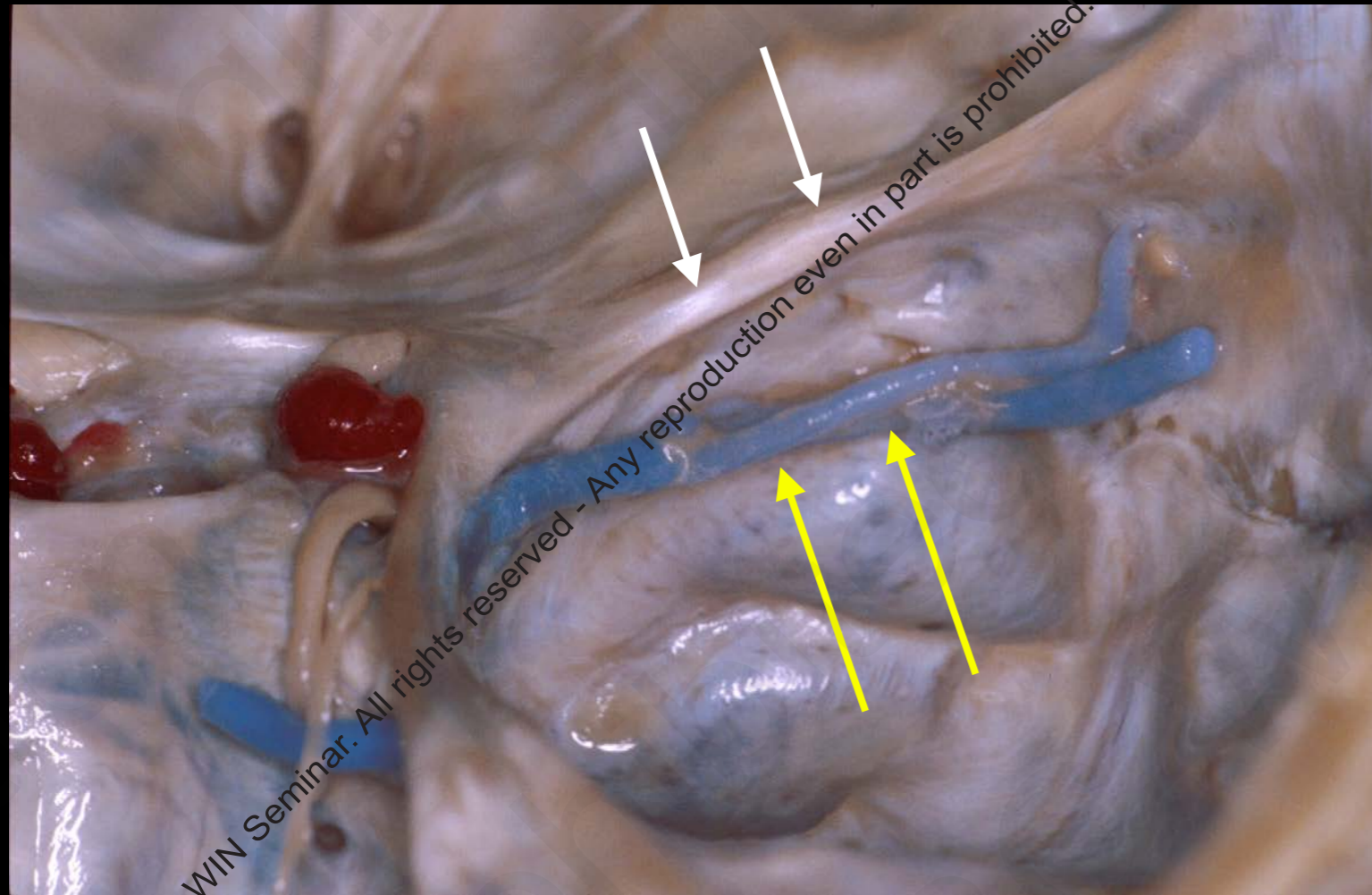
- courses along the lateral sulcus, drains the brain around the sylvian fissure
- classic anatomy where the SMCV drains anteriorly into the cavernous sinus the SMCV

the superficial middle cerebral vein



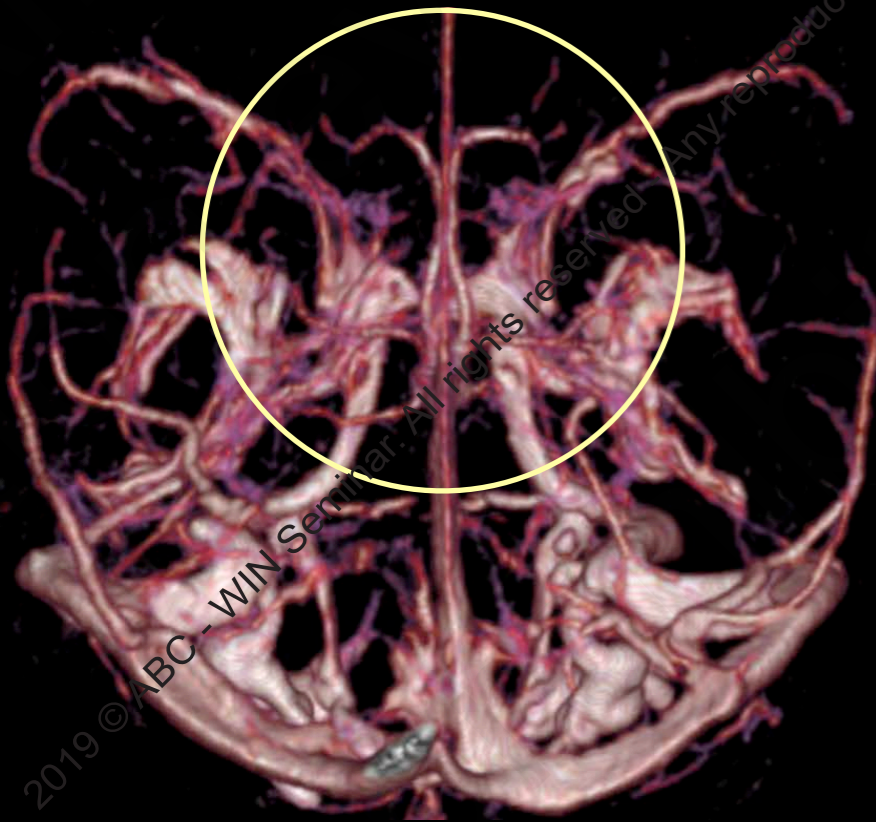
- absent about 19-29 % of the time (*Gailloud et al, San Millán et al, Suzuki et al*)

the superficial middle cerebral vein



- in the majority of cases, drains anteriorly towards the MCF
- may run under the lesser and attach to the dura under the lesser wing, but maintains characteristics of a pial vein \neq a dural sinus

the superficial middle cerebral vein “cavernous sinus capture”



bilateral capture



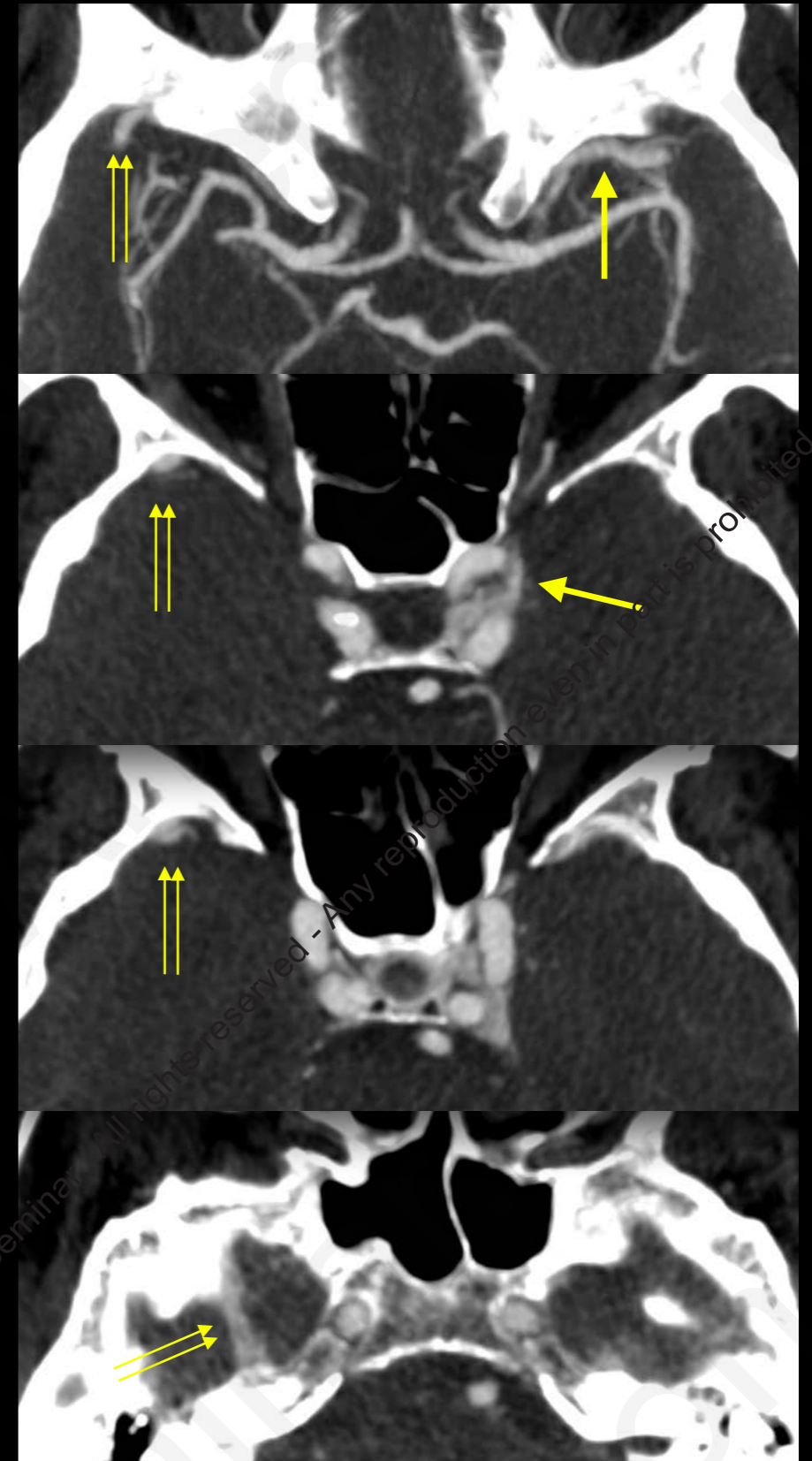
unilateral capture



no capture

- the connection between the SMCV and CS is secondary in nature and occurs peri-natally or post-natally (Padgett)
- secondary CS capture of encephalic drainage (Lasjaunias)

the superficial middle cerebral vein “cavernous sinus capture” - pitfall



CS asymmetry \neq CS thrombosis = reflects SMCV drainage...

the termination of the superficial middle cerebral vein

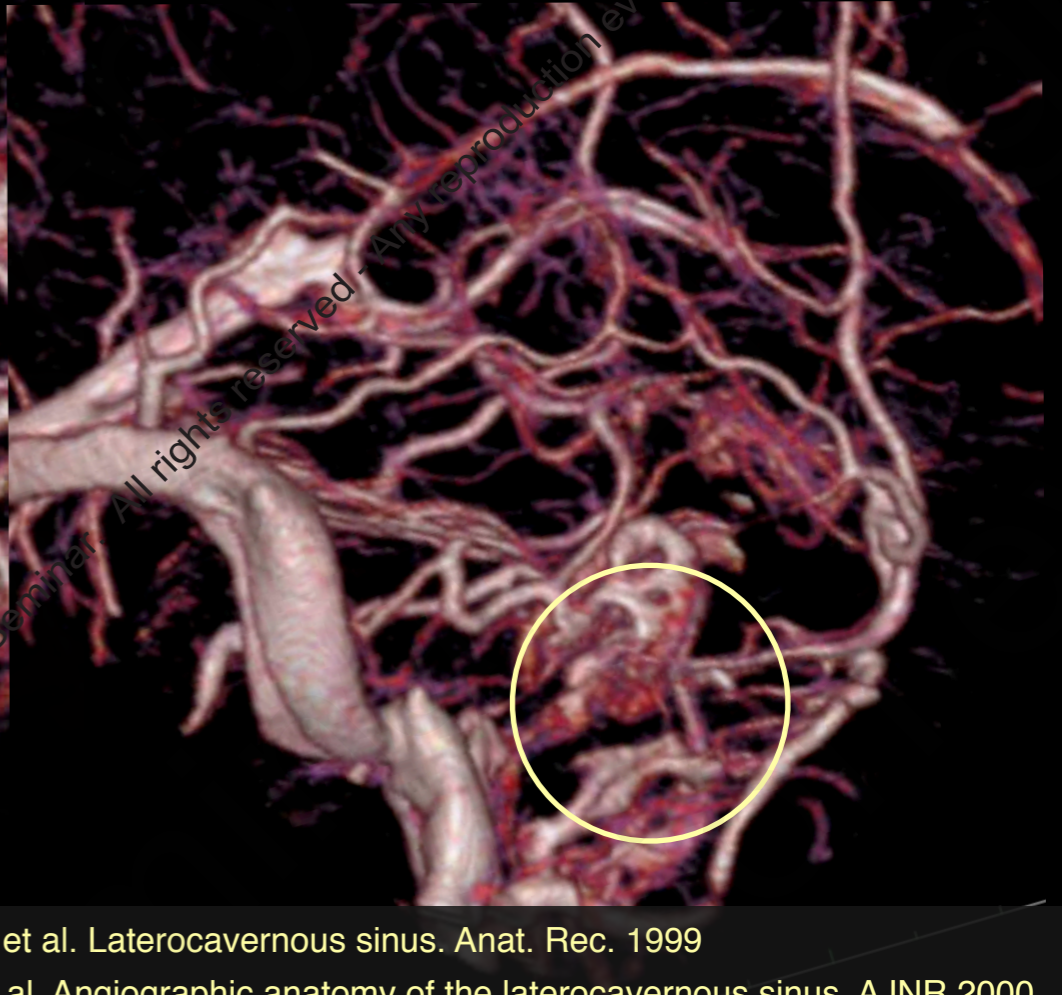
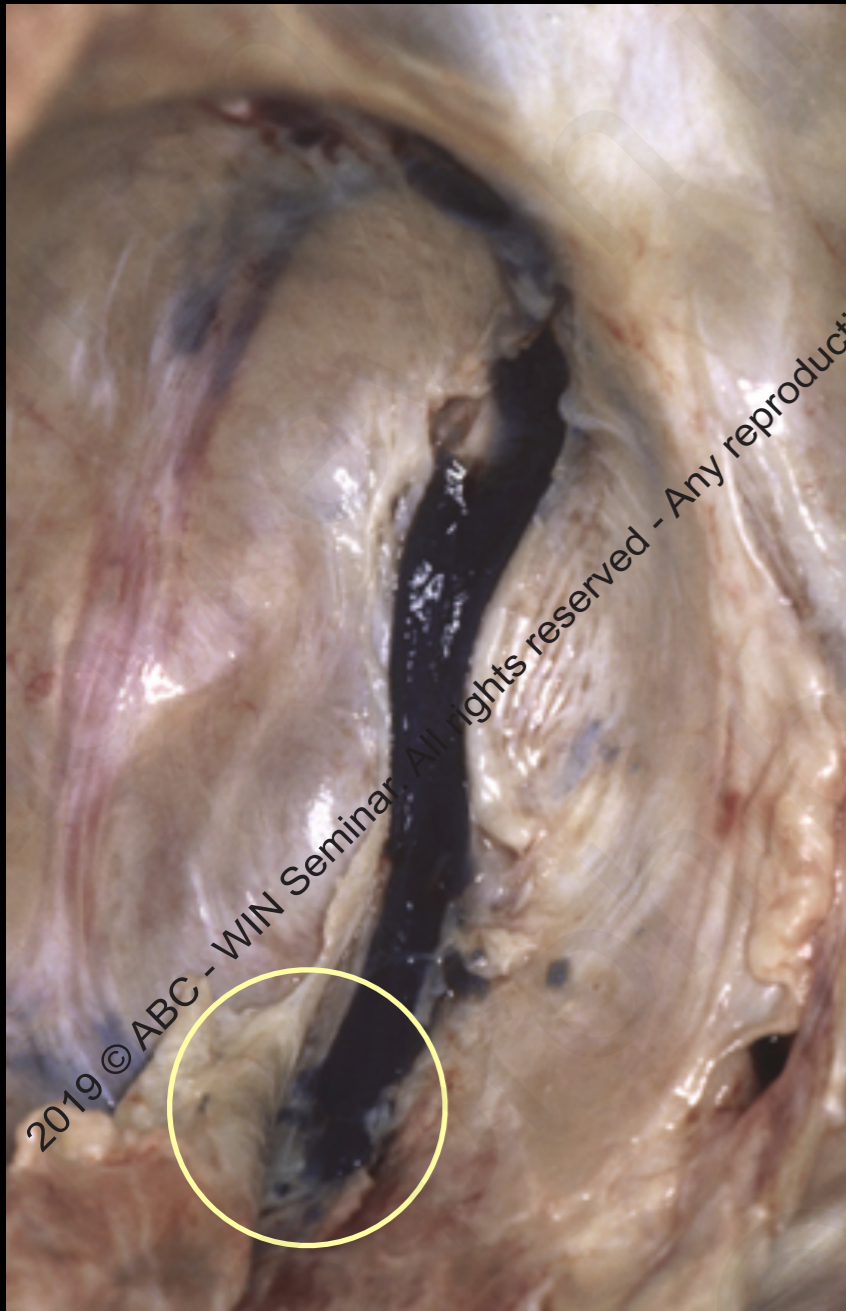
3 different final drainage pathways of the SMCV in the MCV

1. into the cavernous sinus (CS)
2. into a paracavernous sinus (PCS)
3. into a laterocavernous sinus (LCS)

the paracavernous sinus

- also known as the sphenobasal or sphenotemporal / sphenopetrosal sinus
- usually a sinus of the deep (inner) layer of dura mater but may correspond to a vein
- termination of the SMCV and or DMCV or both
- runs from the inferior margin of the lesser sphenoid wing, courses along the floor of the MCF and drains into the EVFO, SPS, TS or a combination
- its location in the MCF varies from lateral to more medial
- corresponds to a persistent primitive tentorial sinus of Padgett

the paracavernous sinus

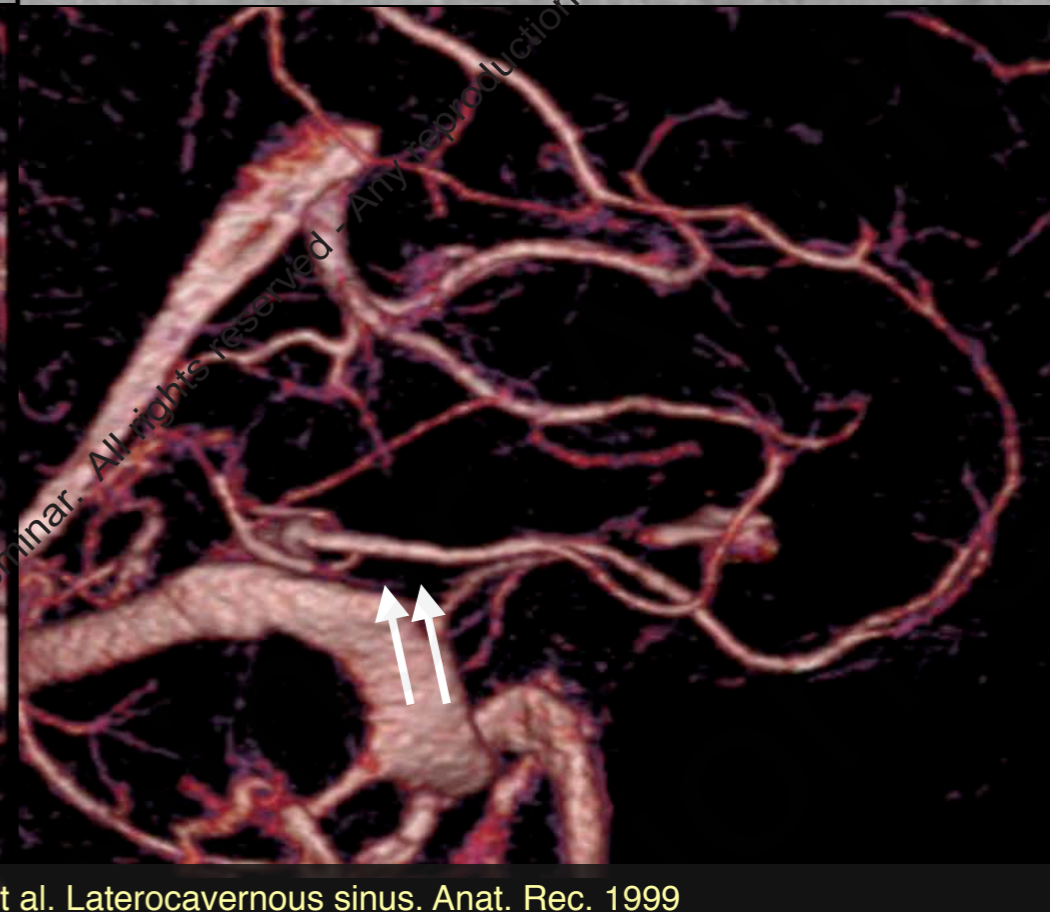
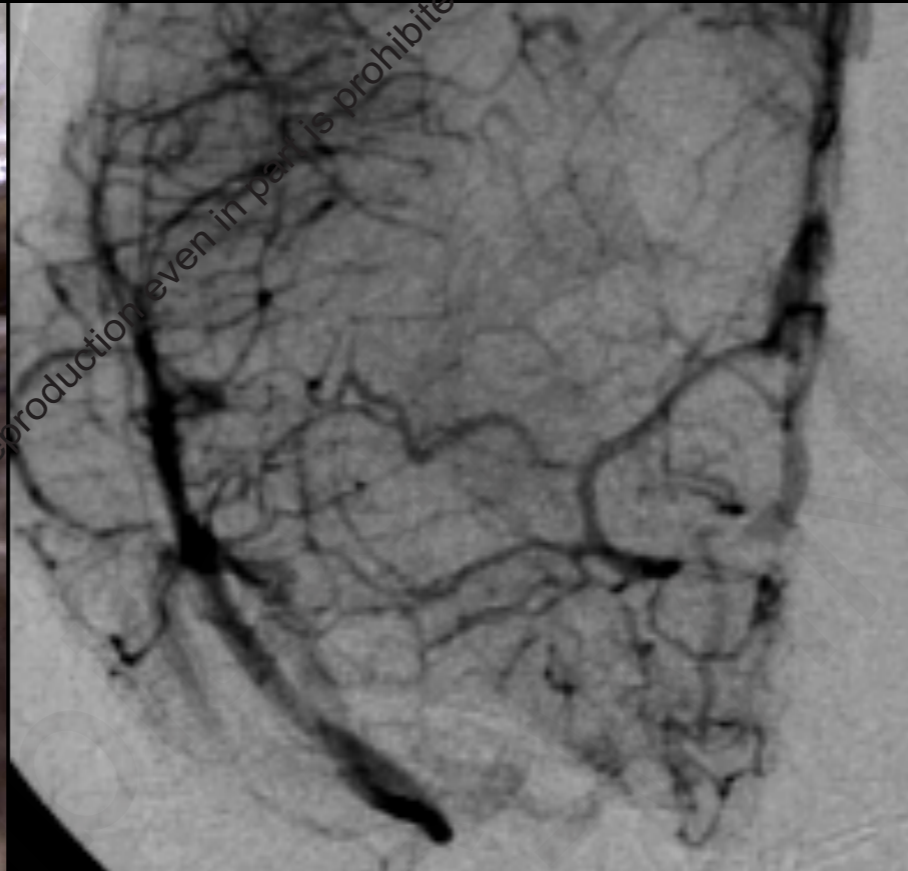


connection to the EVFO → PP

San Millán et al. Laterocavernous sinus. Anat. Rec. 1999

Gailloud et al. Angiographic anatomy of the laterocavernous sinus. AJNR 2000

the paracavernous sinus

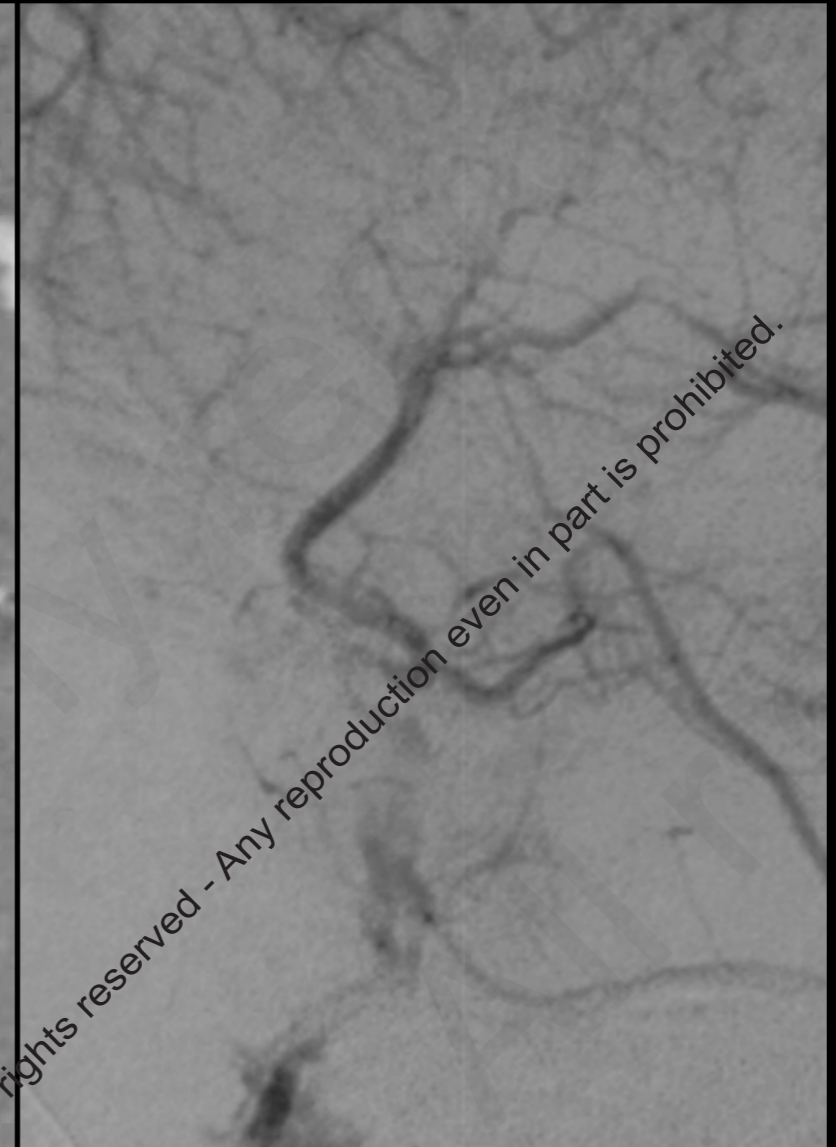
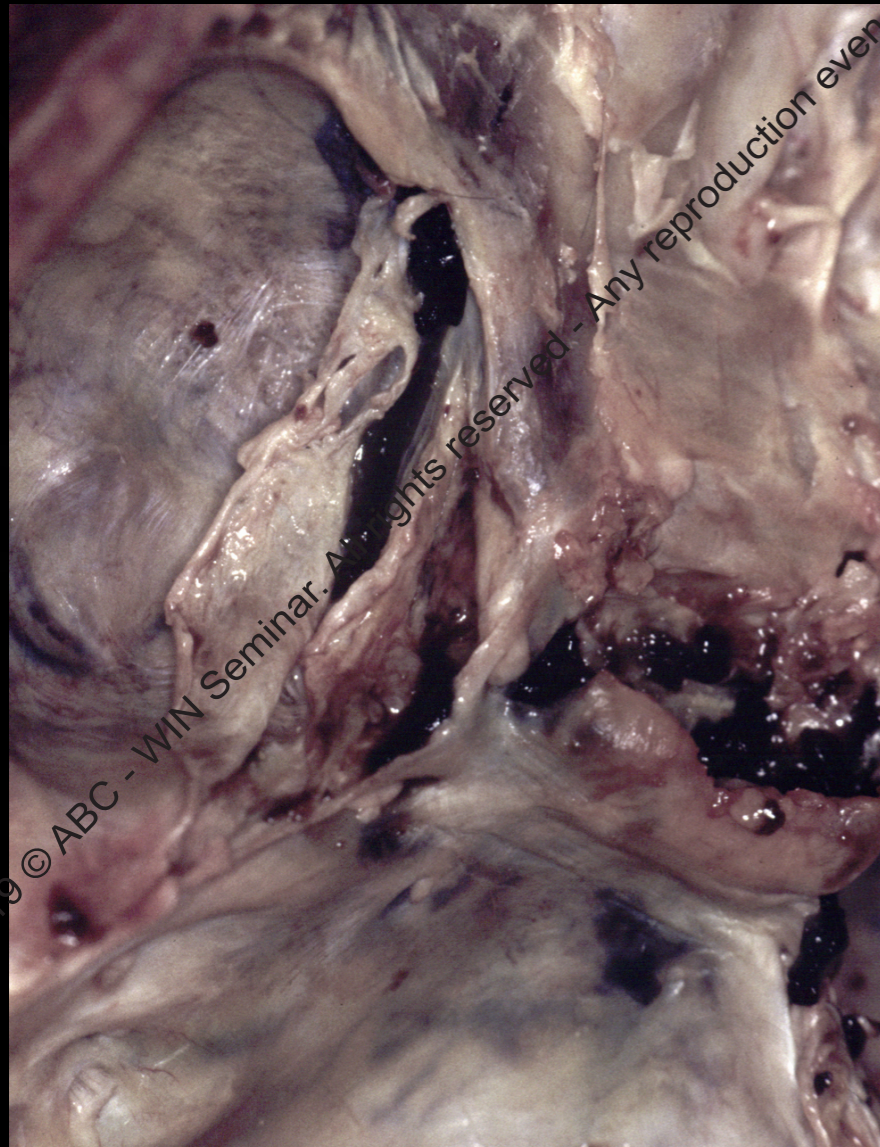


connection to TS through SPS
direct connection to TS

the laterocavernous sinus

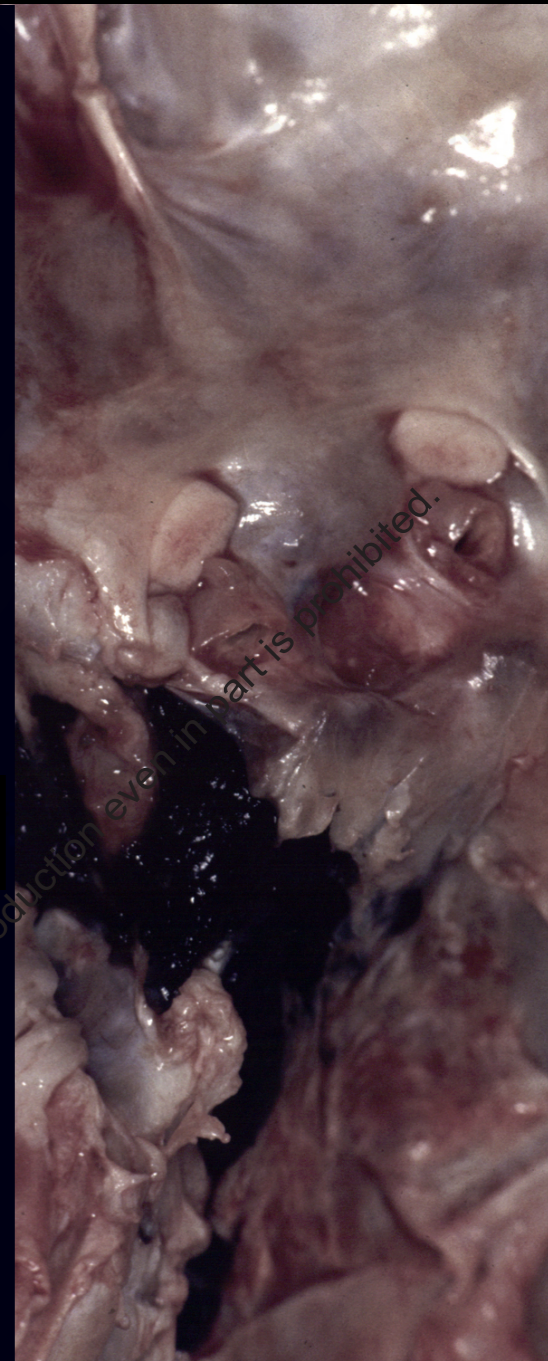
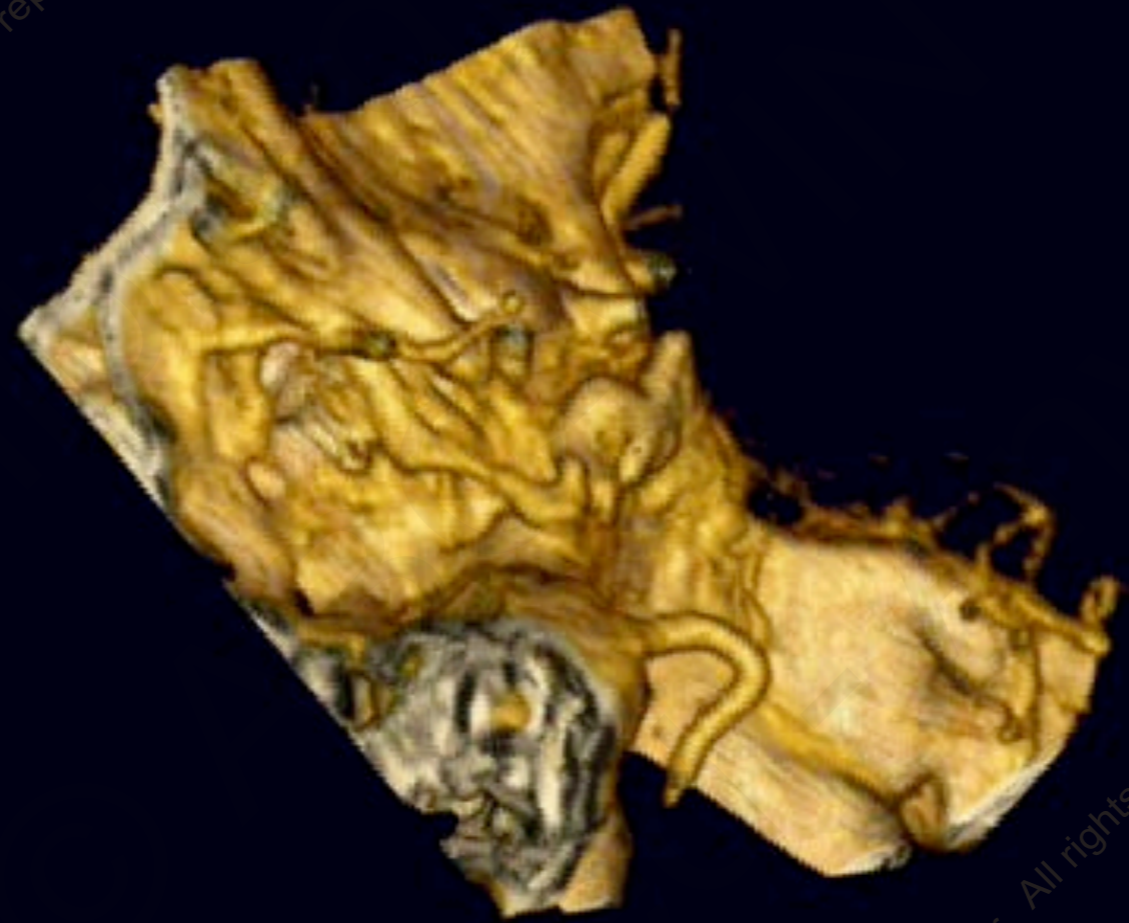
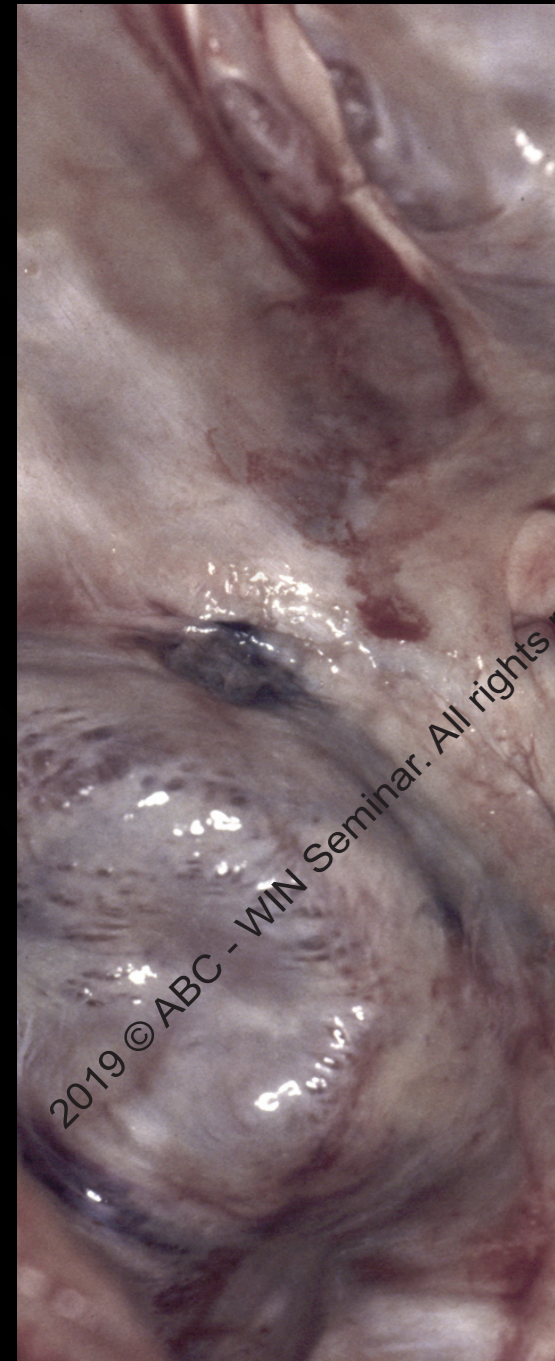
- a venous sinus located within the superficial and deep layers of the lateral wall of the laterosellar space, enters the antero-superior aspect of the lateral wall
- termination of the SMCV and or DMCV or both
- corresponds to a persistent primitive tentorial sinus of Padget, intermediate position
- may drain into the CS, usually its postero-lateral compartment
- may offer “en passant” communications with the CS on its way to the EVFO, SPS or TS
- may be the site of indirect laterosellar DAVF

the laterocavernous sinus



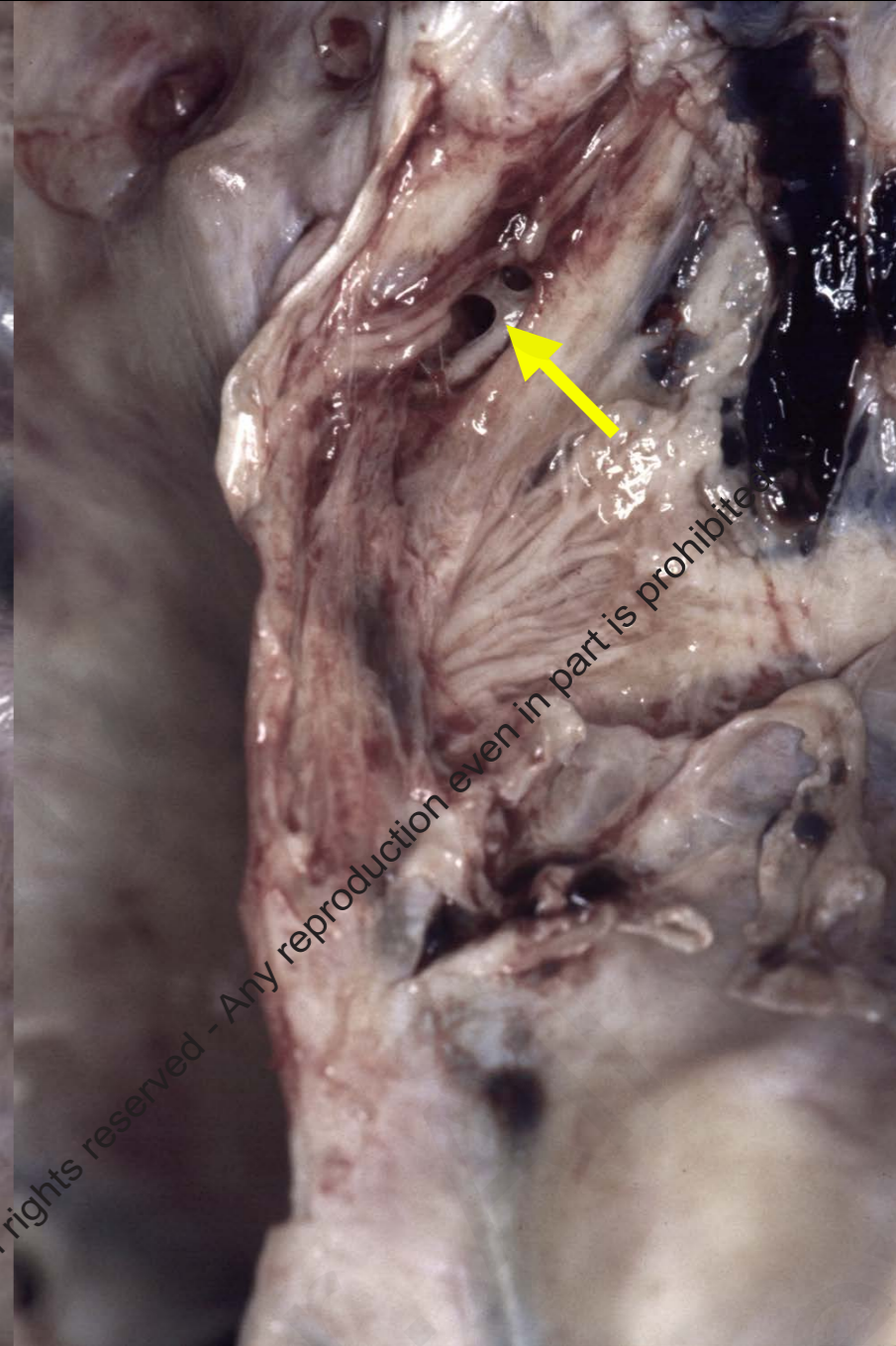
a venous channel within the layers of the lateral wall of the laterosellar space

the laterocavernous sinus



joining the posterior portion of the CS

the laterocavernous sinus



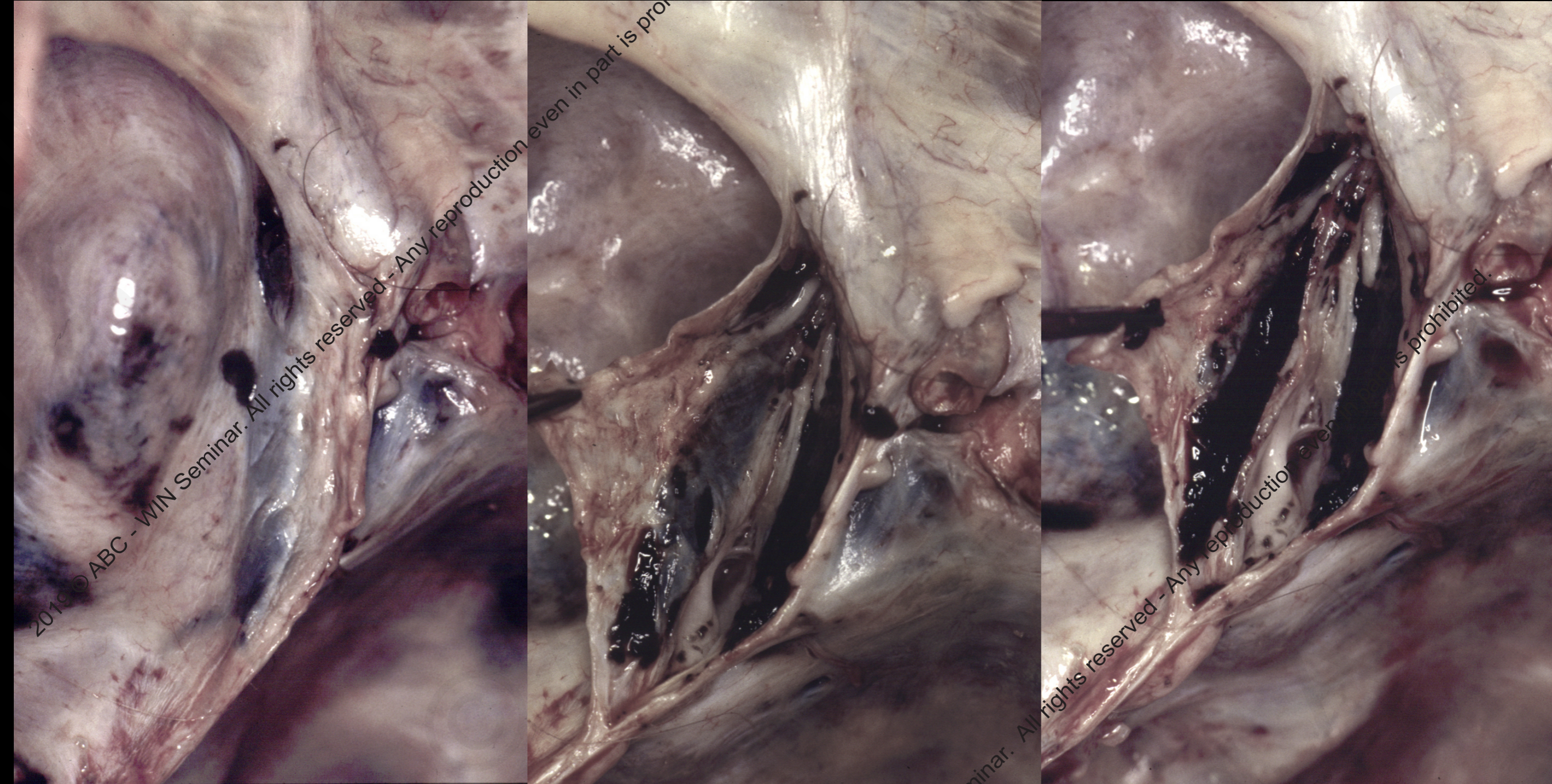
no connection to the CS → EVFO → PP

the laterocavernous sinus



no connection to the CS → SPS

the laterocavernous sinus

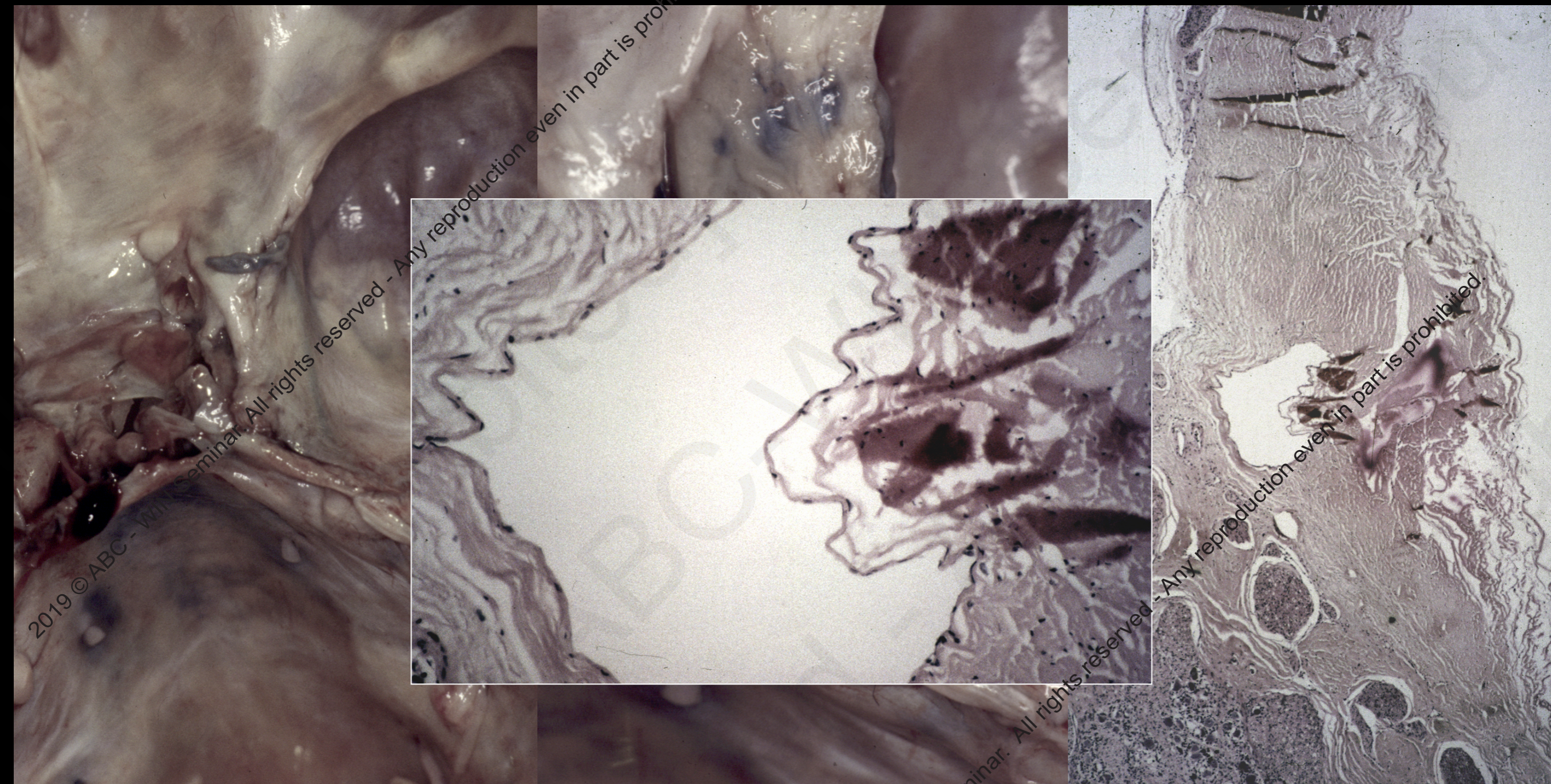


“en passant” connection to the CS → SPS

San Millán et al. Laterocavernous sinus. Anat. Rec. 1999

Gailloud et al. Angiographic anatomy of the laterocavernous sinus. AJNR 2000

the laterocavernous sinus



draining a DMCV → SPS, no connection to the CS

San Millán et al. Laterocavernous sinus. Anat. Rec. 1999

Gailloud et al. Angiographic anatomy of the laterocavernous sinus. AJNR 2000

the termination of the superficial middle cerebral vein

- **anatomical study** (*San Millán et al.*)

- 29 cadavers, 58 sides
- “classic” CS termination: **13.8%**
- PCS termination: **32.8%**
- LCS termination: **24.2%**
 - into CS: **7.2%**
 - into PP: **21.4%**
 - into SPS: **71.4%**

SMCV capture by CS : **21%**

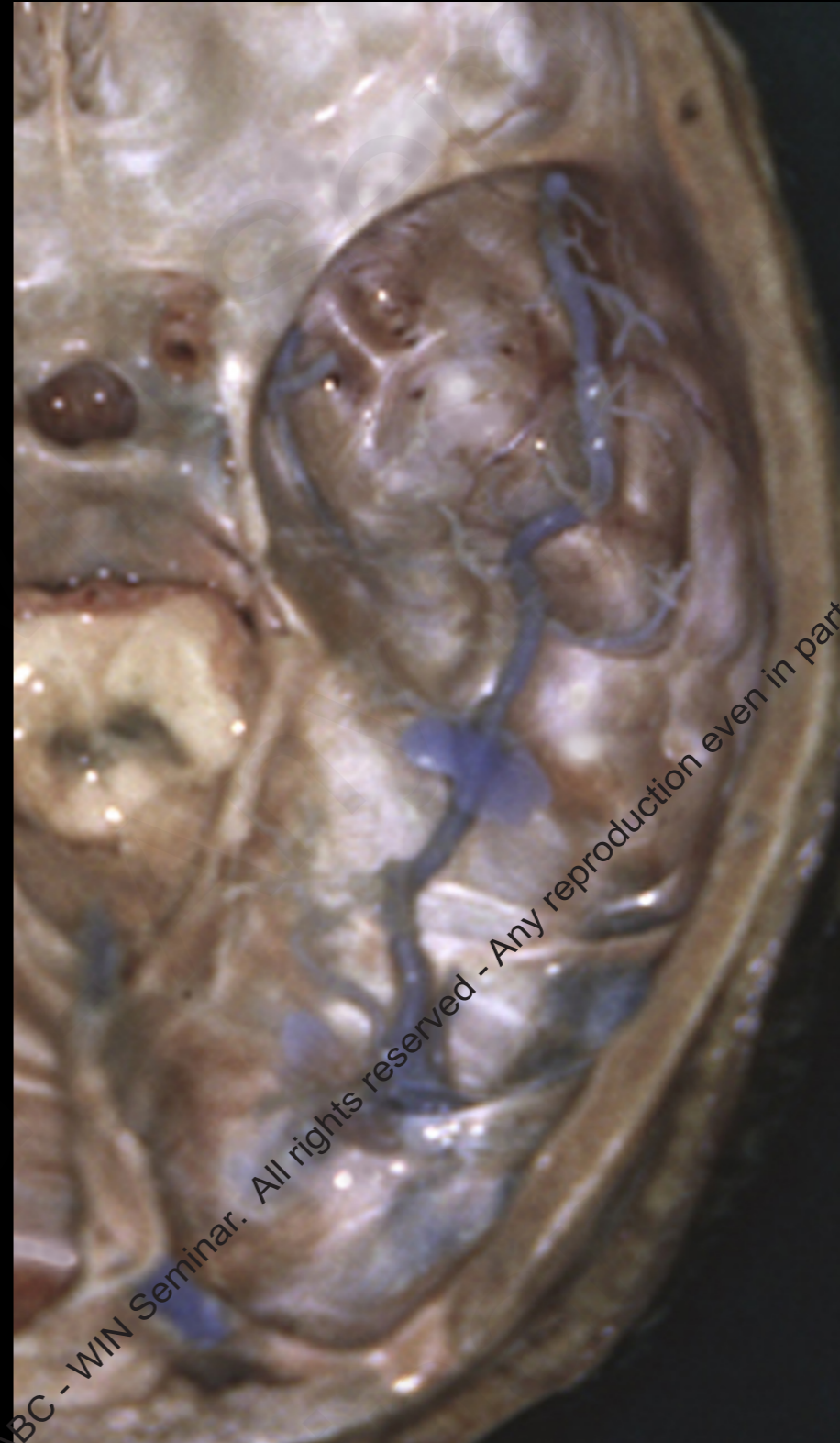
- **angiographic study** (*Gailloud et al.*)

- 100 venous phases
- “classic” CS termination: **20%**
- PCS termination: **39%**
- LCS termination: **22%**
 - into CS: **32%**
 - into PP: **27%**
 - into SPS: **18%**

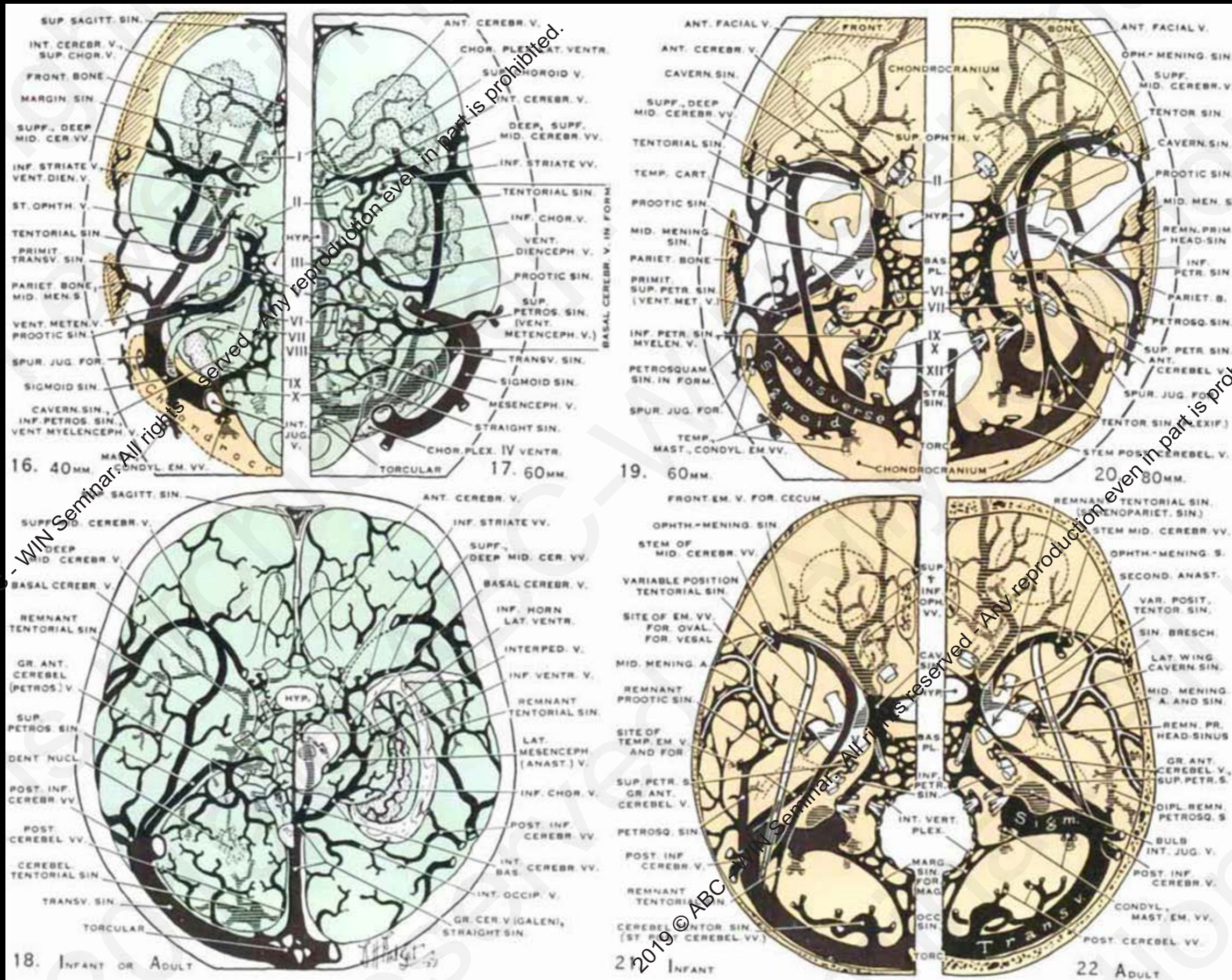
SMCV capture by CS : **52%**

the superficial middle cerebral vein

- ~ prenatally and at birth, the CS and IPS seldom drain encephalic blood (Padgett)
- the function of the CS at these stages is to drain the orbit towards the IJV by way of the IPS
- secondary anastomoses between the SMCV and CS may occur but are not obligatory and will depend on the fate of the *primitive tentorial sinus of Padgett*
- the *primitive tentorial sinus of Padgett*, often a vein, runs along the floor of the developing MCF from the edge of the lesser sphenoid wing to the transverse sinus
- may persist in the adult as a vein or a sinus



the superficial middle cerebral vein



the primitive tentorial sinus of Padgett (1956)

the termination of the superficial middle cerebral

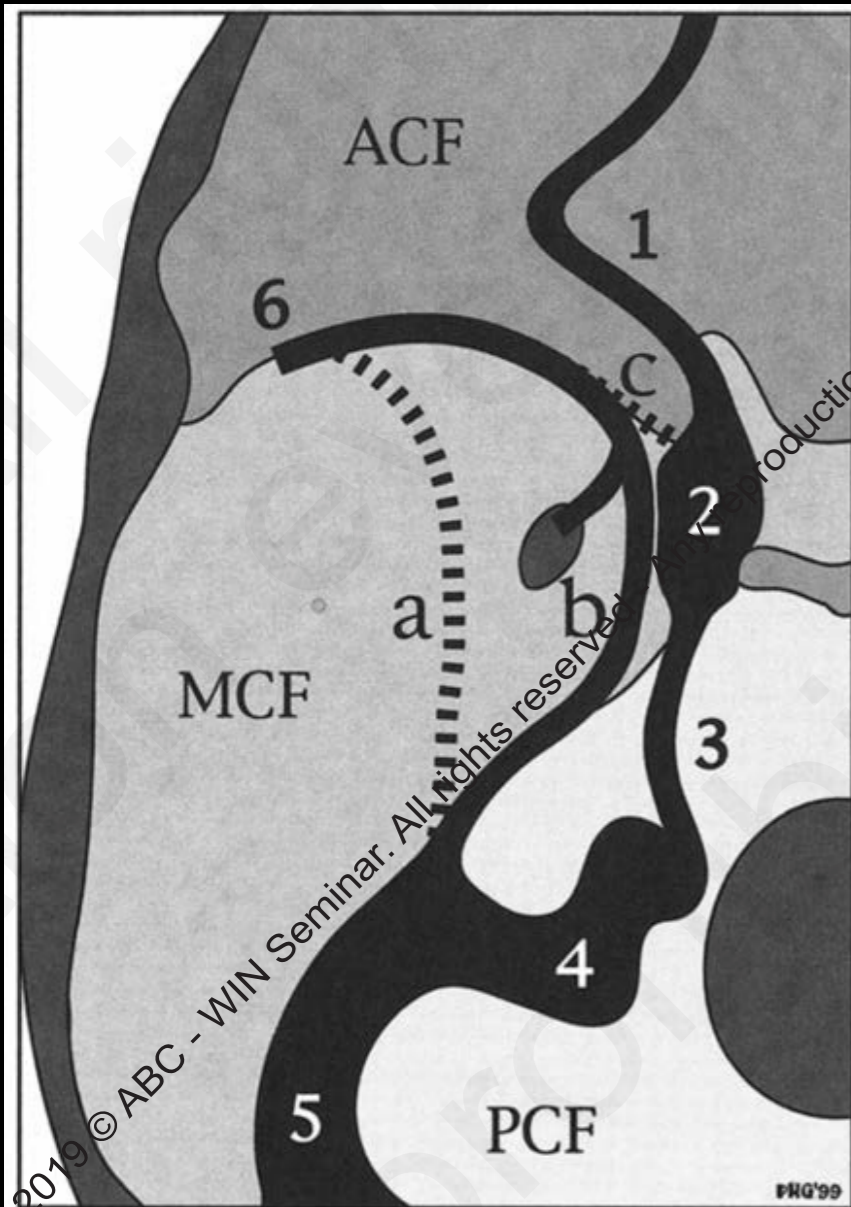
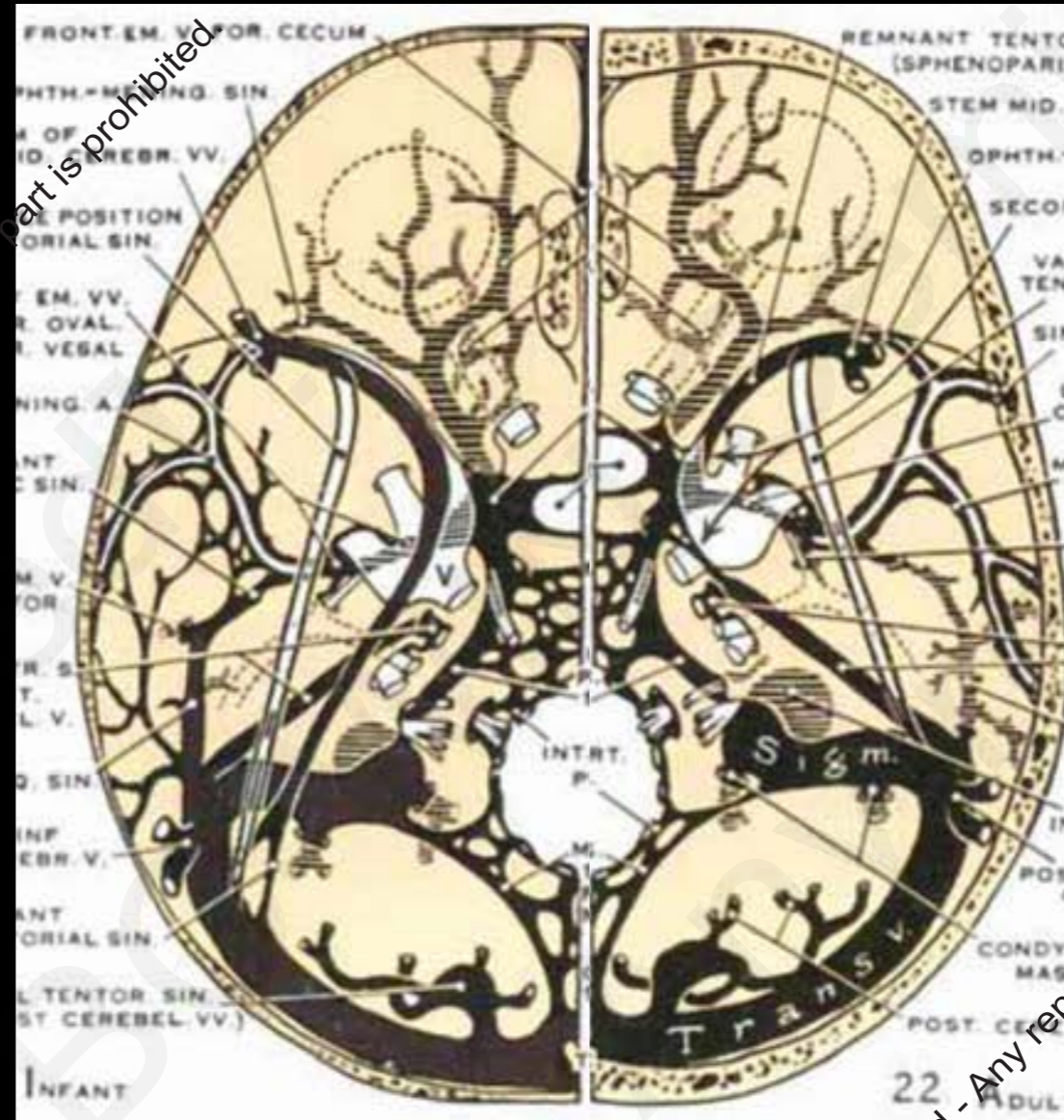


FIG 1. Schematic representation of the three basic drainage pathways of the SMCV according to San Millán Ruiz et al (4). Superior view of the anterior, middle, and posterior cranial fossa (ACF, MCF, and PCF, respectively). The SMCV may continue as a paracavernous sinus coursing laterally over the MCF (a), as an LCS enclosed within the lateral wall of the CS (b), or may terminate into the anterosuperior aspect of the CS (c). Venous outflow toward the pterygoid plexus via a skull base foramen is shown for the LCS. 1, superior ophthalmic vein; 2, CS; 3, inferior petrosal sinus; 4, sigmoid sinus; 5, transverse sinus; 6, SMCV.

Gailloud et al, 2000



- 3 different fates of the PTSP
 1. medial position, fusion with CS : lateral compartment of the CS
 2. intermediate position in the lateral wall of the CS : laterocavernous sinus (LCS)
 3. lateral position in the floor of the MCF: paracavernous sinus (PCS)
- cavernous capture : 1. and maybe 2. if LCS connected to CS
- absence of cavernous capture: 2 and maybe 2. if no connection between LCS and CS

the superficial middle cerebral vein



Fate of the three embryonic dural sinuses in infants: the primitive tentorial sinus, occipital sinus, and falcine sinus

Katsuhiko Mizutani¹ • Tomoru Miwa¹ • Takenori Akiyama¹ • Yoshiaki Sakamoto² • Hirokazu Fujiwara³ • Kazunari Yoshida¹

Received: 3 November 2017 / Accepted: 10 January 2018 / Published online: 22 January 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract

Purpose The primitive tentorial, occipital, and falcine sinuses are thought to attain the adult pattern or regress between the fetal stage and adulthood. The anatomy of these three primitive dural sinuses has seldom been studied in the infant population, and it remains unclear when these dural sinuses reach the adult condition. Using computed tomography digital subtraction venography (CT-DSV), we analyzed the anatomy of these embryonic dural sinuses in infants.

Methods We included 13 infants who underwent CT-DSV prior to neurosurgery and 35 cases with unruptured cerebral aneurysms as normal adult controls. Three embryonic dural sinuses, i.e., the primitive tentorial, occipital, and falcine sinuses, were retrospectively analyzed in CT-DSV images of infants and adults. We also analyzed the drainage patterns of the superficial middle cerebral vein (SMCV), determined by the connection between the primitive tentorial sinus and the cavernous sinus.

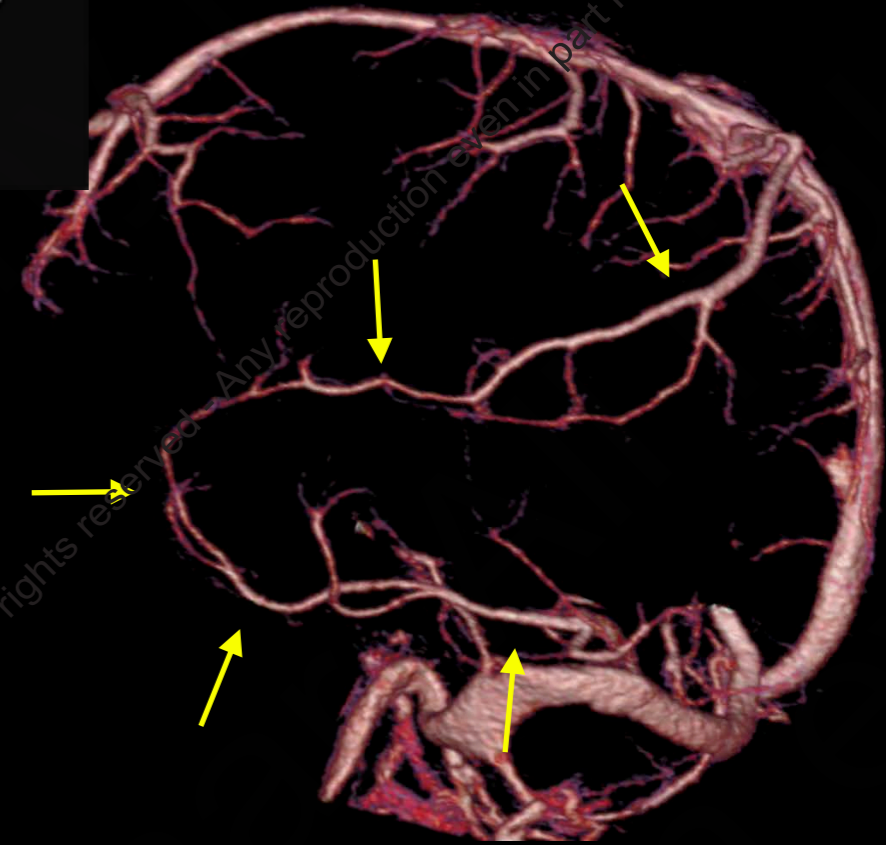
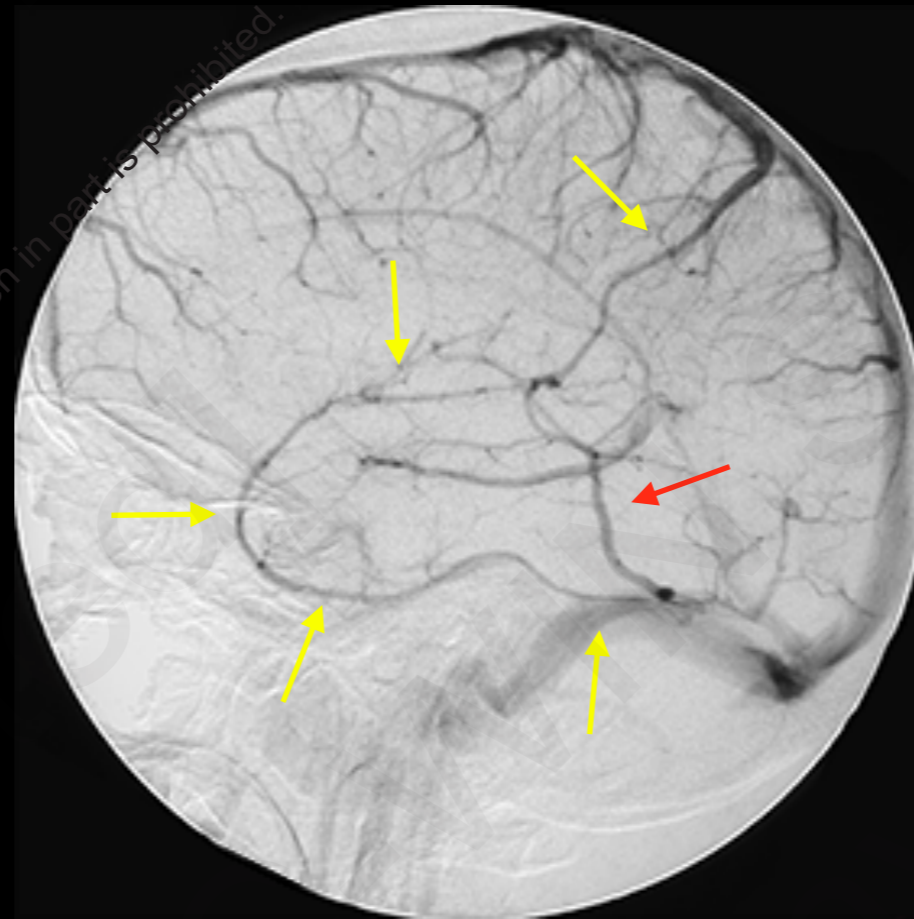
Results The primitive tentorial, occipital, and falcine sinuses were present in 15.4%, 46.2%, and none of the infants, respectively, and in 10.0, 8.6, and 2.9% of the adults, respectively. The difference in SMCV draining pattern between infants and adults was insignificant. The incidence of the occipital sinus was significantly higher in infants than in adults.

Conclusions The connection between the primitive tentorial sinus and the cavernous sinus appears to be established before birth. The occipital sinus is formed at the embryonic stage and mostly regresses after infancy. The falcine sinus is usually obliterated prenatally. Our findings form the basis for interventions by pediatric interventional neuroradiologists and neurosurgeons.

- Mizutani et al. suggest that the connection between the SMCV and CS established pre-natally

great anastomotic vein of Trolard

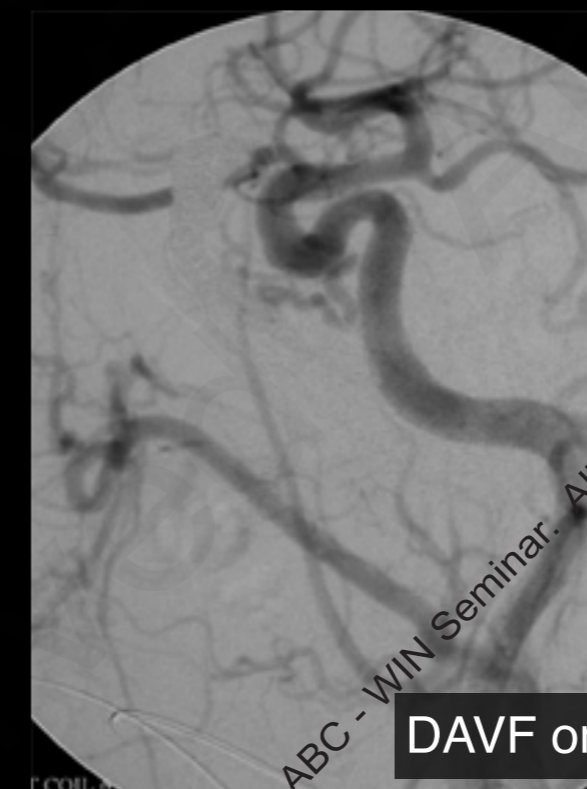
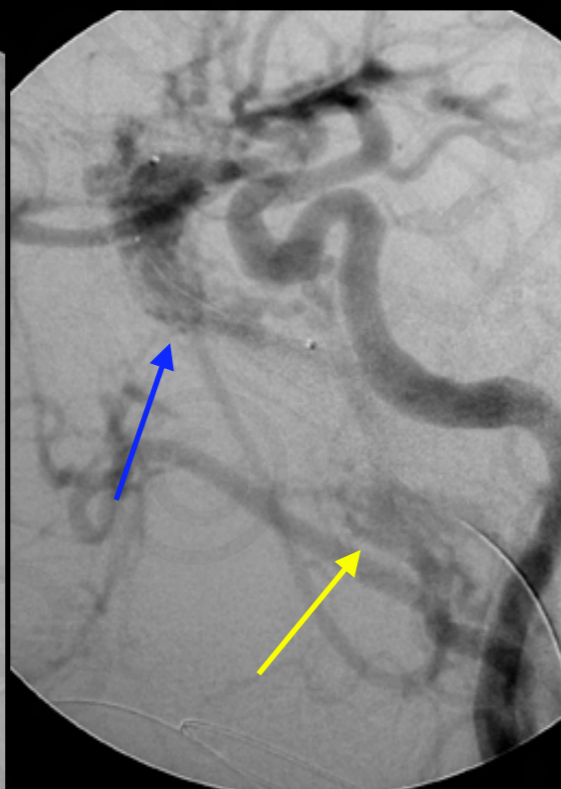
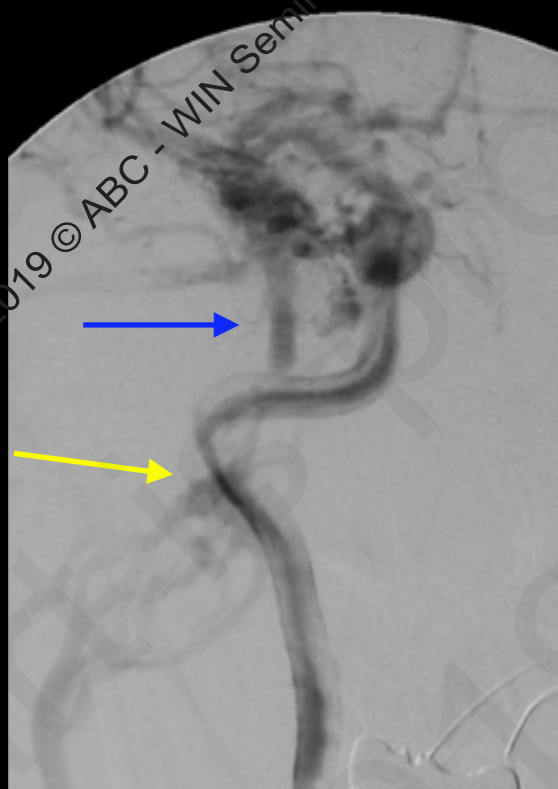
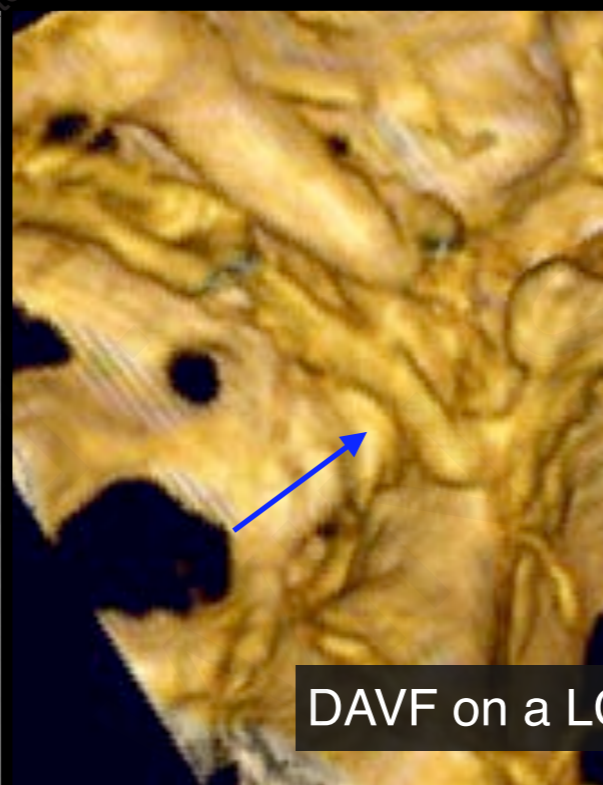
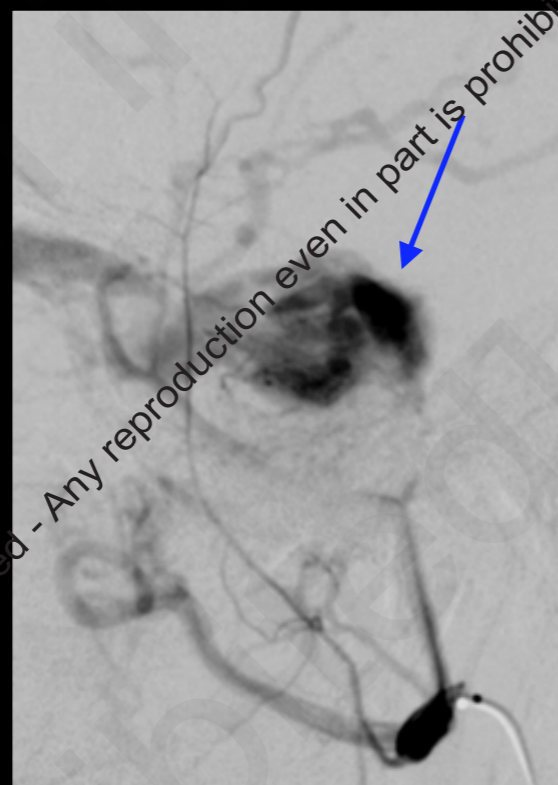
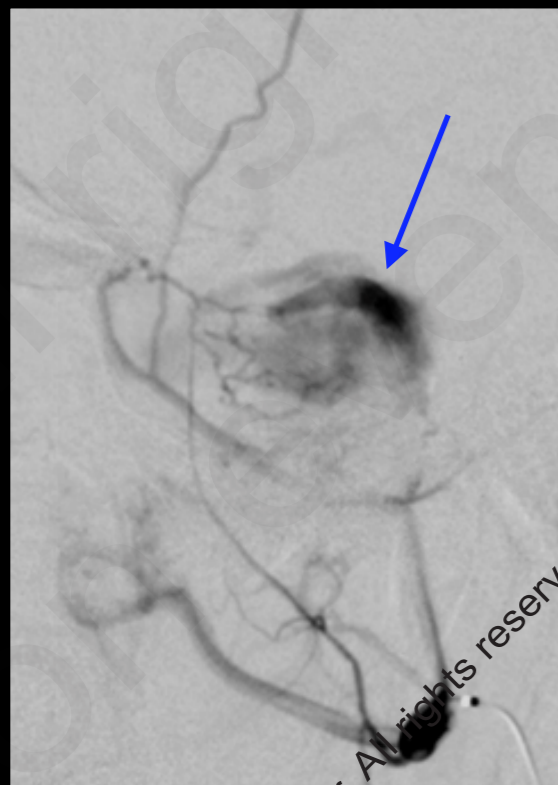
— 10 —
Grande veine anastomotique. — Presque toujours, de la partie moyenne du sinus pétreux supérieur, on voit partir une veine, qui, traversant d'arrière en avant la fosse sphéno-temporale, va aboutir au milieu du bord postérieur de la petite aile du sphénoïde. Son origine varie : il n'est pas rare de la voir provenir de la partie antérieure du sinus caverneux, à côté de la veine ophthalmique; une fois, je l'ai vue naître de la partie postérieure du sinus pétreux : elle contournait alors la base du rocher. Pendant son trajet dans la fosse sphéno-temporale, elle est contenue dans la dure-mère et constitue un véritable sinus qui croise les veines méningées moyennes et communique avec elles. Arrivé sur le bord tranchant de l'apophyse d'Ingrassia, elle se place dans la scissure de Sylvius, envoie à la base du cerveau une petite branche que je reprendrai tout à l'heure, devient très-volumineuse, se dirige en haut, d'avant en arrière, va terminer dans le sinus longitudinal supérieur vers le tiers postérieur de celui-ci. Elle communique dans son trajet avec toutes les autres veines de la convexité de l'hémisphère.



FACULTÉ DE MÉDECINE DE PARIS N° 256
THÈSE
POUR
LE DOCTORAT EN MÉDECINE
Présentée et soutenue le 31 octobre 1868,
PAR PAULIN TROLARD

“arising from the superior petrosal sinus, there is that crosses the sphenotemporal fossa within the dura mater (sinus), goes over the lesser sphenoid wing, follows the sylvian fissure and then courses superiorly towards the posterior third of the superior sagittal sinus...” → greater anastomotic vein...

dural arteriovenous fistula of the laterosellar region... not all cavernous



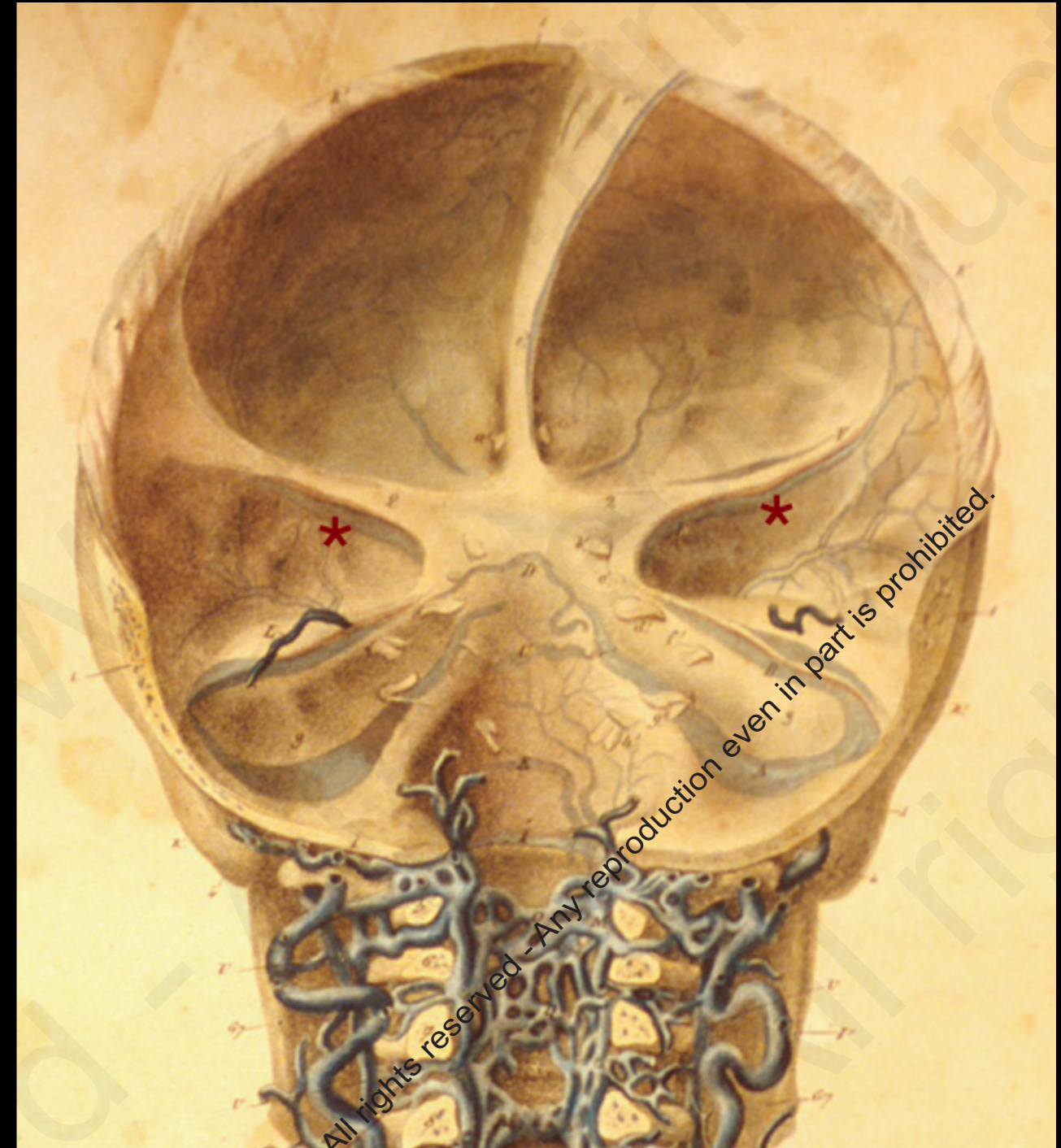
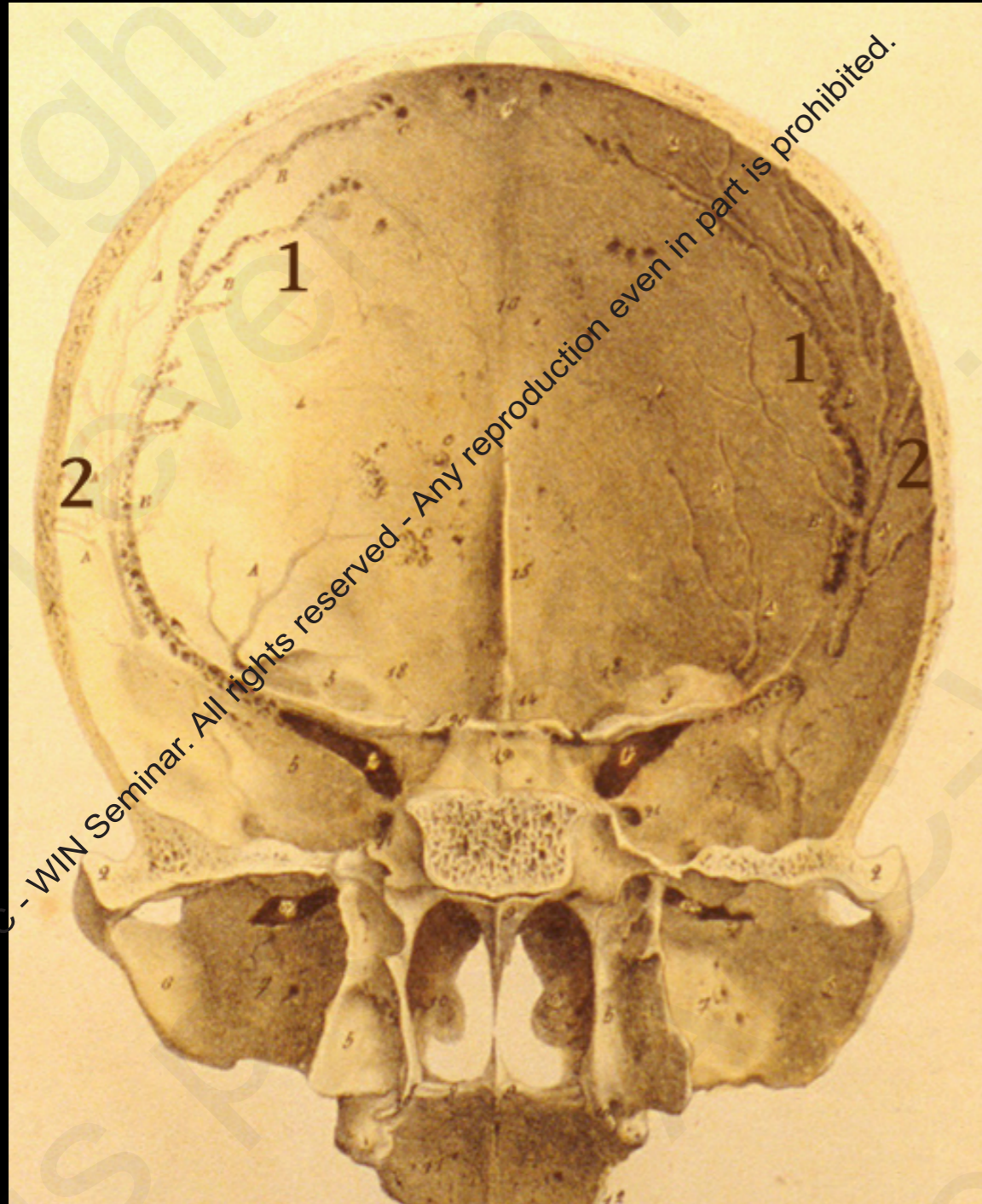
- if DAVF on a LCS that is not connected to the CS, classic CS transvenous route not possible
- connection of the SMCV (DMCV) to the CS will determine whether cortical reflux occurs in cases of cavernous AVF

the sphenoparietal sinus of Breschet (1829)

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

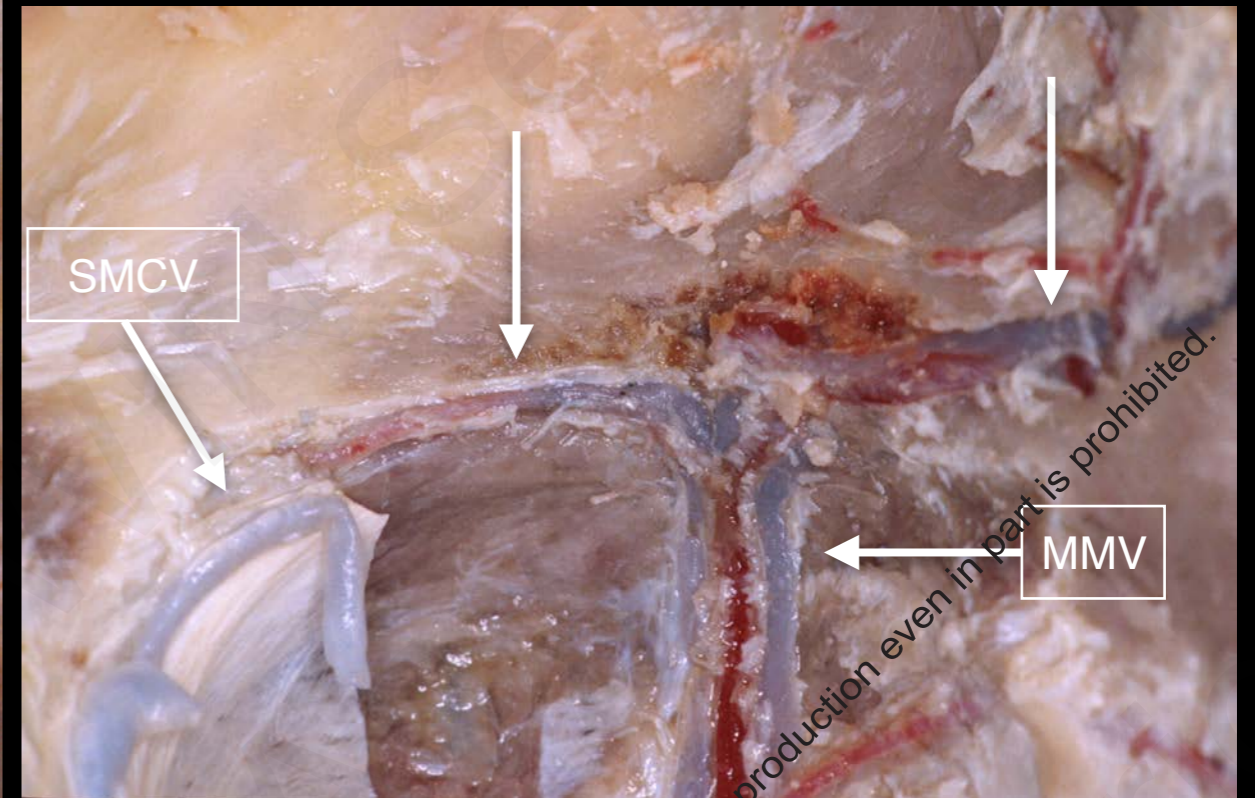
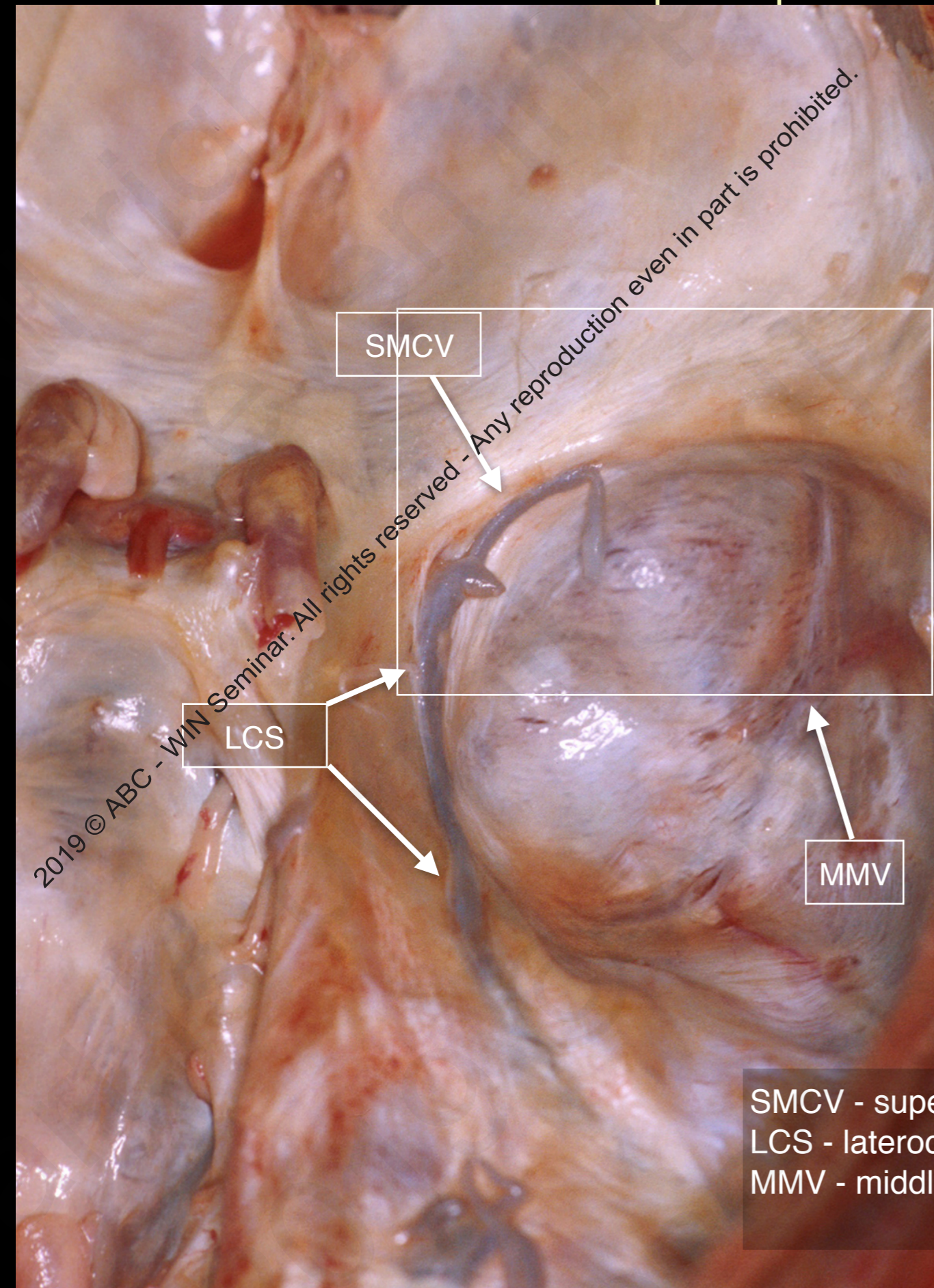
2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

the sphenoparietal sinus of Breschet (1829)



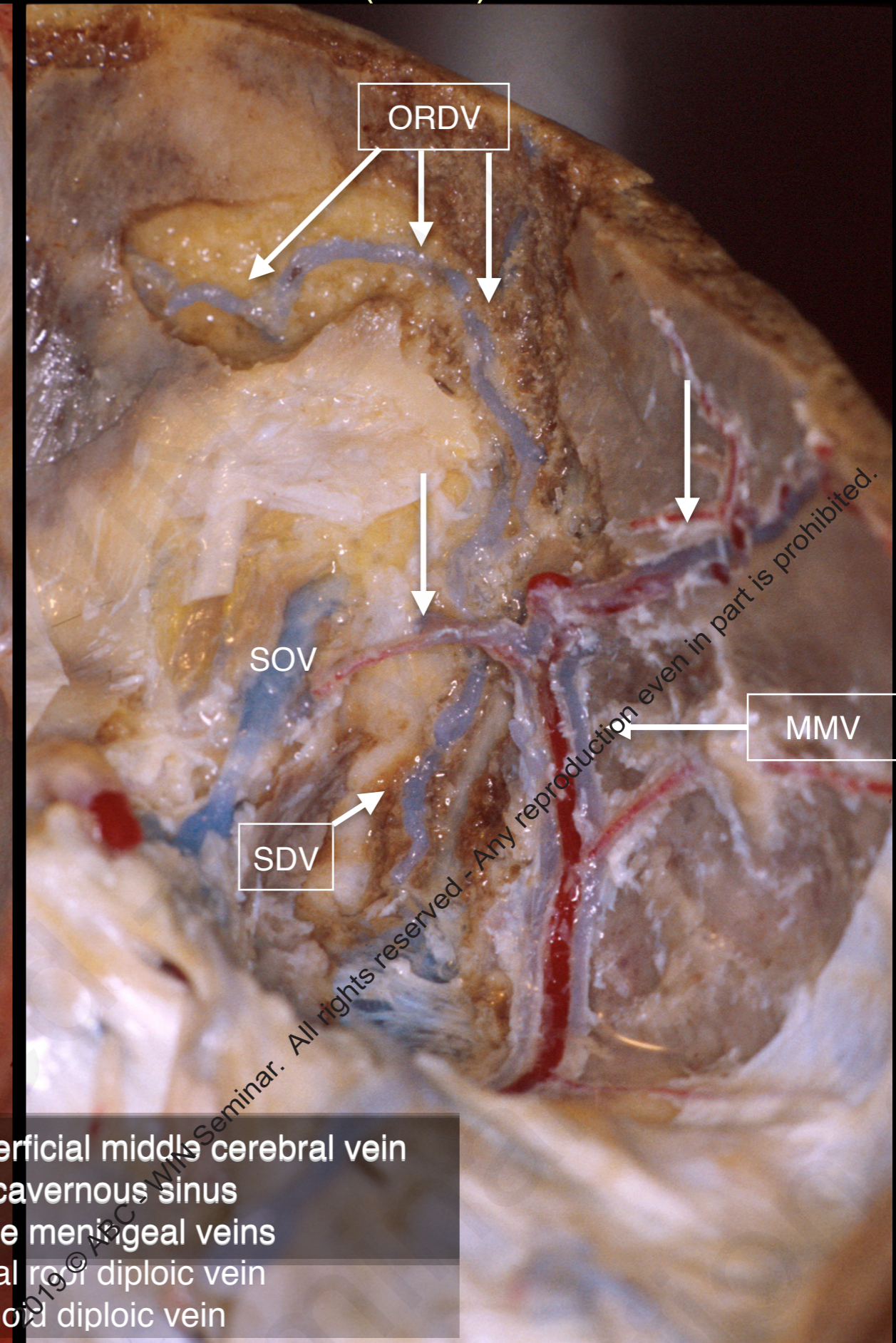
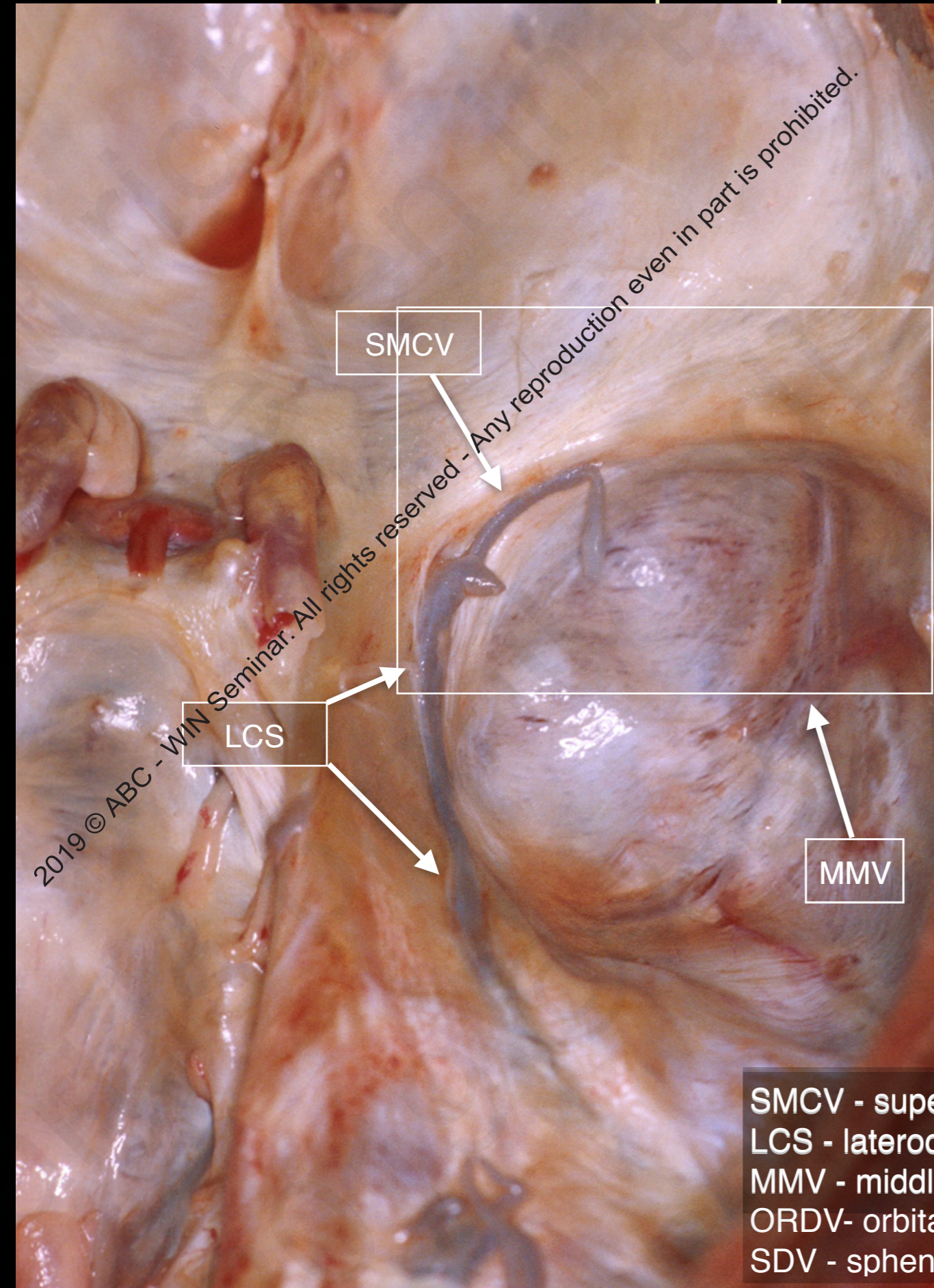
a “sinus found within the limits of the anterior and medial portions of the base of the skull, which occupies a transversally oriented gutter that runs inward into the cavernous sinus. This sinus receives several branches from the skull bones, the dura mater, and the diploic vein of the temporal bone” quoted by Cruveilhier 1852

The sphenoparietal sinus of Breschet (1829)



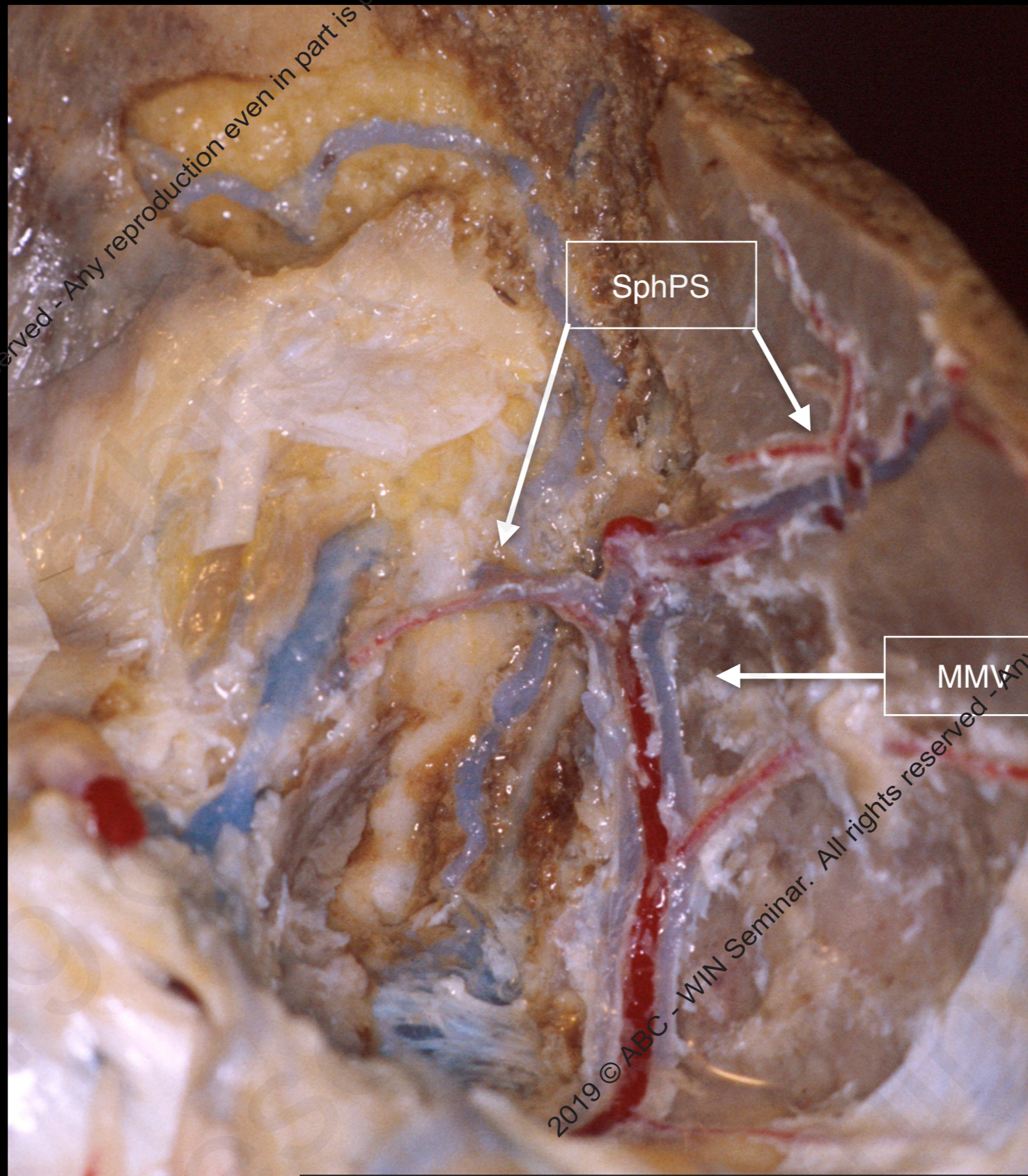
SMCV - superficial middle cerebral vein
LCS - laterocavernous sinus
MMV - middle meningeal veins

The sphenoparietal sinus of Breschet (1829)

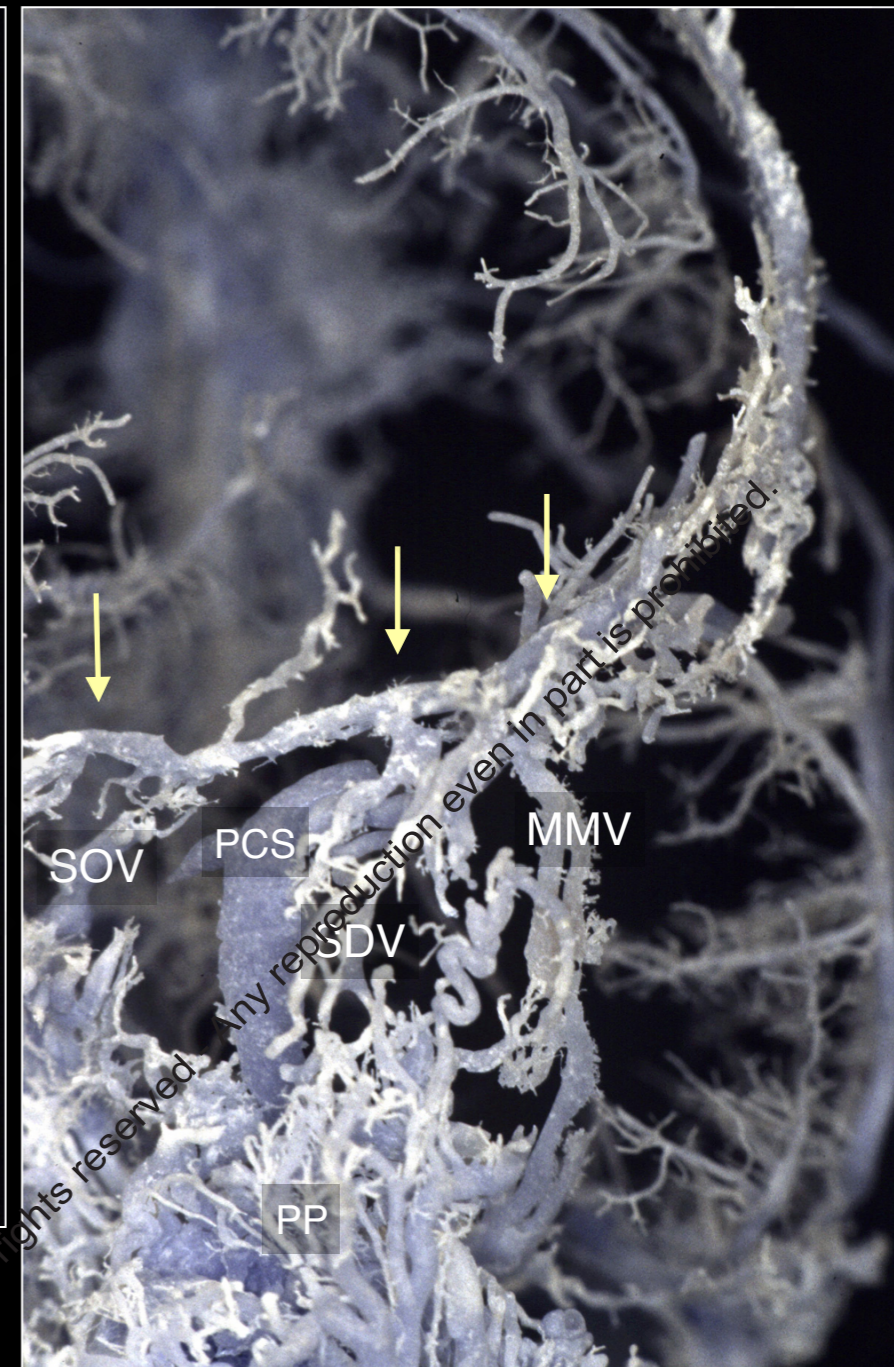
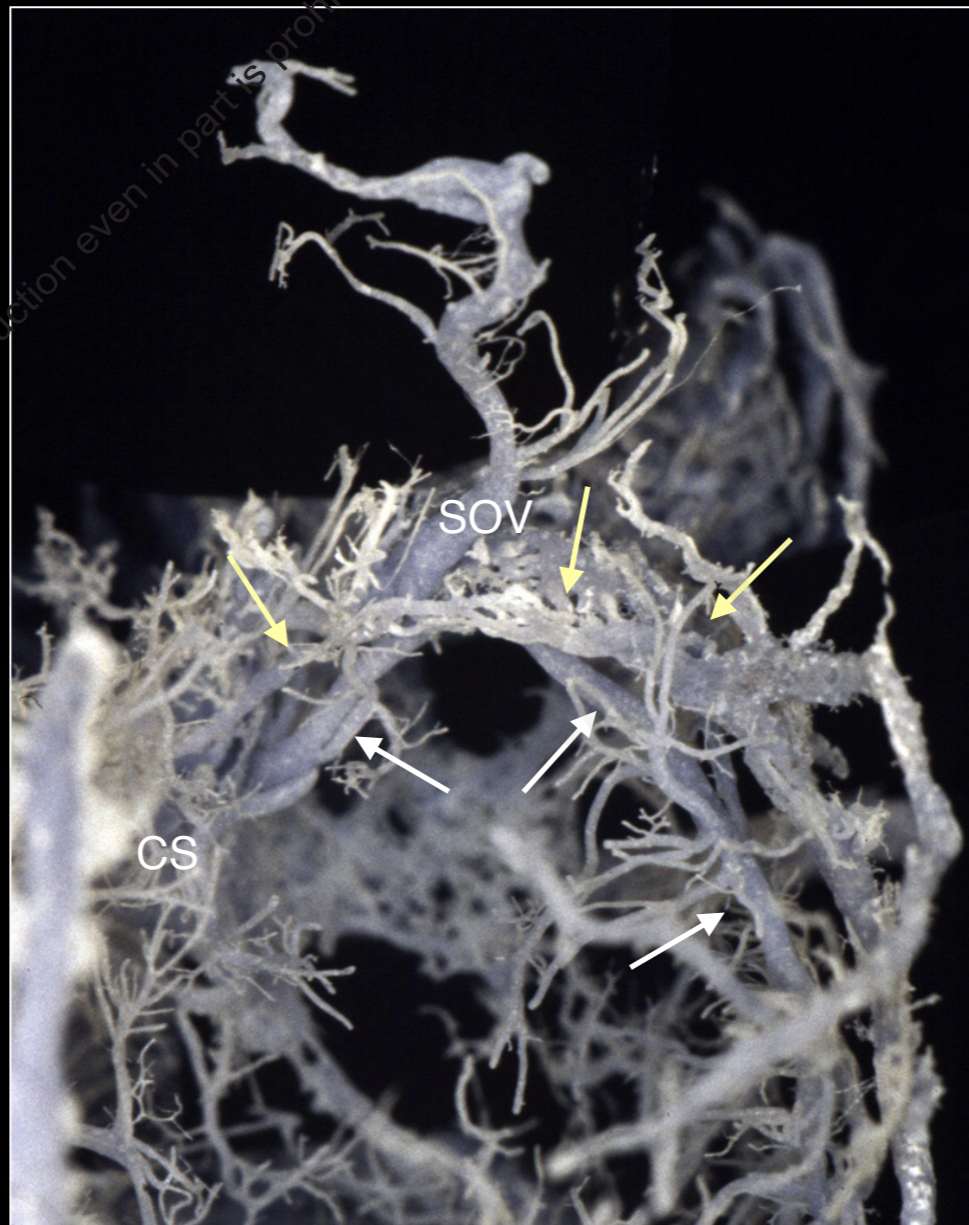
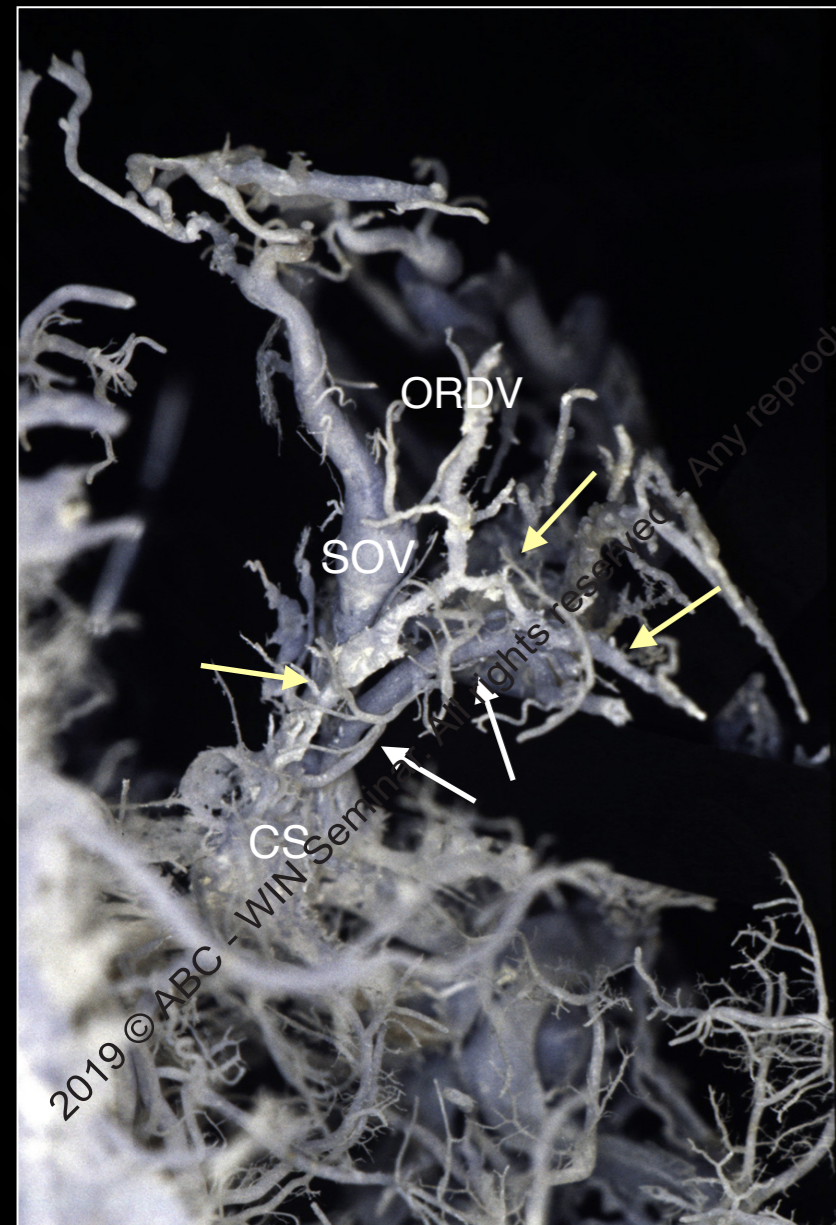


SMCV - superficial middle cerebral vein
LCS - laterocavernous sinus
MMV - middle meningeal veins
ORDV- orbital root diploic vein
SDV - sphenoid diploic vein

the sphenoparietal sinus of Breschet (1829)



the sphenoparietal sinus of Breschet (1829)



← superficial middle cerebral vein

→ sphenoparietal sinus

ORDV orbital roof diploic vein

CS - cavernous sinus

SOV - superior ophthalmic vein

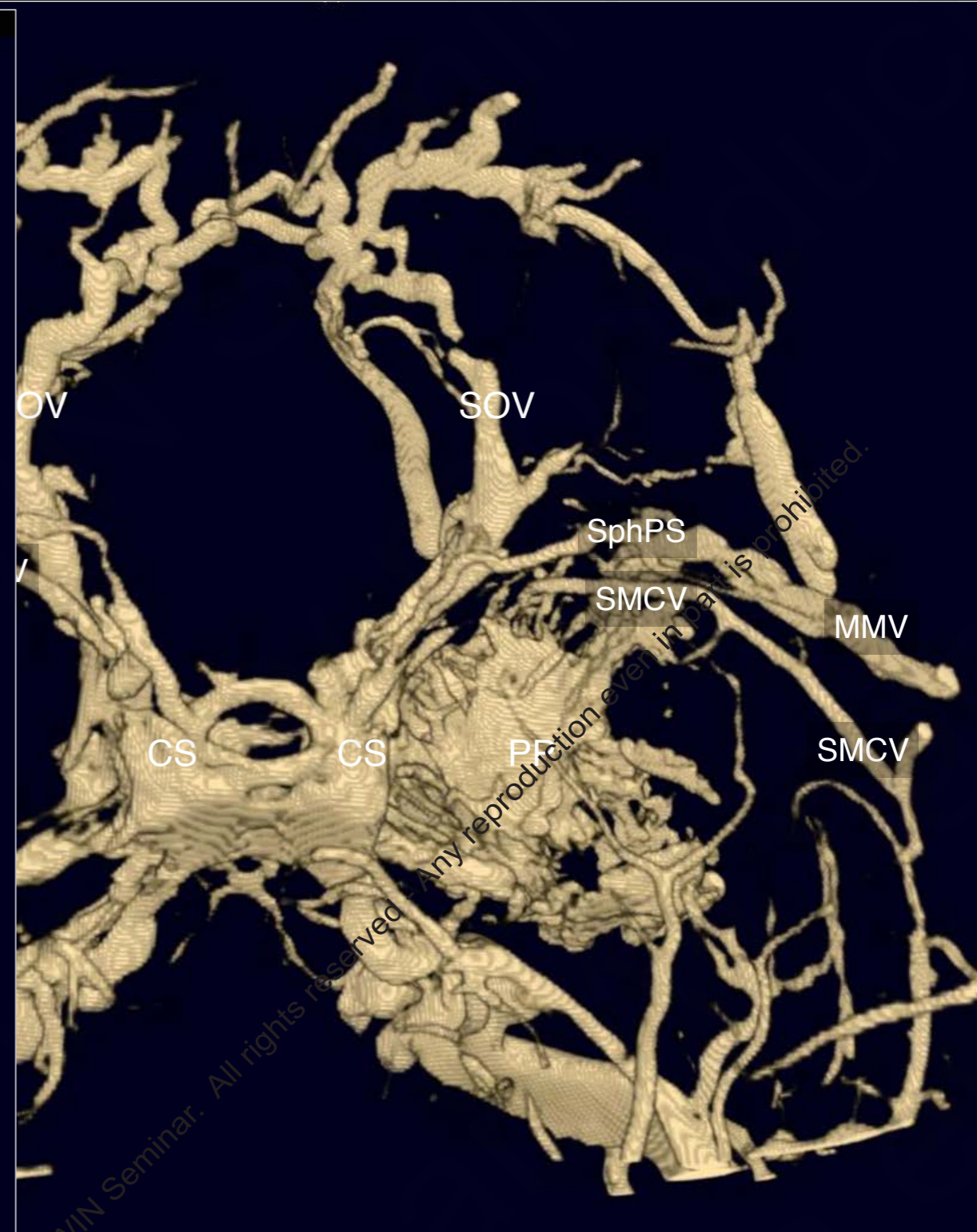
SDV - sphenoid diploic vein

PCS - paracavernous sinus

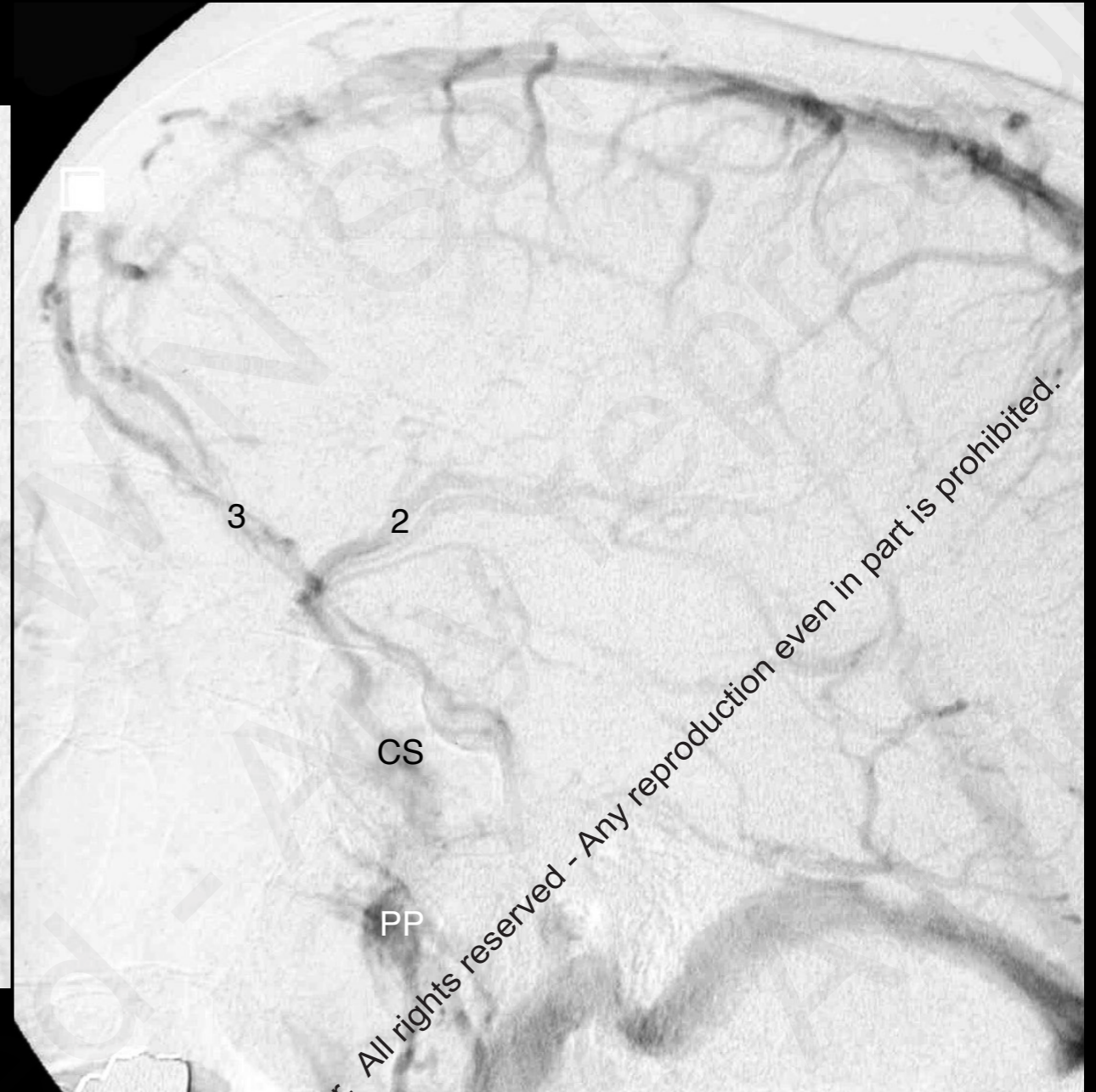
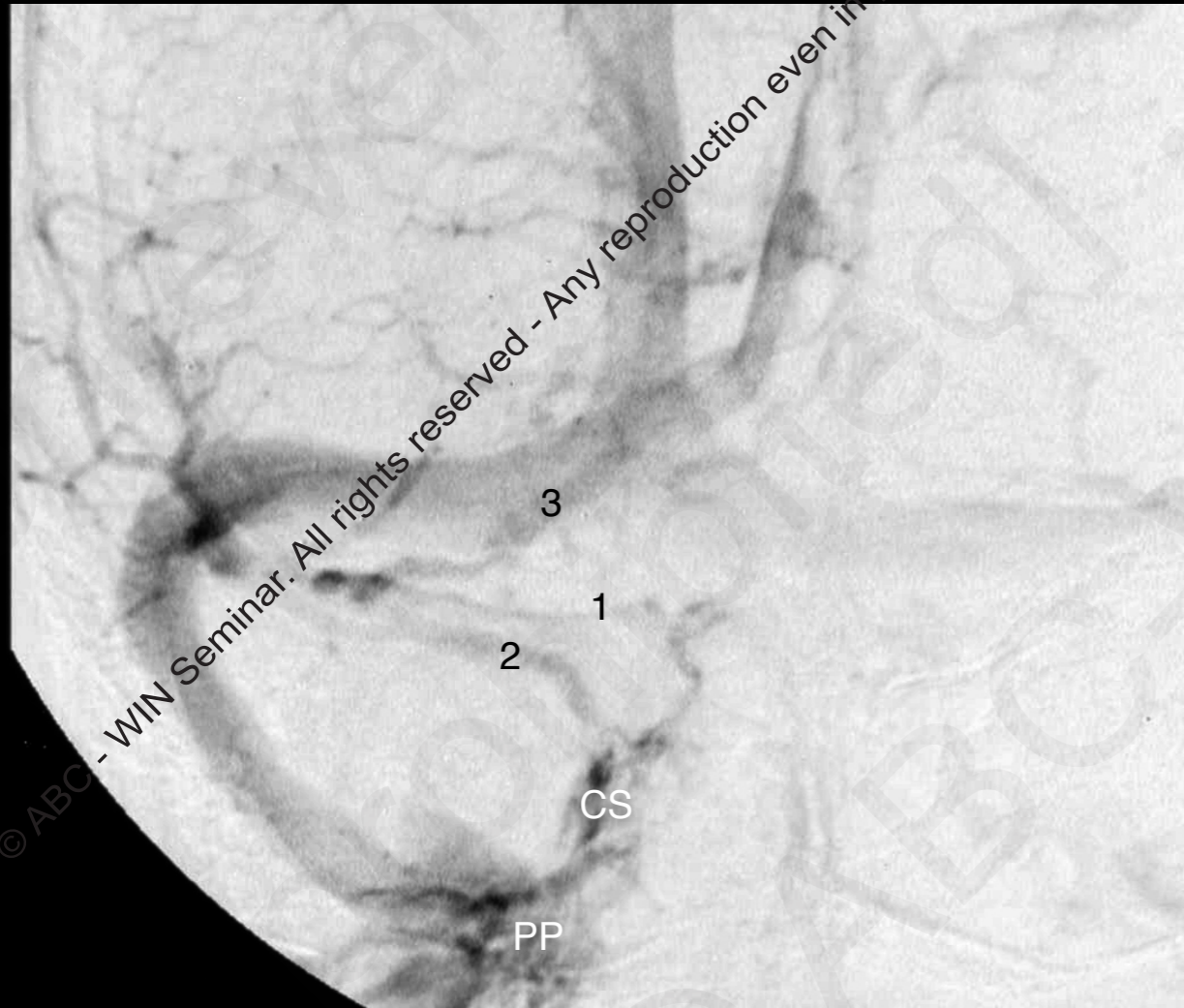
MMV - middle meningeal vein

PP - pteryoid plexus

the sphenoparietal sinus of Breschet (1829)



the sphenoparietal sinus of Breschet (1829)



- 1 - sphenoparietal sinus
- 2 - superficial middle cerebral vein
- 3 - orbital roof diploic vein

DSA

the sphenoparietal sinus of Breschet (1829)



- 1 - sphenoparietal sinus
- 2 - superficial middle cerebral vein
- 3 - orbital roof diploic vein
- 4 - paracavernous sinus

DSA



the sinus of the lesser wing (sphenoparietal sinus)

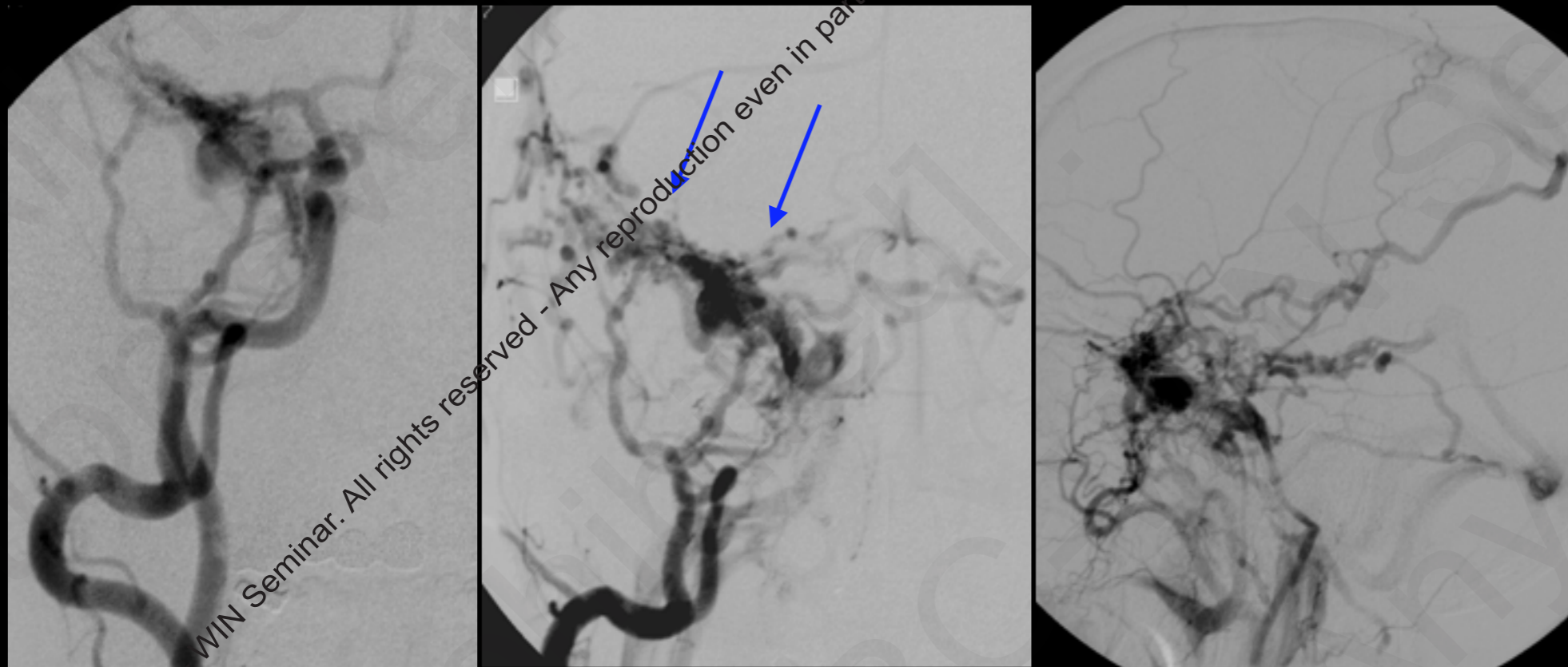
≠

the termination of the superficial middle cerebral vein
(SMCV)

two different embryological origins (prootic sinus vs primitive telencephalic veins/PTSP)

confusion traced back to Hédon's thesis in 1888?

SMCV dural arteriovenous fistula...



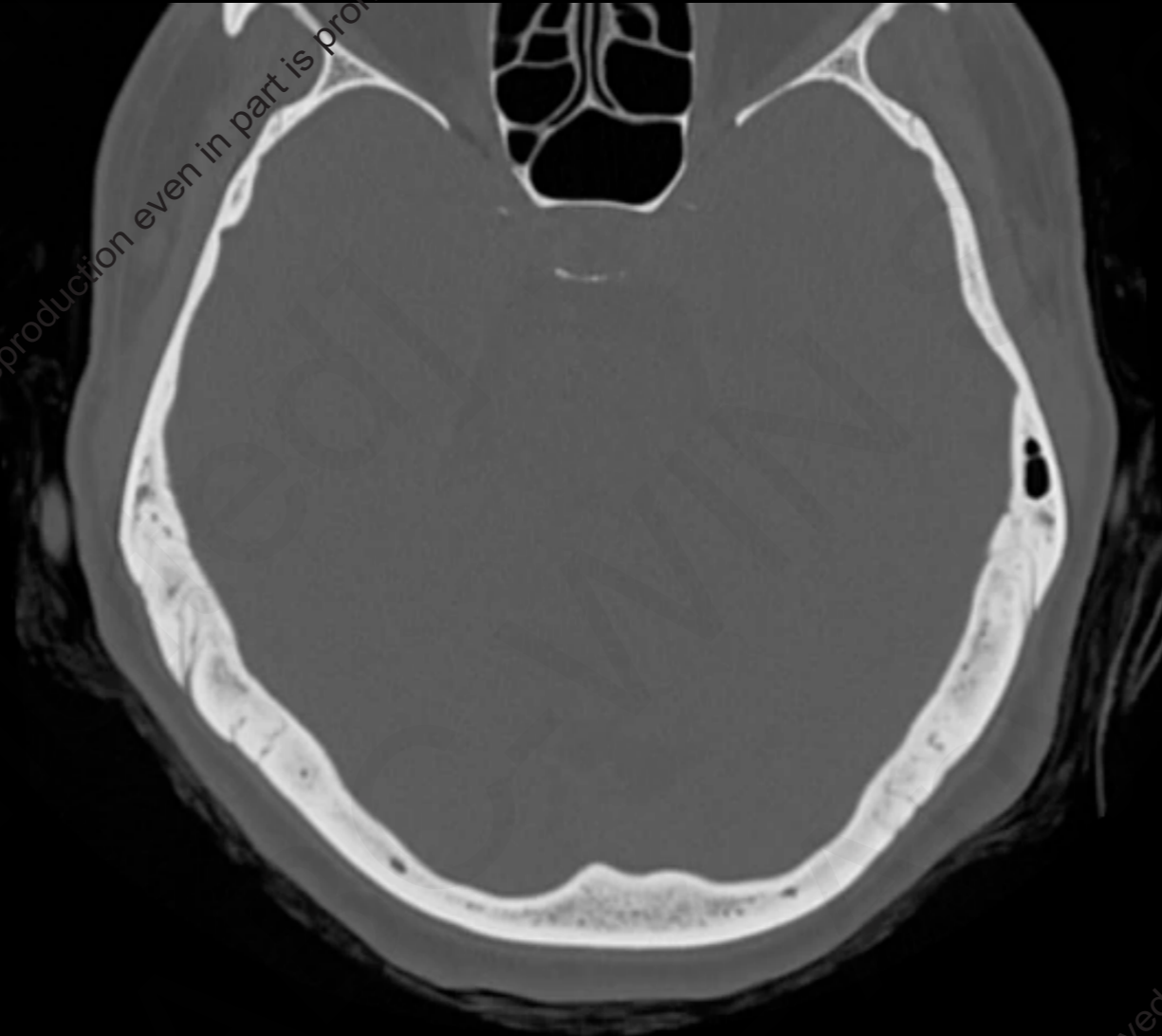
...may run under the lesser and attach to the dura under the lesser wing, but maintains characteristics of a pial vein \neq a dural sinus...

the petrosquamosal sinus (PSS)

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

2019 © ABC - WIN Seminar. All rights reserved - Any reproduction even in part is prohibited.

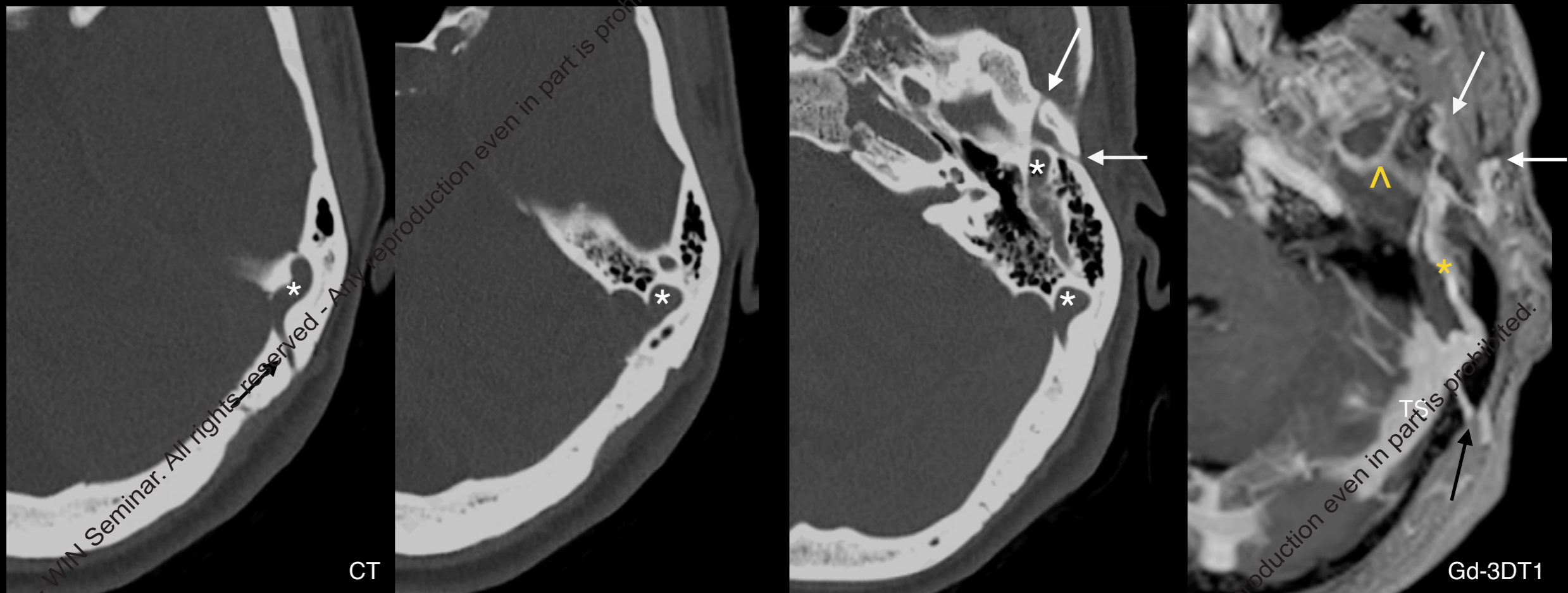
the petrosquamosal sinus (PSS)



the petrosquamosal sinus (PSS)

- transient embryological channel connecting the transverse sinus (TS) to the external jugular vein (EJV)
- may persist in the adult as a small remnant of little functional importance or as the main /only outflow pathway of the TS

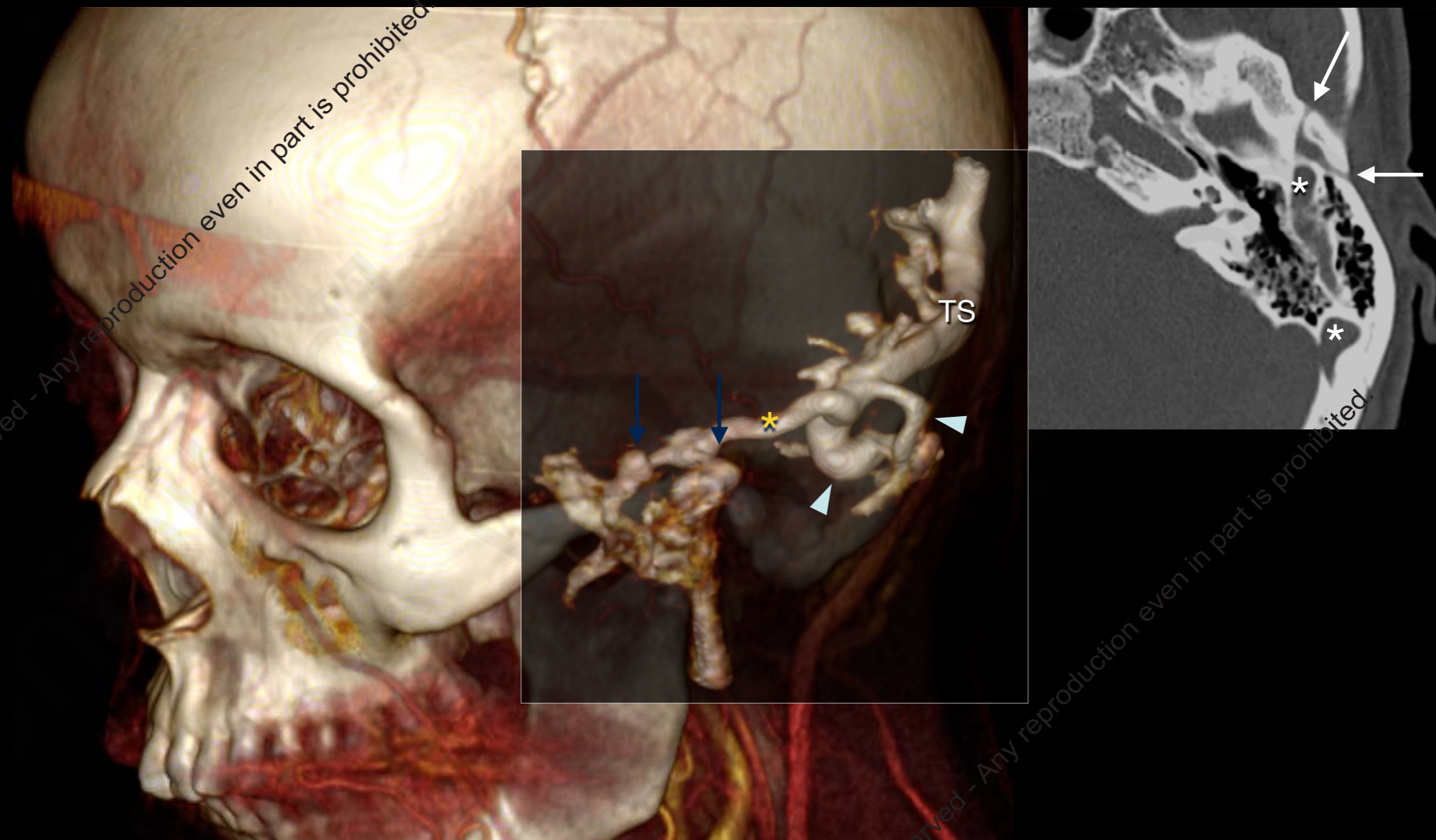
the petrosquamosal sinus (PSS)



the petrosquamosal sinus (PSS)

- transient embryological channel connecting the transverse sinus (TS) to the external jugular vein (EJV)
 - may persist in the adult as a small remnant of little functional importance or as the main / only outflow pathway of the TS
- TS / SS junction → the petrosquamosal fissure as an osseous groove or osseous canal (canal of Vergi)
- connects with the emissary vein of the foramen ovale (EVFO) through the floor of the middle cranial fossa
 - connects with the deep/superficial temporal veins through a canal in the temporal bone around the glenoid fossa (spurious jugular foramen or post-glenoid foramen)

the petrosquamosal sinus (PSS)

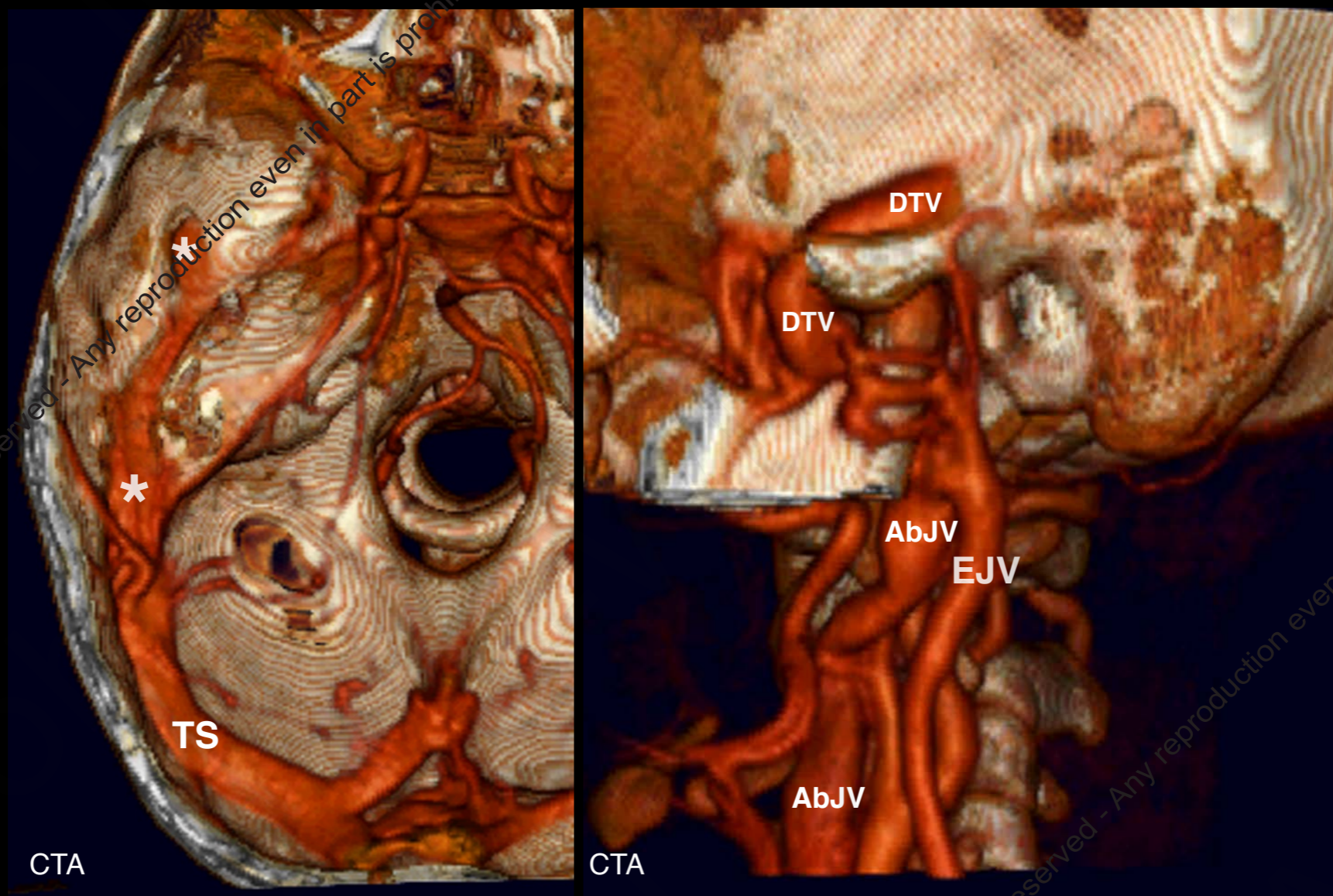


the petrosquamosal sinus (PSS)

- transient embryological channel connecting the transverse sinus (TS) to the external jugular vein (EJV)
- may persist in the adult as a small remnant of little functional importance or as the main /only outflow pathway of the TS

- TS / SS junction → the petrosquamosal fissure as an osseous groove or osseous canal (canal of Vergi)
 - connects with the emissary vein of the foramen oval (EVFO) through the floor of the middle cranial fossa
 - connects with the deep/superficial temporal veins through a canal in the temporal bone around the glenoid fossa (temporal or post-glenoid foramen)

the petrosquamosal sinus (PSS)



the petrosquamosal sinus (PSS)

- transient embryological channel connecting the transverse sinus (TS) to the external jugular vein (EJV)
- may persist in the adult as a small remnant of little functional importance or as the main /only outflow pathway of the TS

- TS / SS junction → the petrosquamosal fissure as an osseous groove or osseous canal (canal of Vergi)
 - connects with the emissary vein of the foramen oval (EVFO) through the floor of the middle cranial fossa
 - connects with the deep/superficial temporal veins through a canal in the temporal bone around the glenoid fossa (temporal or post-glenoid foramen)

the petrosquamosal sinus (PSS)



the petrosquamosal sinus (PSS)

- transient embryological channel connecting the transverse sinus (TS) to the external jugular vein (EJV)
- may persist in the adult as a small remnant of little functional importance or as the main /only outflow pathway of the TS

- TS / SS junction → the petrosquamosal fissure as an osseous groove or osseous canal (canal of Vergi)
 - connects with the emissary vein of the foramen oval (EVFO) through the floor of the middle cranial fossa
 - connects with the deep/superficial temporal veins through a canal in the temporal bone around the glenoid fossa (temporal or post-glenoid foramen)

conclusion

- rich and variable venous anatomy, dural and diploic veins constant
- the sphenoparietal sinus of Breschet **is not** the termination of the SMCV and really represents an osteo-dural venous channel of the lesser sphenoid wing
- the termination of the SMCV in the MCF is subject to anatomical variation in the adult depending on the fate of the primitive tentorial sinus of Padget
 1. CS
 2. LCS
 3. PCS
- apart from diploic and meningeal veins, veins in the floor of the ACF are rarely encountered → emissary veins of the foramen caecum or of the cribriform plate
- rare persistent venous channels such as the PSS
- clinical implications