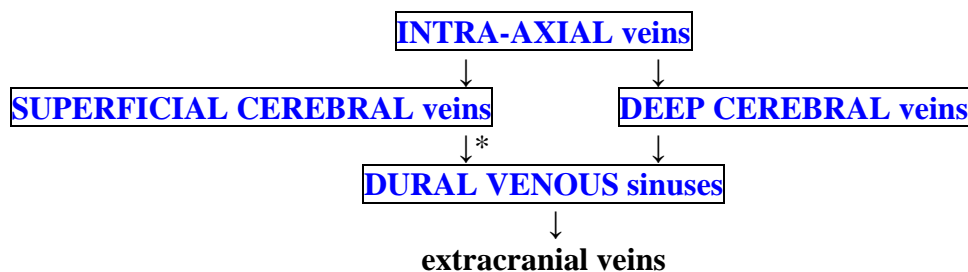


Blood Supply of BRAIN (veins)

Last updated: October 6, 2023

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Superior Sagittal Sinus (SSS, Sinus sagittalis superior)	6
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Venous sinus confluence (s. confluens sinuum, torcular Herophili).....	11
Sinus occipitalis.....	11
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*via *bridging veins* (cross subdural space – source of subdural hematomas)

Brain veins and sinuses are unlike those of the body:

- do not parallel arteries or mirror arterial territories.
- systemic veins have numerous collateral pathways; few collaterals exist inside skull.

- cerebral veins have no muscular layers or valves – can dilate and *reverse blood flow direction* if sinus into which they drain is occluded.
- superficial veins mostly can be surgically sacrificed; but not deep isolated veins → venous infarction!

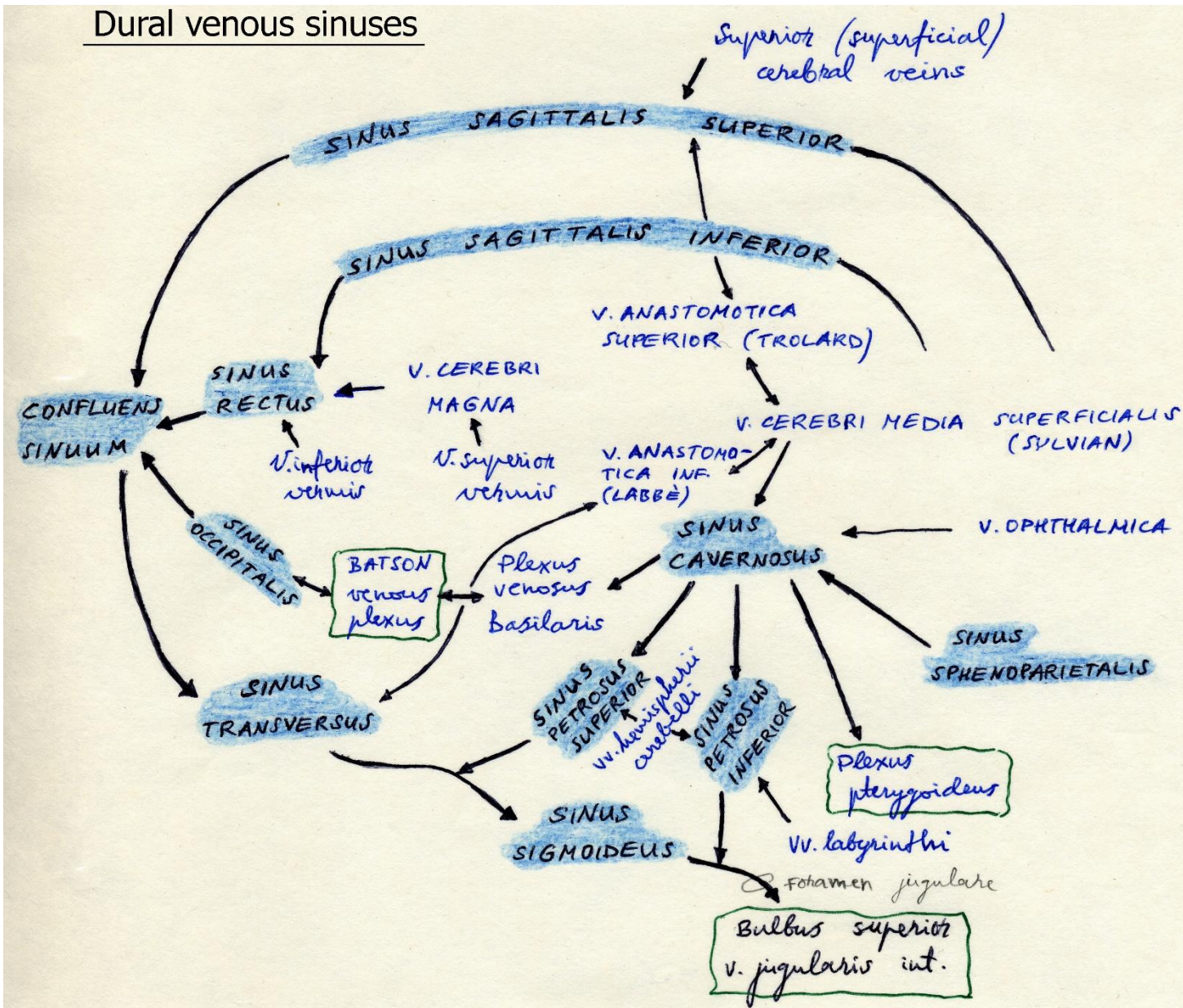
DURAL VENOUS SINUSES

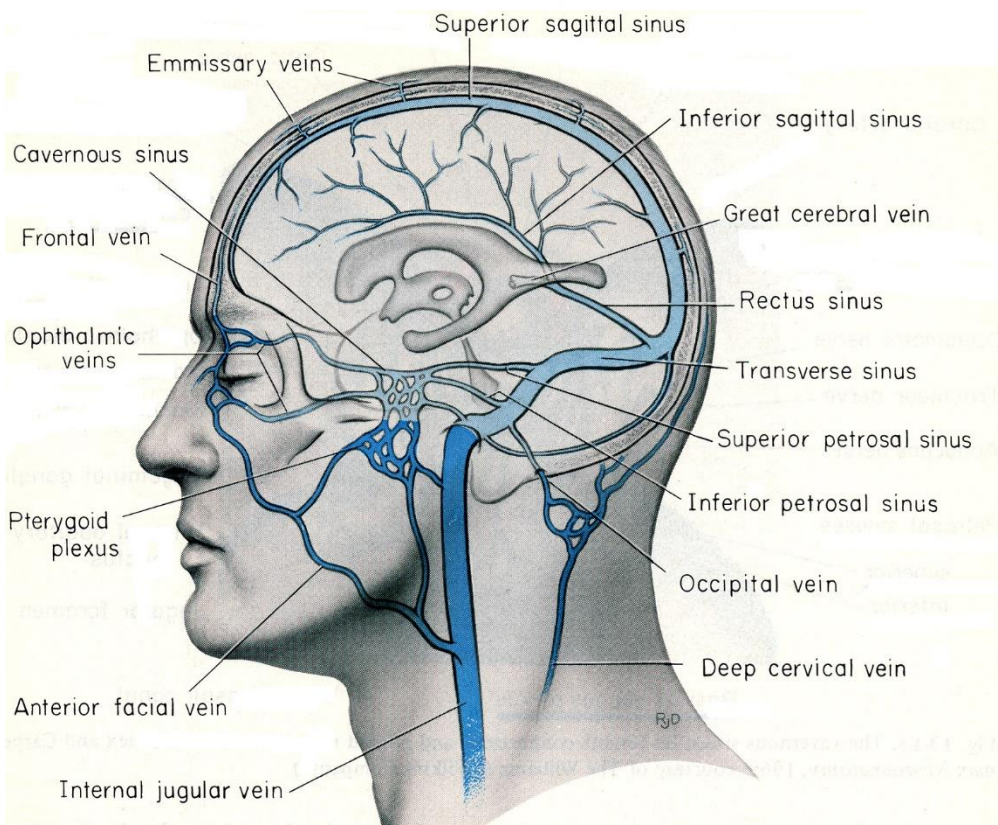
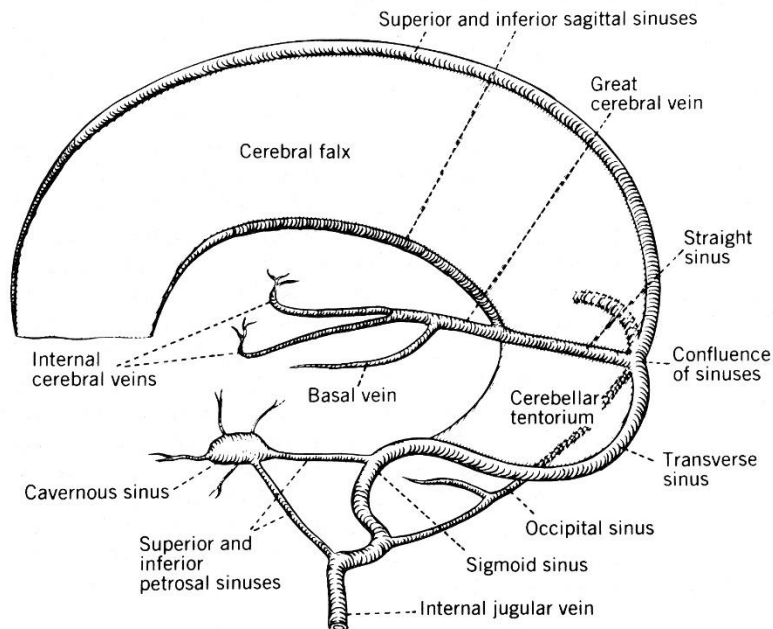
- endothelium-lined venous channels tarp dura mater periostinio ir meninginio lapelių.

N.B. any part of dura can be a sinus! (asymmetry, variations are common, dural venous channels can be found anywhere >>)

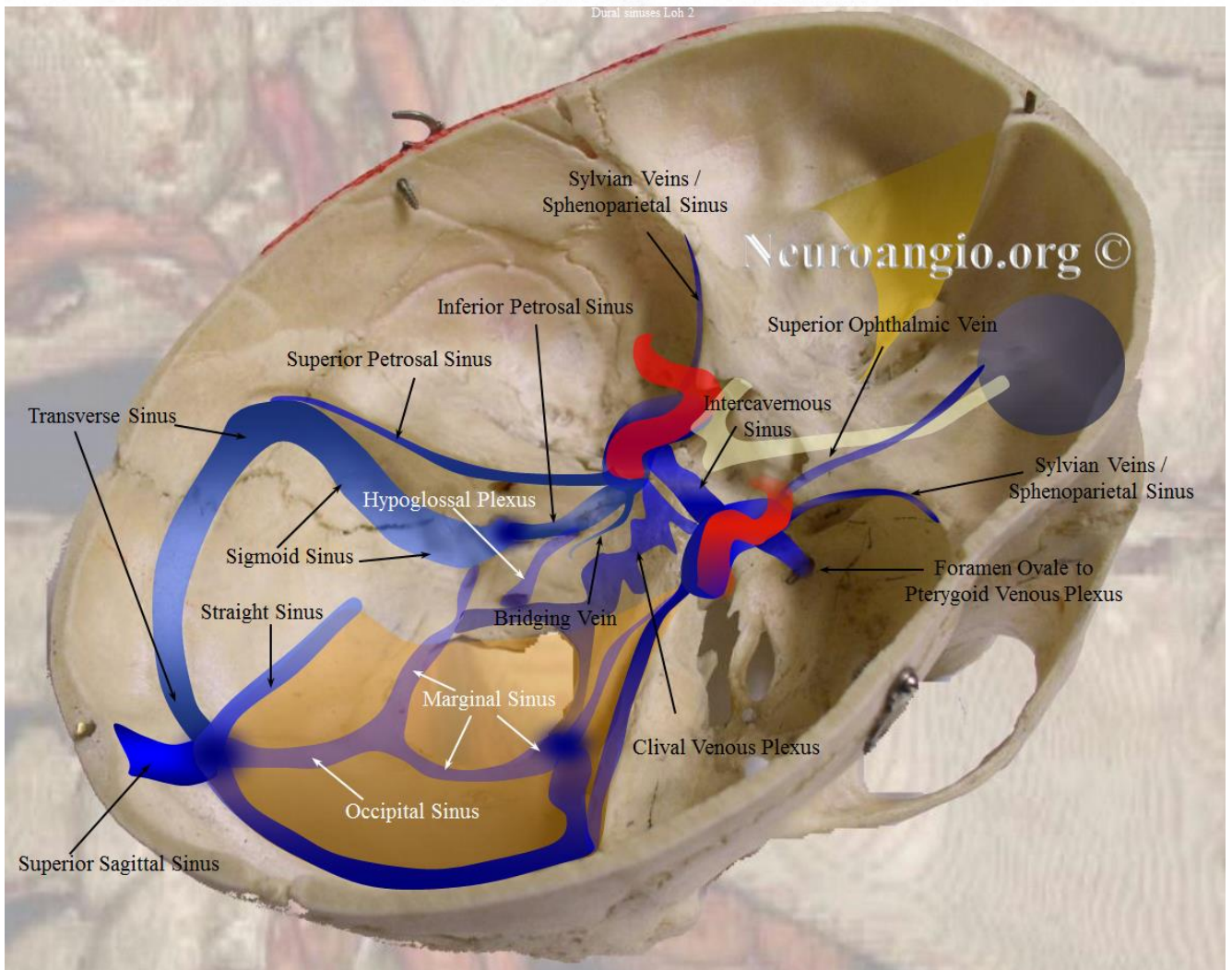
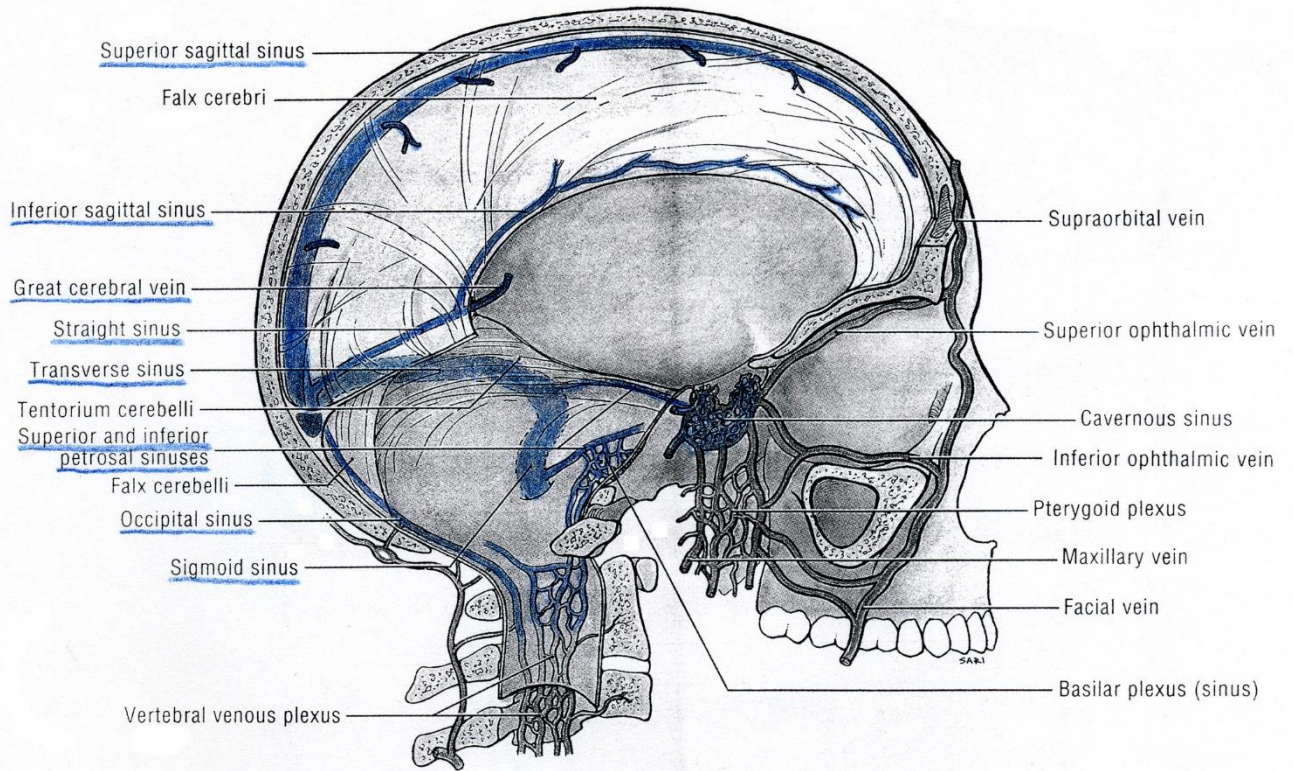
- no valves (flow may be bidirectional)
- nekolasuoja (trikampis skerspjūvis).

Dural venous sinuses

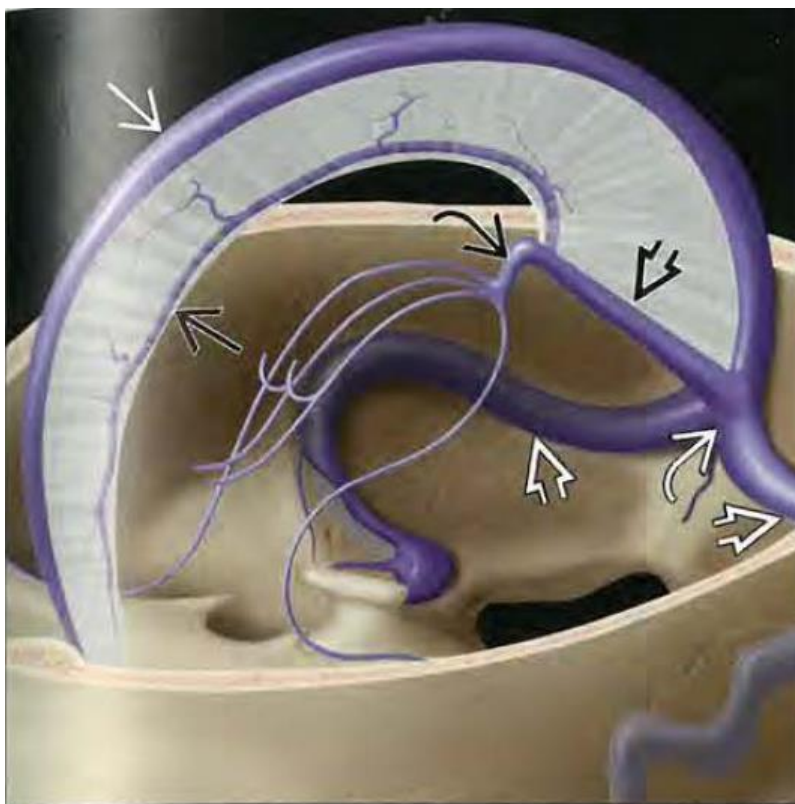
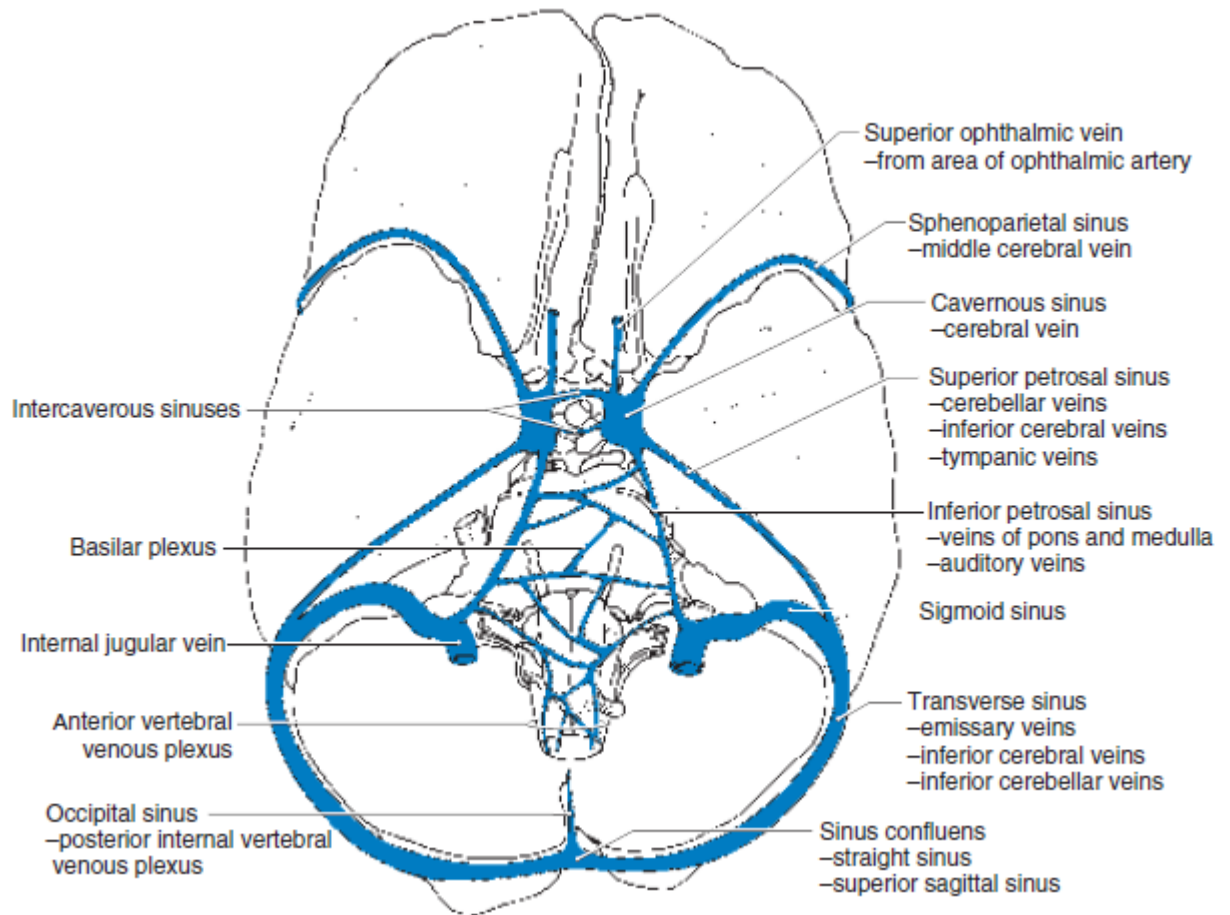










Intracranial venous sinuses and veins are *light blue* while extracranial veins are *dark blue*.

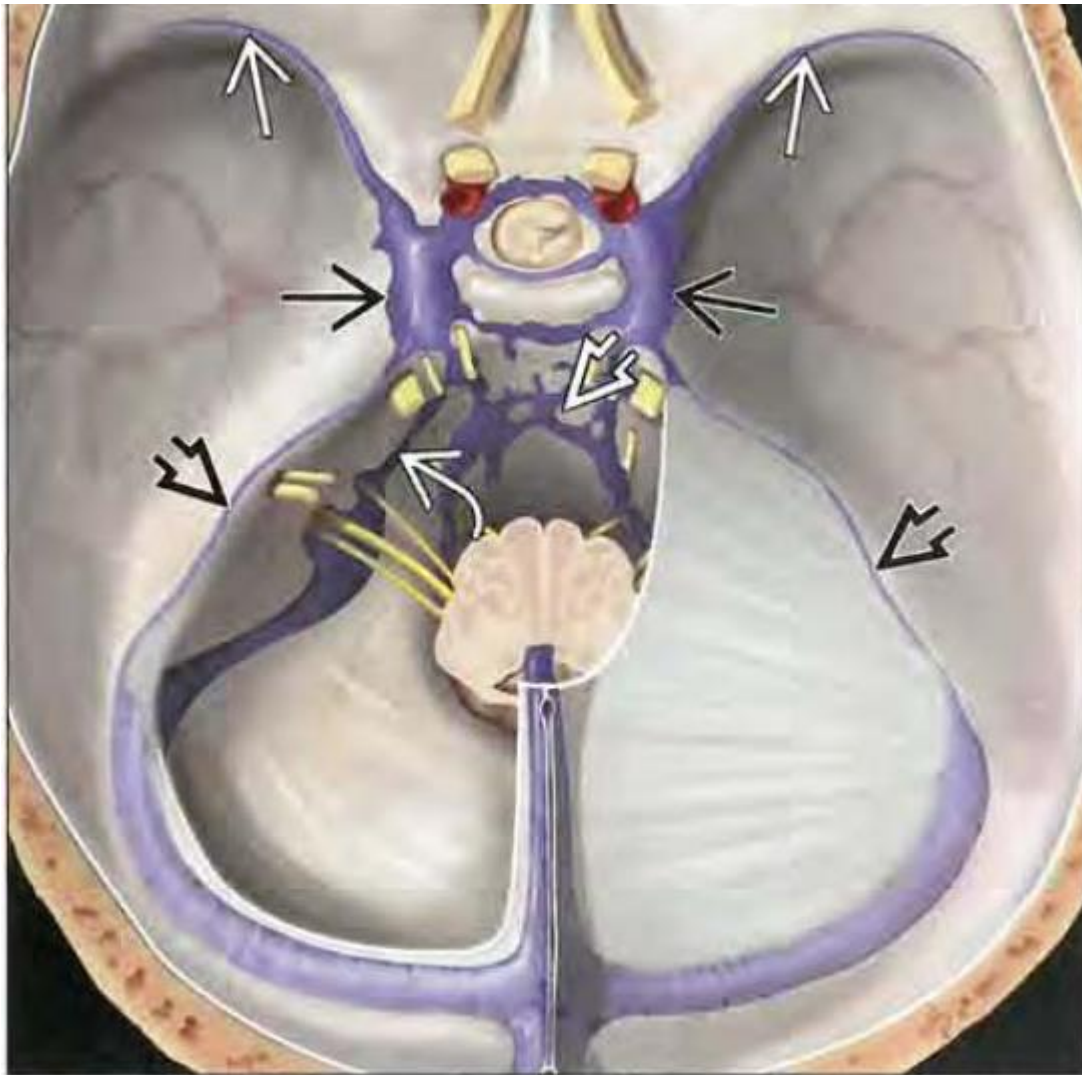


Source of picture: Neuroangio.org >>



9-3. The falx cerebri extends posteriorly from the crista galli to the falcotentorial junction and contains the SSS  and the ISS . The vein of Galen , straight sinus , sinus confluence , and TSs  are also illustrated.

Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>

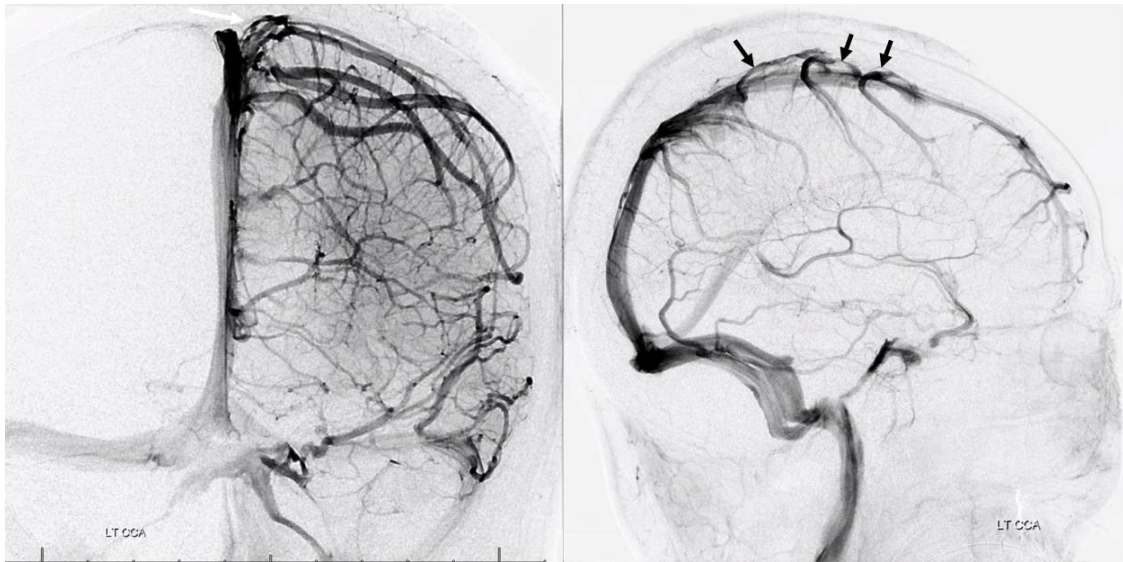


9-4. Graphic shows the numerous interconnections among the cavernous sinuses \Rightarrow , clival venous plexus \Rightarrow , sphenoparietal sinuses \Rightarrow , and the superior \Rightarrow and inferior \Rightarrow petrosal sinuses.

Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>

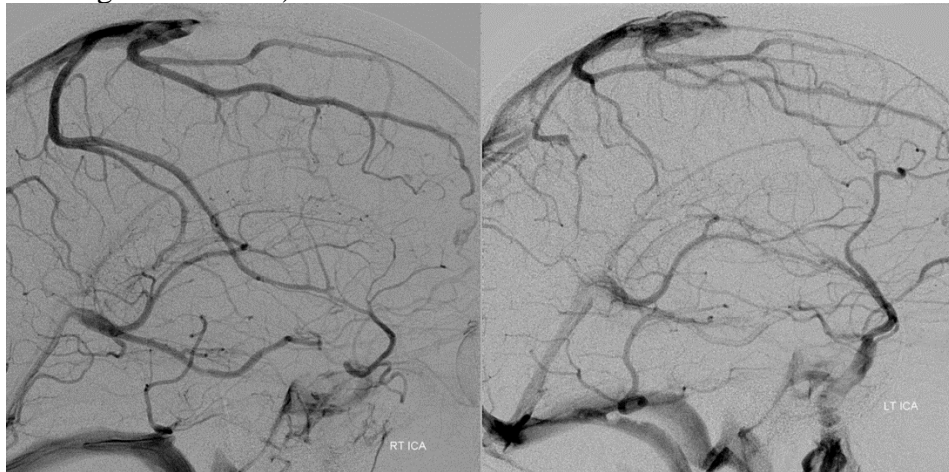
SUPERIOR SAGITTAL SINUS (SSS, SINUS SAGITTALIS SUPERIOR)

- ina *falx cerebri* viršutiniu kraštu in *sulcus sagittalis* - along the nasion–inion midsagittal line.
- starts at **foramen caecum** and ends at CONFLUENS SINUUM (or SINUS TRANSVERSUS DEX.); SSS often divides before reaching torcular, anatomical variant of no clinical significance.
- collects *superior (superficial) cerebral veins* (major - anastomotic vein of Trolard, vein of Rolando); those veins, very often, first drain into a dural "*venous lakes*" just lateral and superior to the sinus (sinus is usually slightly below the upper edge of dura):



Source of picture: Neuroangio.org >>

- turi išsiplėtimus į šonus – **LATERAL VENOUS LACUNAE**:
 - endothelium-lined lumens (usually reduced to sponge-like labyrinth by numerous dural trabeculae and arachnoid granulations).
 - **CSF resorption**.
 - width increases with age (in very old, they may extend 2 cm lateral to midline).
- filling defects – *arachnoid (pacchionian) granulations* and *fibrous septa* within SSS are common findings on imaging.
- on coronal imaging appears as triangular.
- normal SSS variants:
 - 1) **hypoplastic or absent** anterior segment (associated with dominance of cavernous sinus draining frontal lobes)



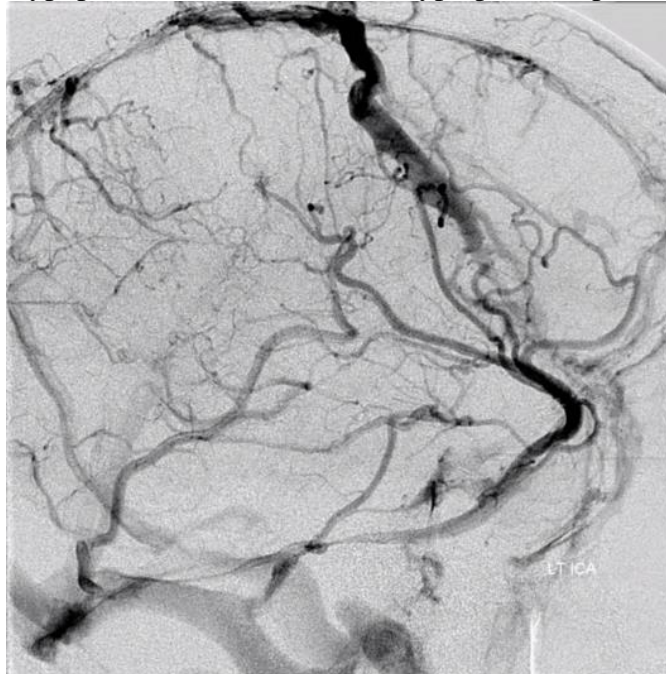
Source of picture: Neuroangio.org >>

Hypoplastic anterior SSS with hyperplastic inferior SS:



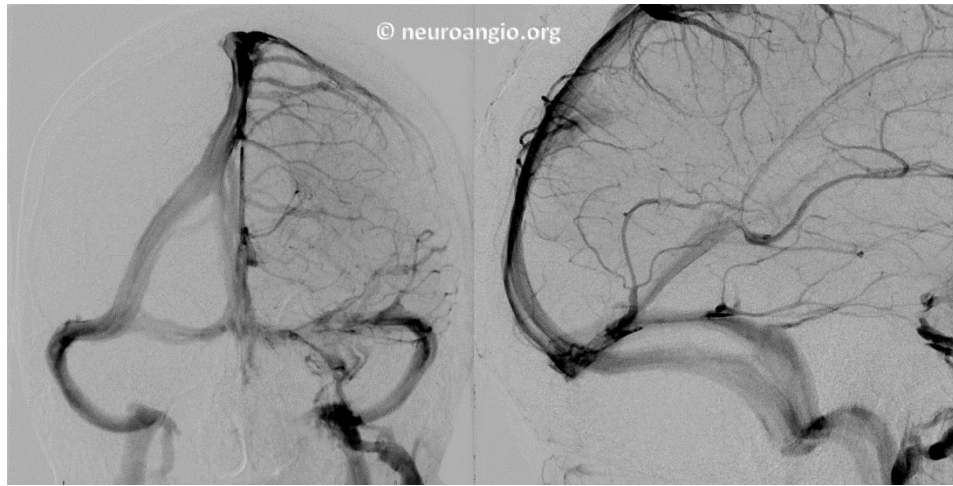
Source of picture: Neuroangio.org >>

Hypoplastic anterior SSS with hyperplastic diploic vein:



Source of picture: Neuroangio.org >>

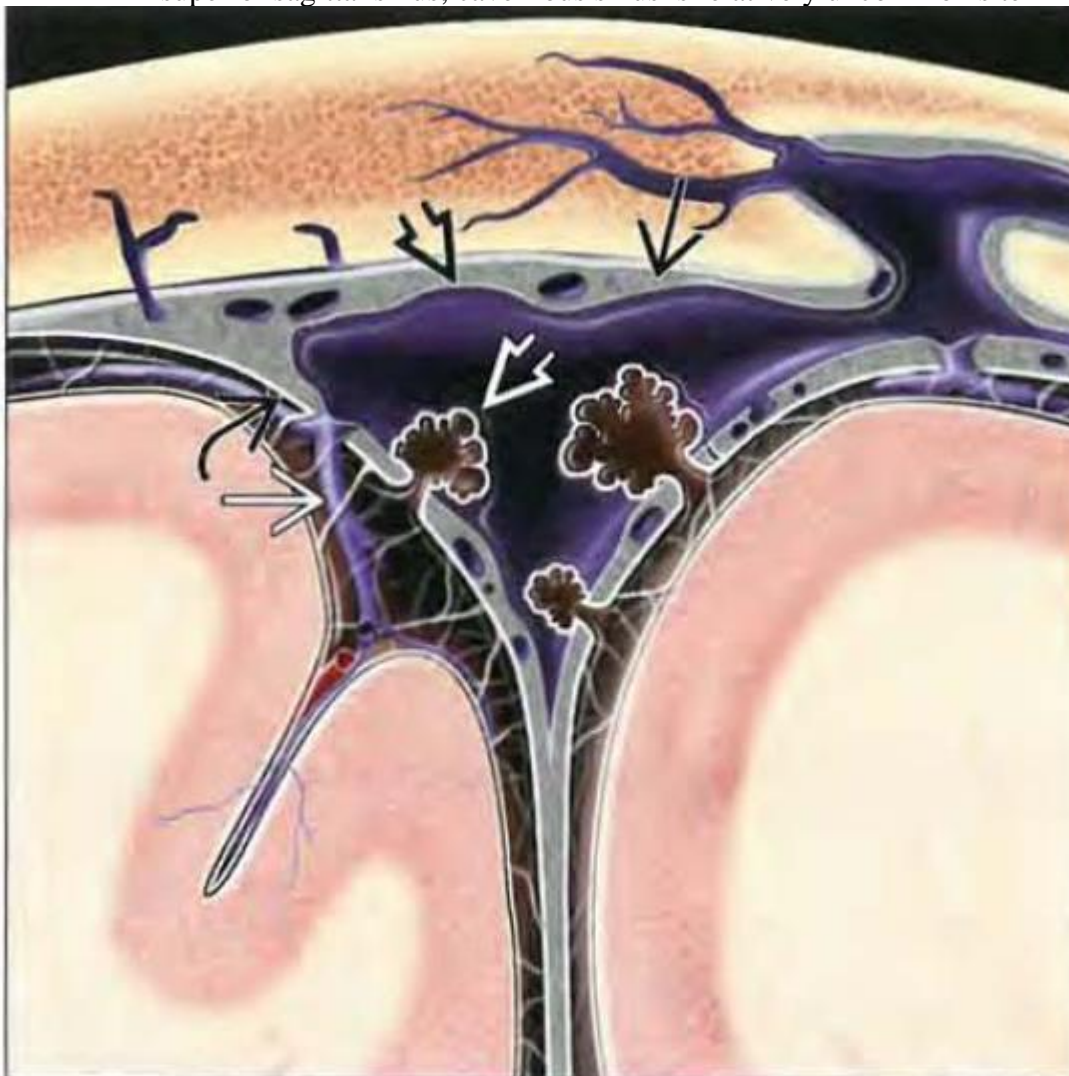
- 2) **off midline position:** in majority of subjects SSS *deviates to the right* of sagittal plane/superior sagittal suture by up to 11 mm (Tubbs et al 2001, Samadian et al 2011); in other cases remains in midline but toward its termination in the venous sinus confluence may gradually course off midline:



Source of picture: Neuroangio.org >>

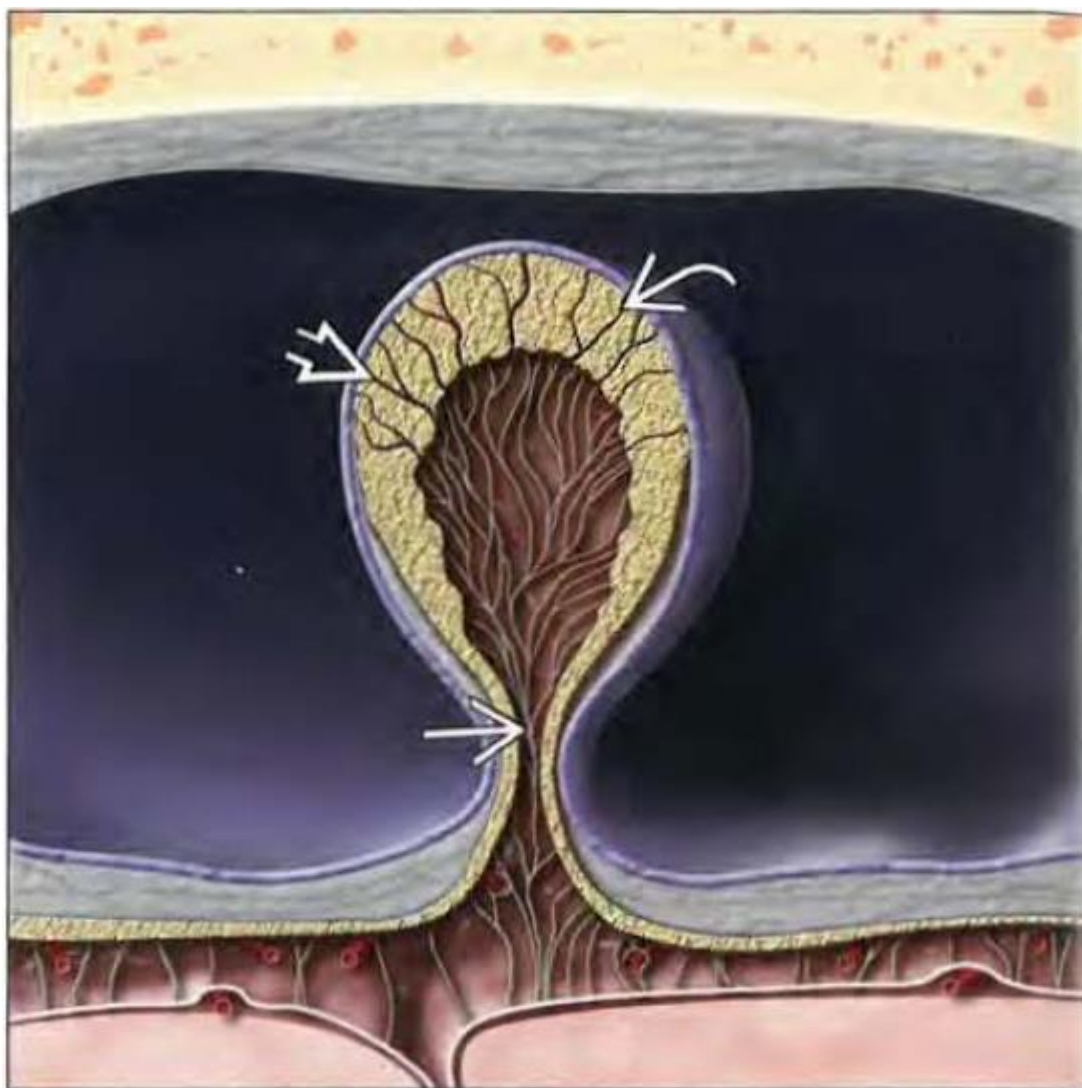
Arachnoid (pacchionian) granulations:

- can occur in all dural venous sinuses, the most common locations - transverse and superior sagittal sinus; cavernous sinus is relatively uncommon site



9-1. Coronal graphic shows the SSS between the outer and inner dural layers. CSF-containing projections (arachnoid granulations) extend from the subarachnoid space into the SSS. Cortical veins also enter the SSS.

Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>



9-2. Graphic depicts an arachnoid granulation (AG) projecting into a venous sinus. CSF ➡ extends from the SAS into the AG and is covered by a cap of arachnoid cells ➡. Channels in the cap ➡ drain CSF into the sinus.

Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>

SINUS SAGITTALIS INFERIOR

- eina apatiniu (laisvuoju) *falx cerebri* kraštu, lygiagrečiai SINUS SAGITTALIS SUP.
- susilieja (at falcotentorial junction) su *great cerebral vein* ir sudaro SINUS RECTUS.
- often small and inconsistently visualized on imaging.
- įteka *paviršinės venos*, drenuojančios facies medialis apatinę dalį (cingulate gyrus) and corpus callosum.

SINUS RECTUS (STRAIGHT SINUS)

- eina kur *falx cerebri* tvirtinasi prie *TENTORIUM CEREBELLI*.
- susidaro susijungus *great cerebral vein* su SINUS SAGITTALIS INF.
- įteka *v. inferior vermis cerebelli*.

- baigiasi įtekėjimu į CONFLUENS SINUUM (arba į SINUS TRANSVERSUS SIN.).

VENOUS SINUS CONFLUENCE (S. CONFLUENS SINUUM, TORCULAR HEROPHILI)

- often asymmetric - sits mainly to the upper right side of the inion.
- septations and intersinus channels!
- esti ties *INTERNAL OCCIPITAL PROTUBERANCE*.
- sutėka trys sinusai - SINUS SAGITTALIS SUP., SINUS RECTUS, SINUS OCCIPITALIS.
- įstėka SINUS TRANSVERSI DEX. et SIN.
- variant - **persistent falcine sinus** (2%) - midline venous structure that connects ISS or vein of Galen directly with SSS (2/3 have absent/rudimentary straight sinus).

SINUS OCCIPITALIS

- inconstant in the adult and more likely present than absent in the child.
- prasideda nuo CONFLUENS SINUUM.
- eina *falx cerebelli* pagrindu, per *INTERNAL OCCIPITAL CREST*.
- ties **foramen magnum** pereina į marginal sinus (which loosely surrounds foramen magnum), nugaros smegenų *Batson's venous plexus*.

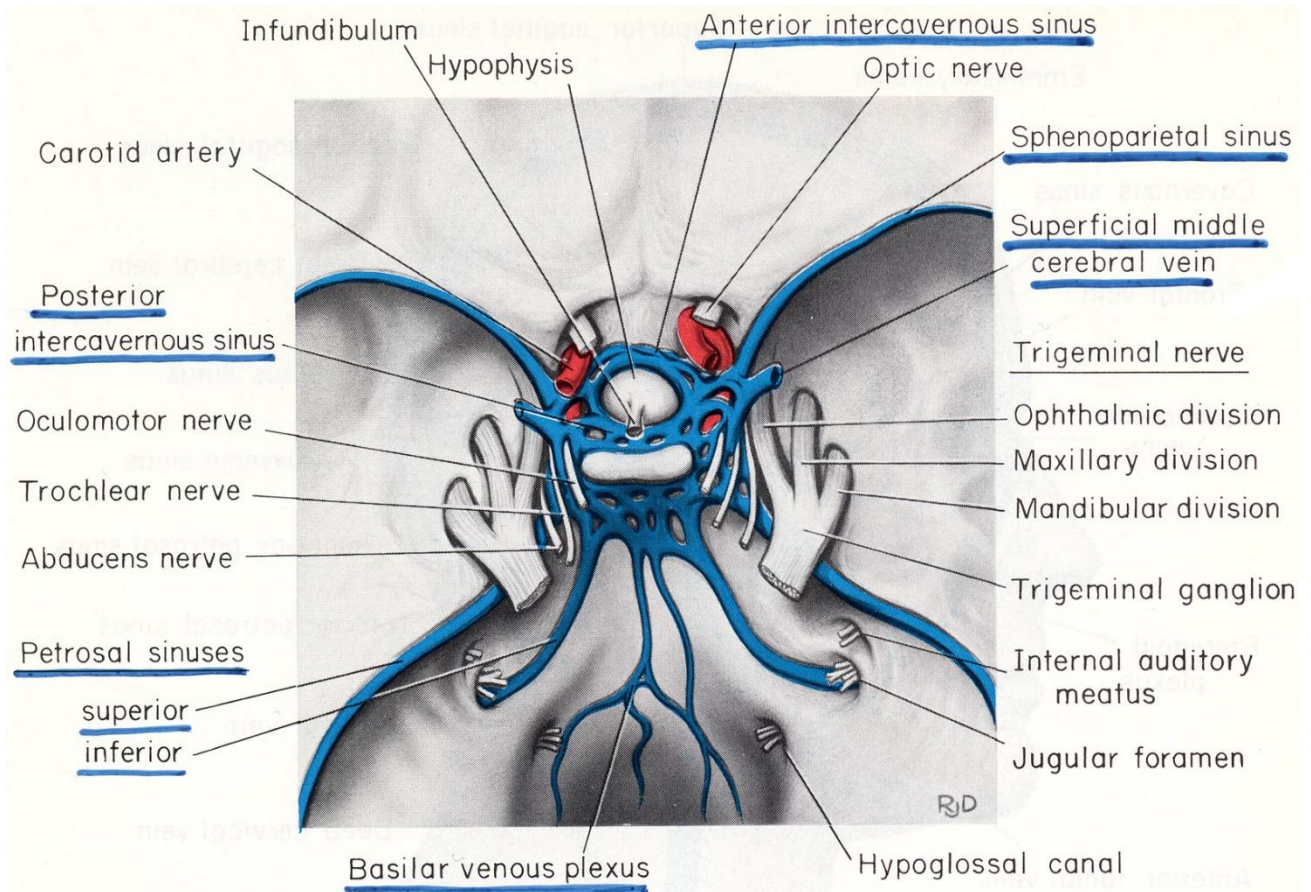
SINUS TRANSVERSUS (S. TRANSVERSE SINUS, LATERAL SINUS)

- prasideda nuo CONFLUENS SINUUM.
- eina along *occipital attachment of tentorium cerebelli*.
 - position of the lower border of the proximal transverse sinus is best approximated via the insertion of semispinalis capitis into the cranium.
 - course of the transverse sinus varies widely and no single plane or surface marking can be used to predict its route accurately!!!
- frequently asymmetrical in size (*right is usually dominant one*); atretic segments are common – correlate with size of jugular foramen (helps to distinguish from acquired thrombosis);
- pereina į SINUS SIGMOIDEUS (at occipito-petrosal bone junction).
- įteka *inferior cerebral veins*.
- frequent filling defects - arachnoid granulations and fibrous septa.

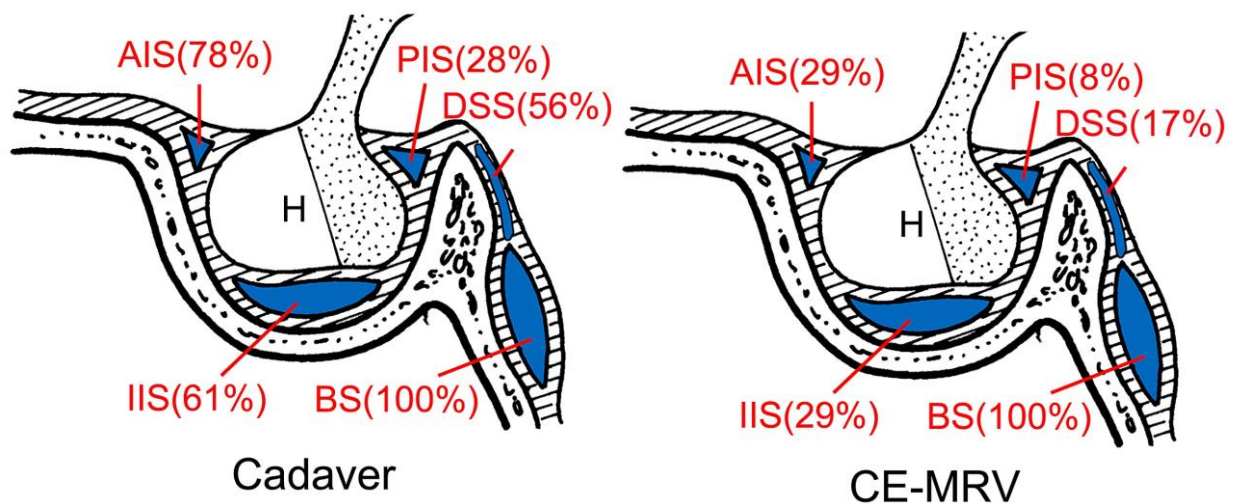
SINUS SIGMOIDEUS

- S-shaped, lying deep to *processus mastoideus*, immediately posterior to *PARS PETROSA OSSIS TEMPORALIS*.
- tai SINUS TRANSVERSUS tęsinys (ties jų jungtimi įteka SINUS PETROSUS SUP.).
- ties **foramen jugulare** pereina į jugular bulb* (įteka SINUS PETROSUS INF.) → *v. jugularis interna* **pseudolesions with flow asymmetry* are common - should not be mistaken for "real" masses (e.g. schwannoma or paraganglioma) – CT shows that jugular spine and cortex around jugular foramen are intact, not eroded or remodeled
- frequently asymmetrical
- may be (significantly) larger than TRANSVERSE SINUS if receives large *vein of Labbé*.
- sometimes, extensive emissary veins (mastoid, occipital, condylar) drain transverse-sigmoid sinus complex → hypoplastic jugulars.

SINUS CAVERNOSUS



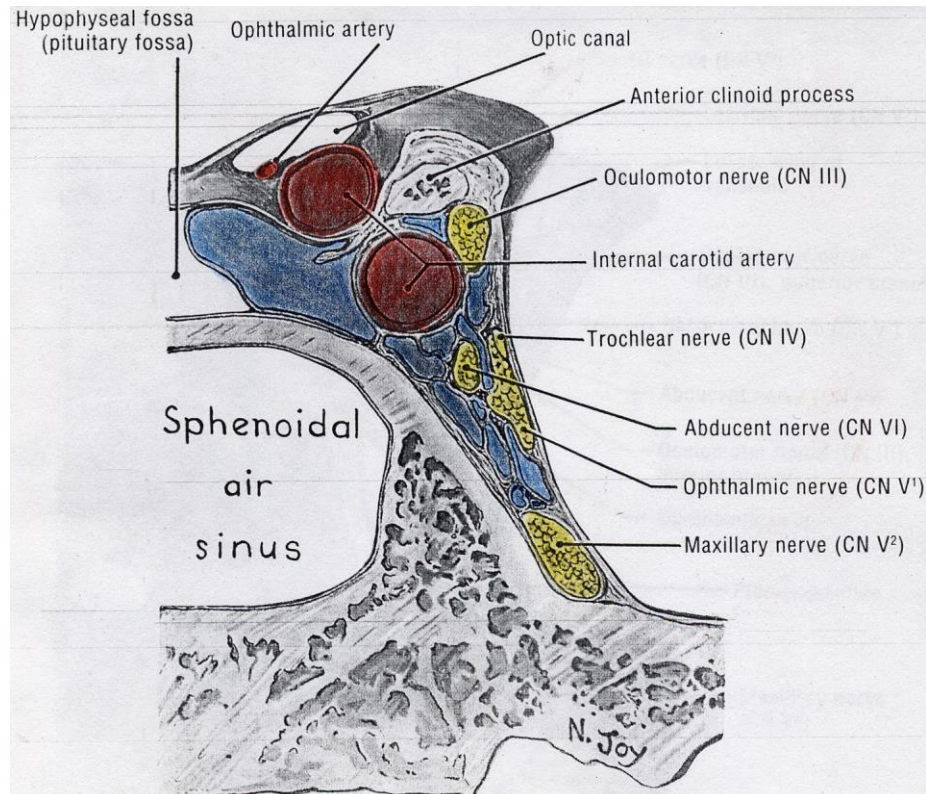
- irregularly shaped, variable in size, heavily trabeculated (multiple compartments – Latin “cavernous” = “full of small spaces”)!
 - paired sinus on either side of *SELLA TURCICA*, extending from superior orbital fissures anteriorly to clivus & petrous apex posteriorly.
 - located between *SELLA TURCICA* and *MECKEL'S CAVE*.
 - prominent lateral and much thinner-often almost inapparent-medial dural wall.
 - bilateral sinuses are interconnected SINUS INTERCAVERNOSUS ANT. et POST. (ventral and dorsal to hypophysis) → **CIRCULUS VENOSUS** (s. **CIRCULAR SINUS OF RIDLEY**):

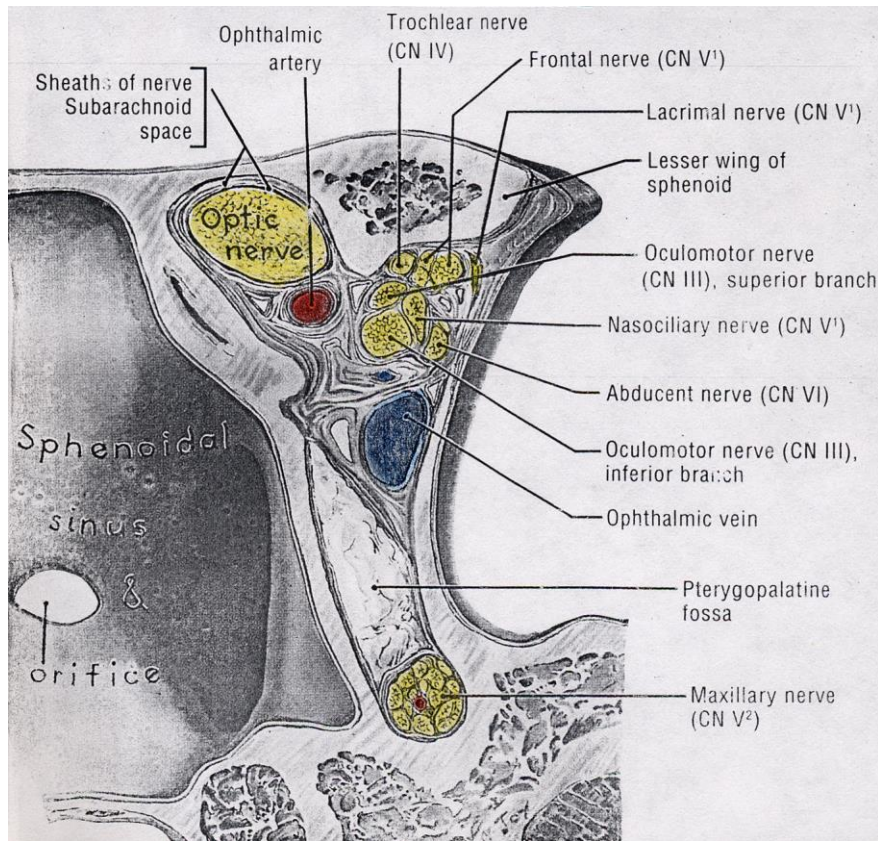


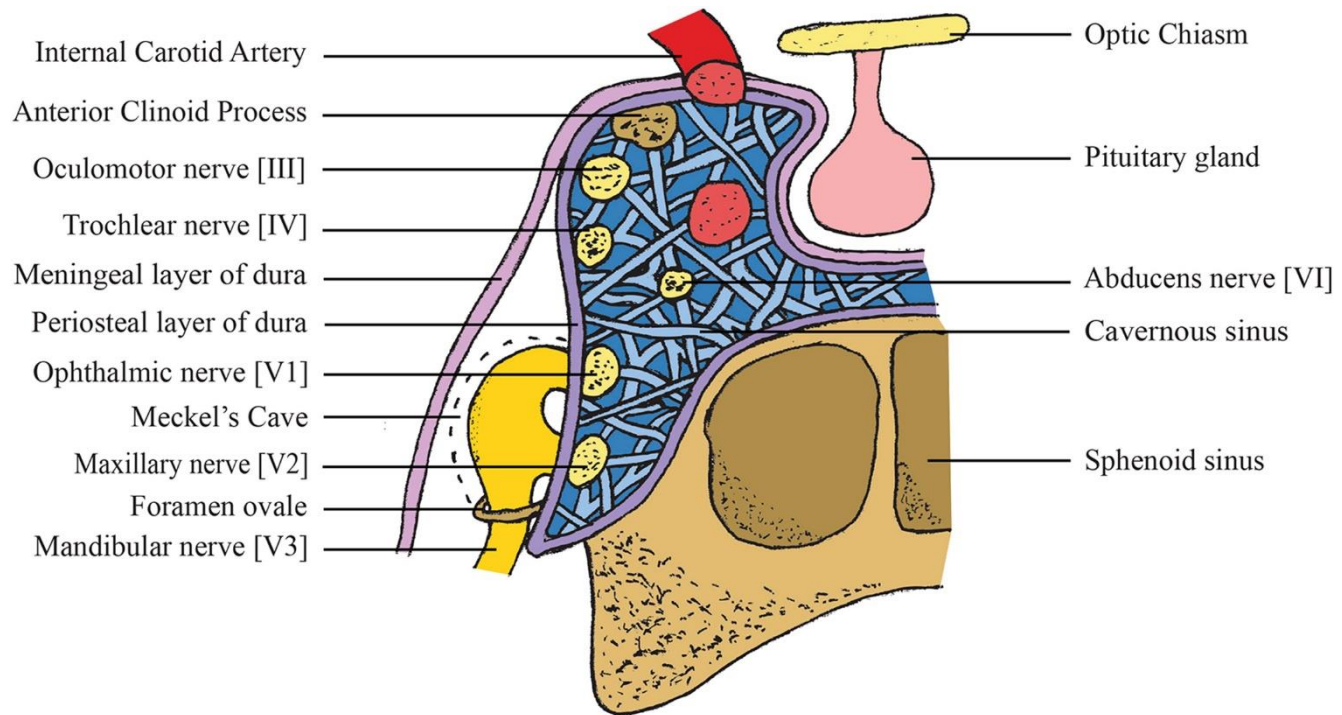
AIS: anterior intercavernous sinus; BS: basilar sinus; DSS: dorsum sellae sinus; H: hypophysis; IIS: inferior intercavernous sinus

- receive:

- 1) *vv. ophthalmicae* (mainly *superior ophthalmic vein*) - most constant tributary to cavernous sinus! It is from **ECA territory** (ICA may add if ophthalmic artery extensively supplies nasal tissues)
 - 2) *v. cerebri media superficialis* (*s. superficial Sylvian veins*) via SINUS SPHENOPARIETALIS
 - 3) variant – may receive *basal vein of Rosenthal*
- drain to:
 - 1) SINUS PETROSUS SUP. et INF.
 - 2) *pterygopalatine / pterygoid venous plexuses* (through foramen ovale and emissary veins)
 - 3) *clival (dorsum sellae sinus, basilar sinus) venous plexus* → jugular veins or marginal sinus, **Batson's venous plexus**
 - structures inside: **intracavernous ICA, CN6.**
 - along lateral wall: CN3, CN4, CN5₁ (inferiorly - CN5₂):







SINUS PETROSUS SUPERIOR

- eina in groove along *CREST OF PETROUS TEMPORAL BONE* (kur tvirtinasi *TENTORIUM CEREBELLI*).
- jungia SINUS CAVERNOSUS su SINUS TRANSVERSUS-SINUS SIGMOIDEUM jungtimi.
- įteka *vv. hemispherii cerebelli sup.*, kartais *v. cerebri media superficialis*.

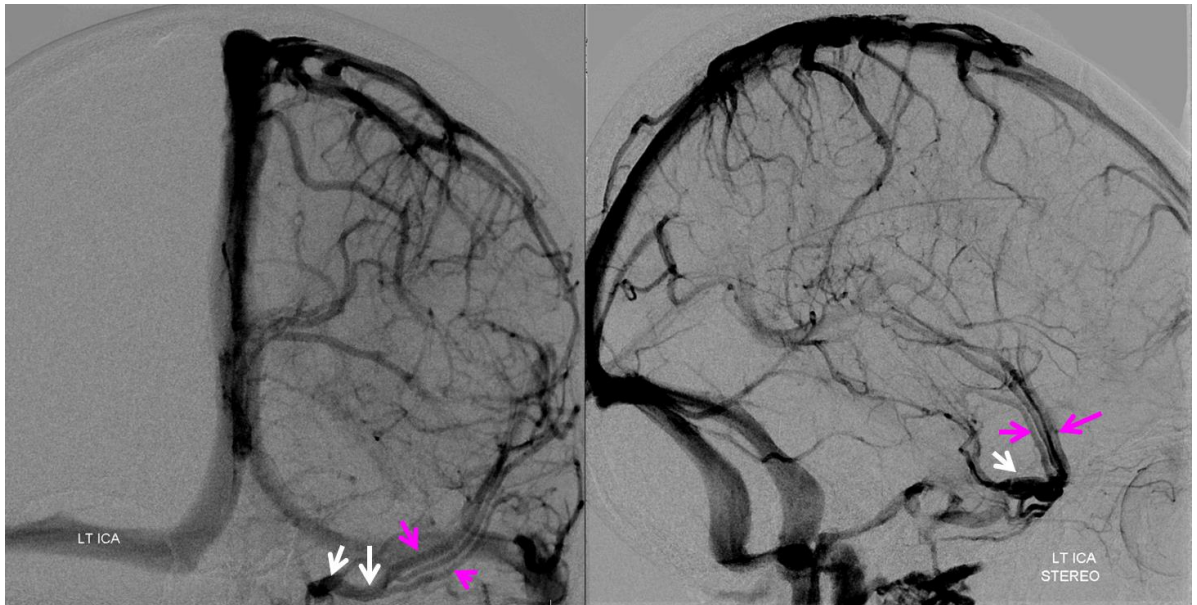
SINUS PETROSUS INFERIOR

- courses in groove on *PETROOCCIPITAL FISSURE* (or just above it)
- jungia SINUS CAVERNOSUS & *clival (basilar) venous plexus* → *superior bulb of internal jugular vein*-SINUS SIGMOIDEUM jungtimi.
- įteka *vv. labyrinthi, vv. hemispherii cerebelli inf., smegenų kamieno venos*.

SINUS SPHENOPARIETALIS

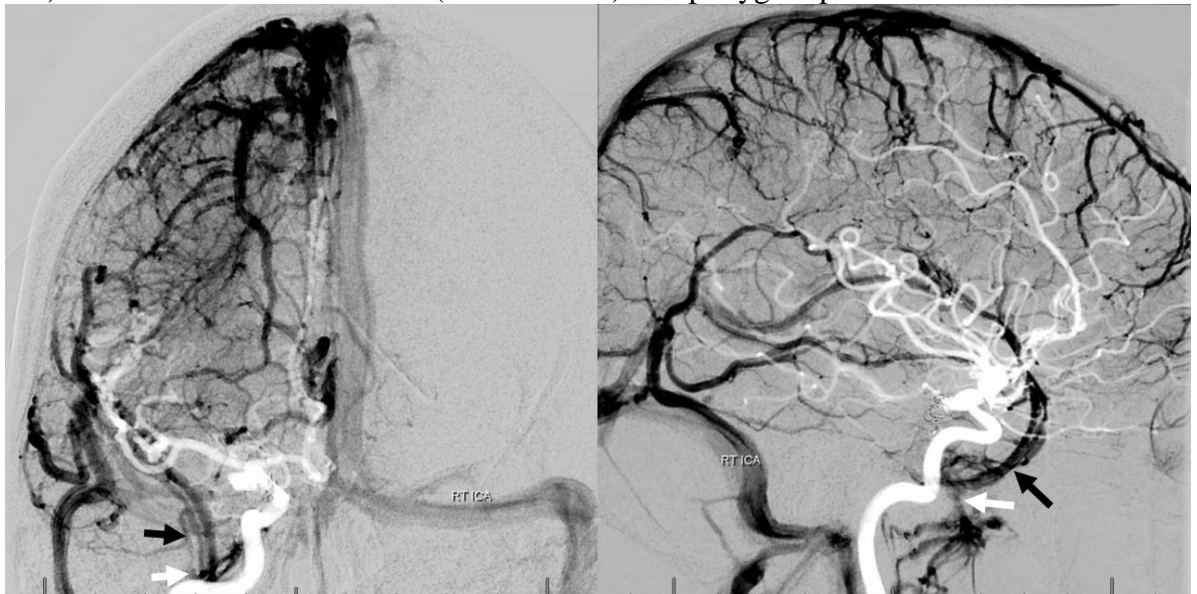
- prasidea ties *OS PARIETALE*.
- eina *ALA MINOR OSSIS SPHENOIDALIS* pakraščiu (sphenoid ridge).
- flows into SINUS CAVERNOSUS.
- receives *superficial Sylvian veins*
- some believe that superficial sylvian veins drain into cavernous or superior petrosal sinus directly, and a true sphenoparietal sinus is an independent entity:

Three separate superficial Sylvian veins (*purple*) run adjacent to sphenoid ridge to join a common channel (*white*) which may be a common vein or perhaps a short sphenoparietal sinus



Source of picture: Neuroangio.org >>

- sometimes superficial sylvian veins may bypass cavernous sinus by taking lateral course (*black arrows*) and drain via foramen ovale (*white arrows*) into pterygoid plexus:



Source of picture: Neuroangio.org >>

MENINGEAL VEINS

- epidural veins that drain dural structures (falx cerebri, tentorium, cranial dura mater).

EMISSARY VEINS

– jungia veninius sinusus su diploe ir skalpo venomis: Radiology >>

- 1) **condylar emissary vein** – per *condylar canal* sujungia SINUS SIGMOIDEUS su *external vertebral venous plexus*.
- 2) **mastoid emissary vein** – per *foramen mastoideum* sujungia SINUS SIGMOIDEUS su *v. occipitalis*.
- 3) **occipital emissary vein** – praduria *squama occipitalis* ir sujungia CONFLUENS SINUUM su *v. occipitalis*.

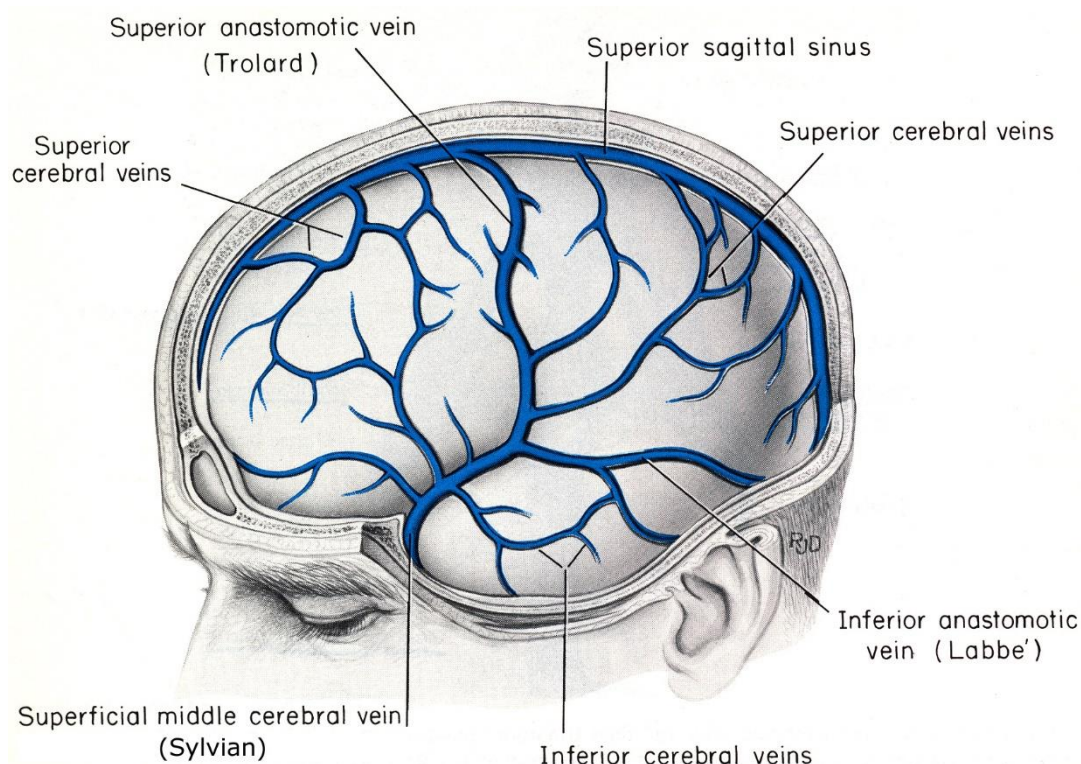
- 4) **parietal emissary vein (Santorini)** – sujungia SINUS SAGITTALIS SUP. su *v. temporalis superficialis*.
- usually no clinic significance; but sometimes surgeons encounter *profound* bleeding from the bone when they “turn a flap”, followed by *unexplained (venous) brain infarct* - likely due to encounter of particularly large and functionally important emissary vein.

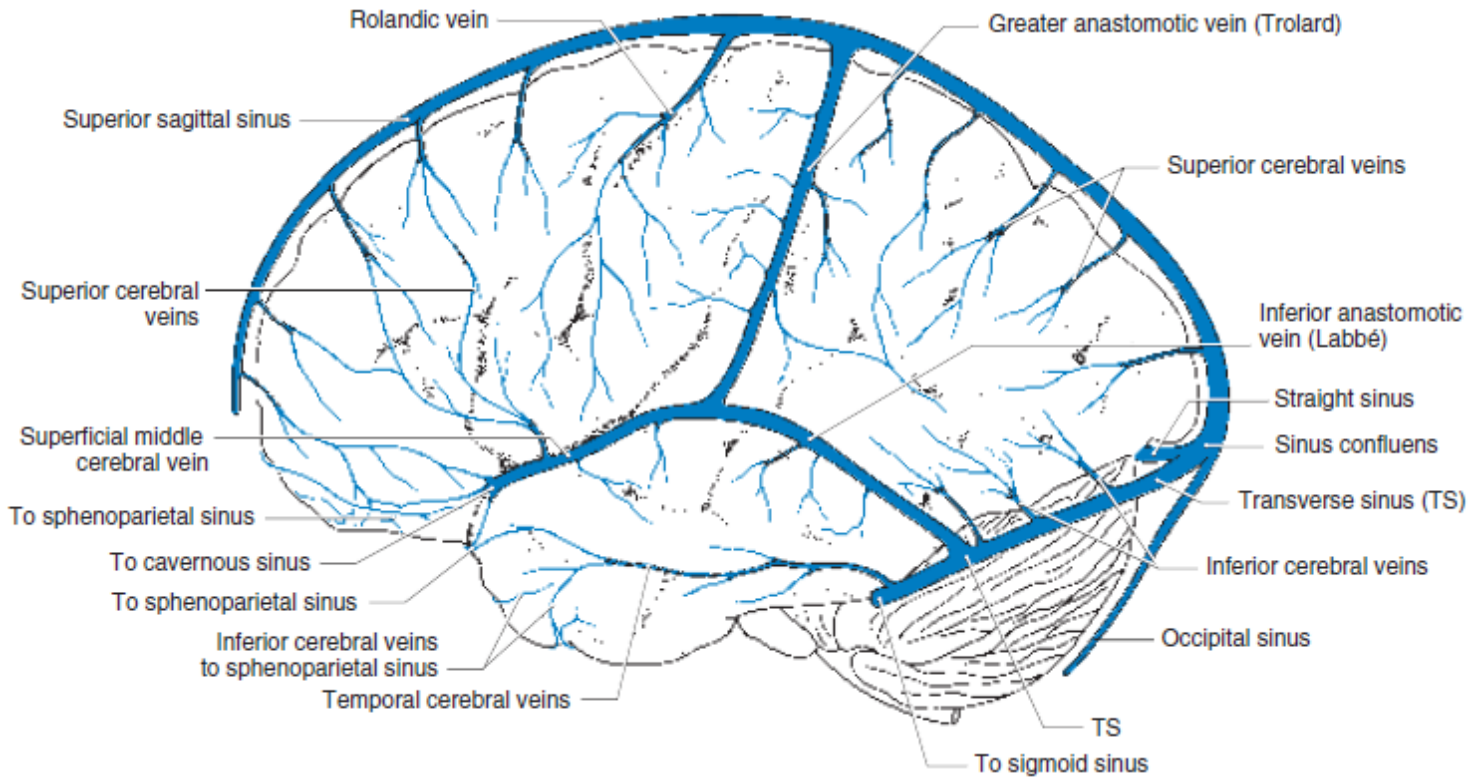
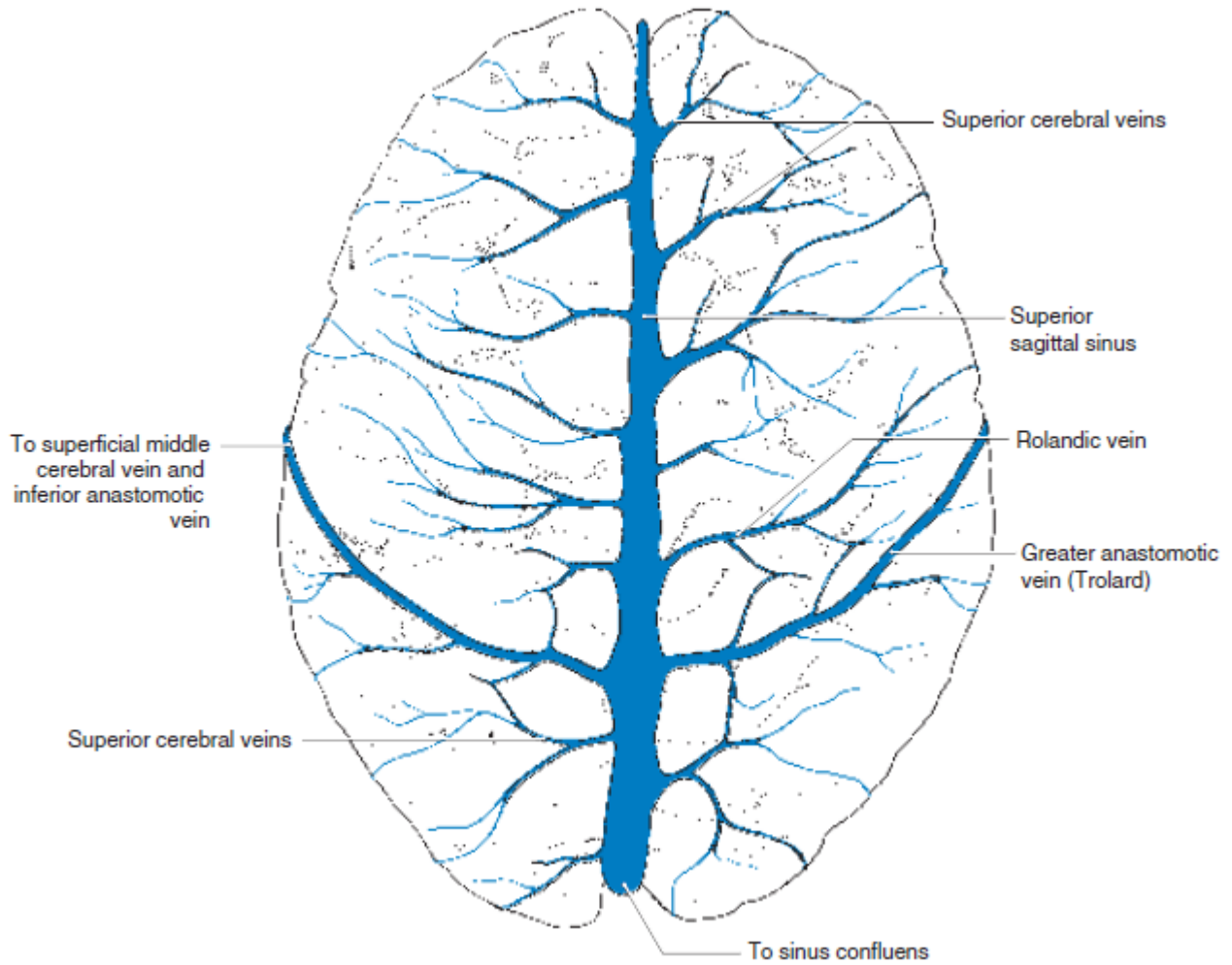
DIPLOIC VEINS

- run between tables of skull bone - drain diploe. Radiology >>
- communicate extensively with extracranial venous system, meningeal veins, and dural sinuses (i.e. can receive emissary veins).
- main diploic veins:
 - 1) frontal
 - 2) anterior temporal
 - 3) posterior temporal
 - 4) occipital

SUPERFICIAL CEREBRAL VEINS

- drain **CORTEX** and **SUBCORTICAL WHITE MATTER**.
- lie along cortical sulci.
- highly variable (vs. deep cerebral veins).
- anastomose freely in pia → form larger veins → empty into DURAL SINUSES.







9-6. Lateral graphic depicts the superficial cortical veins. The 3 named anastomotic veins—Trolard ↗, Labbé ↘, and the superficial middle cerebral vein →

If one or two are dominant, third anastomotic vein is usually hypoplastic or absent!

Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>

1. SUPERIOR CEREBRAL veins

- tai 8-15 venų drenuojančių **convex (lateral) & medial surfaces** į SINUS SAGITTALIS SUP.*
(veins enter sinus by coursing in subdural space obliquely forward – blood flow in these veins, as they enter sinus, is opposite to that in sinus!)
*dalis medialinio paviršiaus venų įteka į SINUS SAGITTALIS INF.
- pagal drenuojamas žievės sritis skirstomos: *prefrontal veins*, *frontal veins*, *parietal veins*, *temporal veins*, *occipital veins*.

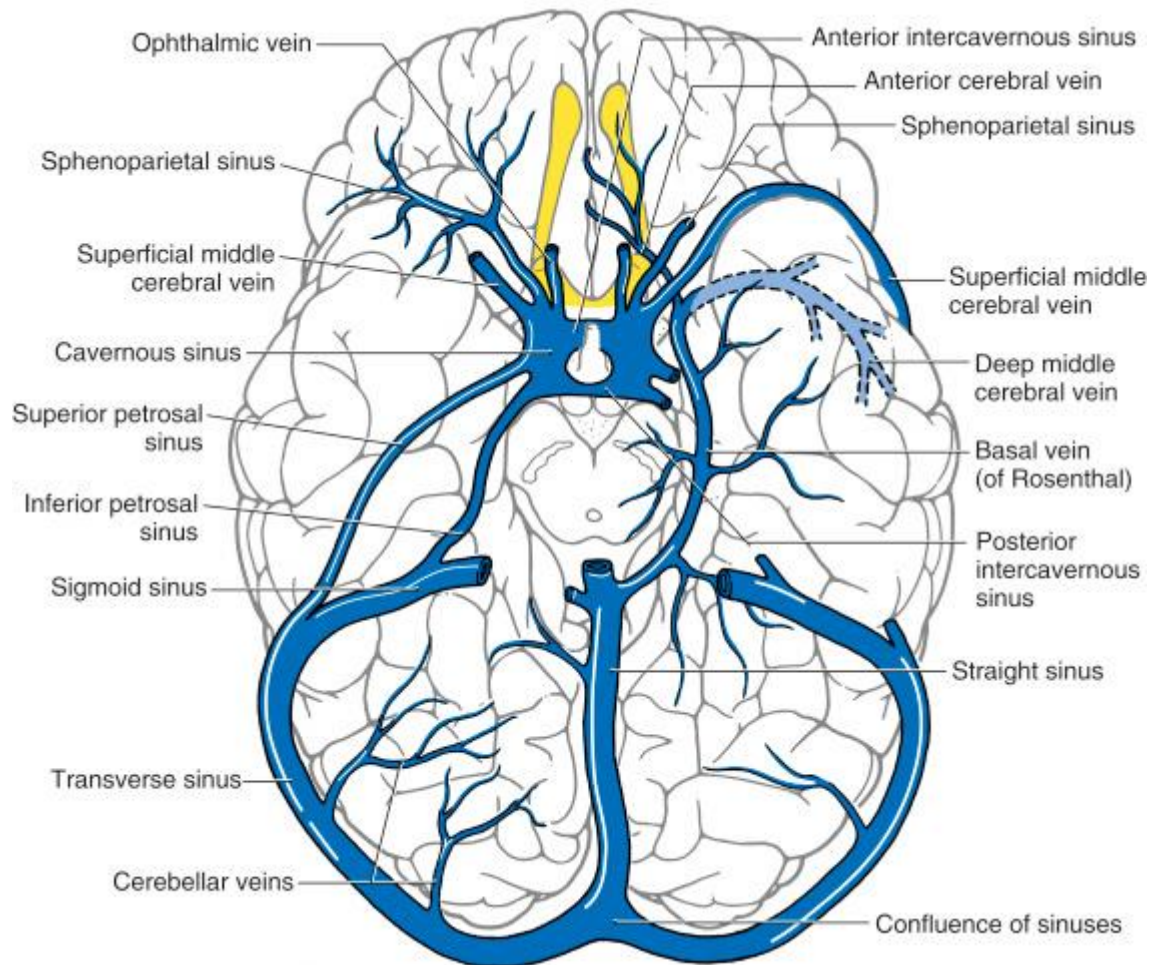
2. INFERIOR CEREBRAL veins

- drenuoja **inferior surface & ventral parts of convex surface** į BASAL SINUSES (cavernous, sphenoparietal, transverse, superior petrosal).
- example – *basal vein of Rosenthal* (it is erroneous to call it deep vein).

3. SUPERFICIAL SYLVIAN / MIDDLE CEREBRAL vein

- eina along *LATERAL FISSURE*.
- drenuoja **convex surface** į SINUS CAVERNOSUS.

- **deep Sylvian / middle cerebral vein** probably belongs here too



Anastomotic veins – jungia *superficial middle cerebral vein* su DURAL SINUS:

4. SUPERIOR ANASTOMOTIC vein (TROLARD) (in *POSTCENTRAL SULCUS**) – jungia superficial middle cerebral vein su SINUS SAGITTALIS SUP.; major drainage from motor and sensory cortex; **ROLANDO vein** runs in central sulcus.

*N.B. **sensorimotor cortex venous drainage is posteriorly** – fMRI regions are shifted posteriorly from true anatomic regions along venous drainage!

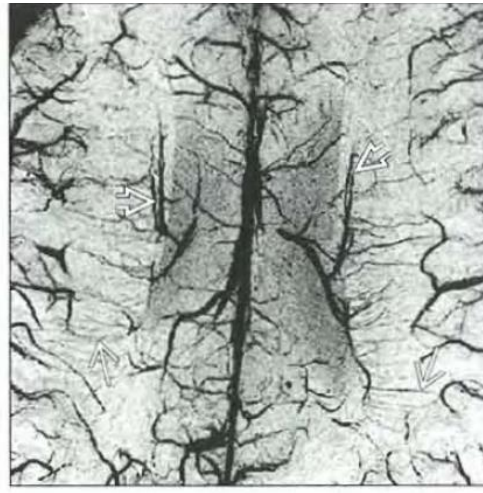
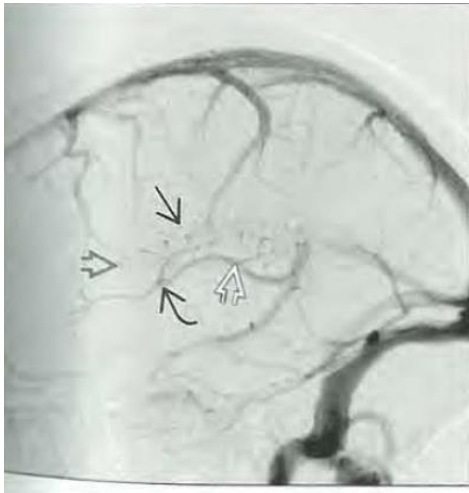
5. INFERIOR ANASTOMOTIC vein (LABBÉ, BROWNING) – jungia superficial middle cerebral vein su SINUS TRANSVERSUS. about surgical aspects - see Onc62 p.

N.B. **inferomedial surface** is drained into **DEEP CEREBRAL VEINS!**

DEEP (INTERNAL) CEREBRAL VEINS

- drain **DEEP STRUCTURES** (deep white matter, basal nuclei, diencephalon, choroid plexuses).

- constant structures (vs. superficial cerebral veins – highly variable).
- phylogenetically older than superficial system
- drains subependymal structures.
- empty into **great cerebral vein**.
- deep and superficial veins are in fact joined by fine **MEDULLARY VEINS** (unnamed, originate between one and two centimeters below cortex, run straight course, perpendicular to brain surface, towards ventricles where they join **SUBEPENDYMAL VEINS**); **venous angioma (DVA)** is abnormally dilated medullary vein.



9-9. Venous phase DSA shows tiny medullary veins draining into subependymal veins, seen here as "dots" on end. The septal and thalamostriate veins converge near the foramen of Monro to form the internal cerebral vein. 9-10. Close-up axial view of 3.0 T T2* SWI scan shows deoxyhemoglobin in innumerable small medullary veins that course through the white matter to converge at right angles with the ventricles and drain into the subependymal veins.

1. INTERNAL CEREBRAL VEINS

- paired, course posteriorly in cavum velum interpositum near midline (in tela choroidea ventriculi tertii).
- susijungę abiejų pusių venos (in rostral quadrigeminal cistern) sudaro *great cerebral vein of Galen*.
- susidaro iš trijų venų (ties **interventricular foramen**):
 - 1) **(anterior and posterior) veins of septum pellucidum**.
 - 2) **superior thalamostriate** (s. **terminal**) **vein** – eina kartu su *STRIA TERMINALIS*; įteka (*transverse*) *caudate veins*, *lateral vein of lateral ventricle* (deep parts of parietal and temporal lobes).
 - 1) and 2) are so called **SUBEPENDYMAL VEINS**; they meet (forming **venous angle**) at posterior lip of Monro foramen
 - 3) **superior choroidal vein** ← lateral ventricles rezginiai

2. BASAL VEIN (ROSENTHAL) – some experts say, it is superficial vein just runs on inferior surface!

Deep veins = Internal cerebral vein system

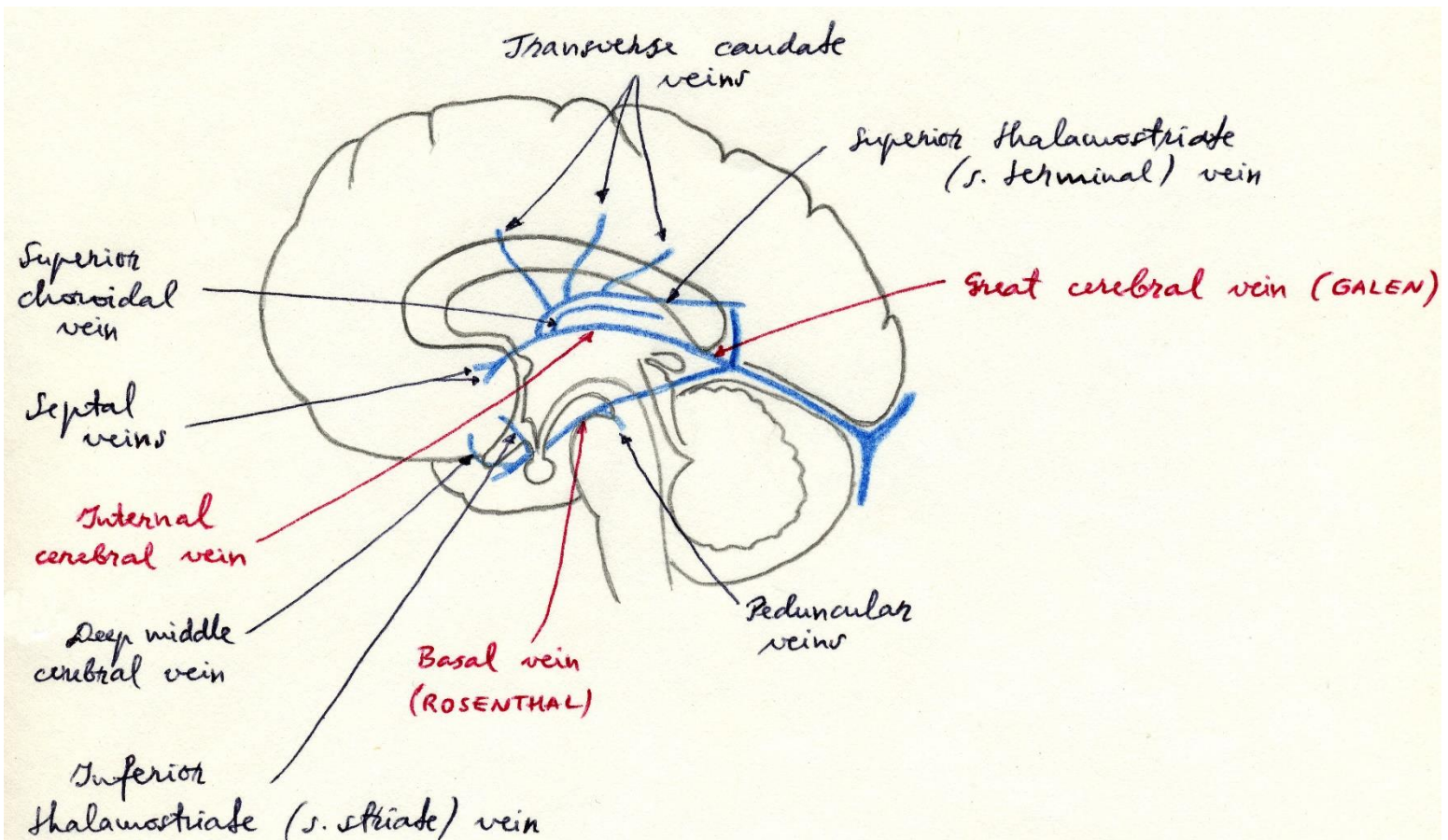
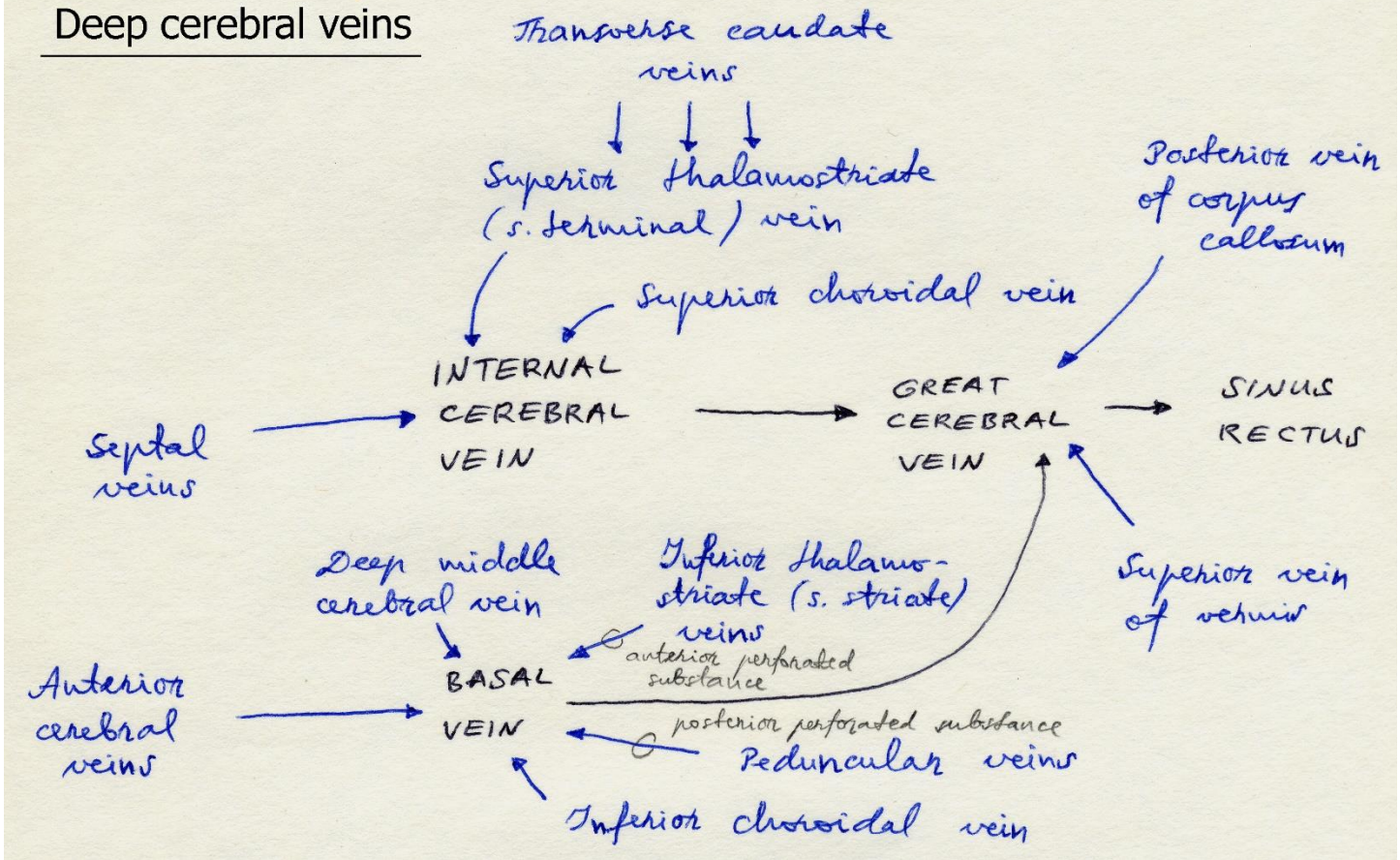
- prasideda ties *VALLECULA* susiliejus dviem venų sistemoms:
 - 1) **anterior cerebral veins** (lydi *ACA*) ← orbital cortex, rostral corpus callosum
 - 2) **deep middle cerebral vein** (lies in depth of lateral fissure) ← insular & opercular regions, basal ganglia
- basal veins pass dorsocaudally along medial surface of temporal lobe → circle midbrain (in ambient cistern) → empty into *great cerebral vein of Galen*.
- i basal vein įteka:
 - 1) **inferior thalamostriate** (s. **striate**) **veins** – išeina per *ANTERIOR PERFORATED SUBSTANCE*.
 - 2) **inferior choroidal vein** – drenuoja apatinę lateral ventricle rezginio dalį.
 - 3) smulkios venos: *peduncular veins* (išeina per *POSTERIOR PERFORATED SUBSTANCE*), *vein of olfactory gyrus*, *inferior ventricular vein*.

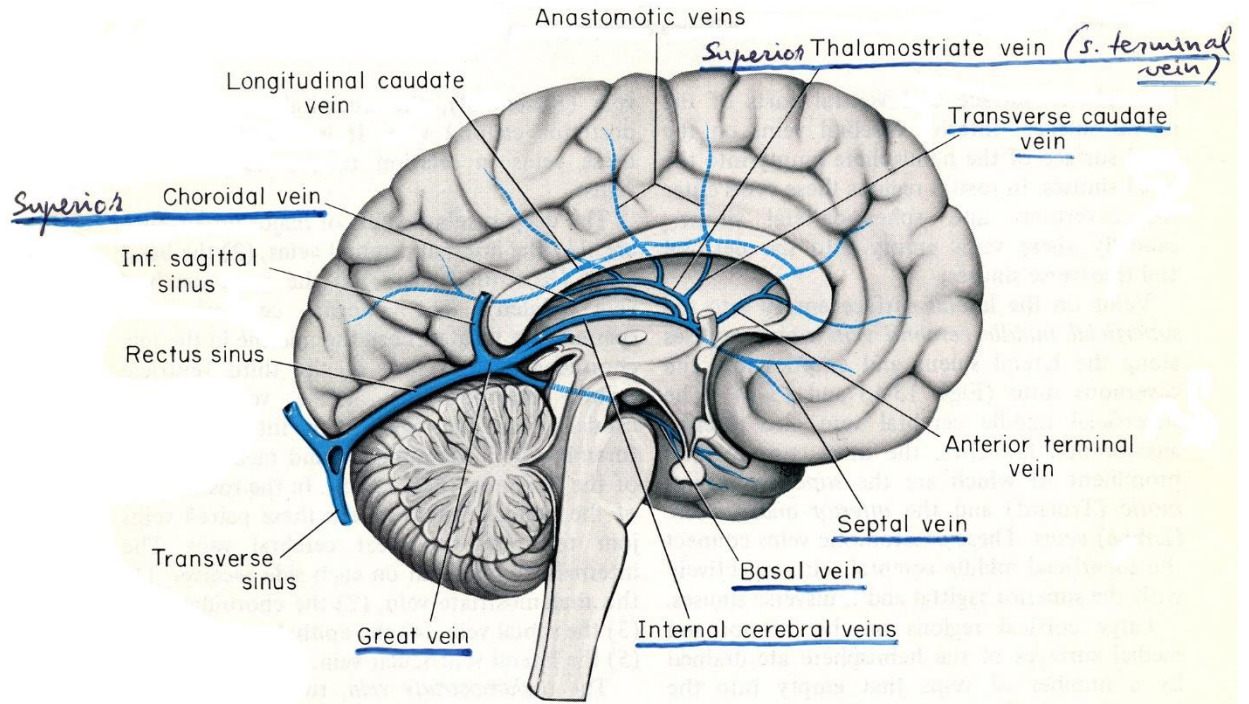
3. GREAT CEREBRAL VEIN (GALEN)

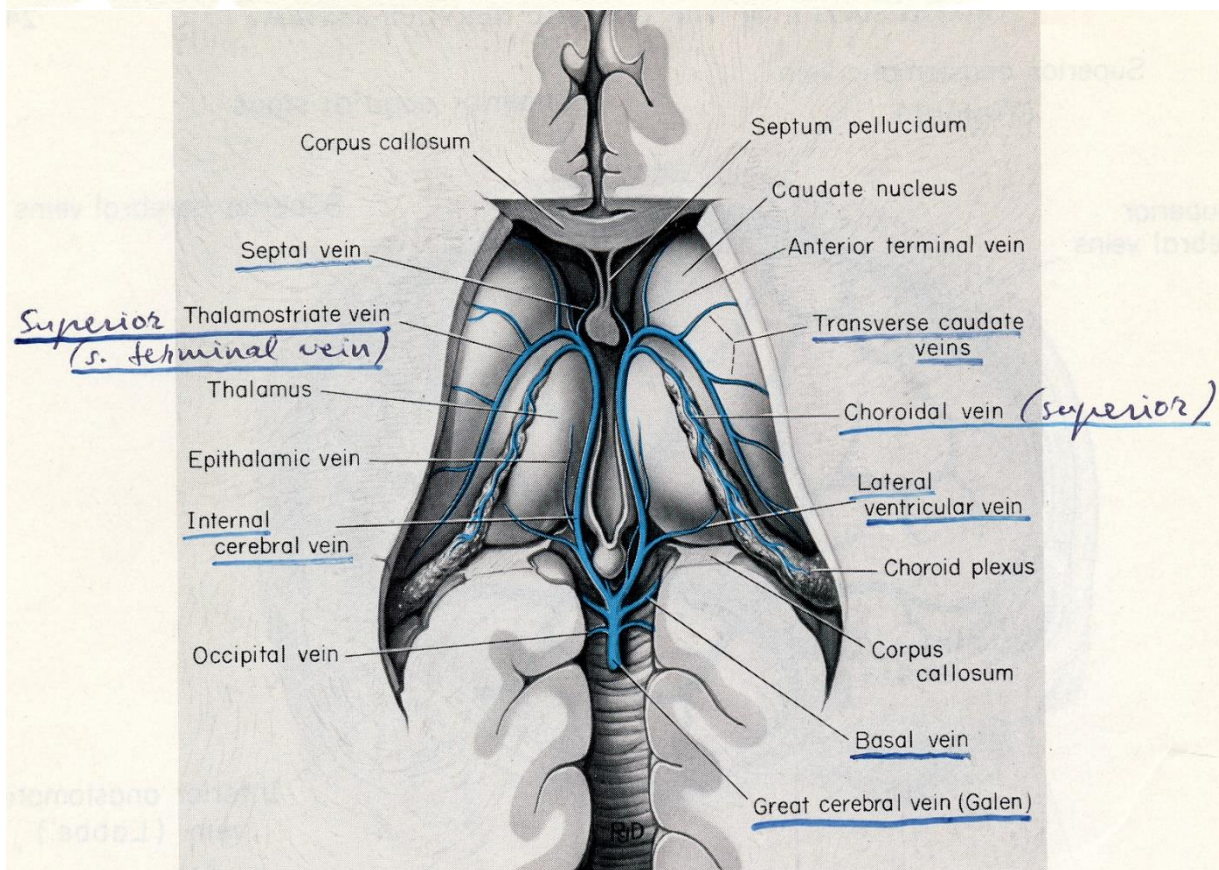
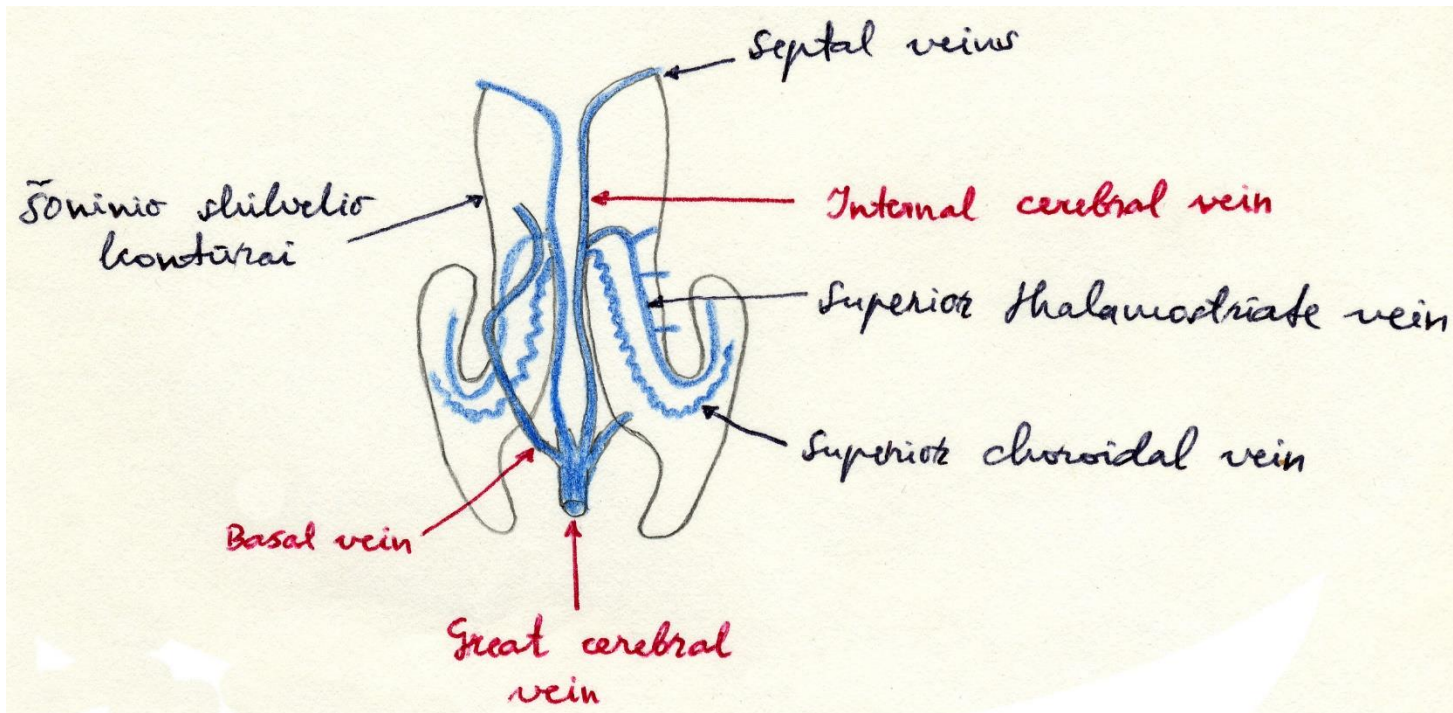
- short, thick, single vein!

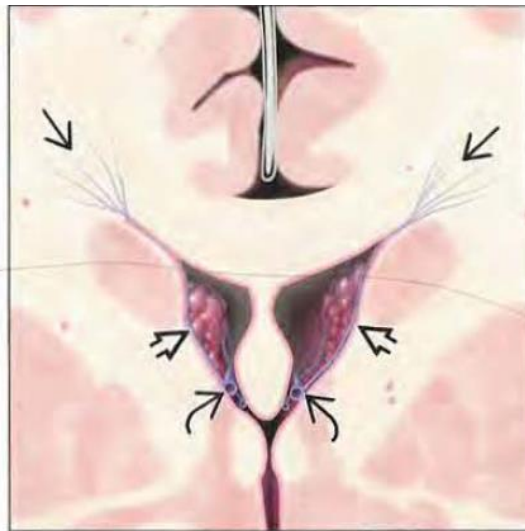
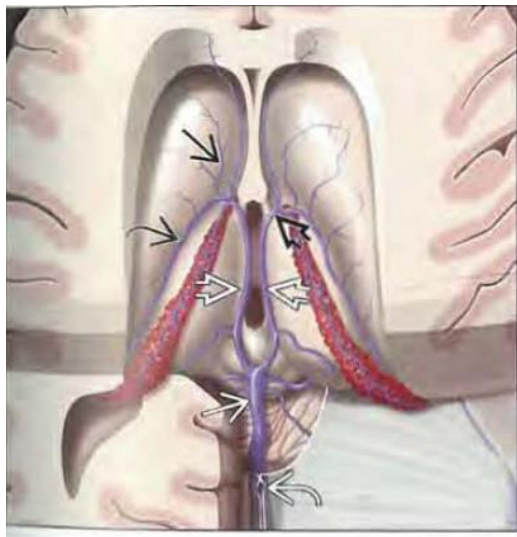
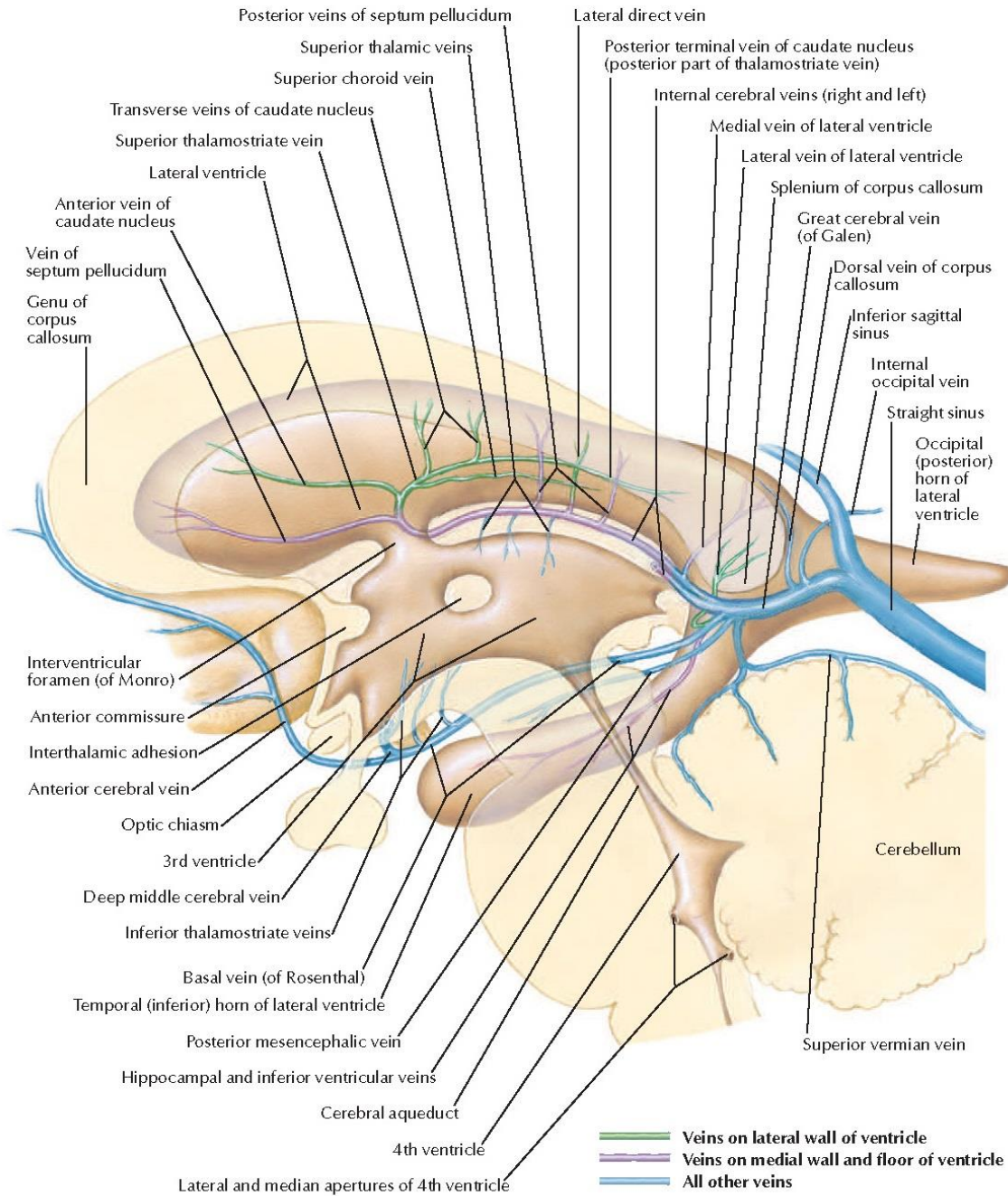
- formed by confluence of two *internal cerebral veins*.
- lies in *QUADRIGEMINAL CISTERN* (tarp *SPLENIUM CORPORIS CALLOSI* ir *PINEAL GLAND*).
- susijungia su *SINUS SAGITTALIS INF.* ir sudaro *SINUS RECTUS*.
- receives:
 - 1) **basal veins (Rosenthal)**
 - 2) **posterior vein of corpus callosum**
 - 3) **v. superior vermis**

Deep cerebral veins



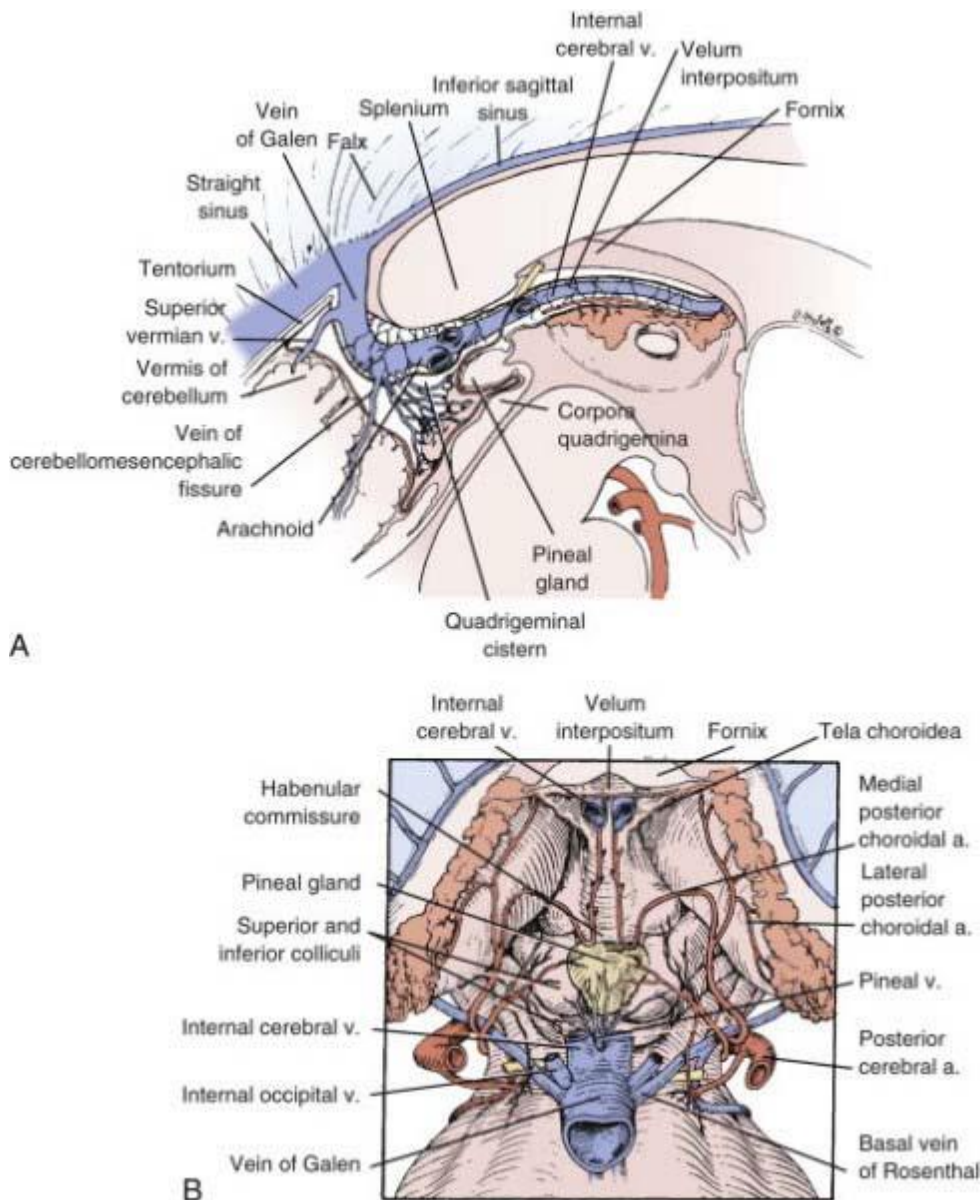






9-7. Deep cerebral and subependymal venous drainage is seen from the top down. Caudate and terminal veins form the thalamostriate veins, which drain into the internal cerebral veins, vein of Galen, and straight sinus. 9-8. Coronal graphic through the coronal ventricles depicts the medullary (deep white matter) veins converging at the ventricular margins to drain into the subependymal and thalamostriate veins. From there, they drain into the ICVs.

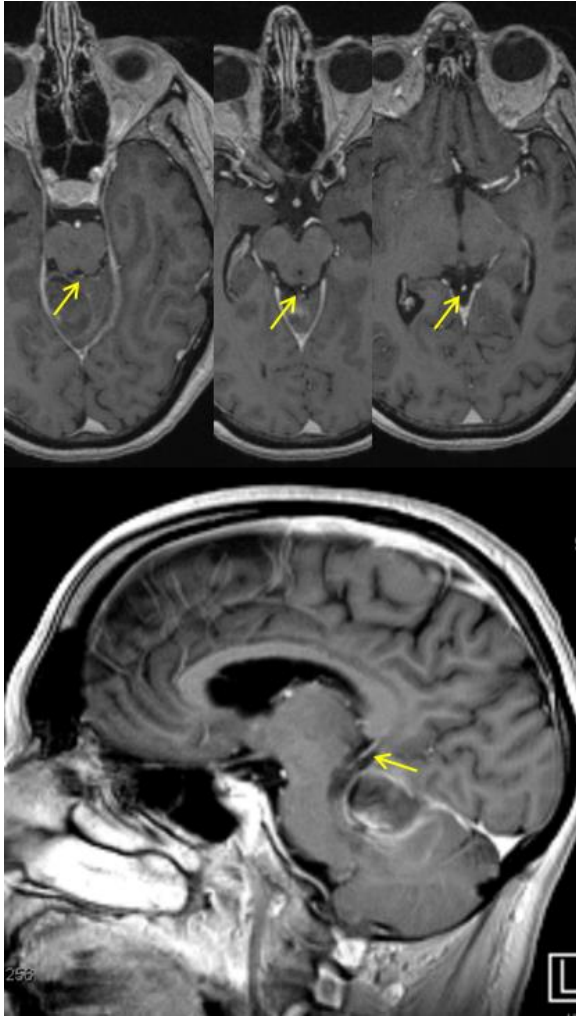
Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>



POSTERIOR FOSSA VEINS

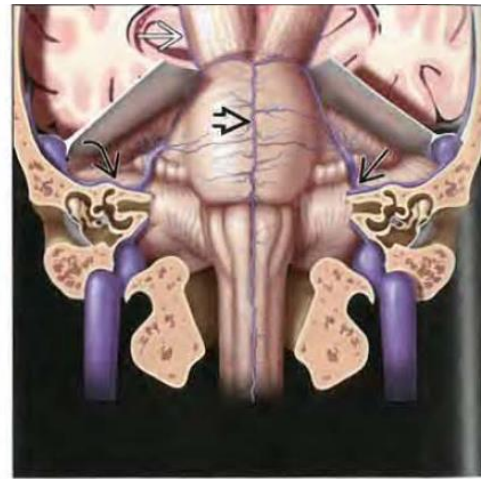
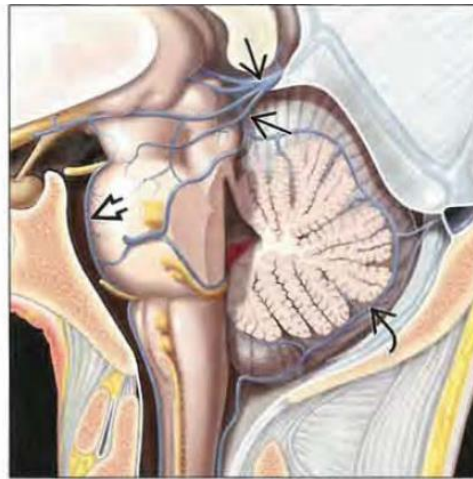
1. **SUPERIOR (GALENIC) GROUP** - drain superiorly into vein of Galen; major named veins in this group:
 - 1) **superior vermian vein** - runs over top of vermis → **precentral cerebellar vein** (single midline vein that lies between lingula and central lobule of vermis) → **vein of Galen**
 - 2) **anterior pontomesencephalic vein** - actually interconnected venous plexus, not single dominant vein; covers cerebellar peduncles and extends over anterior surface of pons

Superior vermian vein:

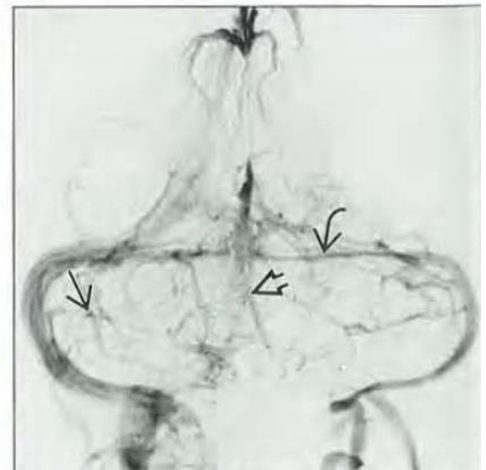
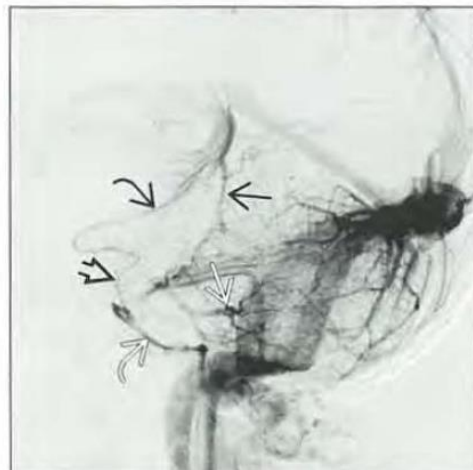


Source of picture: Neuroangio.org >>

9-11. Sagittal graphic through the vermis shows the superior (galenic) group of veins [X], the anterior group with the pontomesencephalic vein [X], and the posterior group [X]. 9-12. Coronal graphic shows the anterior pontomesencephalic [X] and the petrosal [X] venous plexuses draining the pons, anterior cerebellum, and cerebellopontine angle cistern. Note anastomoses with the superior petrosal sinuses [X] and mesencephalic veins [X].



9-13. Venous phase vertebrabascular DSA shows pontomesencephalic venous plexus [X] and galenic group with precentral cerebellar vein [X], basal vein of Rosenthal [X]. Note "star" configuration of petrosal veins [X]. Clival plexus [X] drains into the inferior petrosal sinus. 9-14. AP view shows petrosal "star" [X] and midline vermian veins [X]. Note hypoplastic left transverse sinus segment [X], a common normal variant.



Source of picture: Anne G. Osborn "Osborn's Brain - Imaging, Pathology, and Anatomy" (2012); Publisher: Lippincott Williams & Wilkins; ISBN-13: 978-1931884211 >>

2. **ANTERIOR (PETROSAL) GROUP**; **petrosal (Dandy) vein** (star-shaped vascular collection seen on AP DSA) - large venous trunk that lies in cerebellopontine angle cistern, collecting numerous tributaries from cerebellum, pons, and medulla → superior petrosal sinus.
 - petrosal vein drains anterior-lateral brainstem + anterior-superior and inferior cerebellar surfaces into superior petrosal sinus
3. **POSTERIOR (TENTORIAL) GROUP**; most prominent veins in this group are **inferior vermian veins** - paired paramedian structures that curve under vermis and drain inferior surface of cerebellum into torcular

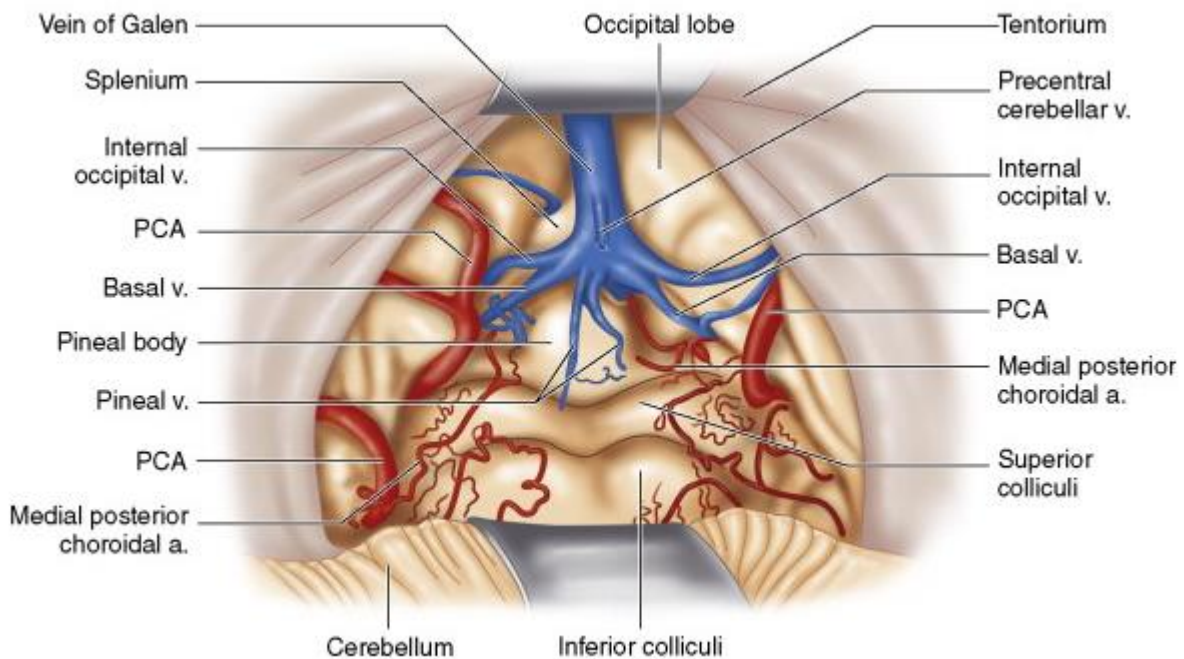
CEREBELLAR VEINS

Vermis, paravermis, deep nuclei:

- 1) **v. superior vermis** → v. cerebri magna (or v. cerebri interna)
- 2) **v. inferior vermis** → SINUS RECTUS OR TORCULAR

Hemispheres:

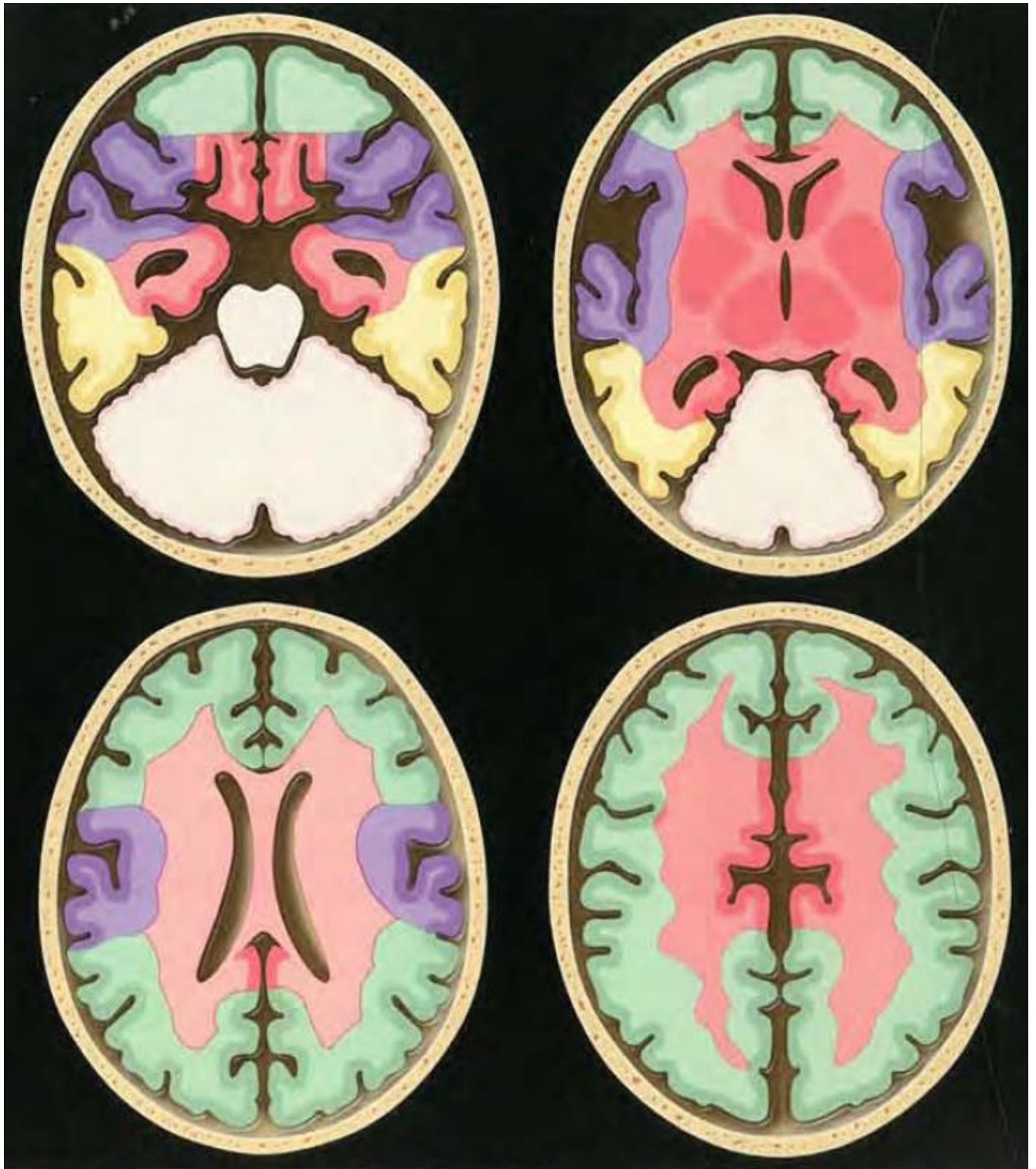
- 1) **v. hemispherii cerebelli sup.** → SINUS PETROSUS SUP.
- 2) **v. hemispherii cerebelli inf.** → SINUS PETROSUS INF.



VENOUS DRAINAGE TERRITORIES

Four basic patterns:

- 1) **peripheral (brain surface) pattern** (*green*) – superficial parts of brain (cortex, subcortical white matter) – drained by cortical veins into SSS
- 2) **deep (central) pattern** (*red*) – central core brain structures (basal ganglia, most white matter, ventricles, medial temporal lobe) – drain into deep venous system
- 3) **inferolateral (perisylvian) pattern** (*yellow*) – area around Sylvian fissure (frontal, parietal, and temporal opercula plus insula) – drained by sphenoparietal and cavernous sinuses.
- 4) **posterolateral (temporoparietal) pattern** (*purple*) – posterior temporal and inferior parietal lobes - drained into vein of Labbé and transverse sinuses.

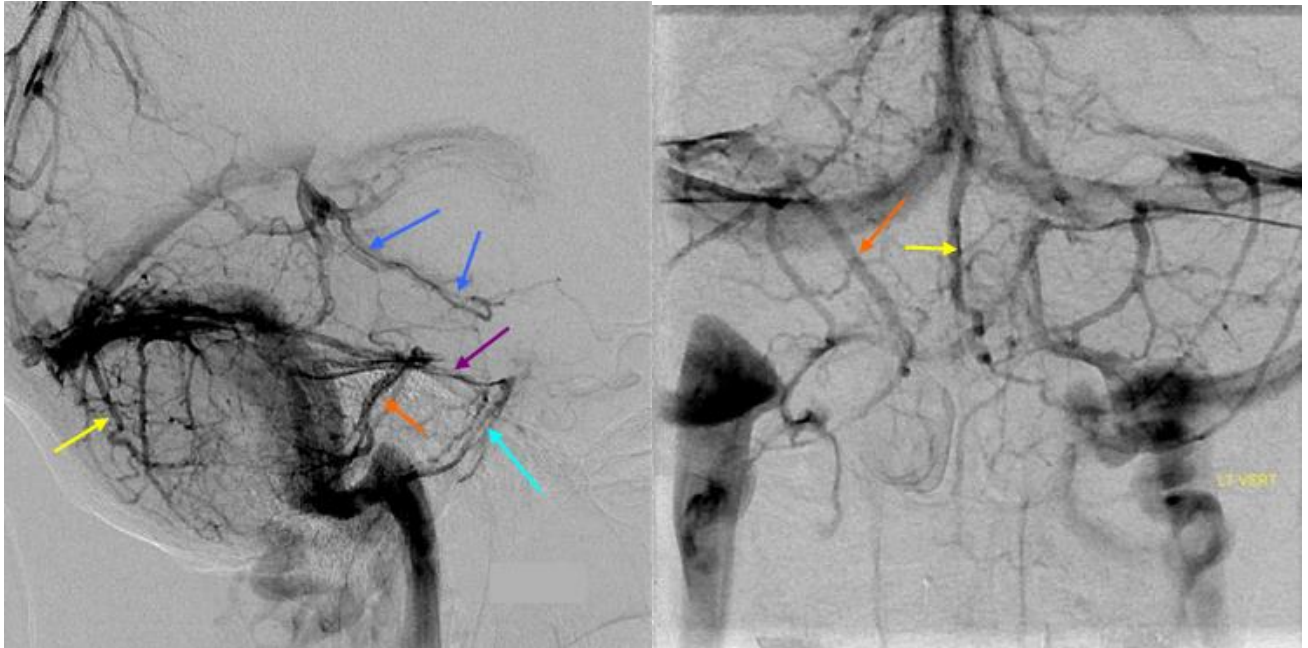


ANGIOGRAPHY

BY ARTERY INJECTED

A. Left VA injection:

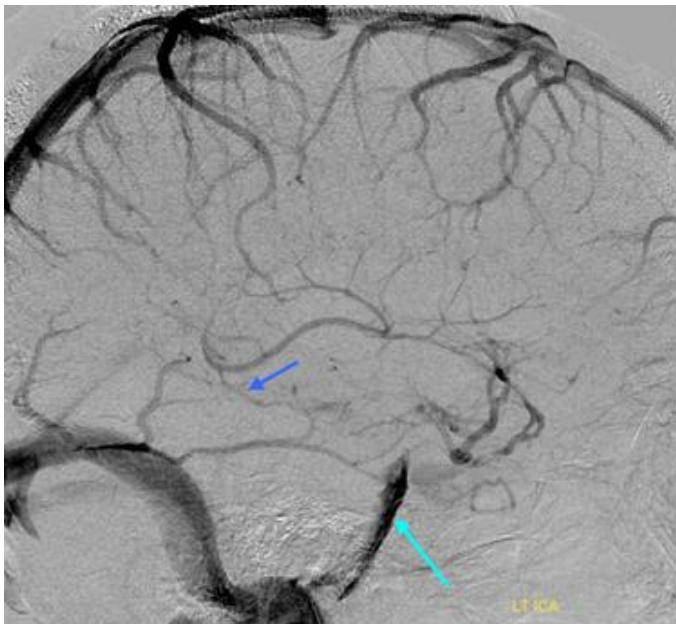
- basal vein of Rosenthal (*dark blue*)
- superior petrosal sinus (*purple*)
- inferior petrosal sinus (*blue*) is well seen
- superior vermian vein (*yellow*).
- ignore *orange*.



Source of picture: Neuroangio.org >>

B. Left ICA injection:

- basal vein of Rosenthal (*dark blue*) appears much smaller in caliber, since the anterior segment of the basal vein drains primarily into the sylvian network
- superior petrosal sinus is not opacified (may erroneously be presumed absent).
- inferior petrosal sinus (*blue*) is well seen



Source of picture: Neuroangio.org >>

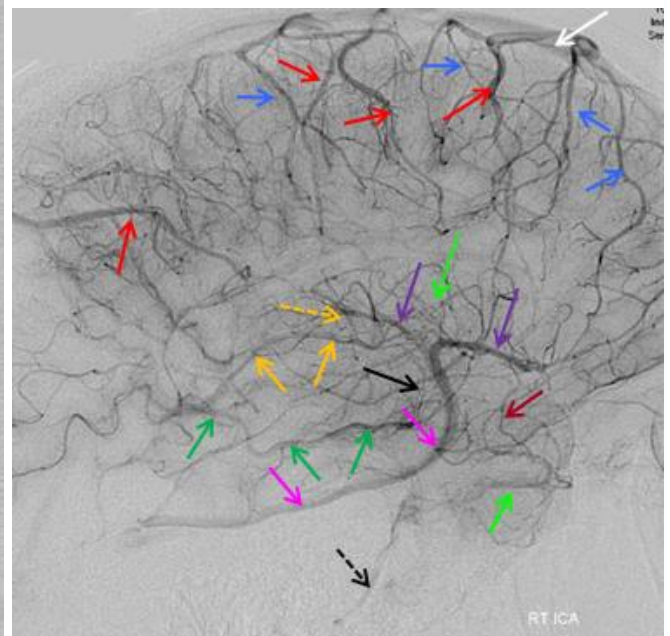
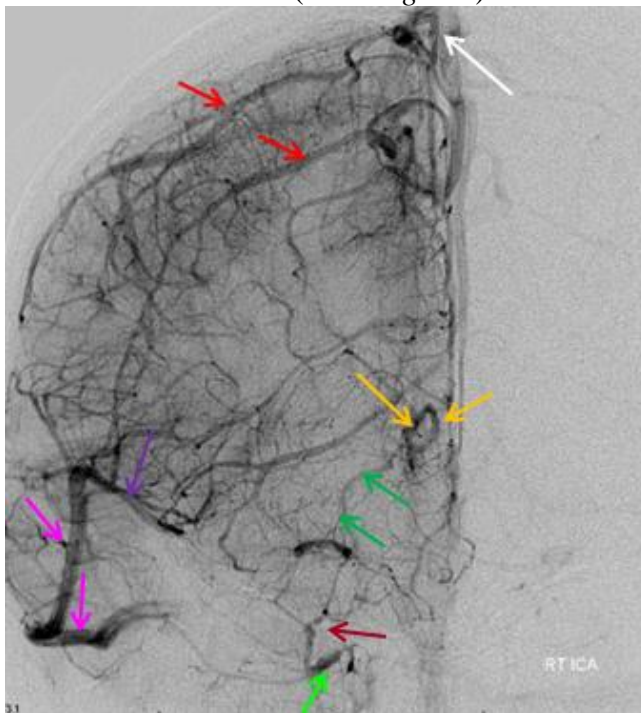
BY TIMING

- **superficial veins** are seen first (incl. basal vein, which is in effect a superficial (surface) vein that happens to be on the bottom of the brain → contrast progresses into **venous sinuses** (opacified well 1-1.5 seconds after superficial cortical veins).
- sequence of **deep vein** opacification is more complex:
 - earliest tributaries of internal cerebral vein (such as septal veins) are seen as early as the cortical surface veins.

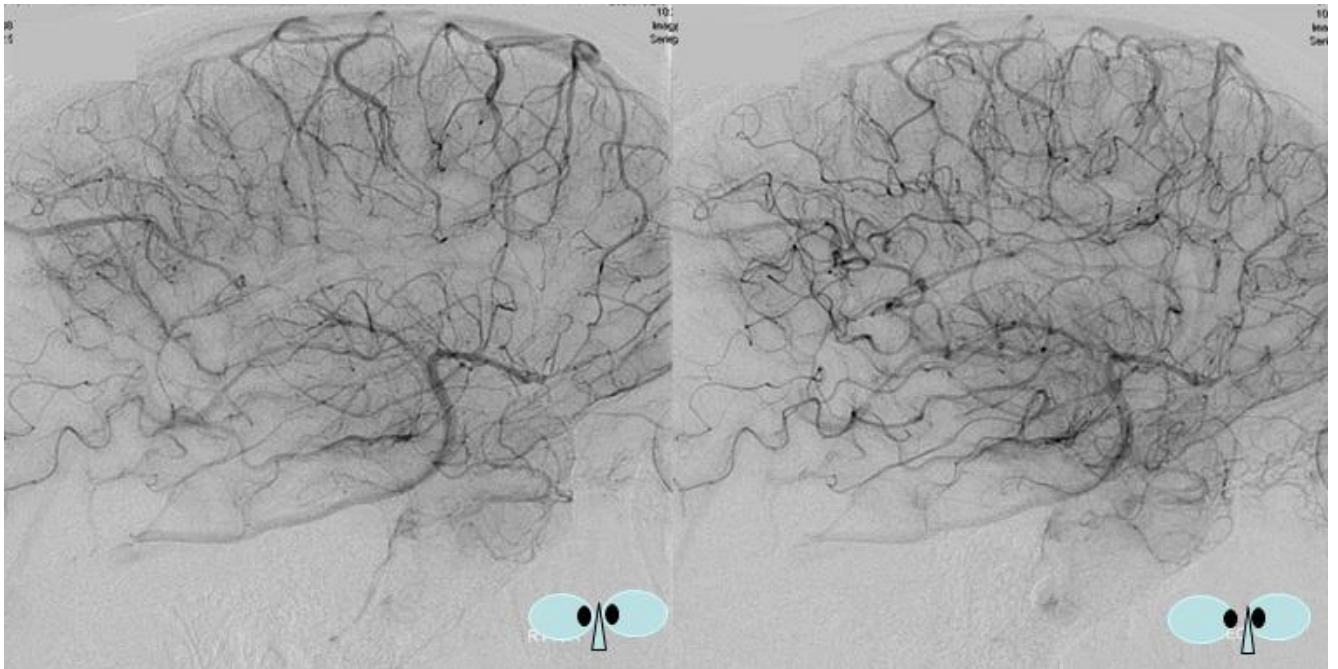
- caudate veins (lateral group of internal cerebral tributaries) come in late and stay EXTREMELY late into venous phase, even after contrast has washed out of dural sinuses.
- **high flow shunts (AVMs)** appear in the arterial or capillary phases.
- **low flow shunts (tumors, inflammatory lesions)** are best seen in late capillary or early venous phases as a region of especially good venous filling in comparison with the rest of the territory.
- **DVAs** are LATE (very convenient if you are looking for one angiographically next to that huge hematoma; N.B. normal veins compressed by hematomas are going to be seen later than usual as well).

Early Venous Phase - surface cortical veins:

- lateral (*red*) and medial (*blue*) superior hemisphere surface vessels
- superficial sylvian venous system (*purple*) draining into inferior temporal vein (*pink*).
- part of sagittal sinus is filled (*white*).
- inferior striate veins (*brown*) draining towards sphenoparietal sinus (green) and subsequently into inferior petrosal sinus (dashed black).
- basal vein (*green*), with relatively small contribution from deep sylvian (insular) veins (black).
- internal cerebral vein (*light orange*) is already visible with its anterior septal (*dashed green*) and thalamostriate veins (*dashed light orange*).



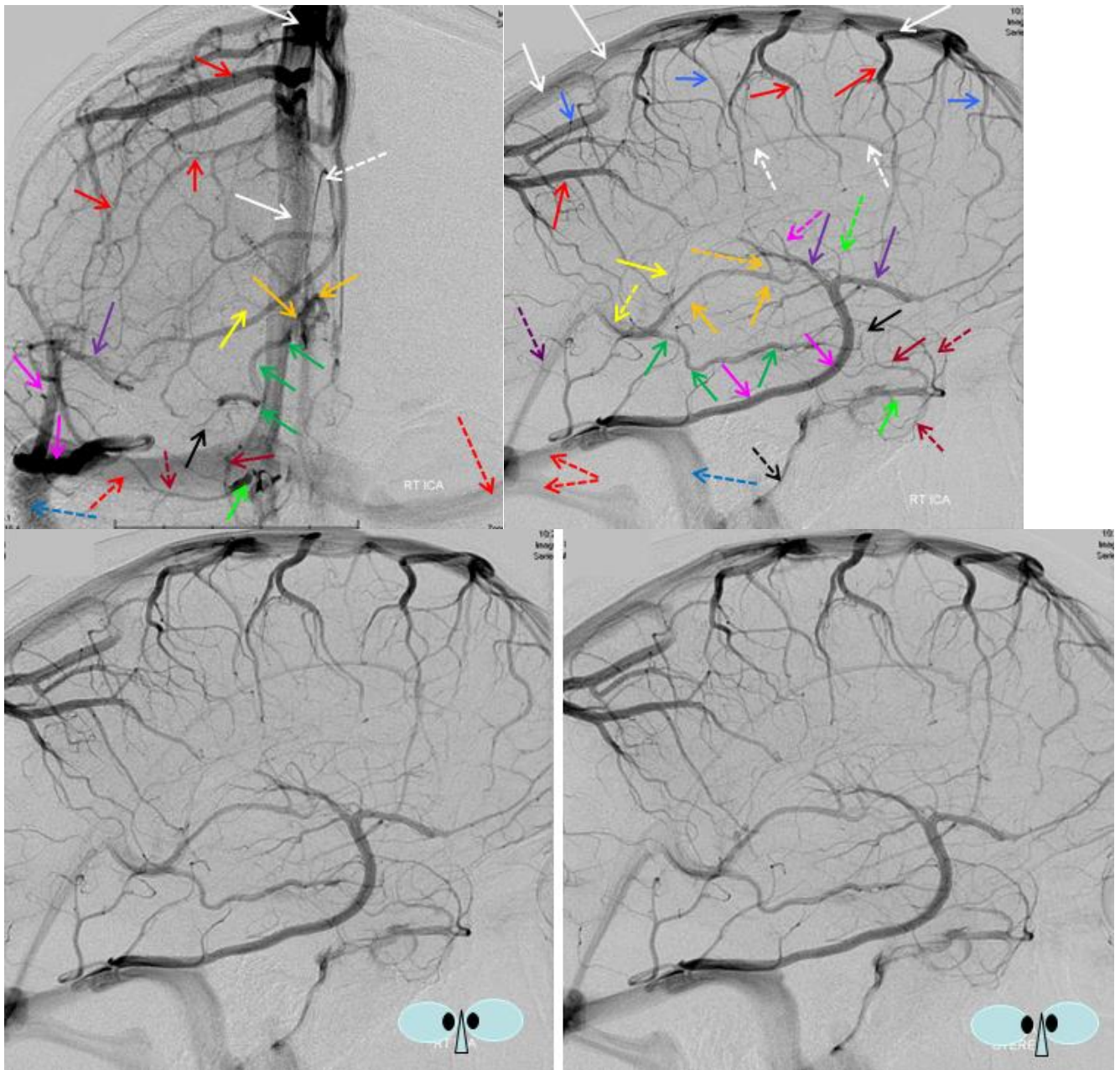
Source of picture: Neuroangio.org >>



Source of picture: Neuroangio.org >>

Mid-venous phase - **best phase of overall** - can see veins and dural sinuses well (only lateral ventricular veins and dural sinuses are better seen in late phase)

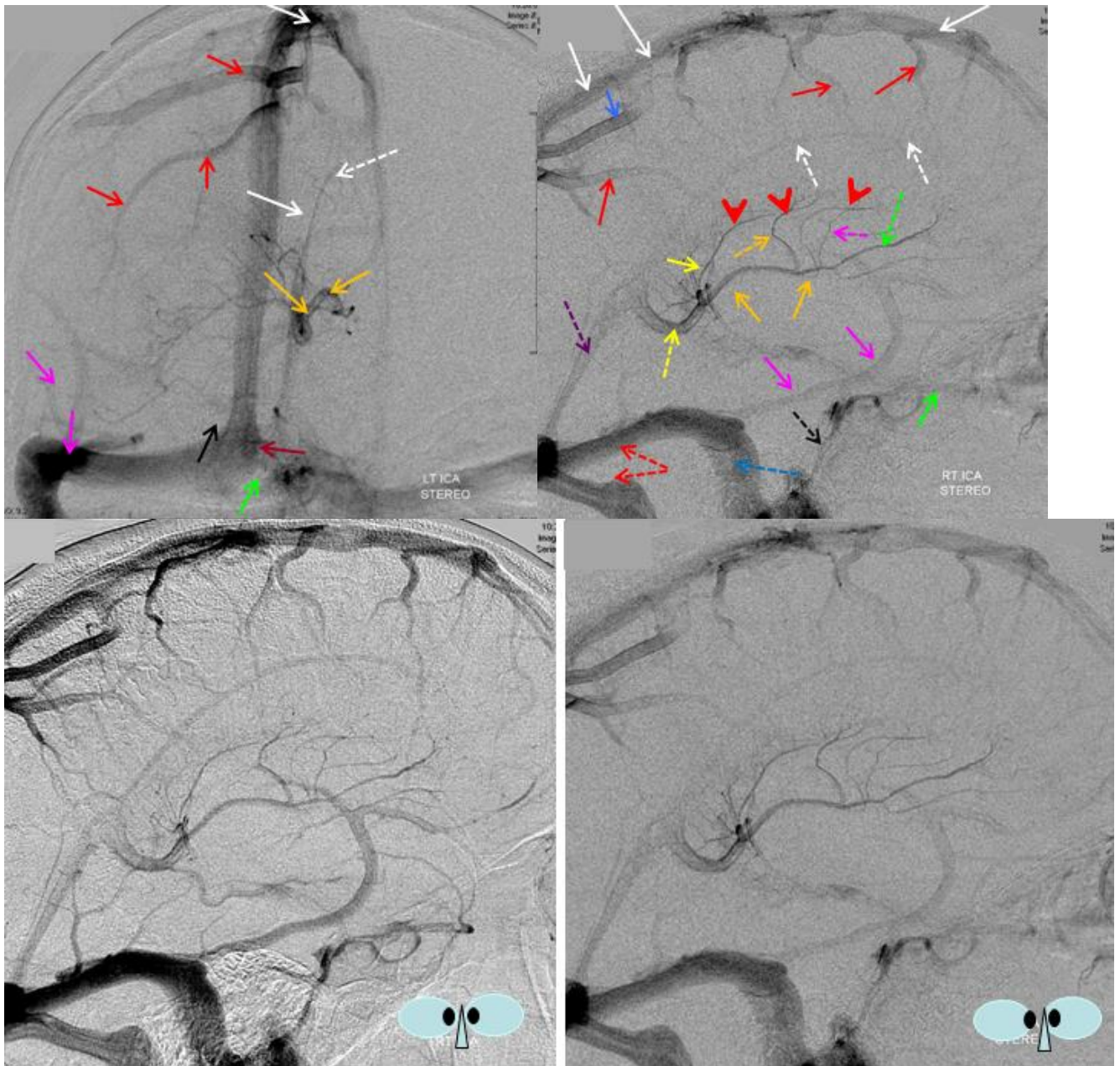
- medial (*blue*) and lateral (*red*) cortical surface vessels.
- dominant superficial sylvian system (*purple*) draining into inferior temporal vein (*pink*).
- temporal pole veins (dashed brown) and striate veins (*brown*) are draining into sphenoparietal sinus (*green*) – it is a “variant”
- basal vein (*dark green*) with deep sylvian tributaries (*black*).
- internal cerebral vein (*light orange*) with anterior septal (*dashed green*) and thalamostriate tributaries (*dashed pink* and *dashed orange*), as well as direct lateral tributary (*yellow*).
- superior (*white*) and inferior (*dashed white*) sagittal sinuses, Vein of Galen (*dashed yellow*) and straight sinus (*dashed purple*), transverse (*dashed red*) and sigmoid (*dashed blue*) sinuses, inferior petrosal sinus (*dashed black*).
- superior petrosal and cavernous sinus are not seen - may be visualized from vertebral or external carotid injections (visualizes cavernous sinus through ophthalmic veins and superior petrosal sinus through cerebellar and brainstem (lateral medullary) veins.



Source of picture: Neuroangio.org >>

Late Venous Phase - visualization of internal cerebral vein and distal parts of dural sinuses.

- tributaries of internal cerebral vein (*orange*) continue to drain contrast when most other brain veins are no longer visualized.
- late veins consist of basal ganglia structures, such as thalamostriate vein (in this case there are two closely spaced veins [*dashed orange* and *dashed pink*] which drain region normally assumed by a single thalamostriate vein), direct lateral vein (*yellow*) and anterior caudate vein (*dashed green*); superior aspect of these veins (*red arrowheads*) outline body of caudate.
- vein of Galen (*dashed yellow*).



Source of picture: Neuroangio.org >>

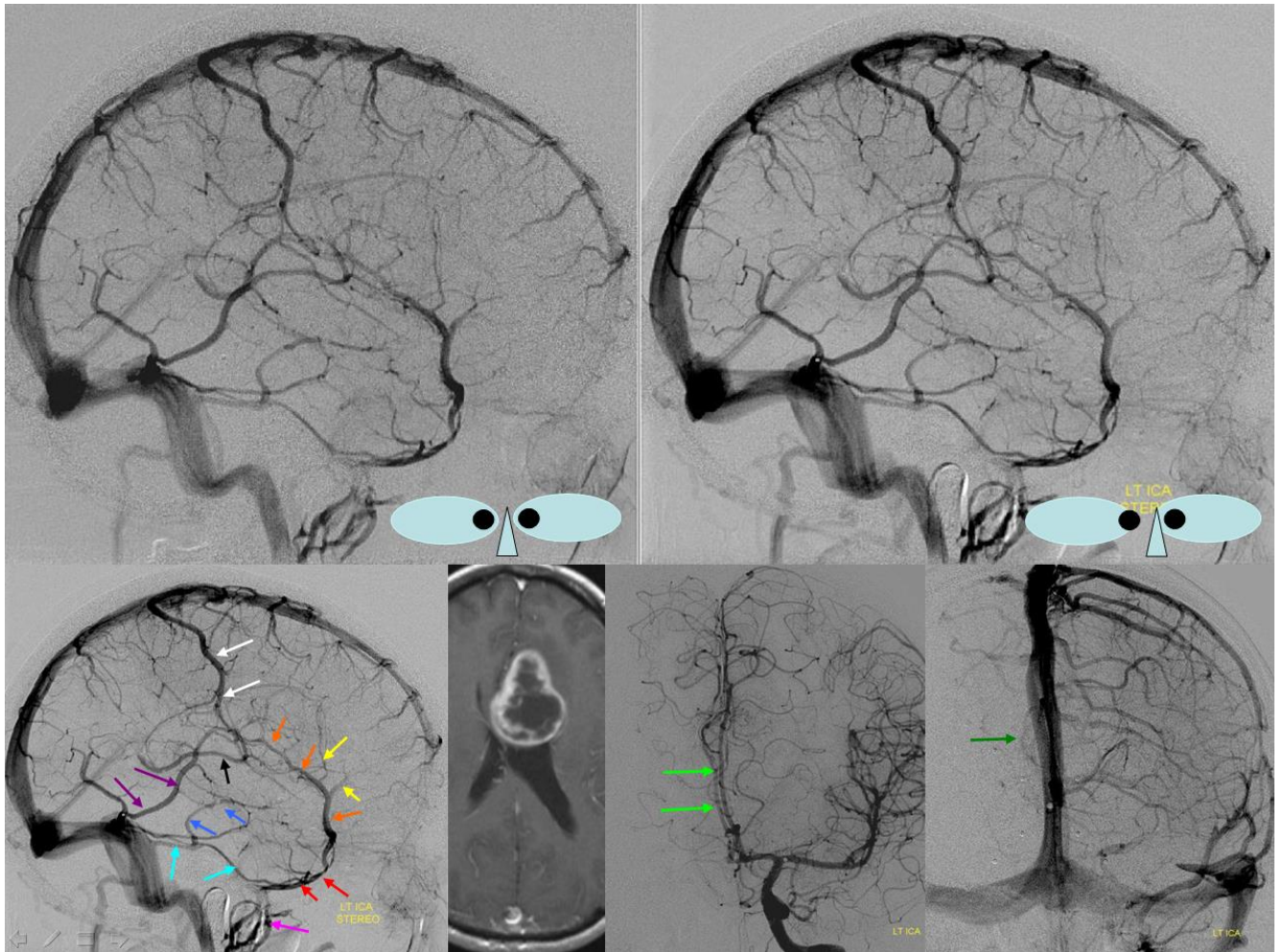
REGIONS

SUPERFICIAL VEINS

Trolard (*white*), Labbé (*purple*), and superficial Sylvian (*orange*)* veins are interconnected at posterior Sylvian fissure – various scenarios of dominance exist; here it is **balanced pattern** so any one of these veins can be sacrificed with very low risk of venous infarction;

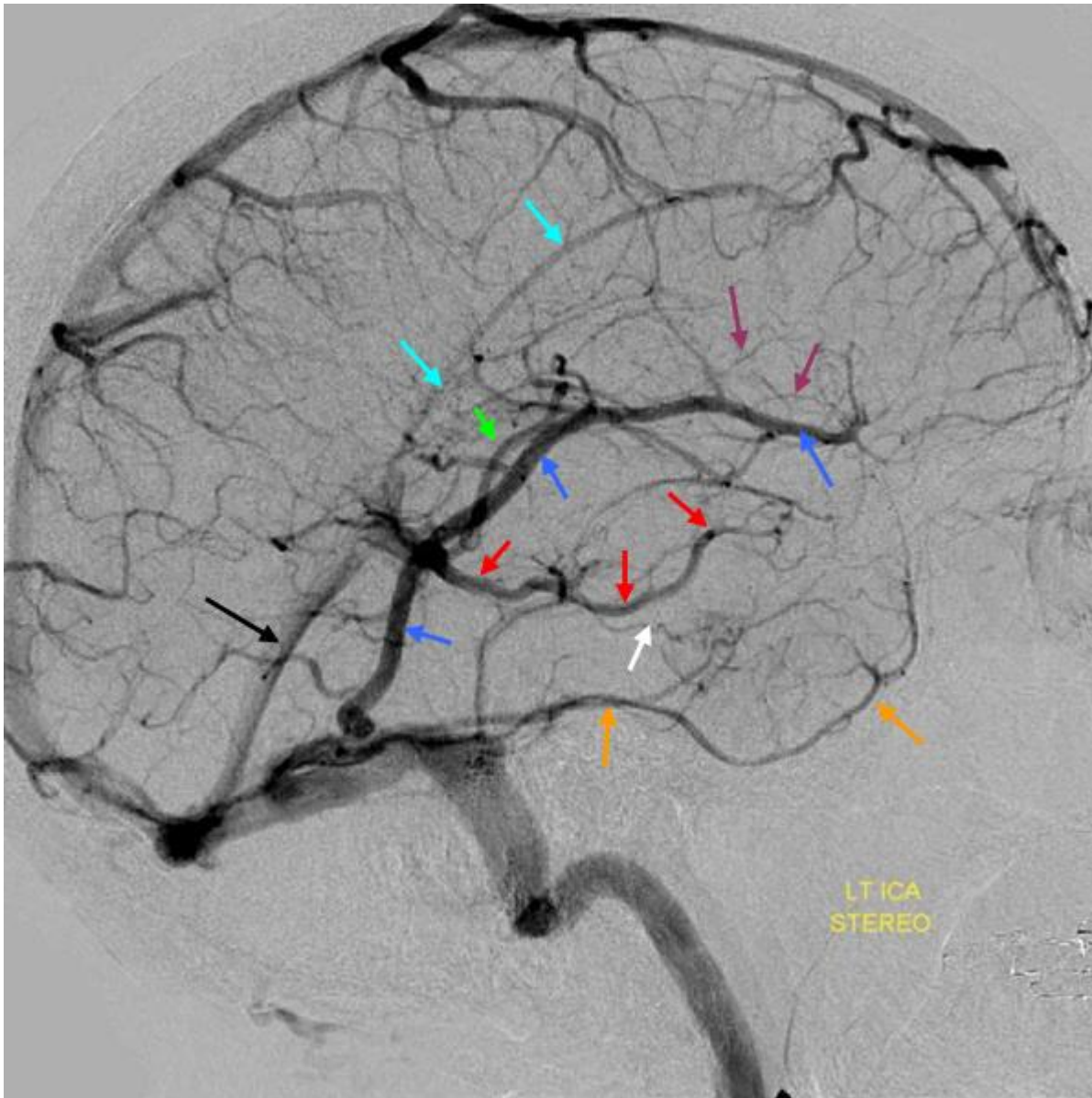
- notice a sigmoid emissary vein (unmarked).
- variant drainage of basal vein (*blue*) into superior petrosal sinus (*light blue*).

*drains into sphenoparietal sinus (*red*) → pterygopalatine venous plexus (*pink*).



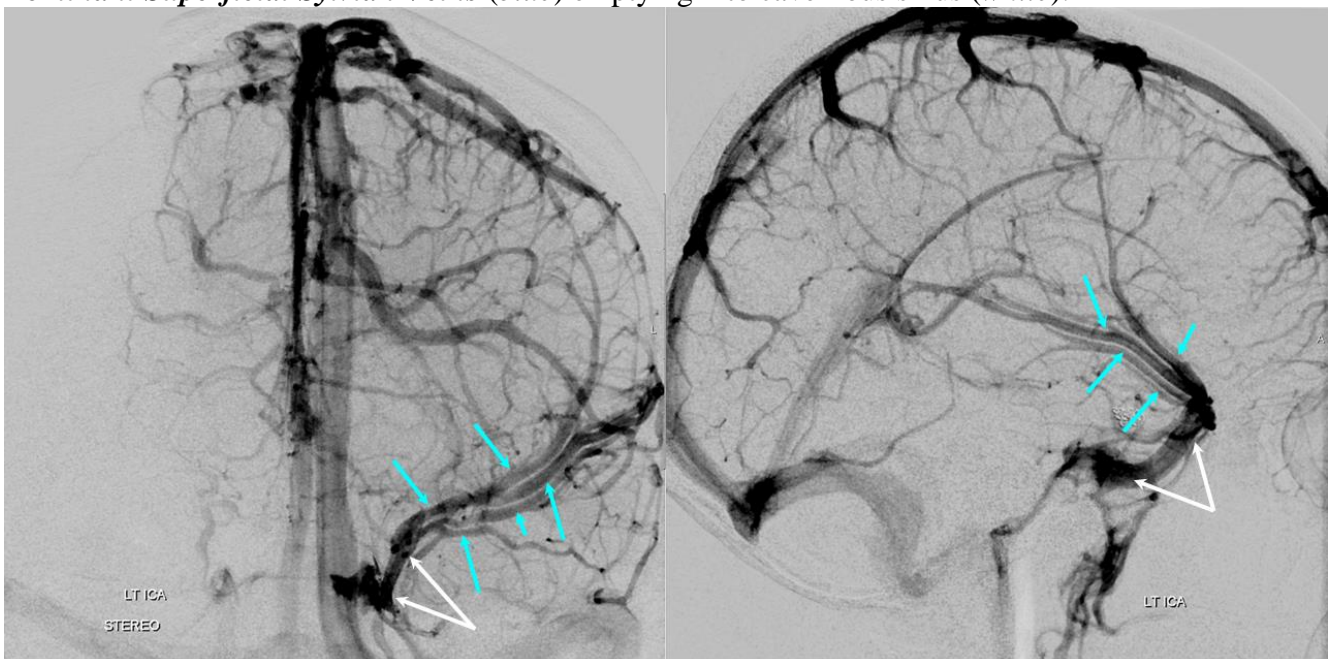
Source of picture: Neuroangio.org >>

Dominant Labbé:



Source of picture: Neuroangio.org >>

Dominant Superficial Sylvian Veins (blue) emptying into cavernous sinus (white):



Source of picture: Neuroangio.org >>

Dominant Superficial Sylvian Vein emptying into superior petrosal sinus via the inferior temporal vein (cavernous sinus drainage pathway is hypoplastic):



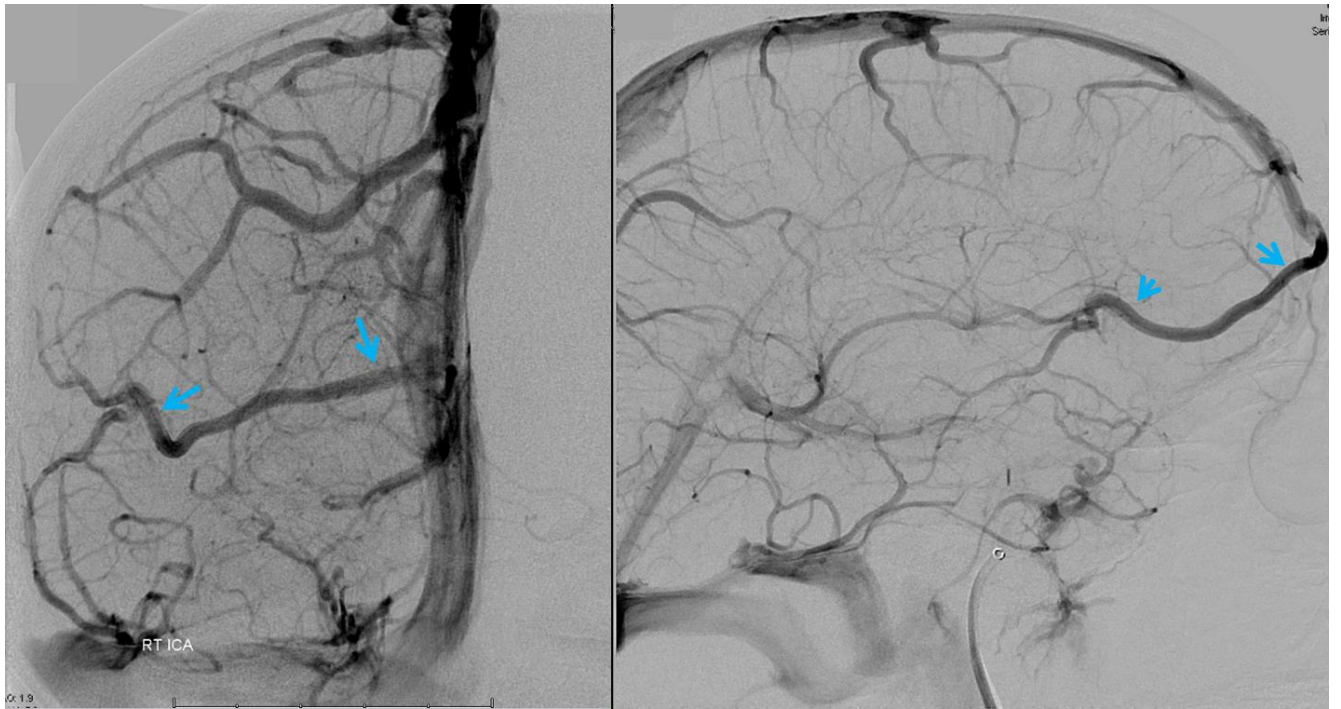
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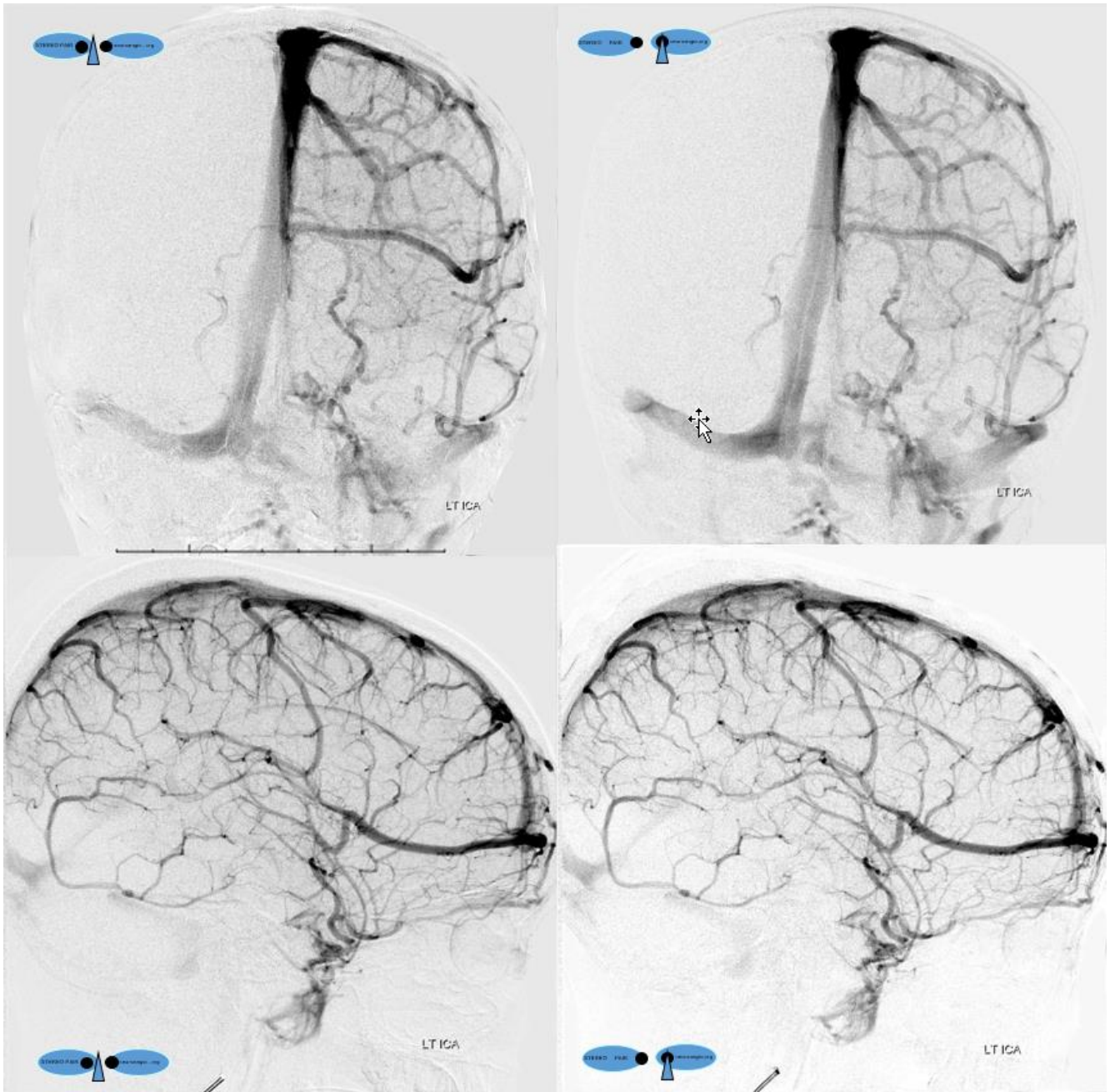
Dominant Trolard:



Source of picture: Neuroangio.org >>

Dominant frontal vein – not safe to take anterior 1/3 of SSS:

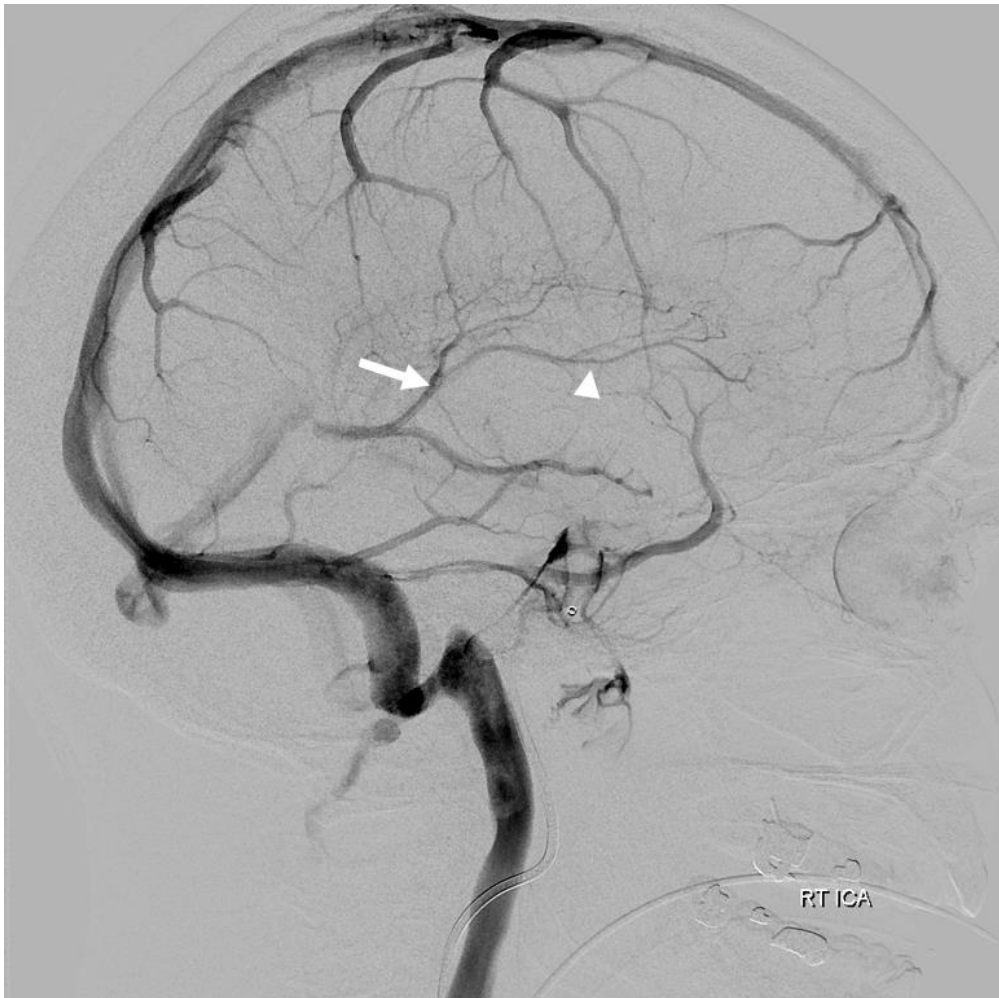




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DEEP VEINS

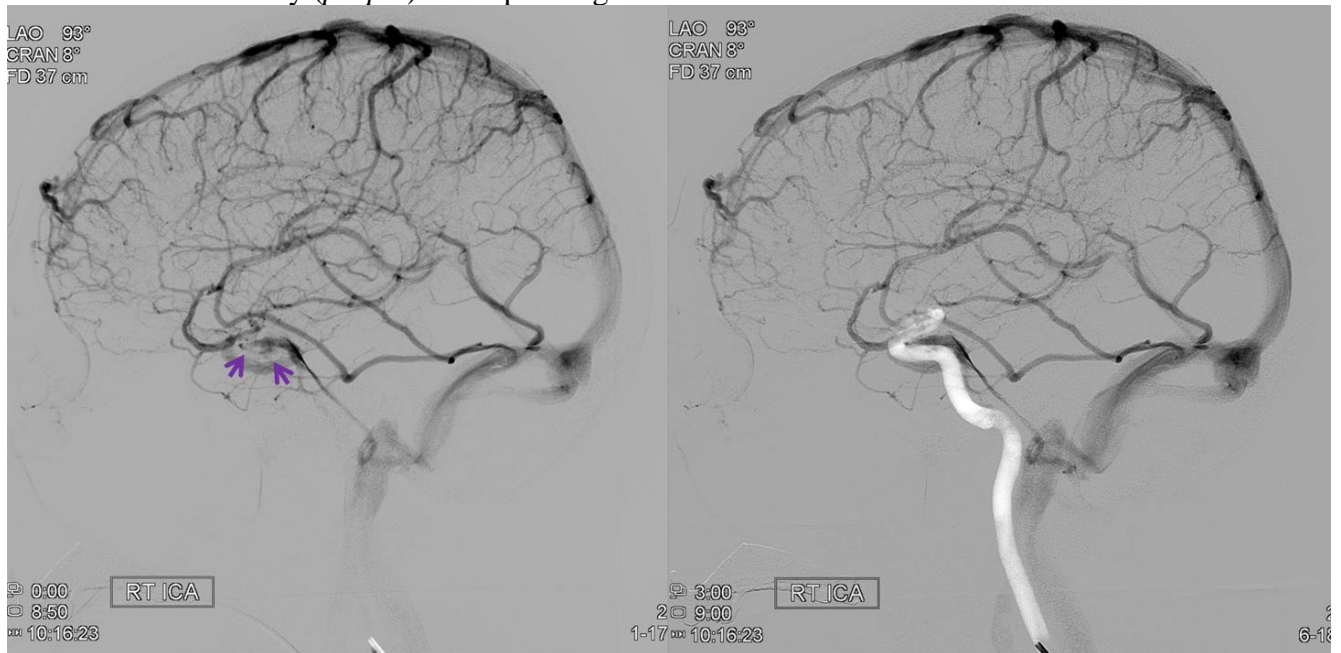
Internal cerebral vein:



Source of picture: Neuroangio.org >>

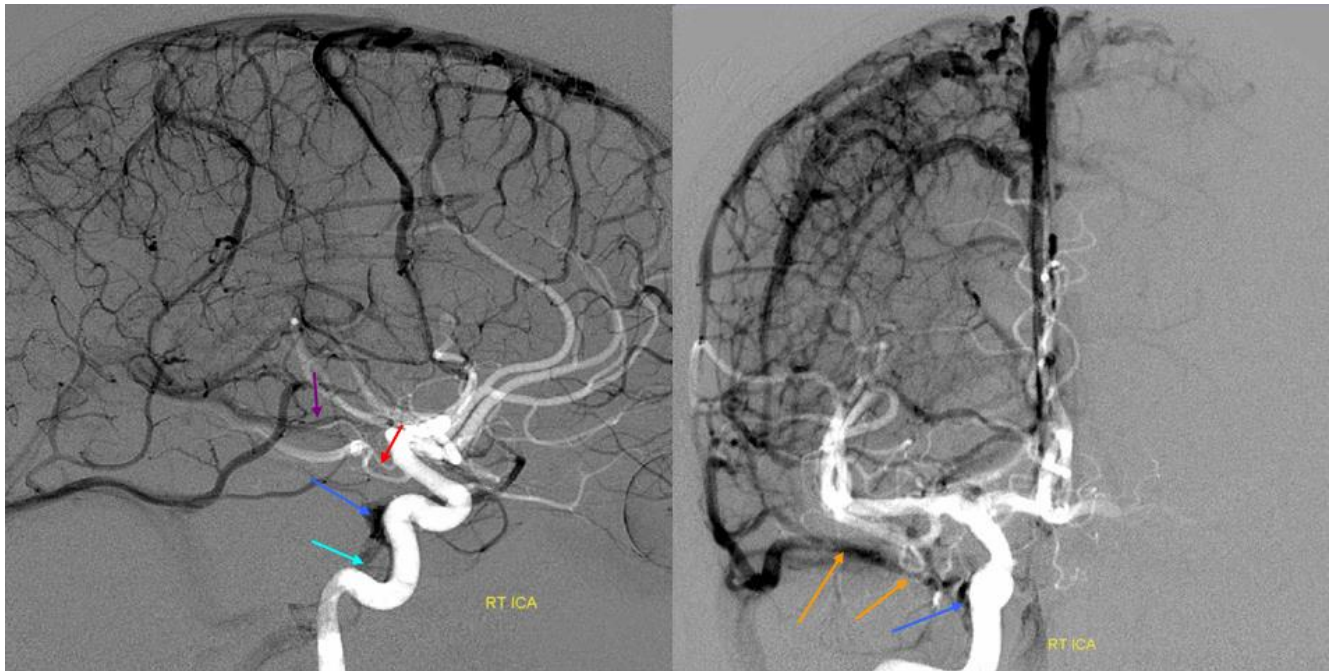
DURAL SINUSES

Intracavernous lucency (*purple*) corresponding to ICA:



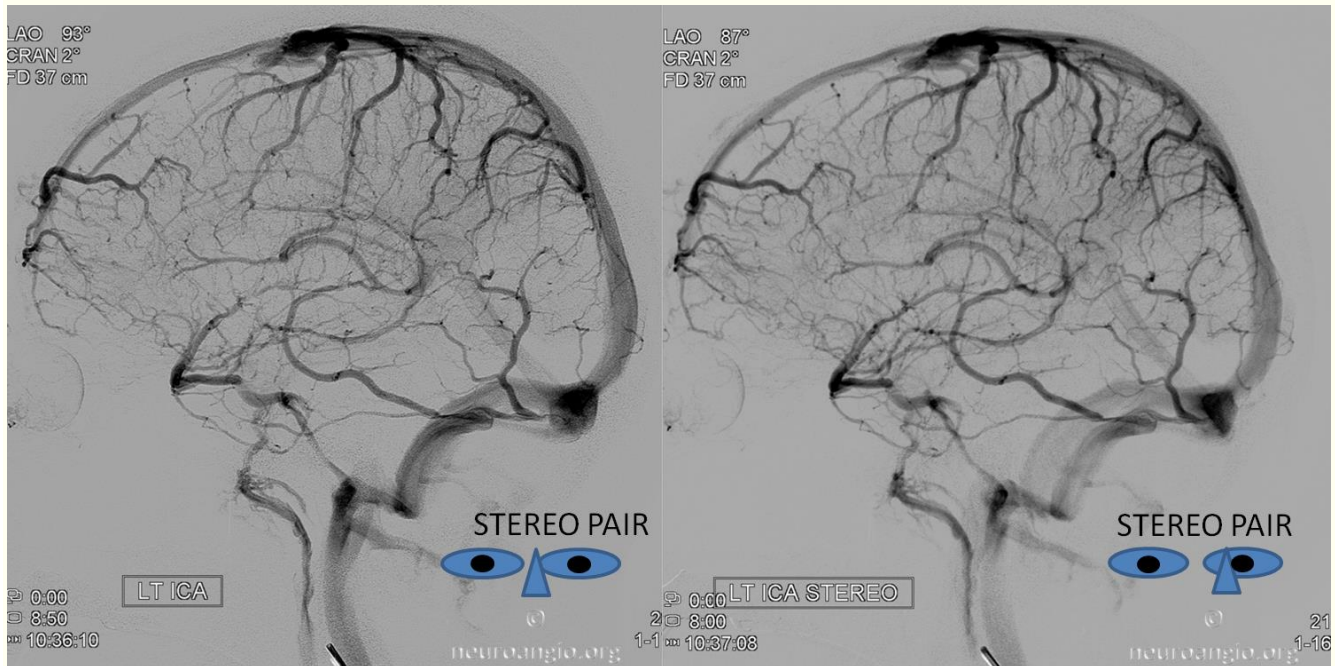
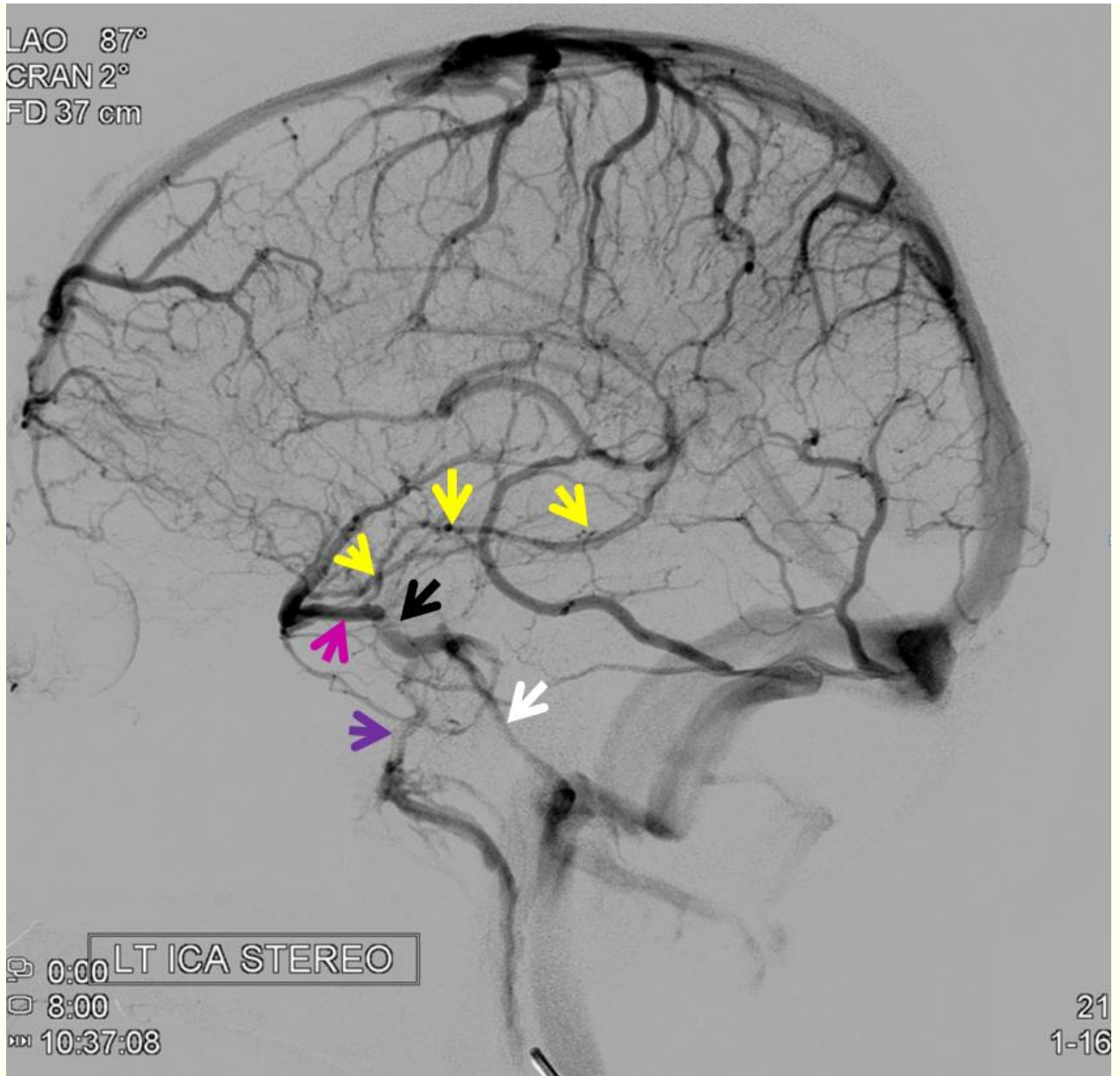
Source of picture: Neuroangio.org >>

Cavernous Sinus (*dark blue*) with sylvian network and sphenoparietal sinus (*orange*) draining into it; inferior petrosal sinus (*light blue*); basal vein (*purple*) and anterior choroidal artery (*red*):



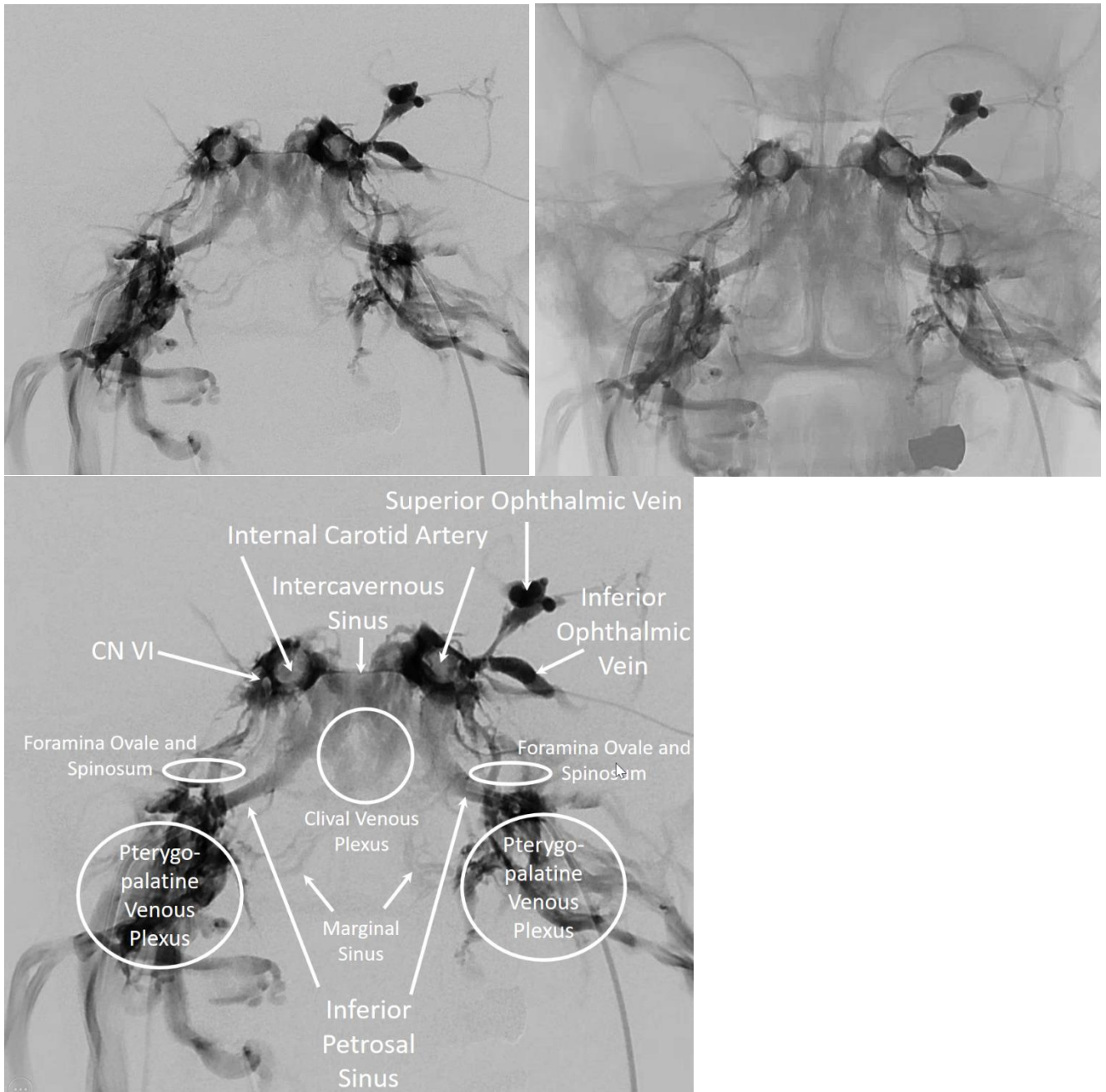
Source of picture: Neuroangio.org >>

Superficial sylvian veins (*pink*) empty via cavernous sinus (*black*) into inferior petrosal sinus (*white*) and pterygopalatine venous plexus thru foramen ovale (*purple*); basal vein contributes (*yellow*, notice full extent of basal vein between CC and Galen):



Source of picture: Neuroangio.org >>

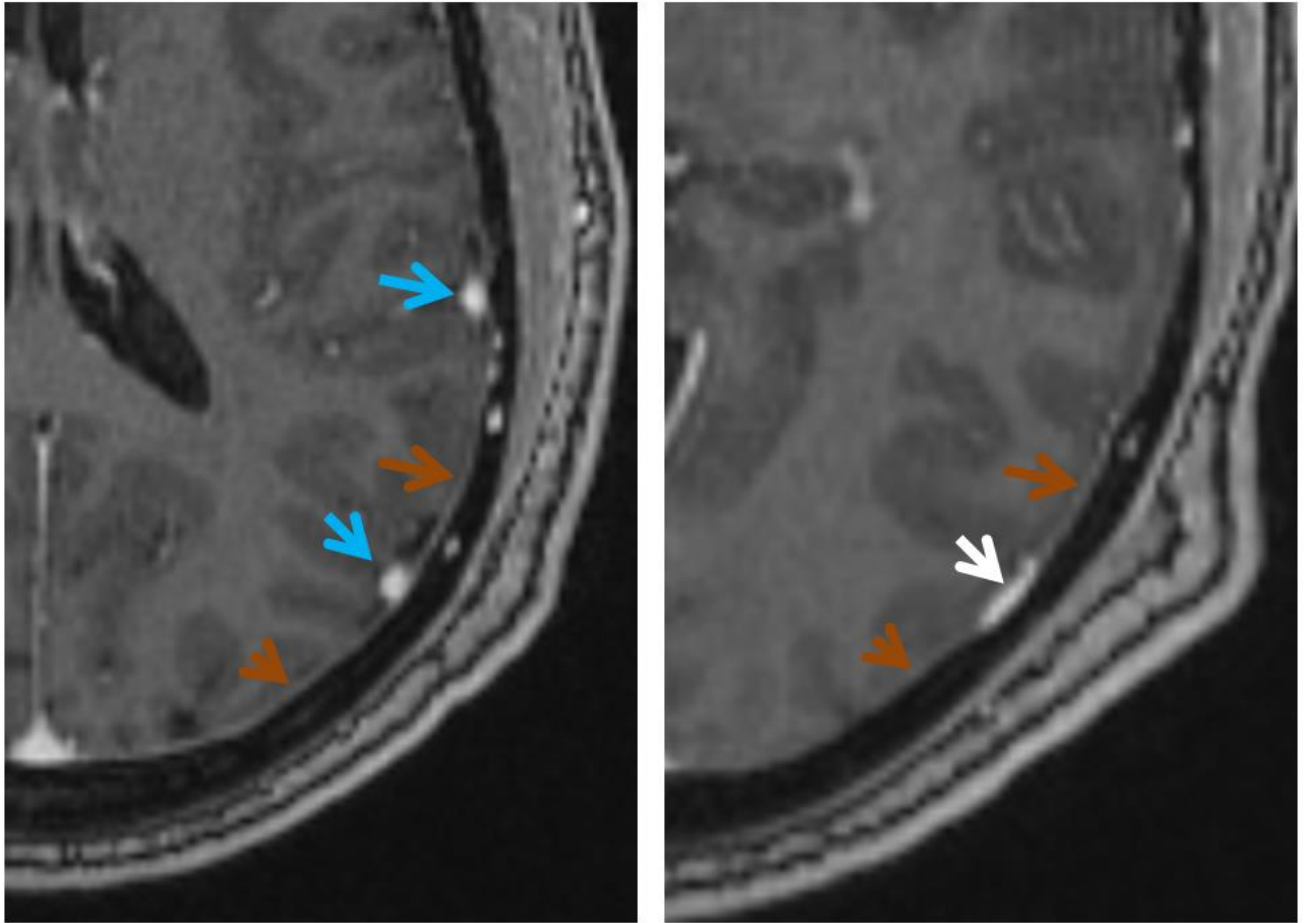
Venous injection into cavernous sinus during petrosal venous sinus sampling:



Source of picture: Neuroangio.org >>

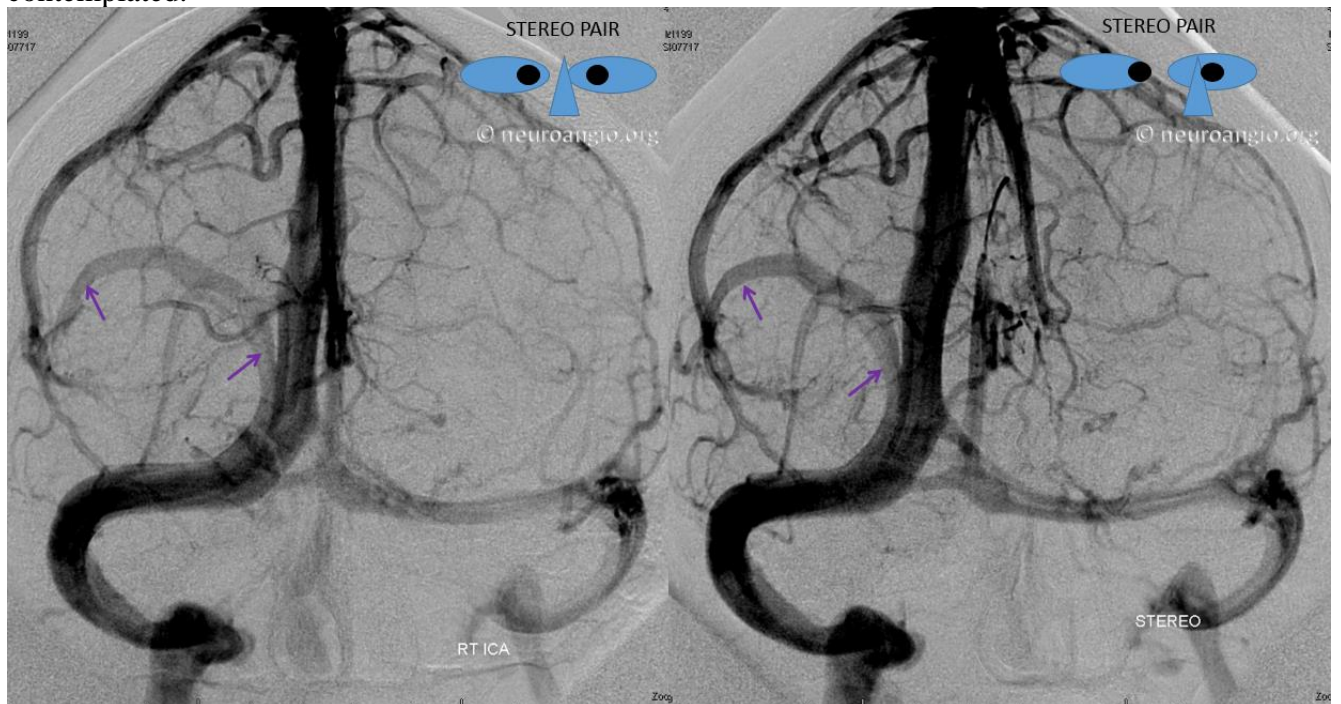
DURAL VENOUS CHANNELS

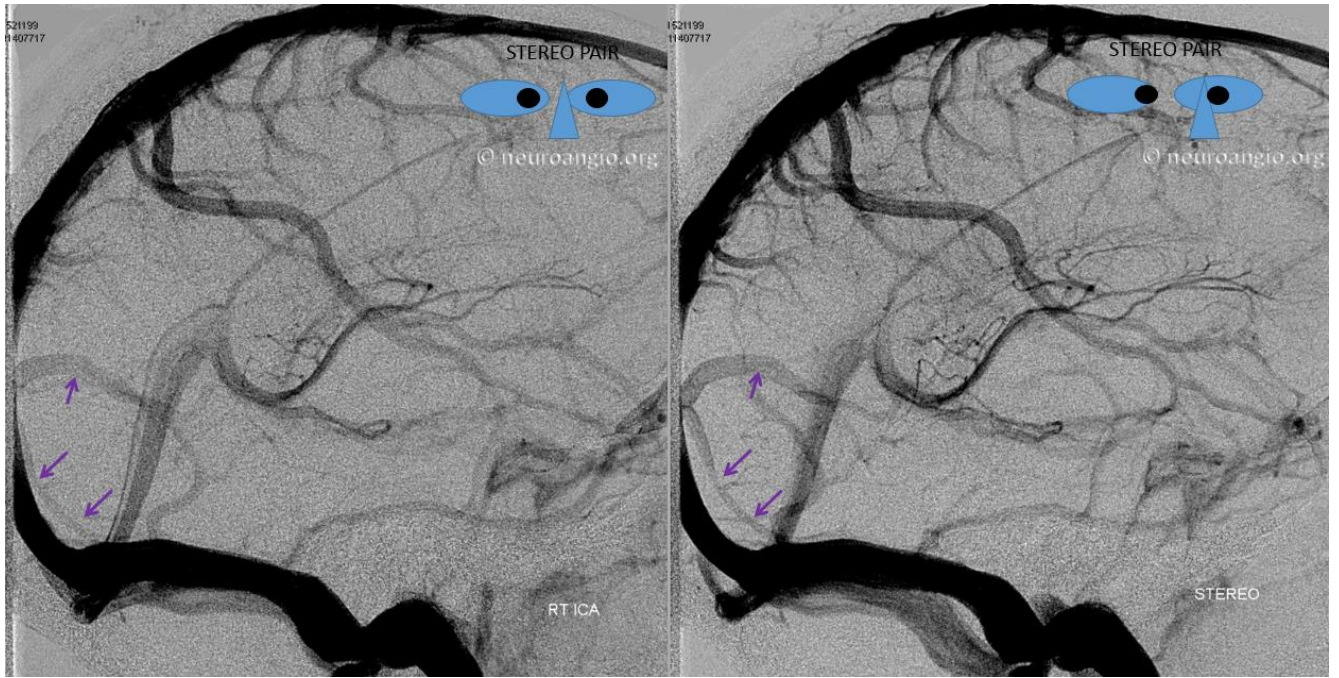
Best way to differentiate on T1w: cortical vein (*light blue arrows*) is located just medial / deep to the dura (*brown arrows*) vs. flattened, oval look of dural venous channel (*white arrow*):



Source of picture: Neuroangio.org >>

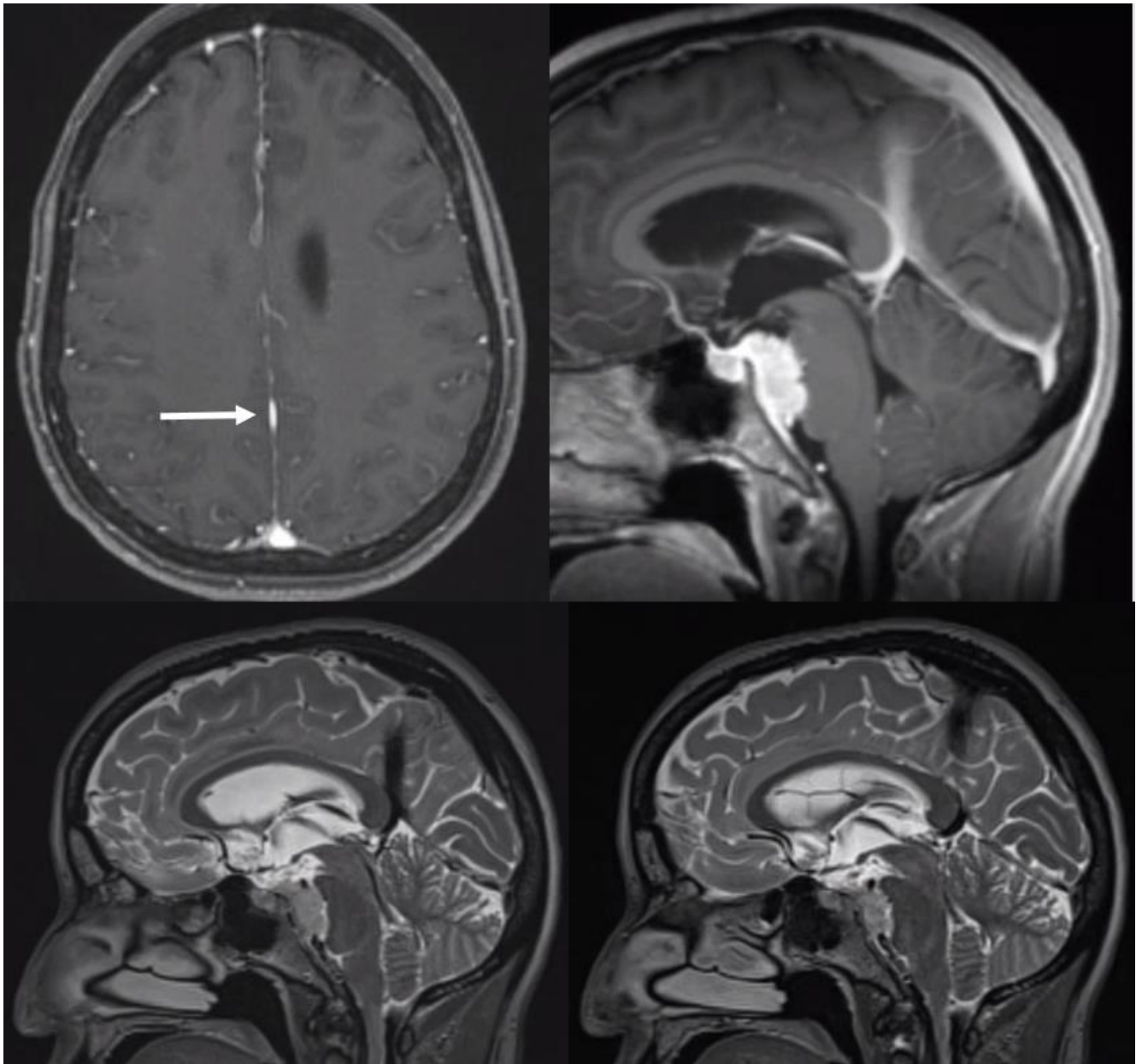
Parieto-occipital sinus (*purple arrows*) which collects regional supratentorial and infratentorial veins, emptying into transverse sinus - only of importance to a surgeon if procedure in the area is being contemplated.





Source of picture: Neuroangio.org >>

Falcine sinus:

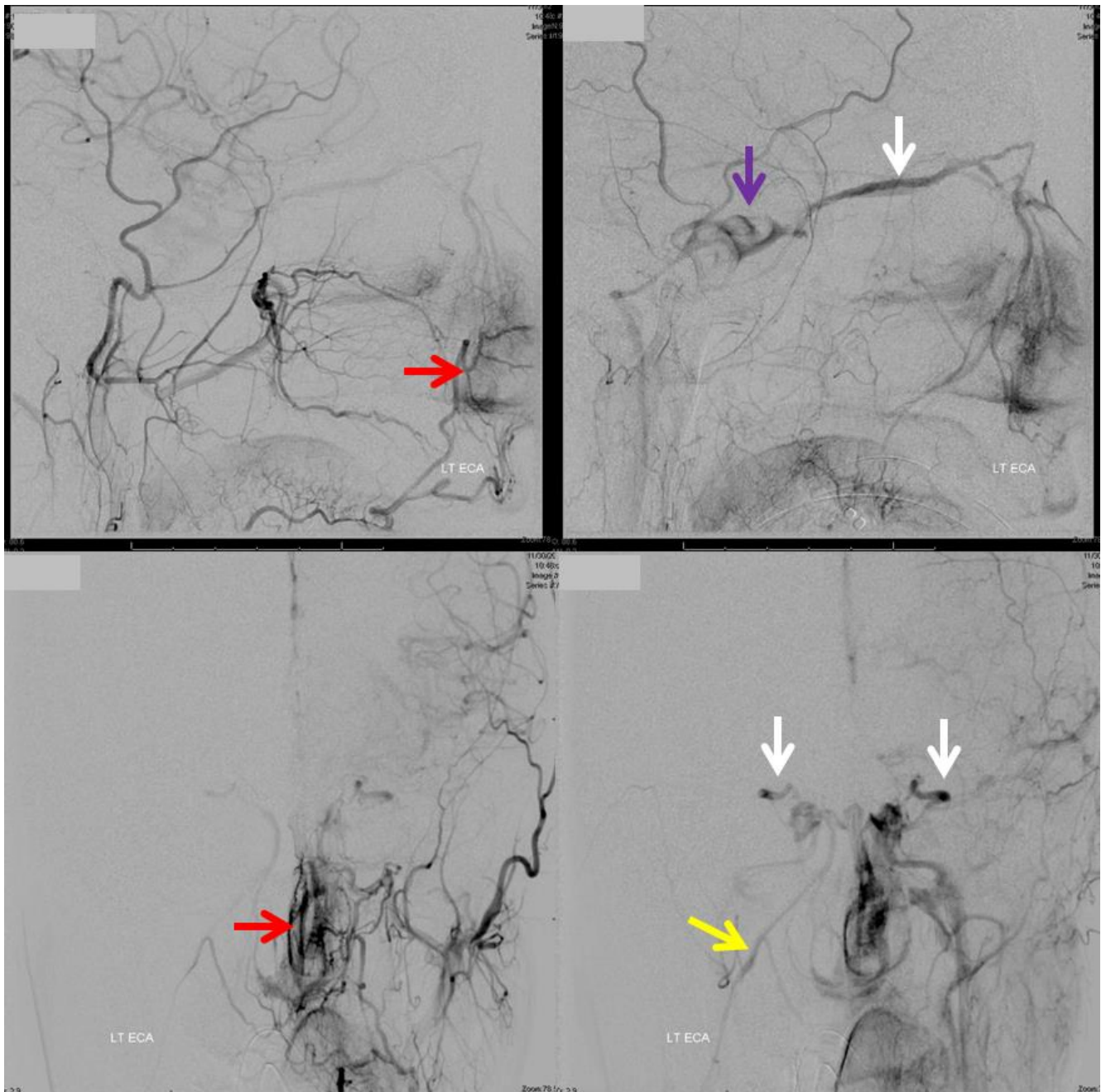


Source of picture: Neuroangio.org >>

OPHTHALMIC VEINS

- receive blood from facial triangle, thus, need ECA or CCA injection (unless there is CC fistula – reverses flow direction in ophthalmic veins).

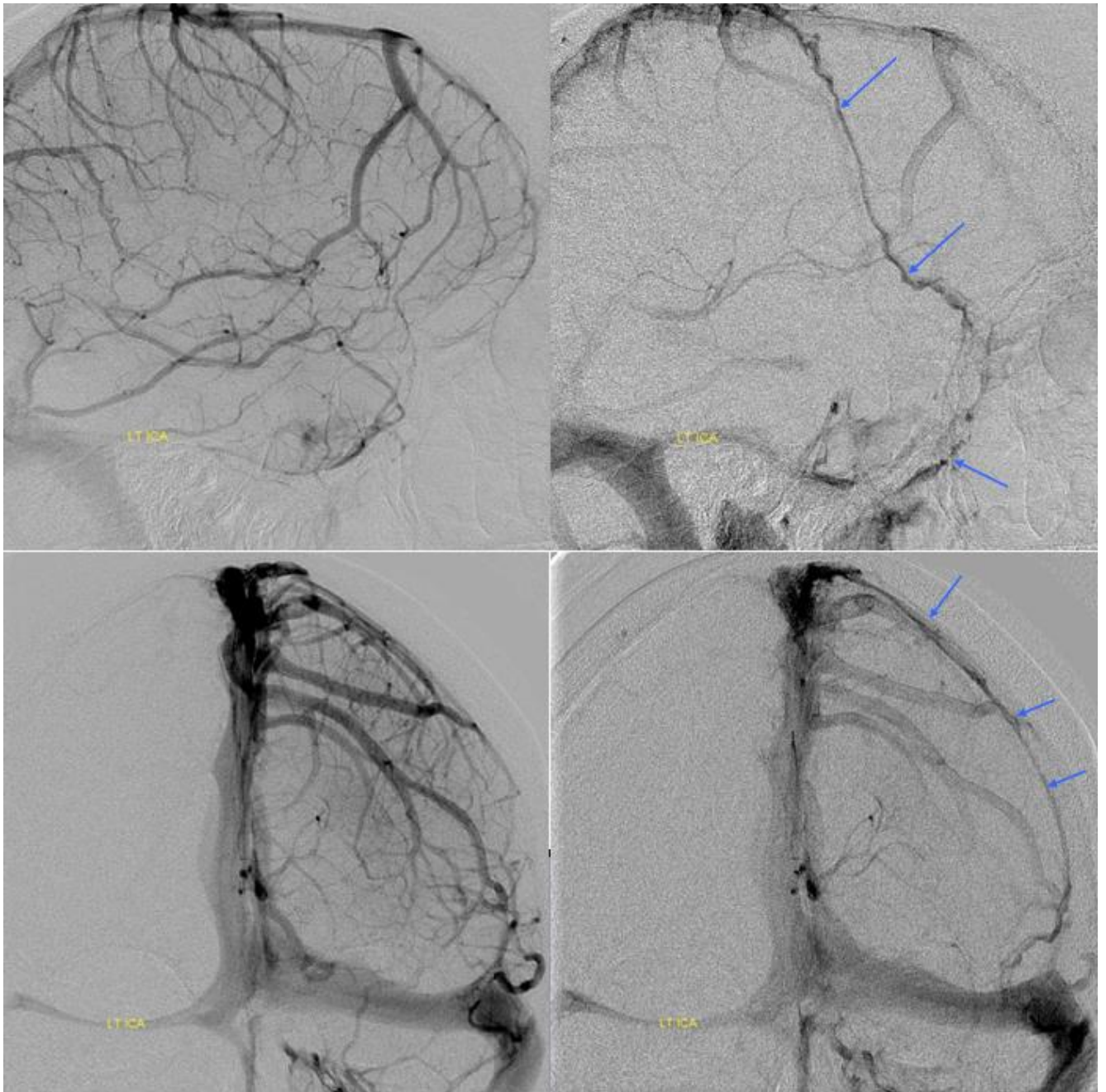
ECA injection - vascular nasal soft tissues (*red*), both SOVs (*white*) draining into both anterior cavernous sinuses (*purple*); notice right angular vein (*yellow*):



Source of picture: Neuroangio.org >>

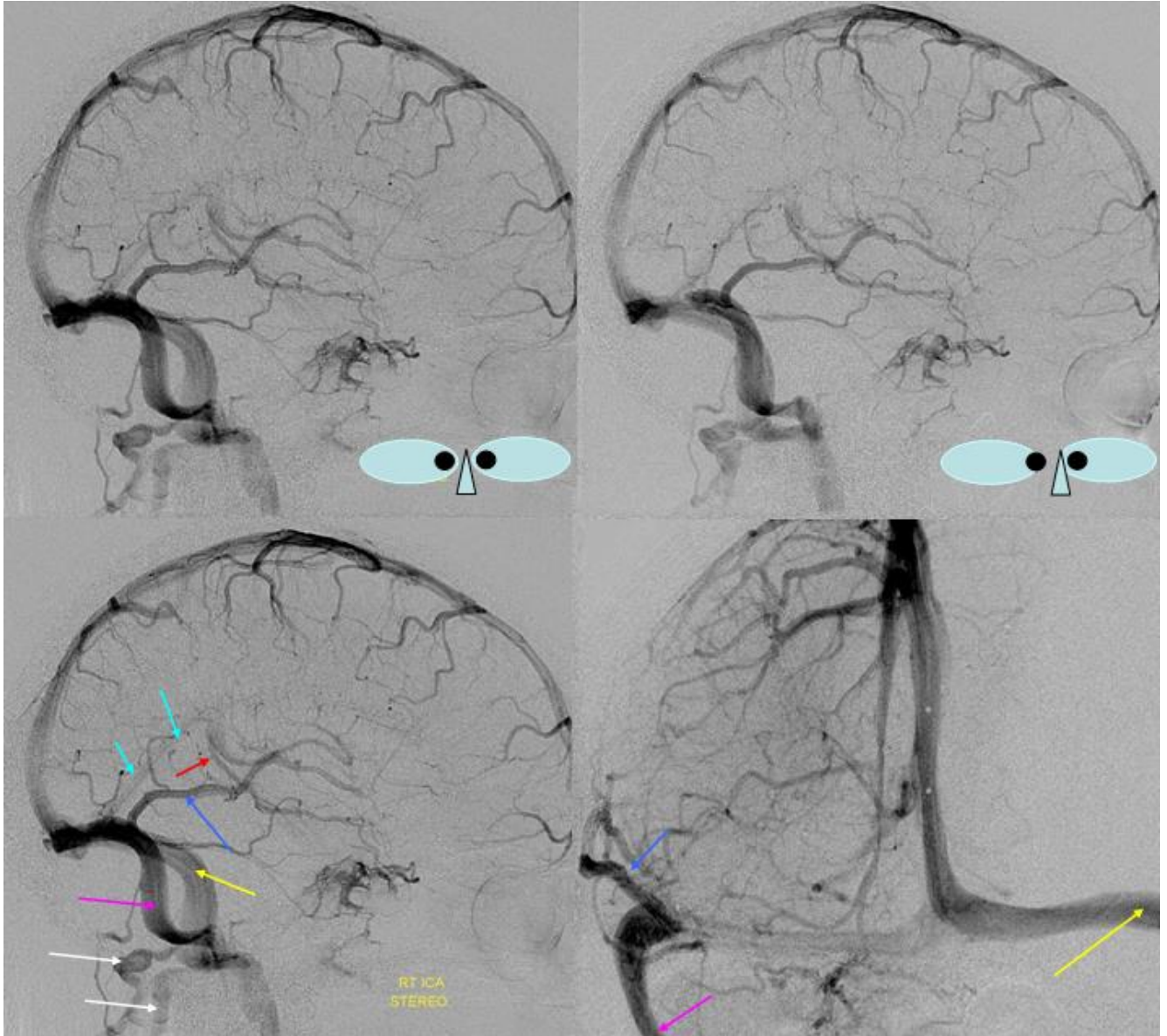
EMISSARY VEINS

Emissary vein near the vertex (from SSS) runs in the subgaleal space towards pterygoid plexus:



Source of picture: Neuroangio.org >>

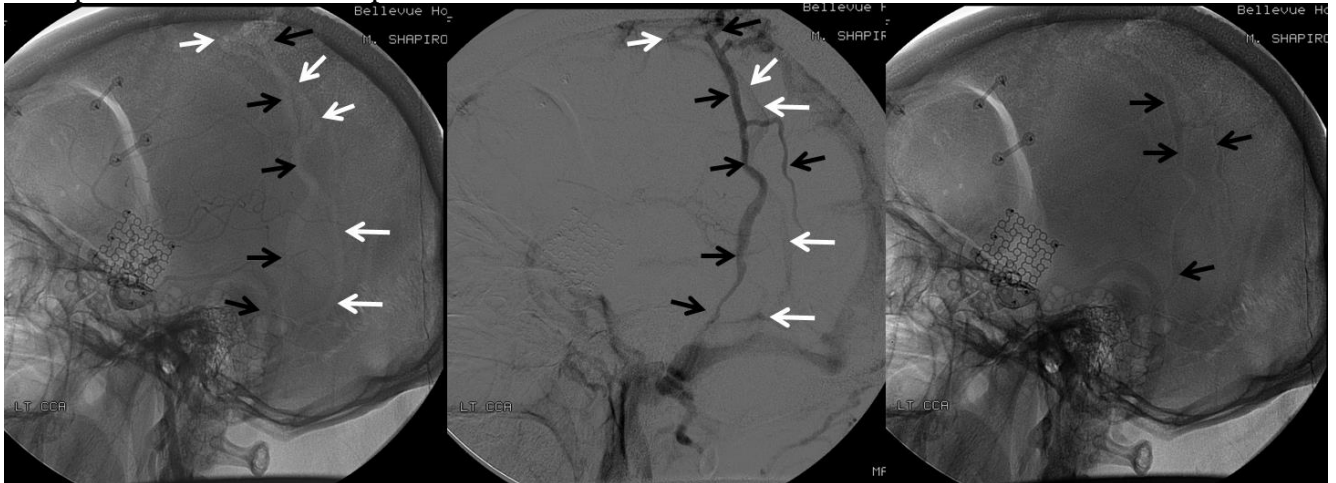
Occipital emissary veins (*white arrows*):



Source of picture: Neuroangio.org >>

DIPLOIC VEINS

Get opacified late in venous phase

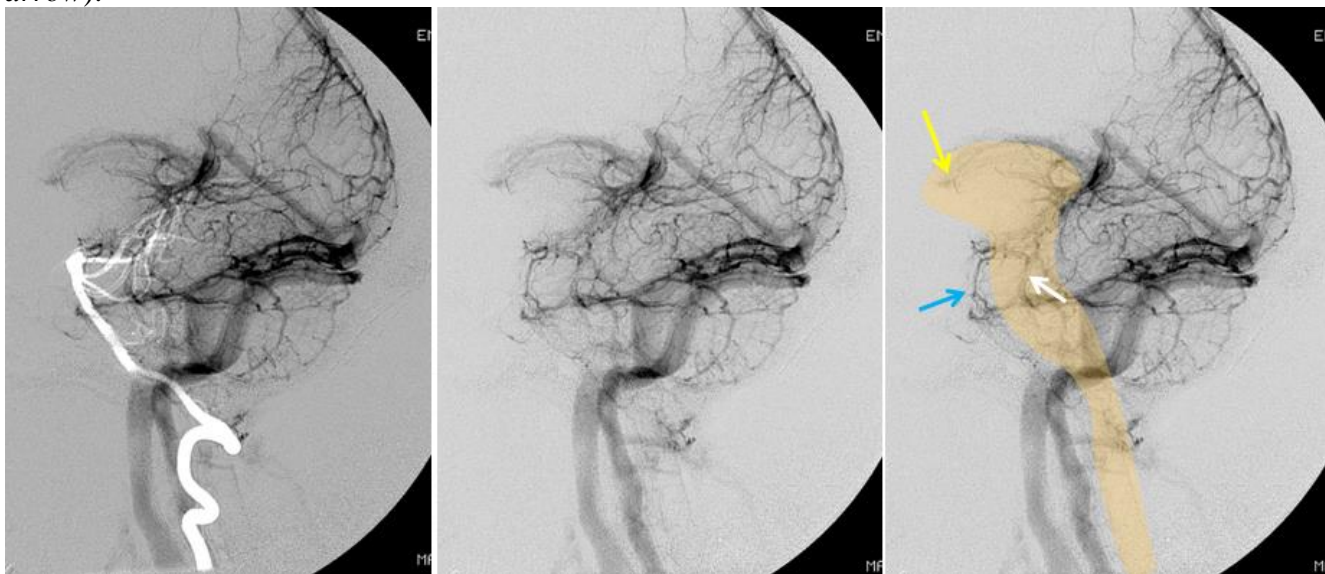


Source of picture: Neuroangio.org >>

POSTERIOR FOSSA

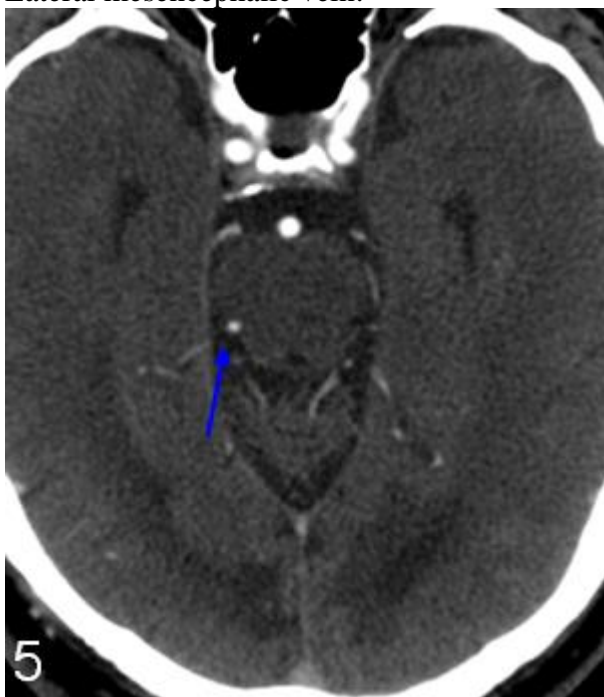
- need bilateral VA injections for best results.

Anterior pontomesencephalic vein (*blue arrow*), more posteriorly located lateral mesencephalic vein (*white arrow*); foramen of Monro is close to anterior most aspect of lateral choroidal vein (*yellow arrow*):



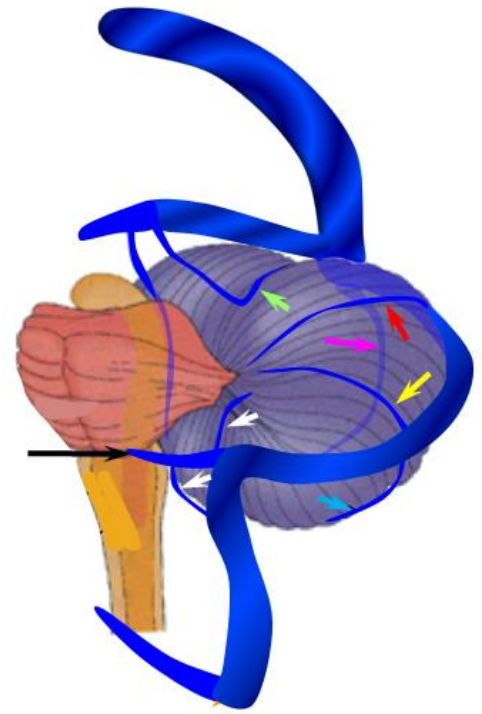
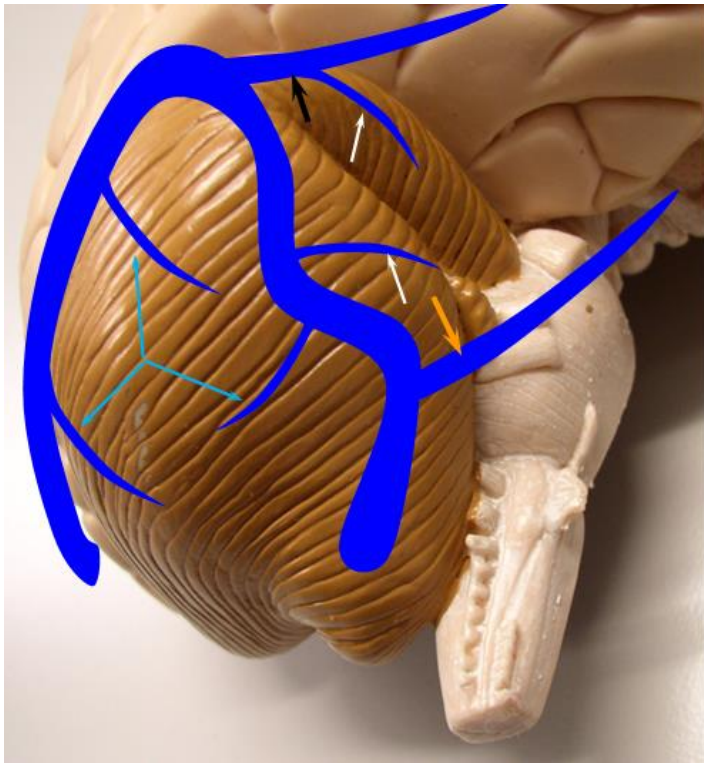
Source of picture: Neuroangio.org >>

Lateral mesencephalic vein:



Source of picture: Neuroangio.org >>

Mesial superior surface vein (*red arrow*) drains into mesial portion of proximal transverse sinus; more lateral superior surface vein (*yellow*) drains into lateral aspect of transverse sinus or proximal sigmoid; anterior veins (*white*) drain into superior petrosal sinus (*black*), inferior petrosal sinus (*orange*), or sigmoid sinus; inferior surface (*blue*) drains into transverse or sigmoid sinus:

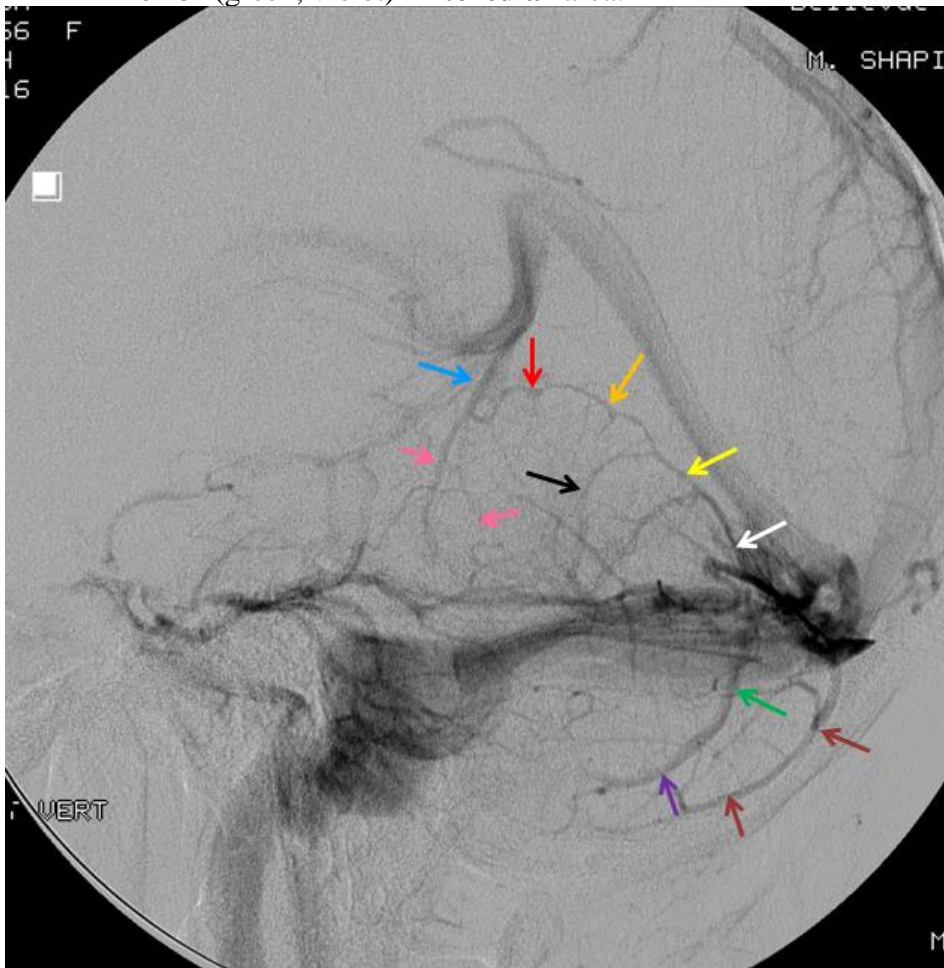


Source of picture: Neuroangio.org >>

Vermian veins:

superior → **precentral vein** (*pink*) → **superior cerebellar vein** (*blue*)

inferior (green, violet) → **torcular area**.



Source of picture: Neuroangio.org >>

BIBLIOGRAPHY for ch. "Vascular" → follow this [LINK >>](#)
Neuroangio >>

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