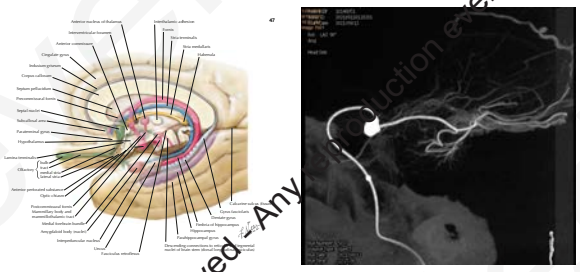
2023 01 15 ABC/WIN seminar in Val d'Isere

Vascular Anatomy of the Limbic System



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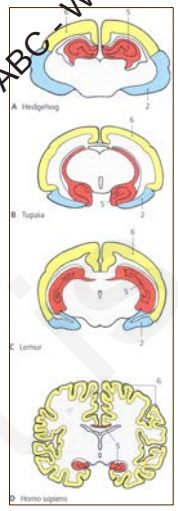
Menu

1. The phylogeny and the functional anatomy of the limbic system
2. Arterial anatomy of the limbic system
   - Anterior ethmoid artery, Olfactory artery, Recurrent artery of Heubner
   - Anterior choroidal artery (Uncal artery)
   - Posterior choroidal artery (Artery of Uchimura)
   - Pericallosal artery (Cingulate gyrus)
   - Posterior cerebral artery (isthmus part of CG)
3. Venous anatomy of the limbic system

Conflict of Interest Statement

The presenter declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



Phylogenesis of the cerebral cortex

During the phylogenesis of mammals the proortion of the paleopallium and the archipallium decreased,while the neopallium became dominant occupying almost the whole surface of the brain.

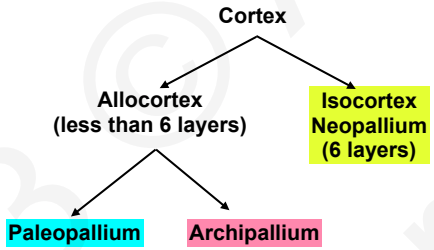
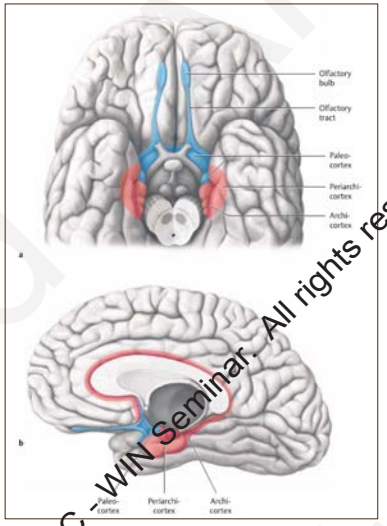


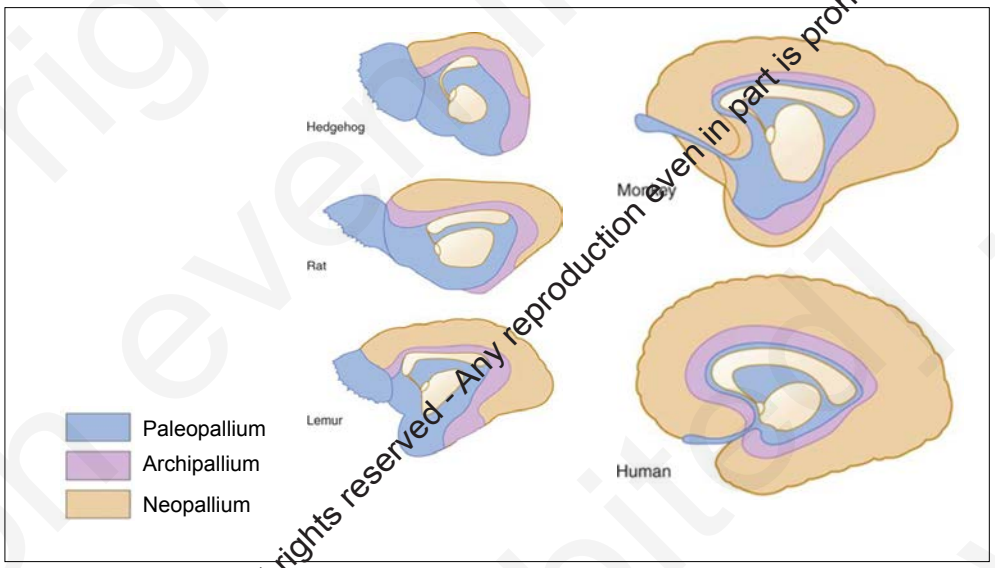
Fig.1

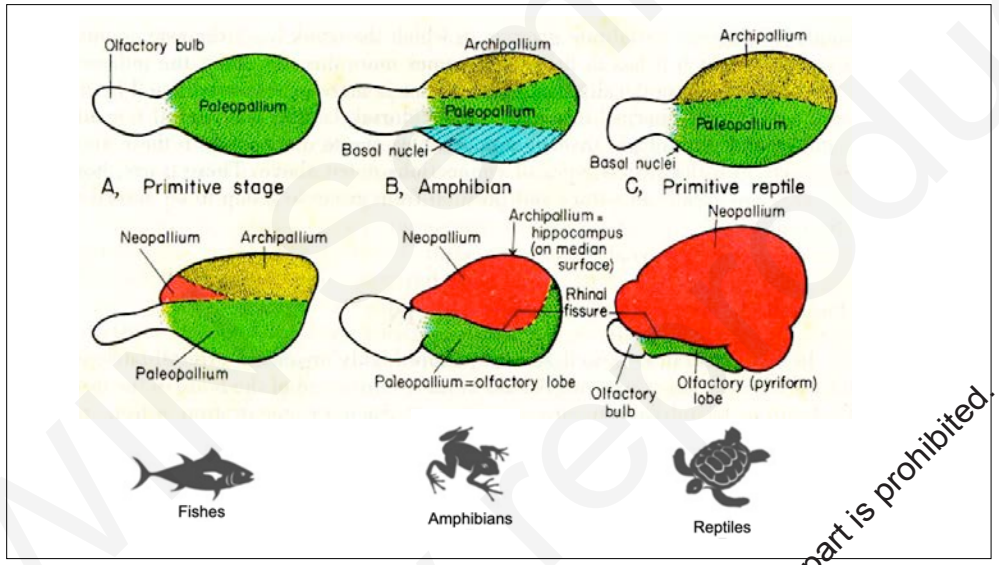


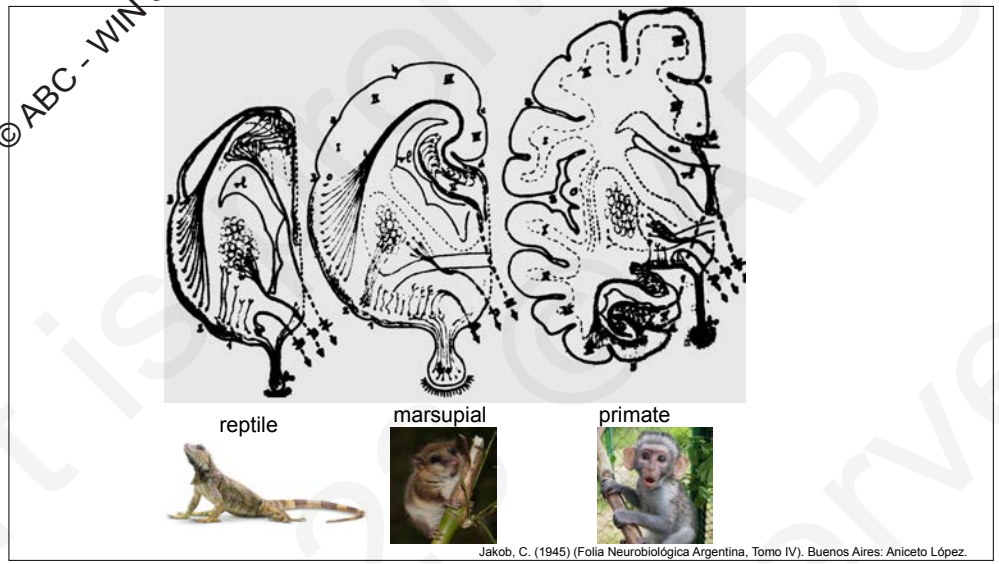
Paleopallium: The oldest cortical area of the telencephalon which contains 3 to 5 layers of neuronal cell bodies. Paleopallium includes the olfactory bulb, olfactory tubercle (approx. at the anterior perforated area) and the piriform cortex (approx. the uncus and the anterior part of the parahippocampal gyrus). All those cortical and non-cortical areas which are related to the sense of smell are summarized as the rhinencephalon or olfactory brain.

Archipallium: Constituted by 3 to 4layers of neurons and includes the hippocampus and related structures (dentate and fasciolar gyri, indusium griseum).

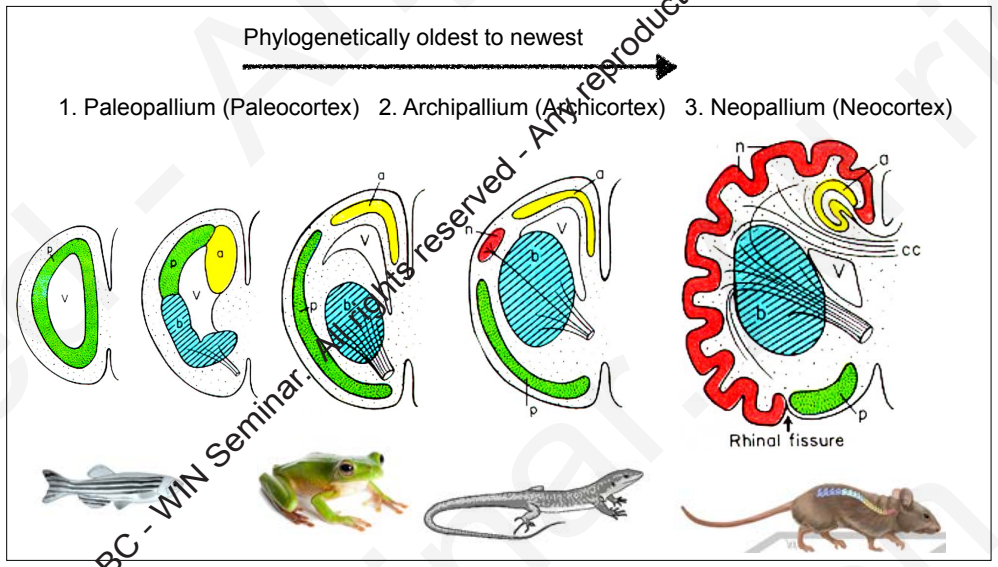
Neopallium: occupies approx. 90% of the total cerebral hemispherial surface. 6 layers of neuronal cell bodies are present.

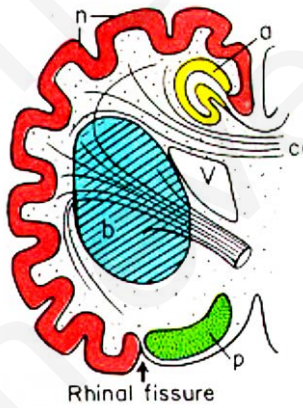


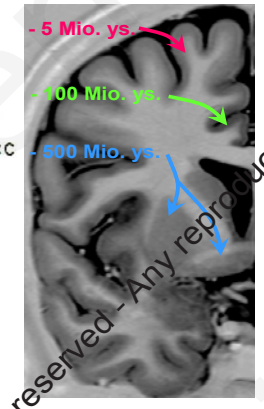


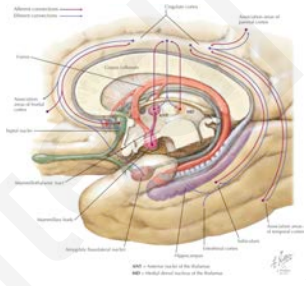


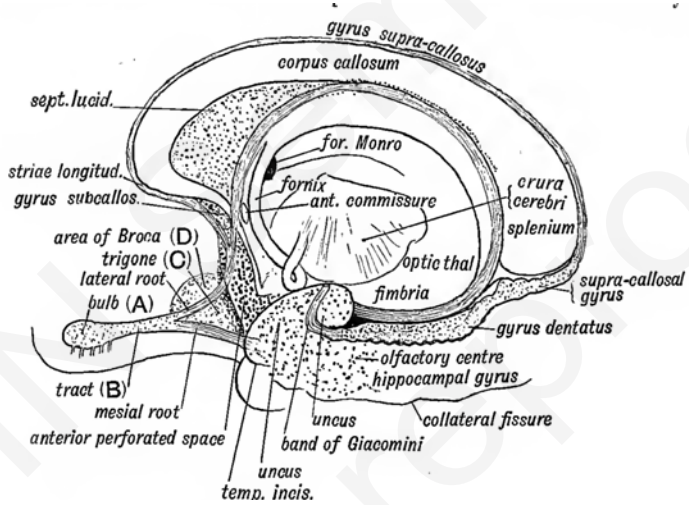
Jakob, C. (1945) (Folia Neurobiológica Argentina, Tomo IV). Buenos Aires: Aniceto López.



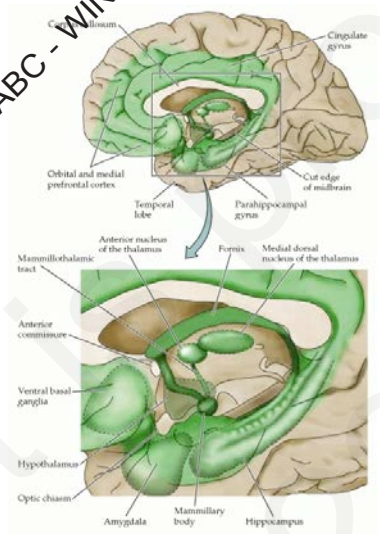








Keith A.Human Embryology and Morphology Nature volume 66, pages 603–604 (1902)



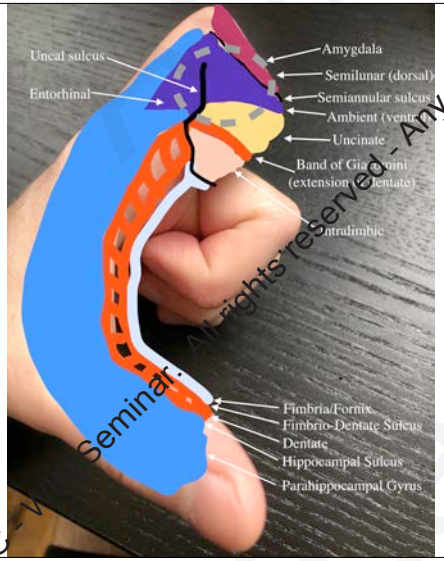
What is the limbic system ?

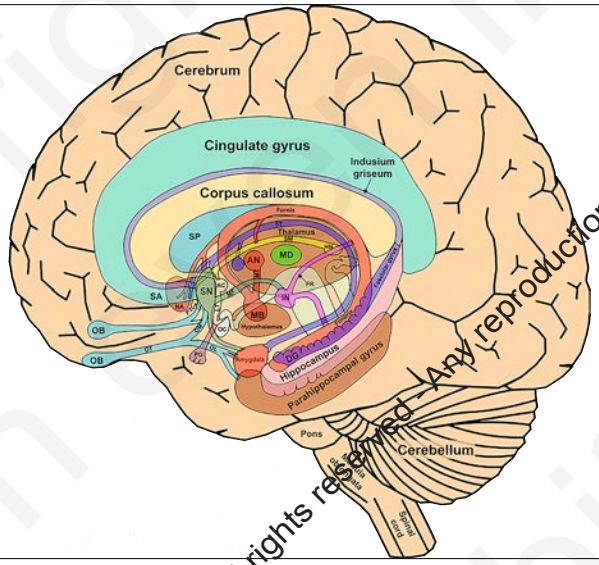
The limbic system is composed of four main parts: the hypothalamus, the amygdala, the thalamus, and the hippocampus. There are several other structures that may be involved in the limbic system as well, but scientists have not reached a unanimous consensus on them.

The limbic lobe is a horseshoe-like structure formed mainly of the subcallosal gyrus, cingulate gyrus, parahippocampal gyrus, and hippocampus.

It should be noted that its inclusion as one of the lobes of the brain is a little contentious, with most authors referring to it as part of the 'limbic system' rather than as a lobe.

Purves D, et al., The Limbic System. editors. Neuroscience. 2nd edition. Sunderland (MA): Sinauer Associates; 2001.





AC Anterior commissure
AN Anterior nucleus of thalamus
DG Dentate gyrus
FR Fasciculus retroflexus
IN Interpeduncular nucleus
LT Lamina terminalis
MB Mammillary body
MD Mediodorsal thalamic nucleus
MF Medial forebrain bundle
MT Mammillothalmic tract
NA Nucleus accumbens
OB Olfactory bulbs
OC Optic chiasm
OL Olfactory striae lateral
OS Olfactory striae medial
OT Olfactory tract
PG Pituitary gland
PT Paraterminal gyrus
SA Subcallosal area
SM Stria medullaris
SN Septal nuclei
SP Septum pellucidum
ST Stria terminallis

Limbic system

Olfactory bulb: Recognizes smell and associate it with memories, Discriminate odors
Filter background odors

Cingulate gyrus: Generates emotions, learning and memory, Respiratory control
Corpus callosum: Area of communication between the two hemispheres
Fornix: Connection between hypothalamus, mamillary bodies thalamus and cingulate cortex
Mamillary body: Memory recognition,Links memory with smell, Feeding reflexes
Thalamus: Multiple relay functions, Regulates sleep and wakefulness
Involved in connections related to consciousness
Hippocampus: Long term memory, Spatial location (first affected by Alzhimer's disease)
Dentate gyrus: Formation of memories and depression
Amygdala: Process and memory of emotions.
Parahippocampal gyrus: Memory encoding and retrieval
Basal ganglia: Motor control and learning, Affected by Parkinson's disease
Hypothalamus: Regulates vegetative functions ,Endocrine control

The arterial system for the limbic lobe

1. Primitive olfactory artery. (olfactory nerve, medial and lateral stria of the olfactory tract)
2. Recurrent artery of Heubner (Nuclei Accumbens, Olfactory tract)

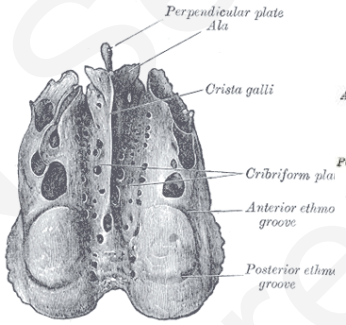
3. P1 perforators and the perforators from the posterior communicating artery (Mammillary bodies, and their projections to the anterior thalamus via the mammillothalamic tract)
4. Subcallosal artery (branch) from anterior communicating artery (lamina terminalis, Septal area :Area septalis, anterior commissure,)
5. The hypothalamo-chiasmatic branches or the antero inferior diencephalic arteries as called by Lang. These branches feed the infundibulum, optic chiasm, subcallosal area, the fornix, and the preoptic areas of the hypothalamus.
6. Pericallosal artery from anterior cerebral artery. (cingulate gyrus, indusium griseum)

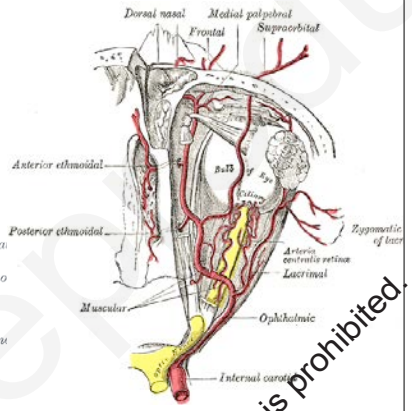
7. Anterior choroidal artery and posterior choroidal artery.
Uncal branch (amygldalo hippocampal formation)
Three arteries (or group of arteries) usually vascularize the hippocampus: the anterior, middle, and posterior hippocam- pal arteries. The anterior and middle arteries arise either from the trunk of the posterior cerebral artery or from its inferior temporal branches, whereas the posterior hippocampal artery frequently arises from the splenial artery, a branch of the posterior cerebral artery. The branches of the longitudinal terminal segment of superficial hippocampal arteries are divided into large and small arteries.

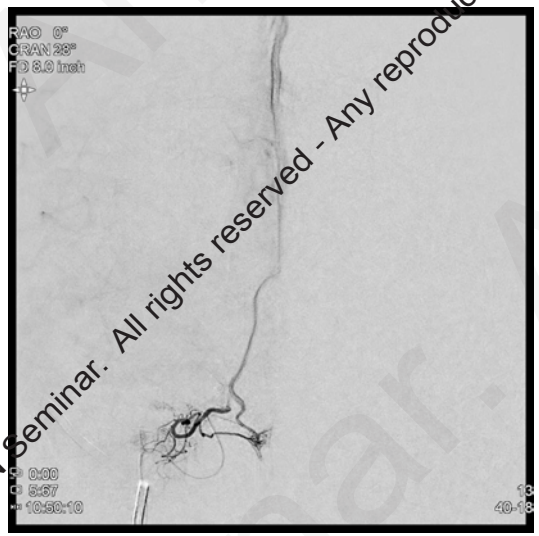
8. Artery of Uchimura (posterior hippocampal artery)

Anterior ethmoid artery, Olfactory artery, Recurrent artery of Heubner
Anterior choroidal artery (Uncal artery)
Posterior choroidal artery (Artery of Lüschimura)
Pericallosal artery (Cingulate gyrus)
Posterior cerebral artery (isthmus part of CG)

The bulbus olfactorius is supplied by
anterior ethmoid artery and olfactory artery







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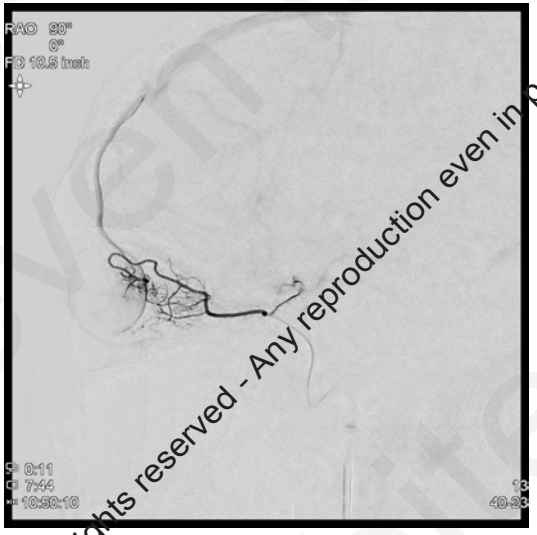

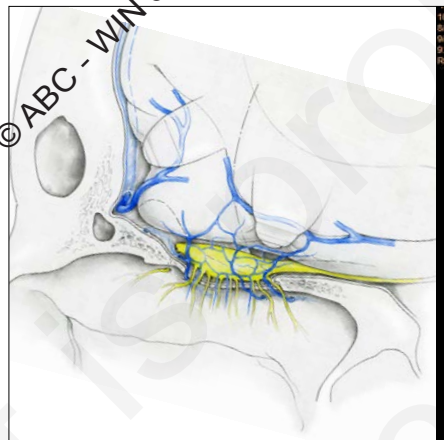

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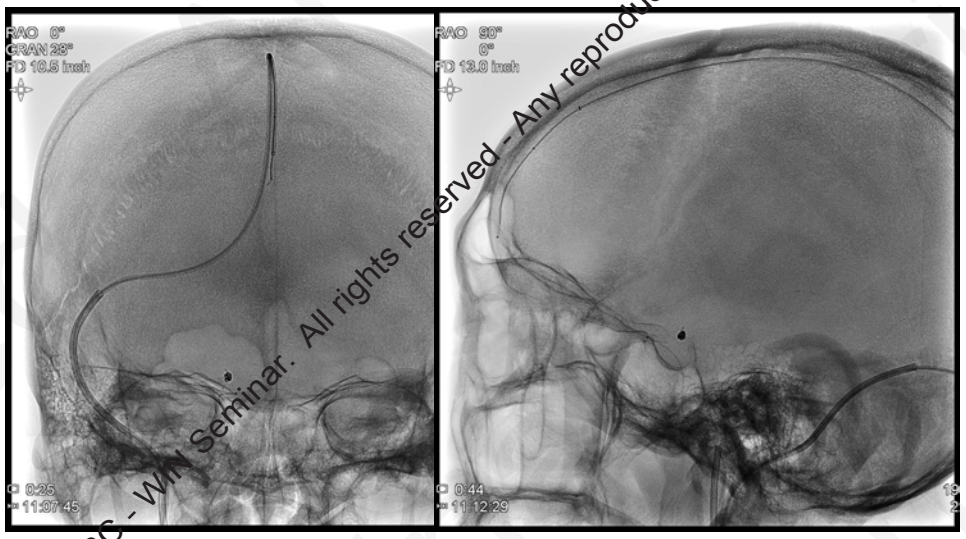
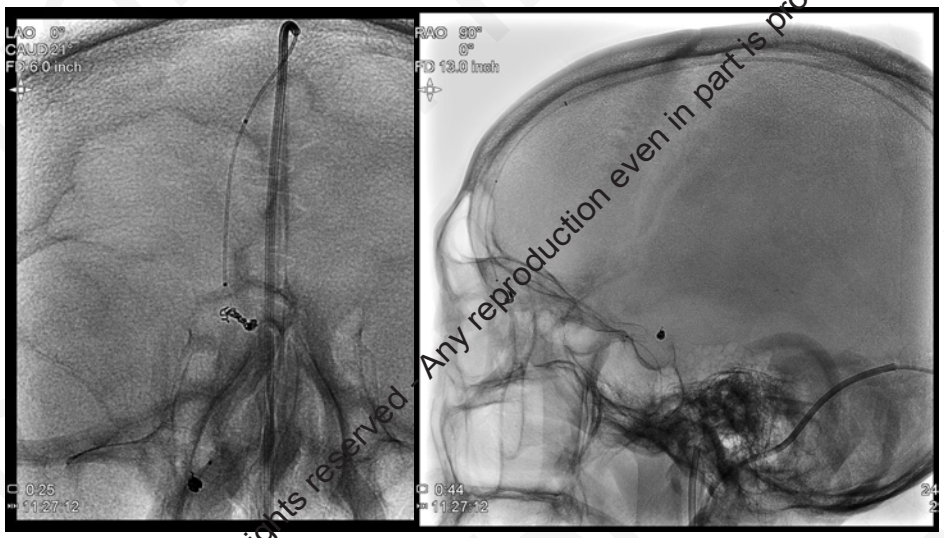
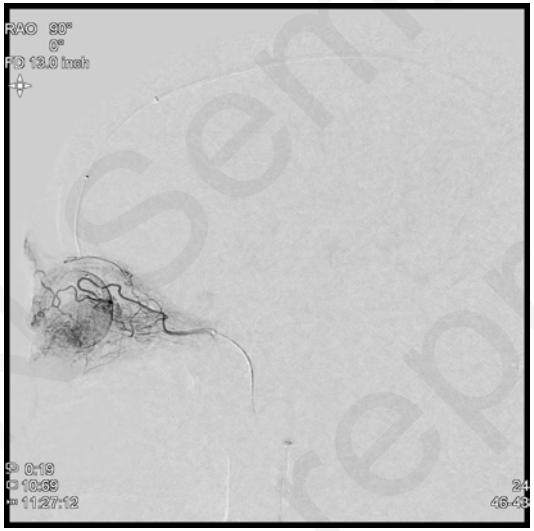
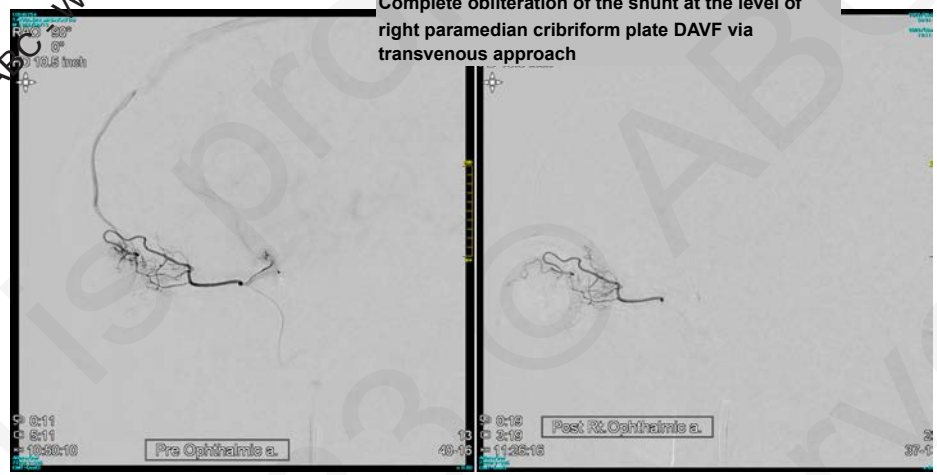


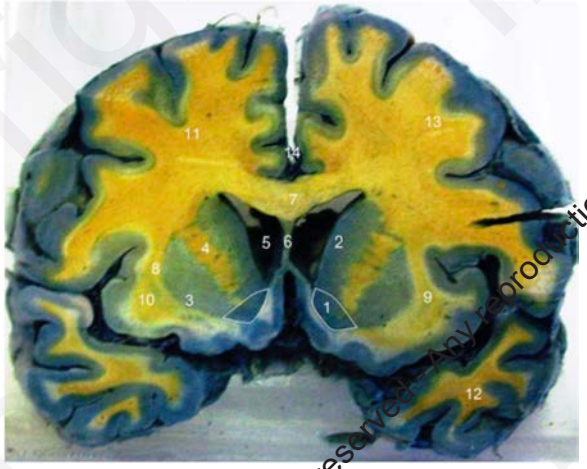






Pre Post

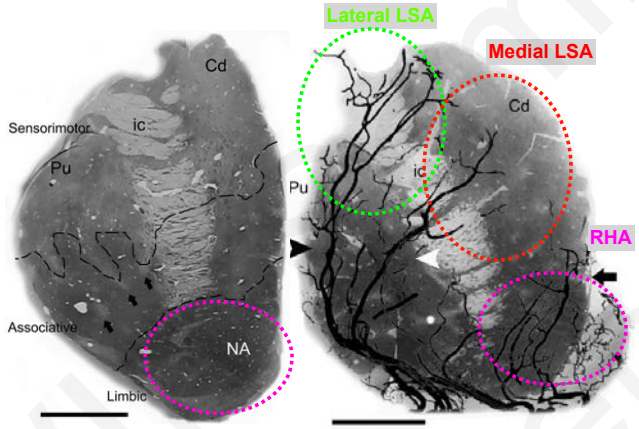
Anterior ethmoid artery, Olfactory artery,
Recurrent artery of Heubner (perforators from A1A2 junction)
Anterior choroidal artery (Uncal artery)
Posterior choroidal artery (Artery of Uchimura)
Pericallosal artery (Cingulate gyrus)
Posterior cerebral artery (isthmus part of CG)



1. Nucleus accumbens (gray mater appears blue).

2 head of the caudate nucleus, 3 putamen, 4 anterior limb of the internal capsule, 5 frontal horn of the lateral ventricle, 6 septum pellucidum, 7 corpus callosum, 8 external capsule, 9 claustrum, 10 extreme capsule, 11 frontal lobe, 12 temporal lobe, 13 middle frontal gyrus, 14 intrahemispheric fissure

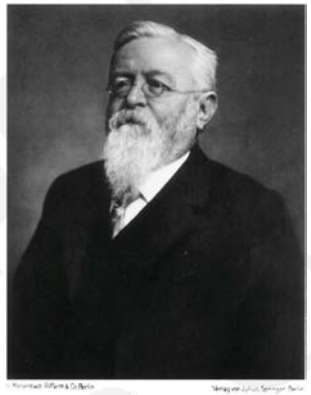
Mavridis I, et al. Anatomy of the human nucleus accumbens: a combined morphometric study. Surg Radiol Anat 2011;33:405–14.



Calbindin (CB)-immunostained 50 mM thick section
from human striatum with overlap of barium sulphate-injected (inverted) medial (open arrowhead) and lateral (closed arrowhead) lenticulostriate arteries (LSA) and **the recurrent artery of Heubner (RAH) (arrow)** from 1.27 cm thick section. Figure shows arrangement of penetrating vessels within striatum mainly co-registering with the matrix compared to striosomes (*). CB-immunoreactive section also shows dorsal–ventral
gradient of weak to strong labelling which corresponds to sensorimotor, associative and limbic corticostriatal zones, respectively. Note co-registering between the lateral LSA and weak CB labelling, the medial LSA and intermediate labelling, and the RAH and strong labelling. Cd, caudate nucleus;
ic, internal capsule; and Pu, putamen. Line bar = 1 cm.

→ NA(nucleus accumbens) a part of the limbic system is supplied from the recurrent arttery of Heubner

Feekes JA,et al. The vascular supply of the functional compartments of the human striatum. Brain 2006;129:2189–201.



Heubner

Photograph of Johann Otto Leonhardt Heubner taken in his later years. From Heubner O: Festschrift. Berlin: Julius Springer, 1913. Reprinted with permission of Springer-Verlag GmbH & Co. KG.

J.Neurosurg. 2000 Volume 93, Number 6

Wöchentlich erscheinen 1–2 Bogen; am Schlusse des Jahrgangs Titel, Namen- und Sachregister.

Centralblatt

für die

medicinischen Wissenschaften.

Preis des Jahrganges 5⅓ Thlr.; zu beziehen durch alle Buchhandlungen und Postanstalten.

Redigirt von

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und

Dr. H. Senator, Privatdocent in Berlin.

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Inhalt: Heubner, Ernährungsgebiet der Hirnarterien (Orig.-Mitth.). — Wilkens, Magen der Wiederkäuer (Schluss). — Holmgren, Farbenempfindung. — Bisch[illegible]feld, der acute Milztumor. — Riegel, Enge des Aortensystems. — Wright, asthenische Geisteskrankheit. — Weaby & Nasmyth, Atheroma cranii. — Quesnel, Unterbindung der Femoralis bei Elephantiasis. — Howman, Pupillenbildung. — Tobold, Laryngoscop. — Bu[illegible], Nachbehandlung nach Ovariotomie. — Wright, Fälle von asthenischer Geisteskrankheiten.

Zur Topographie der Ernährungsgebiete der einzelnen Hirnarterien.

Von

Dr. Heubner,

Privatdocent d. M. in Leipzig.

A reproduction of the first page of Heubner's manuscript in which he identifies the medial striate artery.

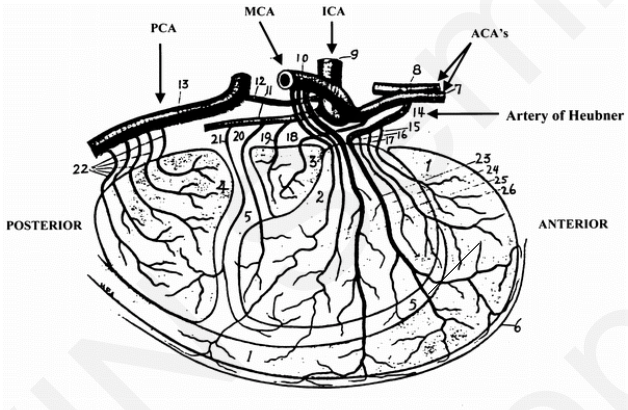
From Heubner O: [On the topography of the nutritional zones of the individual brain arteries.] Zentrabl Med Wiss 10:817-821, 1872 (Ger).

As depicted in this illustration, Heubner's artery supplies the caudate, putamen, and anterior limb of the internal capsule.

The medial striate artery of Heubner arises from the A2 segment in 78% of cases. Less commonly, it arises from the A1 segment (14%) or at the level of the ACoA (8%). In 95% of cases it originates within 4 mm of the ACoA junction (either proximally or distally).

Perlmutter and Rhoton found this artery to be absent (only on one side) in 2% of cases and duplicated (also only on one side) in 2% of cases. By contrast, Gomes and colleagues7 found this artery to be absent in 3% of cases and duplicated in 12% of cases.

On average, the diameter of the recurrent artery of Heubner (mean 1 mm, range 0.2-2.9 mm) is approximately one third the diameter of the A1 segment (mean 2.6 mm). In comparison, the length of the recurrent artery of Heubner (mean 23.4 mm, range 12-33 mm)7 is on average twice the length of the A1 segment (mean 12.7 mm). The greater length of the recurrent artery of Heubner increases its exposure to injury during surgery.



(1), putamen (2), globus pallidus (3), thalamus (4), and internal capsule (5). The anterior circulation is illustrated by the internal carotid artery ([ICA] 9), middle cerebral artery ([MCA] 10), and ACA (7). Branching off the ACA near the ACoA (8) is the vessel that Aitken refers to in his report as Heubner's artery or system (14). As depicted in this illustration, Heubner's artery supplies the caudate, putamen, and anterior limb of the internal capsule. Other major arteries in the drawing include the anterior choroidal artery (11), posterior communicating artery (12), and posterior cerebral artery ([PCA] 13). From Aitken HF: A report on the circulation of the lobar ganglia: made to Dr. James B. Ayer. Boston Med Surg J Suppl 160:25, 1909.

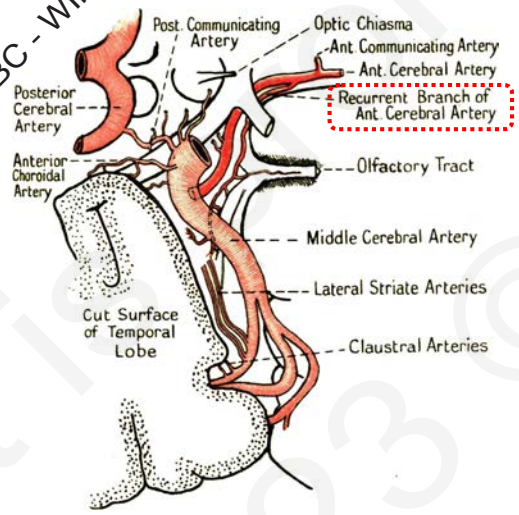
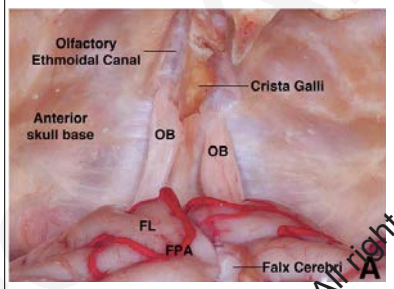
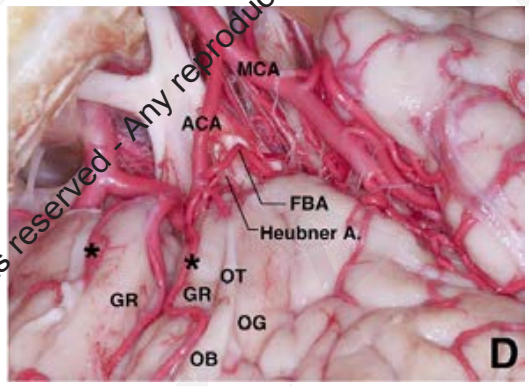


Illustration from Shellshear's article in which the medial striate artery is first referred to as the "recurrent artery" (arrow). From Shellshear JL: The basal arteries of the forebrain and their functional significance. J Anat 55:27-35, 1920. Rprinted with permission of Cambridge University Press.



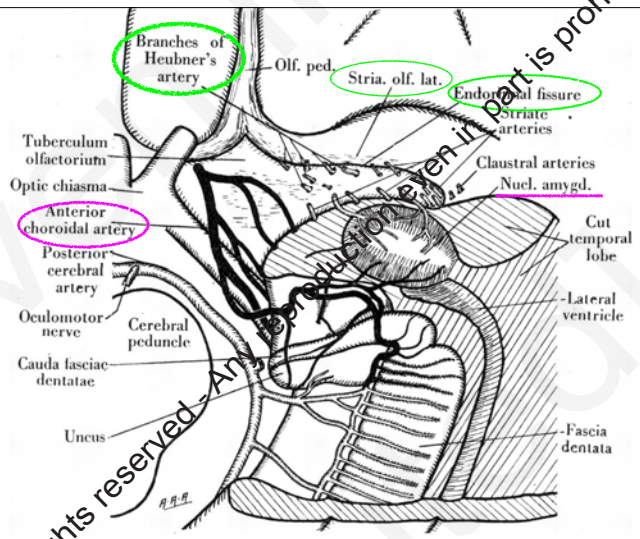


Both **olfactory arteries (*)** originate from the ipsilateral anterior cerebral arteries, beyond the origin of the frontobasal artery, and the recurrent artery of Heubner.

ACA, anterior cerebral artery; AChA, anterior choroidal artery; Ant. Clin. P., anterior clinoid process; Car. A, carotid artery; CN II, cranial nerve II; CN III, cranial nerve III; FL, frontal lobe; FBA, frontobasal artery; FPA, frontopolar artery; GR, gyrus rectus; Heub- ner A., recurrent artery of Heubner; MCA, middle cerebral artery; OB, olfactory bulb; OG, orbital gyri; ON, olfactory nerve; OT, olfactory tract; PCA, posterior cerebral artery; PCoA, posterior communicating artery; Perf. A., perforat- ing arteries; Pit. Stalk, pituitary stalk; Planum Sph., planum sphenoidale; Post. Clin. P., posterior clinoid process.

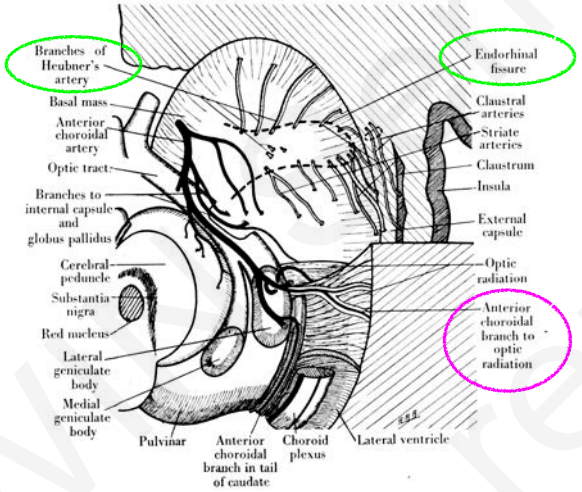
Human brain dissected from the base to show the distribution of the striatal branches through the anterior perforated space and endorhinal fissure.

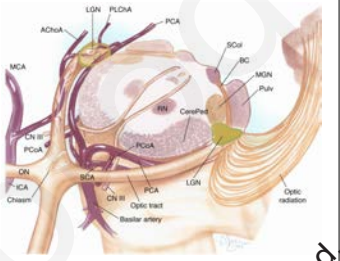
This shows also the **double blood supply to the amygdaloid nucleus** and the distribution of the arteries to the uncus and fascia dentata. Anterior choroidal artery black.



Abbie AA. The Morphology of the Fore-Brain Arteries, with Especial Reference to the Evolution of the Basal Ganglia. Journal of anatomy 1934; 68: 433–70.

RAH supplies paleopallium in the level of entorhinal fissure.





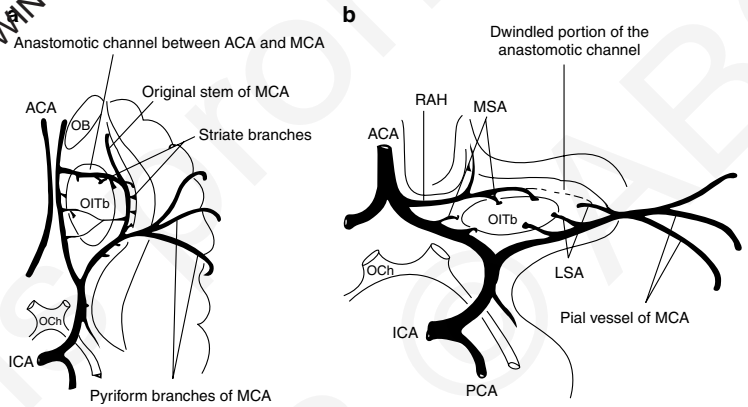
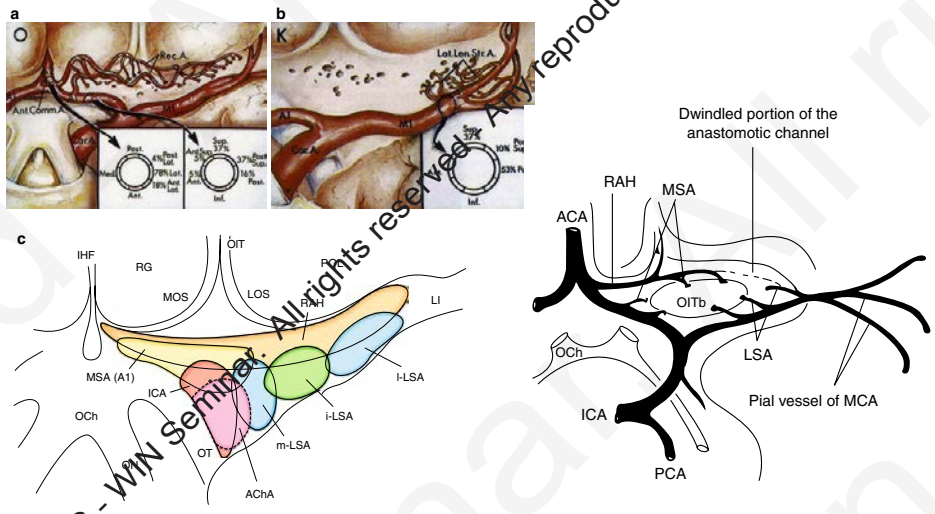
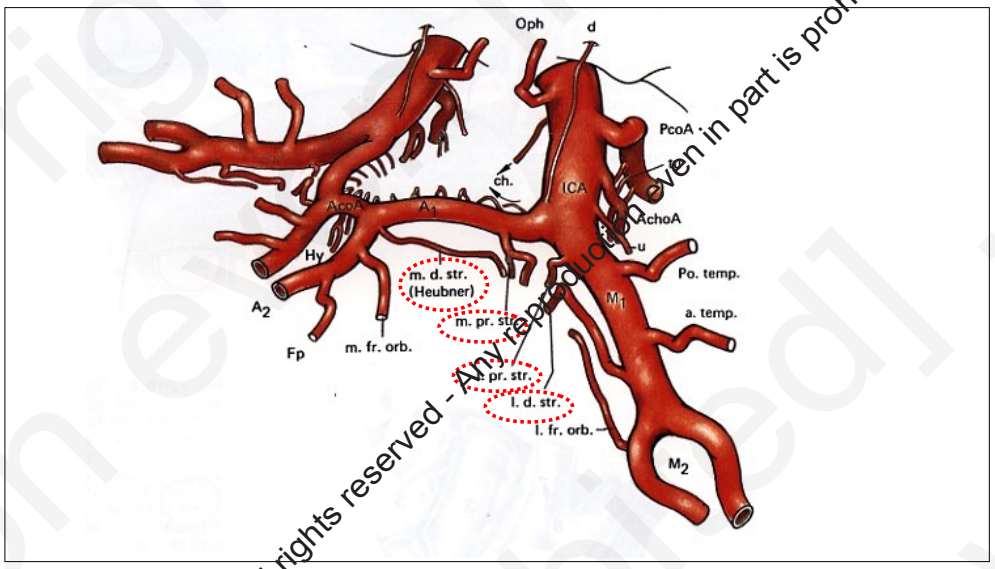
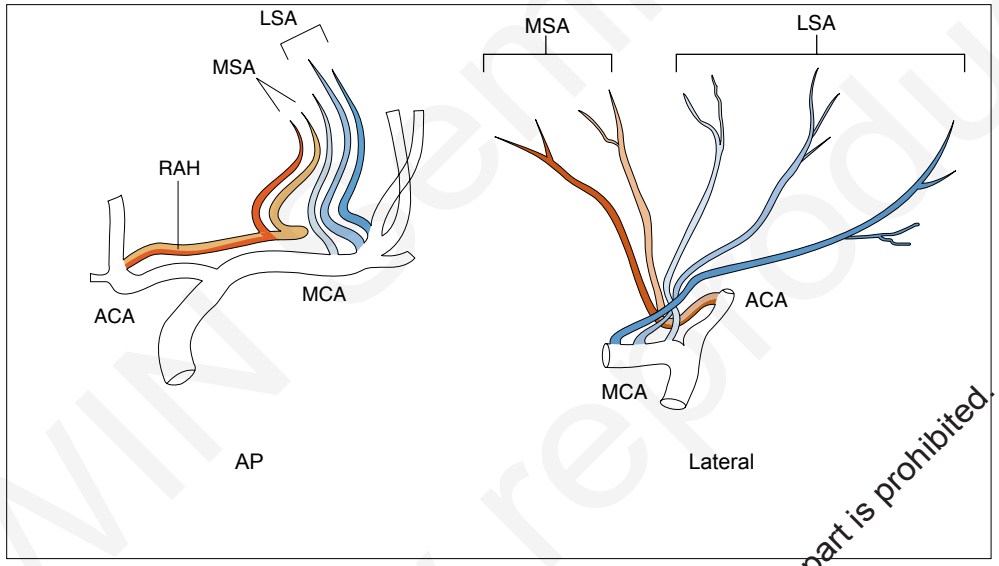


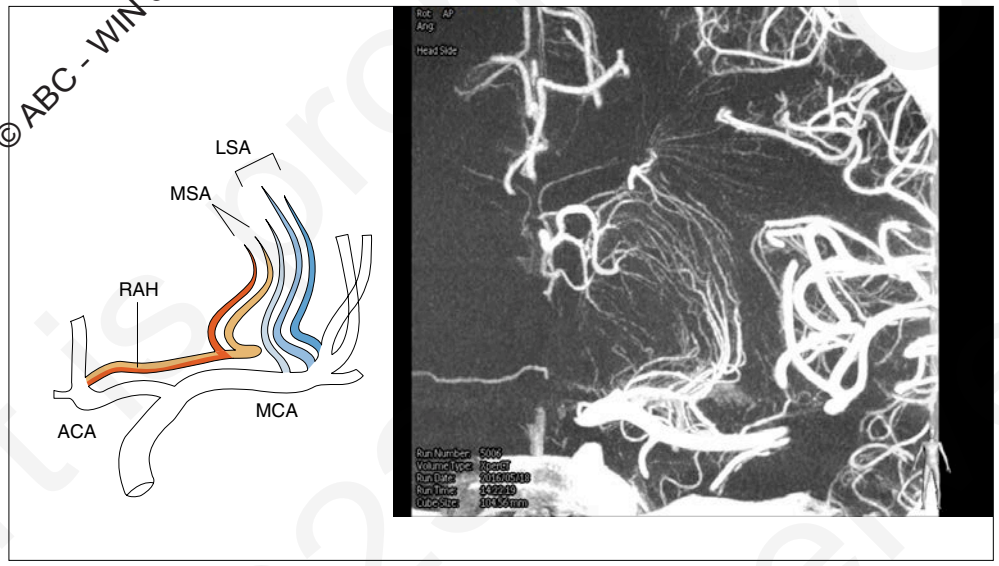
Diagram of the phylogenetic development of the RAH drawn based on the study of Abbie

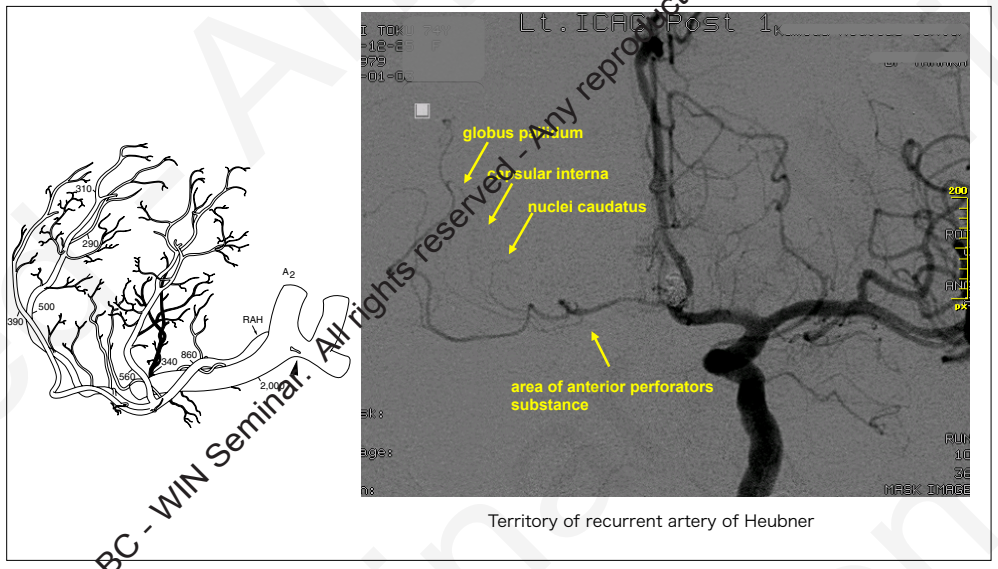
(a) Basal surface of a marsupial forebrain. Note the anastomotic channels between the ACA and the original stem of the MCA, one of which is the predecessor of the RAH. (b) Basal surface of a primate forebrain. The continuation of the ACA channel enlarges and that of the MCA gradually disappears, thus completing the formation of the RAH. ICA internal carotid artery; LSA lenticulostriate arteries; MSA medial striate arteries; OB olfactory bulb; OCh optic chiasm; OlTb olfactory tubercle; PCA posterior cerebral artery

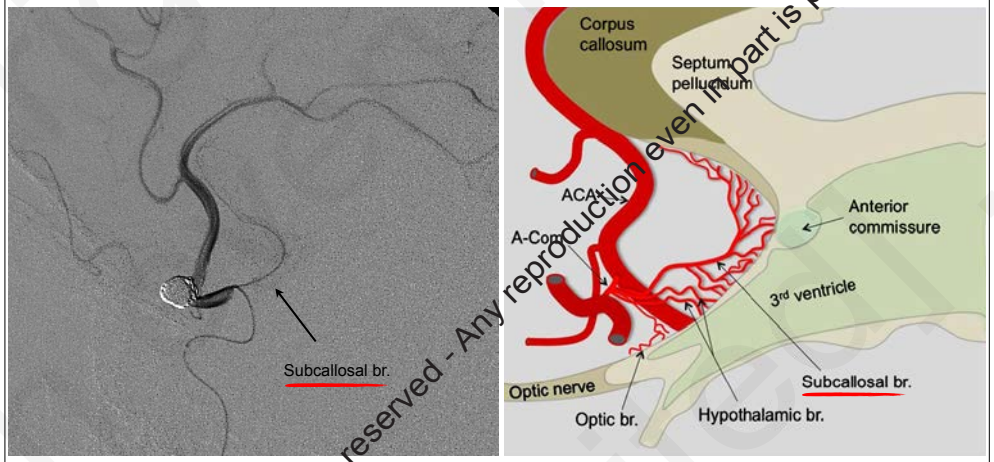




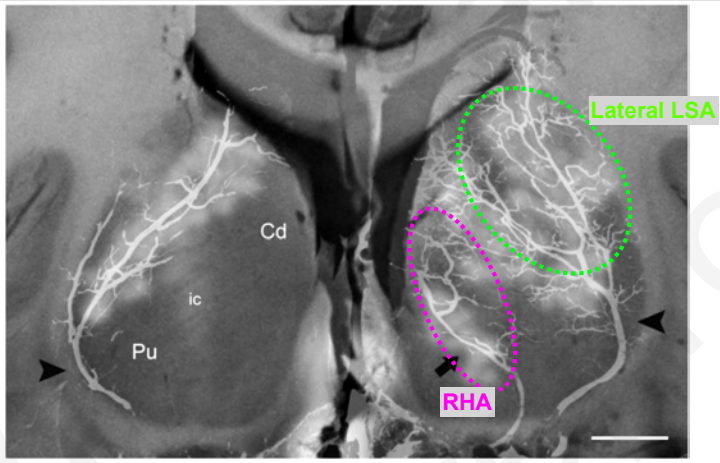




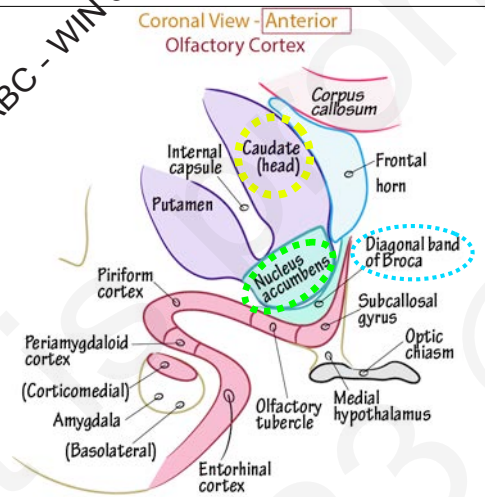


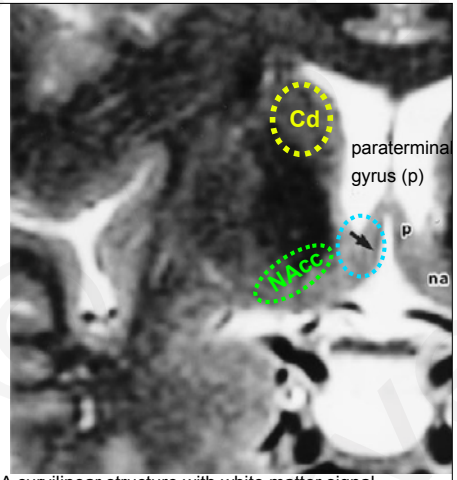


Super selective angiography from the A.com.complex.
Note Subcallosal branch（↑）is visible

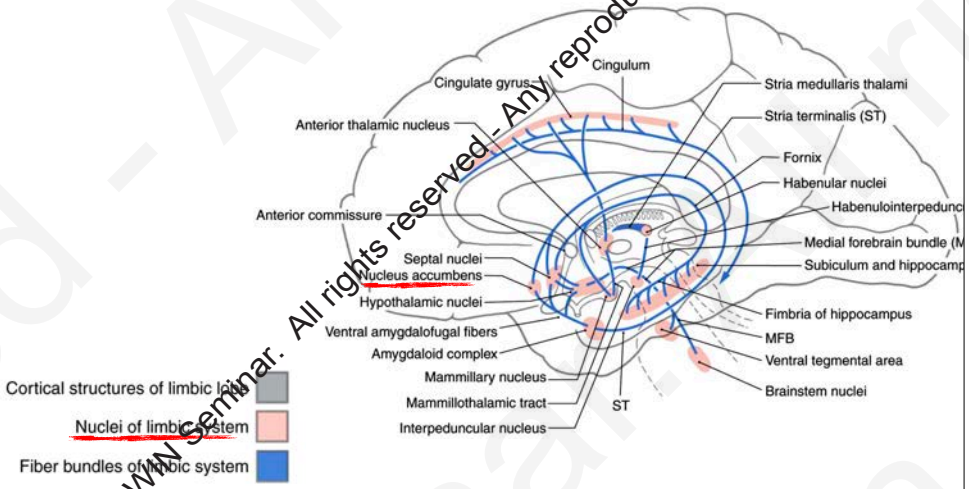


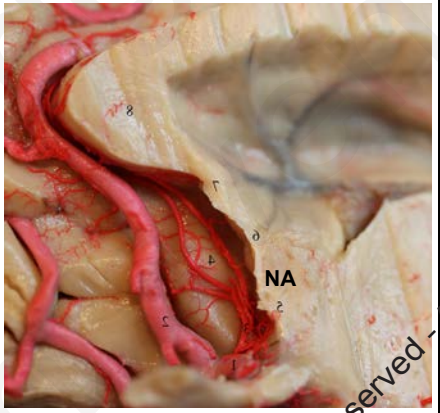
Feekes JA, et al. Tertiary microvascular territories define lacunar infarcts in the basal ganglia. Ann Neurol 2005;57:18–30.





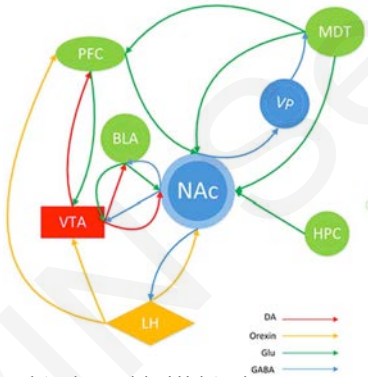
A curvilinear structure with white matter signal intensity (arrow) probably corresponds to the medial olfactory stria and the diagonal band of Broca



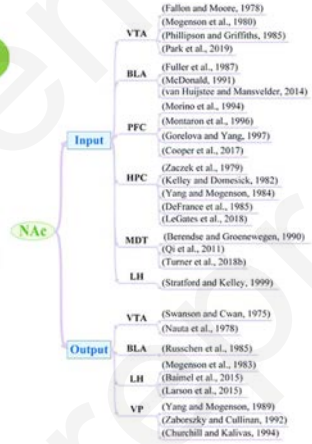


NA: Nuclei Accumbens

What is the role of Nucleus Accumbens ?



BLA, basolateral amygdala; LH, lateral hypothalamus; MDT, mediodorsal thalamus; PFC, prefrontal cortex; HPC, hippocampus; VP, ventral pallidum; VTA, ventral tegmental area.



Schematic of brain circuitry implicated in the comorbidity of depression and addiction. Dopaminergic (DA; red), glutamatergic (Glu; green), and orexin neuron (yellow) inputs converge on γ-aminobutyric acid (GABA)ergic (blue) neurons in **the nucleus accumbens (NAc) to coordinate and regulate behaviors of depression and addiction.**

Xu L, et al. The Nucleus Accumbens: A Common Target in the Comorbidity of Depression and Addiction. Front Neural Circuits 2020;14:37.

Behavioural Brain Research
Volume 329, 30 June 2017, Pages 221-228

Facebook usage on smartphones and gray matter volume of the nucleus accumbens

Christian Montag [a, b], Alexander Markowetz [c], Konrad Blaszkiewicz [c], Ionut Andone [c], Bernd Lachmann [a], Rayna Sariyska [a], Boris Trendafilov [c], Mark Eibes [c], Julia Kolb [d], Martin Reuter [d, e], Bernd Weber [e, f, g], Sebastian Markett [d, e]

[a] Institute of Psychology and Education, Ulm University, Ulm, Germany

Higher daily frequency of checking Facebook (SNS) on the smartphone was robustly linked with smaller gray matter volumes of the nucleus accumbens.

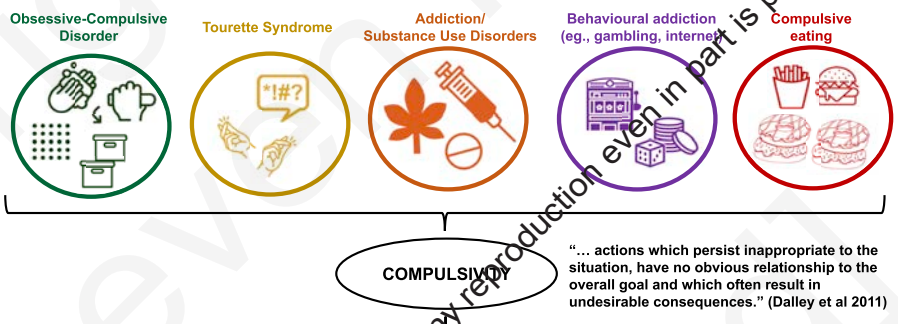
Montag C, et al. Facebook usage on smartphones and gray matter volume of the nucleus accumbens. Behav Brain Res 2017;329:221–8.

Obsessive-Compulsive Disorder (OCD) is the considered as the cause of right NAcc.

One recent longitudinal study has identified lower NAcc volumes as risk factors for alcohol use onset in a community sample of adolescents .

"Reward circuits" are located within the mesocorticolimbic dopamine systems originating in the ventral tegmental area (VTA), projecting to the nucleus accumbens (NAc), the amygdaloid nucleus (AMY), and prefrontal cortex area.

Schippers MC, et al. Deep Brain Stimulation of the Nucleus Accumbens Core Affects Trait Impulsivity in a Baseline-Dependent Manner. Front Behav Neurosci 2017;11:52.



Robbins TW, et al. Obsessive-Compulsive Disorder: Puzzles and Prospects. Neuron 2019;102:27–47.

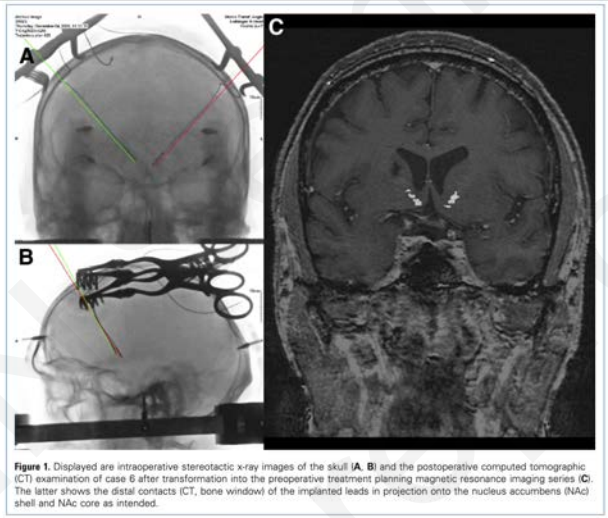
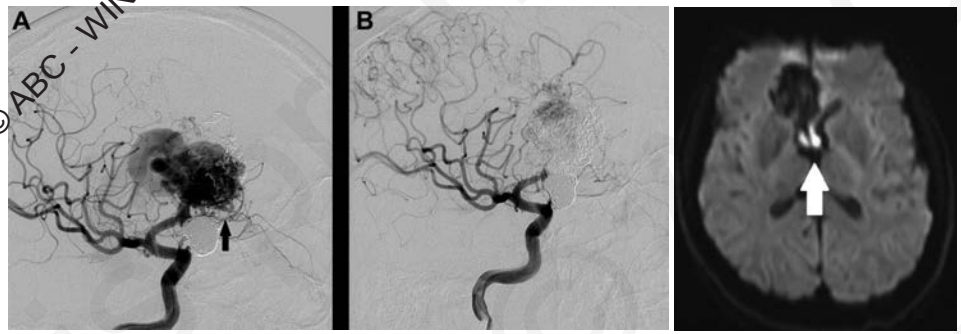


Figure 1. Displayed are intraoperative stereotactic x-ray images of the skull (**A**, **B**) and the postoperative computed tomographic (CT) examination of case 6 after transformation into the preoperative treatment planning magnetic resonance imaging series (**C**). The latter shows the distal contacts (CT, bone window) of the implanted leads in projection onto the nucleus accumbens (NAc) shell and NAc core as intended.

Voges J, et al. Deep brain stimulation surgery for alcohol addiction. World Neurosurg 2013;80:S28.e21–31.

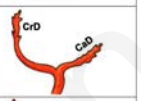
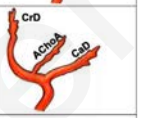
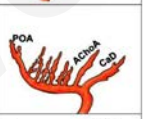
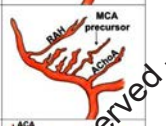
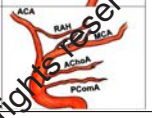


Right anterior oblique view on digital subtraction angiography (DSA). (A) DSA performed after the first arteriovenous malformation (AVM) embolization. A small subcallosal a. is visible (black arrow); it arises from the anterior communicating artery. (B) DSA performed at the end of the last AVM embolization. The subcallosal a. is not visibly seen anymore. due to the plugged by SQUID 18.

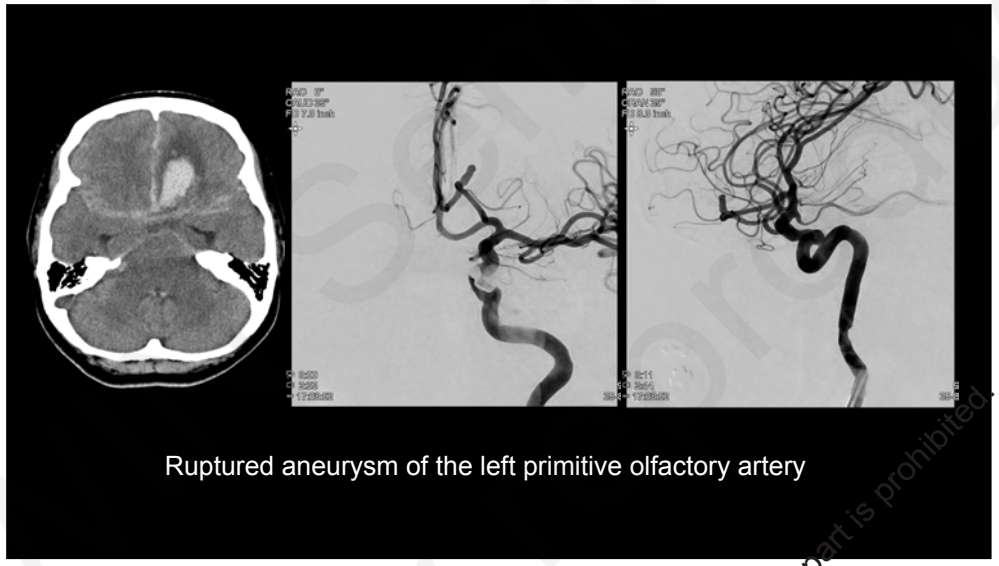
The presentation of ScA infarction is anterograde amnesia, sometimes associated with other symptoms such as **retro-grade amnesia**, behavioral or personality changes, psychomotor retardation, or **Korsakoff psychosis.**

Michel, P.et al. Bilateral Fornical Columns Infarction Secondary to an Arteriovenous Malformation Embolization, World Neurosurg. 2020 Mar;135:113-117.

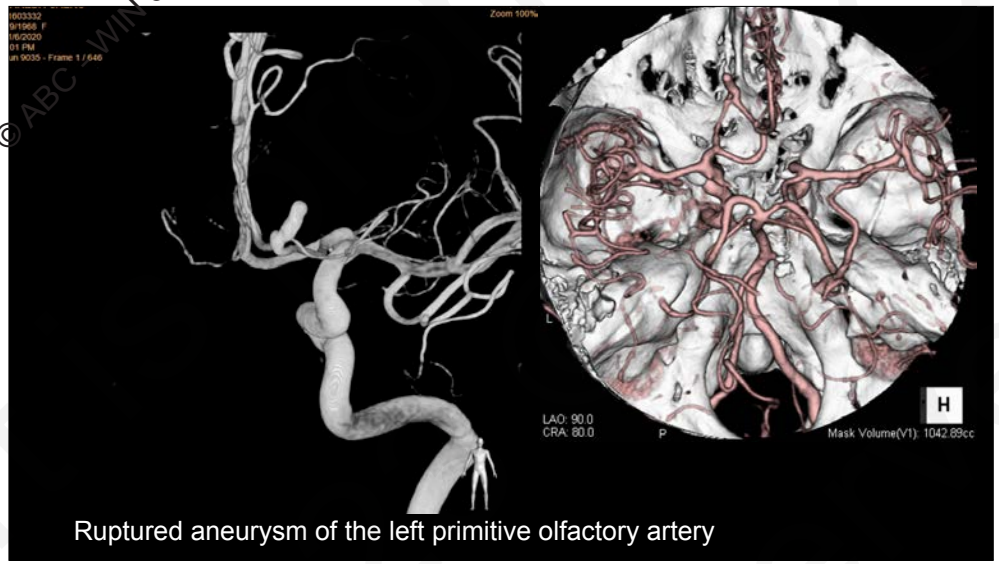
Arterial anatomy of the limbic system
Anterior ethmoid artery
Recurrent artery of Heubner
Olfactory artery
Anterior choroidal artery (Uncal artery)
Posterior choroidal artery (Artery of Uchimura)
Pericallosal artery (Cingulate gyrus)
Posterior cerebral artery (isthmus part of CG)

Embryo size	Critical events	Graphic illustration
4-5 mm	The caudal and cranial divisions (CaD, CrD) of the primitive ICA are visible	
9 mm	The anterior choroidal artery (AChoA) arises from the the cranial division of the ICA	
10-14 mm	The primitive olfactory artery (POA), future anterior cerebral artery, gives birth to multiple plexiform vessels	
15-18 mm	The RAH origins from the plexiform channels, while the precursor of the MCA begins to be visible more caudally	
20-30 mm	The POA transforms definitively into the ACA, from which the RAH origins. The MCA, the AChoA and the PComA are visible in the adult configuration	

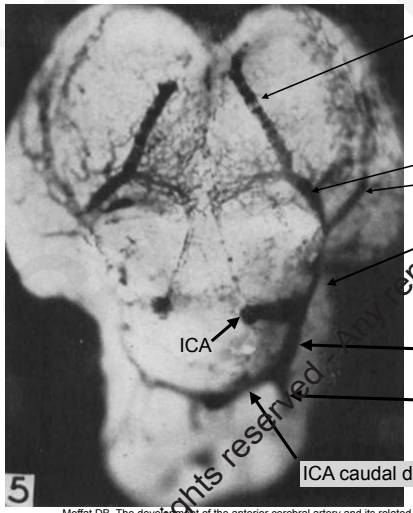
Cranial division of internal carotid artery
= Primitive olfactory artery



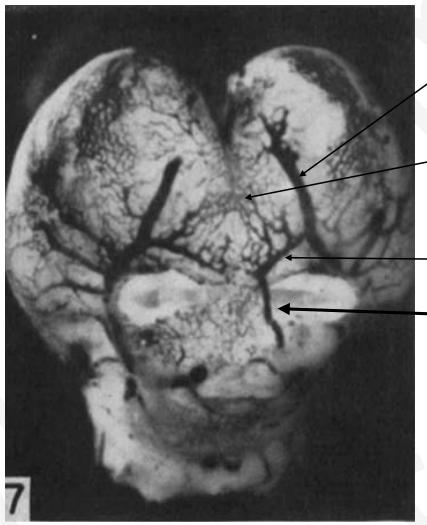
Ruptured aneurysm of the left primitive olfactory artery



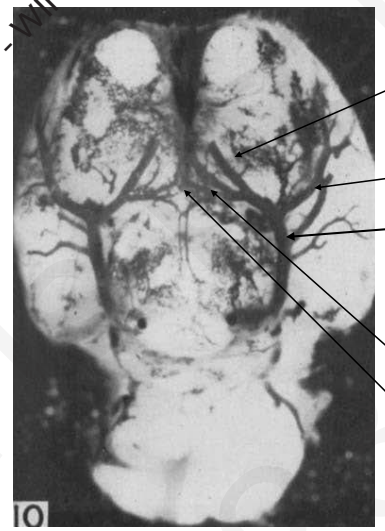
Ruptured aneurysm of the left primitive olfactory artery



Moffat DB. The development of the anterior cerebral artery and its related vessels in the rat. Am J Anat 1961;108:17–29.



Moffat DB. The development of the anterior cerebral artery and its related vessels in the rat. Am J Anat 1961;108:17–29.



Moffat DB. The development of the anterior cerebral artery and its related vessels in the rat. Am J Anat 1961;108:17–29.

Diagram of the base of the brain to show the derivation of the anterior cerebral artery. The adult vessels are shown in solid black while the embryonic vessels are shown on the opposite side of the diagram.

The optic stalk has been divided. MC, middle cerebral artery;

A, anterior cerebral artery;

O, olfactory branch of anterior cerebral artery;

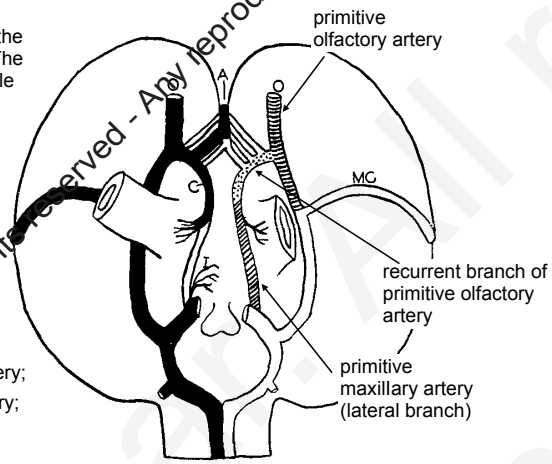
C, chiasmal branch of anterior cerebral artery;

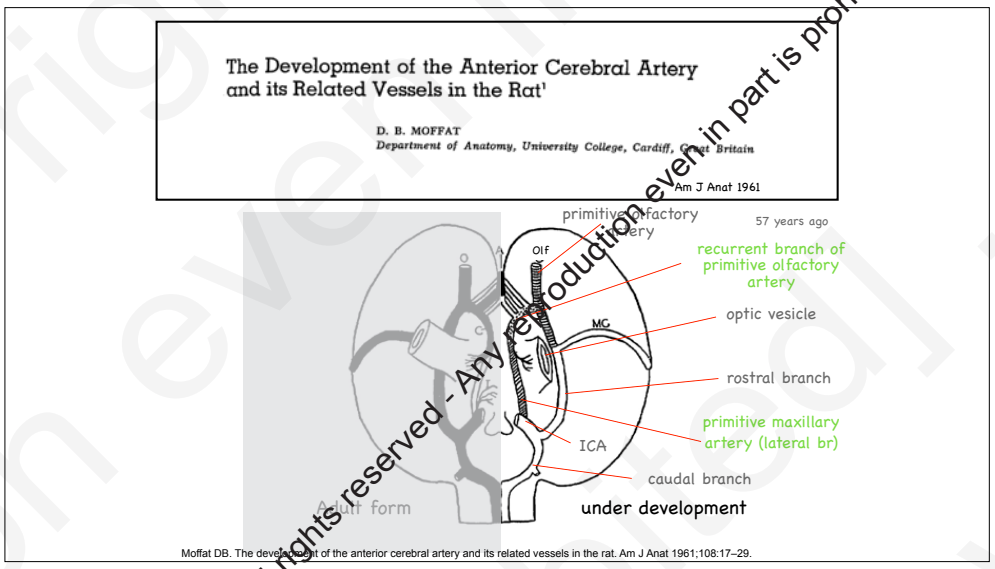
I, infundibular artery;

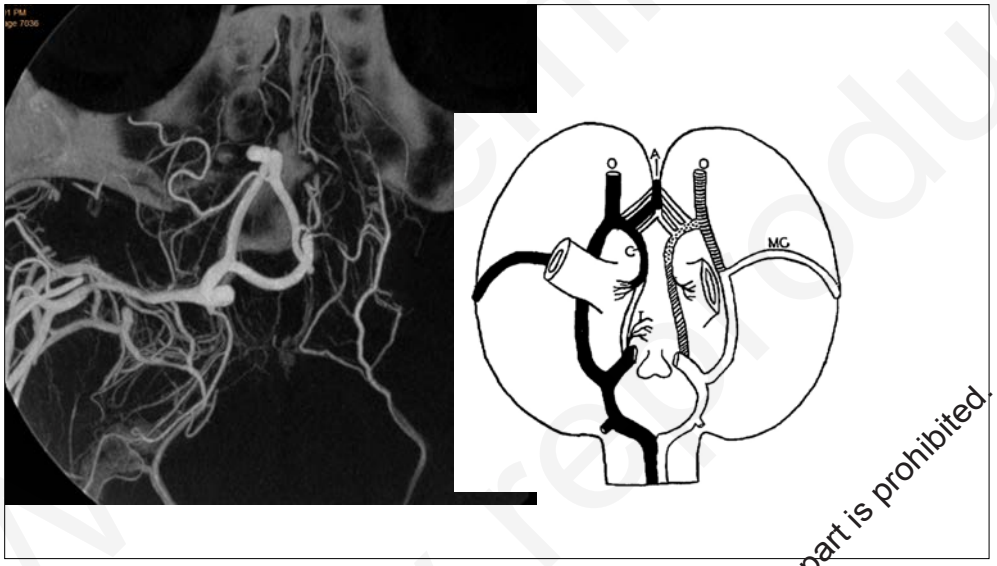
horizontal hatching, primitive olfactory artery;

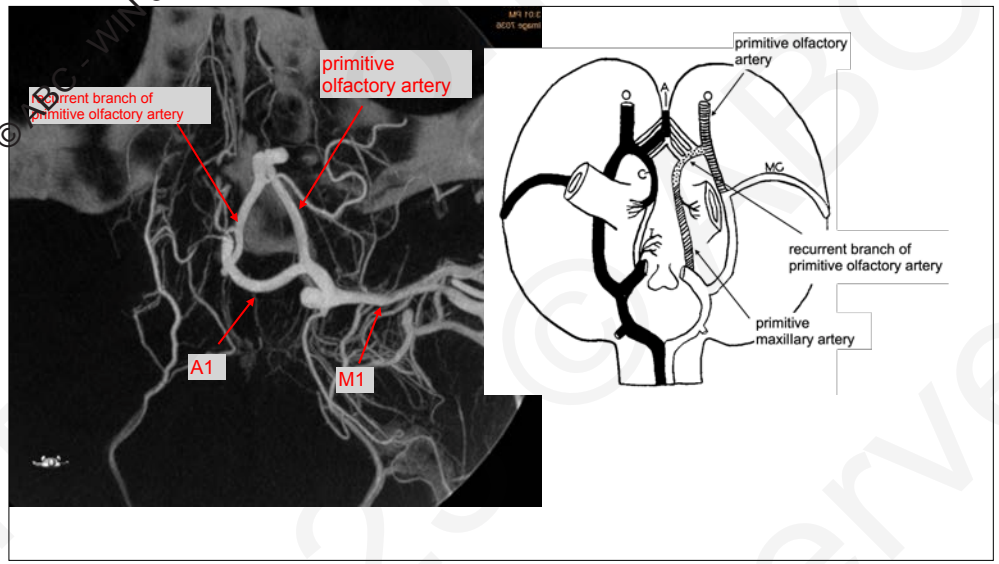
diagonal hatching, primitive maxillary artery;

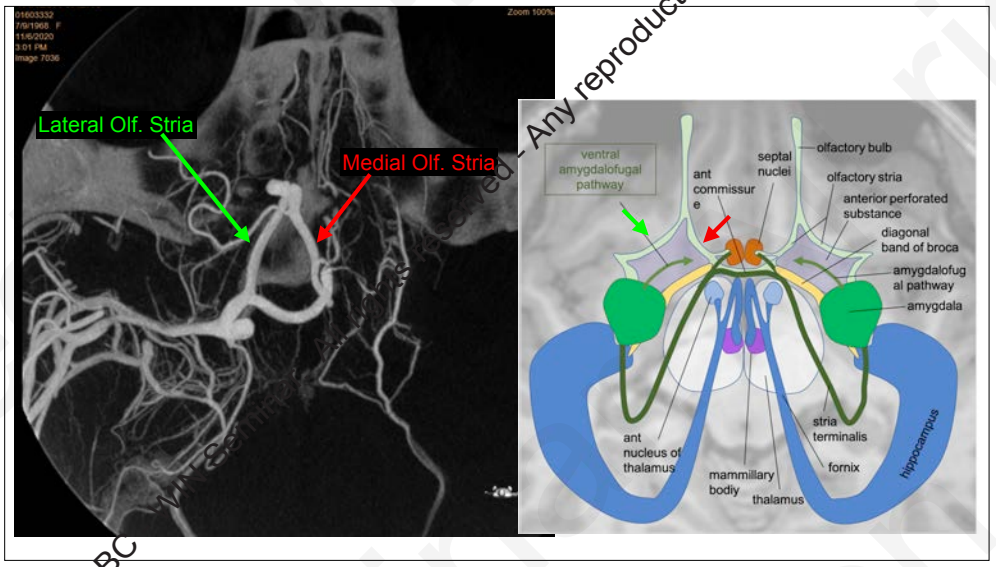
stipple, recurrent branch of primitive olfactory artery.

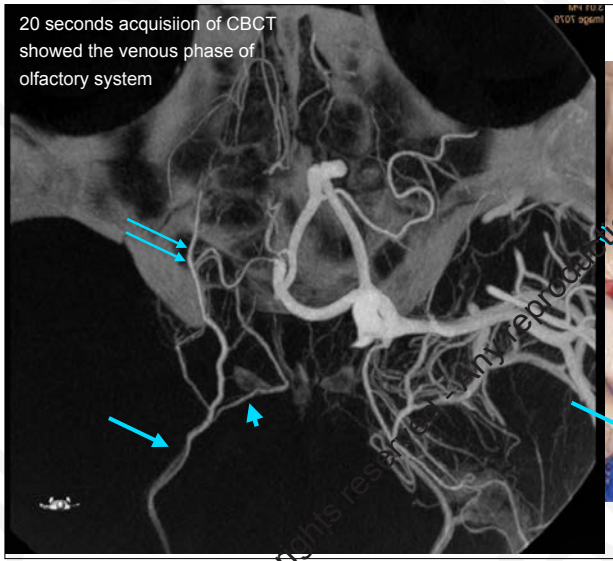


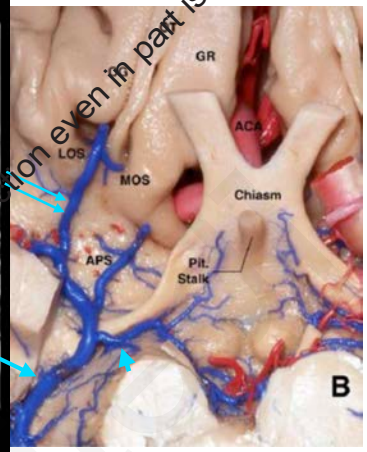


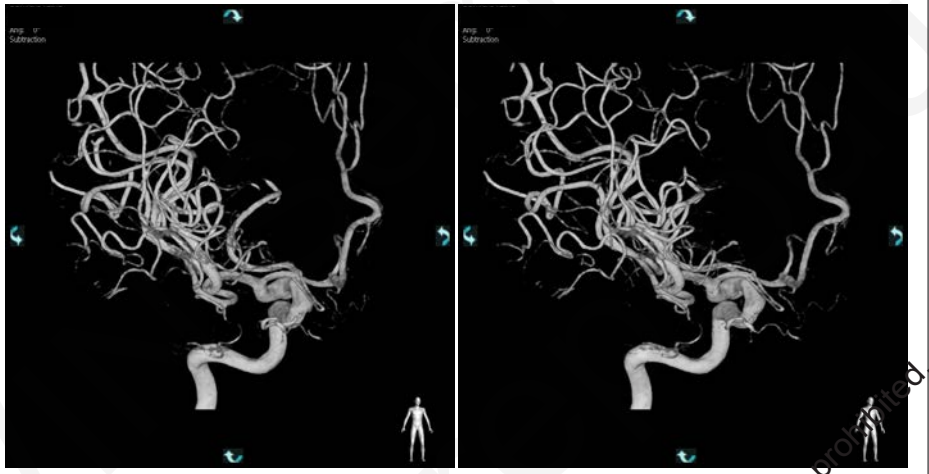




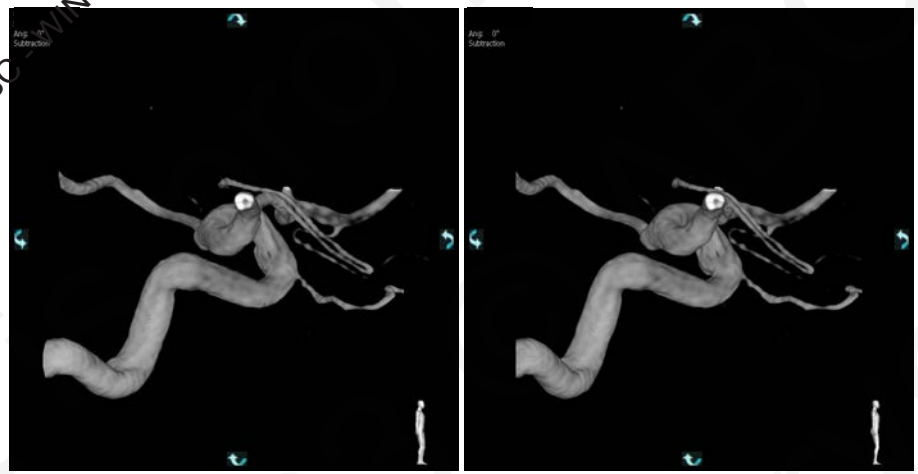




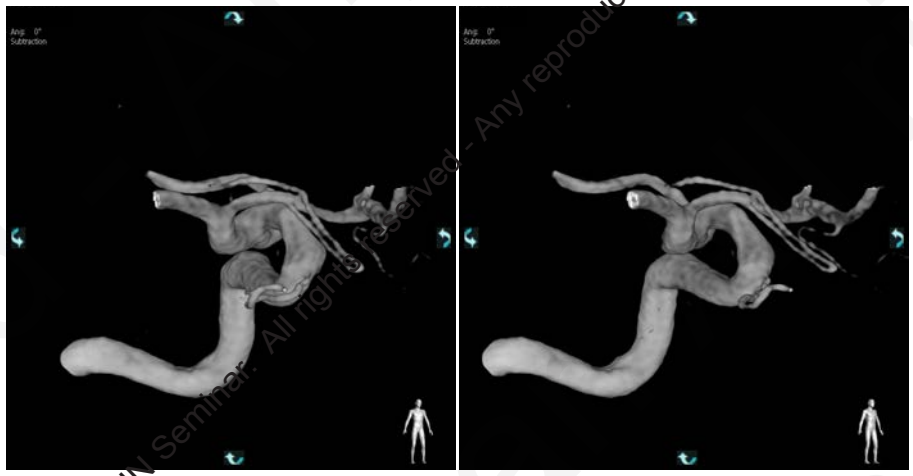




Primitive olfactory artery is a vestiges of dominant artery in the development of rhinencephalon.



courtesy by Dr.Kominami



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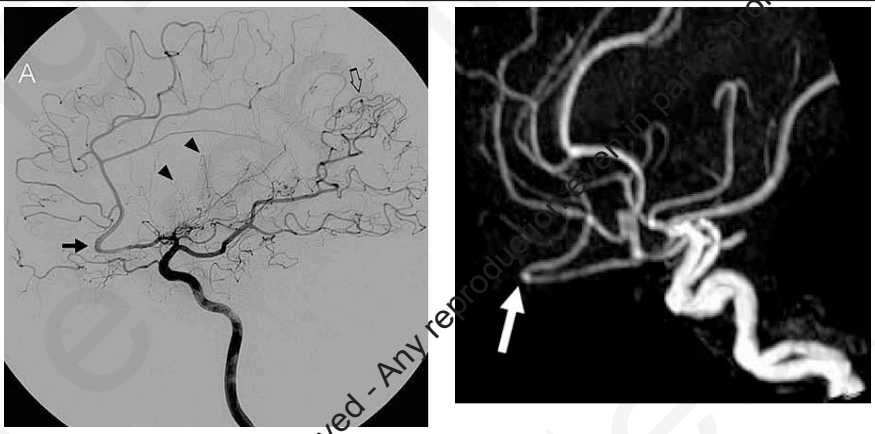
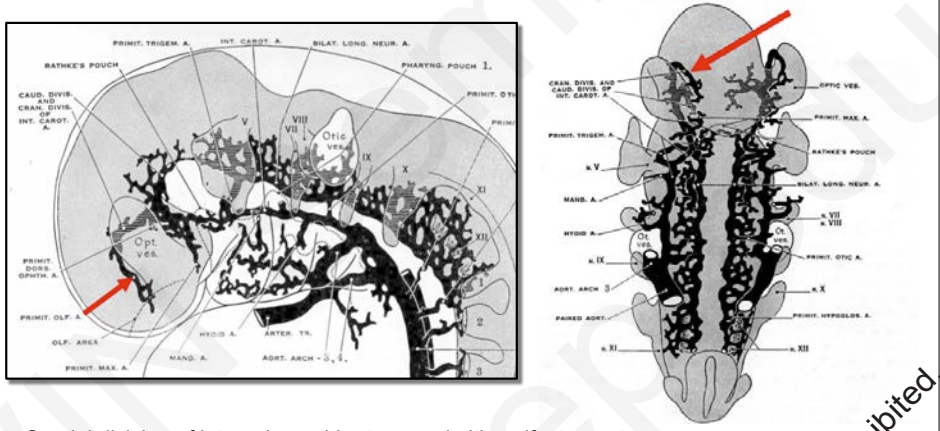


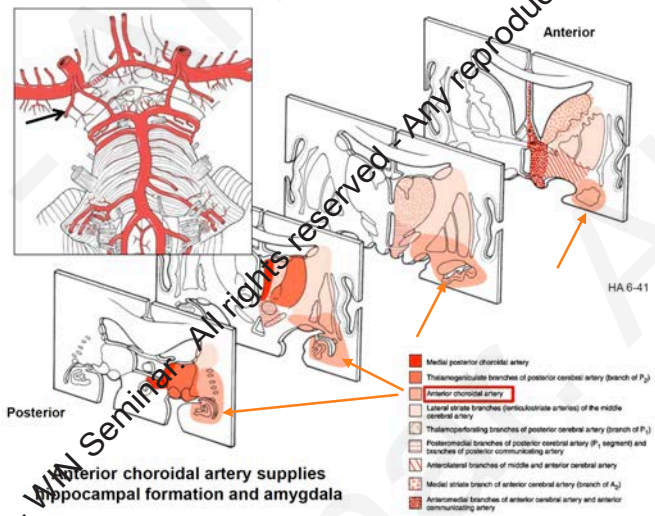
Cranial division of internal carotid artery = primitive olfactory artery



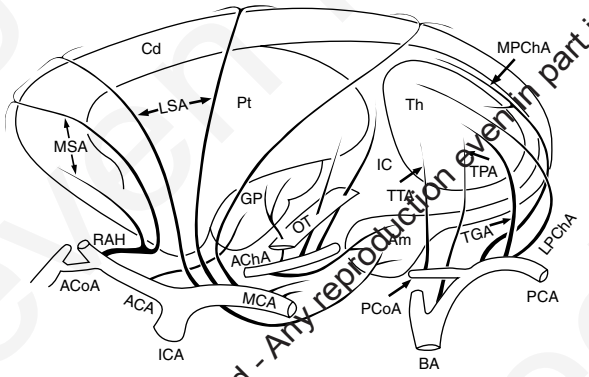
Cranial division of internal carotid artery = primitive olfactory artery

Menu

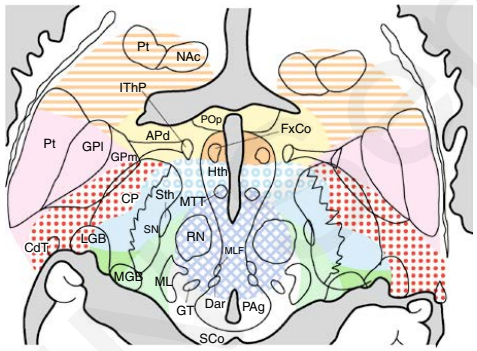
1. Functional anatomy of the limbic system
2. Arterial anatomy of the limbic system
   - Anterior ethmoid artery, Olfactory artery, Recurrent artery of Heubner
   - Anterior choroidal artery (Uncal artery)
   - Posterior choroidal artery,Artery of Uchimura,
   - Cingulate gyrus (CG), isthmus part of CG,
3. Venous anatomy of the limbic system

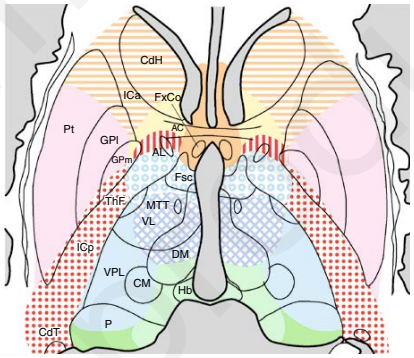


Anterior choroidal artery supplies hippocampal formation and amygdala



Outline of the basal perforating arteries (adapted from Aitken, 1928). Am amygdaloid body; BA basilar artery; Cd caudate nucleus; **GP globus pallidus**; **IC internal capsule;**
LPChA lateral posterior choroidal artery; LSA lenticulostriate arteries; MCA middle cerebral artery; **MPChA** medial posterior choroidal artery; MSA medial striate arteries; OT optic tract; PCA posterior cerebral artery; Pt putamen; RAH recurrent artery of Heubner; TGA thala- mogeniculate artery; TPA thalamoperforate artery; Th thalamus; TTA thalamotuberal artery



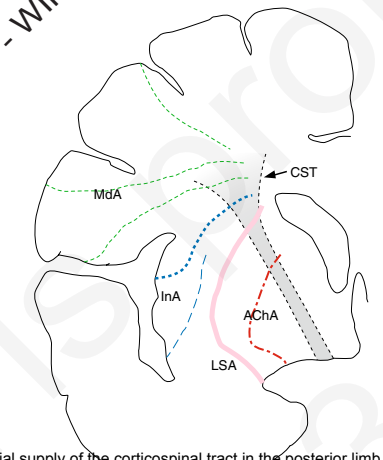


AChA (anterior choroidal artery)

MPChA (medial posterior choroidal artery)

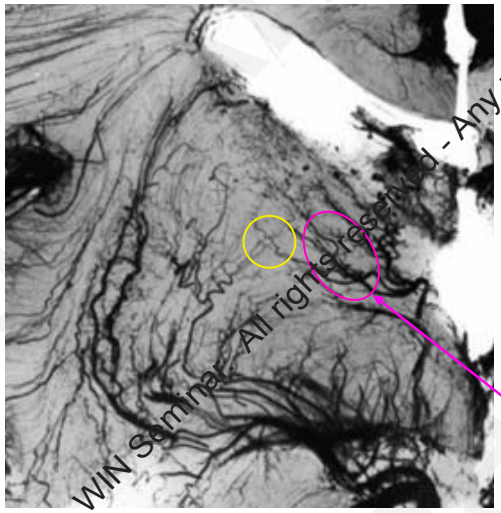
LPChA (lateral posterior choroidal artery)

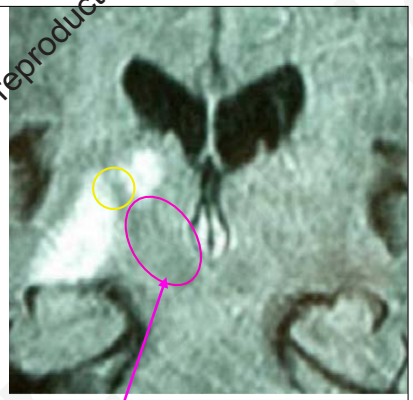
Takahashi S. Neurovascular Imaging 2011



Arterial supply of the corticospinal tract in the posterior limb of the internal capsule and the corona radiata. AChA anterior choroidal artery; InA insular arteries; LSA lenticulostriate arteries; MdA medullary arteries of the cerebrum

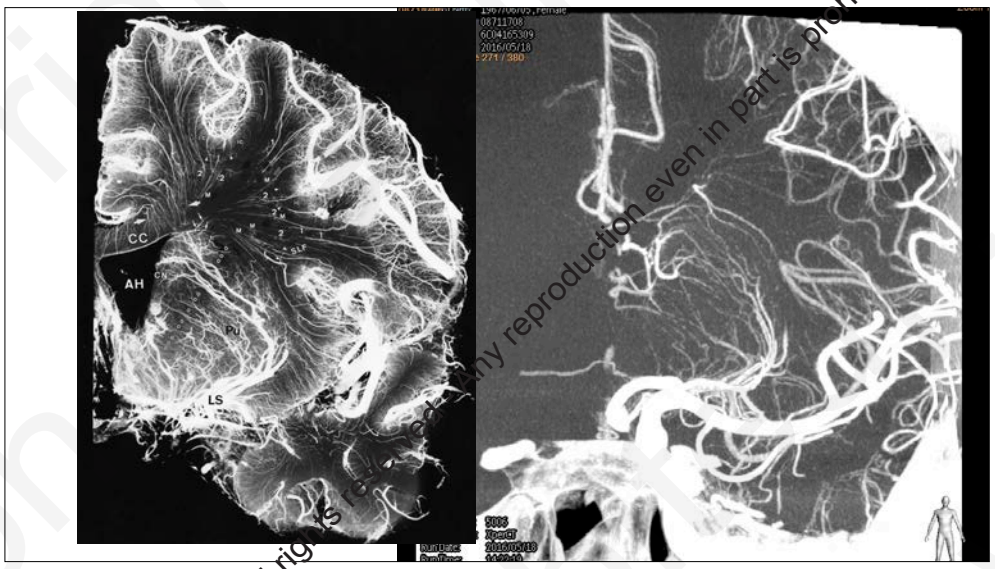
LSA infarctio, post AIS

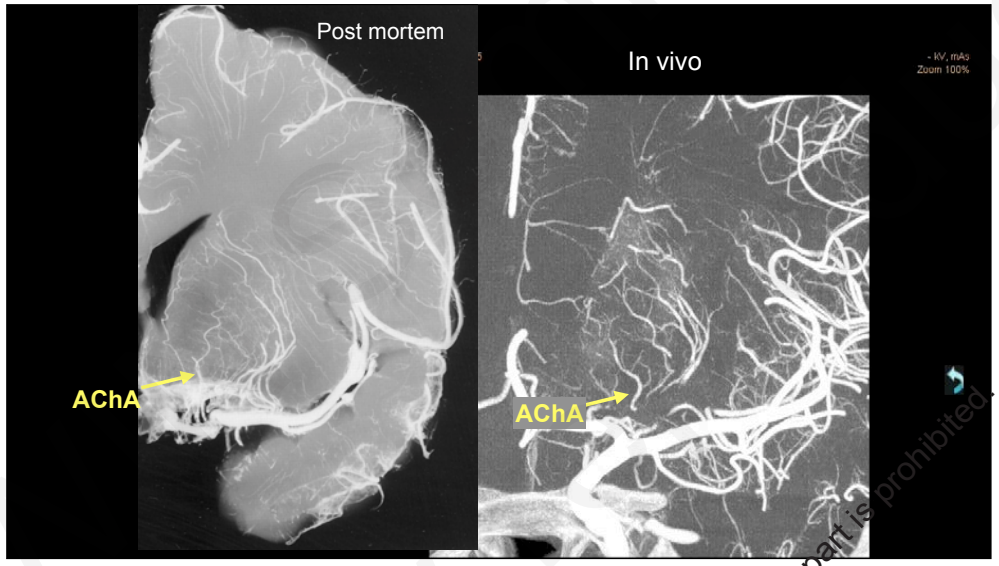


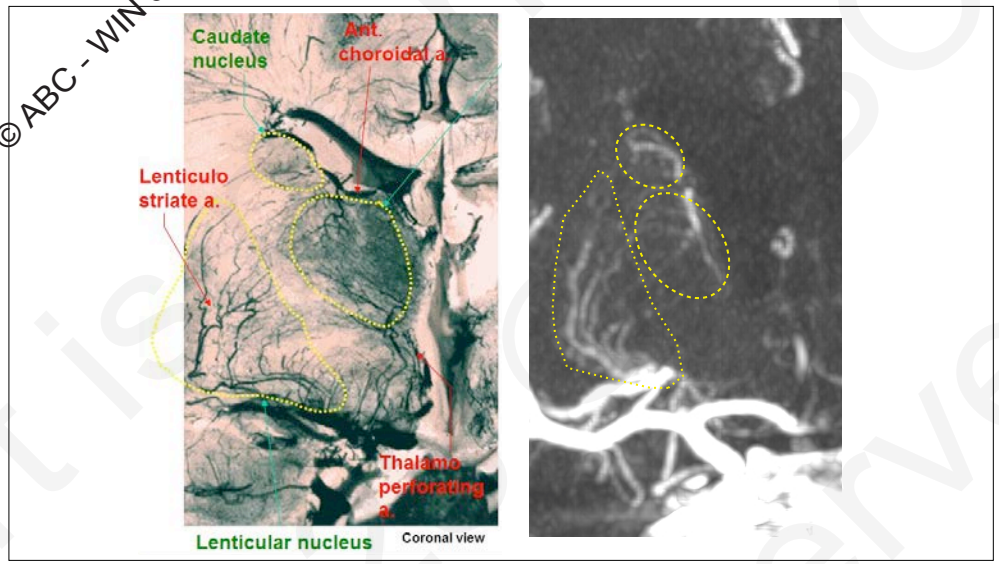


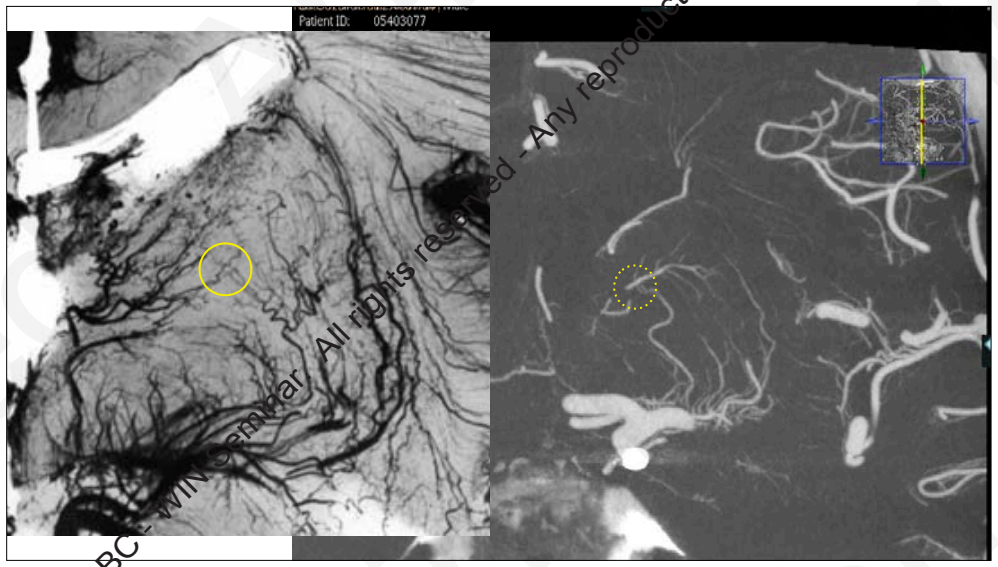
Cross point of striatal division (LSA) and hippocampal division (choroidal a.)

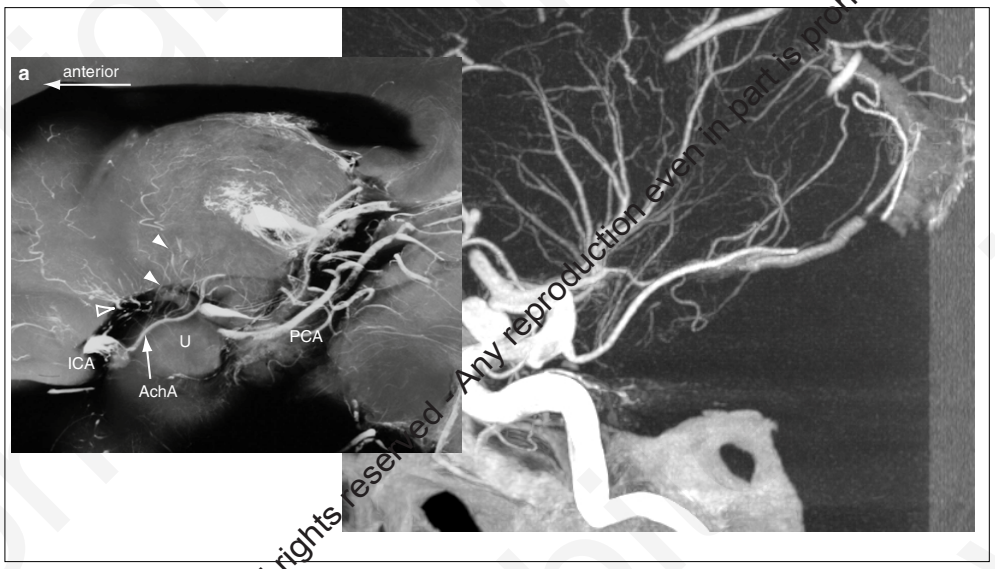
Anterior Choroidal a.
(telencephalic segment)

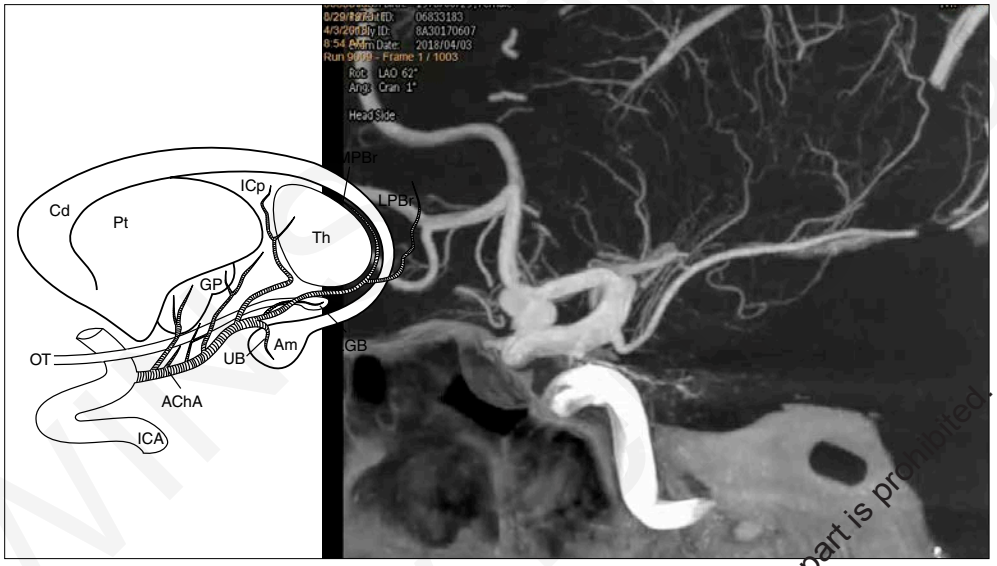


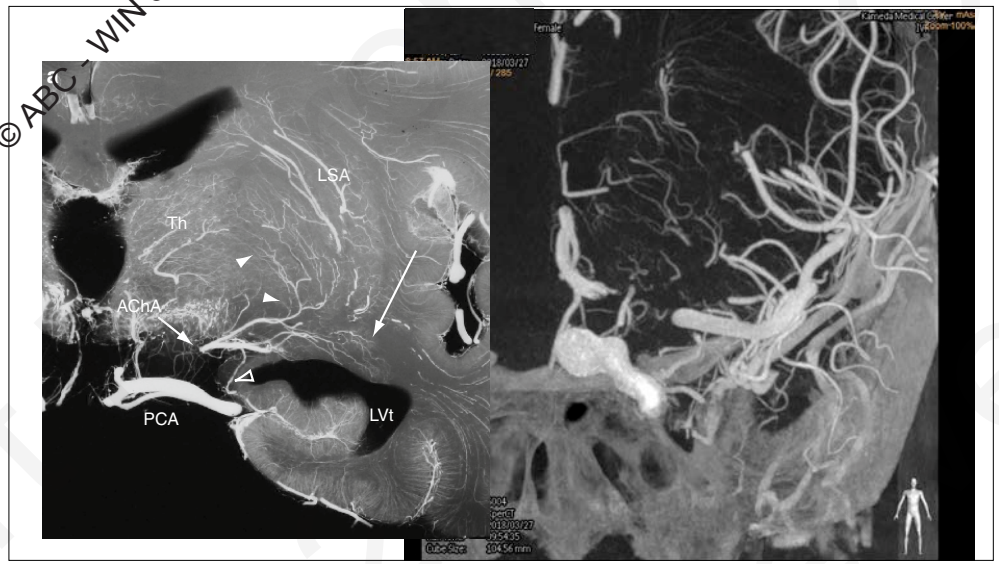


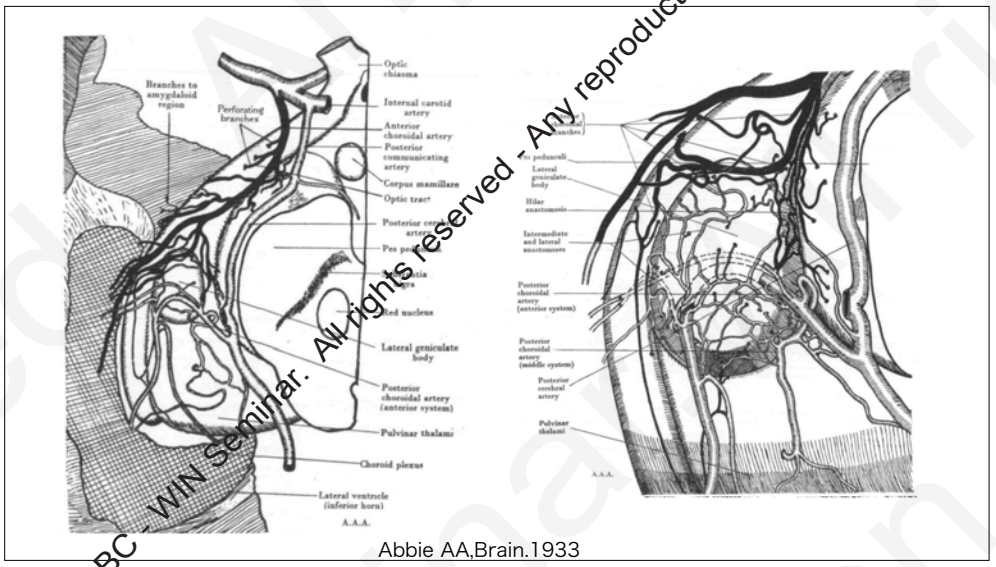




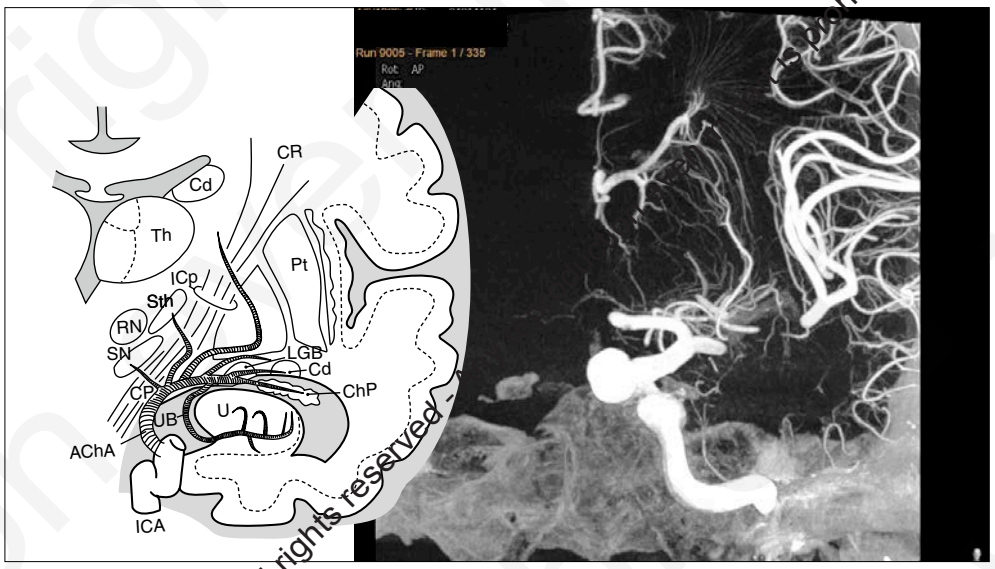


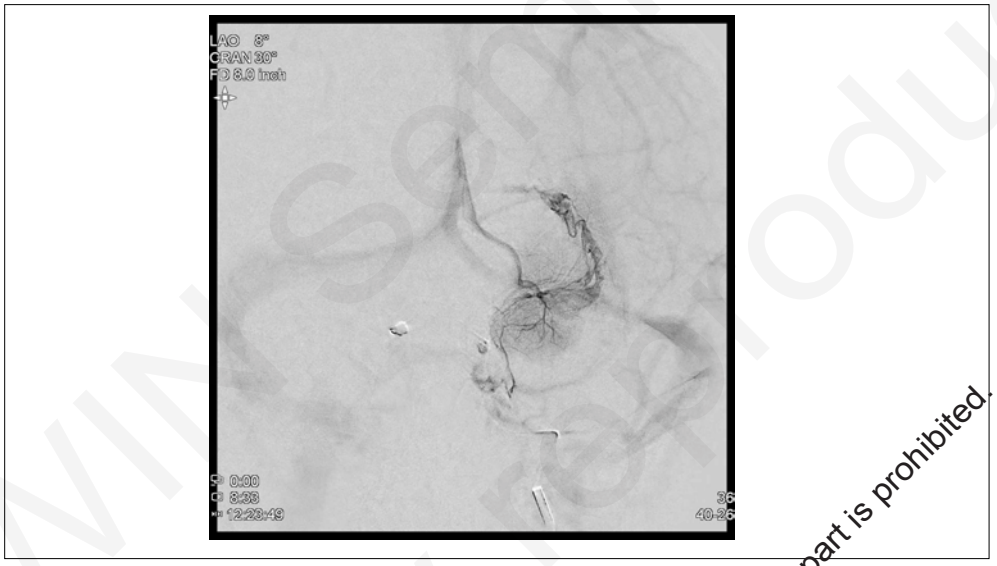


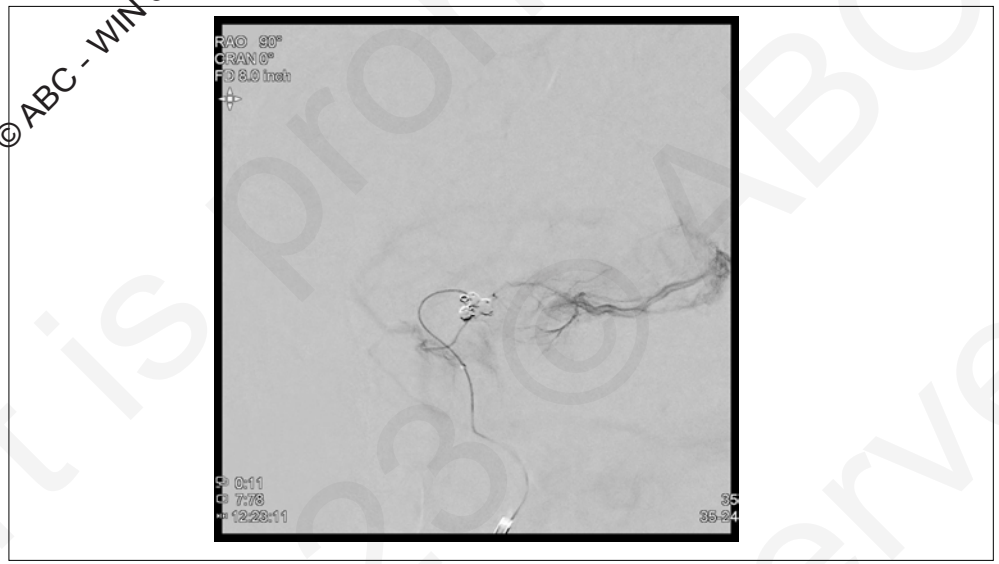


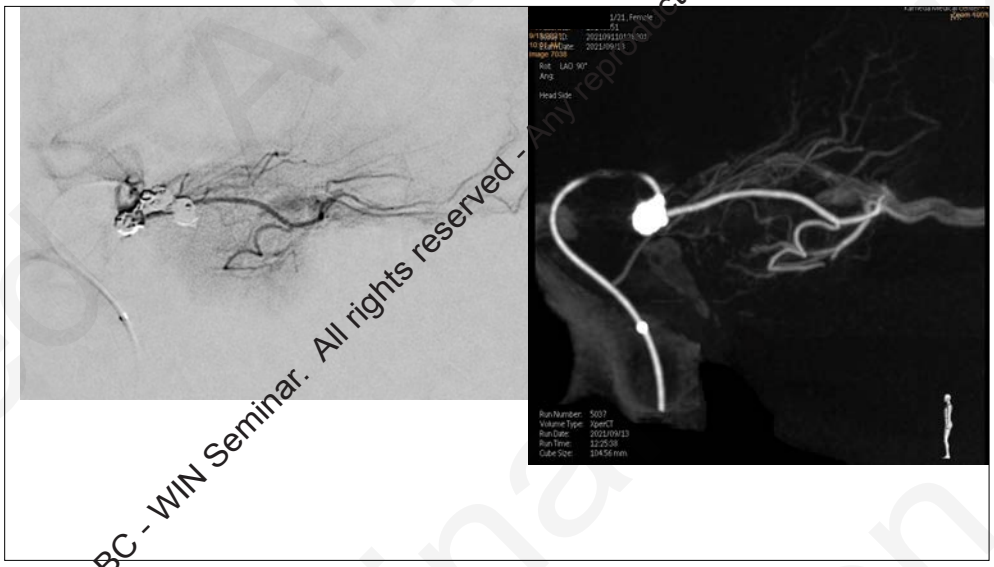


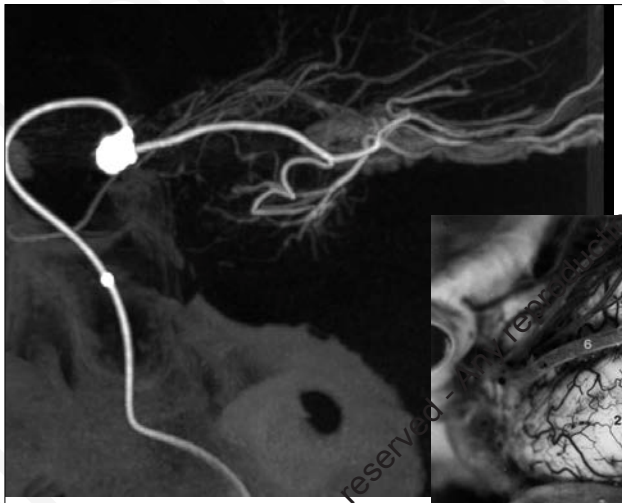
Abbie AA,Brain.1933



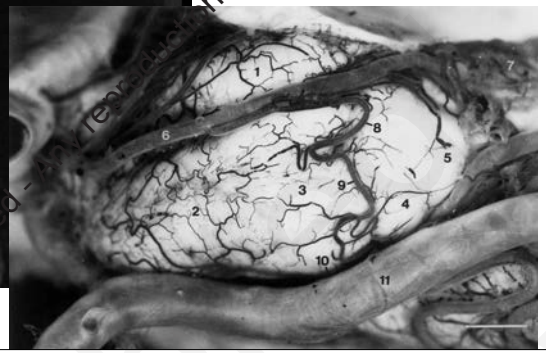






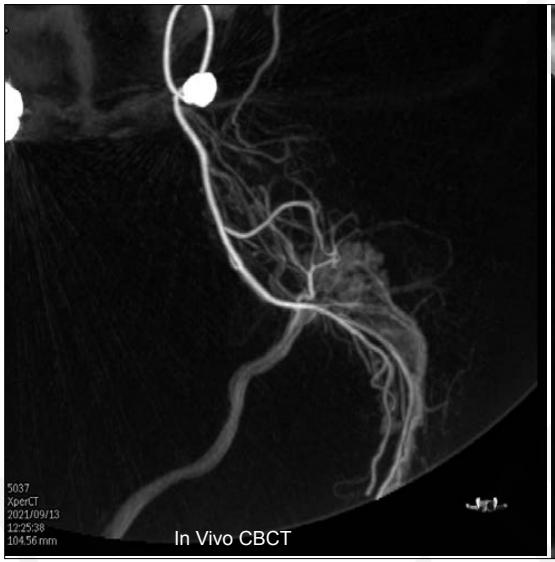


In Vivo CBCT



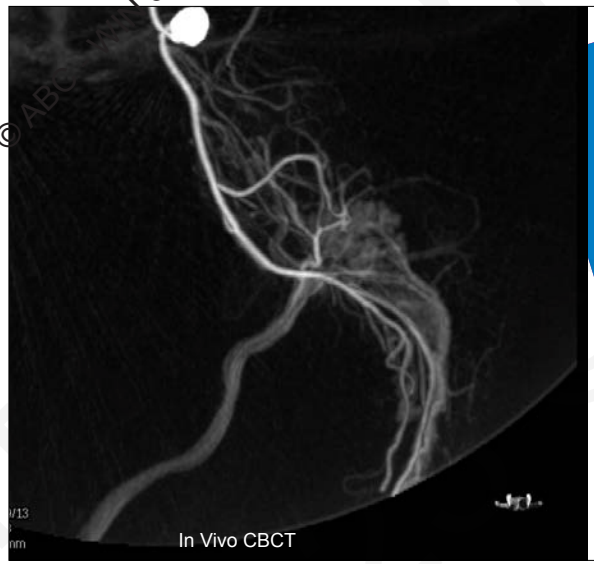
Uncal branch of the anterior choroidal artery running along the uncal part of the superficial hippocampal sulcus

Duvernoy HM, 2013



In Vivo CBCT

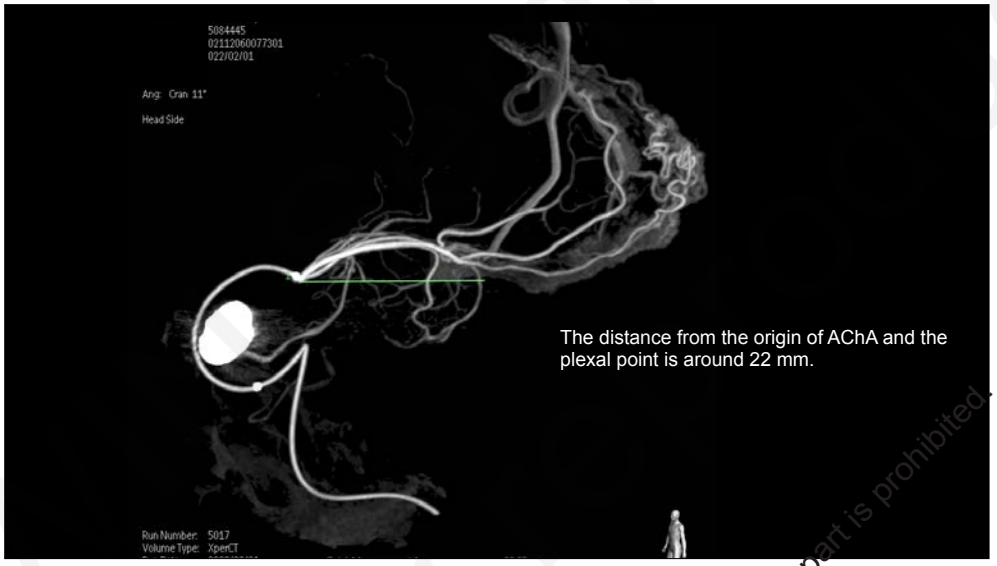
Duvernoy HM, 2013

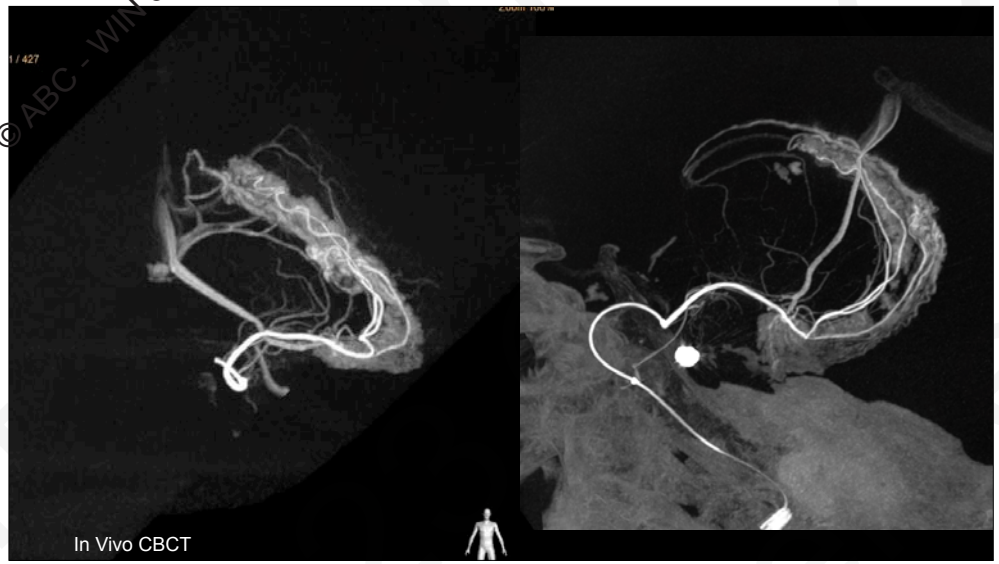


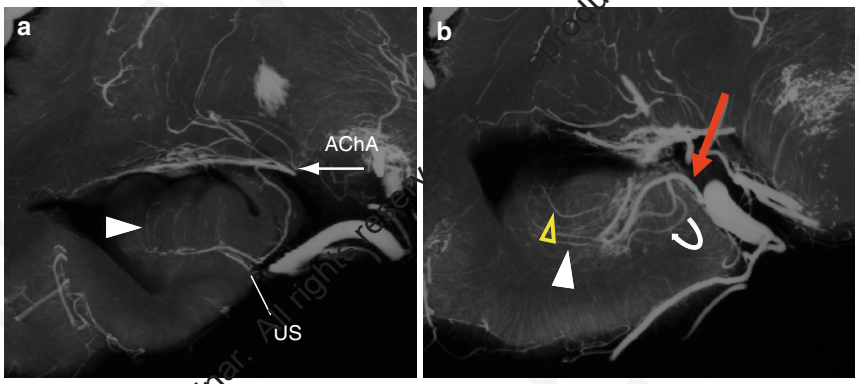
In Vivo CBCT

Duvernoy HM, 2013

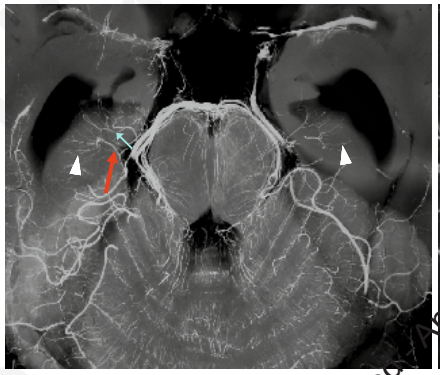
In Vivo CBCT



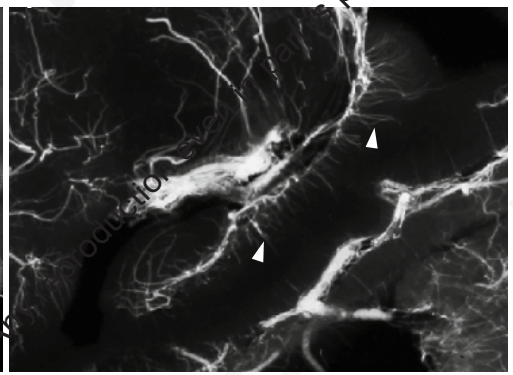




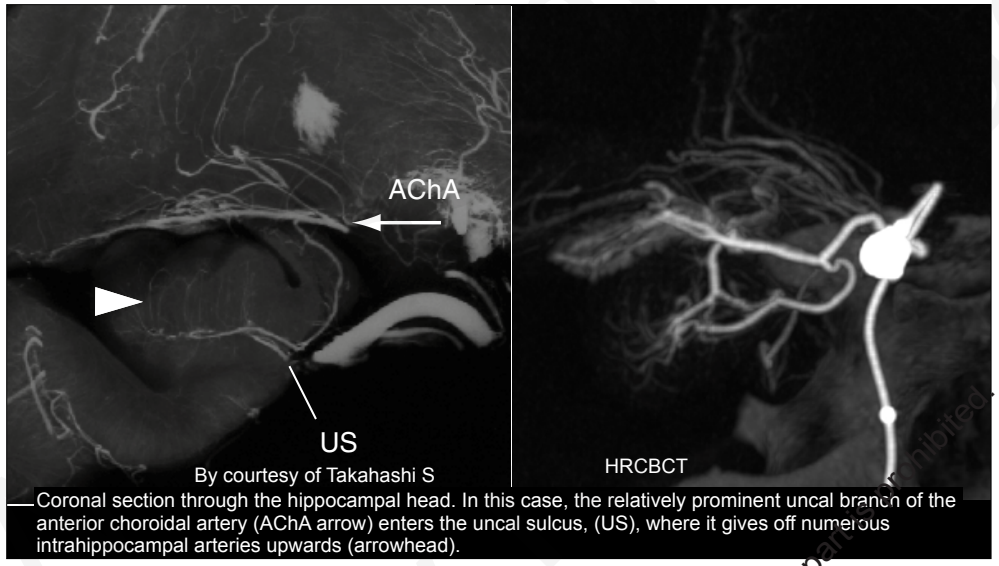
Microangiograms demonstrating vascular supply of the intrahippocampal arteries. (a) Coronal section through the hippocampal head. In this case, the relatively prominent uncal branch of the anterior choroidal artery (AChA arrow) enters the uncal sulcus, (US), where it gives off numerous **intrahippocampal arteries upwards (arrowhead)**. (b) Coronal section through the hippocampal body showing superficial hippocampal artery (large red arrow). Subicular arteries (curved arrow) are noted. The large ventral (solid arrowhead) and dorsal (open yellow arrowhead) intrahippocampal arteries follow the rolling layers of the hippocampus, and very fine arteries that parallel them in between may represent small ventral intrahippocampal arteries.



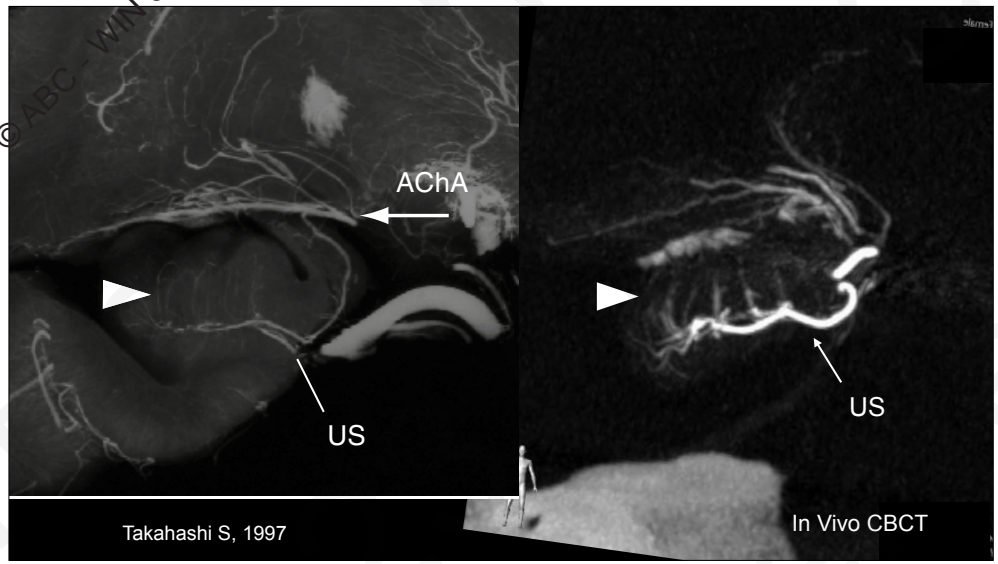
Anterior and middle hippocampal arteries (arrow) and their longitudinal terminal segments (small blue arrow)



intrahippocampal arteries (arrowheads)

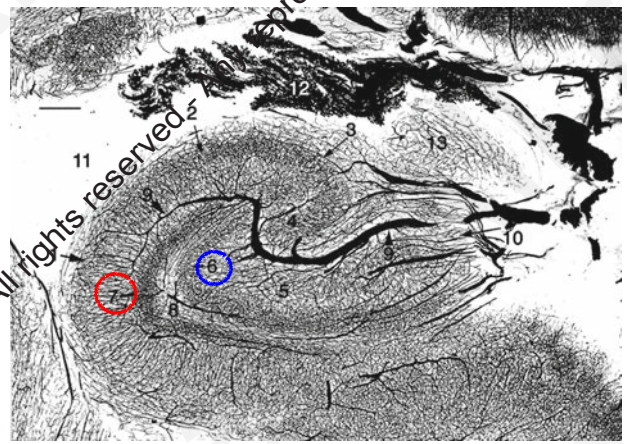


Coronal section through the hippocampal head. In this case, the relatively prominent uncal branch of the anterior choroidal artery (AChA arrow) enters the uncal sulcus, (US), where it gives off numerous intrahippocampal arteries upwards (arrowhead).

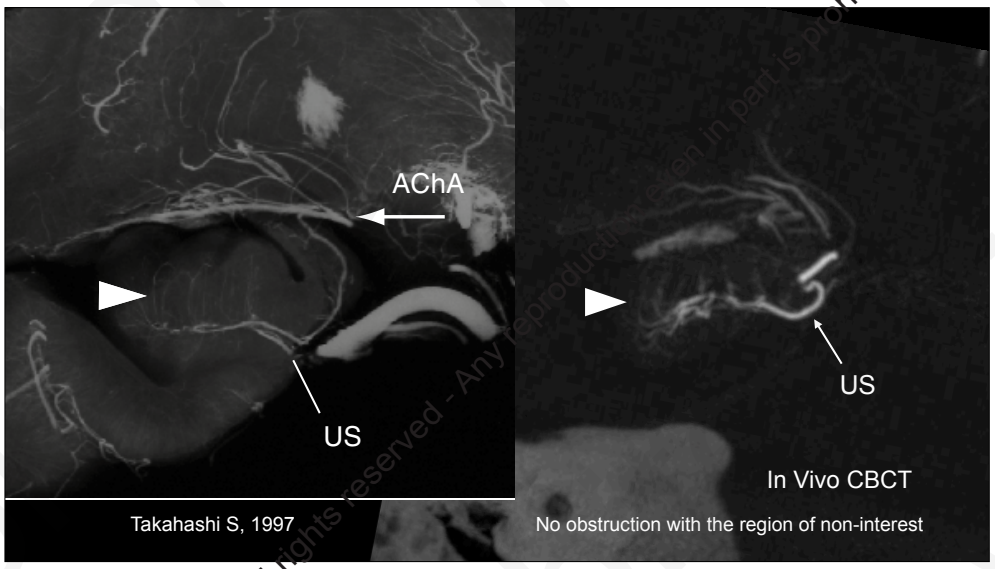


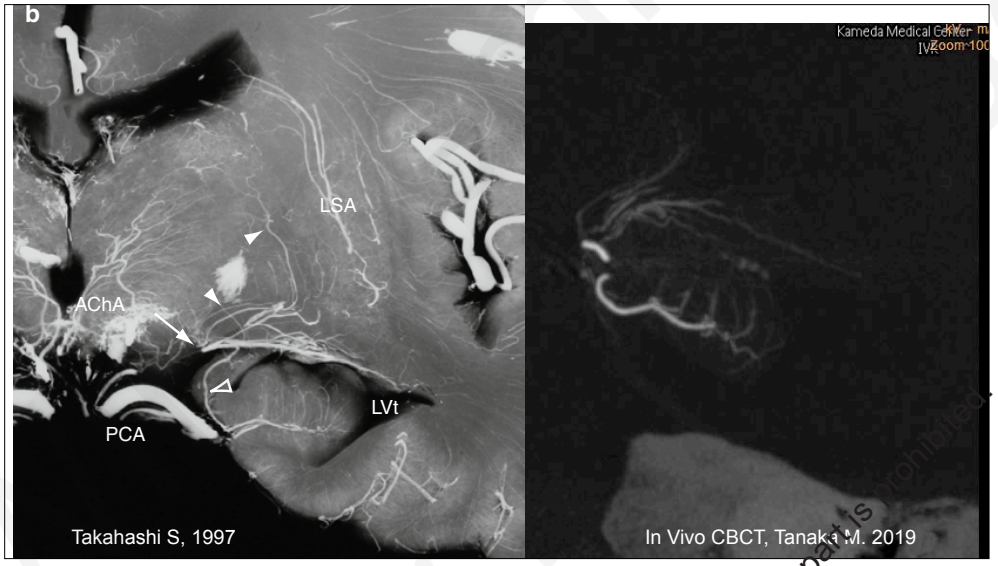
4. CA4 fields of the cornu Ammonis

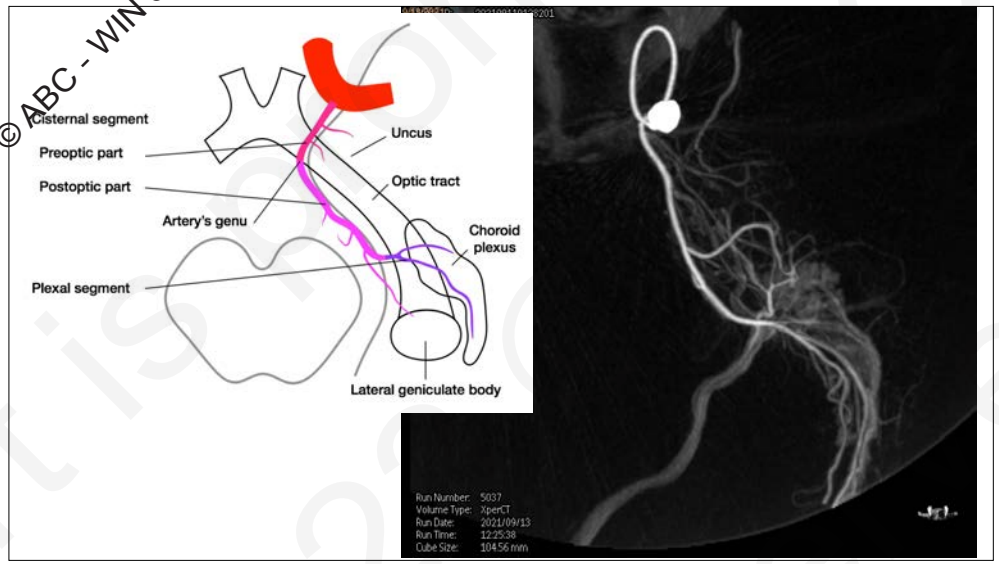
Note the **high capillary density** in the strata molecularia of the cornu Ammonis (7) and the gyrus dentatus (6)

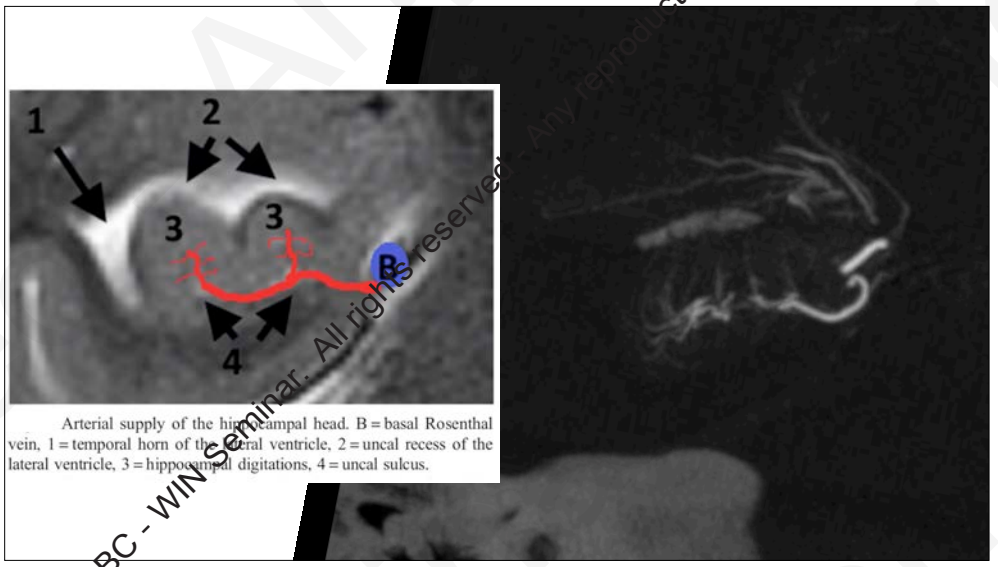


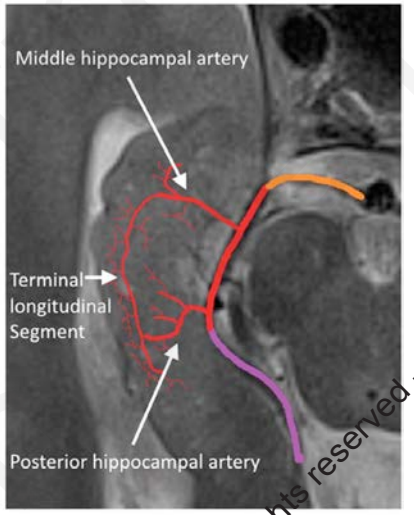
9: Large dorsal intrahippocampal artery with a preponderant territory

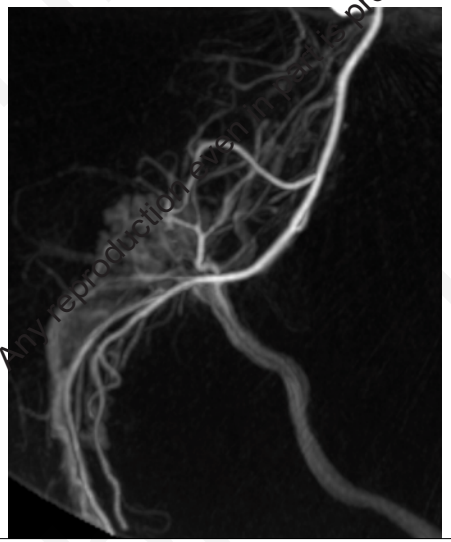


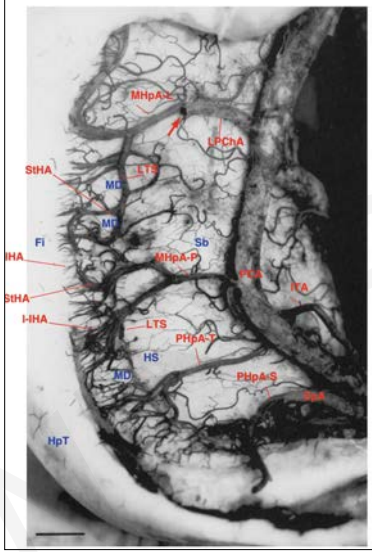


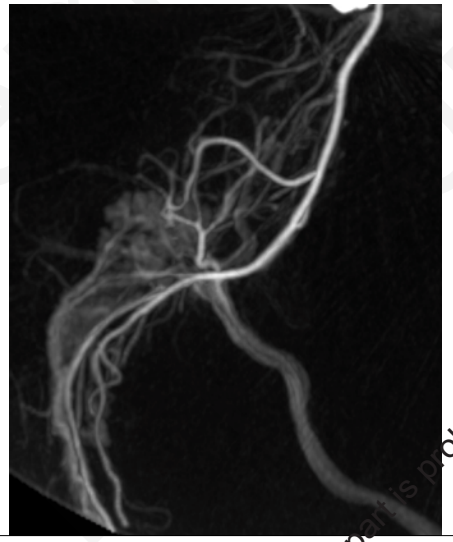


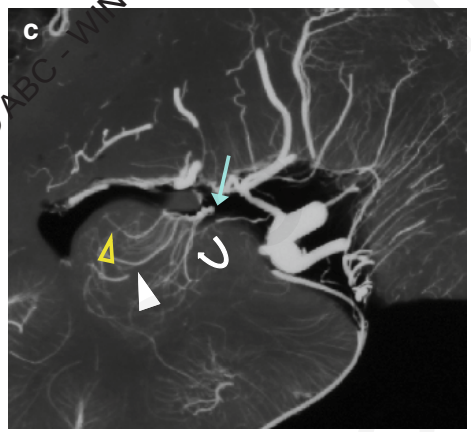


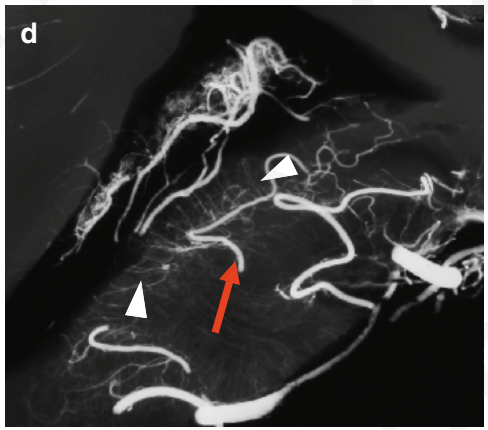


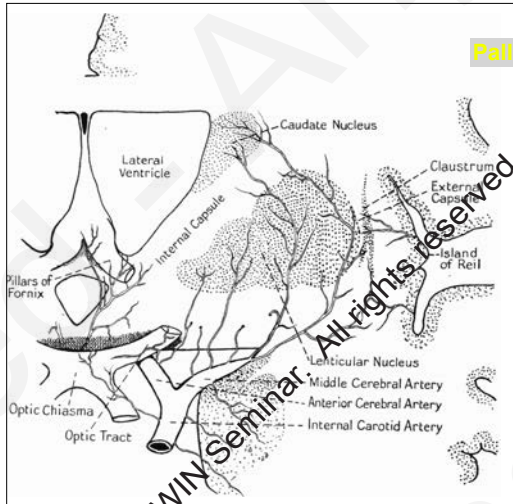


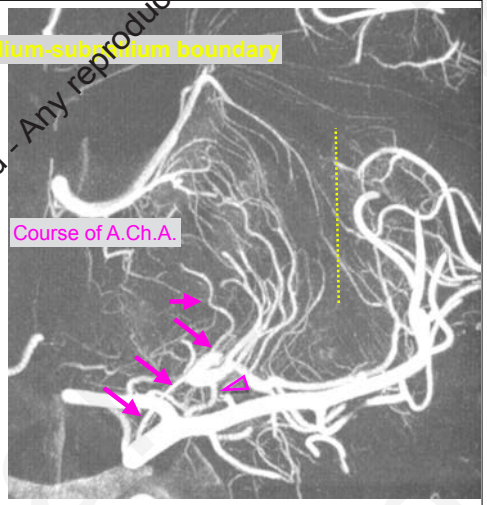




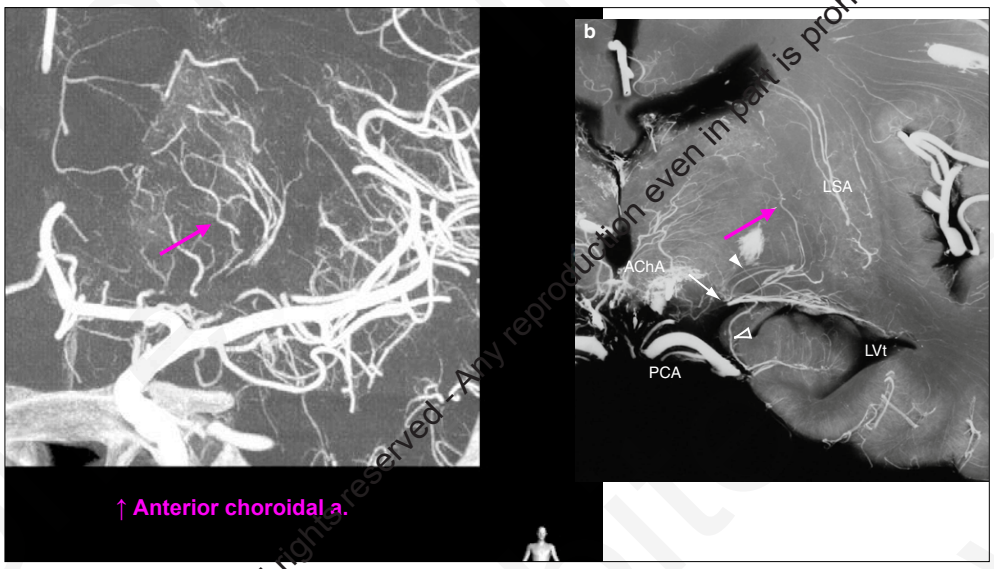








Uncal branch from A.Ch.A.

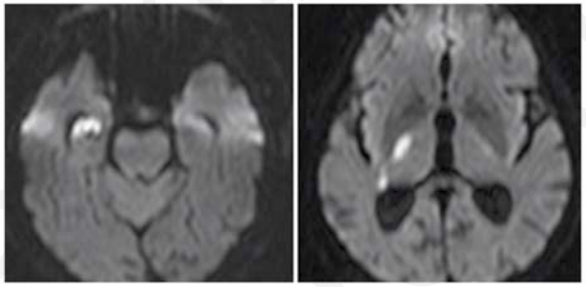


↑ Anterior choroidal a.

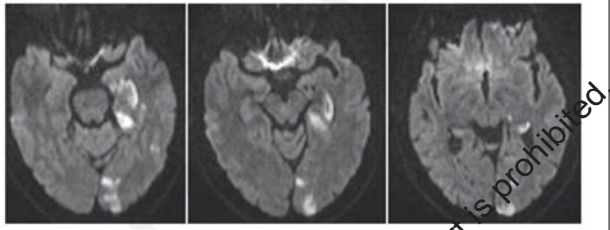
Ischemic stroke.

Infarction limited to the hippocampus is rare.

The hippocampal head can be involved in anterior choroidal artery infarctions (up)



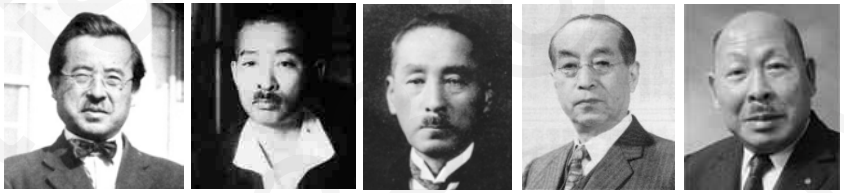
The entire hippocampus in posterior cerebral artery infarction (down).



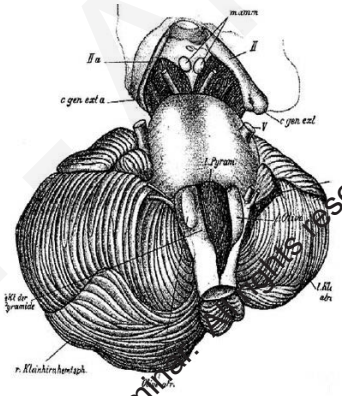
So wird z.B. das Corp. genicul. ext. nicht nur von einem Seitenast der hinteren Hirnarterie, sondern auch von Abzweigungen aus der dem Carotis gebiet entstammen den Art.chorioidea mit Blut gespeist.

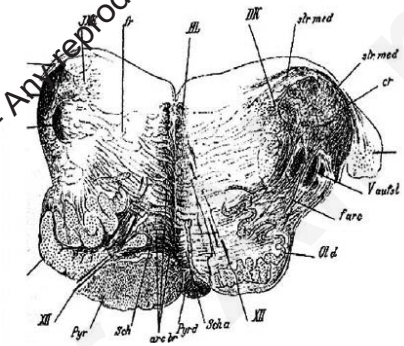
→ For example, **the lateral geniculate body supplied** with blood not only from a side branch of the posterior cerebral artery, but also from branches **from the art. chorioidea** originating from the carotid area

Constantin von Monakow (1853 –1930)



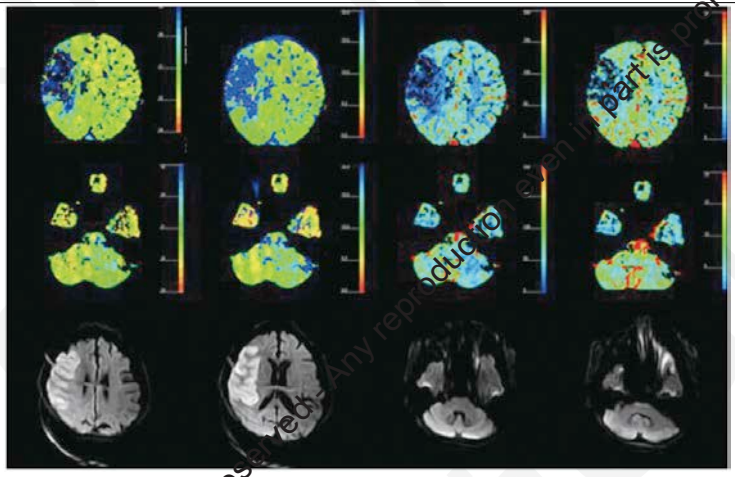
Akert K, Yonekawa Y:Japanese scientists at the Hirnanatomisches Institut and the Brain Research Institute of the University of Zürich, Brain Nerve 49:483-488, 1997.





Diaschisis : Asymmetry between supra and infratentorial neuronal tissue

The pathology showing long-term massive asymmetries of the cortico-cerebellar and pyramidal systems due to multiple long-term perinatal lesions (‘Porenzephalie’) in the right cortical hemisphere and the left cerebellar hemisphere.

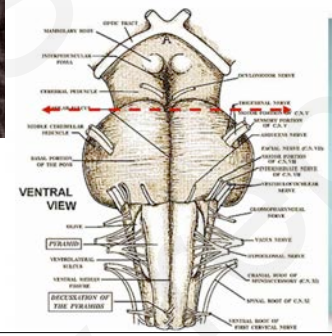


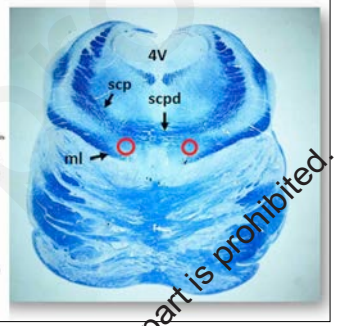
CCD: Crossed cerebellar Diaschisis

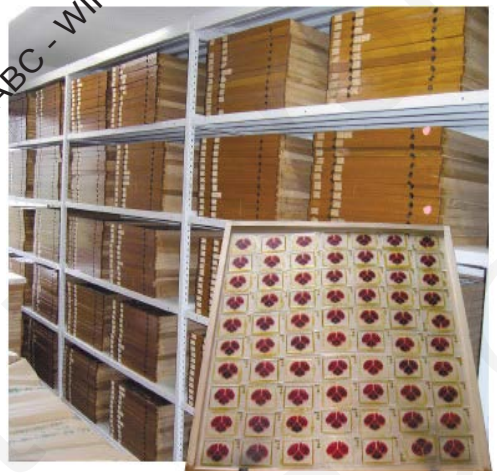
Baron JC, Bousser MG, Comar D, et al: Crossed cerebellar diaschisis in human supratentorial brain infarction. Trans Am Neurol Assoc 105:459-461, 1980.

Prof.Gennosuke Fuse graduated from Tokyo Imperial University medical school. Then he studied abroad in Switzerland. He studied micoanatomy in University of Zurich from 1907 to 1911 and from 1914 to 1916 with Constantin von Monakow.

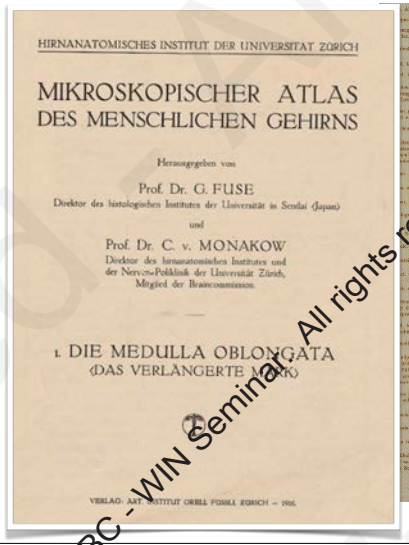
His name is lent to the Kölliker-Fuse nucleus.

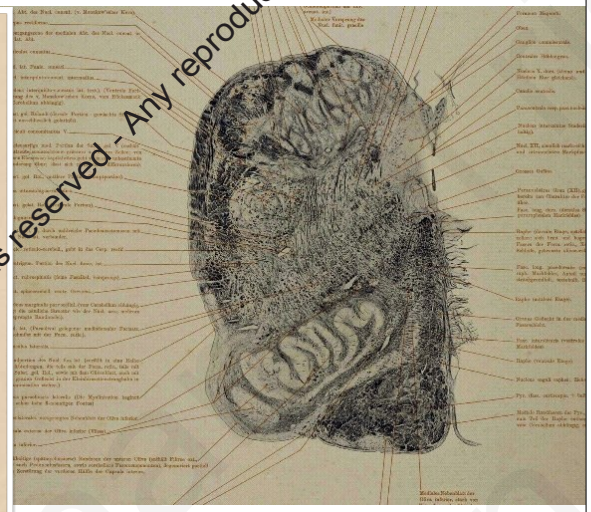






Fuse's collection: one million of histological sections (100 types of specimnes)





Arterial anatomy of the limbic system
Anterior ethmoid artery, Olfactory artery
Recurrent artery of Heubner
Anterior choroidal artery (Uncal artery)
Posterior choroidal artery (Artery of Uchimura)
Pericallosal artery (Cingulate gyrus)
Posterior cerebral artery (isthmus part of CG)

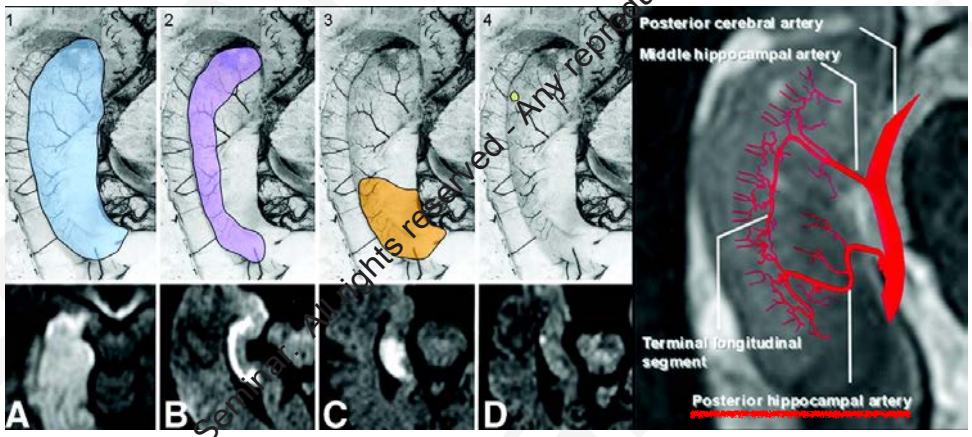
Jushi Uchimura
[1897-1980]

Uchimura arteries

4: ant. choroidal a
7: ant temporal a
8. anterior hippocampal a
9: middle hippocampal a
10: posterior hippocampal a
11: PCA
14: hippocampus
16: parahippocampal gyrus

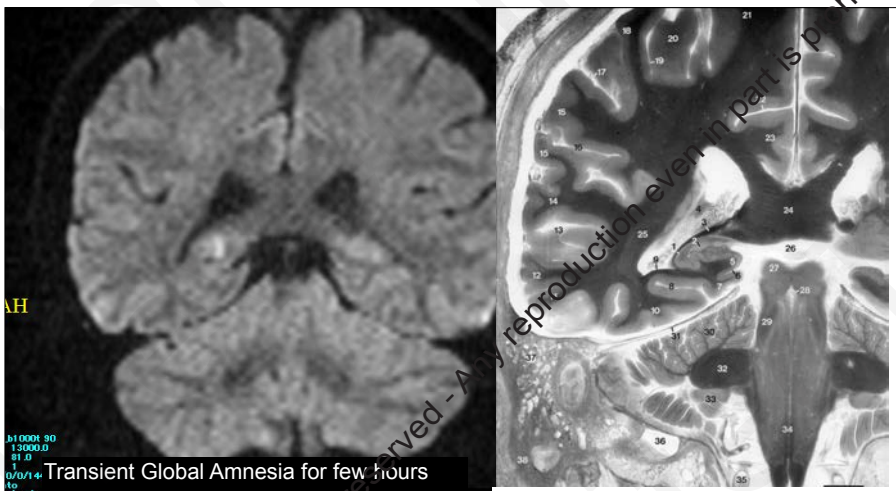
Uchimura J: Über die Gefäß versorgung des selektiven Ammonshornes.
Ztschr ges Neurol Psychiat 112:1-19, 1928

From Sano K: Uchimura artery (arteries). No Shinkei Geka 34:365-373, 2006 (in Japanese)



Artery of Uchimura

Kristina Szabo. Stroke. Hippocampal Lesion Patterns in Acute Posterior Cerebral Artery
Stroke, Volume: 40, Issue: 6, Pages: 2042-2045, DOI: (10.1161/STROKEAHA.108.536144)



Transient Global Amnesia for few hours associated with the focal ischemia of the hippocampal tail, gyrus dentatus,

1 hippocampal tail, cornu Ammonis, 1' inferior part of CA1 with a folded aspect, **2 hippocampal tail, gyrus dentatus,** 3 crus of fornix, 4 atrium of the lateral ventricle, 5 isthmus

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1 hippocampal tail, cornu Ammonis, 1' inferior part of CA1 with a folded aspect, 2 hippocampal tail, gyrus dentatus, 3 crus of fornix, 4 atrium of the lateral ventricle, 5 isthmus

Arterial anatomy of the limbic system
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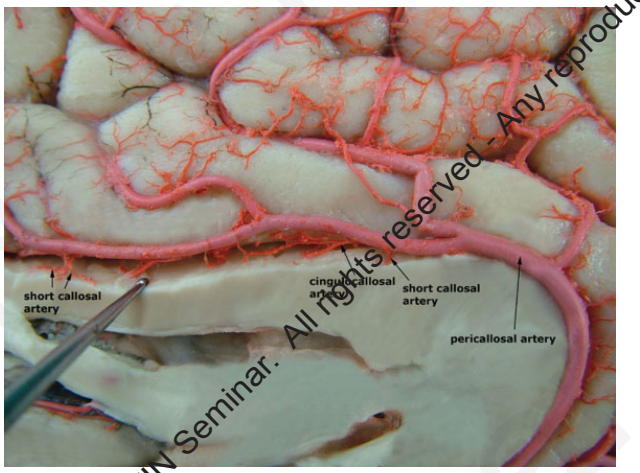
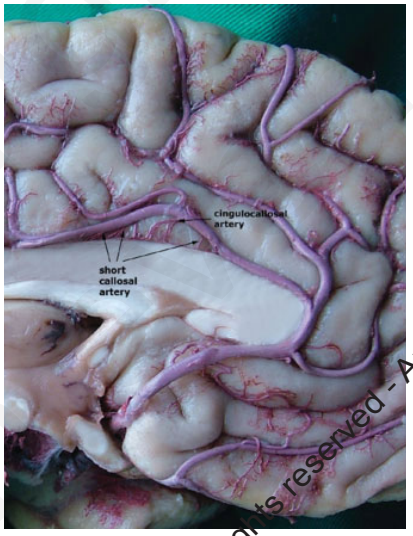
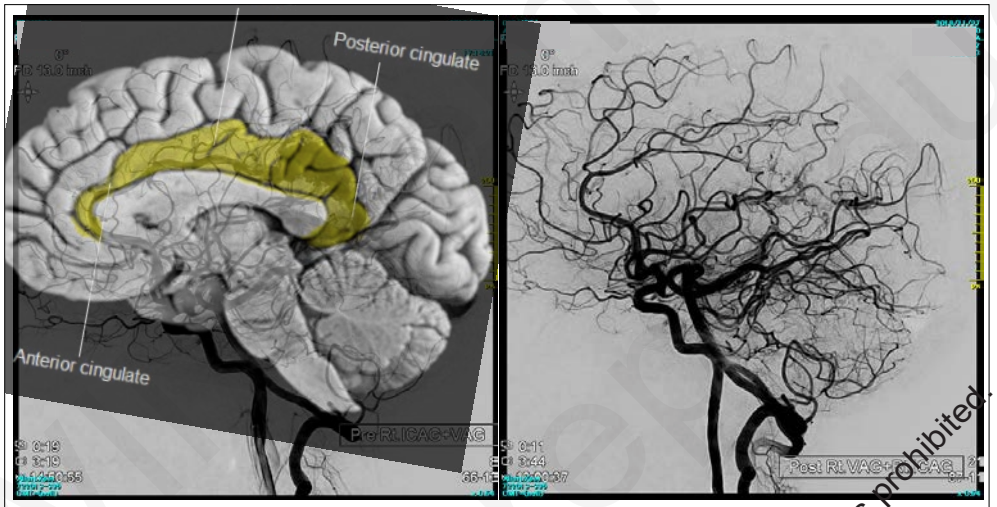
Recurrent artery of Heubner
Anterior choroidal artery (Uncal artery)
Posterior choroidal artery (Artery of Uchimura)
Pericallosal artery (Cingulate gyrus, Indusium griseum)
Posterior cerebral artery (isthmus part of CG)



Kahilogullari G et al. Clin Anat. 2008 Jul;21(5):383-8.

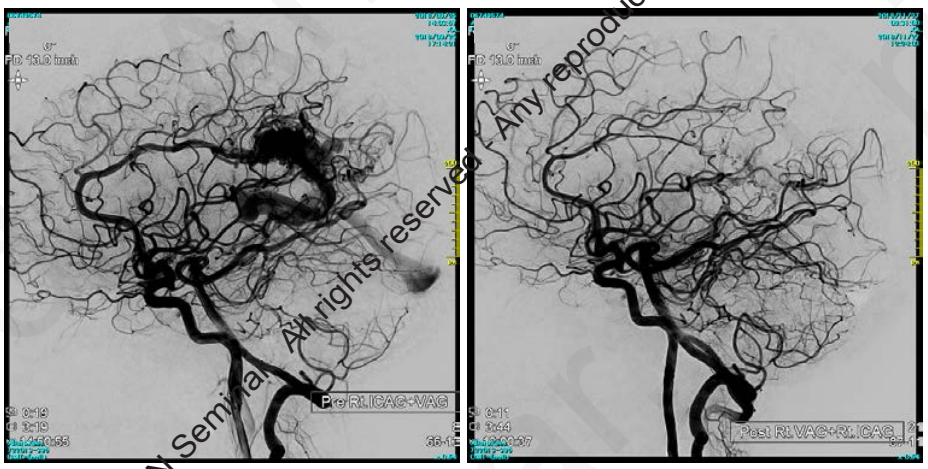


Kahilogullari G et al. Clin Anat. 2008 Jul;21(5):383-8.



Pre Post

Fig.10



Pre Post

Cingulate sulcal AVM (limbic AVM) : complete obliteration with two sessions.

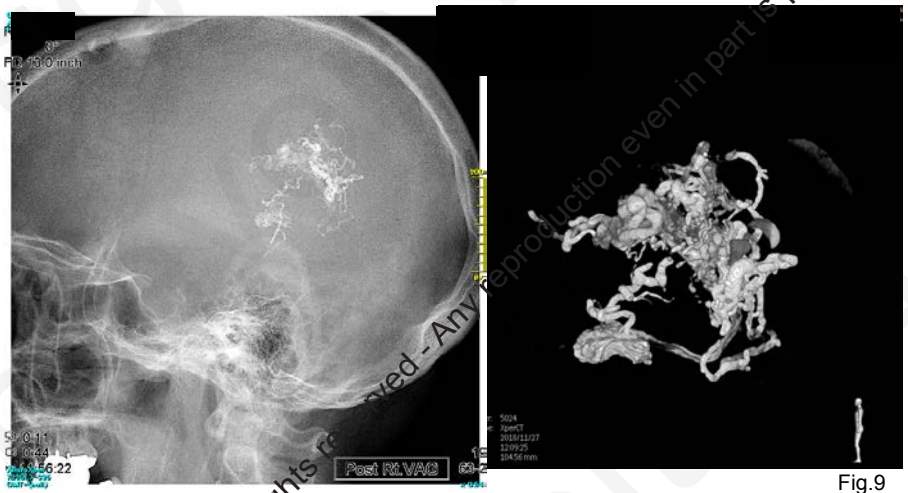
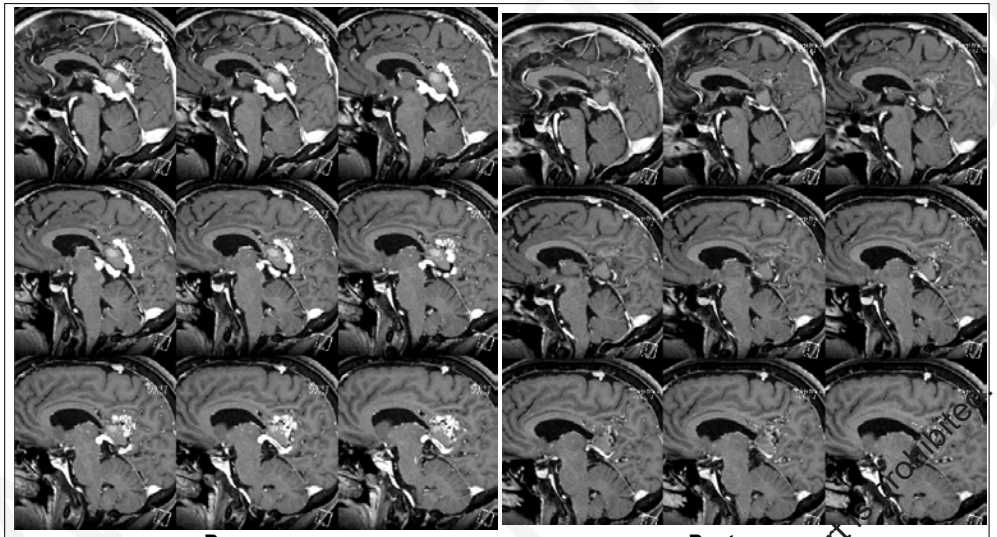
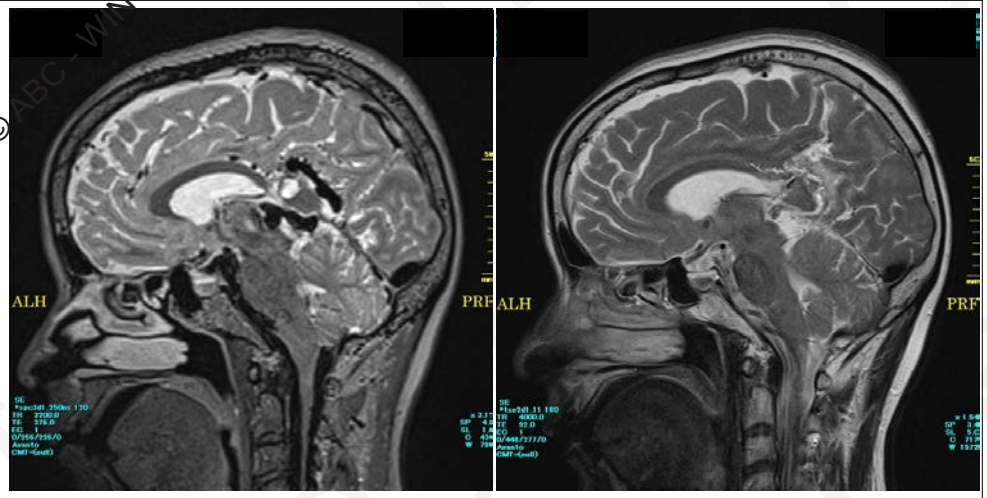


Fig.9



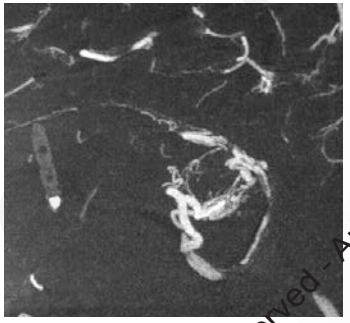
Pre **Post**

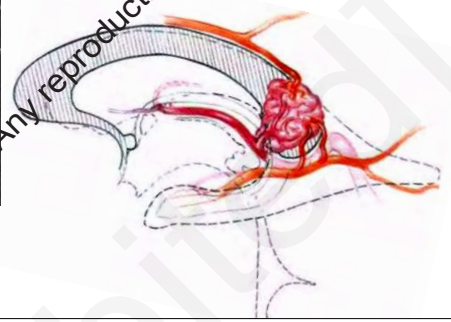


Pre **Post@3months** **mRS2**

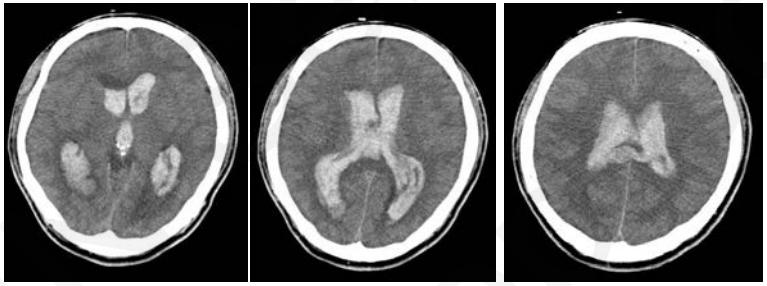
Arterial anatomy of the limbic system
Anterior ethmoid artery, Olfactory artery
Recurrent artery of Heubner
Anterior choroidal artery (Uncal artery)
Posterior choroidal artery (Artery of Uchimura)
Pericallosal artery (Cingulate gyrus, Indusium griseum)
Posterior cerebral artery (isthmus part of CG)

Embolization of ruptured callosal AVM

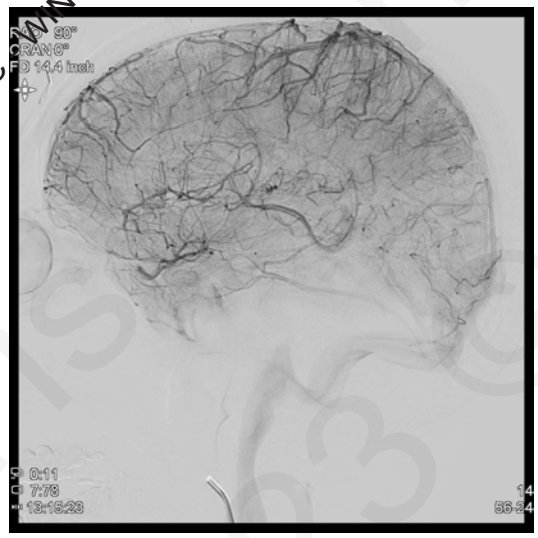


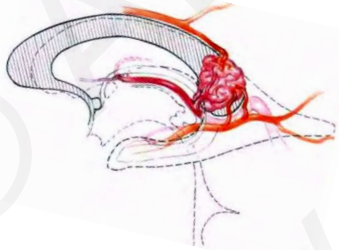


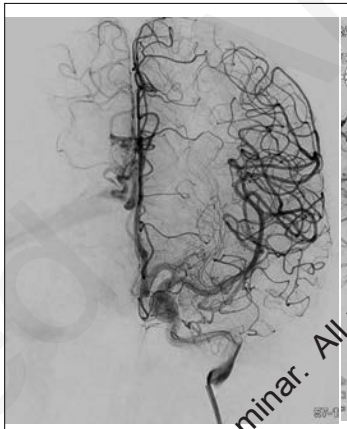
A 39 year-old-man presented with sudden onset of loss of consciousness.

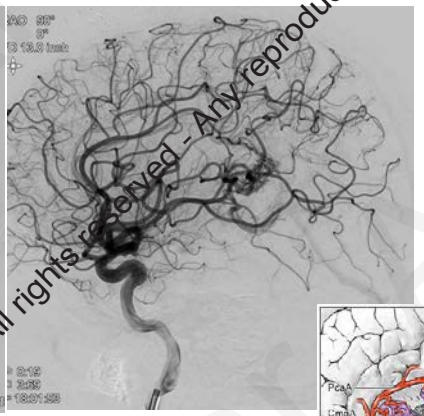


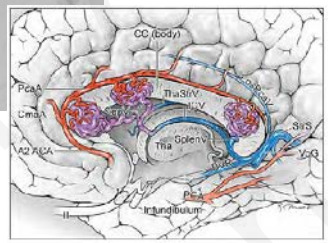
WFNS grade 5, H&H grade 5,
Comatose (GCS 4, JCS200), flaccid extremities.
pupils 4.0/4.0, no marked light reflex

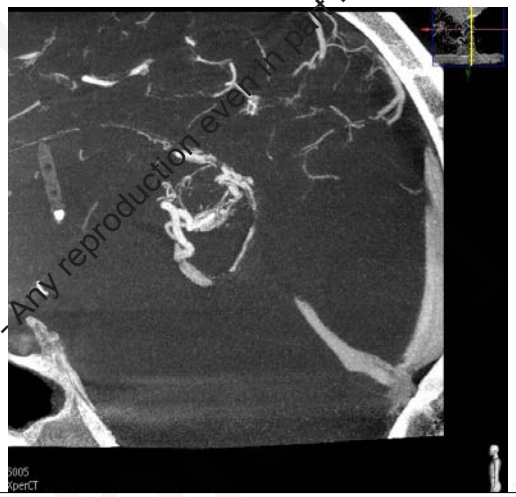




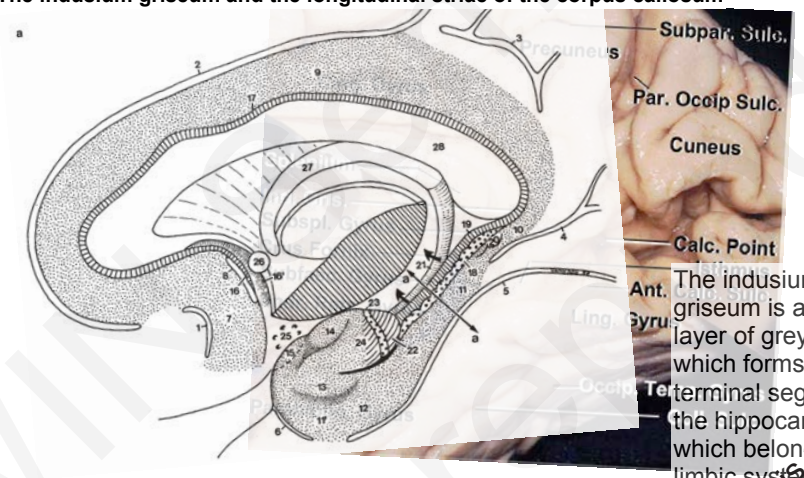






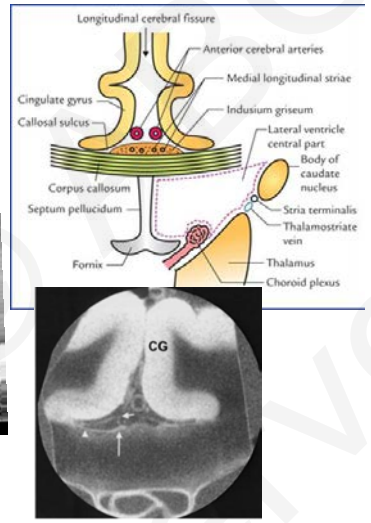


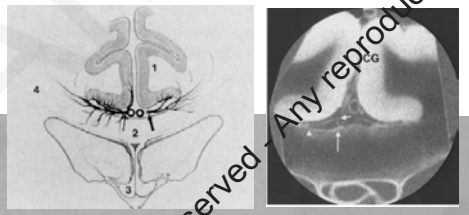
The indusium griseum and the longitudinal striae of the corpus callosum

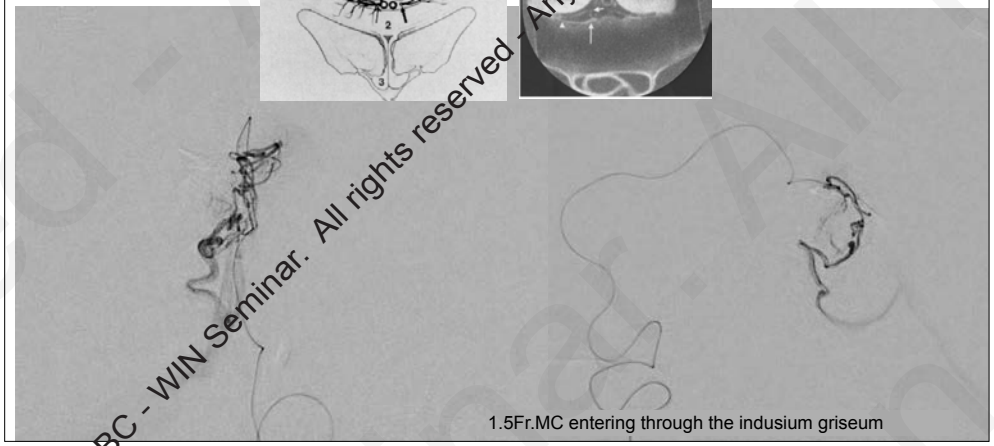


The indusium griseum is a thin layer of grey matter which forms the terminal segment of the hippocampal tail which belongs to the limbic system.

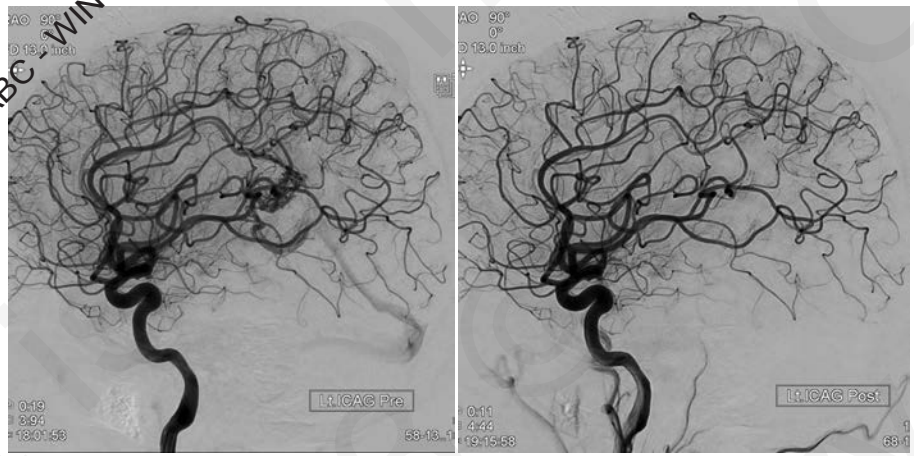
Duvernoy H, 2013





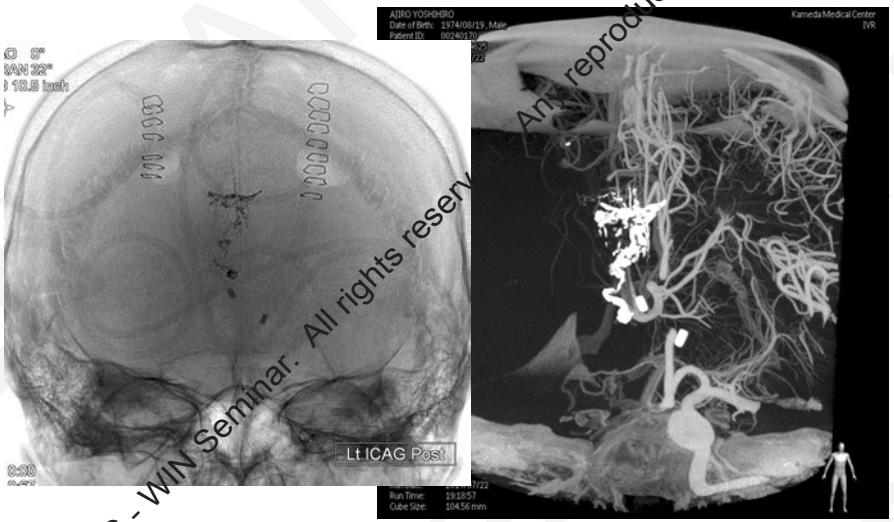


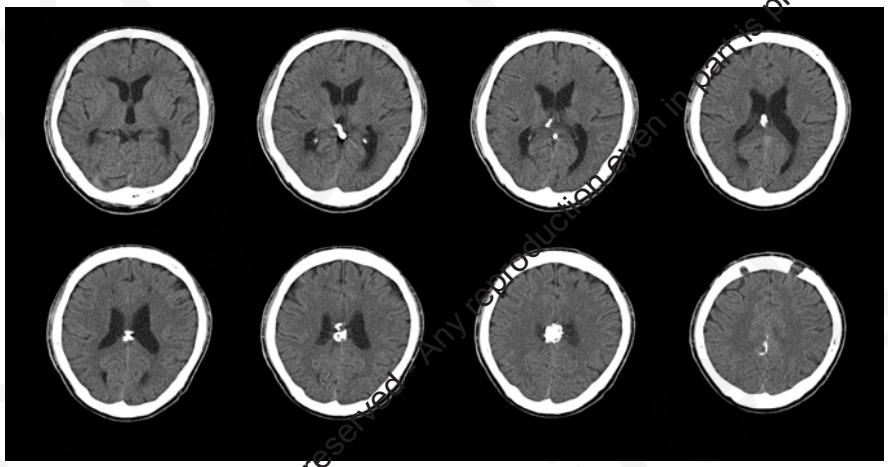
1.5Fr.MC entering through the indusium griseum



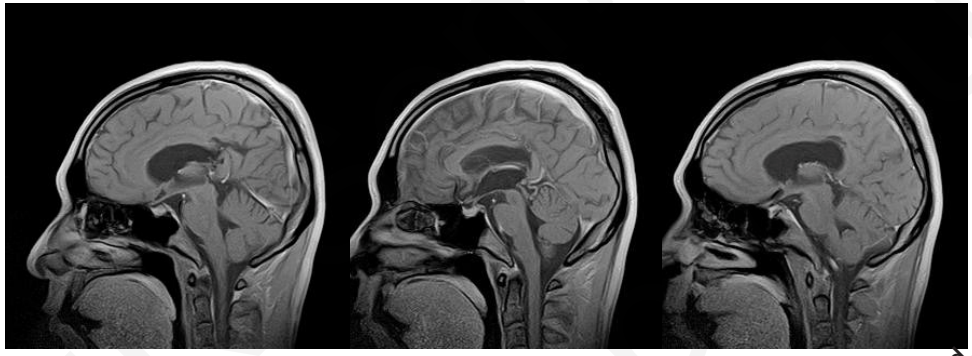
Pre

Post





@2 months post Op.
mRS2



mRS1@2 months post Op.
Recent memory disturbance improved significantly.

Menu

1. The phylogeny and the functional anatomy of the limbic system
2. Arterial anatomy of the limbic system
   - Anterior ethmoid artery, Olfactory artery, Recurrent artery of Heubner
   - Anterior choroidal artery (Uncal artery)
   - Posterior choroidal artery (Artery of Uchimura)
   - Pericallosal artery (Cingulate gyrus)
   - Posterior cerebral artery (isthmus part of CG)
3. Venous anatomy of the limbic system

Telencephalic cortex and its functional regions in vertebrates Phylogenetically, paleopallium, archipallium, and neopallium are the oldest.

Pallium	Area involved
Paleopallium (Rhinecephalon)	the olfactory bulb, olfactory tract, tubercle and striae, the anterior olfactory nucleusm parts of the prepyriform cortex
Archipallium	the hippocampal formation, the dentated gyrusm the fasciolar gyrusm the indusium giseum (supracallosal gyrus)
Neopallium	others of the cerebral cortices

Venous system of the Neopallium, Paleopallium and Archipallium.

Four regions of the **supratentorial** telencephalon of vertebrates:
the neocortex, the archaecortex, the paleocortex, and the ventricles and associated venous groups

Venous system	Related area	Venous structures compare to man
Dorsal venous system	Neopallium	SSS, ISS, straight sinus, Falcine sinus, transverse sinus
Lateral- Ventral venous system	Paleopallium	Tentorial sinus (middle cerebral vein)
Ventral-Lateral venous system	Archipallium	Basal vein of Rosenthal
Ventricular system	lateral and 3rd ventricle	Tributaries of the forerunner of the median prosencephalic vein of Markowski, internal cerebral veins

Infratentorial (cerebellar, midbrain, and hindbrain) venous groups of vertebrates Neocortex, Paleocortex, Paleocortex, Ventricles, Brainstem

Venous system	Related cerebellum area and brain stem	Venous structures compare to man
Dorsal venous system	Neocerebellum	transverse sinus, occipital sinus marginal sinus
Lateral- Ventral venous system	Archi-cerebellum, Cerebellar peduncles, Choroid plexus of 4th ventricle, Brain stem	mesencephalic pontine medullary veins, vein of cerebello-pointone fissure, vein of lateral recess of 4th ventricle
Ventricular system	Paleocerebellum, tectum of the midbrain	paracentral and superior vermian veins, tectal vein

Summary…

1. Vasculature in the paleopallium and archipallium has different arrangement.
2. Paleopallium is the dominant part of the telencephalon phylogenetically corresponding to the olfactory system.
3. The function area of archipallium (like Ammon's horn) is highly vascularized.
4. Anterior choroidal artery is the fundamental architecture for diencephalon and limbic system. It forms the limbic arcade and annexation with posterior choroidal artery.
5. Recurrent artery of Heubner and subcallosal perforators supply the nuclei accumbens.

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