Kharkiv National Medical University
Department of Neurosurgery

Cerebrovascular Diseases

- Annually there are more than 7 million cases of strokes registered all over the world

- 4,6 million of people die each year, that is 9-12% from all death rate (WHO)

- Cerebrovascular disease is the most common life threatening neurological event in the U.S. Intracranial atherosclerosis is responsible for approximately 40,000 of these attacks per year, representing 10% of all ischemic strokes

- During the last 15 years cerebrovascular pathology among the people able to work has grown almost twice and to 2025 year the cerebro-vascular diseases rate will be increased on 30%

◊ Stroke is the third leading cause of death in the United States. Of the more than 700,000 people affected every year, about 500,000 of these are first attacks, and 200,000 are recurrent. About 25% of people who recover from their first stroke will have another stroke within five years

◊ Stroke is a leading cause of serious long-term disability, with an estimated 5.4 million stroke survivors currently alive today. The American Heart Association estimates that in 2003, stroke cost about $51.2 billion in both direct and indirect costs in the United States alone

◊ The most recent prevalence statistics from the American Heart Association estimate that 5,400,000 people have experienced stroke

◊ Every year, an estimated 30,000 people in the U.S. experience a ruptured cerebral aneurysm and as many as 6% may have an unruptured aneurysm

◊ Arteriovenous malformations (AVMs) are present in about 1% of the general population. The risk of hemorrhage from an AVM is 4% percent per year with a 15% chance of stroke or death with each hemorrhage

Features of cerebral blood flow

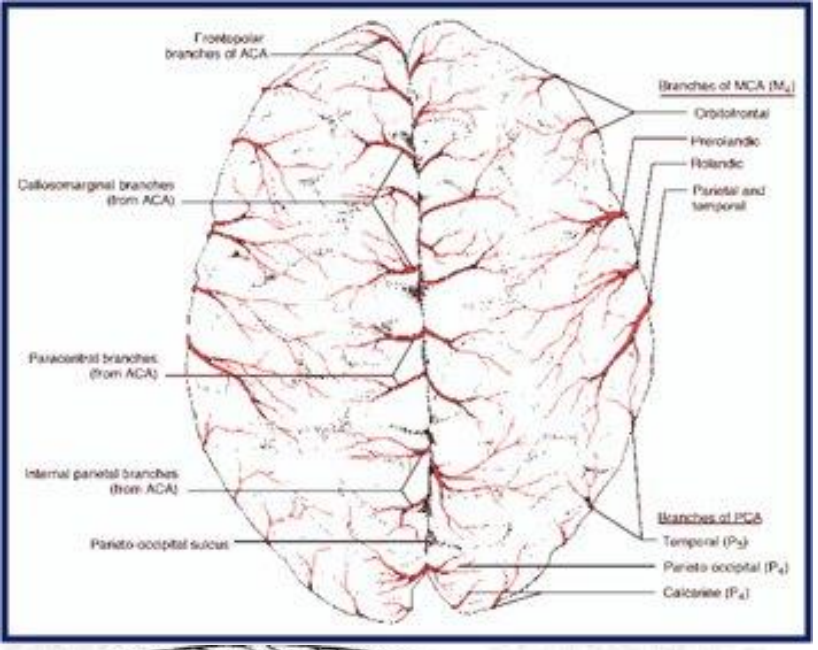
◊cerebral circulation regulates metabolic activity of brain tissue

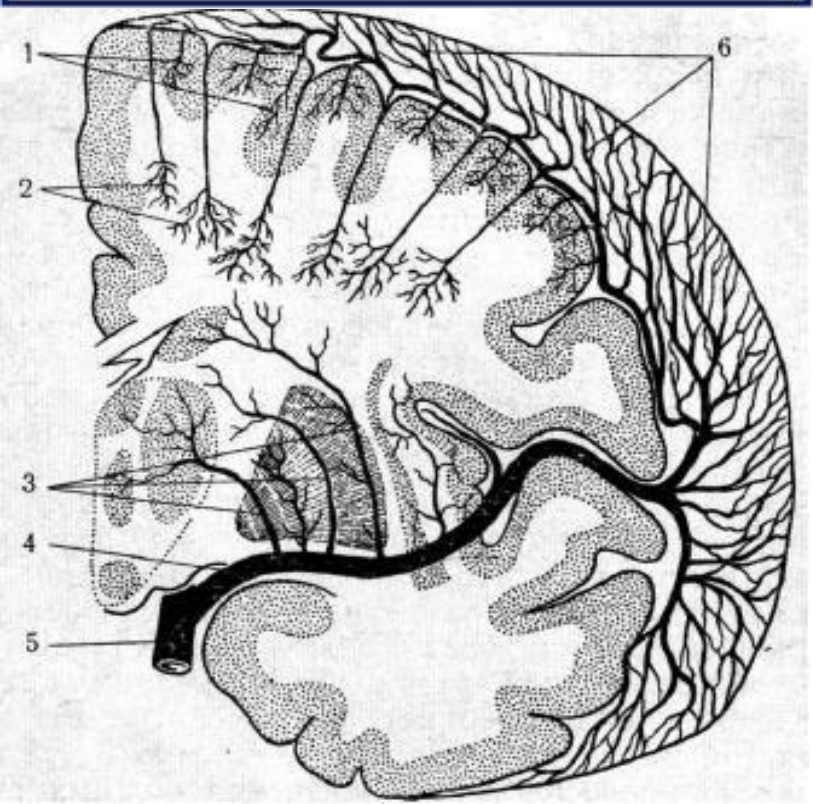
◊brain practically does not keep reserves of oxygen

◊brain mass of approx 1400 gr. (2% of body's); it consumes approximately 20% of all oxygen and 17% of all glucose which incomes the organism

◊ total area of brain capillaries in adult ~ 12 m^2, total length is about 650 km

Anatomy-topographical features of cerebral vessels

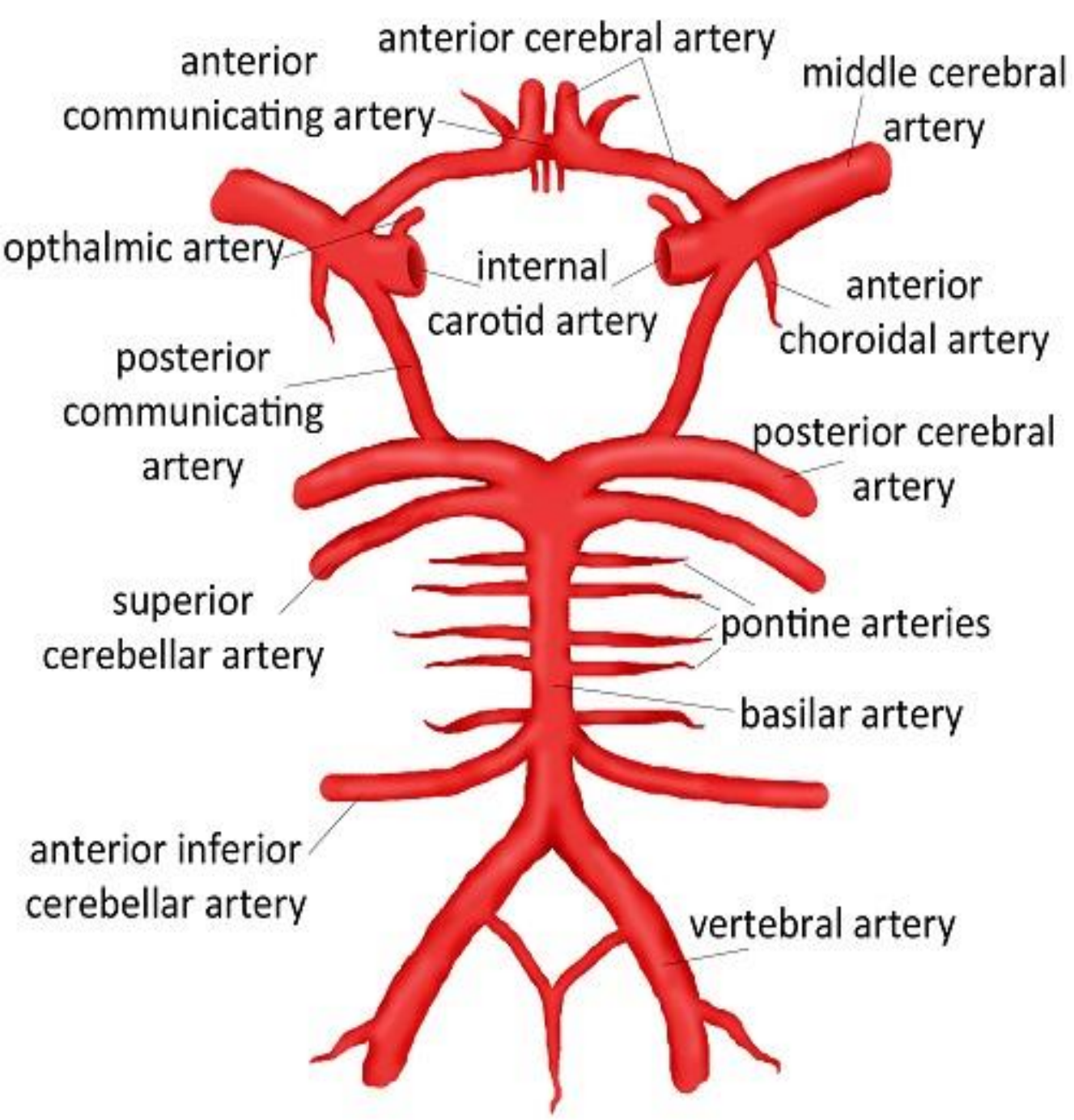




Cerebral arteries and their branches are formed by two systems, on which blood flows into cerebrum:

- ◇ arterial system on the convex of the brain
- ◇ arteries inside the brain of both systems

The vascular system of brainstem is presented by arteries, which depart from the vessels of brain basis and has plenty of anastomosis

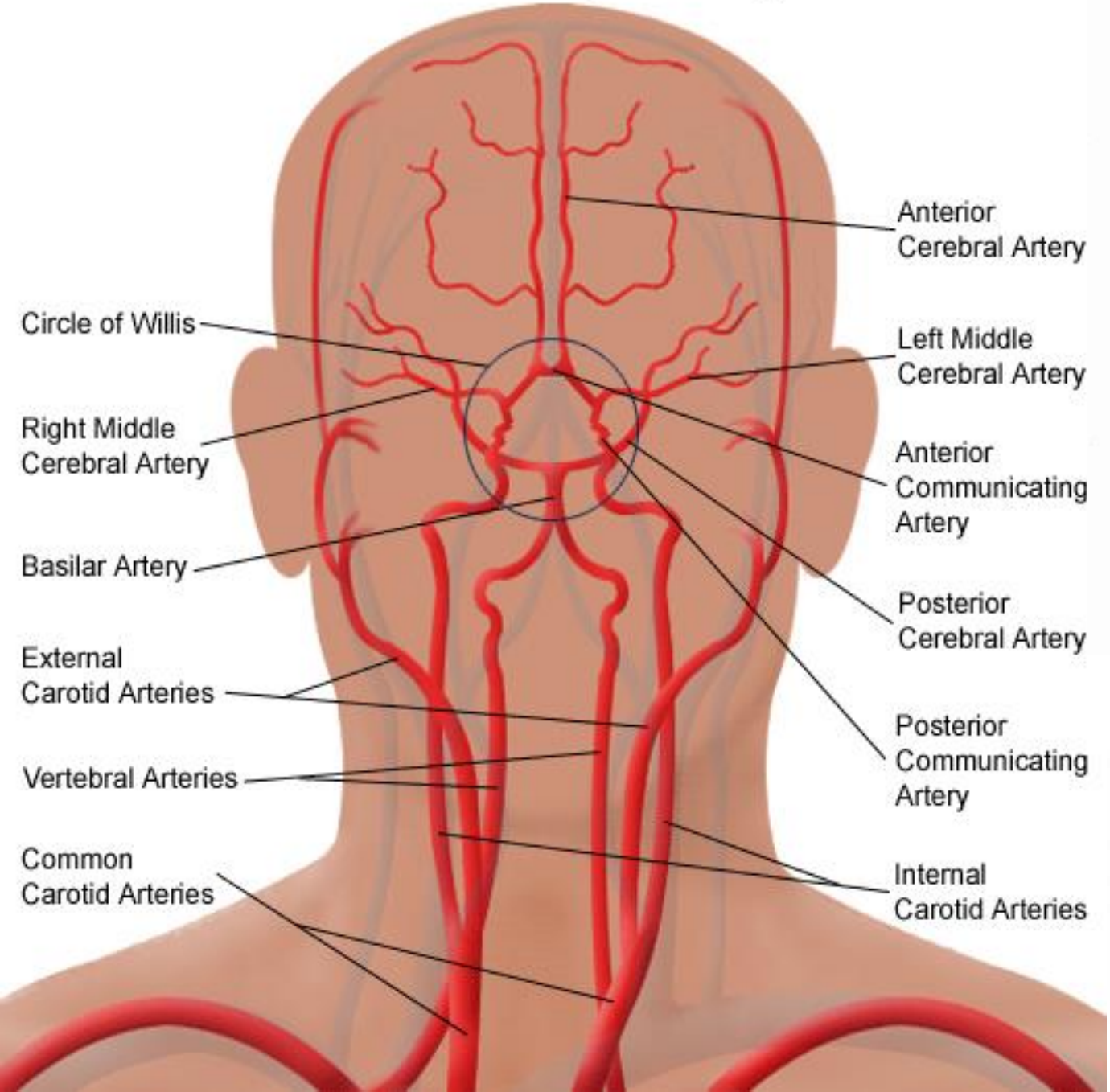


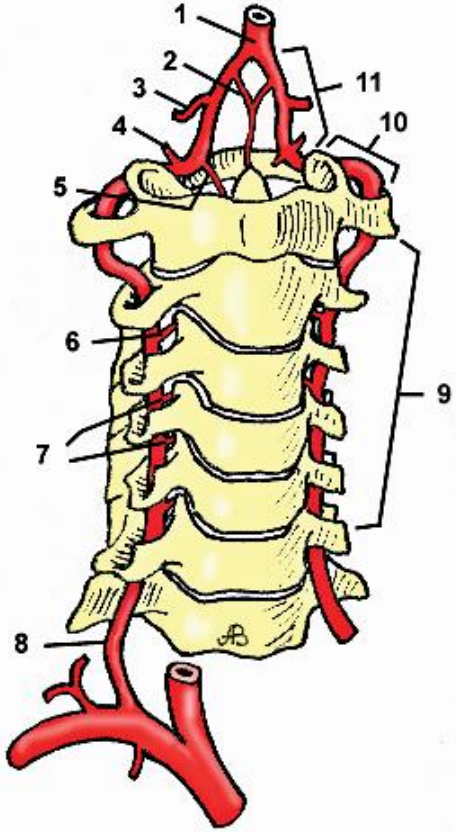
Collateral Circulation

- Circle of Willis
- Variation
- Leptomeningeal Collateral

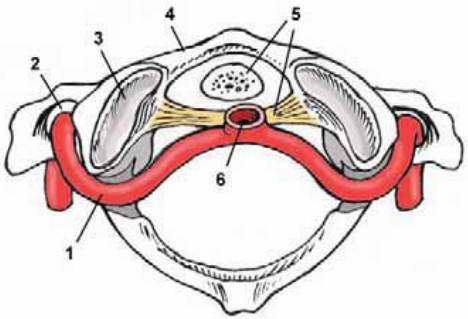
A circle of Willis is a basic level of anastomosis

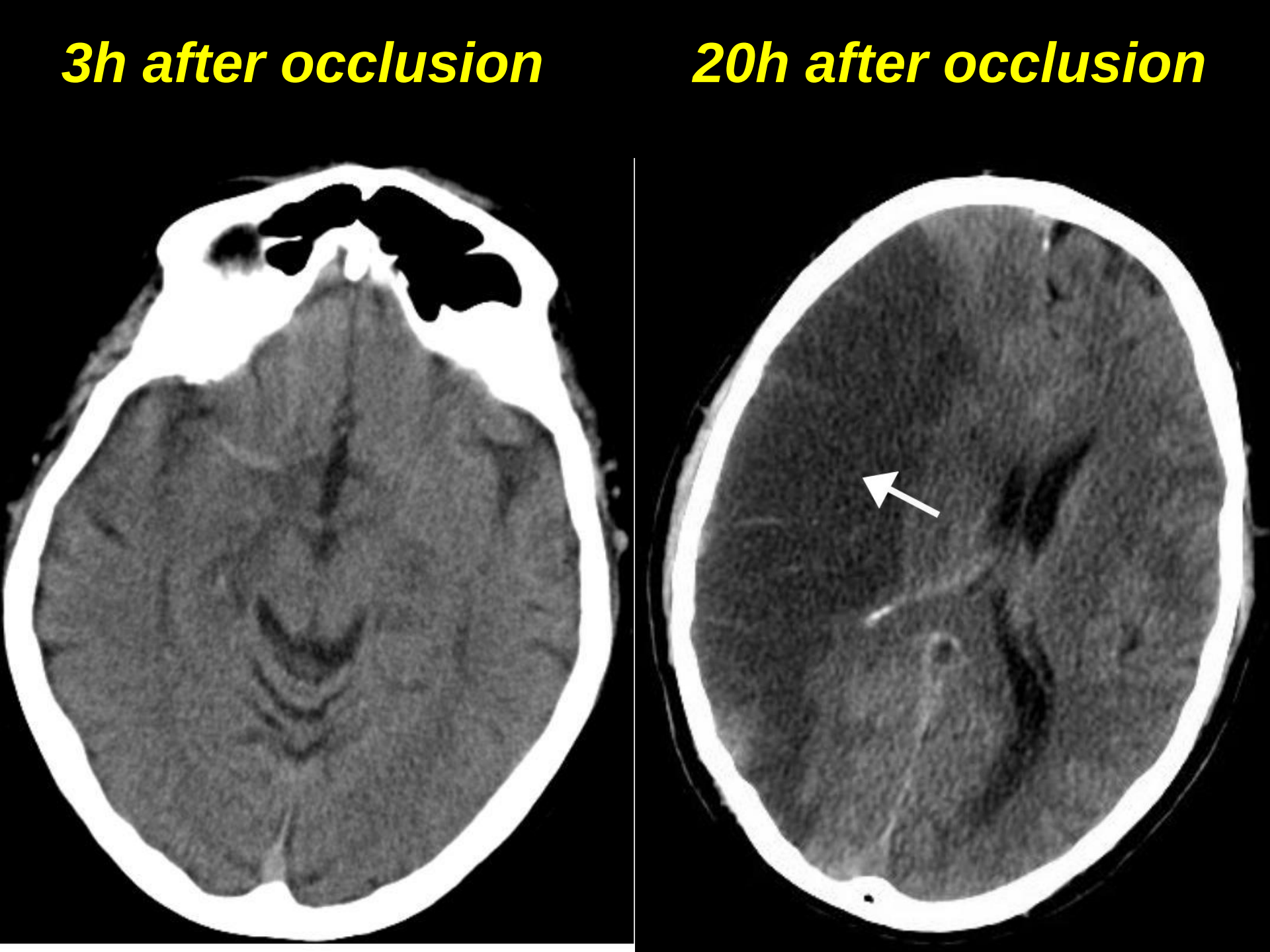
Arterial Circulation of the Brain, Including Carotid Arteries

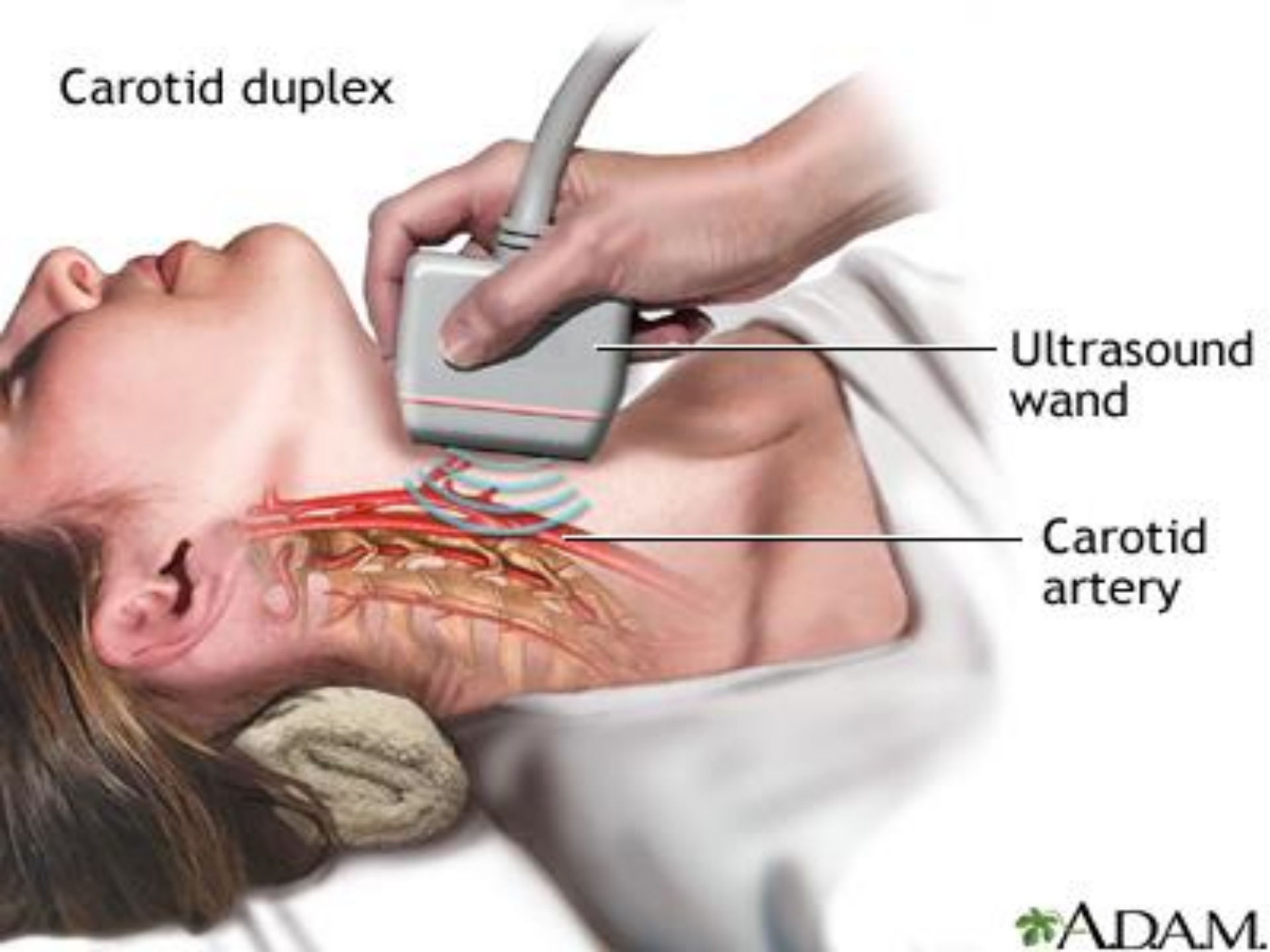




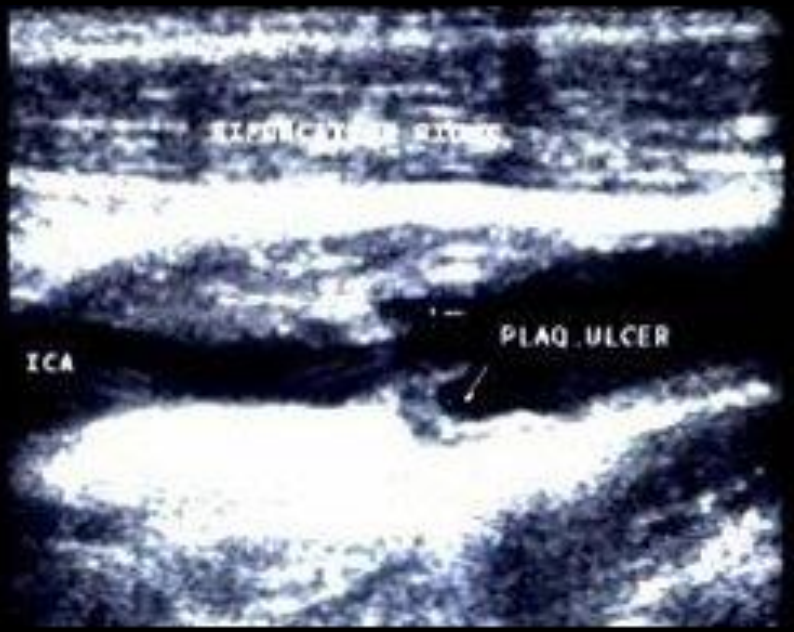
Location VA



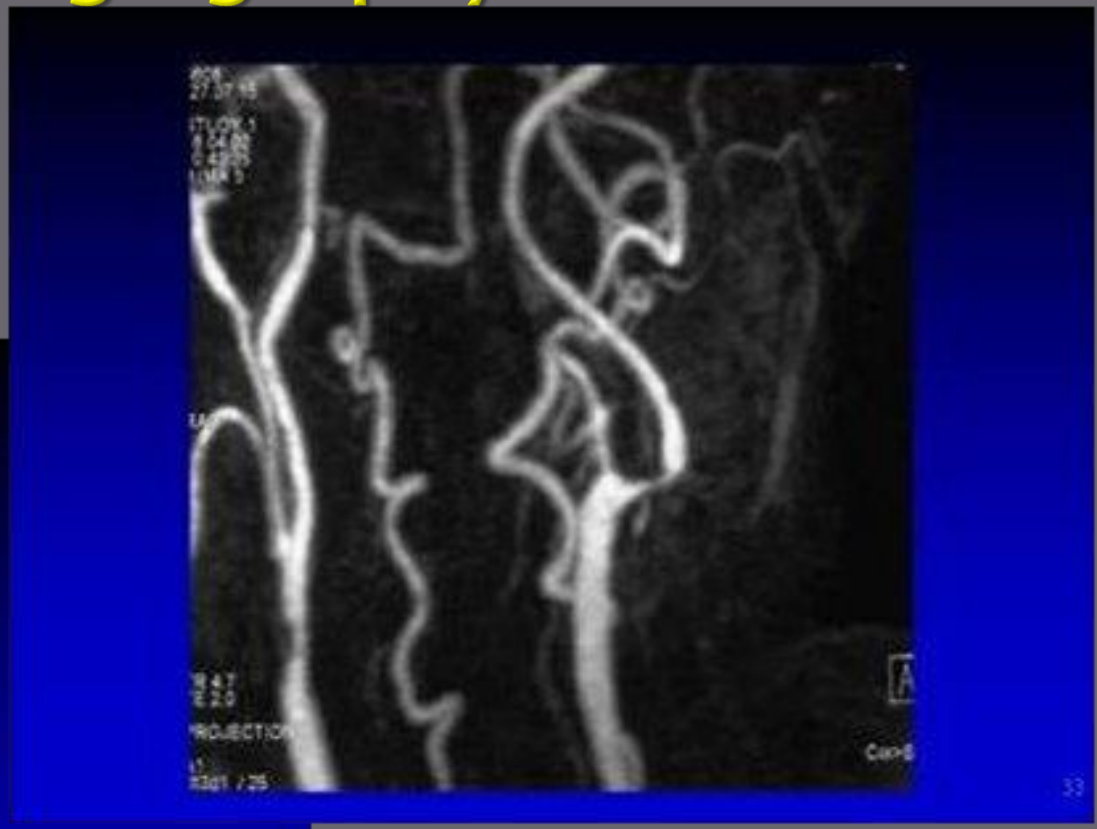

3h after occlusion
20h after occlusion


Carotid duplex
Ultrasound wand
Carotid artery
ADAM.

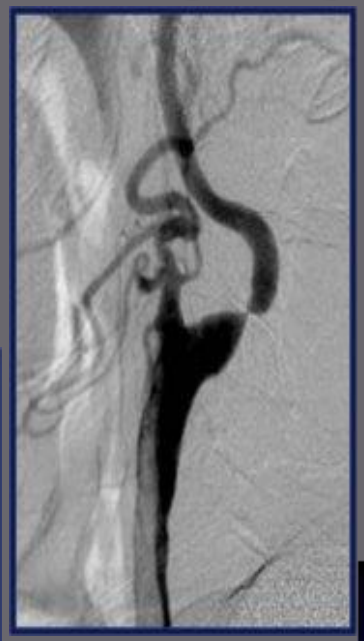
Ultrasonography with a full-duplex scan-out

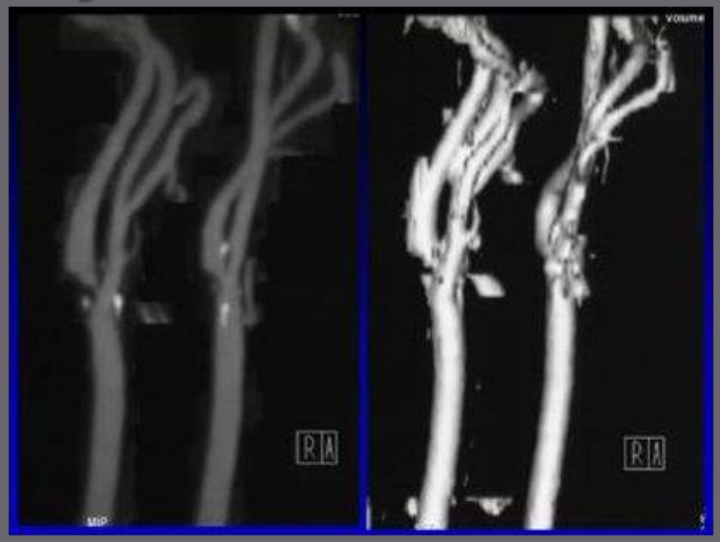


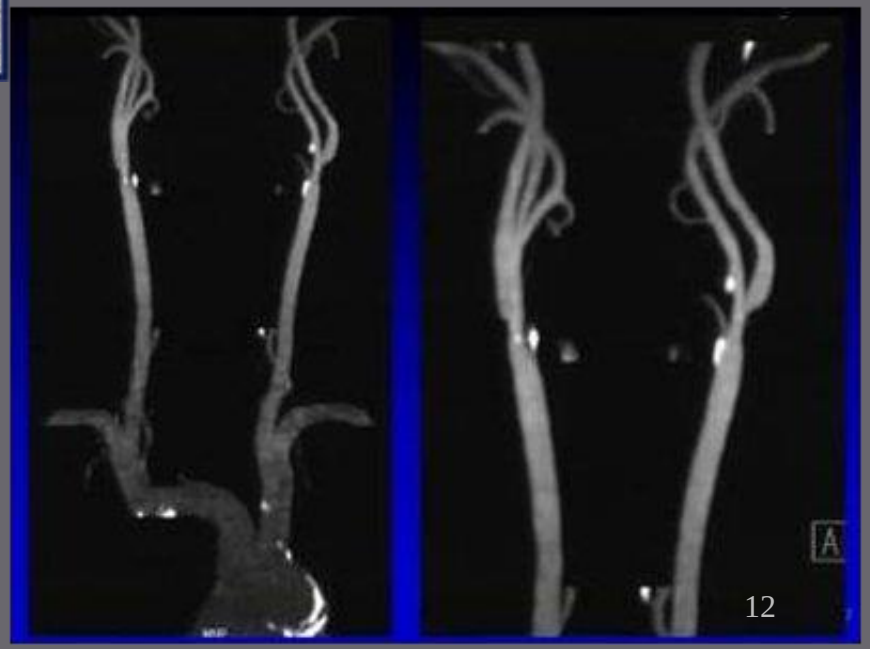
Magnetic-resonance tomography and MR-angiography



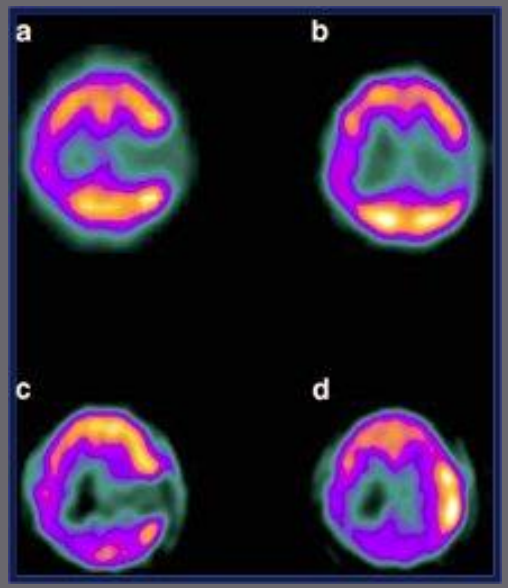
Angiography, digital angiography, 3D-CT-angiography

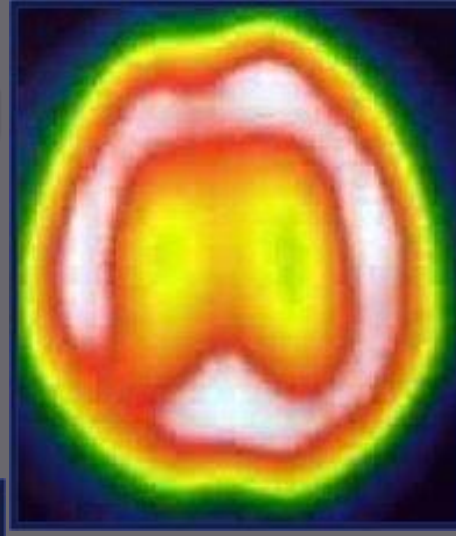


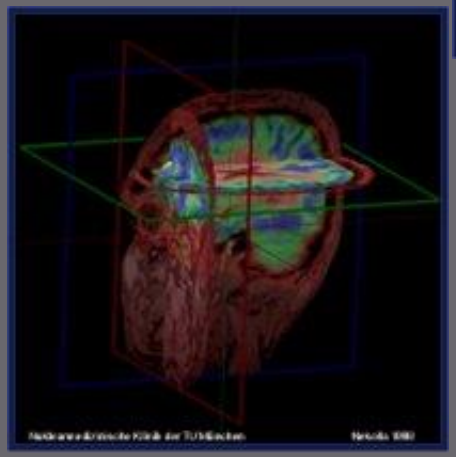


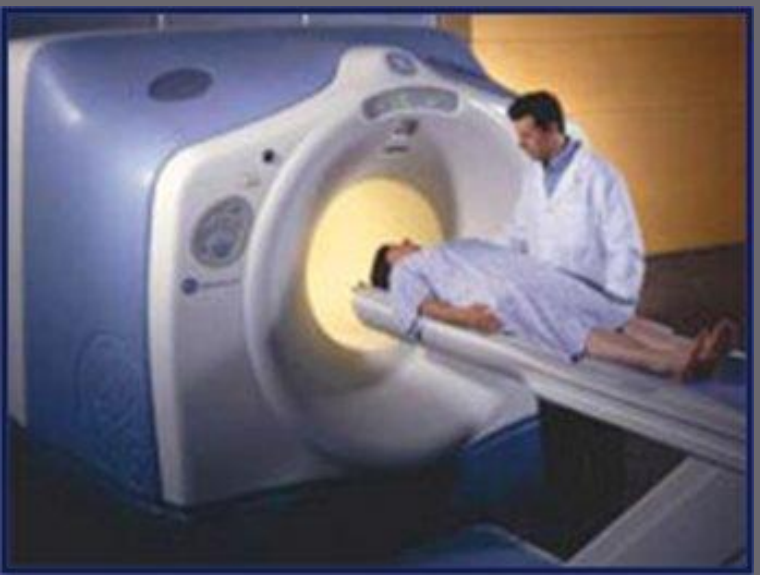


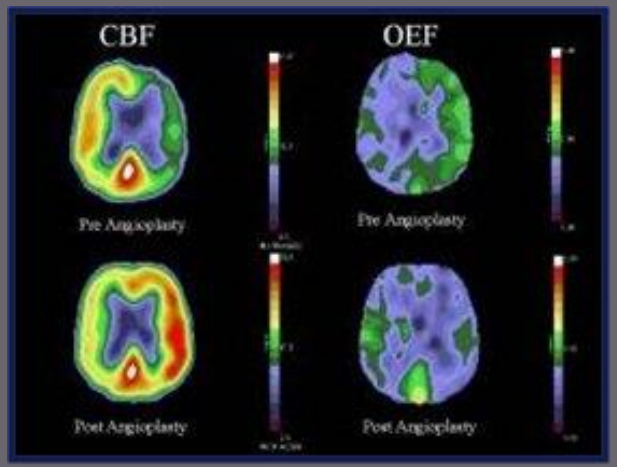
PET scan, OPECT imaging

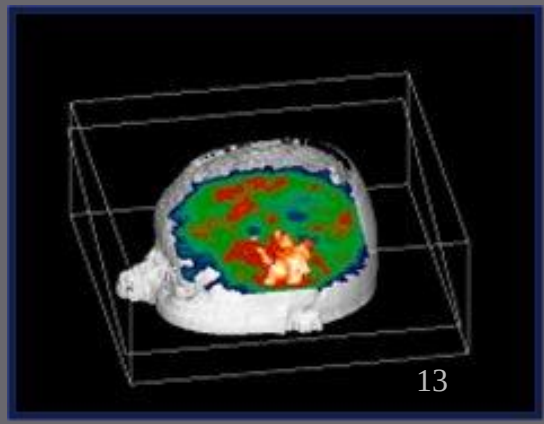




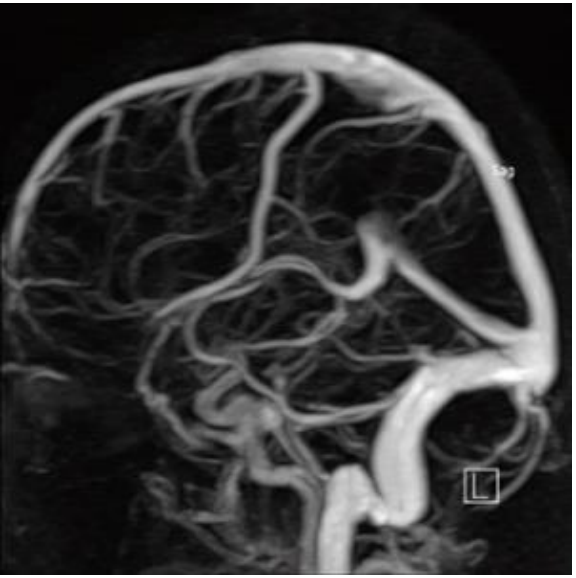




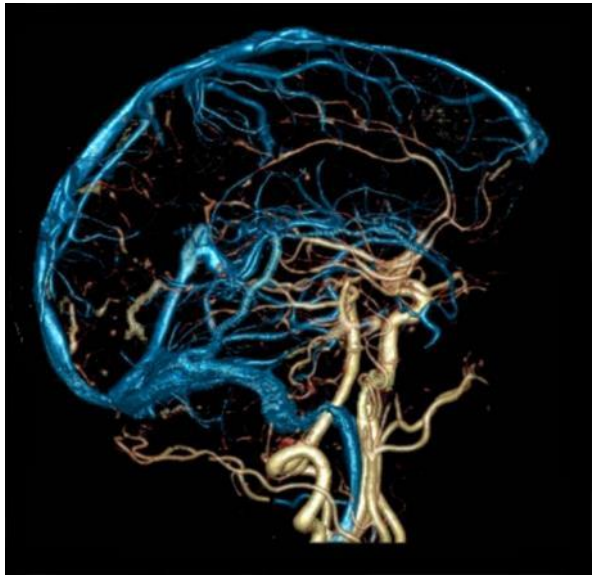




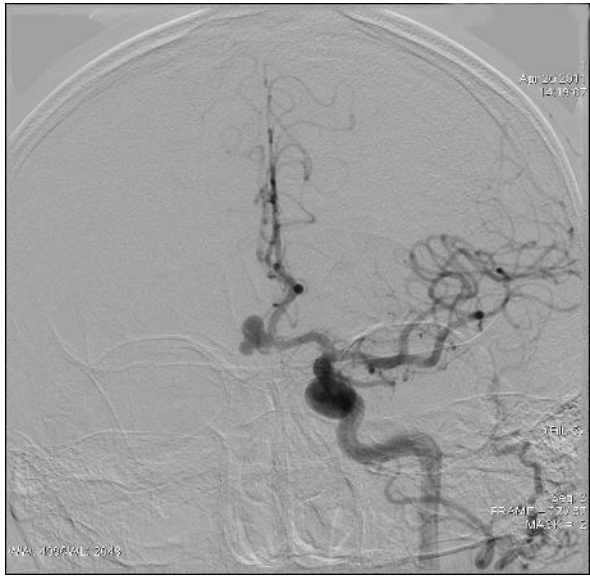
Angiography



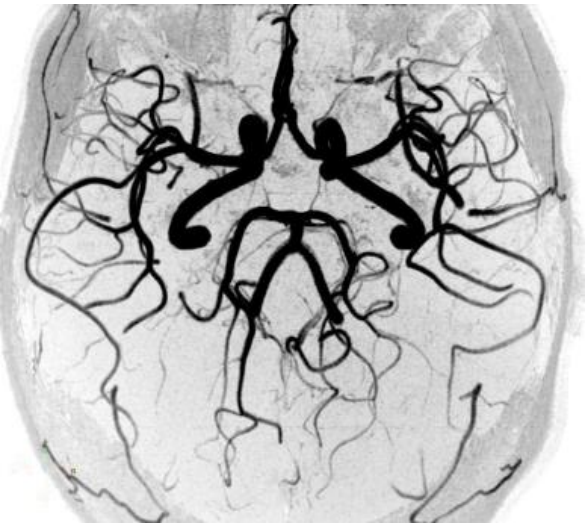
MRI-angiography

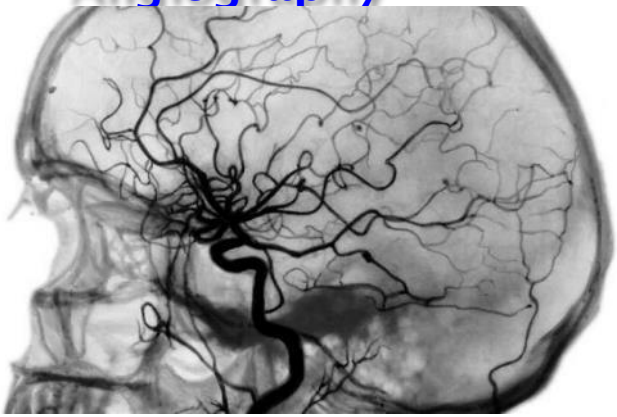


CT-angiography

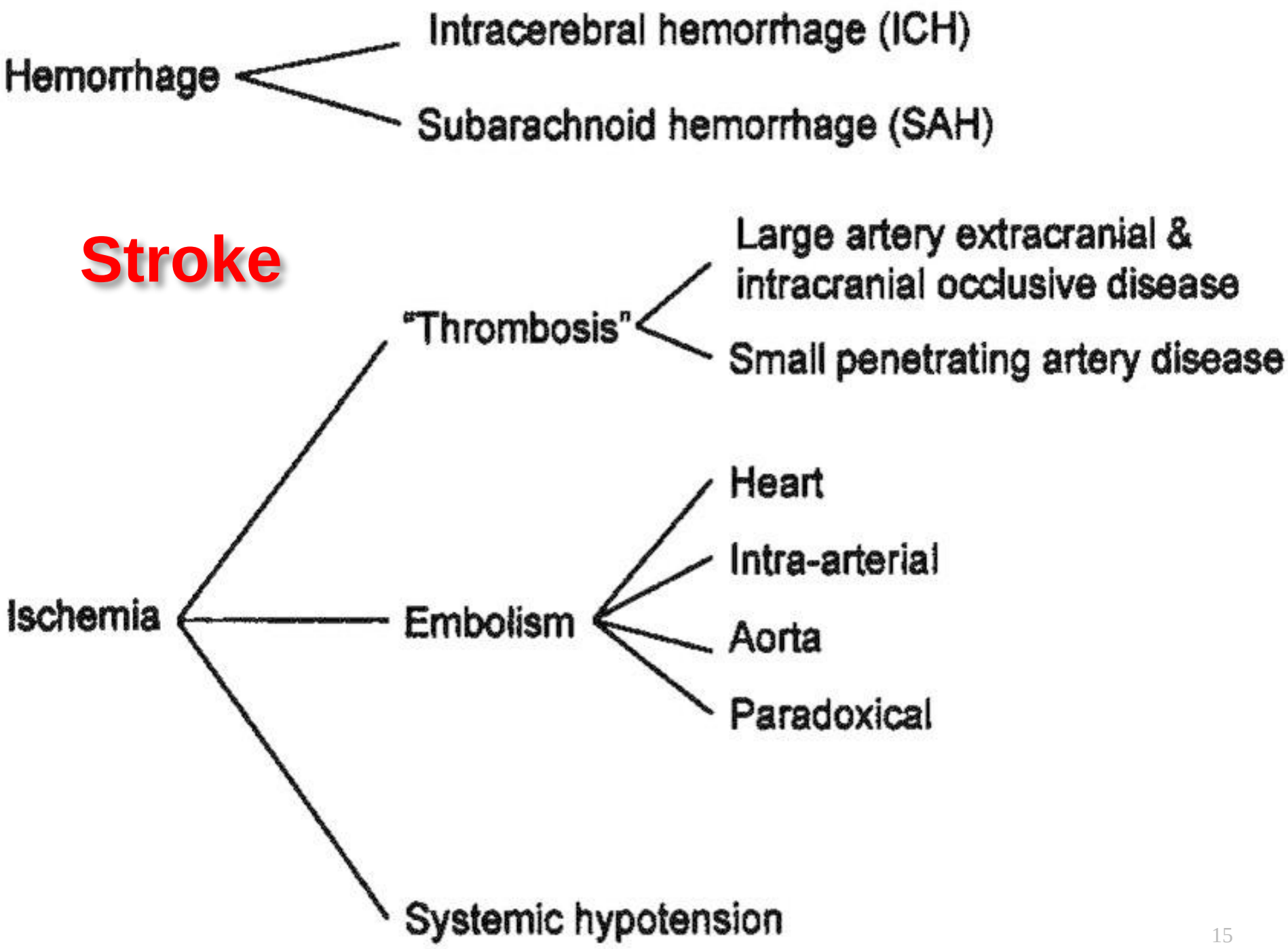


Catheter Angiography





Stroke


Hemorrhage
Intracerebral hemorrhage (ICH)
Subarachnoid hemorrhage (SAH)
Ischemia
"Thrombosis"
Large artery extracranial & intracranial occlusive disease
Small penetrating artery disease
Embolism
Heart
Intra-arterial
Aorta
Paradoxical
Systemic hypotension

Ischemic Stroke

EMBOLIC – An Ischemia Stroke that occurs when an undissolved Solid, Liquid, or Gas embolus blocks a cerebral artery

- Usually occurs suddenly
- Most common are clots that arise from diseased blood vessels in the neck or from abnormally contracting chambers in the heart - i.e. Atrial Fibrillation. Can also be an Air Embolus.
- May show less/more subtle deficits
- May be more sudden
- Patient may stutter as more emboli are thrown

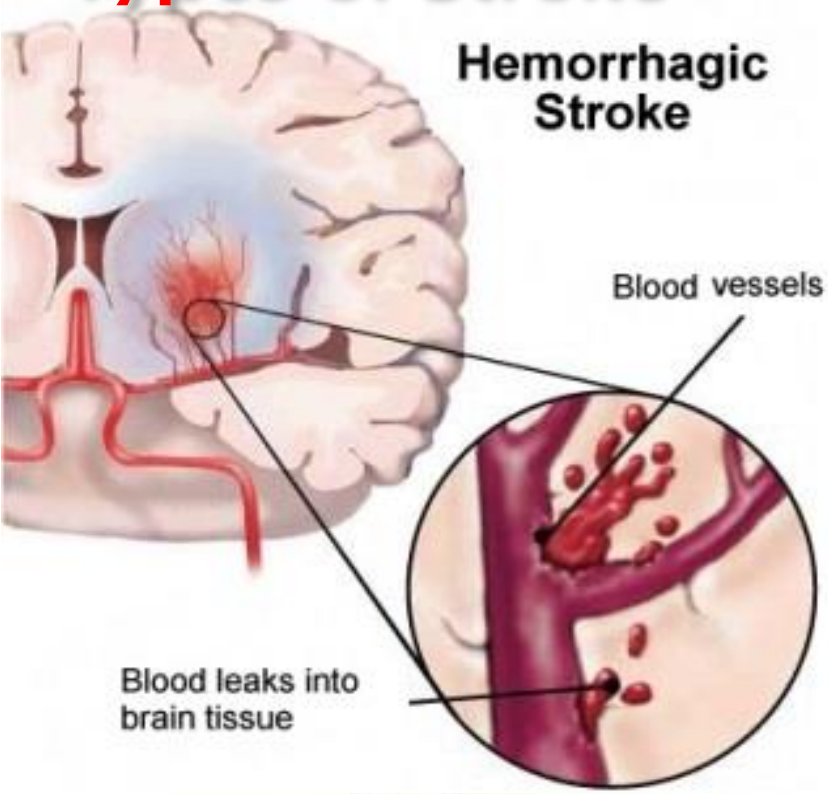
THROMBOTIC – A blood clot that gradually develops in and obstructs cerebral artery

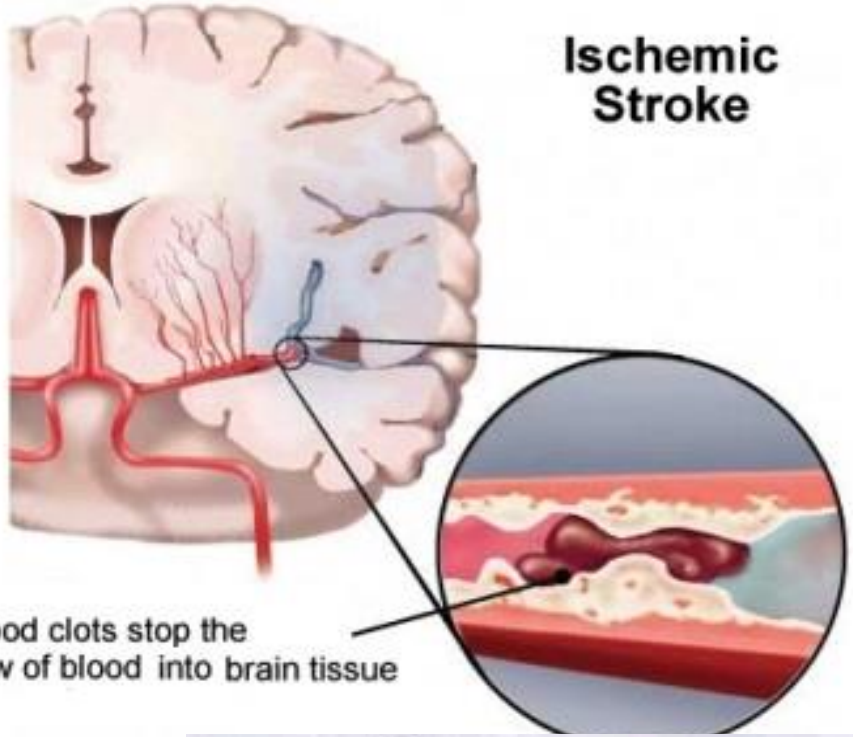
Over time plaque deposits form on the inner walls of arteries (Atherosclerosis)

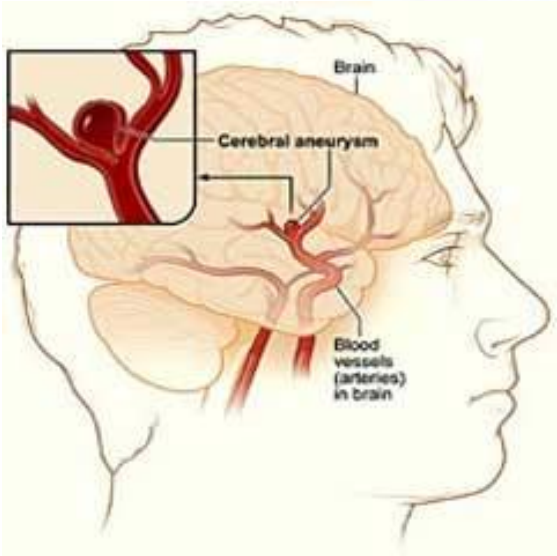
Once the arteries are narrowed, platelets adhere to the rough surfaces and blood clots form blocking the blood flow through a cerebral artery

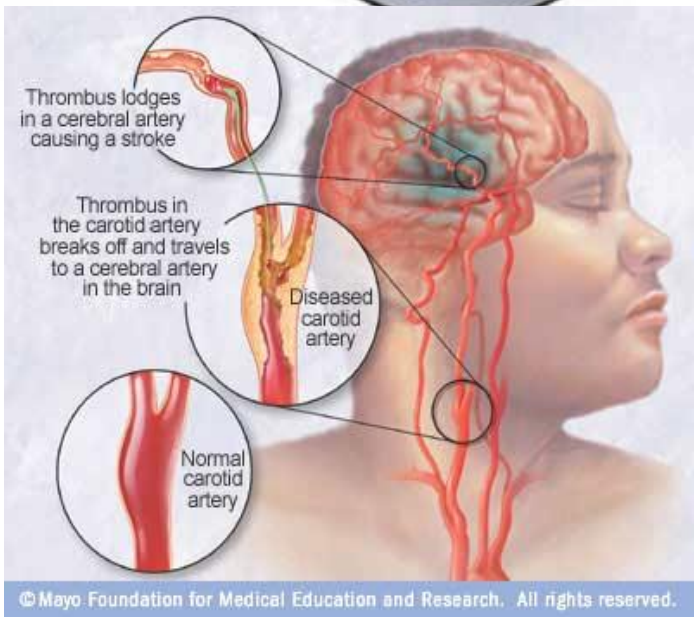
Develops gradually – usually at night, the person awakes with altered mental status, and/or loss of speech, sensory, or motor function

Types of Stroke

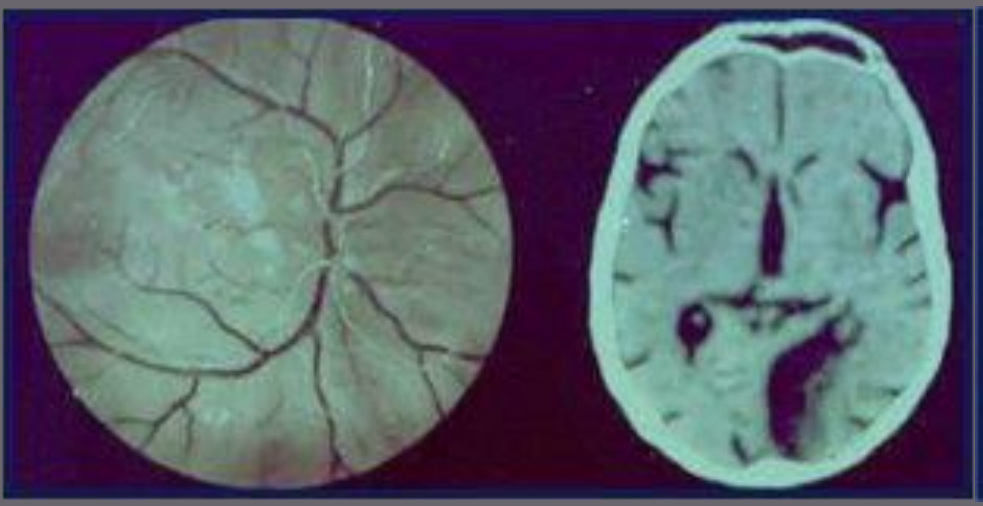






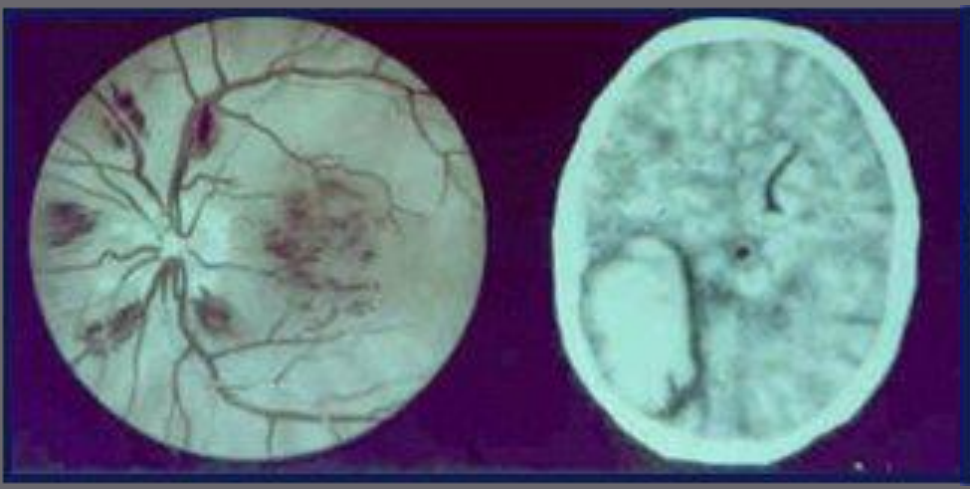


Two Types of Stroke

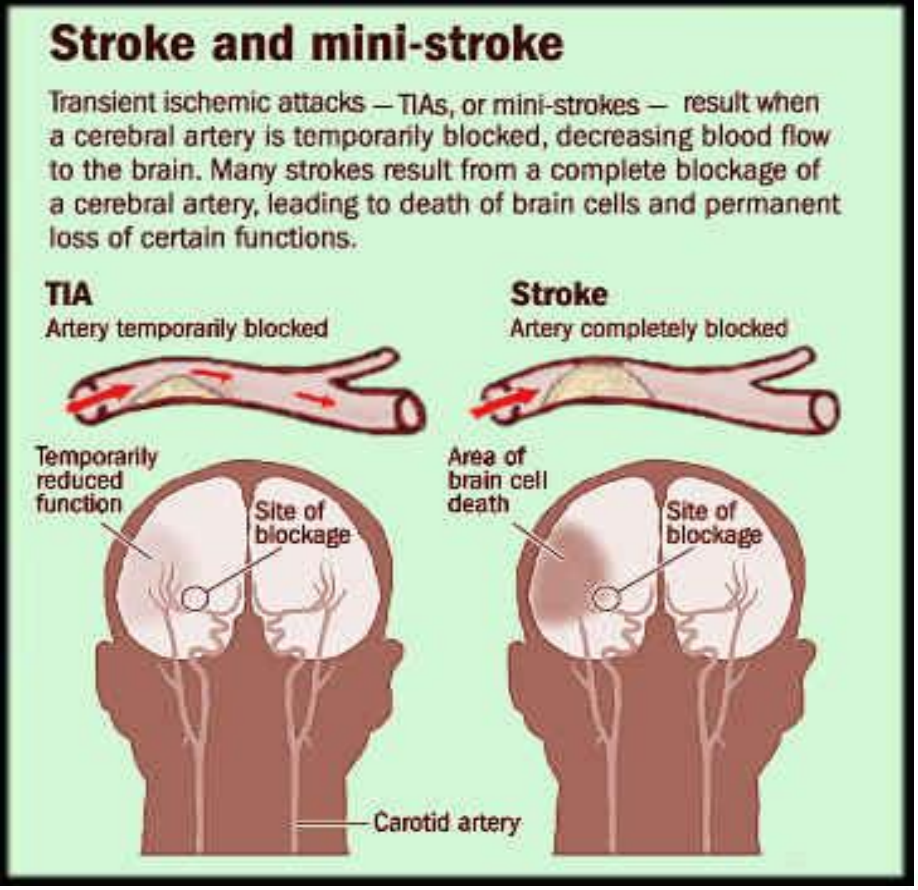


Ischemic
(Occlusive)

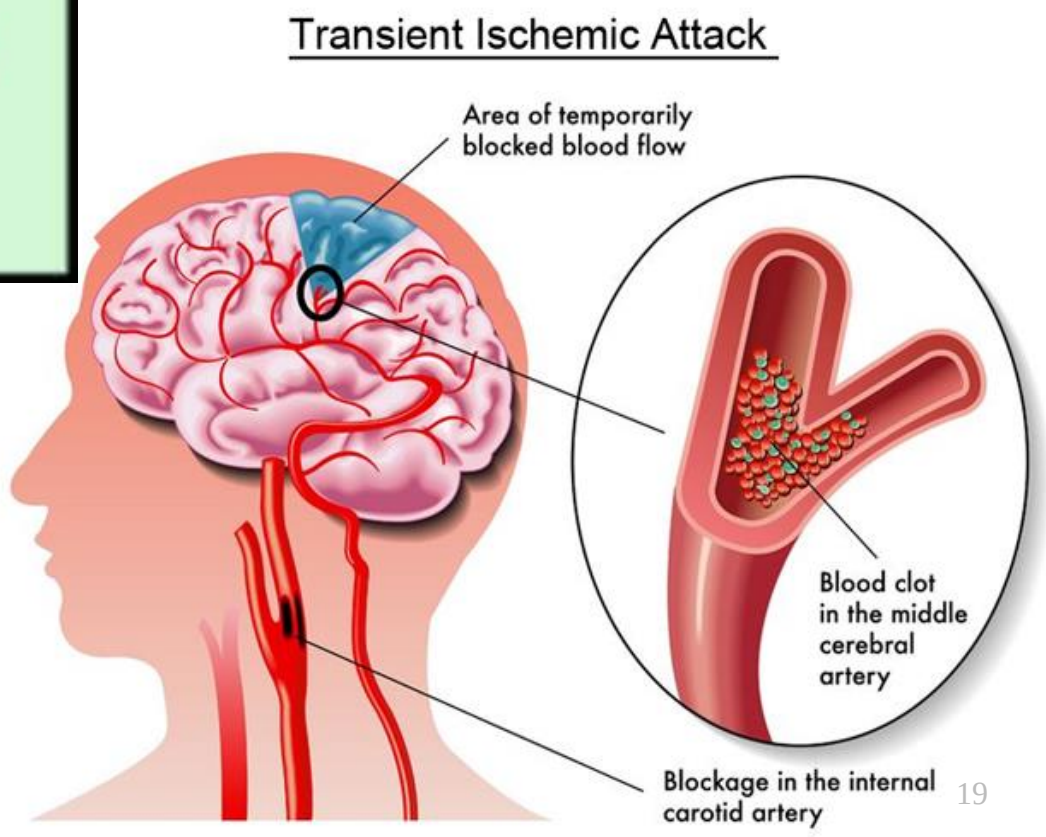
Optic Nerve CT Autopcy



Hemorrhagic
(Bleeding)



These symptoms appear and last less than 24 hours before disappearing. While TIAs generally do not cause permanent brain damage, they are a serious warning sign that a stroke may happen in the future



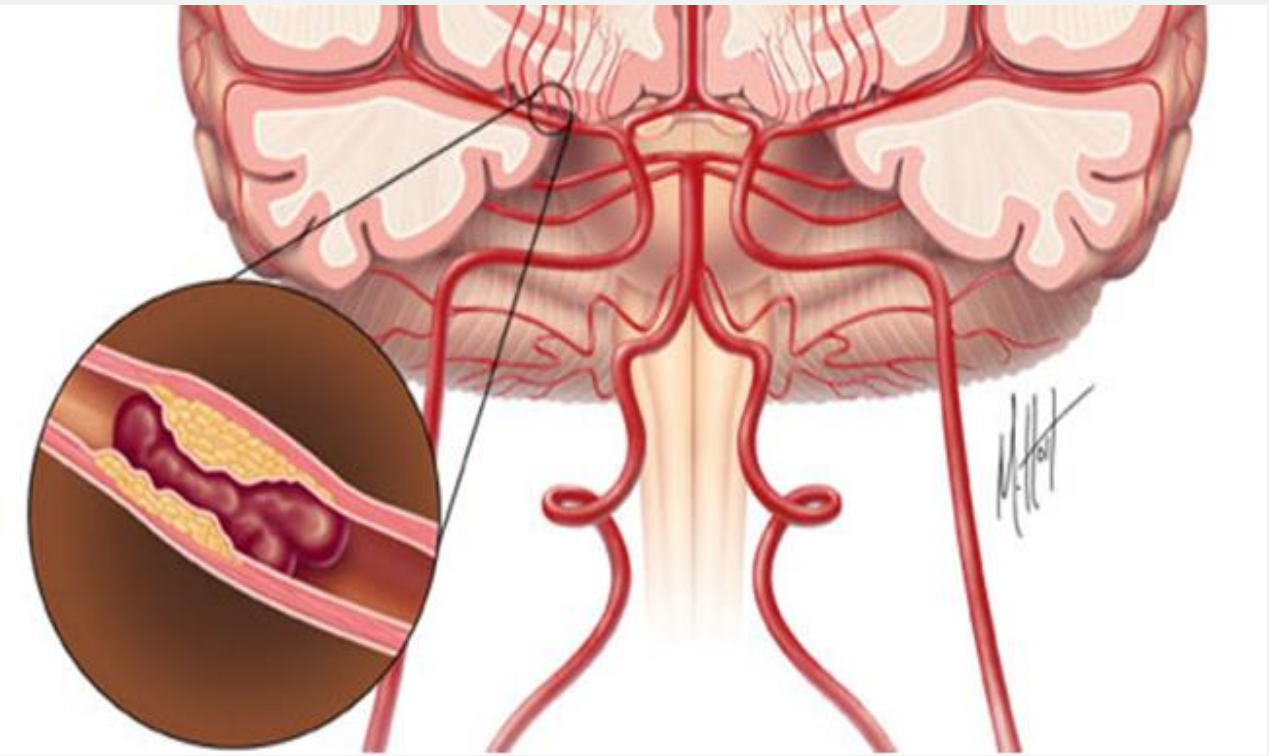
Ischemic Stroke

◊ A Stroke that occurs when a cerebral artery is blocked by a clot or other foreign matter

◊ Accounts for approximately 85% of all strokes

◊ Follows the same pattern as a heart attack

◊ Causing injury, ischemia, and finally infarction (tissue death)

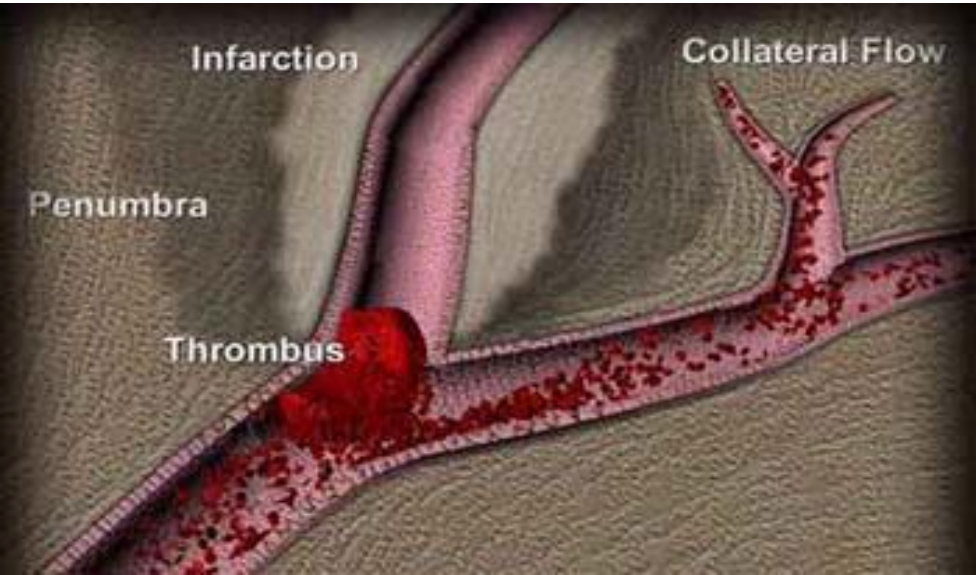


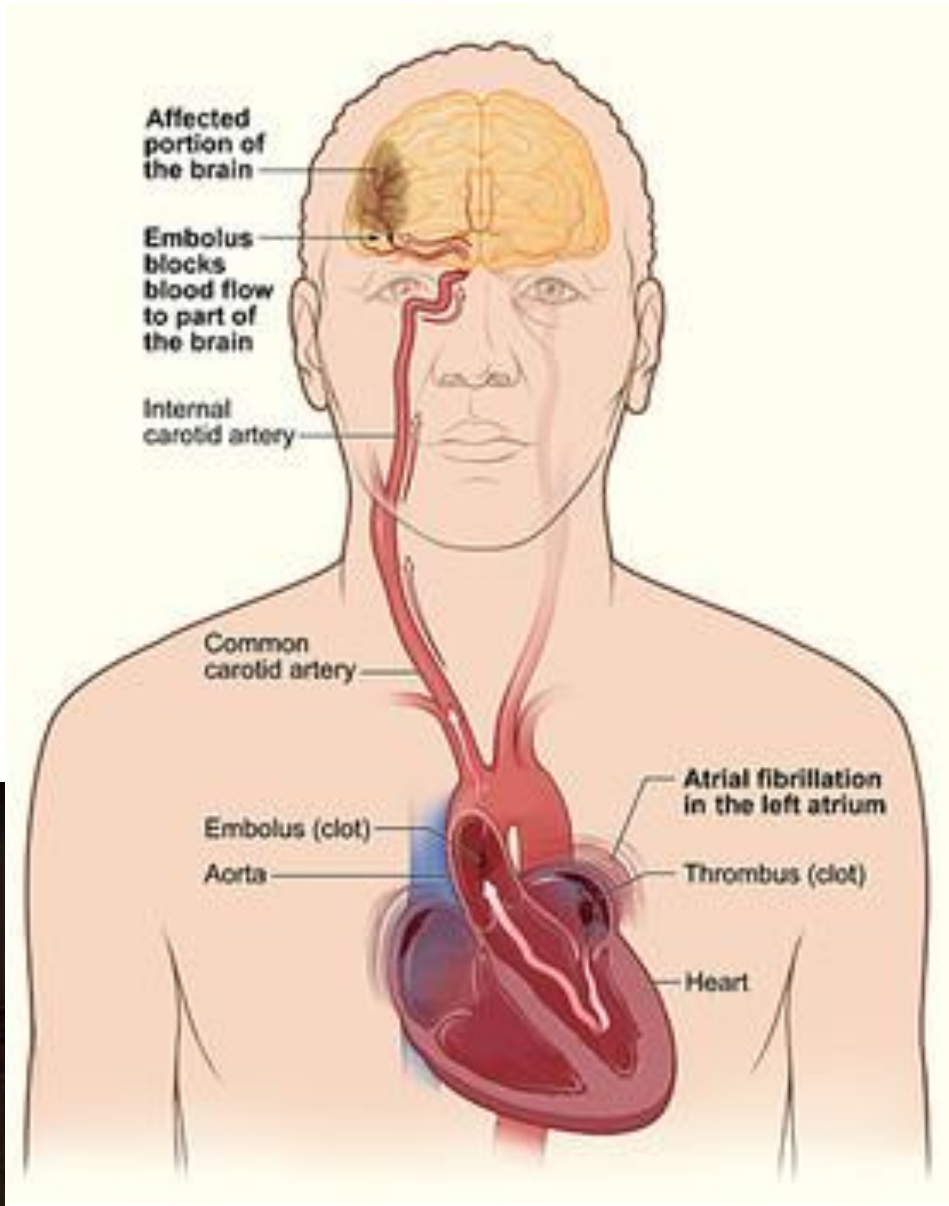
Ischemic Stroke

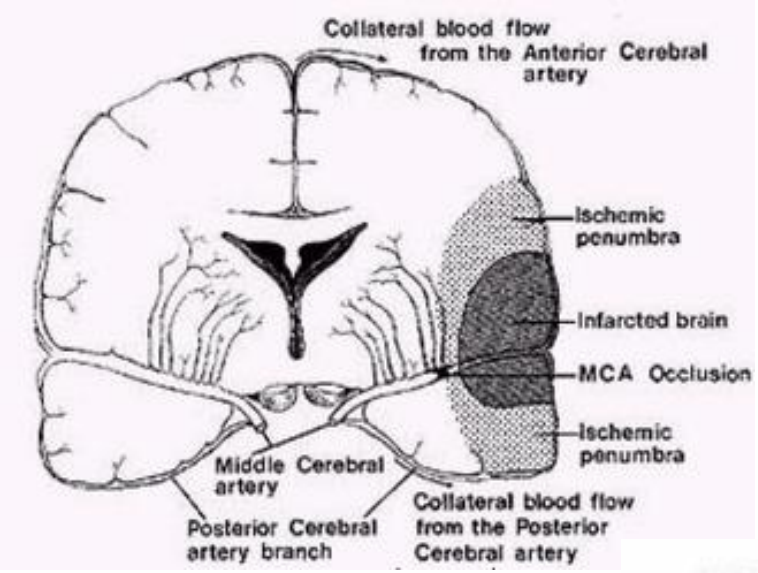
Most common cause: thromboembolism

Possible sources of clot:

- ◊ Heart
- ◊ Large artery (to brain)
- ◊ Small artery (in brain)

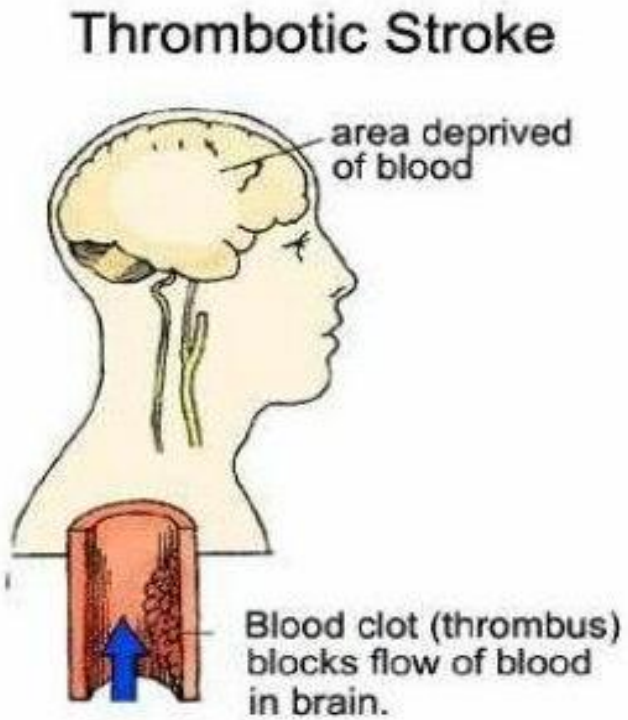


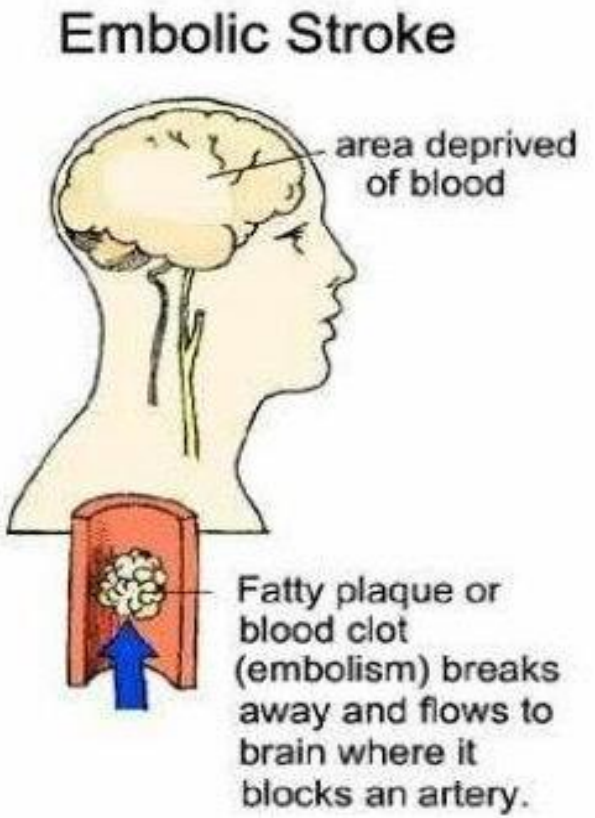


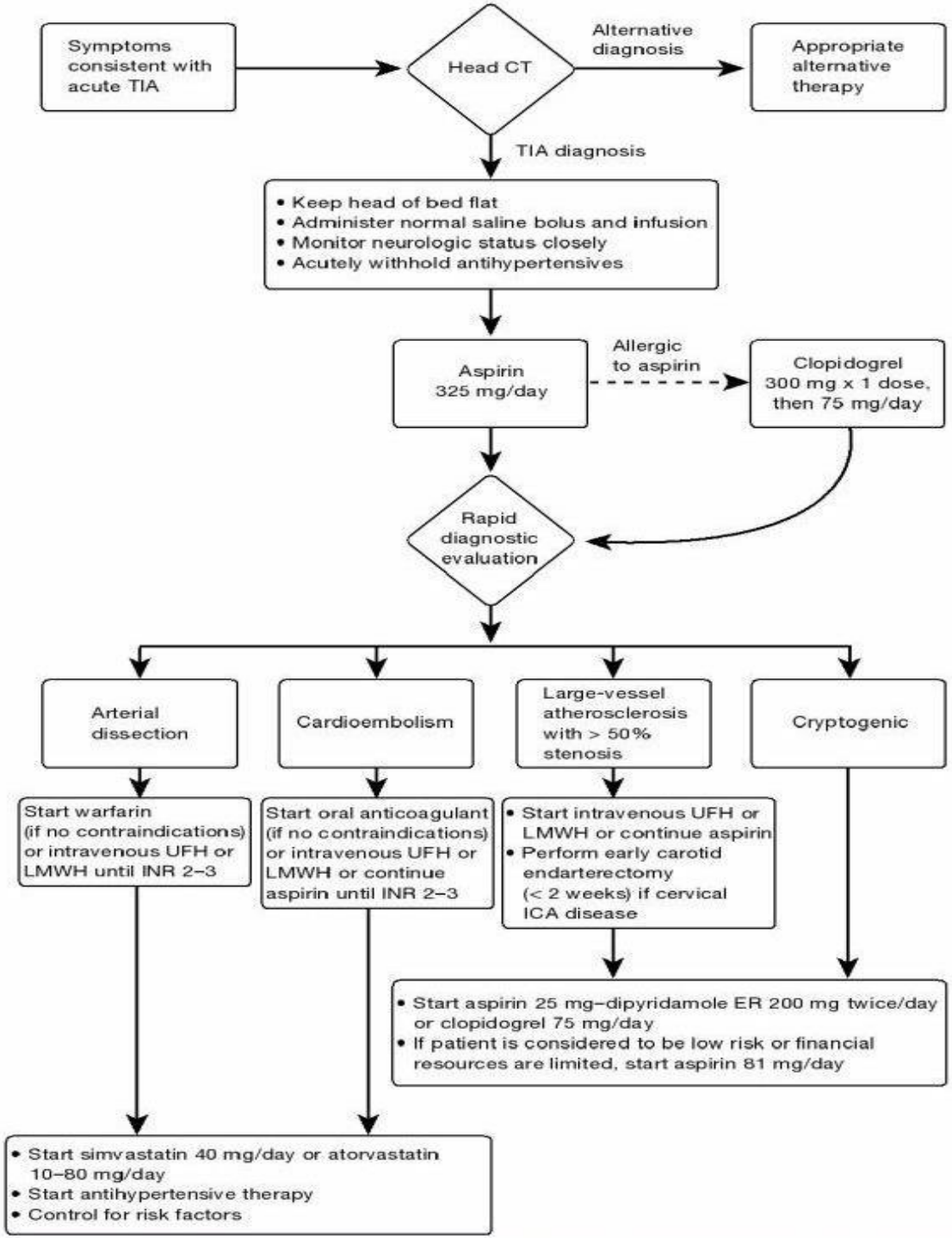


There are two types of Ischemic Stroke:

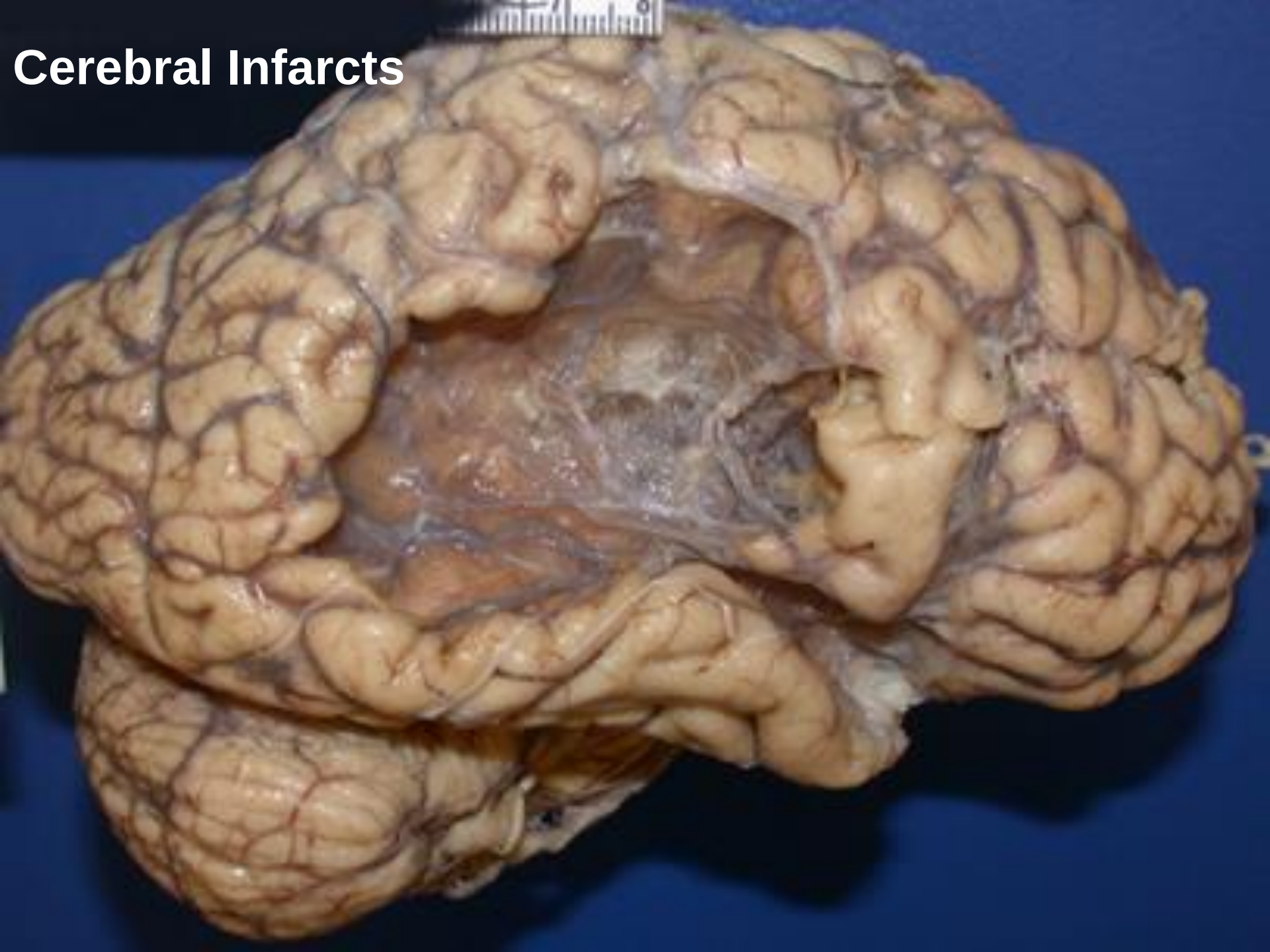
- ◊ Embolic (Embolus)
- ◊ Thrombotic (Thrombosis)





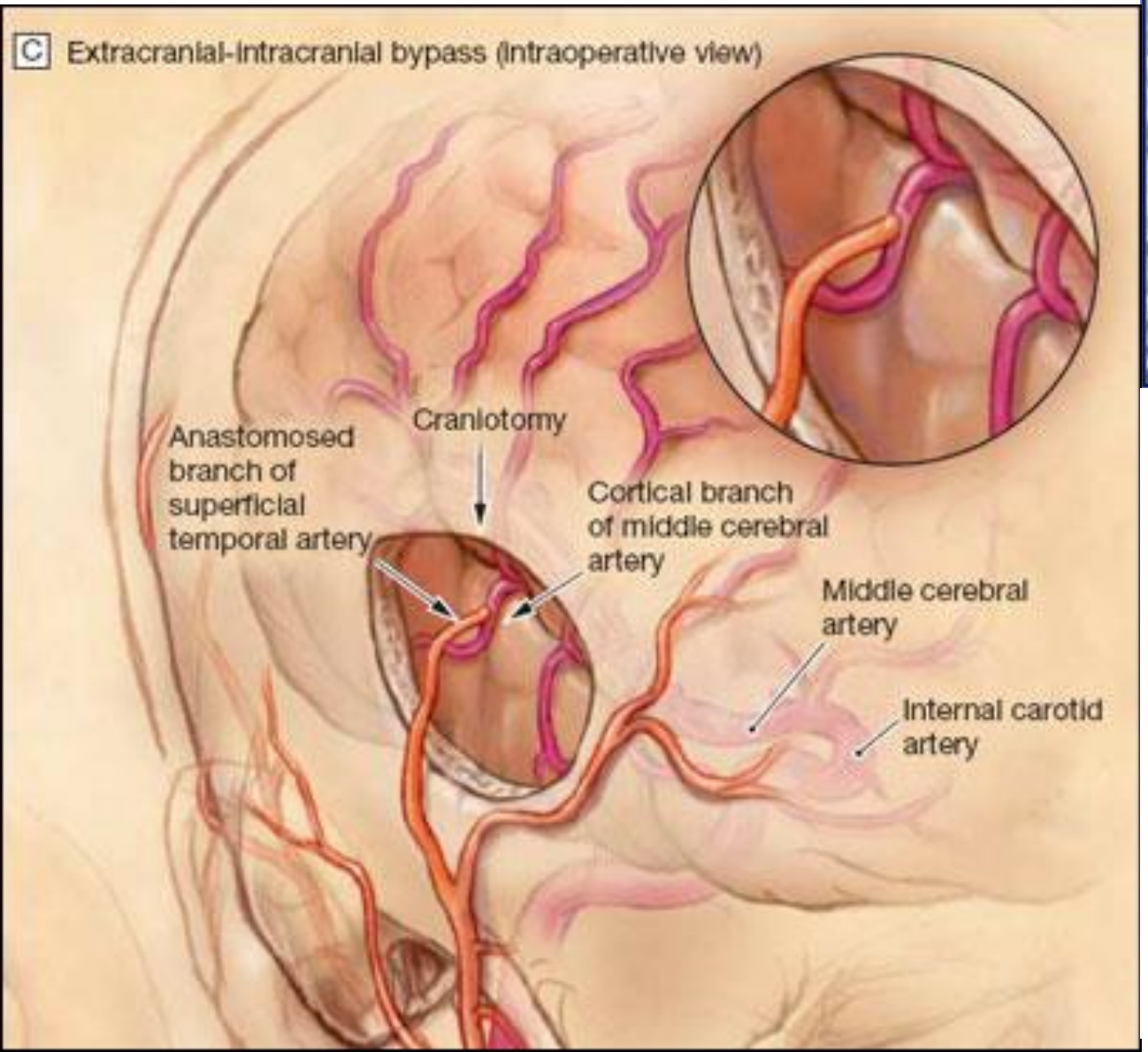

Symptoms consistent with acute TIA
Head CT
Alternative diagnosis
Appropriate alternative therapy
TIA diagnosis
• Keep head of bed flat
• Administer normal saline bolus and infusion
• Monitor neurologic status closely
• Acutely withhold antihypertensives
Aspirin 325 mg/day
Allergic to aspirin
Clopidogrel 300 mg x 1 dose, then 75 mg/day
Rapid diagnostic evaluation
Arterial dissection
Cardioembolism
Large-vessel atherosclerosis with > 50% stenosis
Cryptogenic
Start warfarin (if no contraindications) or intravenous UFH or LMWH until INR 2–3
Start oral anticoagulant (if no contraindications) or intravenous UFH or LMWH or continue aspirin until INR 2–3
• Start intravenous UFH or LMWH or continue aspirin
• Perform early carotid endarterectomy (< 2 weeks) if cervical ICA disease
• Start aspirin 25 mg–dipyridamole ER 200 mg twice/day or clopidogrel 75 mg/day
• If patient is considered to be low risk or financial resources are limited, start aspirin 81 mg/day
• Start simvastatin 40 mg/day or atorvastatin 10–80 mg/day
• Start antihypertensive therapy
• Control for risk factors

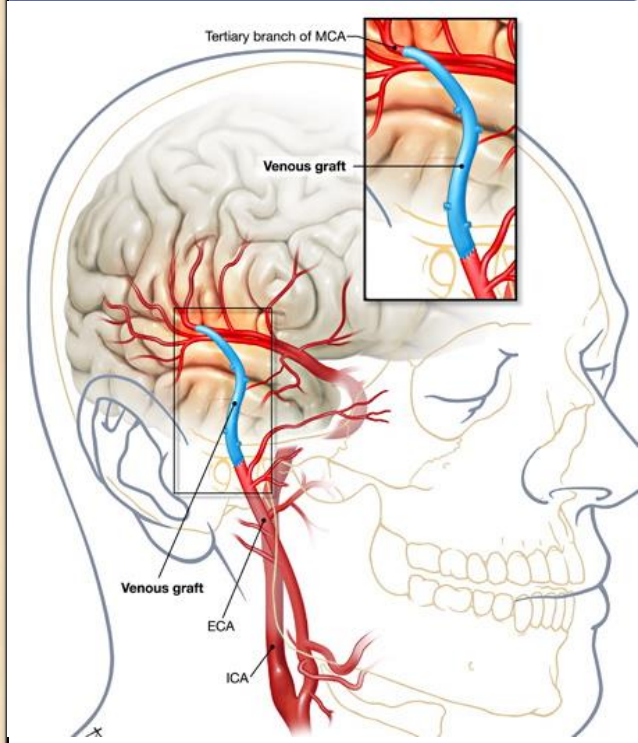
Cerebral Infarcts

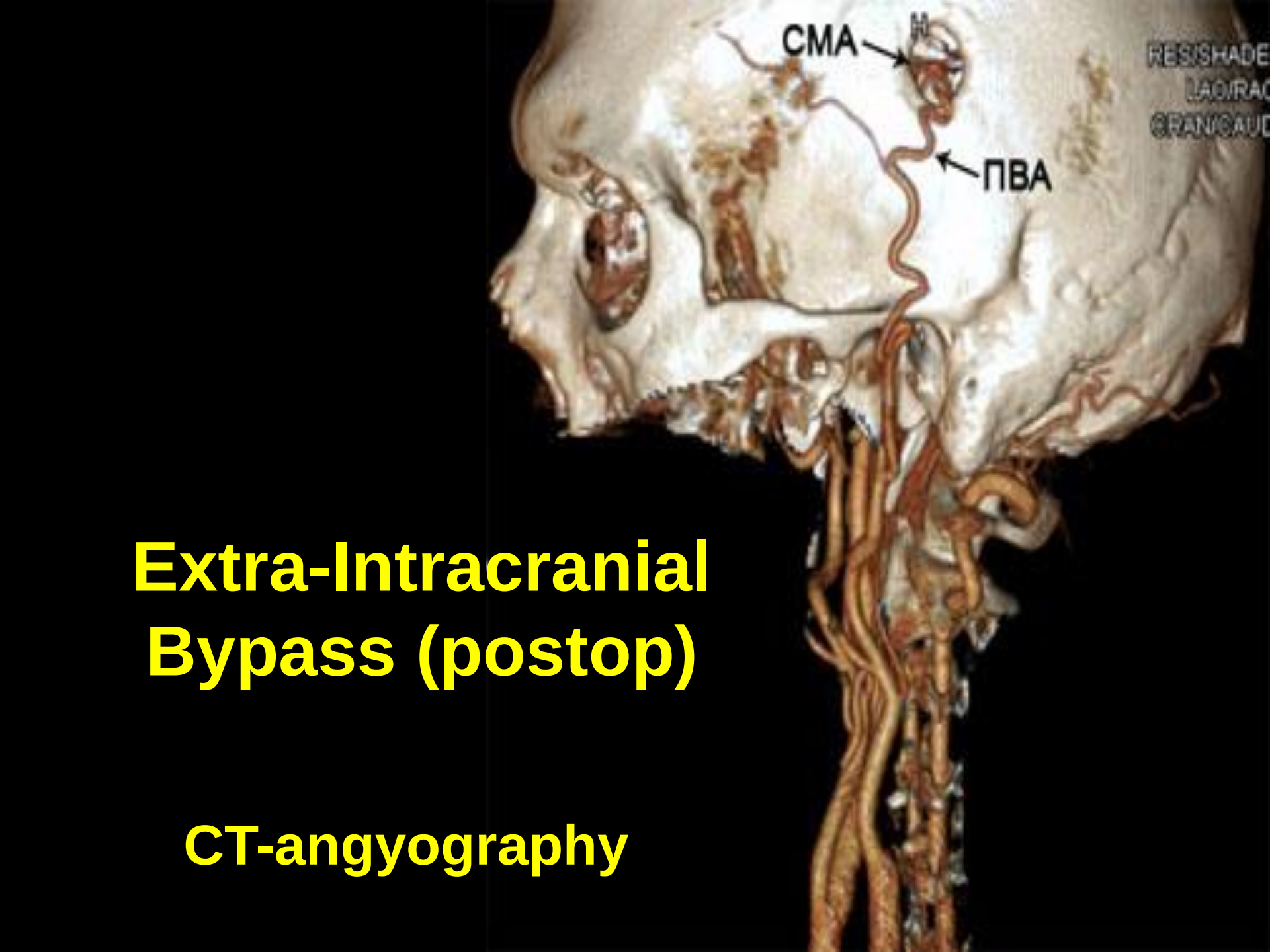


Infarction in the middle cerebellar artery territory

Extra-Intracranial Bypass





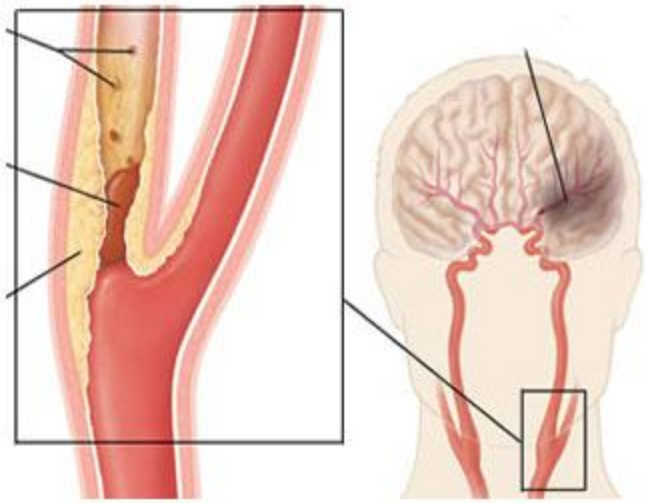


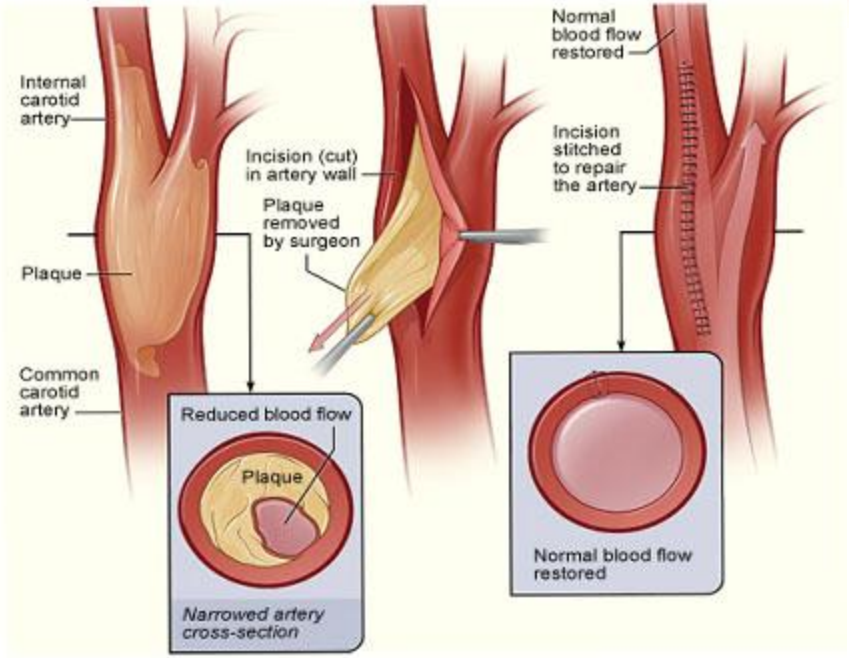
Extra-Intracranial Bypass (postop)

CT-angyography

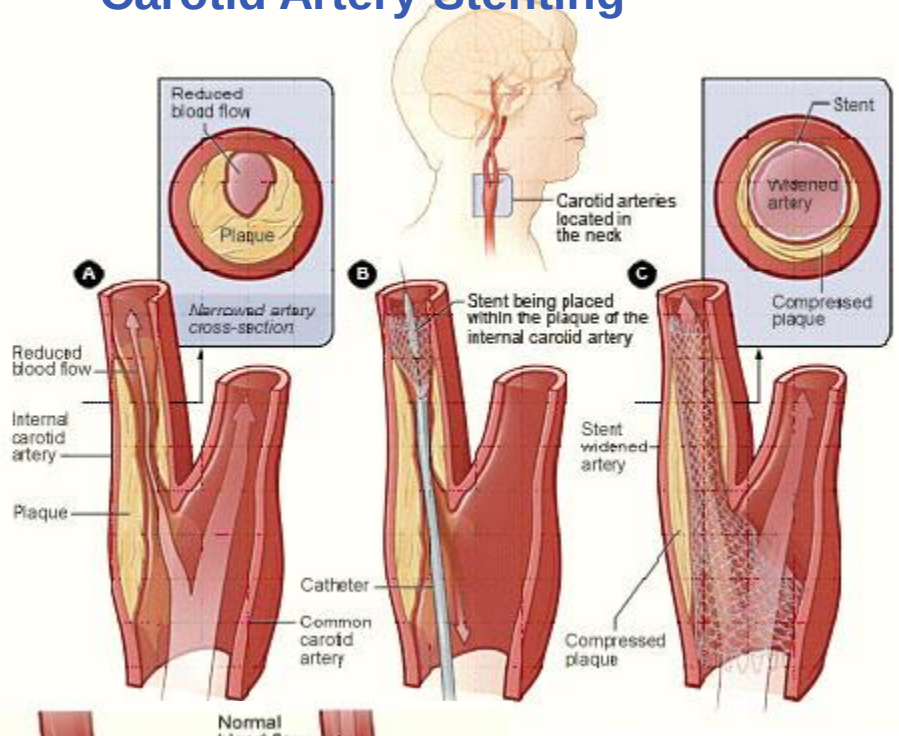
The methods of surgical treatment

Carotid endarterectomy is surgery to remove atheroma (plaque build up) that causes narrowing (stenosis) in the artery to lower the risk for future TIA and stroke

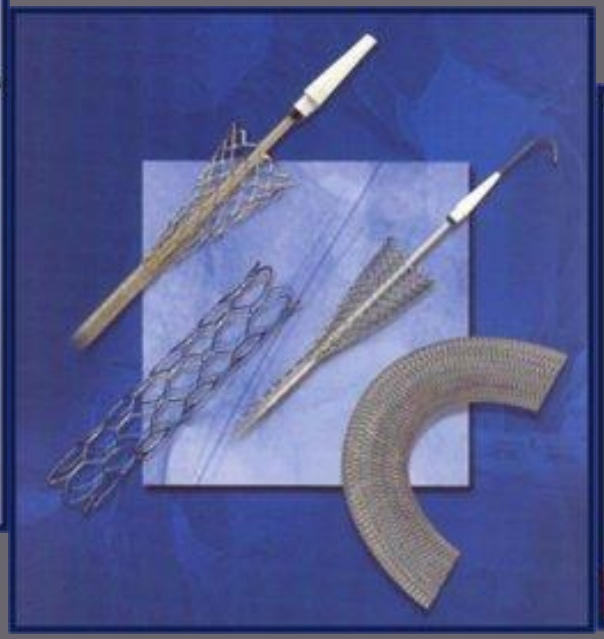


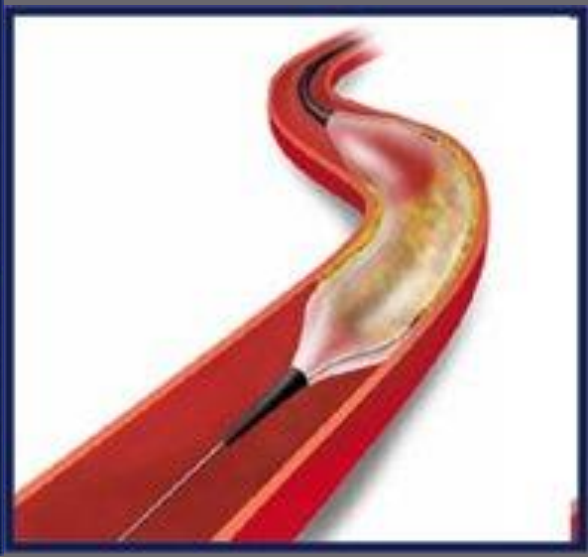


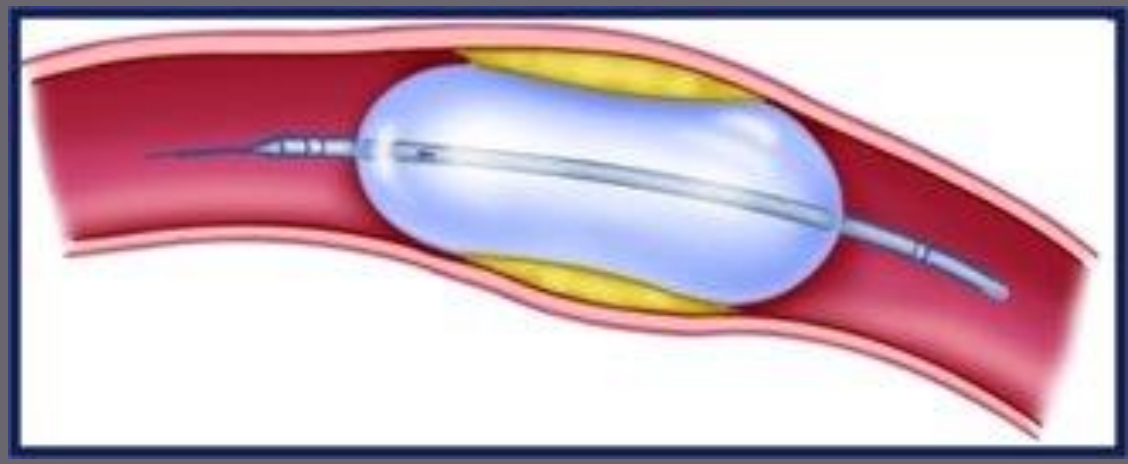
Carotid Artery Stenting



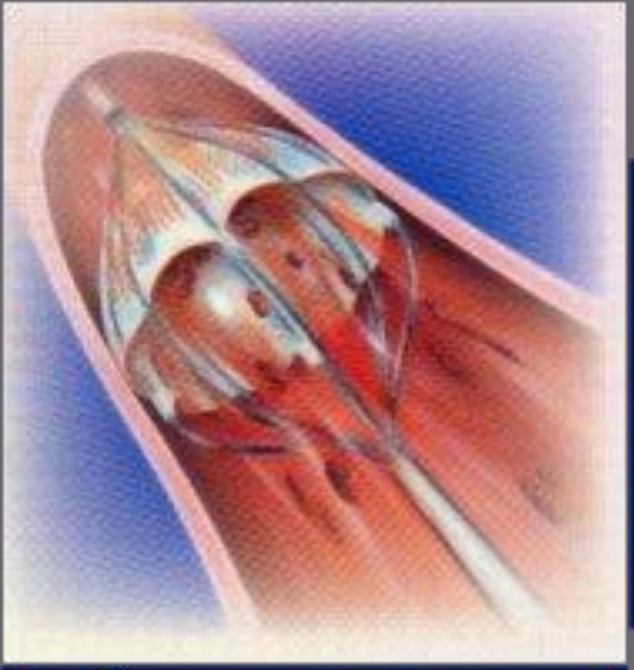
Endovascular angioplasty and stenting

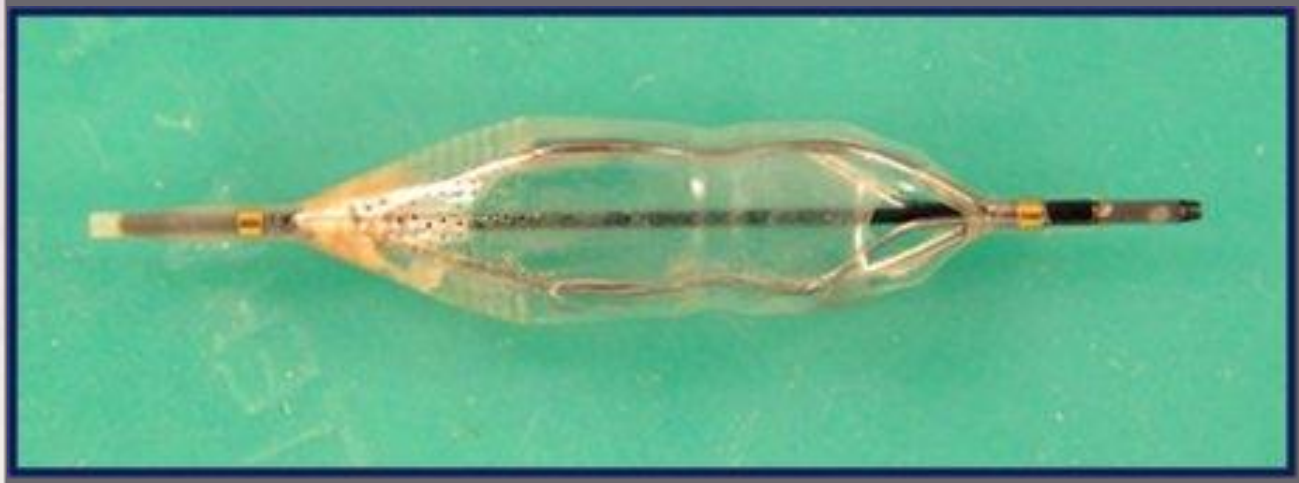


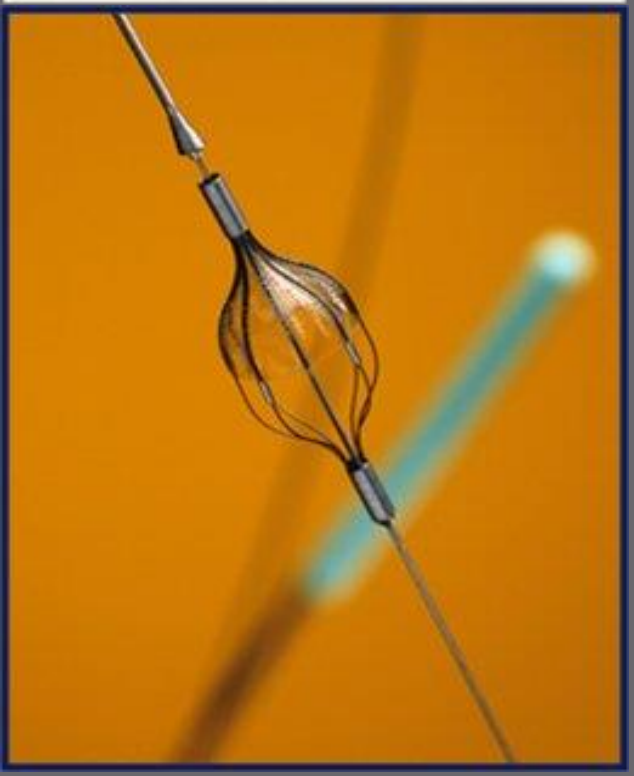




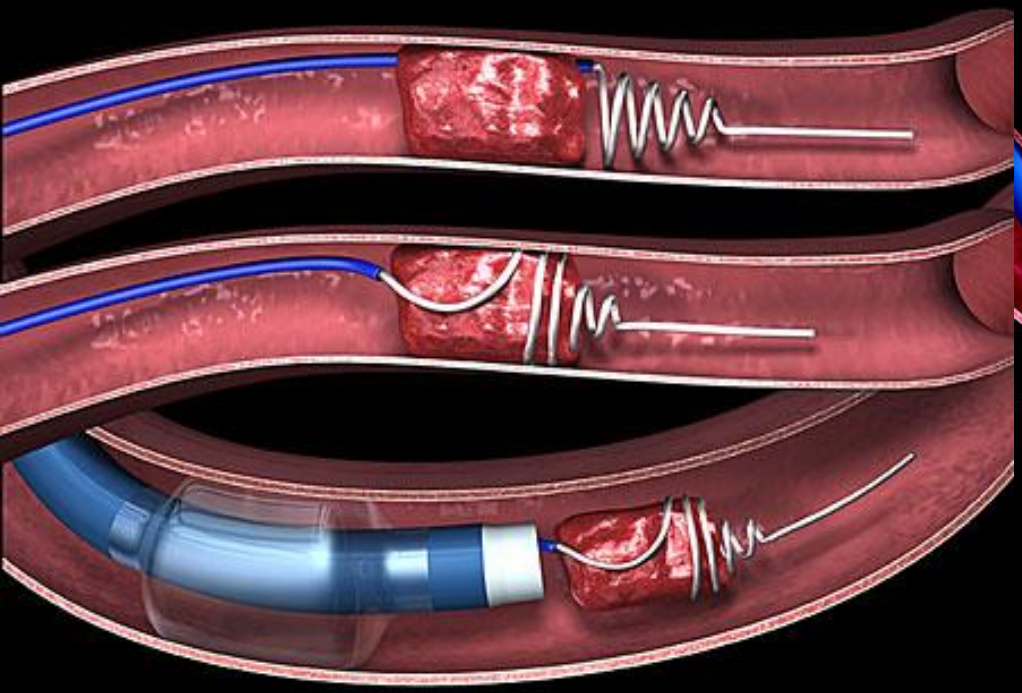
Filters of antiembolic defence

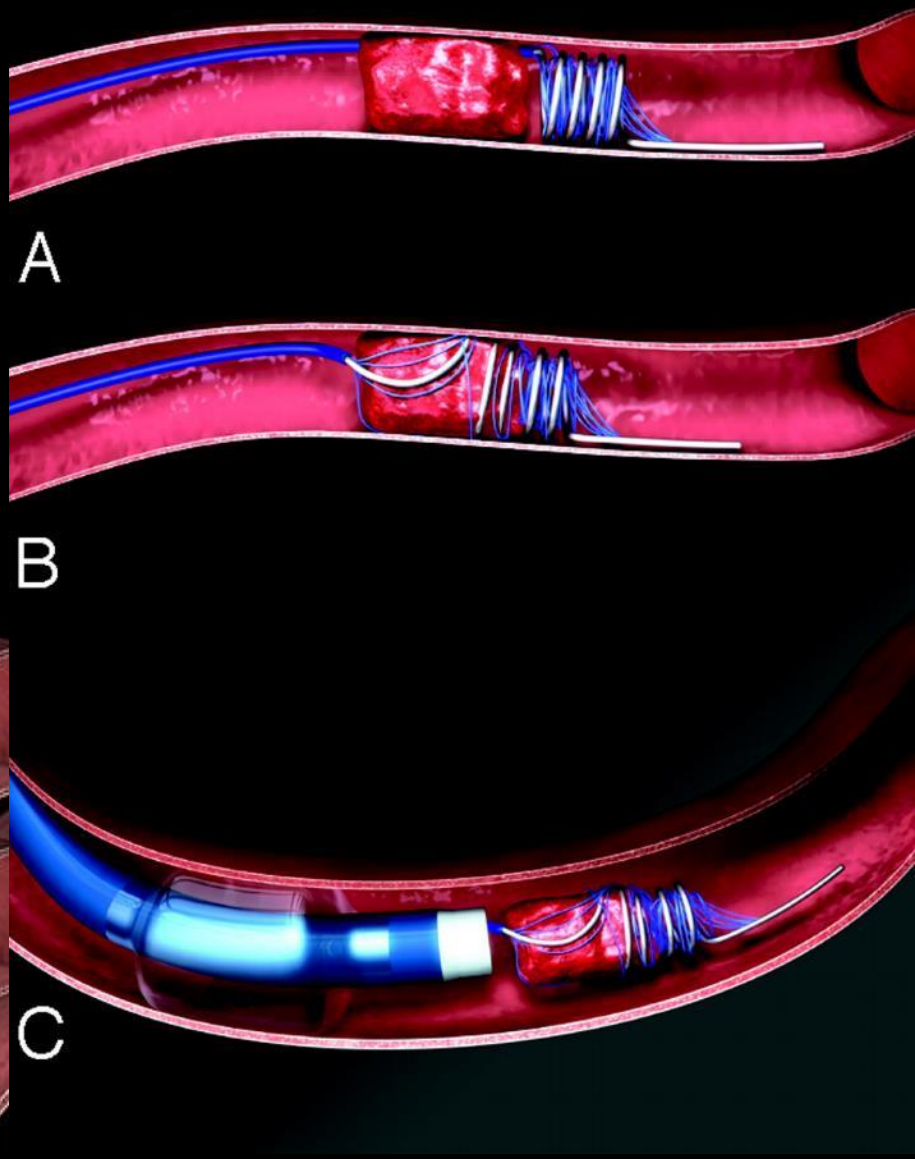






Safety of Mechanical Thrombectomy and Intravenous Tissue Plasminogen Activator in Acute Ischemic Stroke





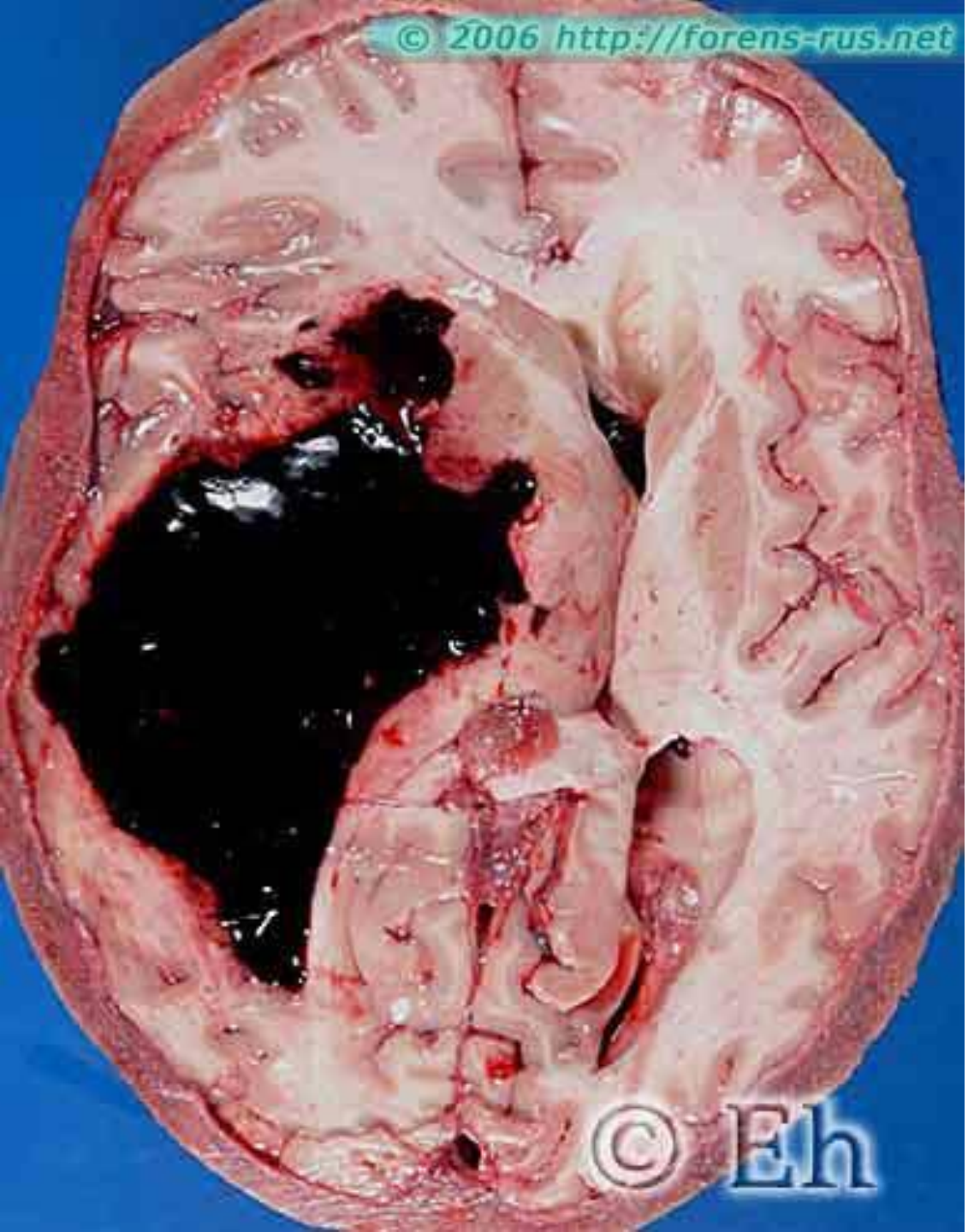
Hemorrhagic stroke

◊ Categorized as being a bleed within the brain (intracerebral) or in the space around the brain (subarachnoid)

◊ Onset is often sudden and marked by a severe headache

◊ Fatal in 50% to 80% of cases

◊ Most hemorrhages occur in hypertensive patients when a small vessel within the brain tissue ruptures



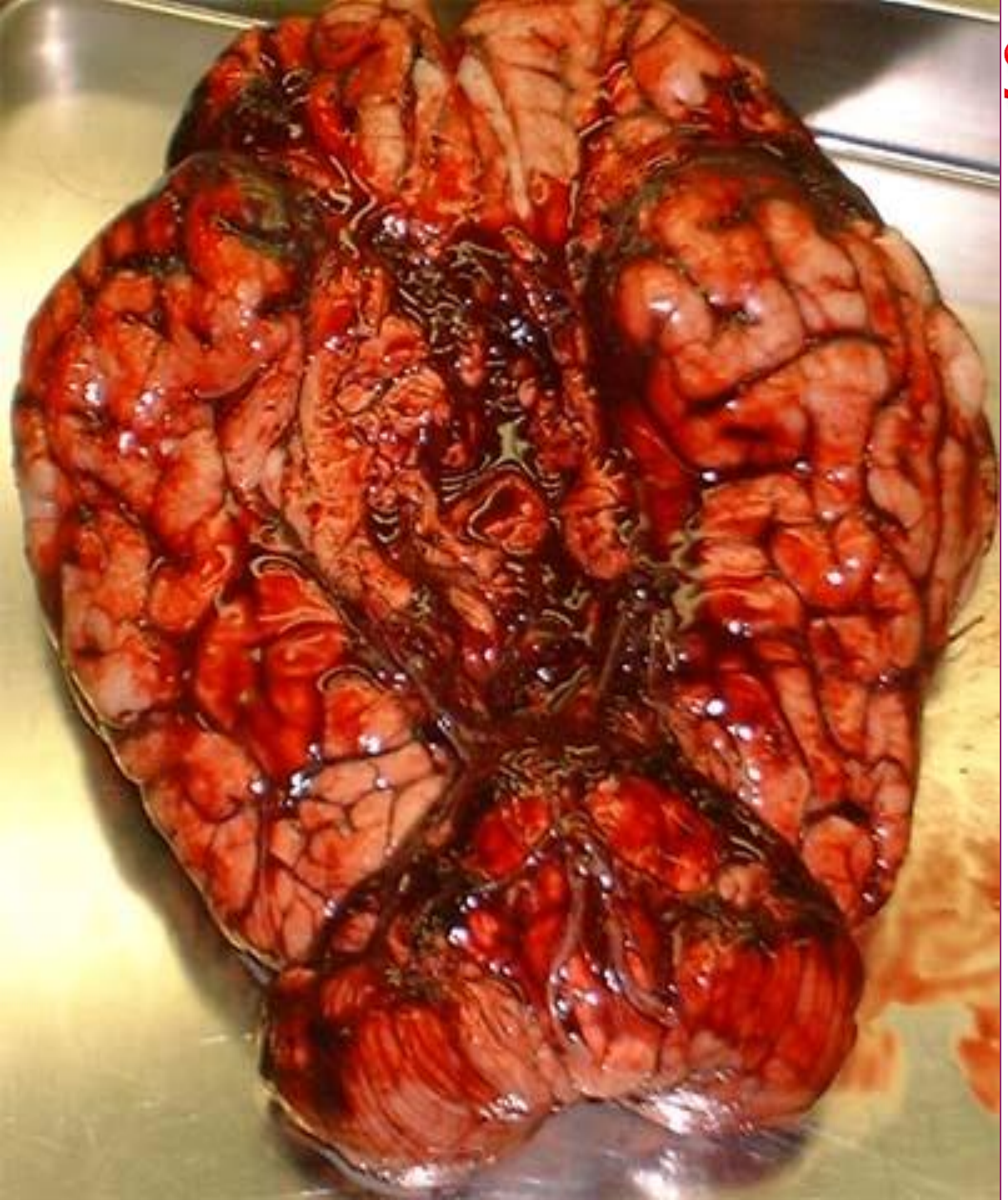
Intracerebral Hemorrhage

Most common cause:

- **Chronic hypertension**

Other causes:

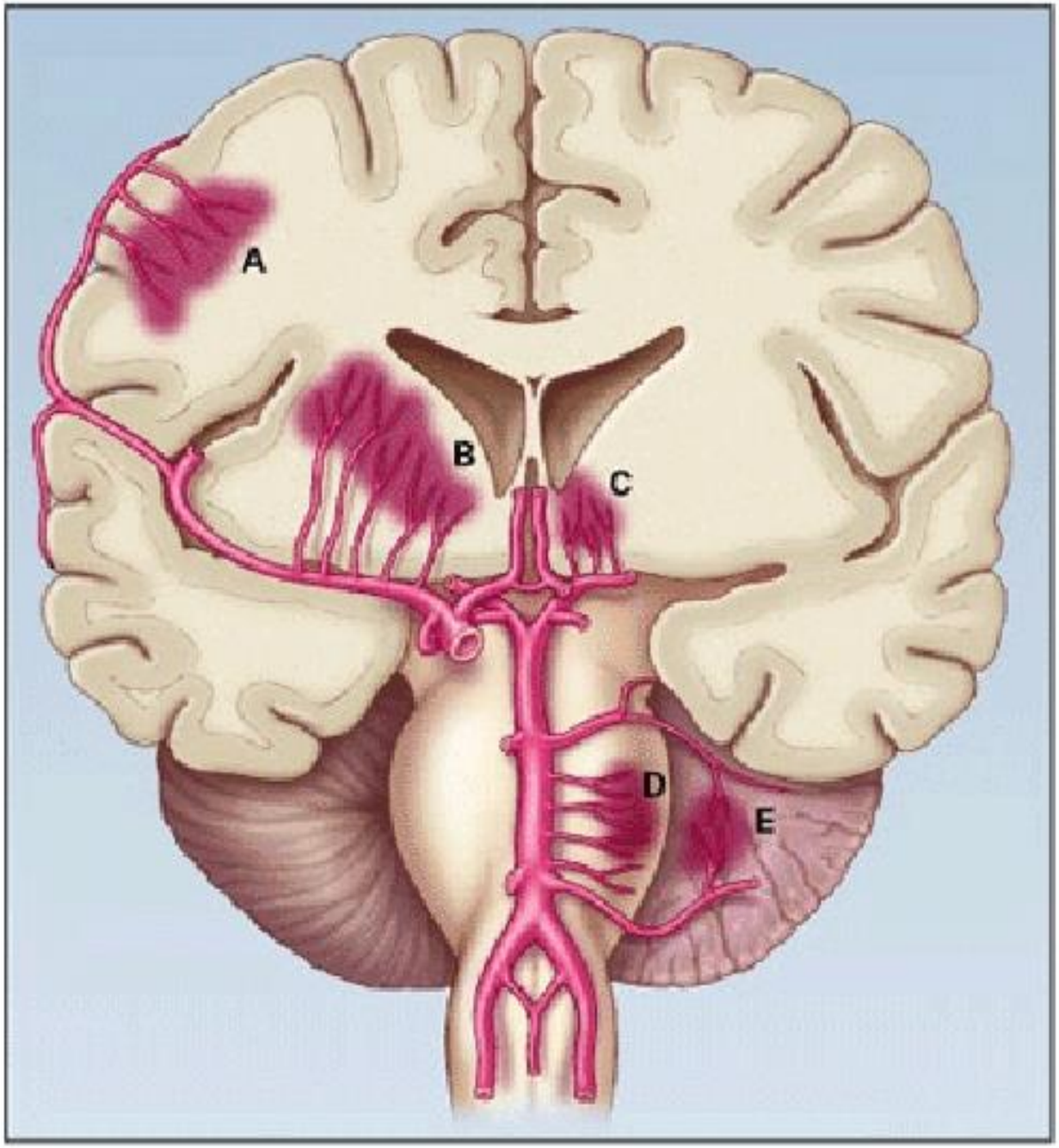
- **Vessel malformation**
- **Tumor, bleeding abnormalitie**



Subarachnoid Hemorrhage

Most common cause:
- **Aneurysm rupture**

Other causes:
- **Vessel malformation**
- **Tumor, bleeding abnormalities**



Typical localisation for hematomas:

A-Subcortical

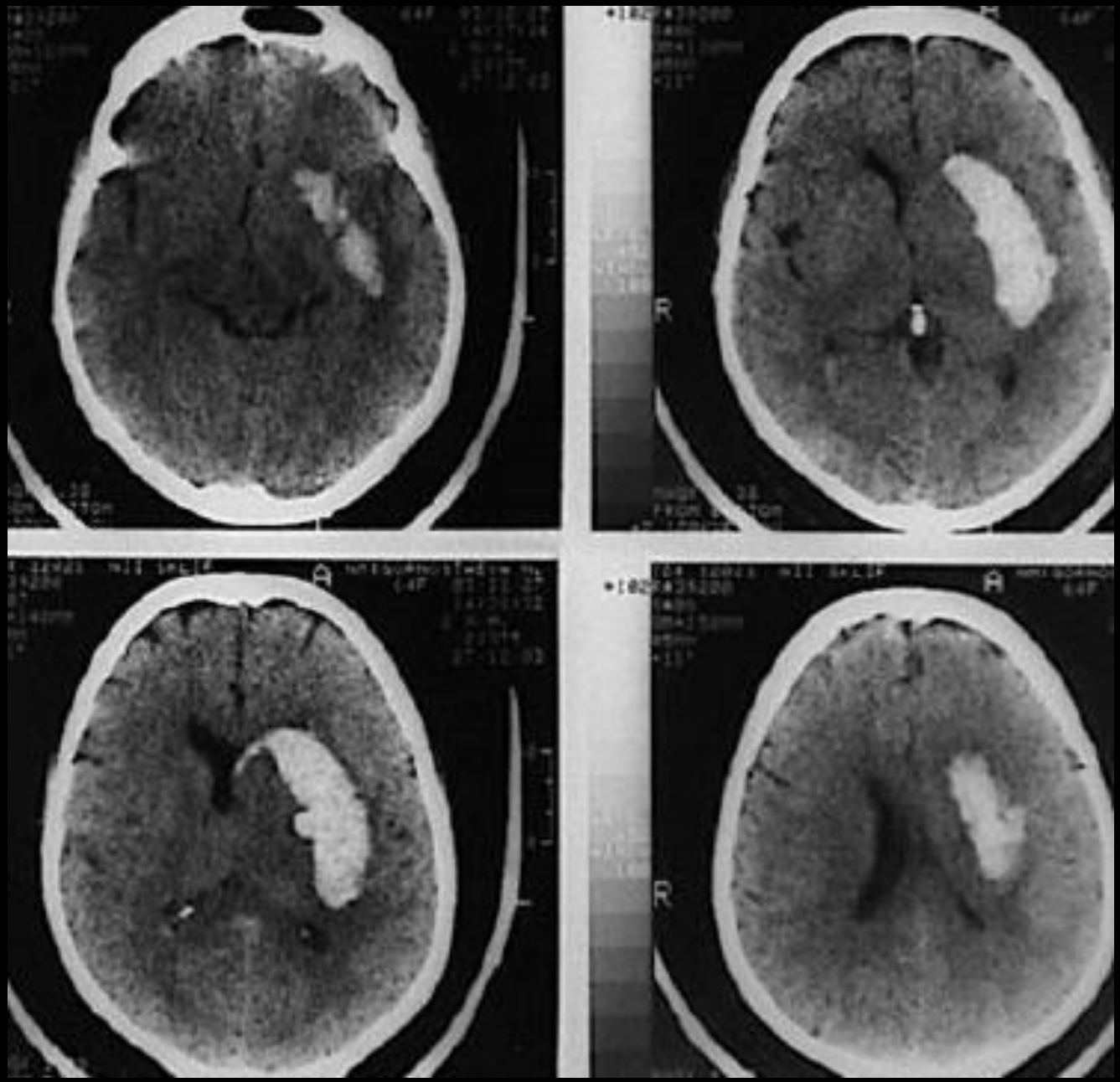
B-Putamenal

C-Thalamic

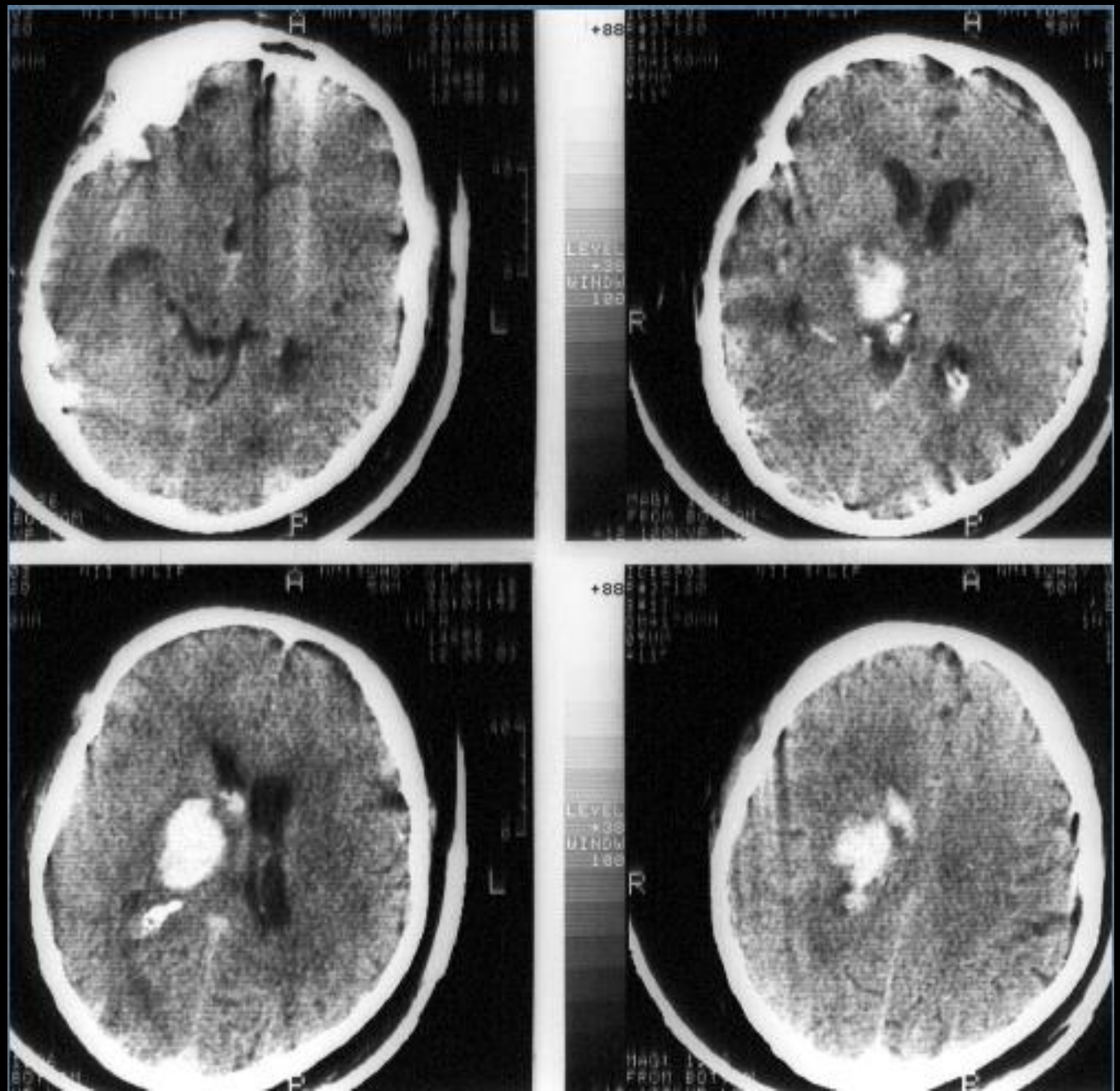
D-Pontine

E-Cerebellar

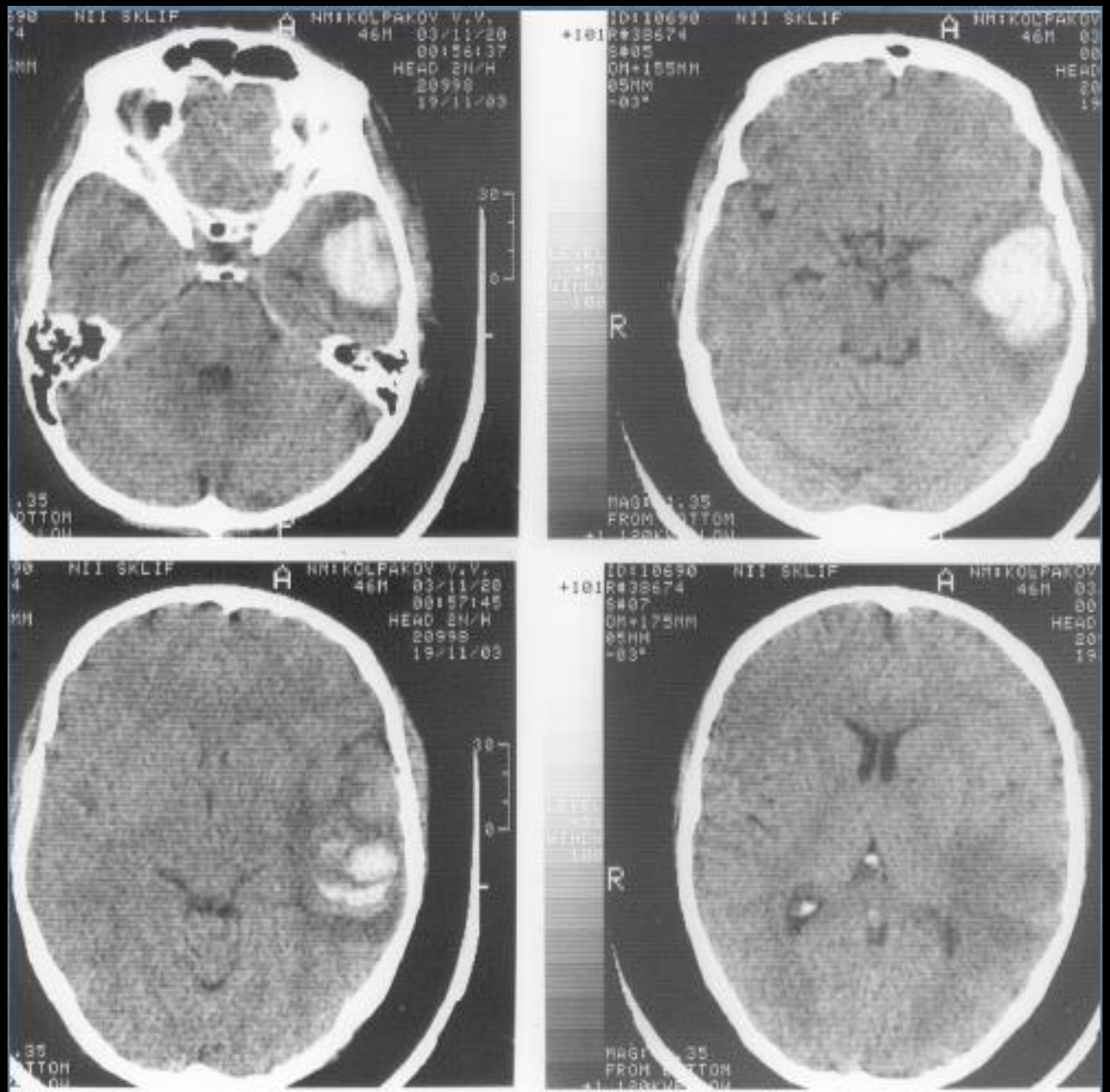
Putamenal hemorrhage



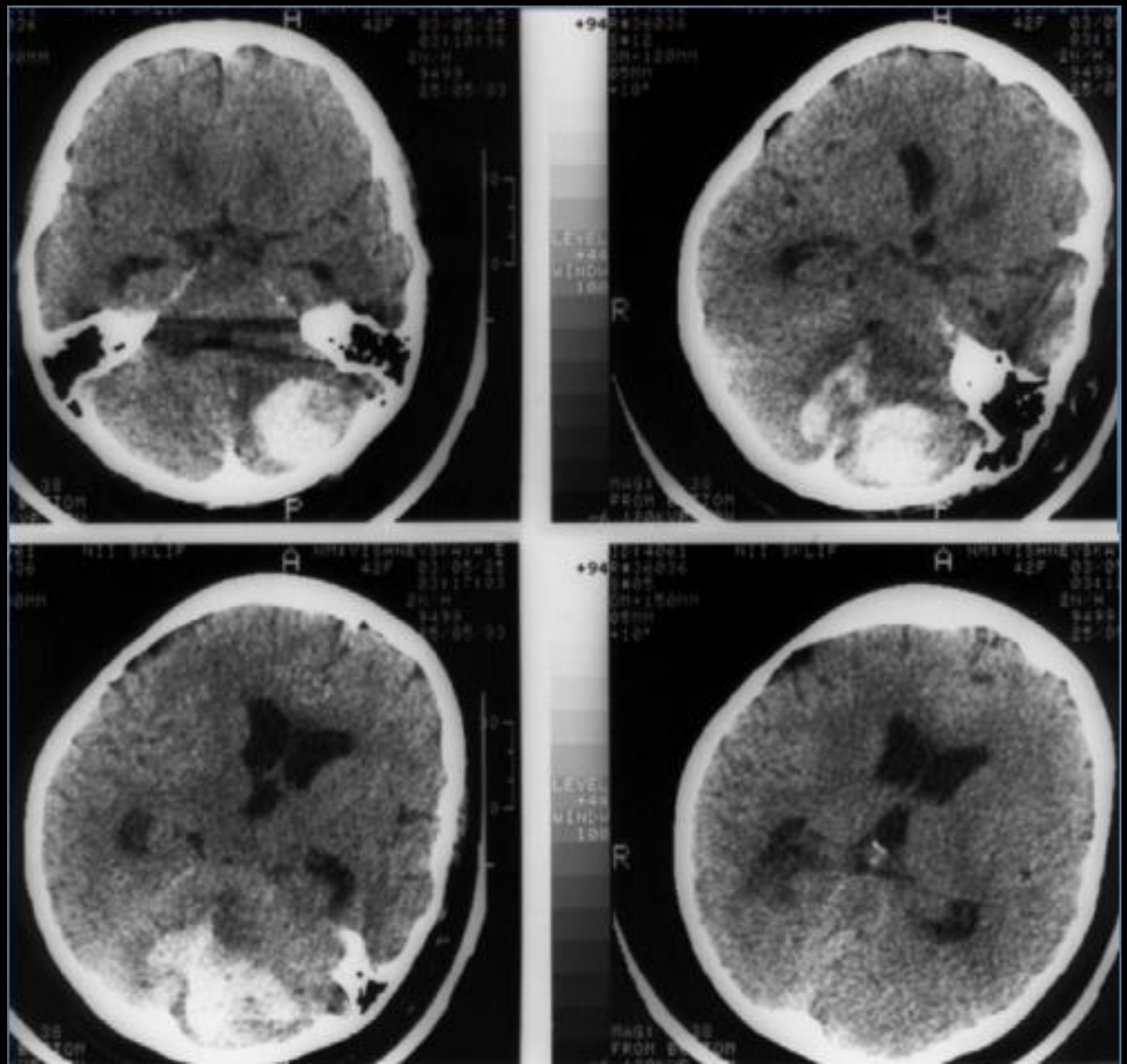
Thalamic

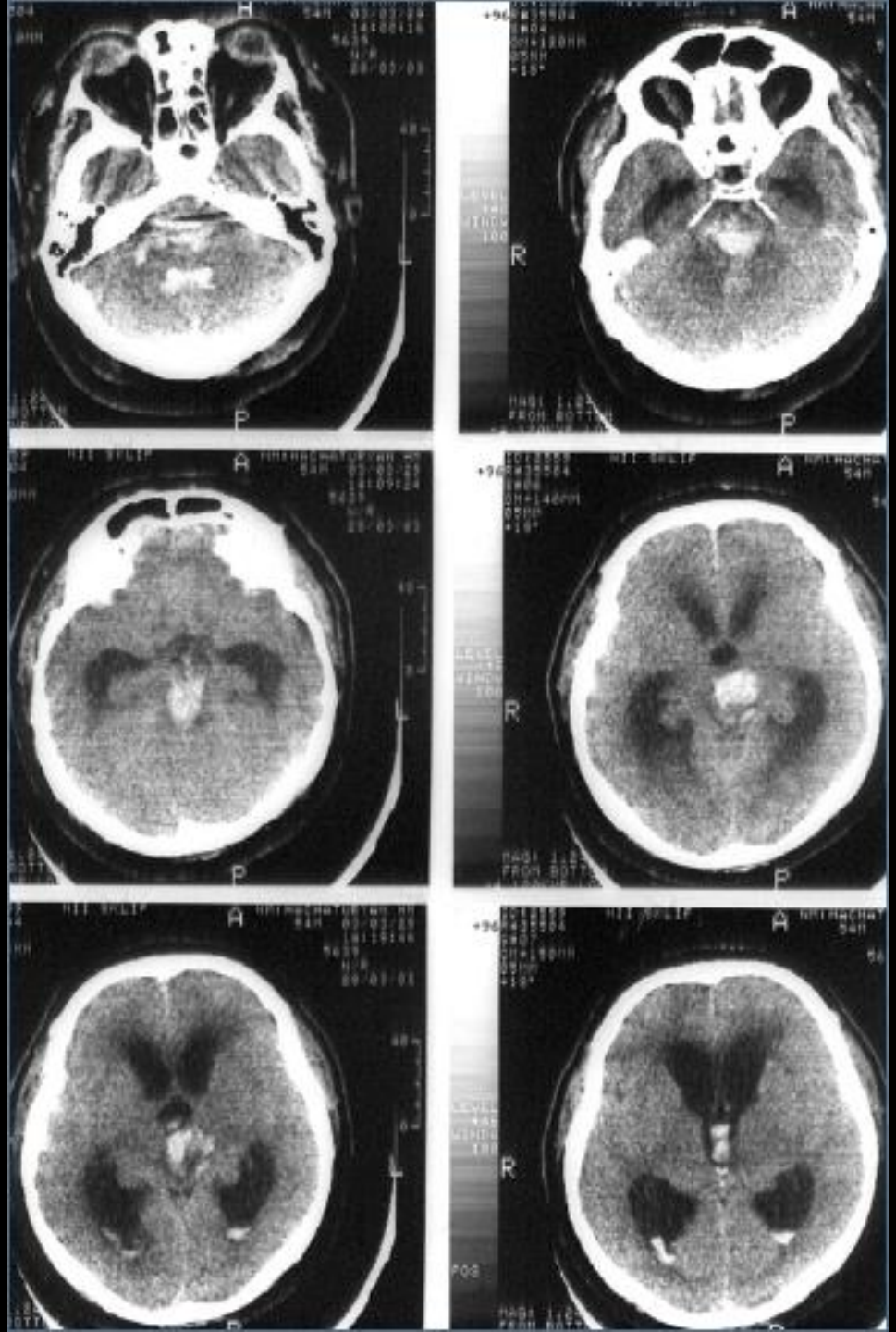


Subcortical

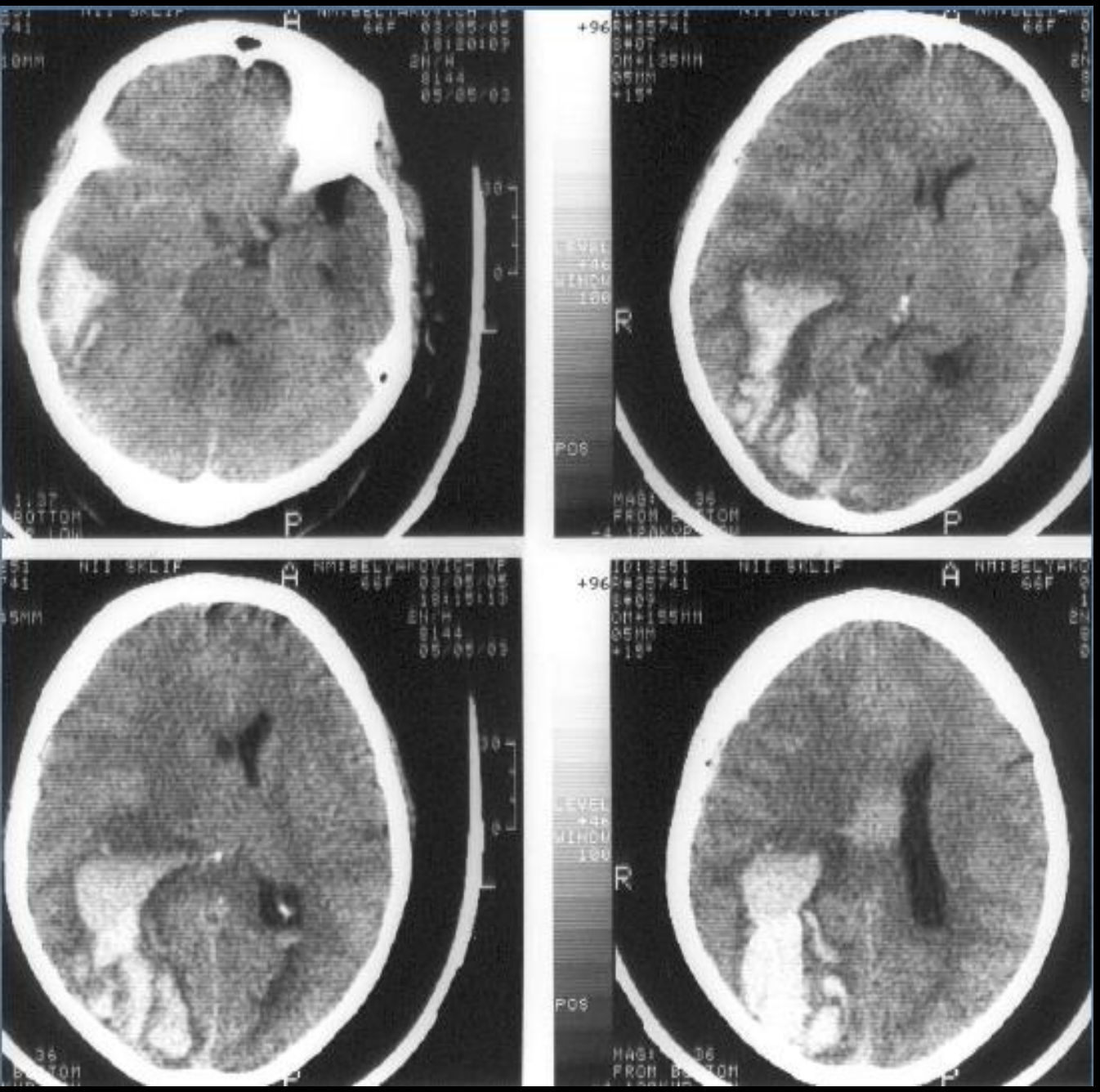


Cerebellar

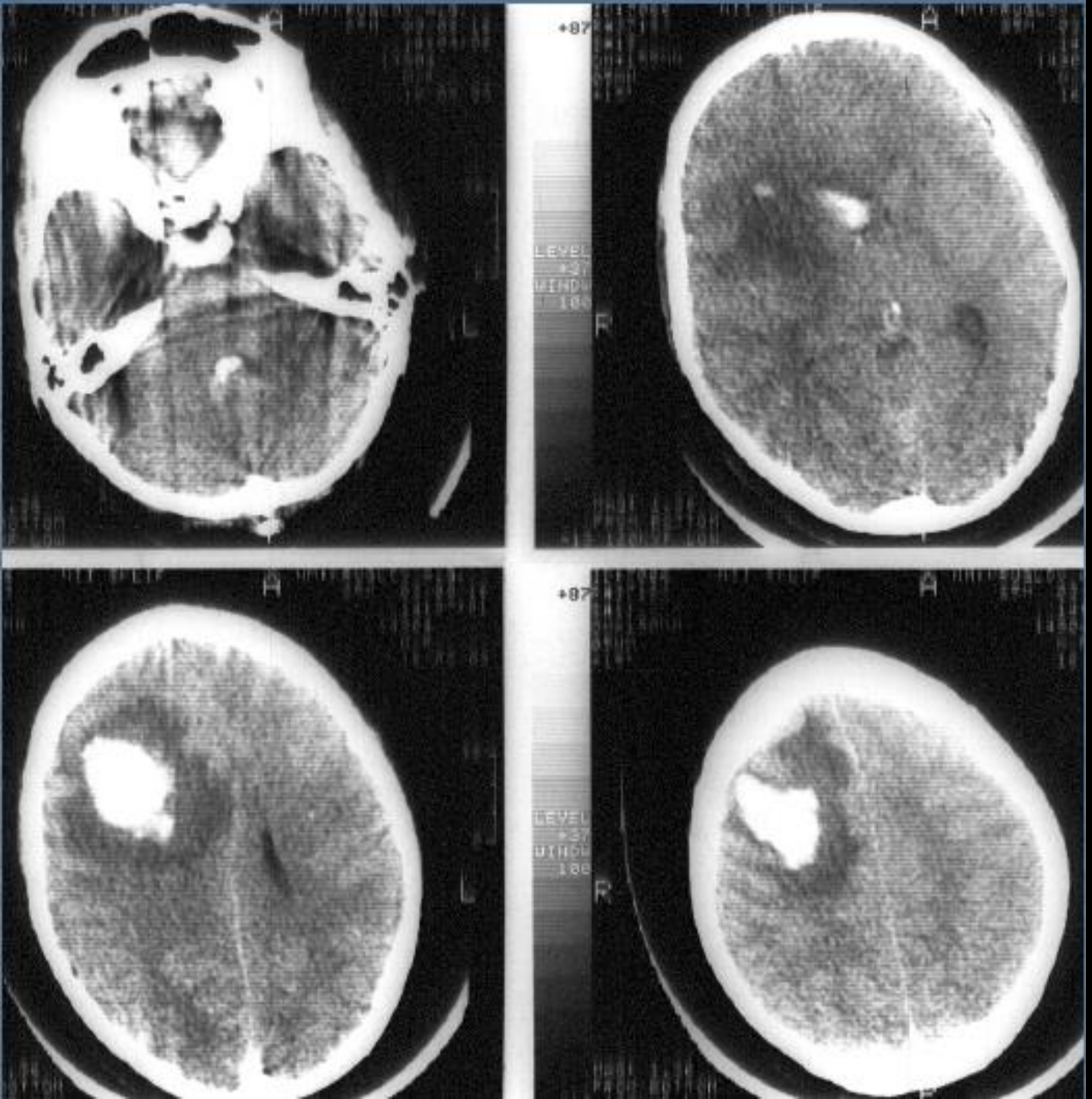




Brainstem hemorrhage

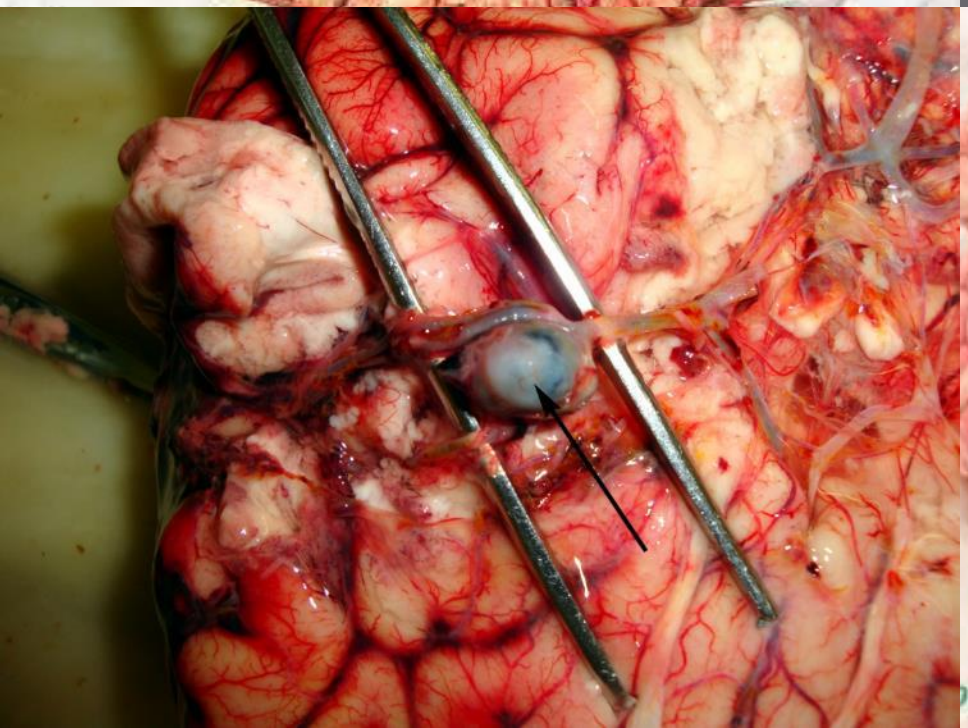


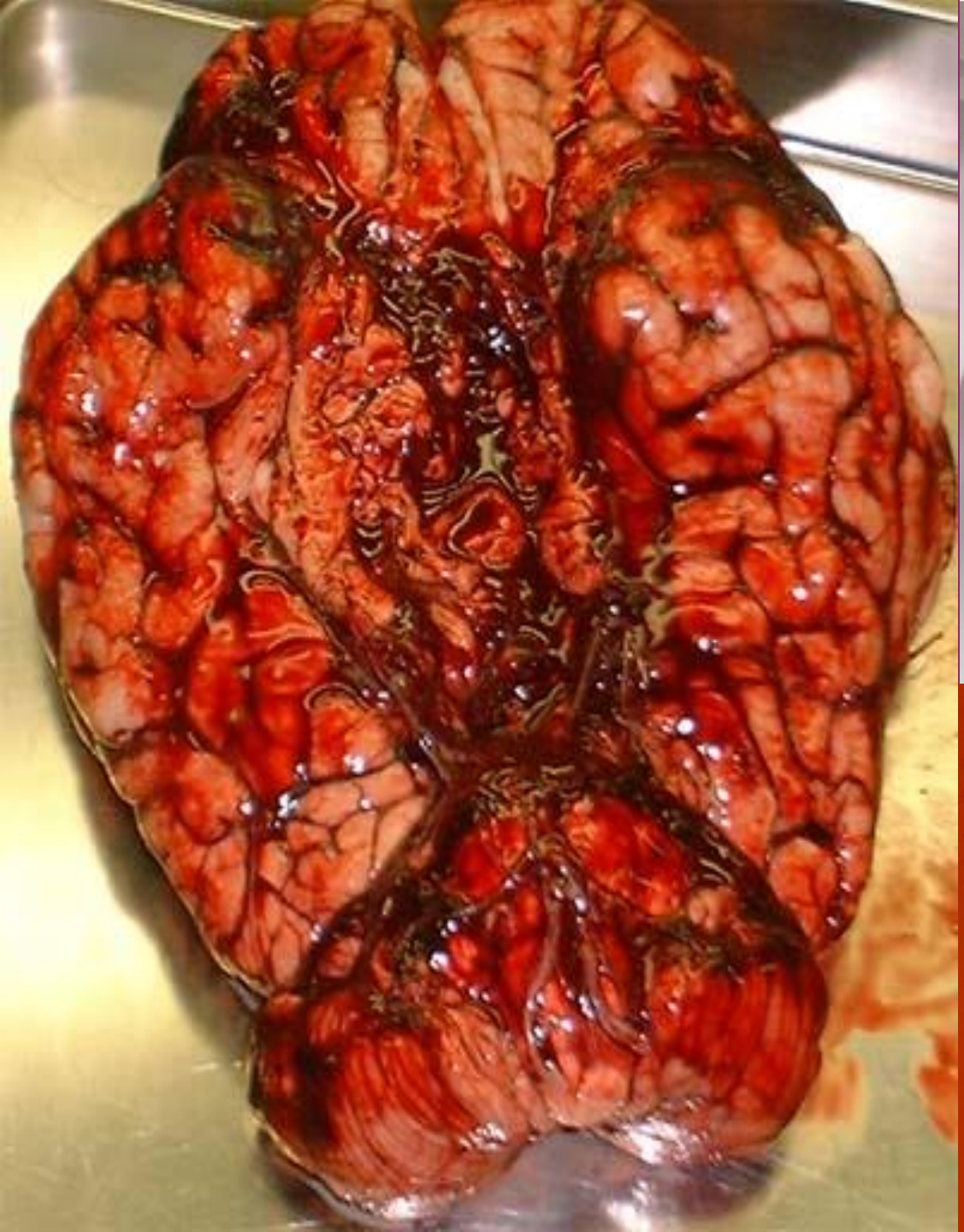
Intracerebral hematoma because of right occipital lobe AVM rupture



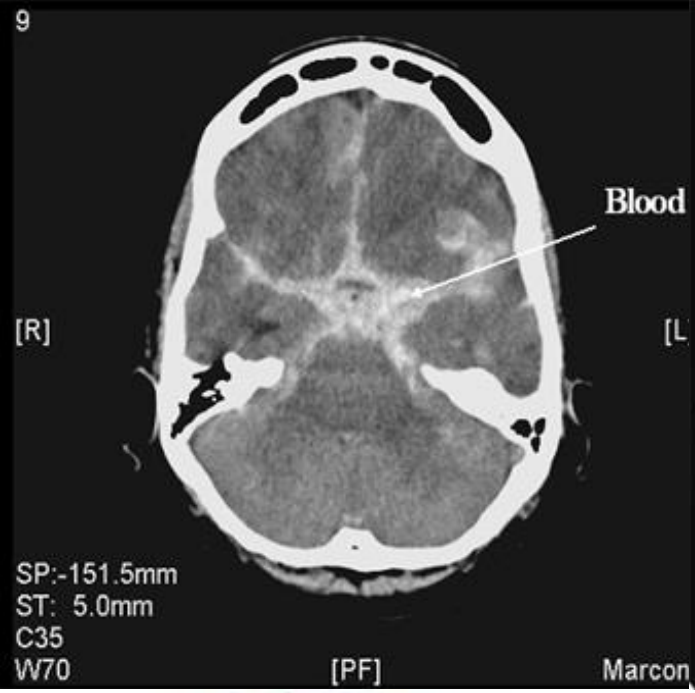
Hemorrhage into metastasis of prostatic cancer

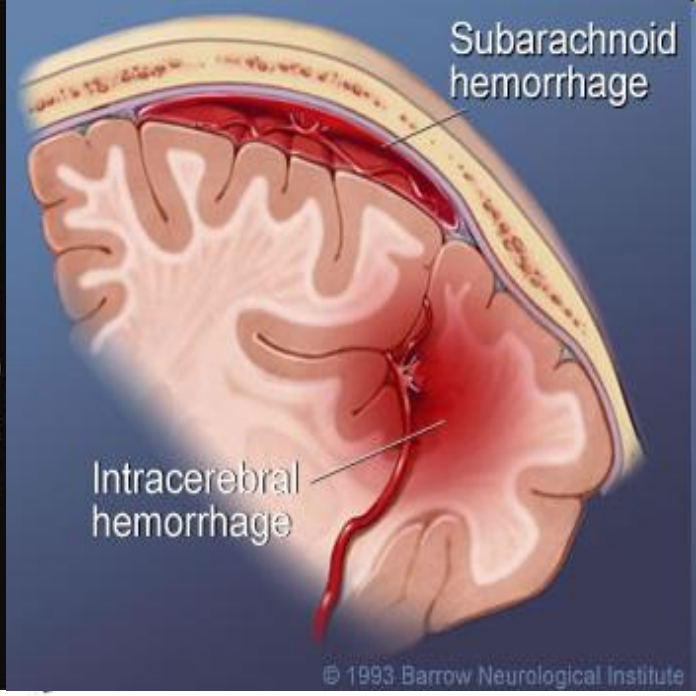
Death from hemorrhagic stroke (autopsy)





SUBARACHNOID HEMORRHAGE





Normal brain (front view)

Subarachnoid hemorrhage

SUBARACHNOID HEMORRHAGE

Hunt & Hess Stroke Scale

For non-traumatic subarachnoid hemorrhage patients

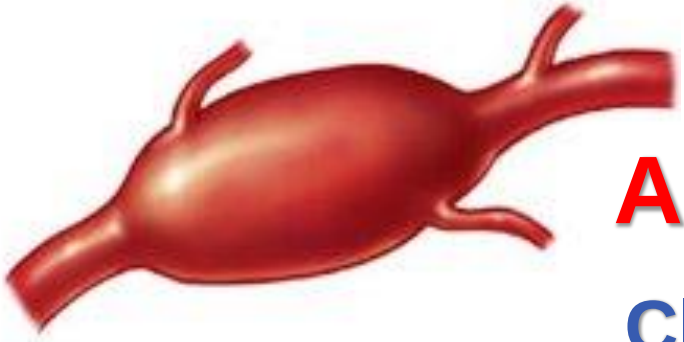
DESCRIPTION	GRADE
Asymptomatic, mild headache, slight nuchal rigidity	1
Moderate to severe headache, nuchal rigidity, no neurologic deficit other than cranial nerve palsy	2
Drowsiness / confusion, mild focal neurologic deficit	3
Stupor, moderate-severe hemiparesis	4
Coma, decerebrate posturing	5

Hospital care

- Critical time periods (arrival at the hospital)
  - Immediate general assessment – 10 min
  - Immediately neuro assessment – 25 min
  - Acquisition of a head CT – 25 min
  - Interpretation of CT scan – 45 min
  - Administration of IV fibrinolytics – 60 min if no bleed
  - Administration of IV fibrinolytics – 3 hours from time of onset
  - Administration of Interarterial fibrinolytics – 6 hours from time of onset
  - Admission to a monitored bed – 3 hours

Aneurysms

Saccular Aneurysm

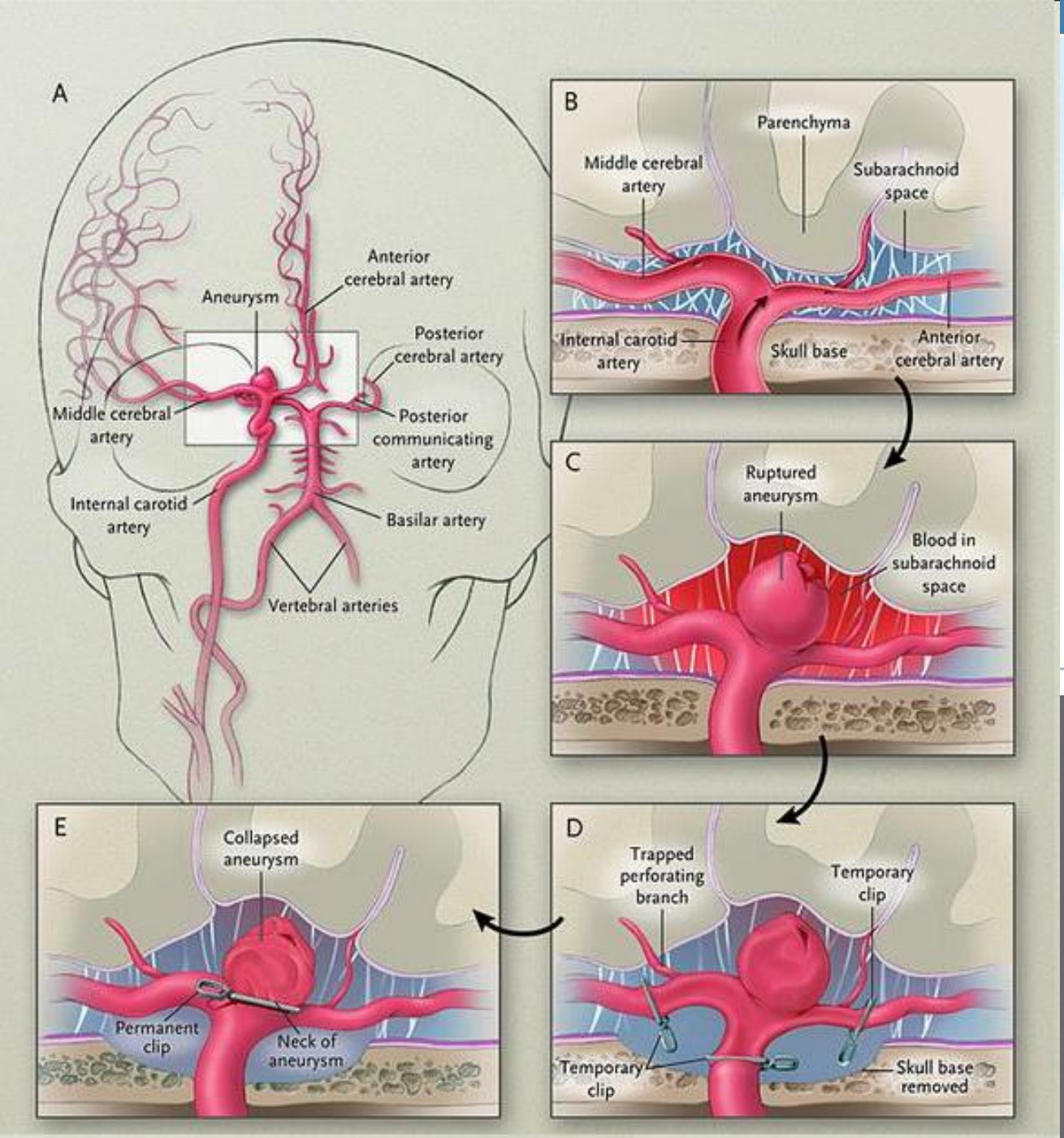


Fusiform Aneurysm

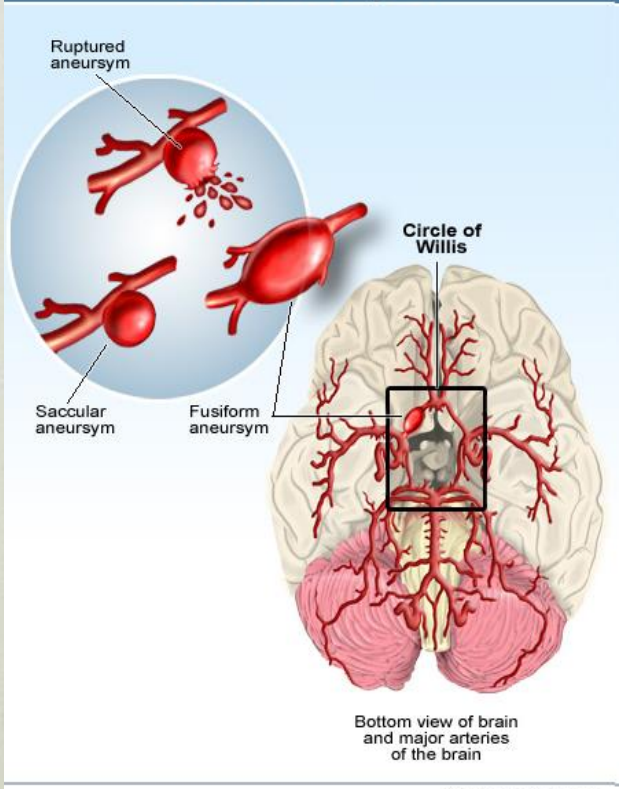
Ruptured Aneursym

Classification morphology:

1. Saccular (berry)
2. Fusiform
3. Dissecting



Brain Aneurysm

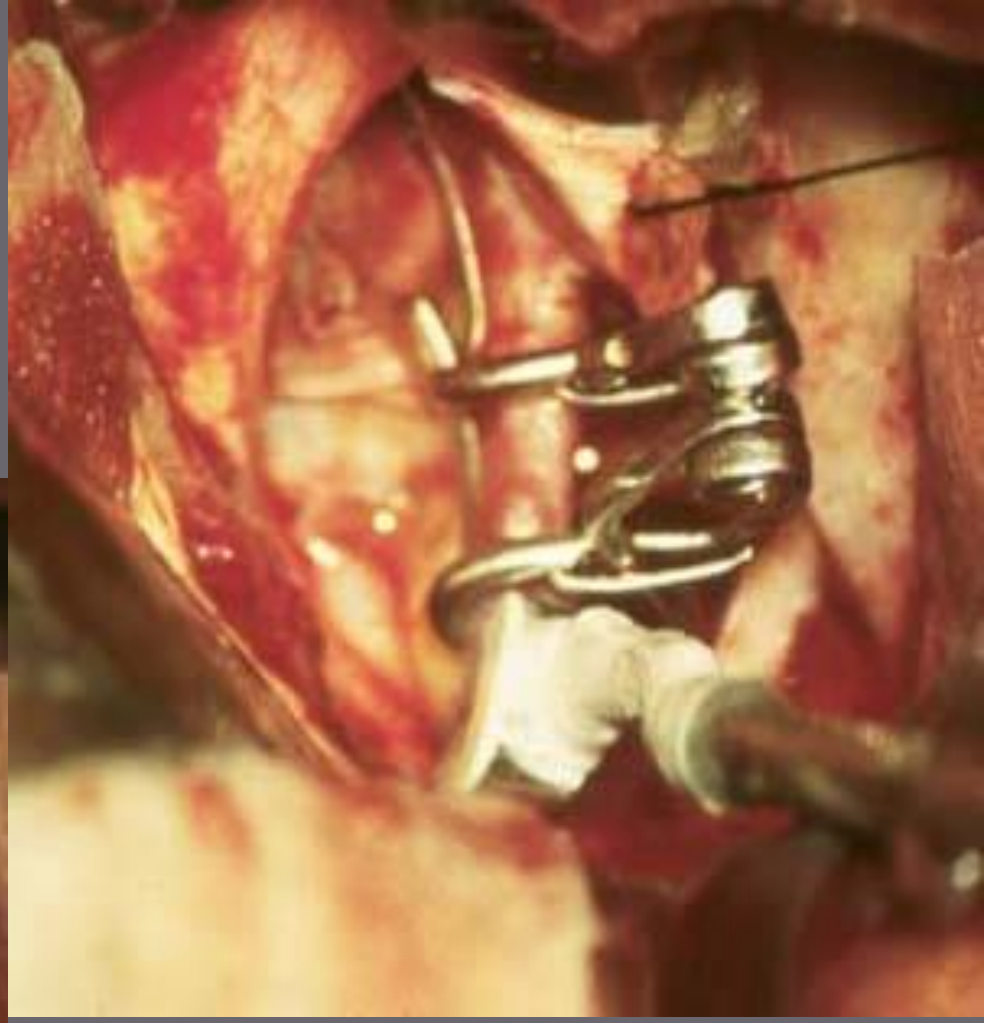


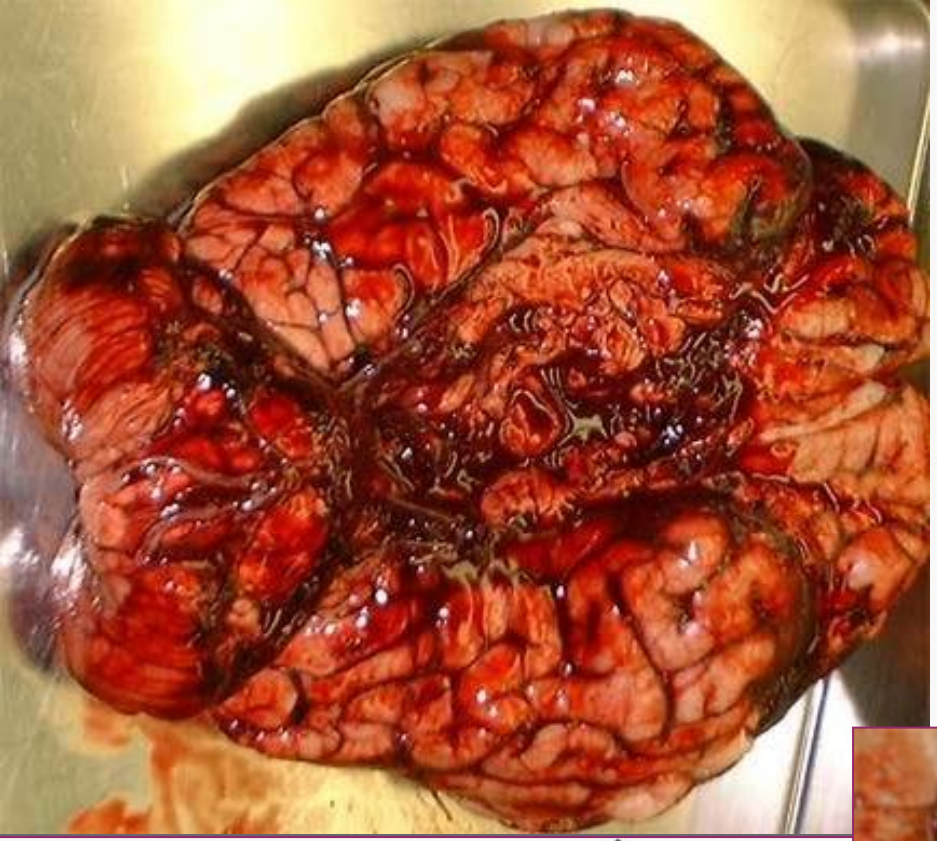
Treatment

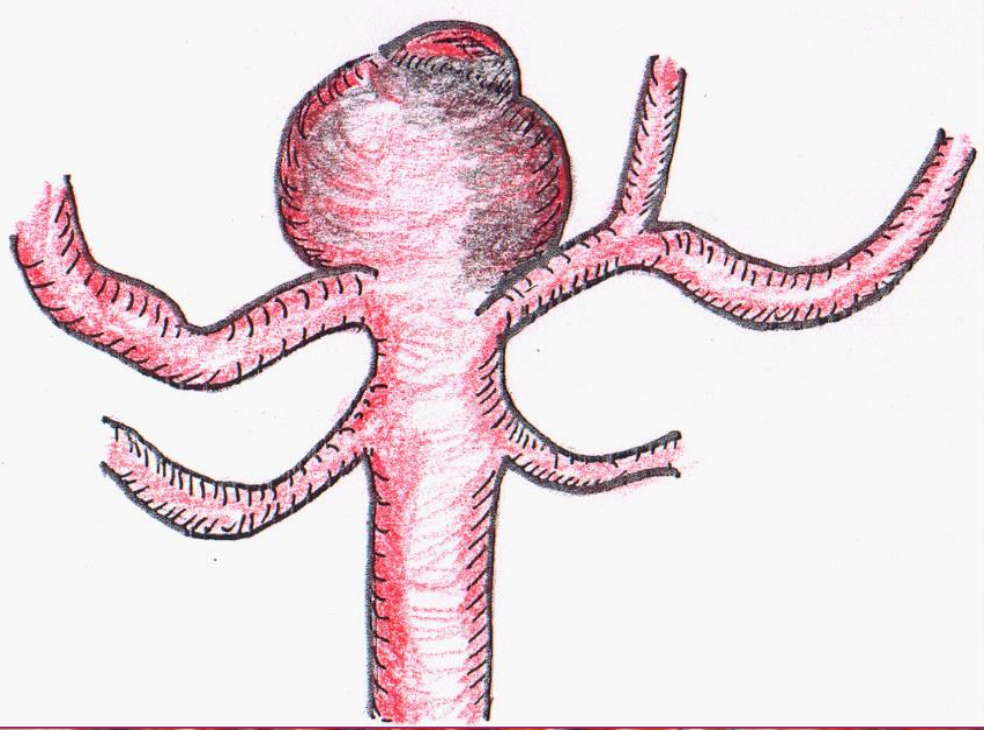
Concern is rebleed and treatment of vasospasm

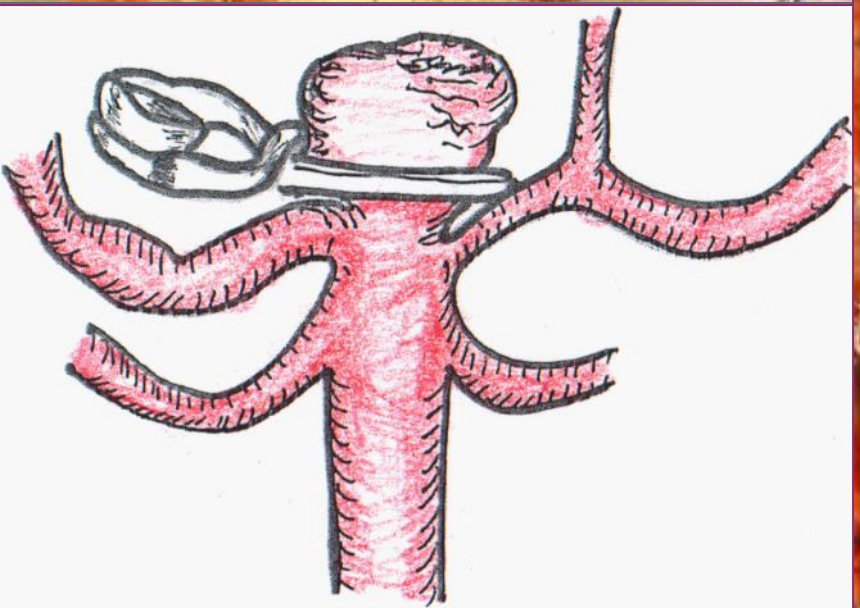
- **Surgical clipping vs. coiling**
- **Vasospasm:**
  - **HHH therapy**
  - **Angioplasty**
  - **Peak day 7-10 (3-21)**

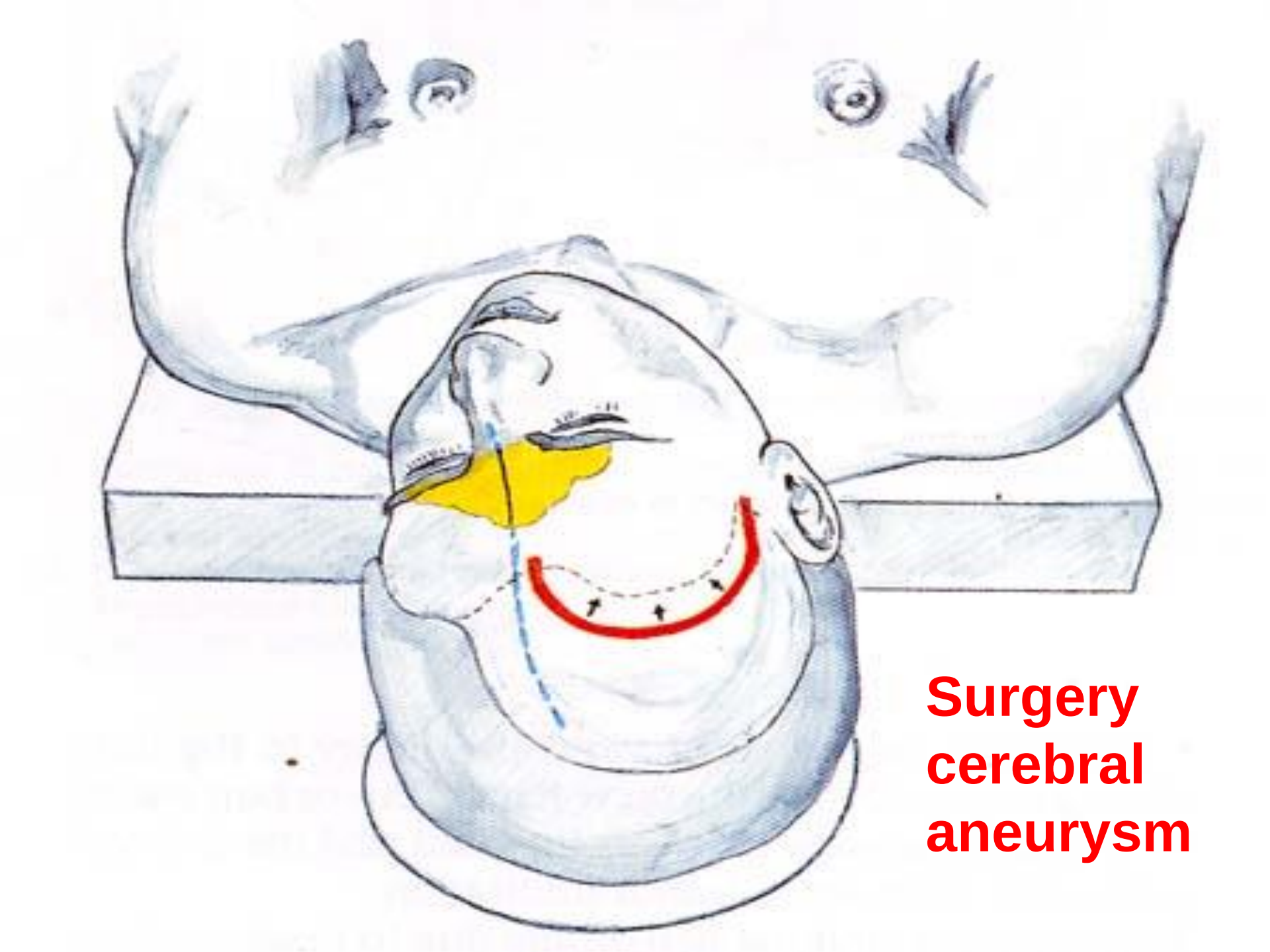
Surgical Clipping of Aneurysm

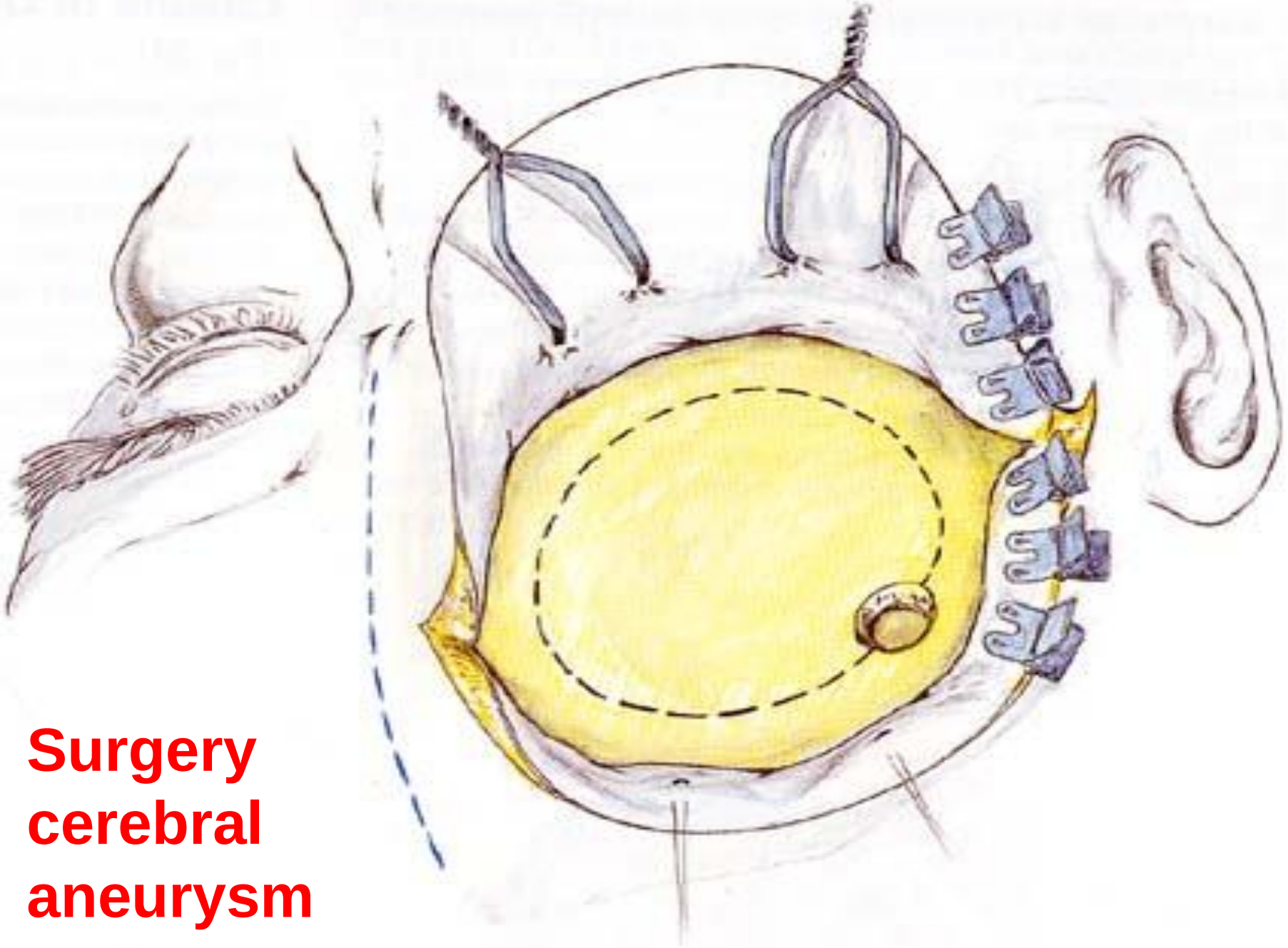




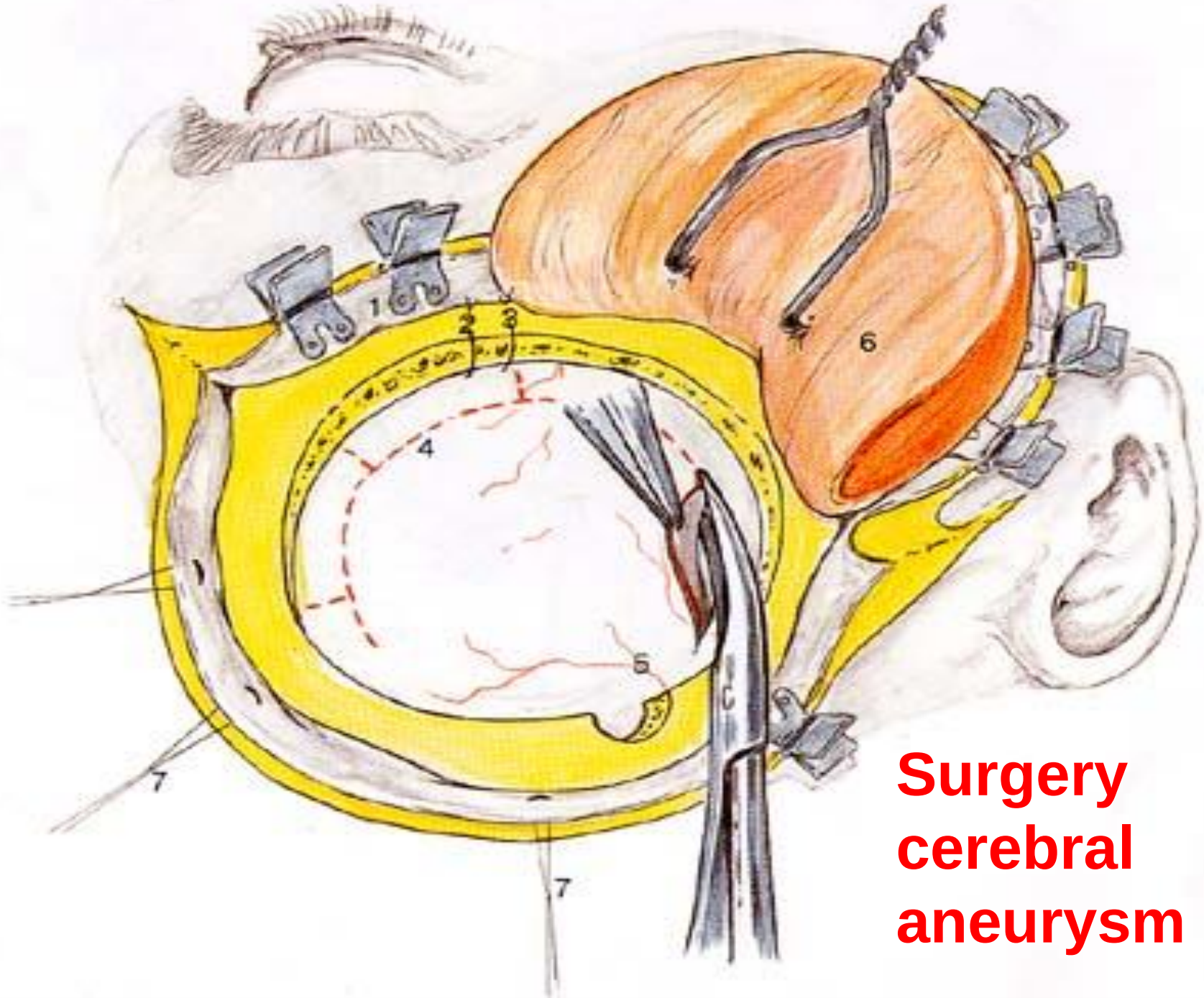




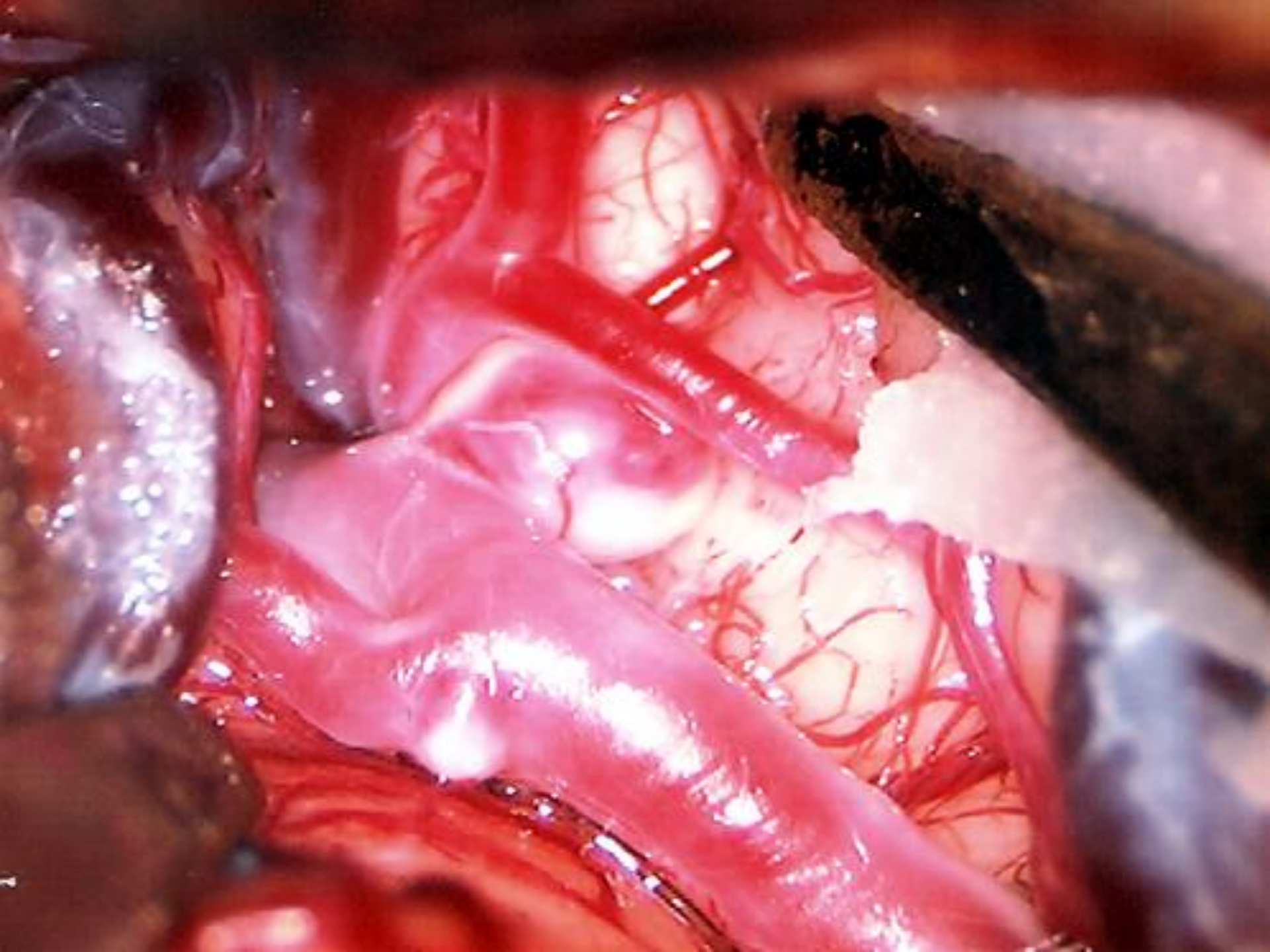

Surgery
cerebral
aneurysm

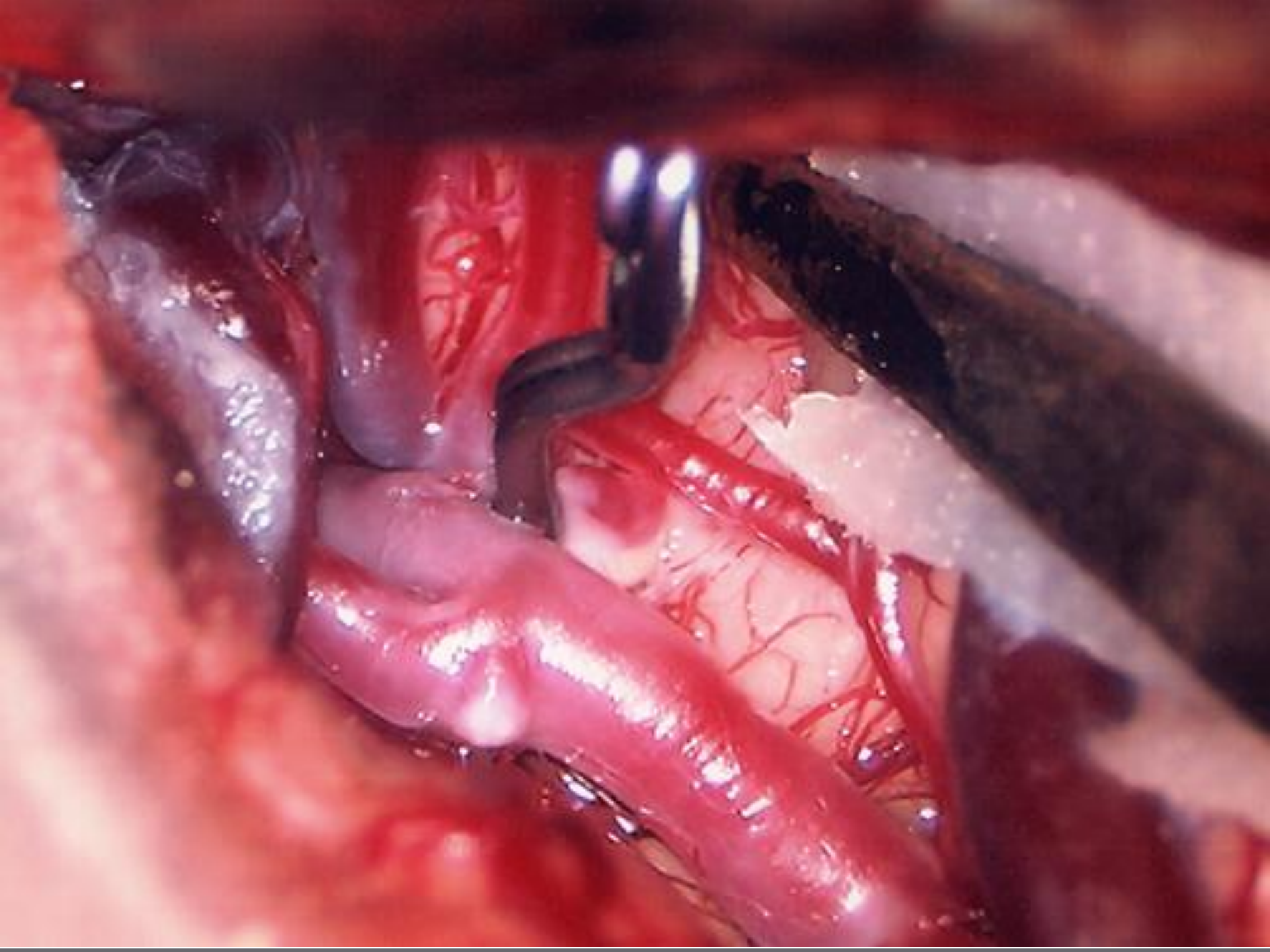


Surgery cerebral aneurysm



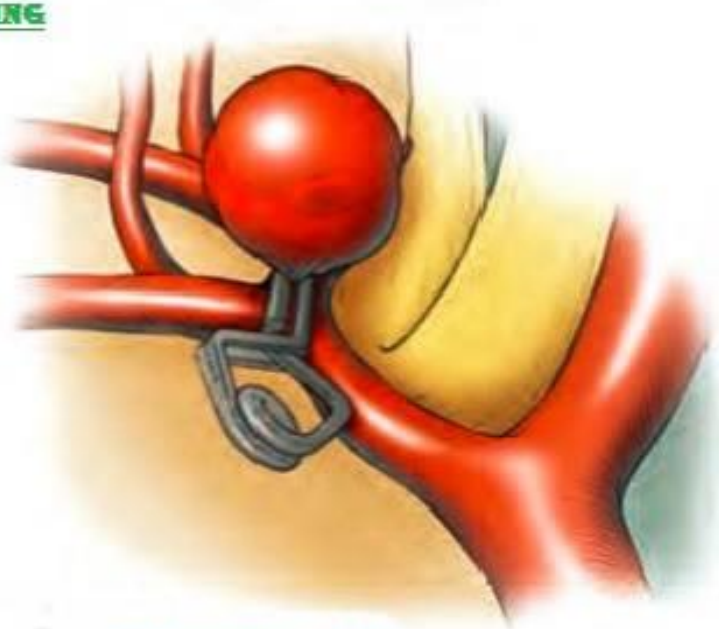
Surgery cerebral aneurysm



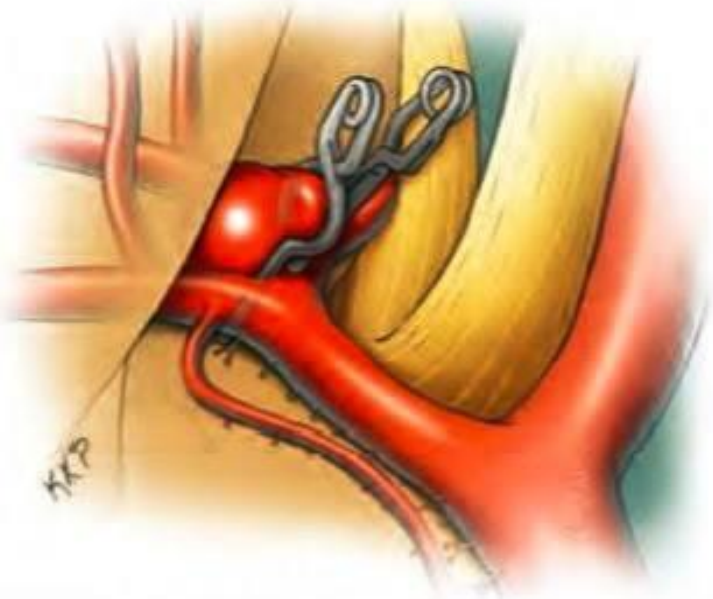


CLIPPING

inferior projection



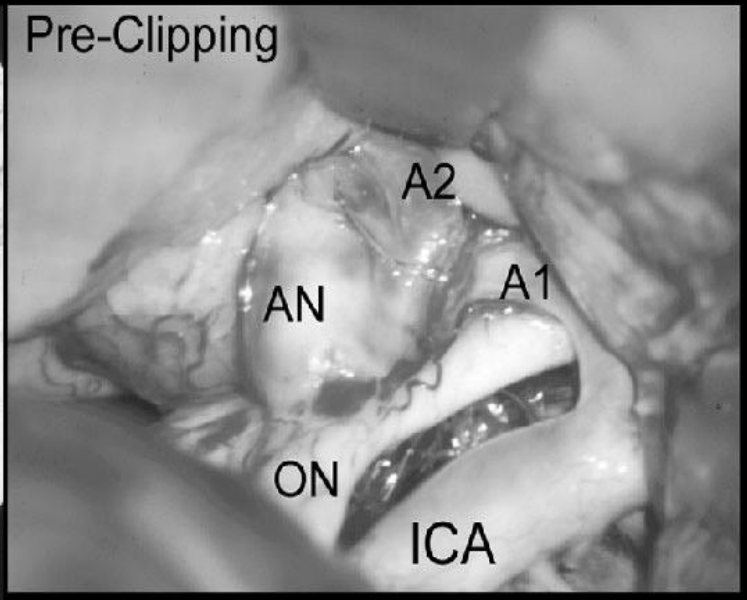
anterior projection

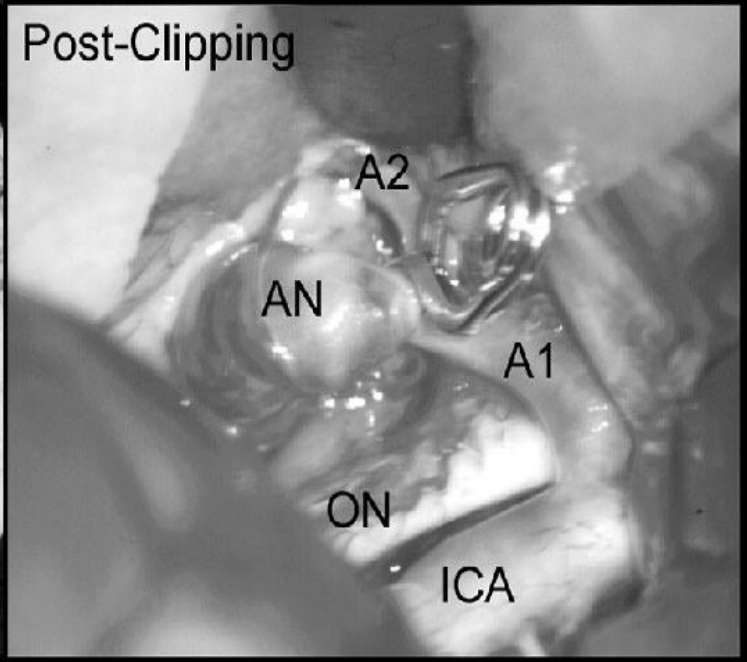


superior projection

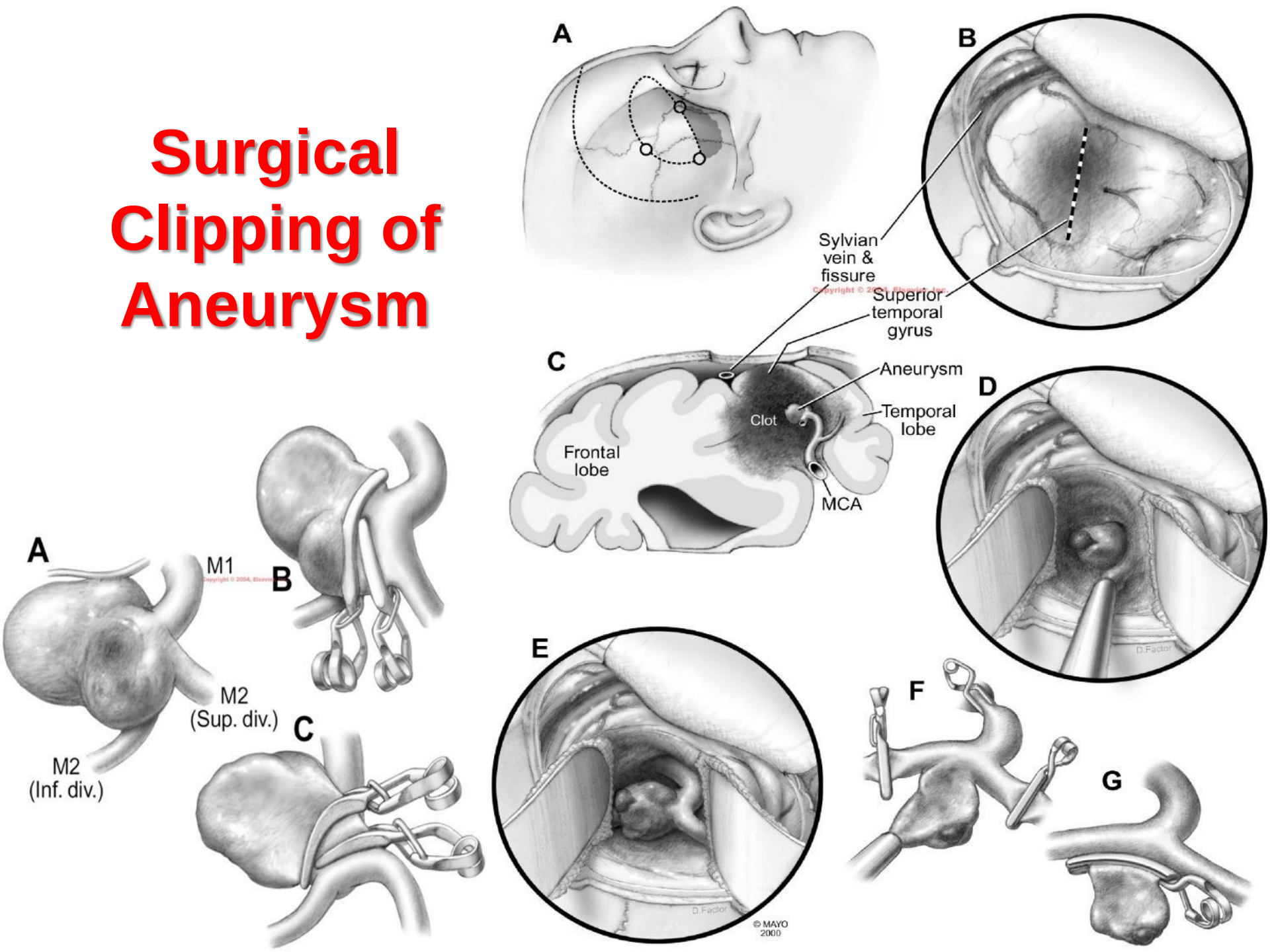
posterior projection

Surgical Clipping of Aneurysm

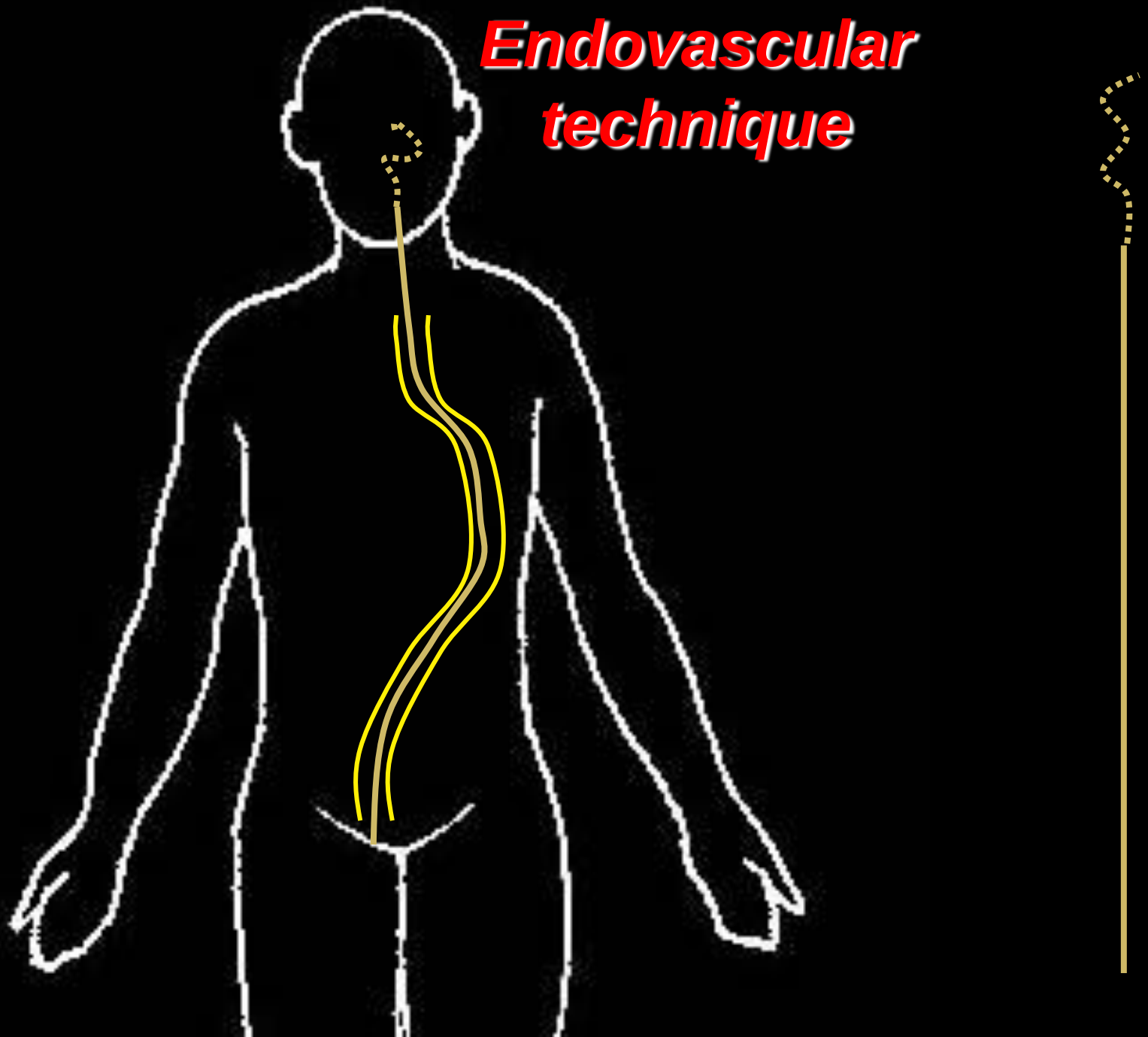




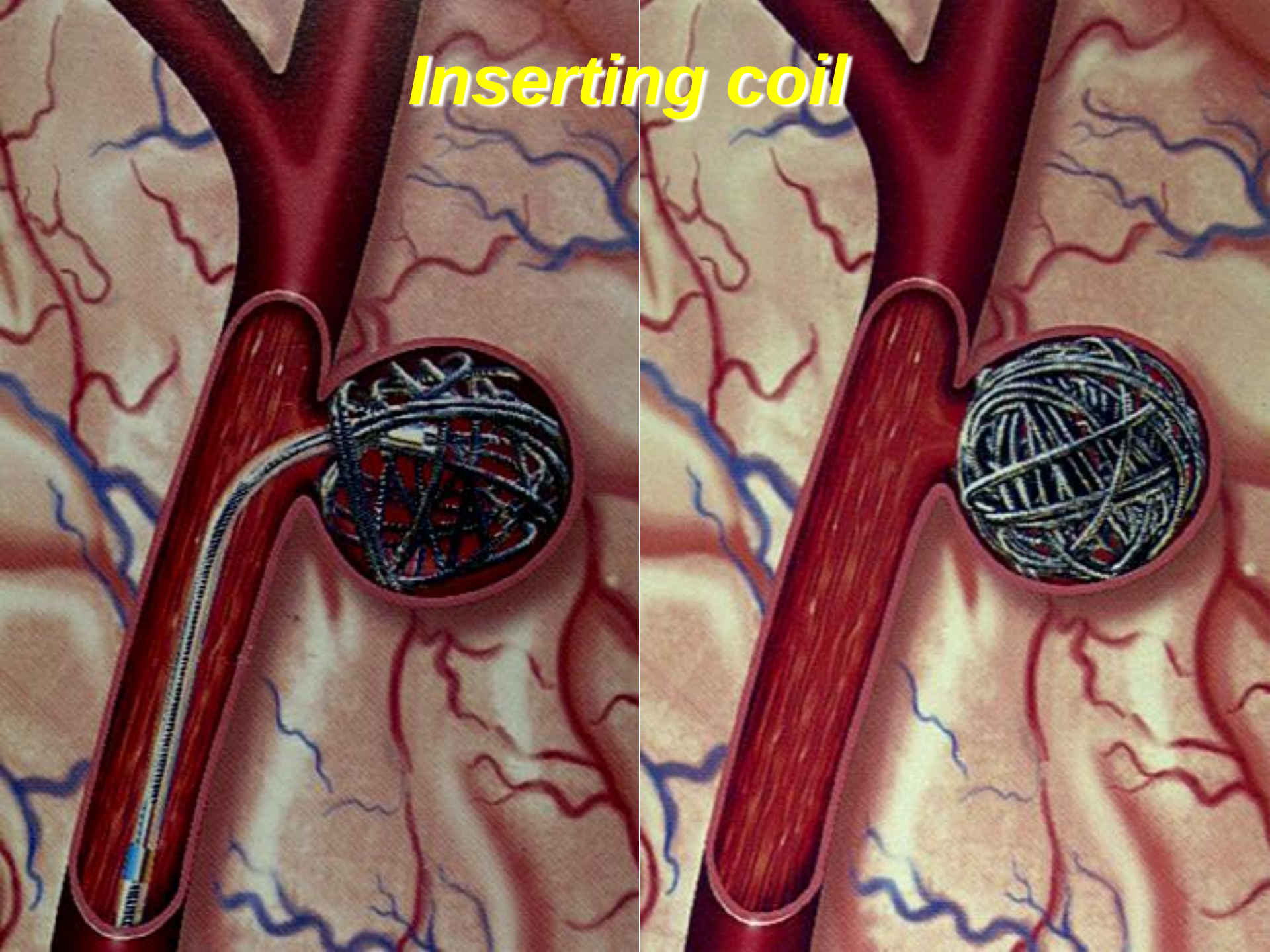
Surgical Clipping of Aneurysm



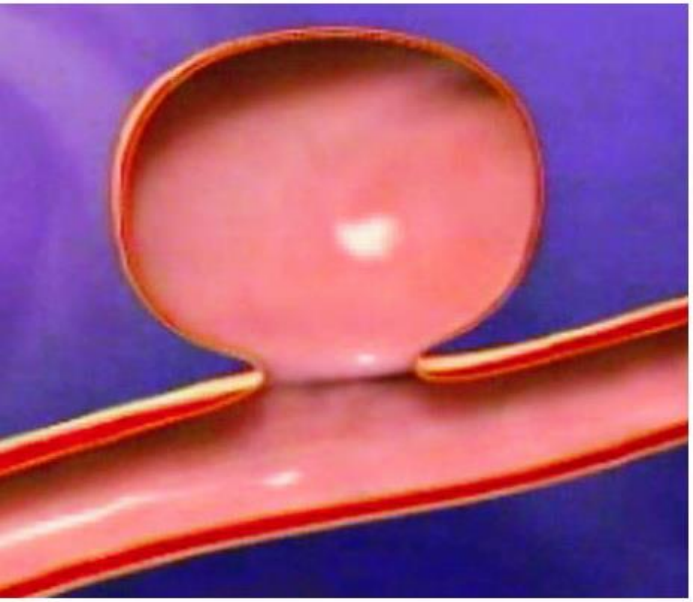
Endovascular technique

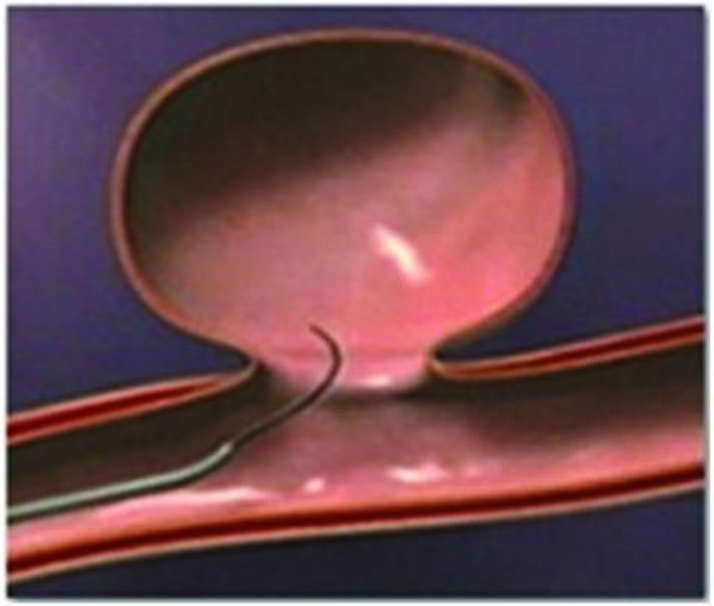


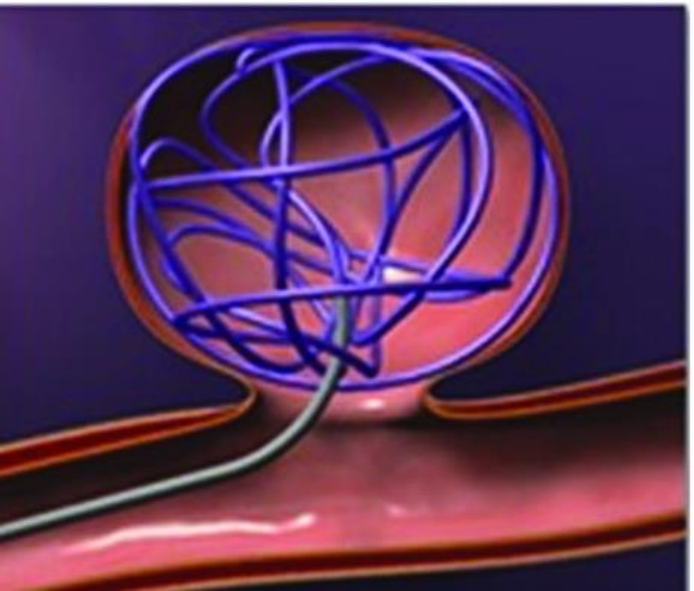
Detachable platinum coil

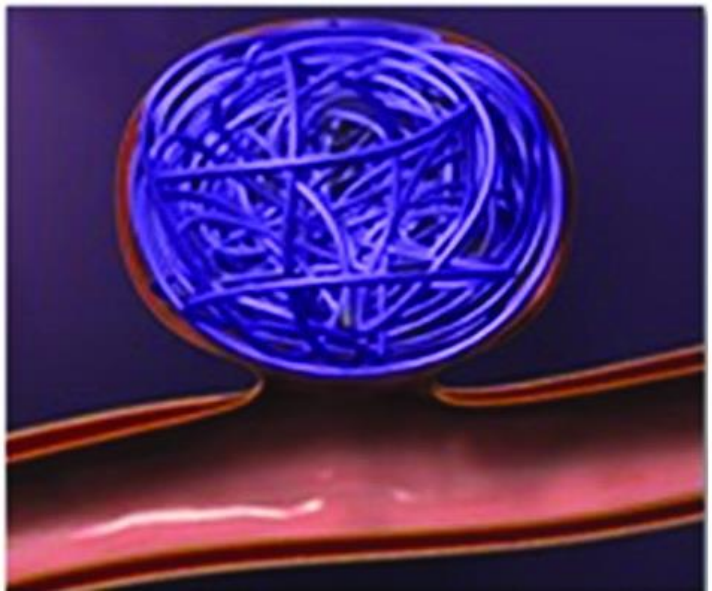

Inserting coil

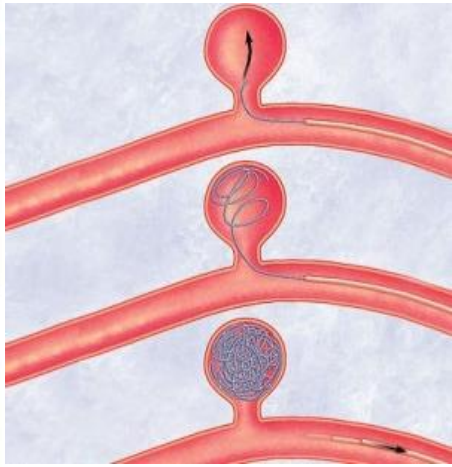
Coiling principle

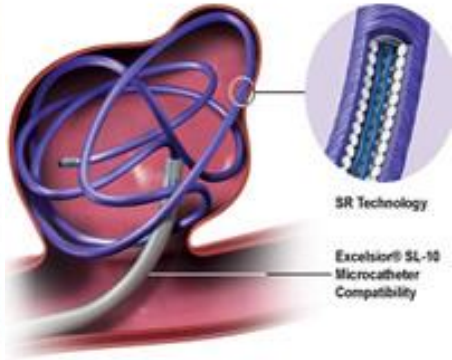




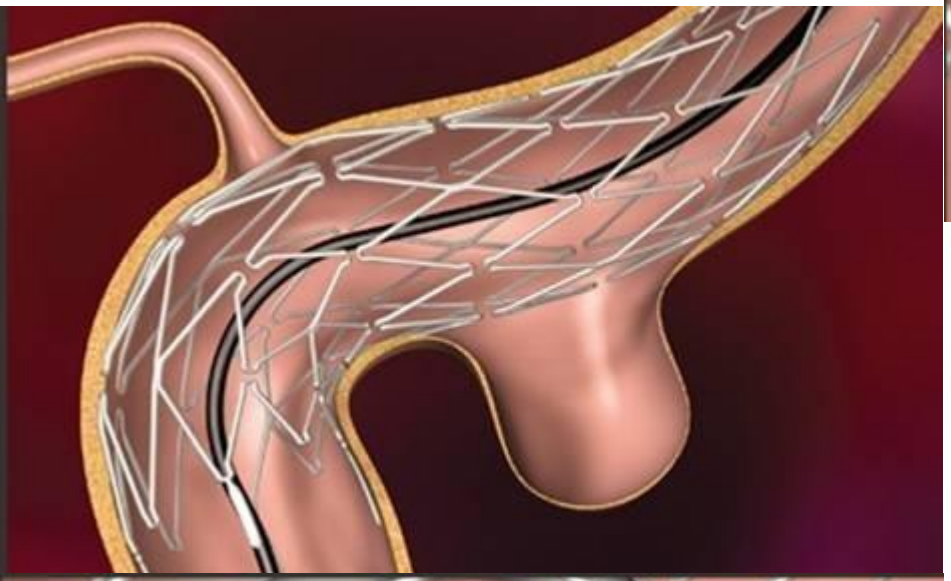


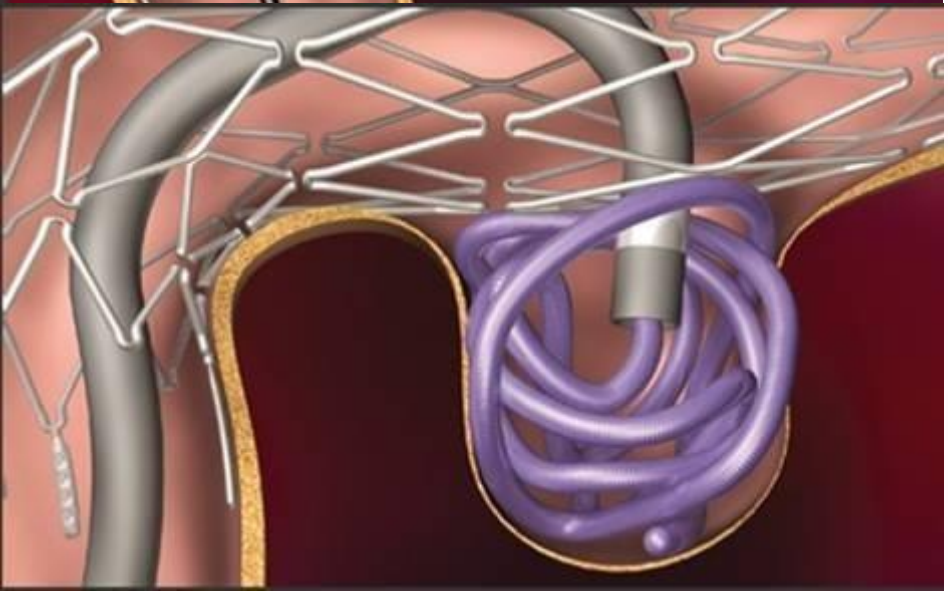


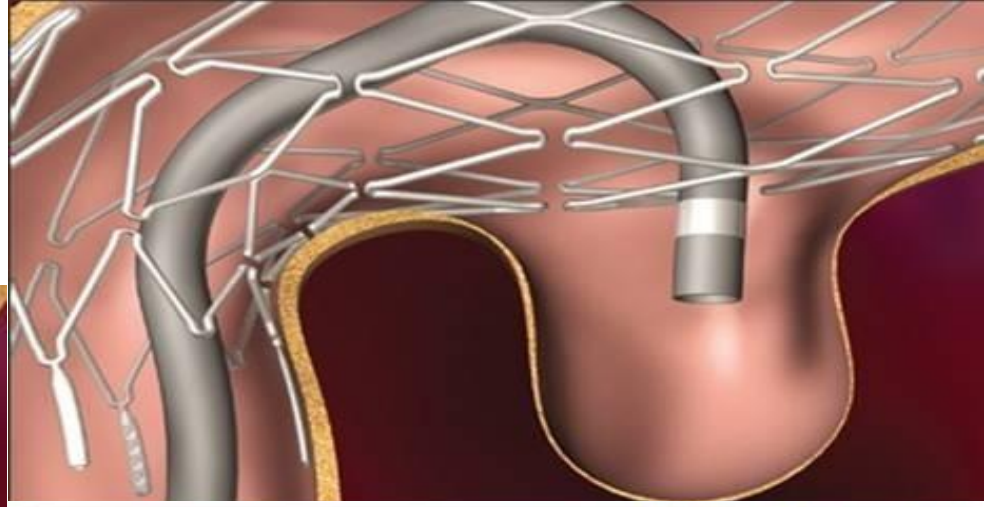


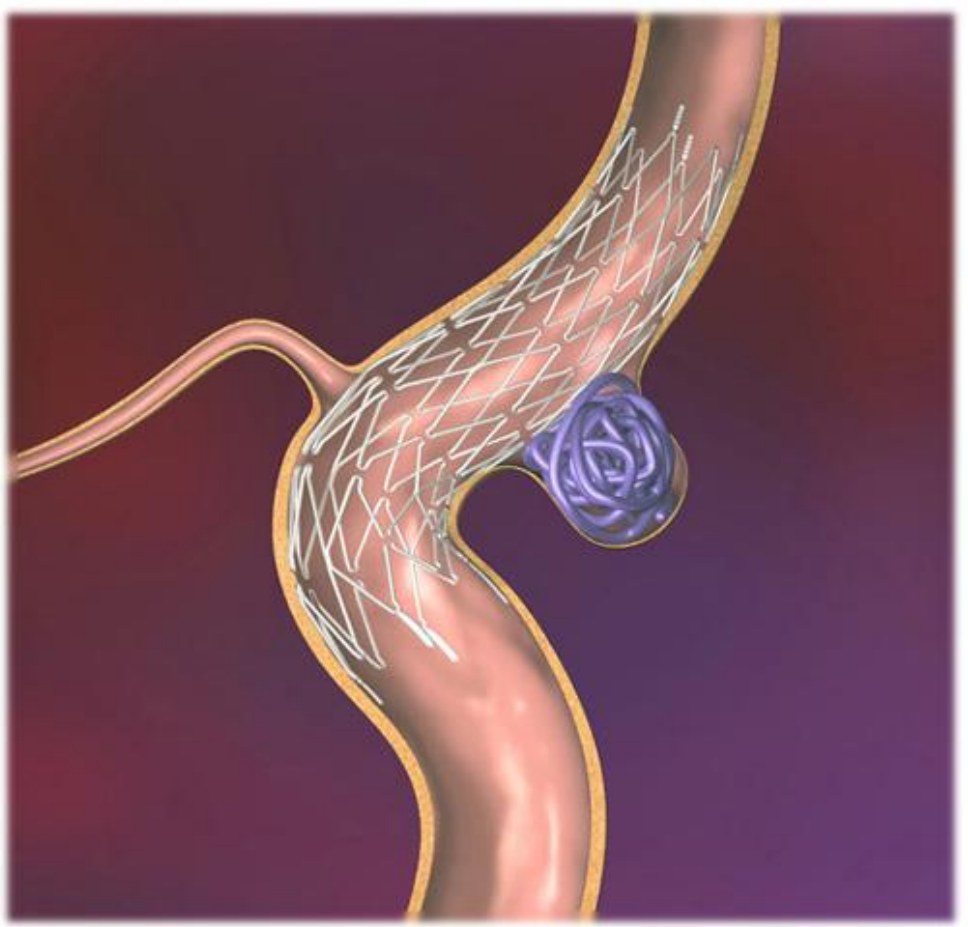


Stent Assisted Coiling

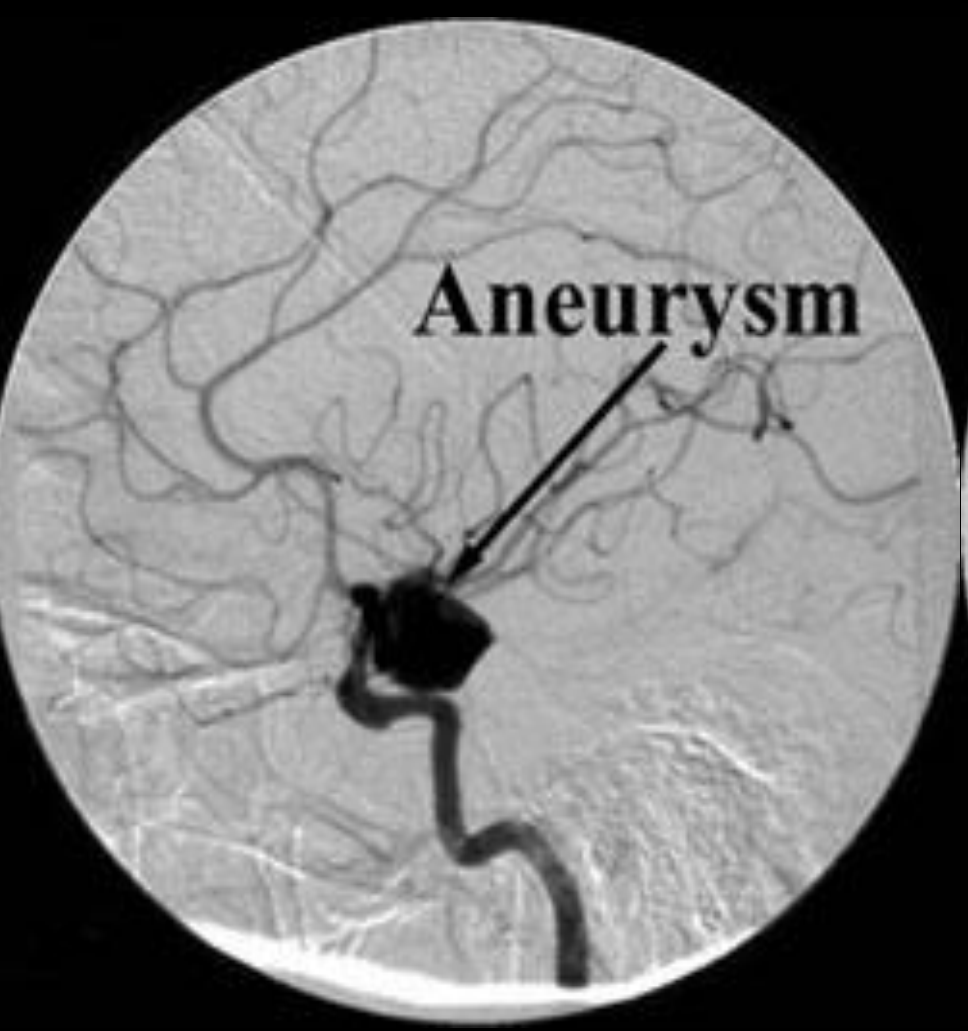




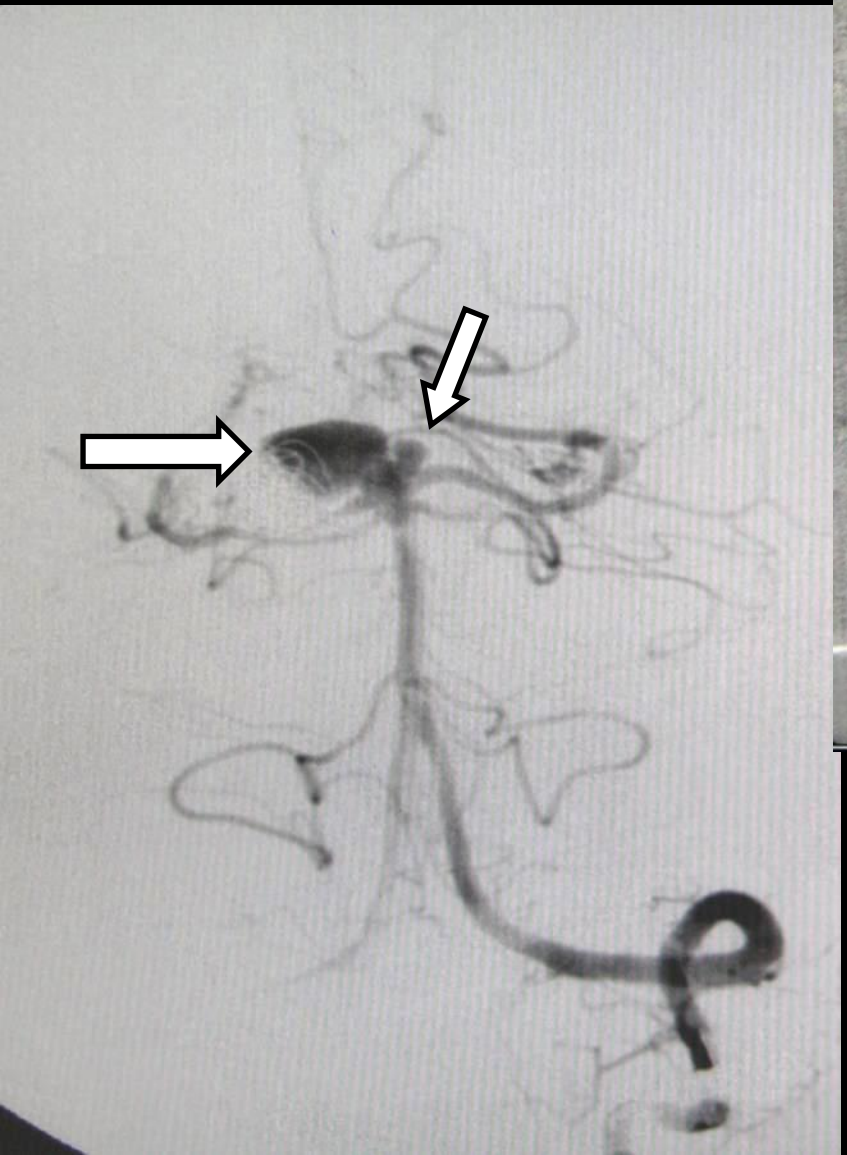


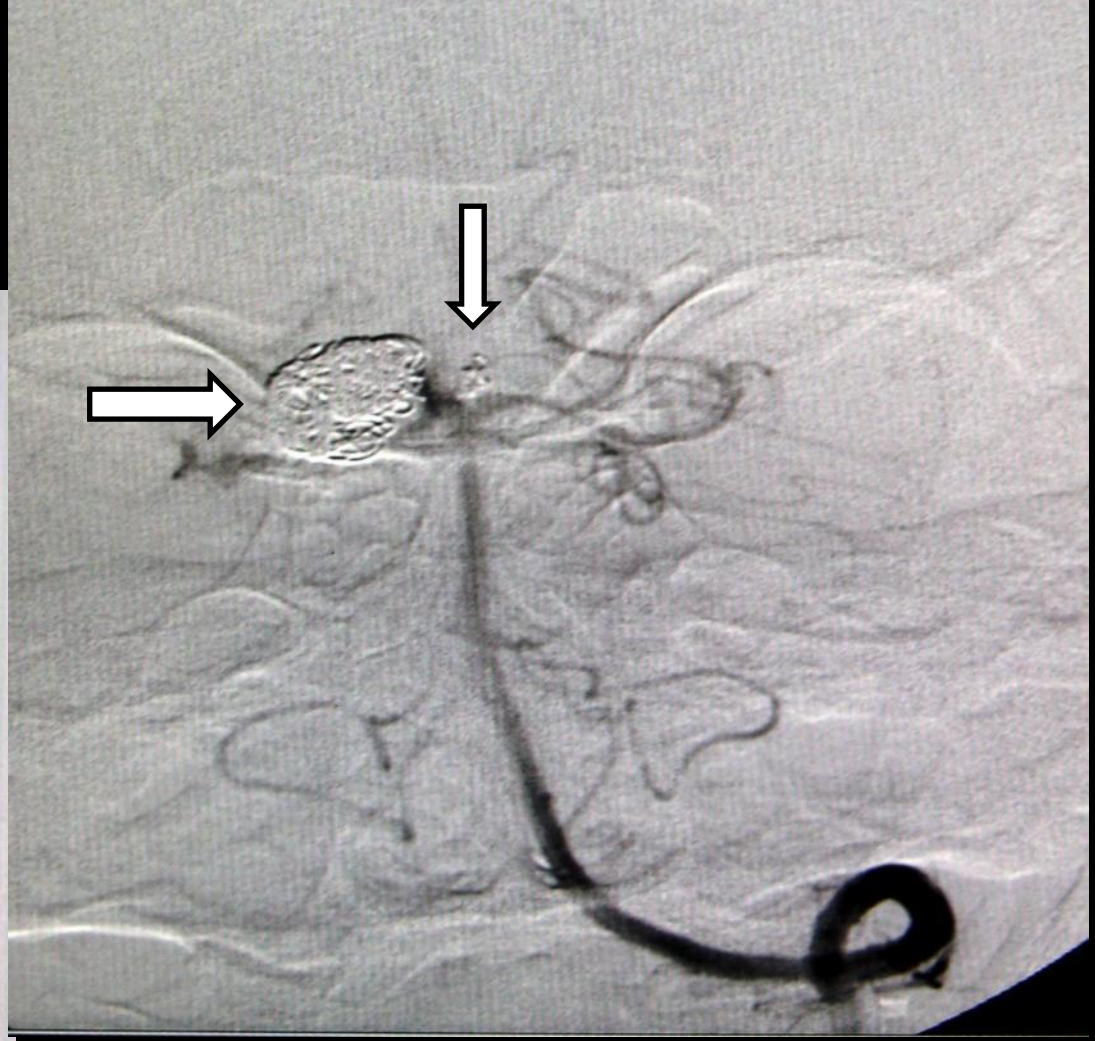


Coiling of Aneurysm

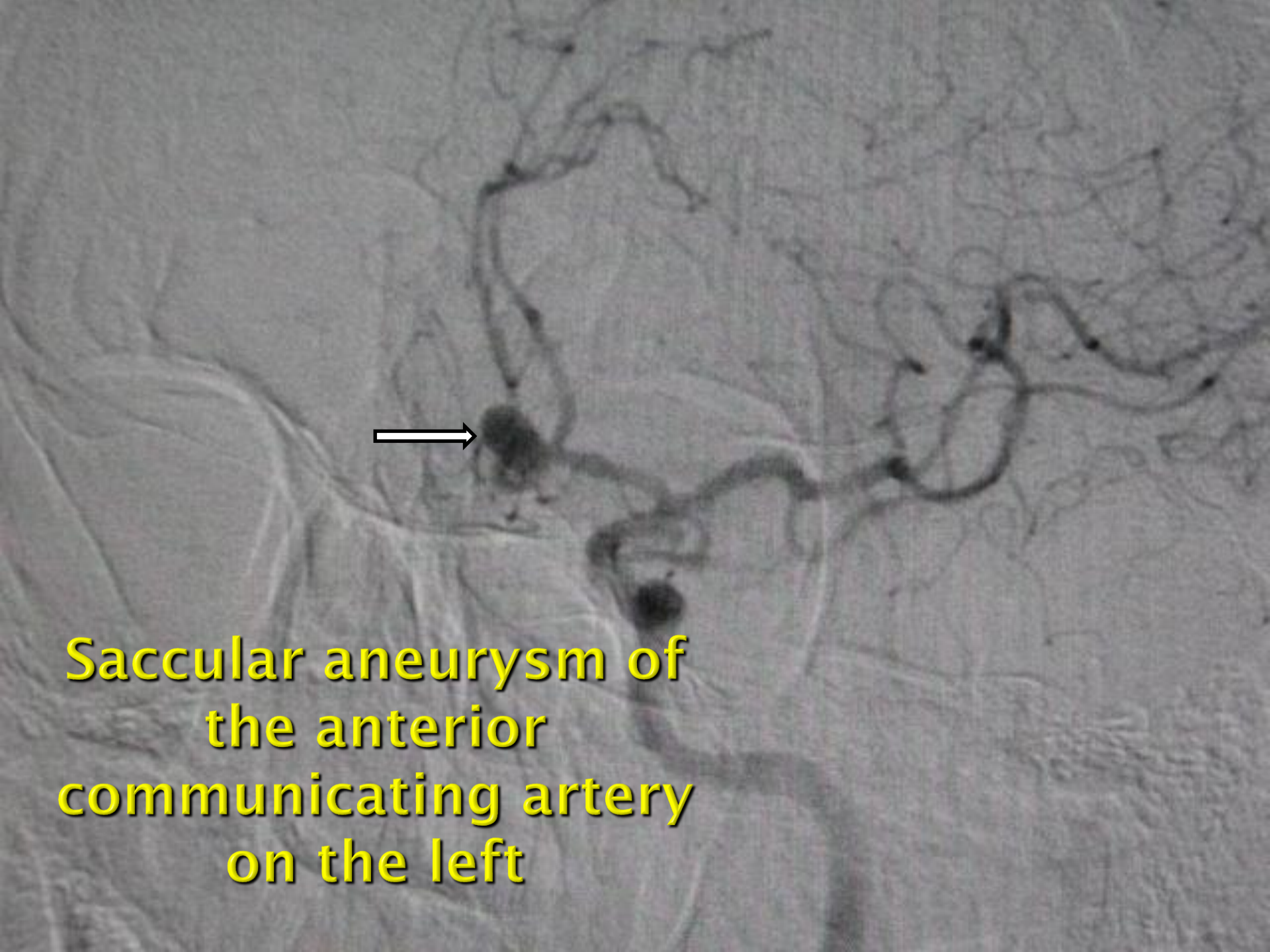


Multiple saccular AA of basilar artery bifurcation

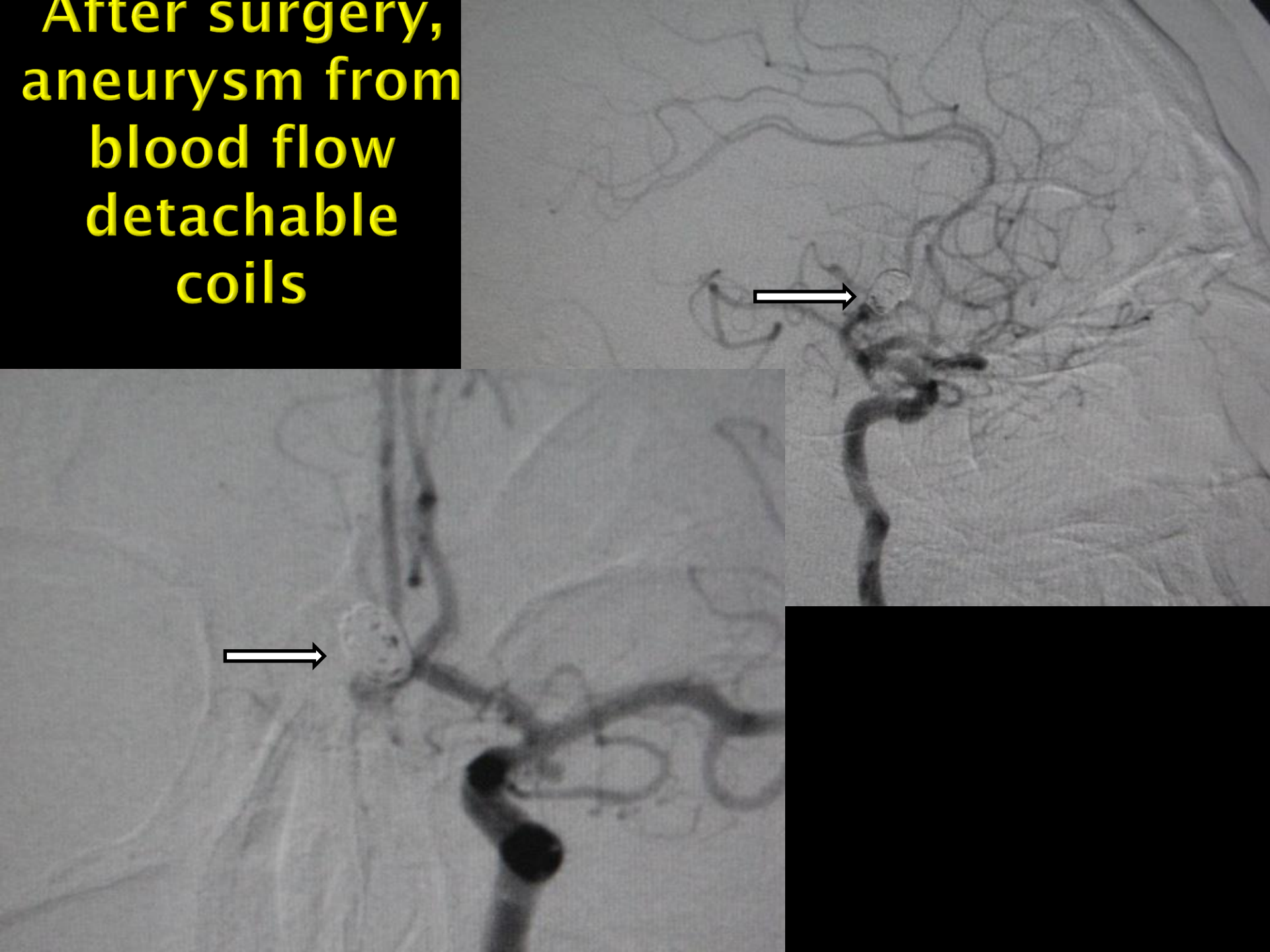


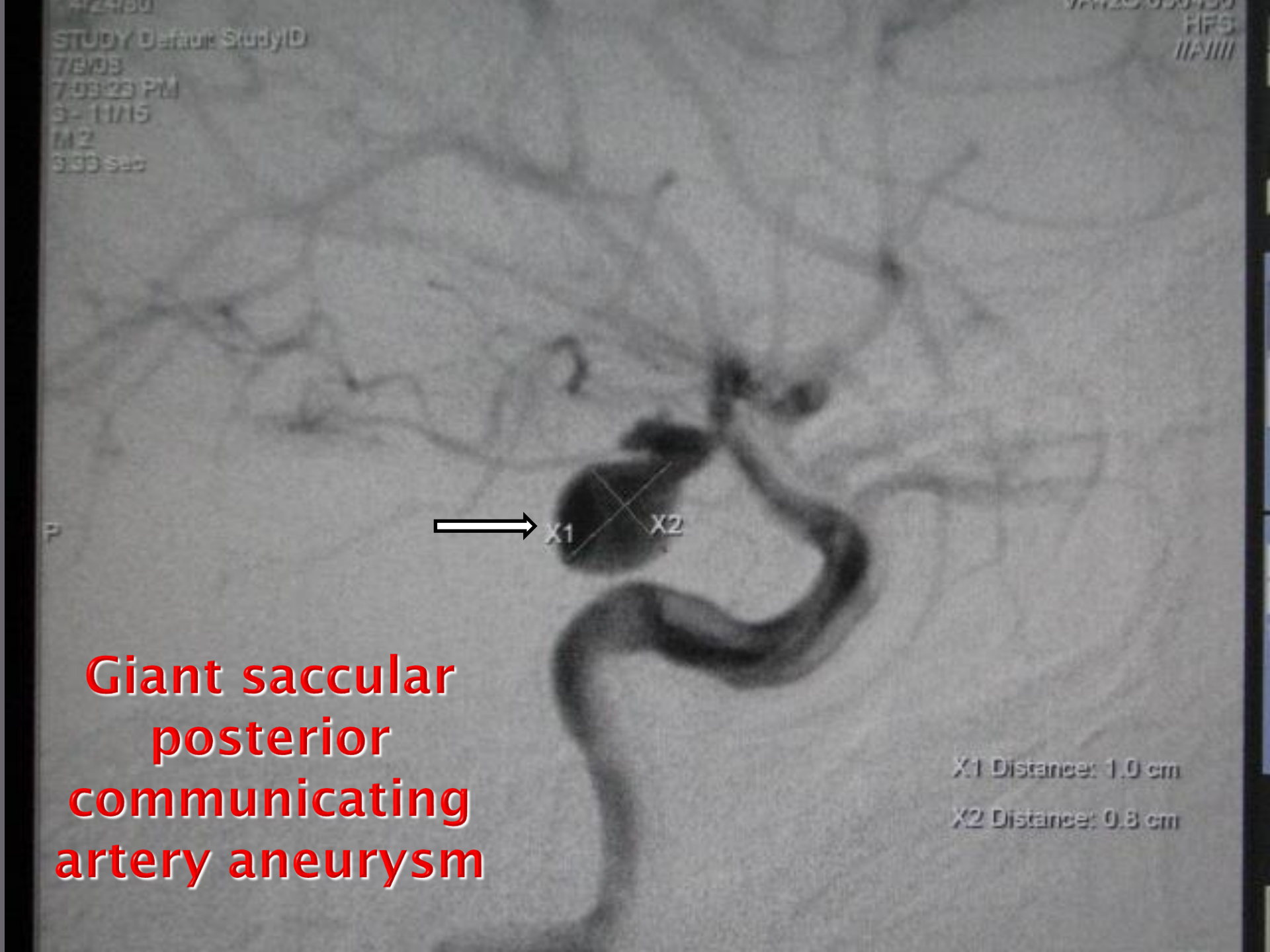


Turning off the saccular aneurysm of the basilar artery blood flow with platinum coils


Saccular aneurysm of
the anterior
communicating artery
on the left

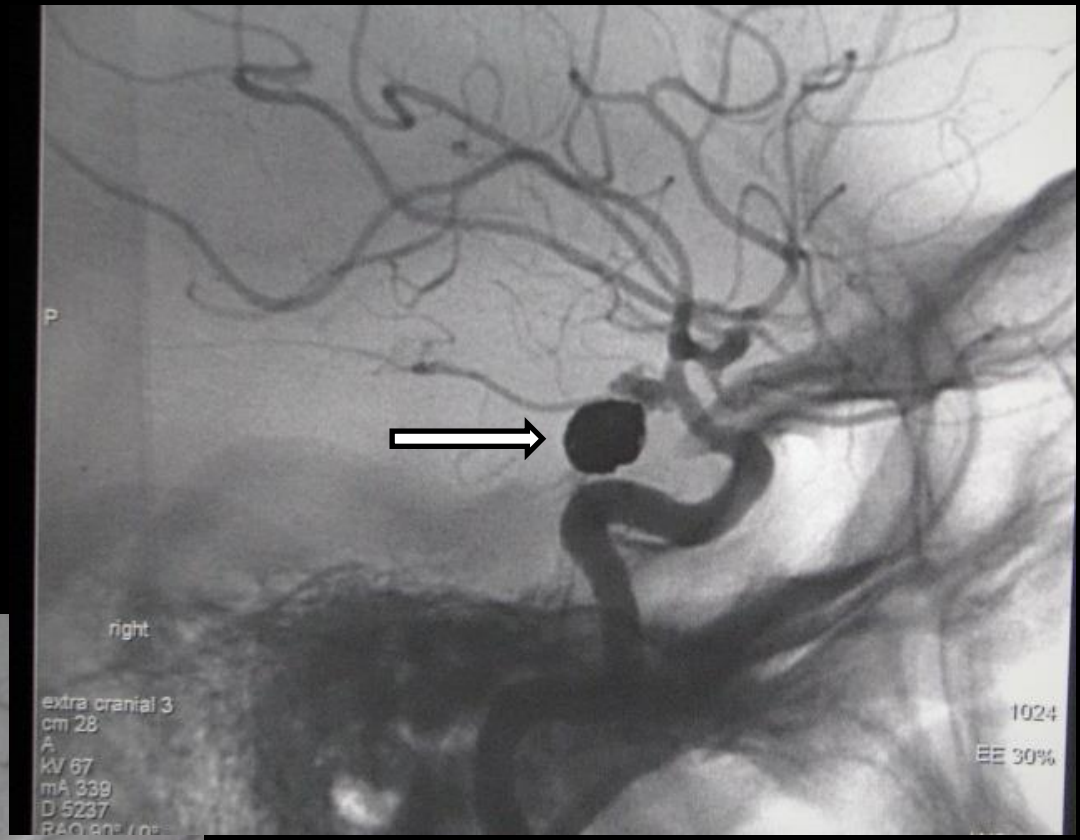
After surgery, aneurysm from blood flow detachable coils



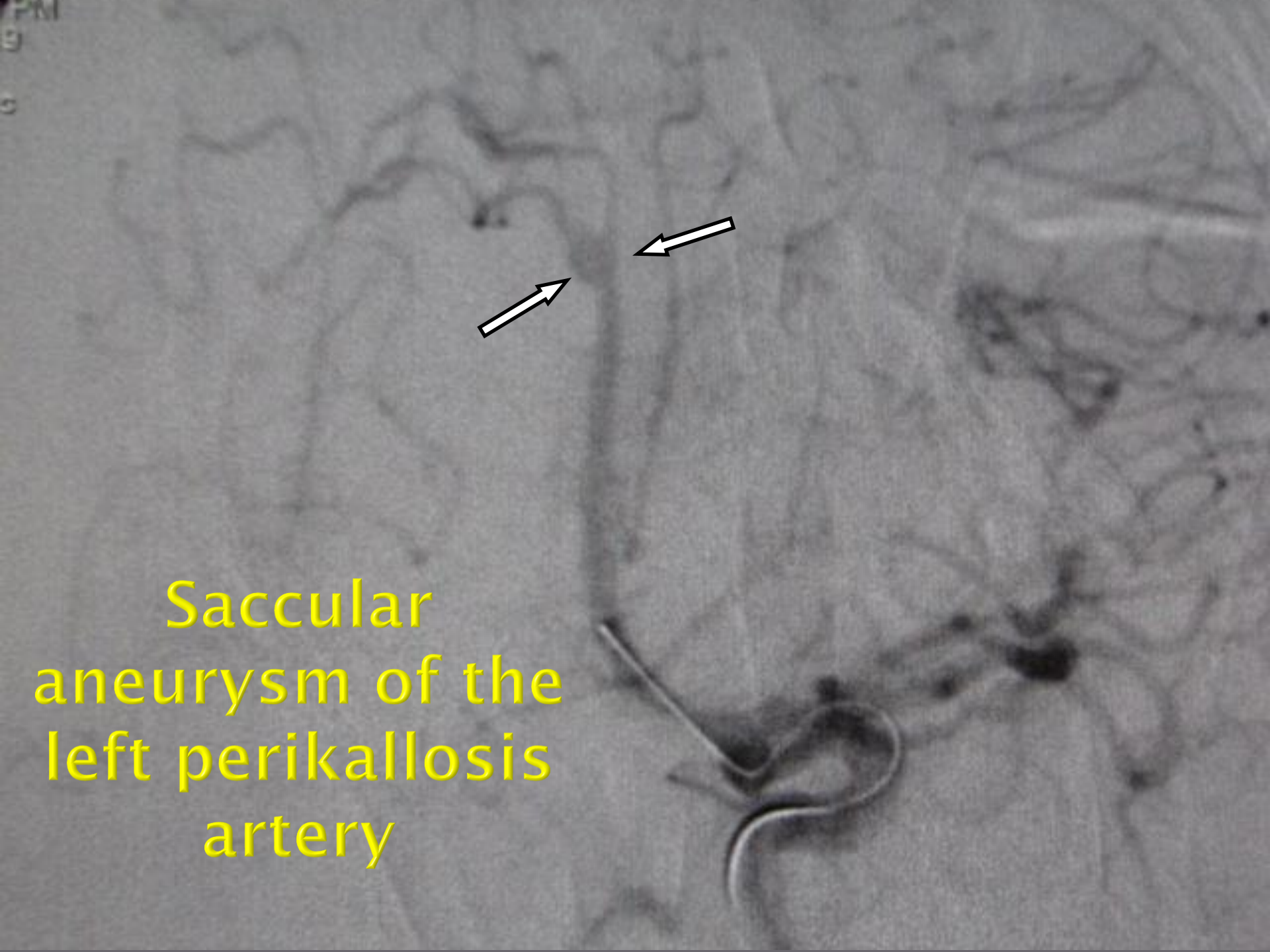


Giant saccular posterior communicating artery aneurysm

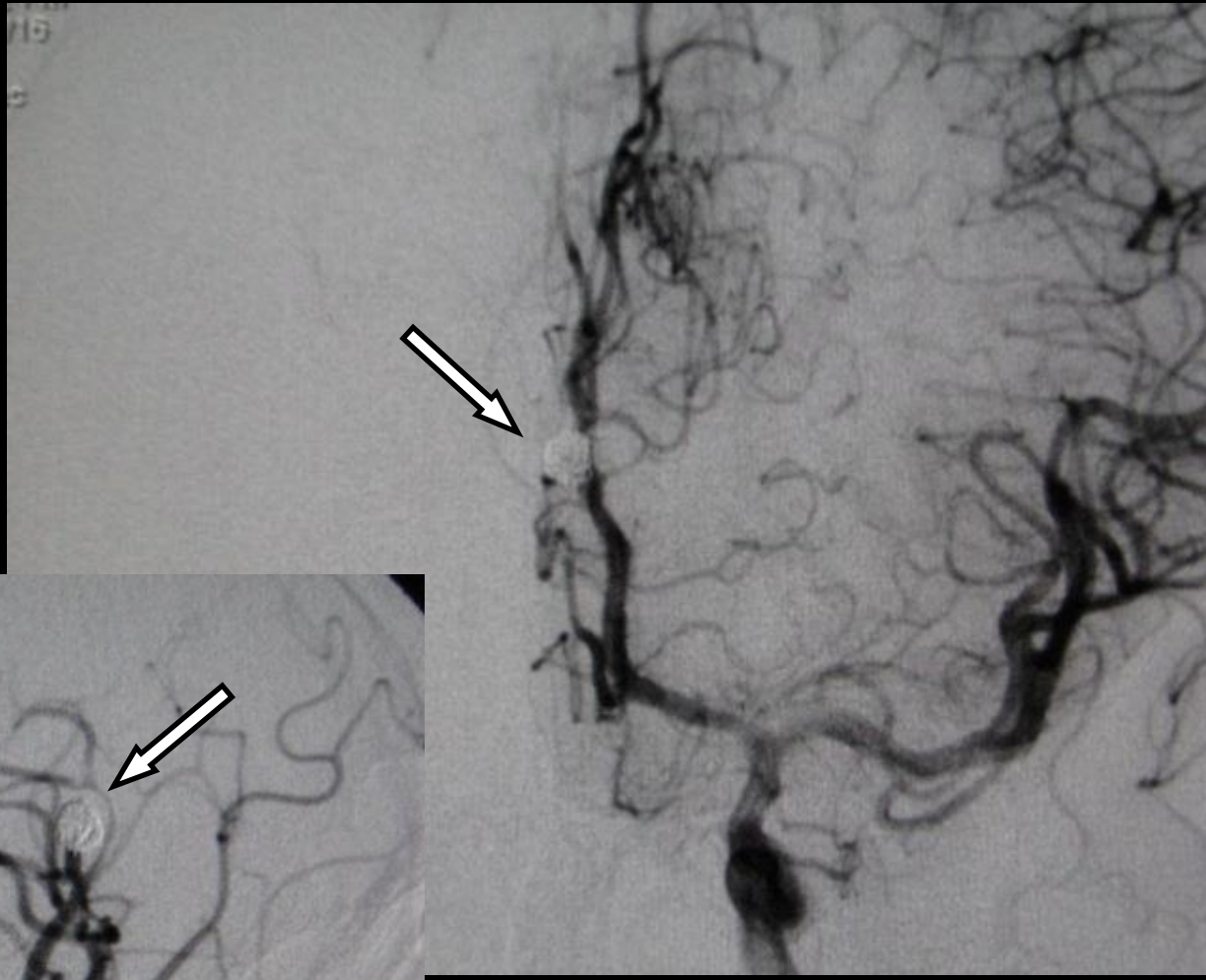
After surgery, aneurysm from blood flow detachable coils



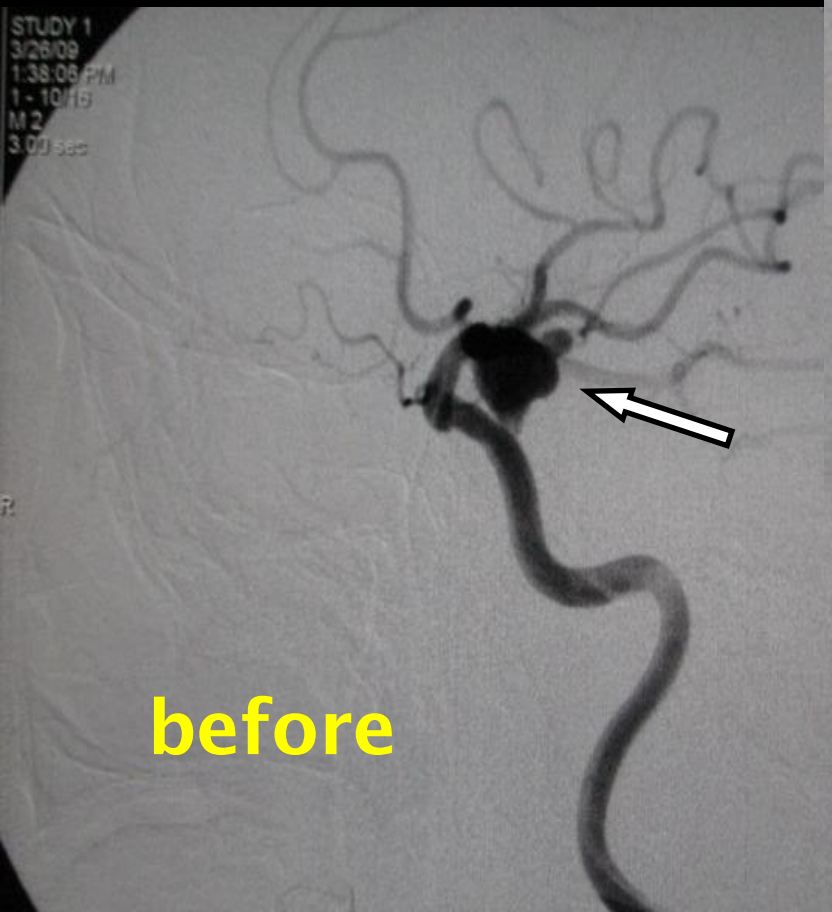

postop
before
Мешотчатая аневризма супраклиноидного отдела внутренней сонной артерии слева


Saccular
aneurysm of the
left perikallosis
artery

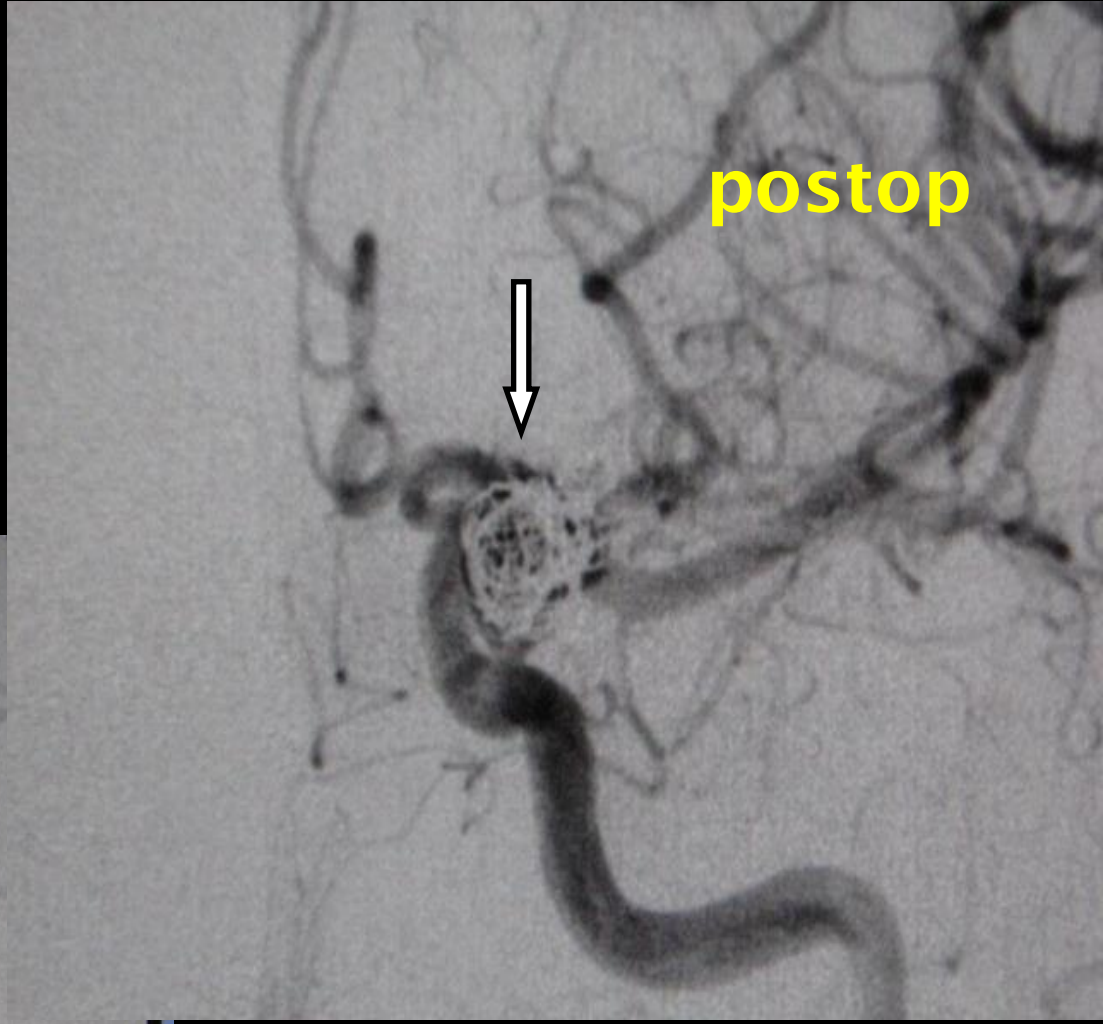
Artery embolization of the left artery perikallosis aneurysm



Saccular aneurysm of the posterior cerebral артерии слева

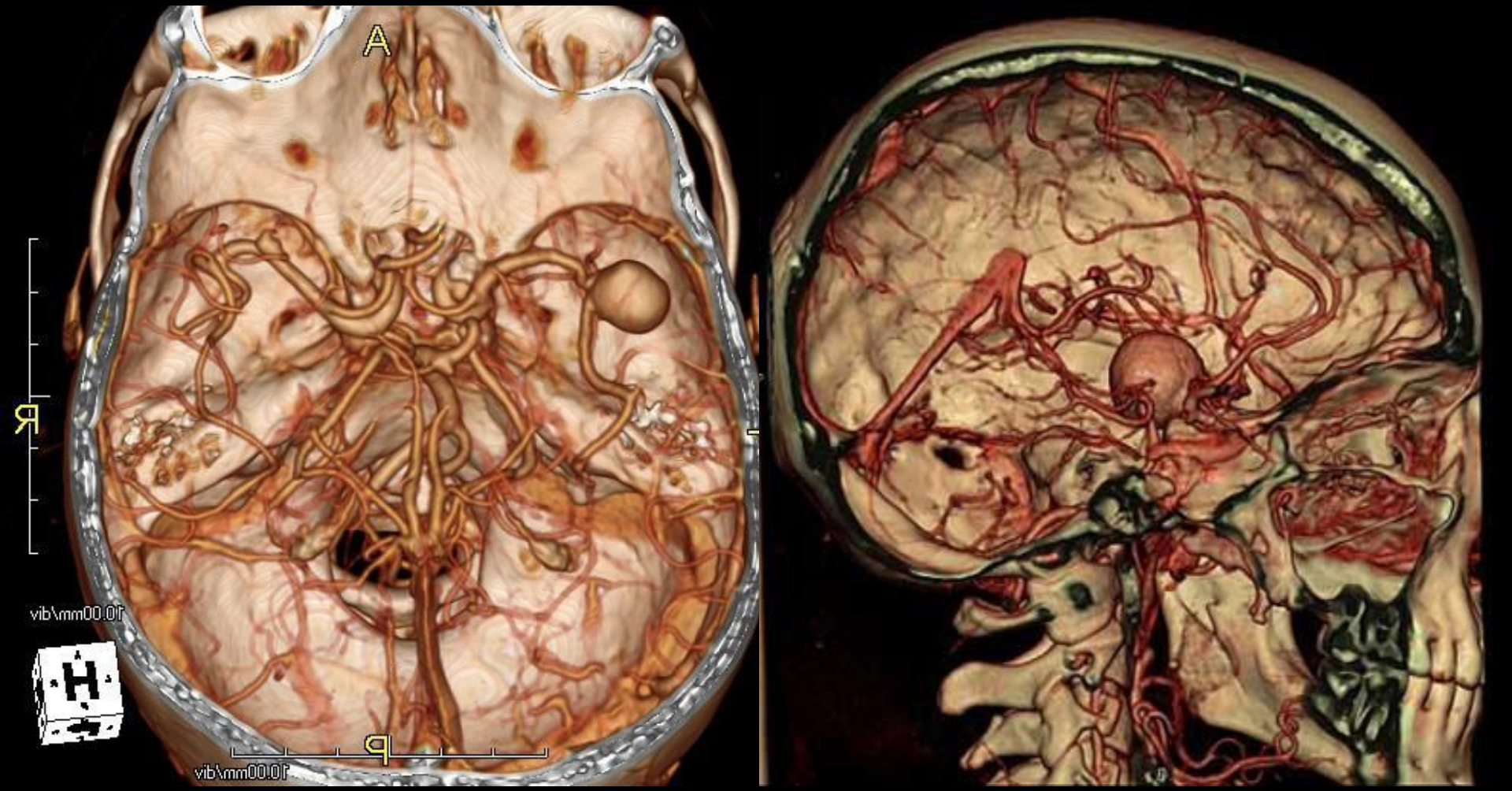


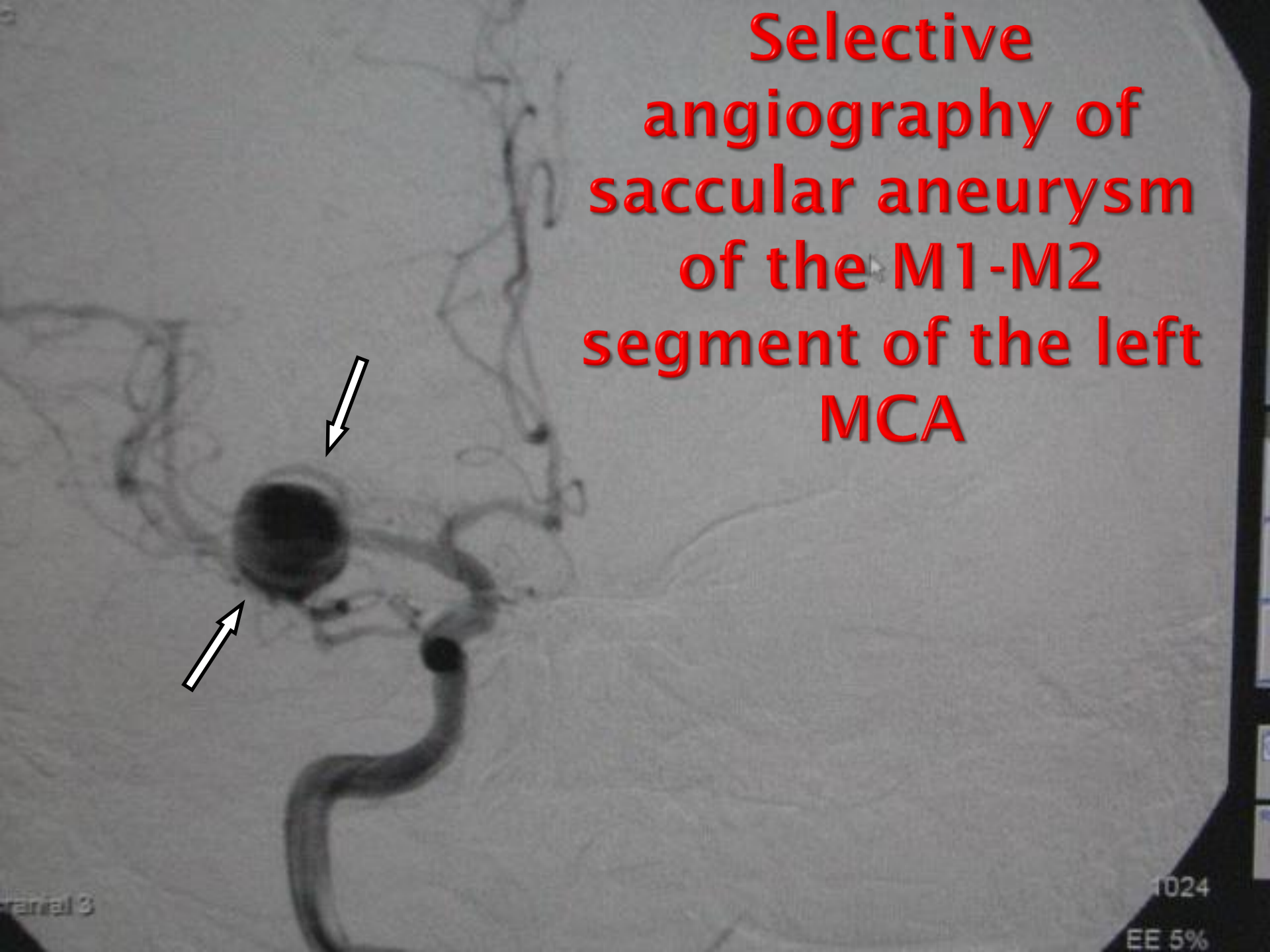
before

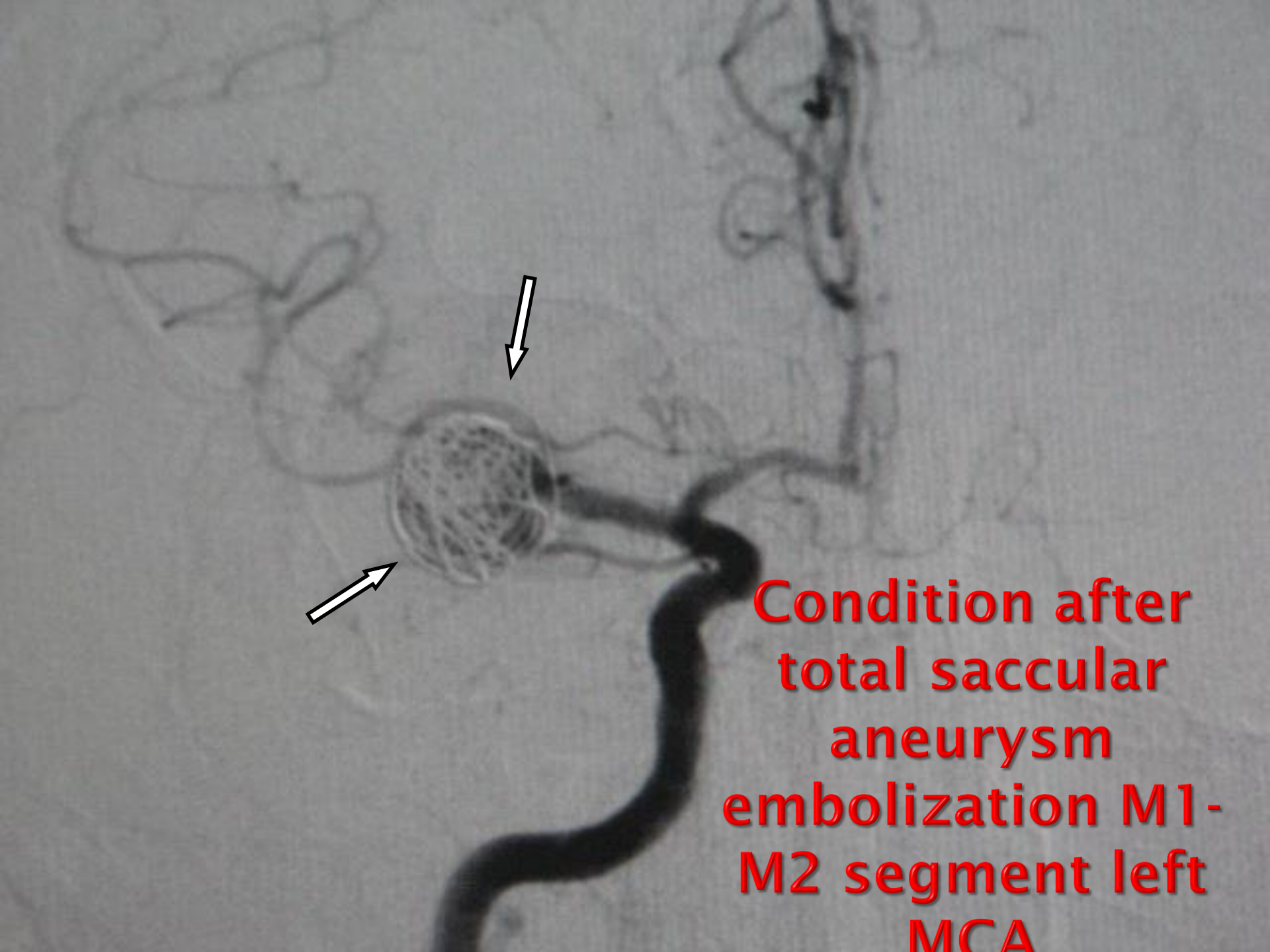


postop

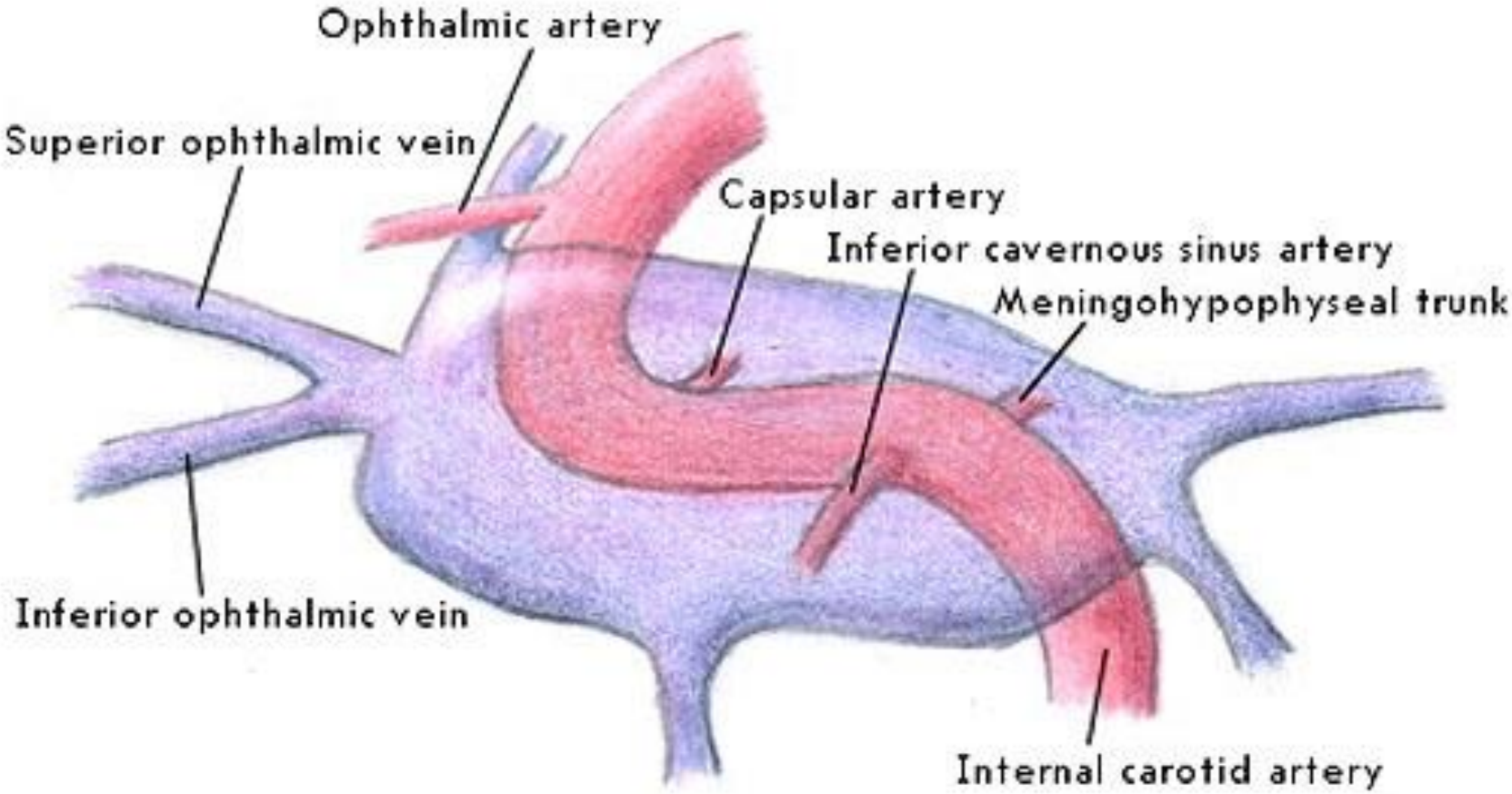
CT-angiography saccular aneurysm segment M1-M2 left MCA

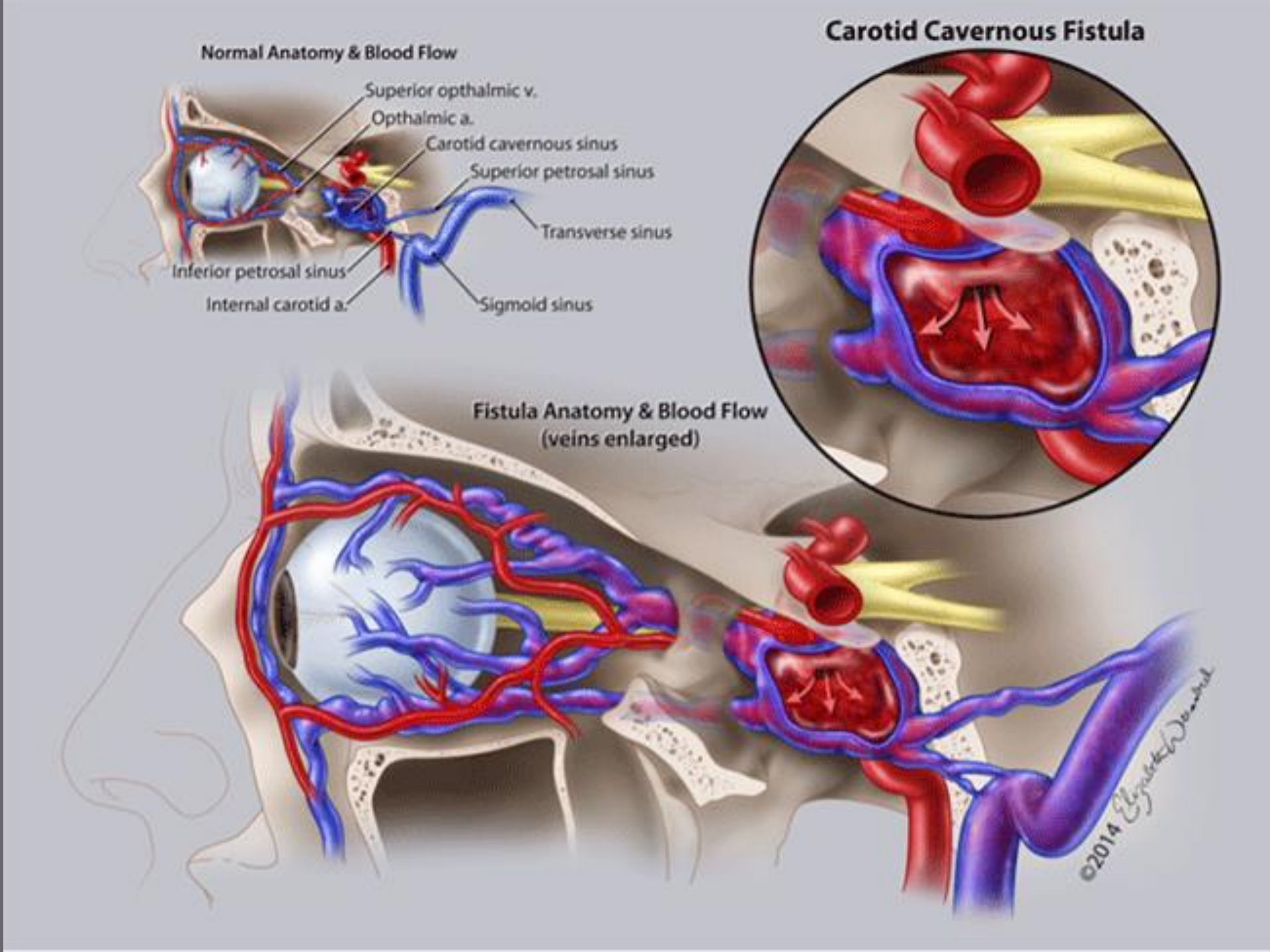


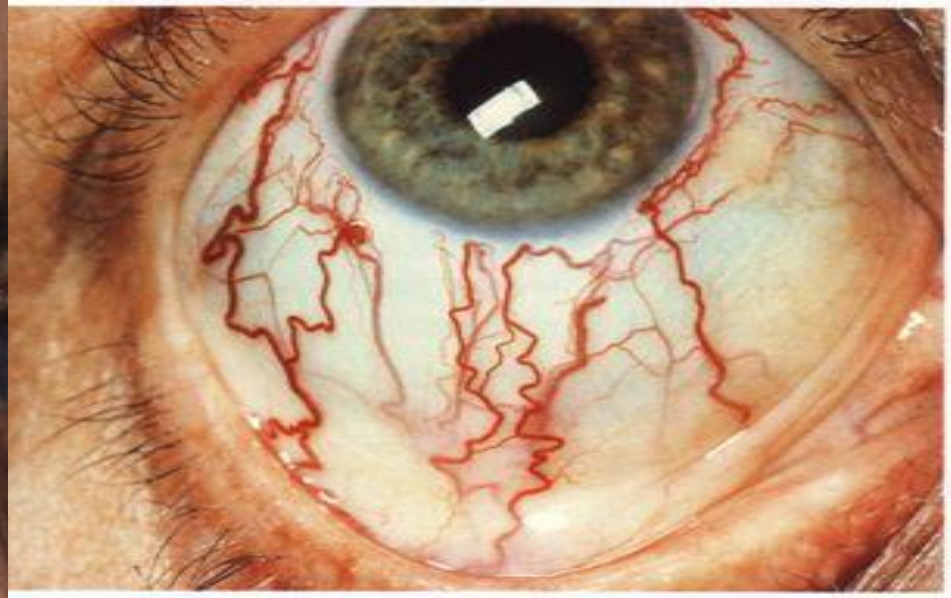

Selective angiography of saccular aneurysm of the M1-M2 segment of the left MCA


Condition after total saccular aneurysm embolization M1-M2 segment left MCA

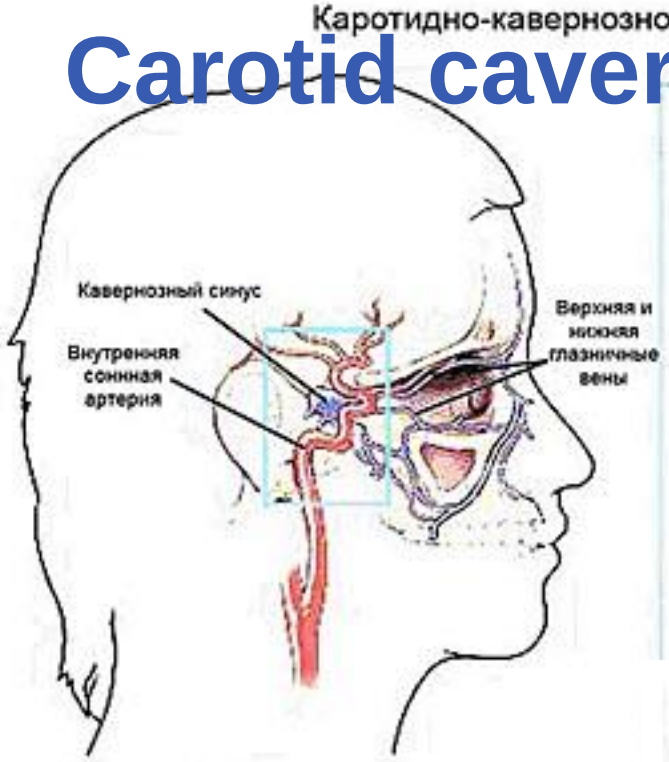
Carotid cavernous fistula

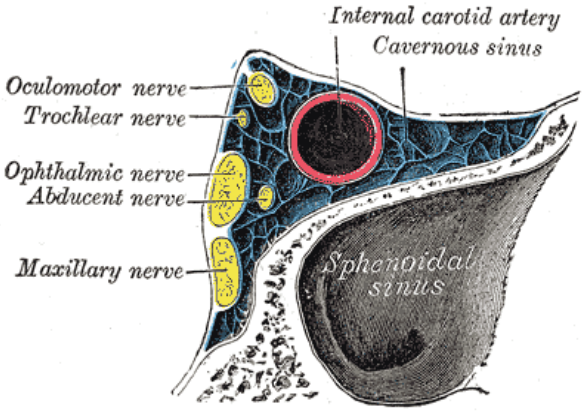


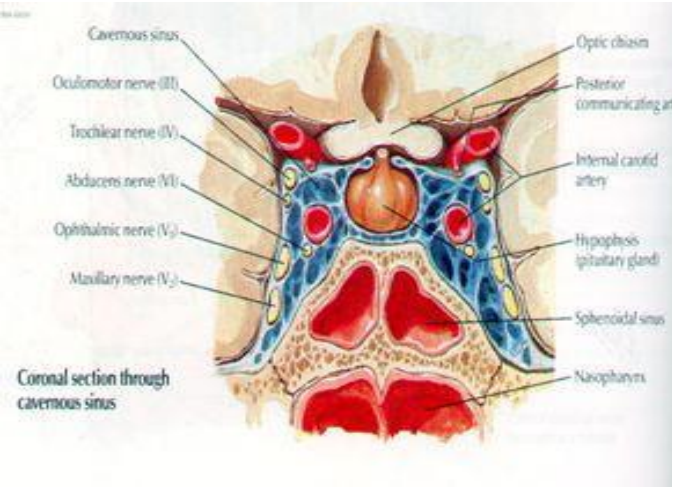

Carotid Cavernous Fistula
Normal Anatomy & Blood Flow
Superior opthalmic v.
Opthalmic a.
Carotid cavernous sinus
Superior petrosal sinus
Transverse sinus
Inferior petrosal sinus
Internal carotid a.
Sigmoid sinus
Fistula Anatomy & Blood Flow
(veins enlarged)
©2014

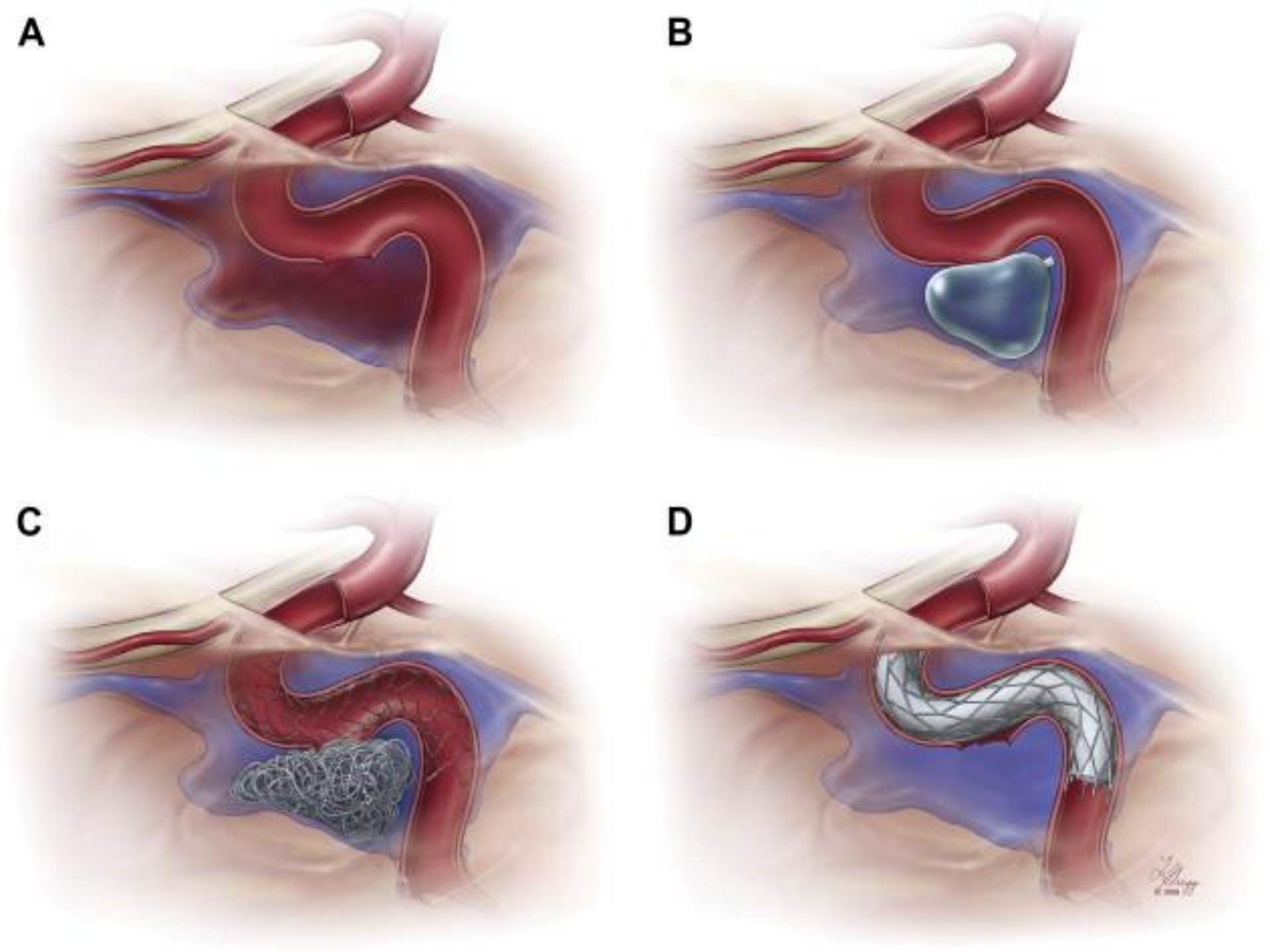


Carotid cavernous fistula treatment








A
B
C
D

Carotid cavernous fistula

preop

postop

Carotid cavernous fistula

preop

postop

ДИНАМИКА ХЕМОЗА ПОСЛЕ ОПЕРАЦИИ

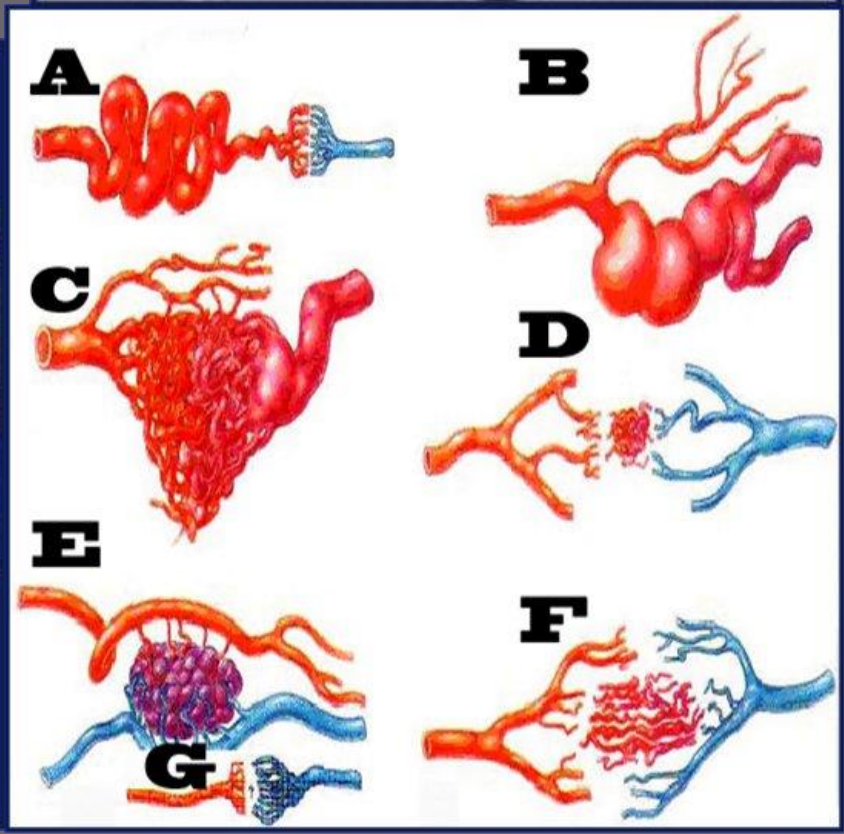
preop

5d posop

2w postop

Arteriovenous Malformations (AVM)

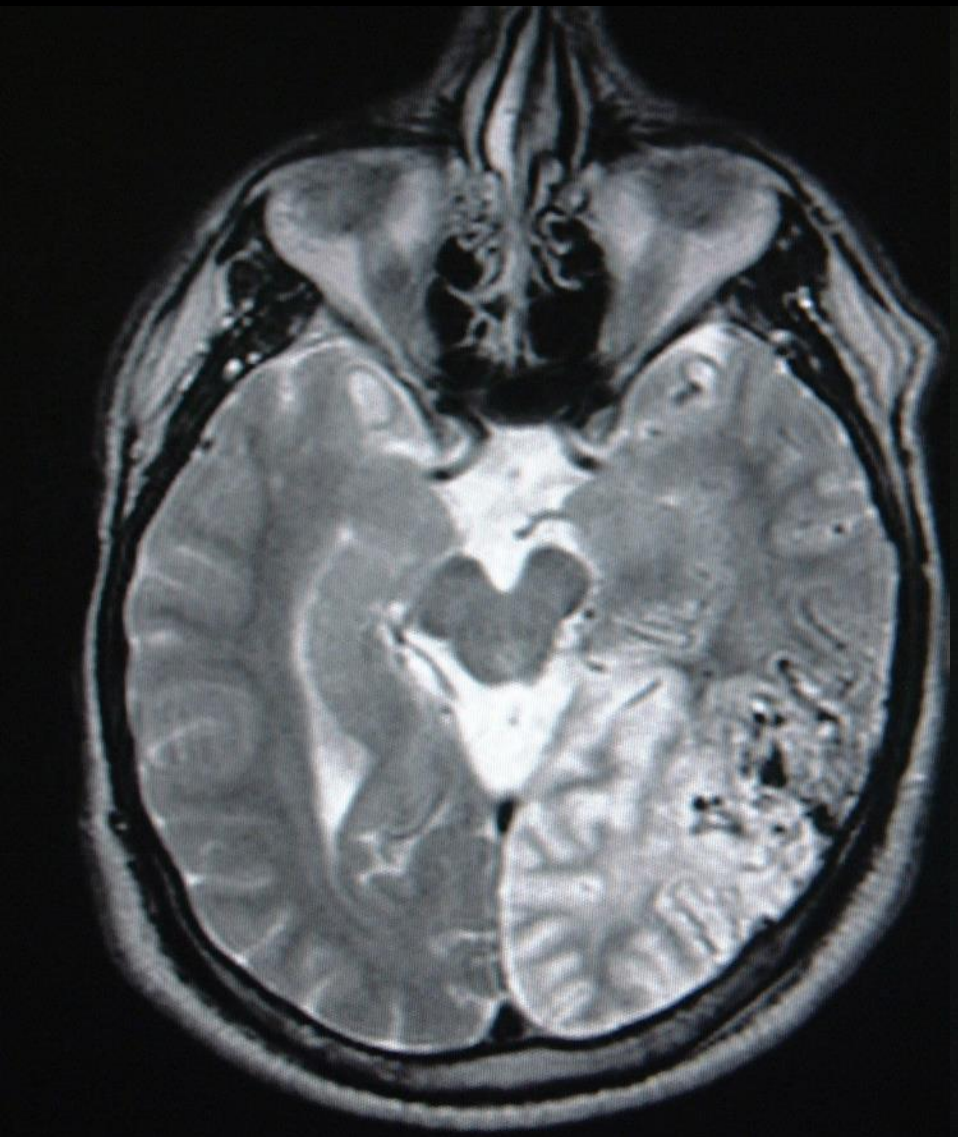
An abnormal collection of blood vessels wherein arterial blood flows directly into draining veins
without brain parenchyma in the

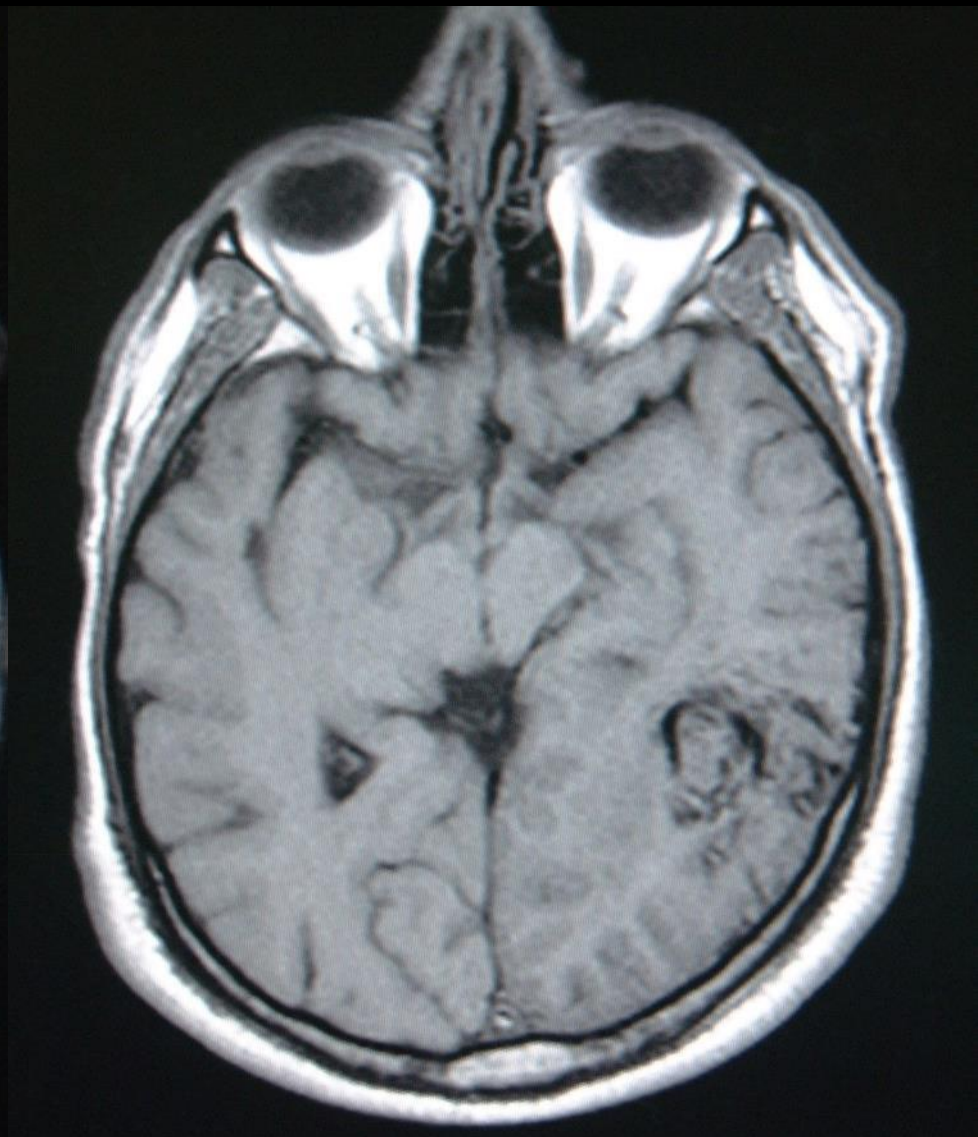


АВМ правой теменной доли

МРТ режим Т1

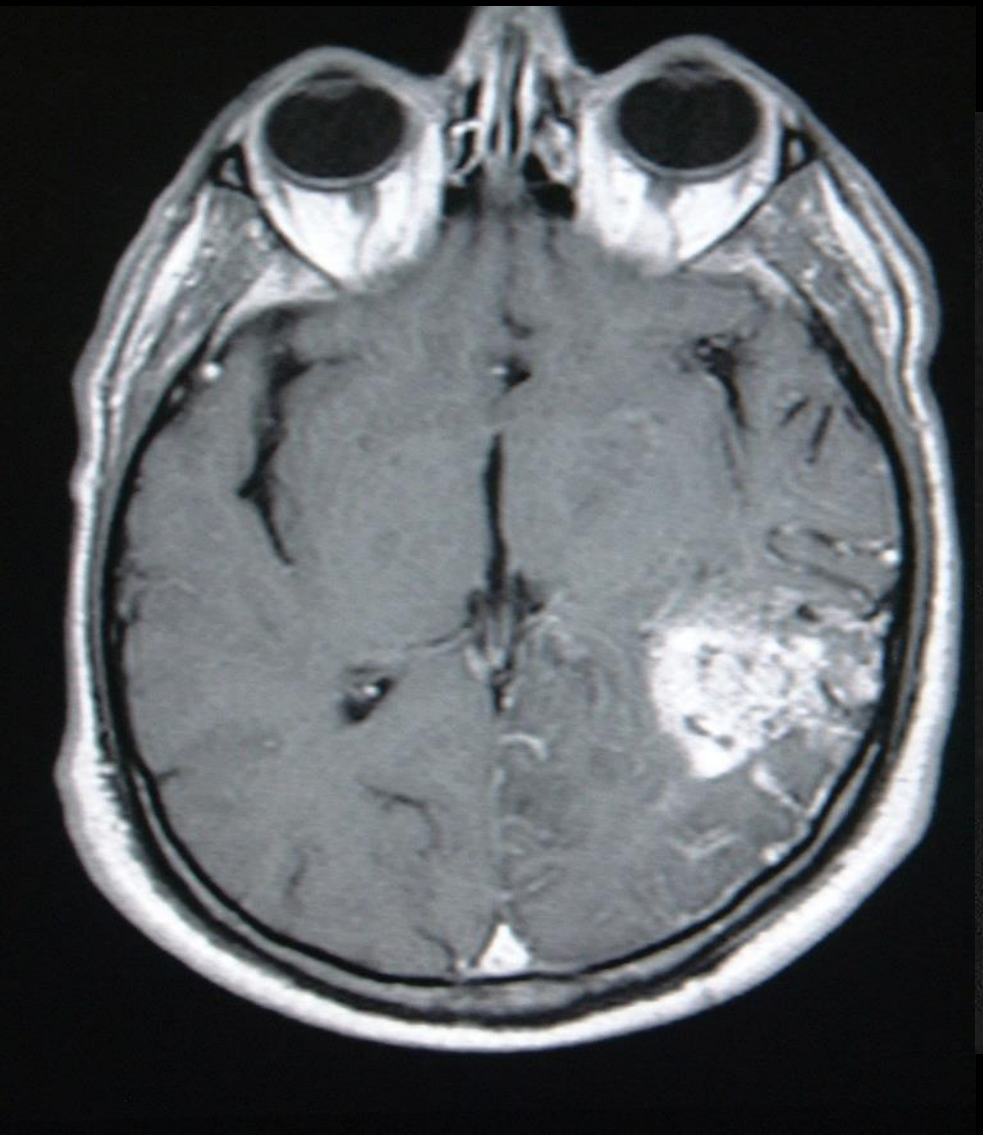
МРТ режим Т2



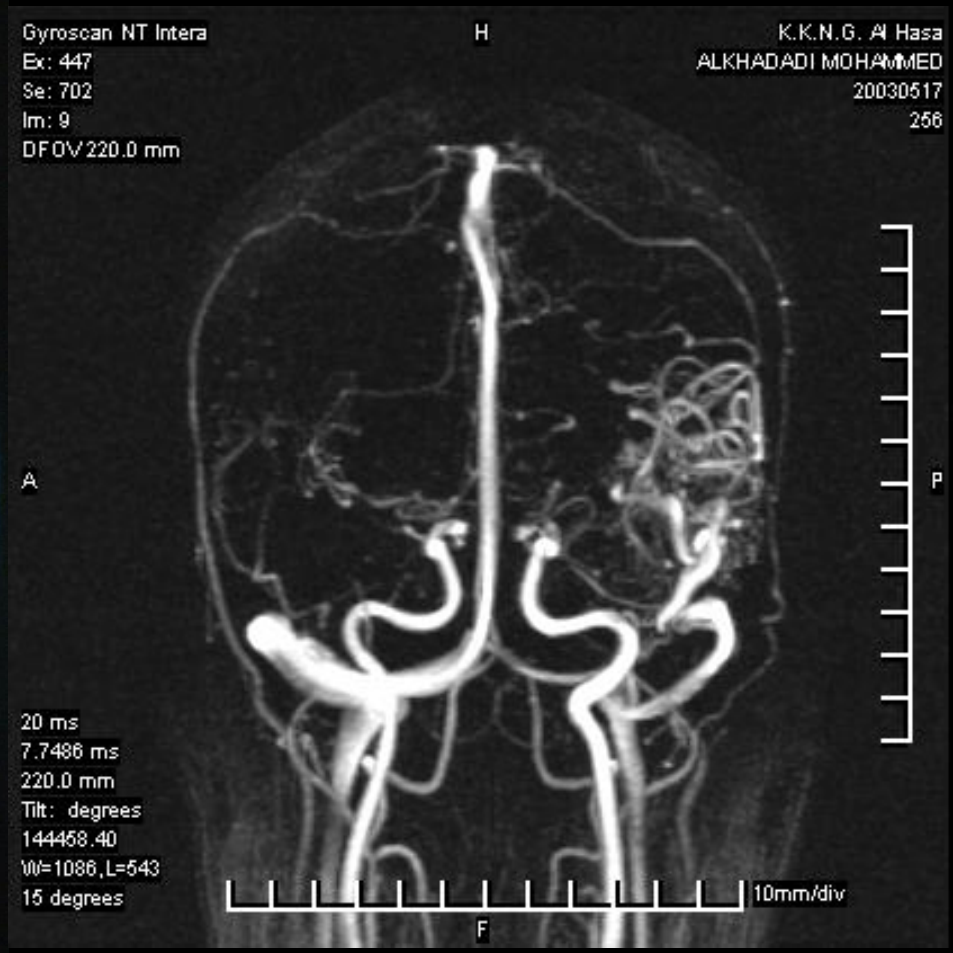


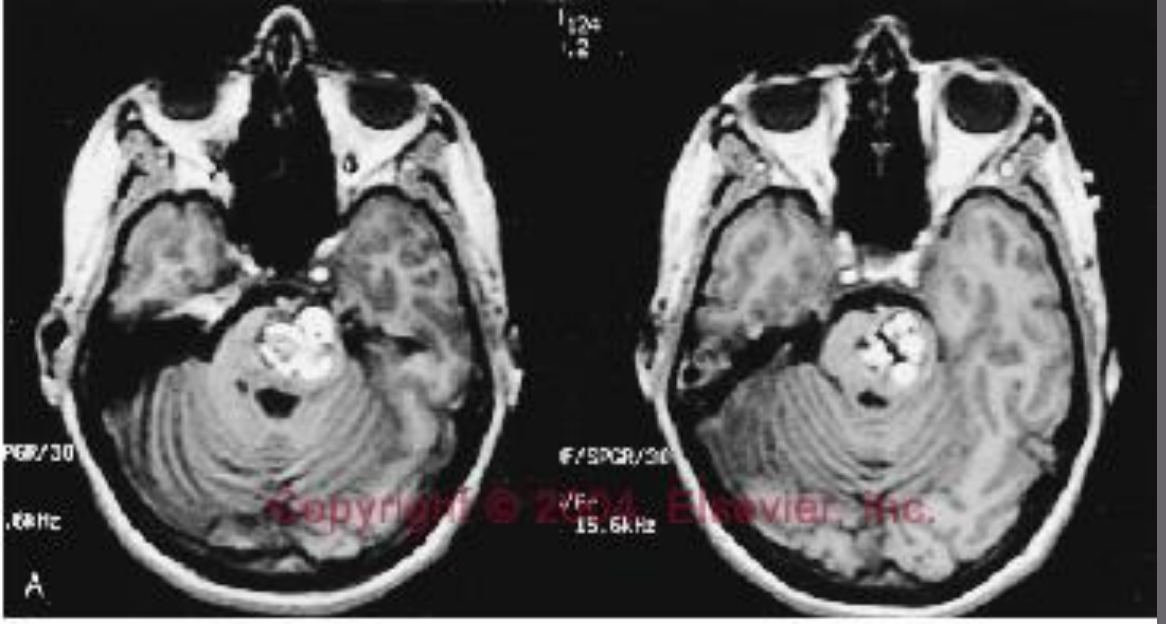
Прежнее наблюдение

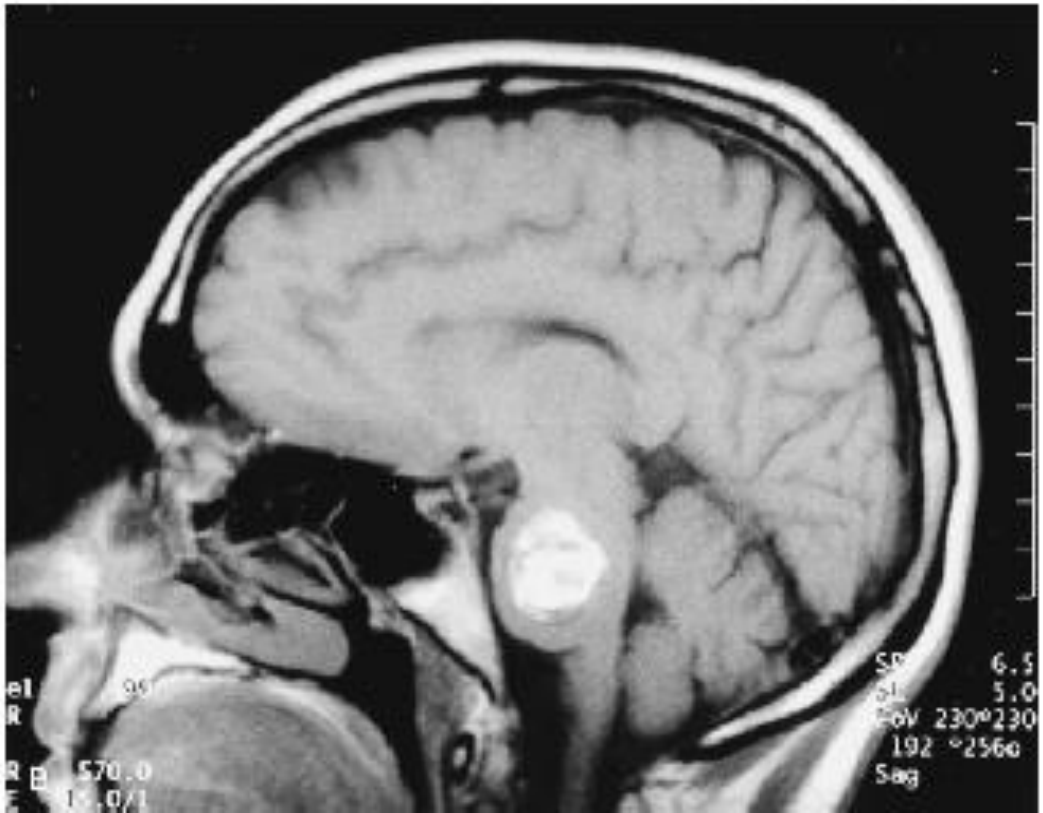
МРТ Flair



МРТ-ангиография

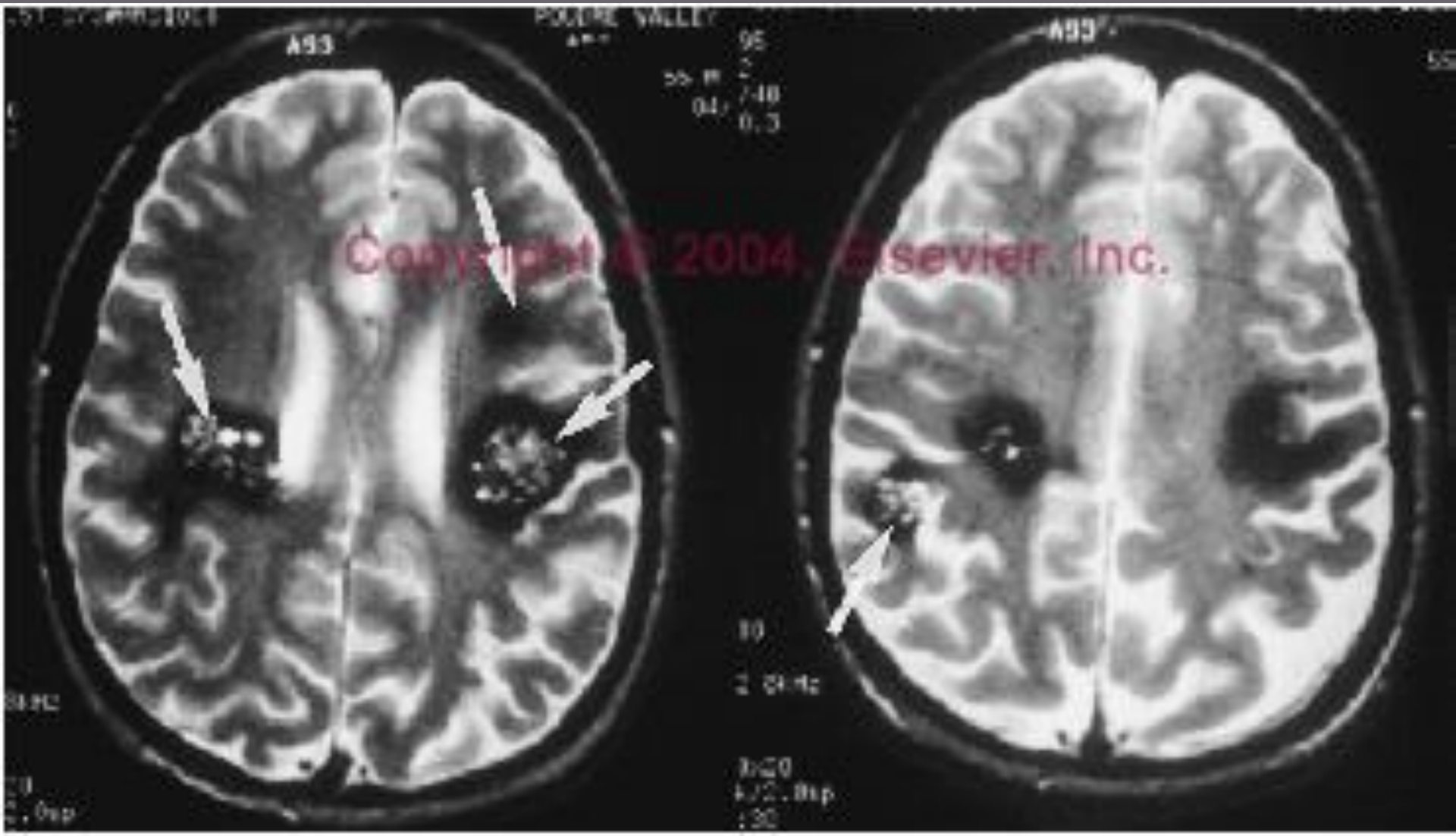






АВМ стволовых отделов

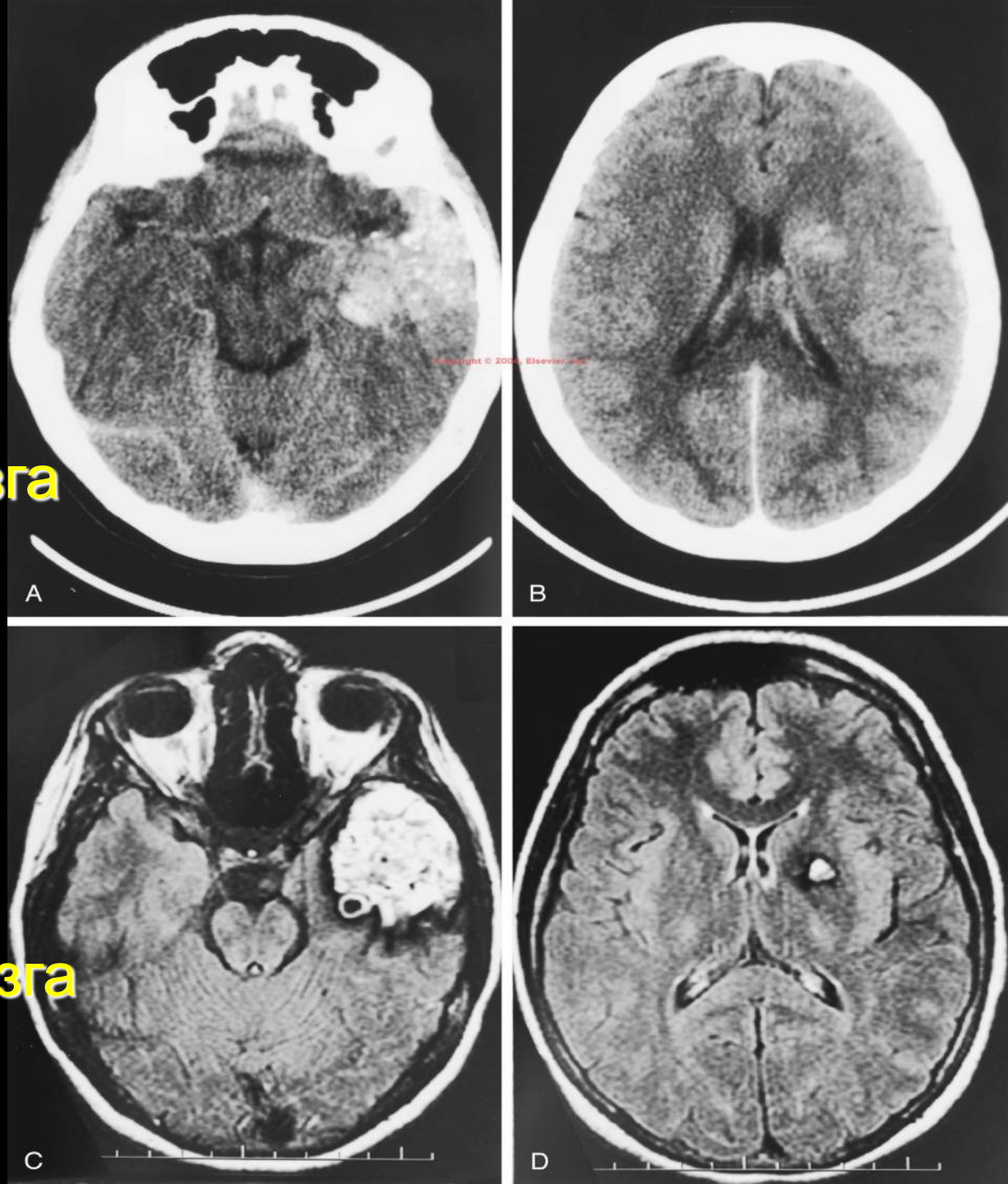
Множественные АВМ



АВМ височной области

СКТ головного мозга

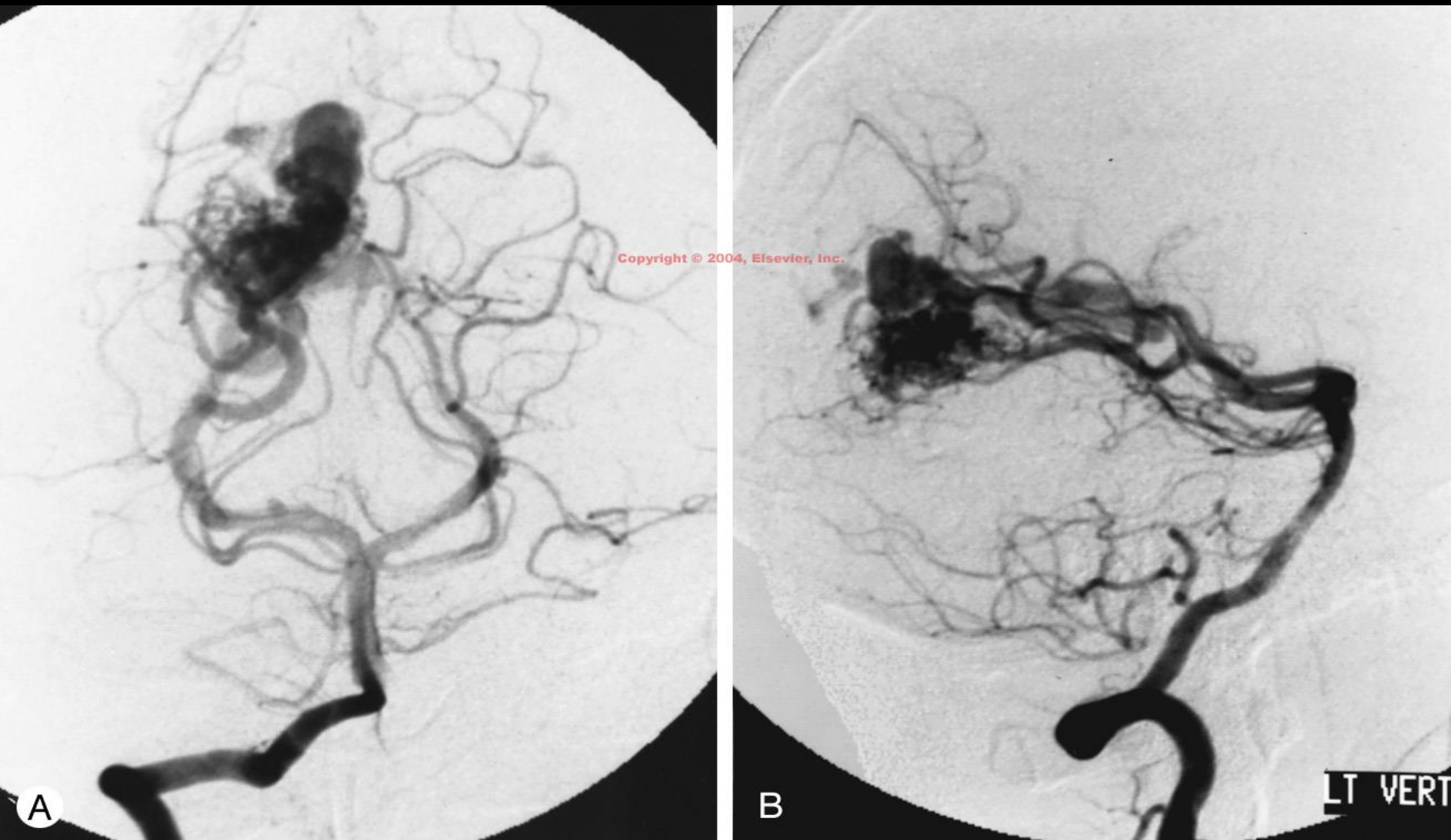
МРТ головного мозга



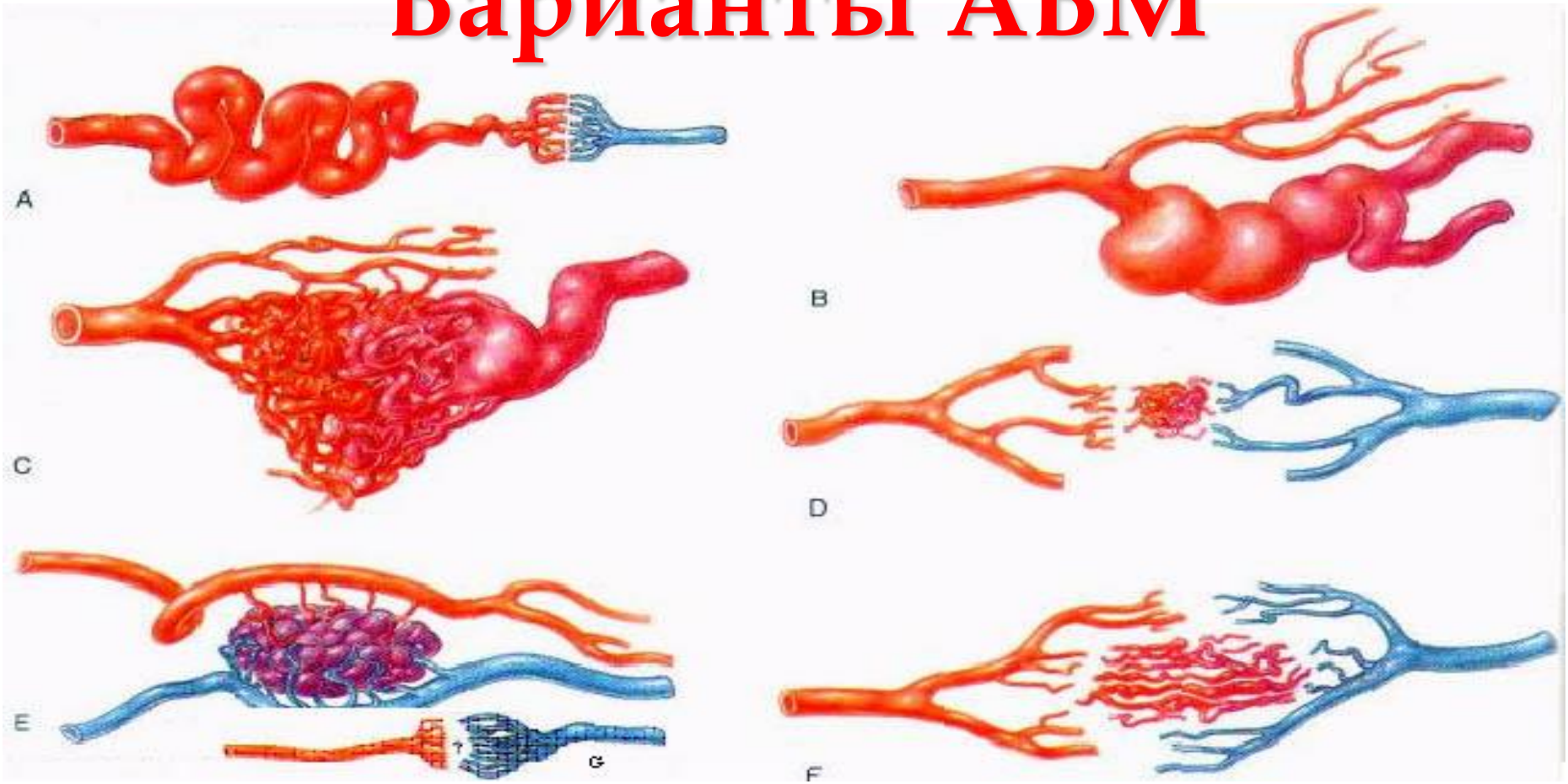
Прежнее наблюдение

КАГ прямая проекция

КАГ боковая проекция

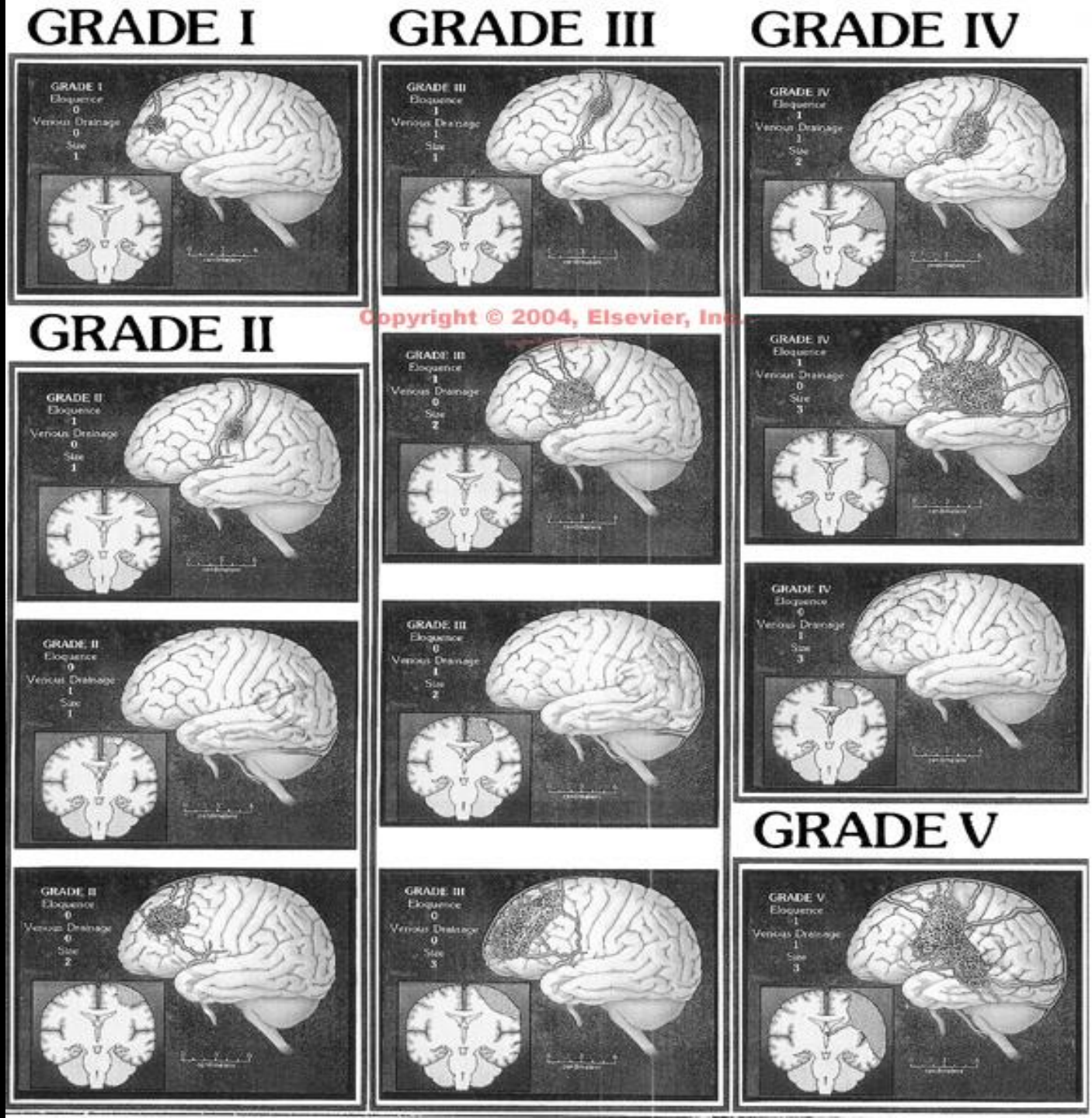


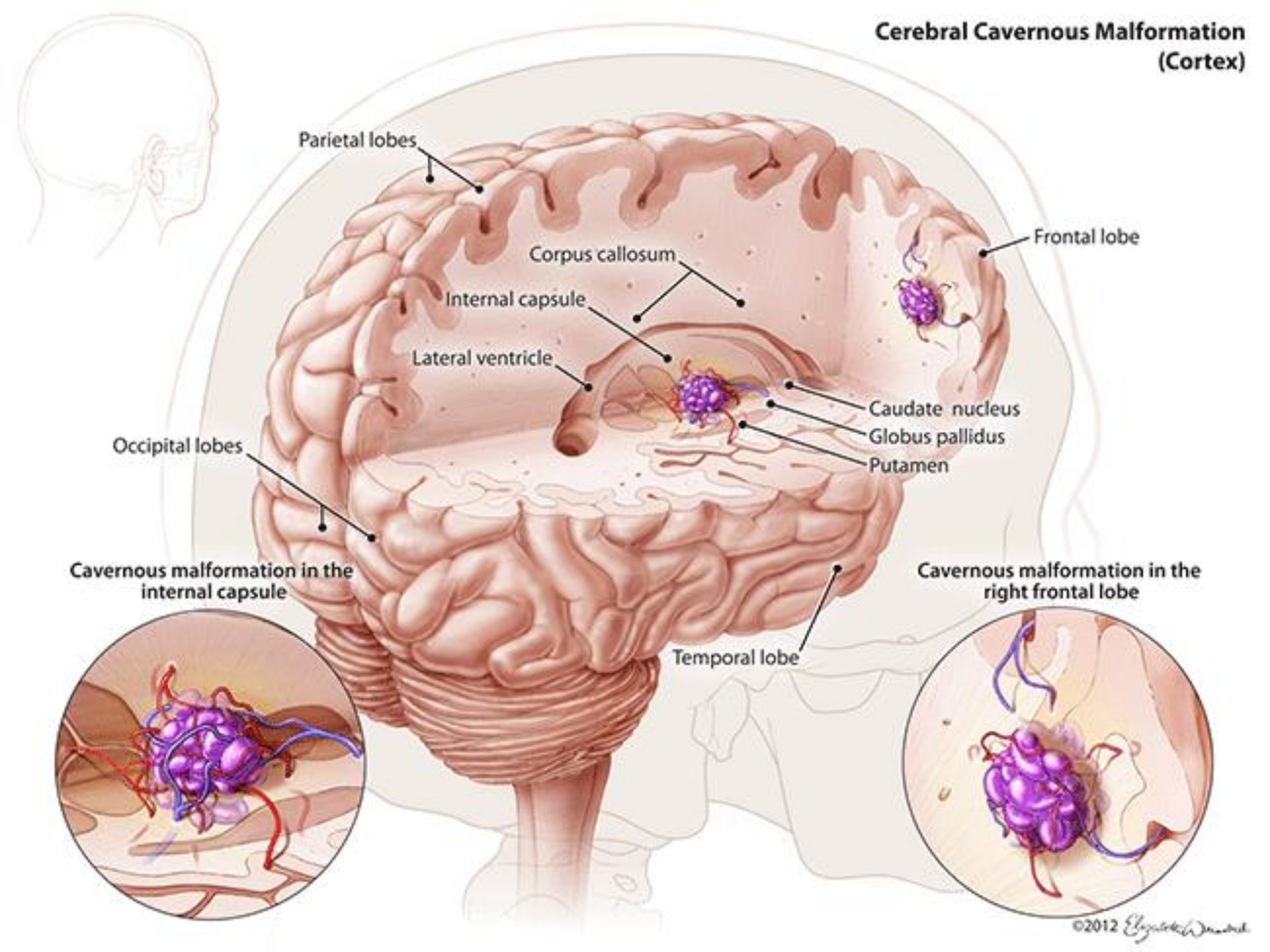
Варианты АВМ



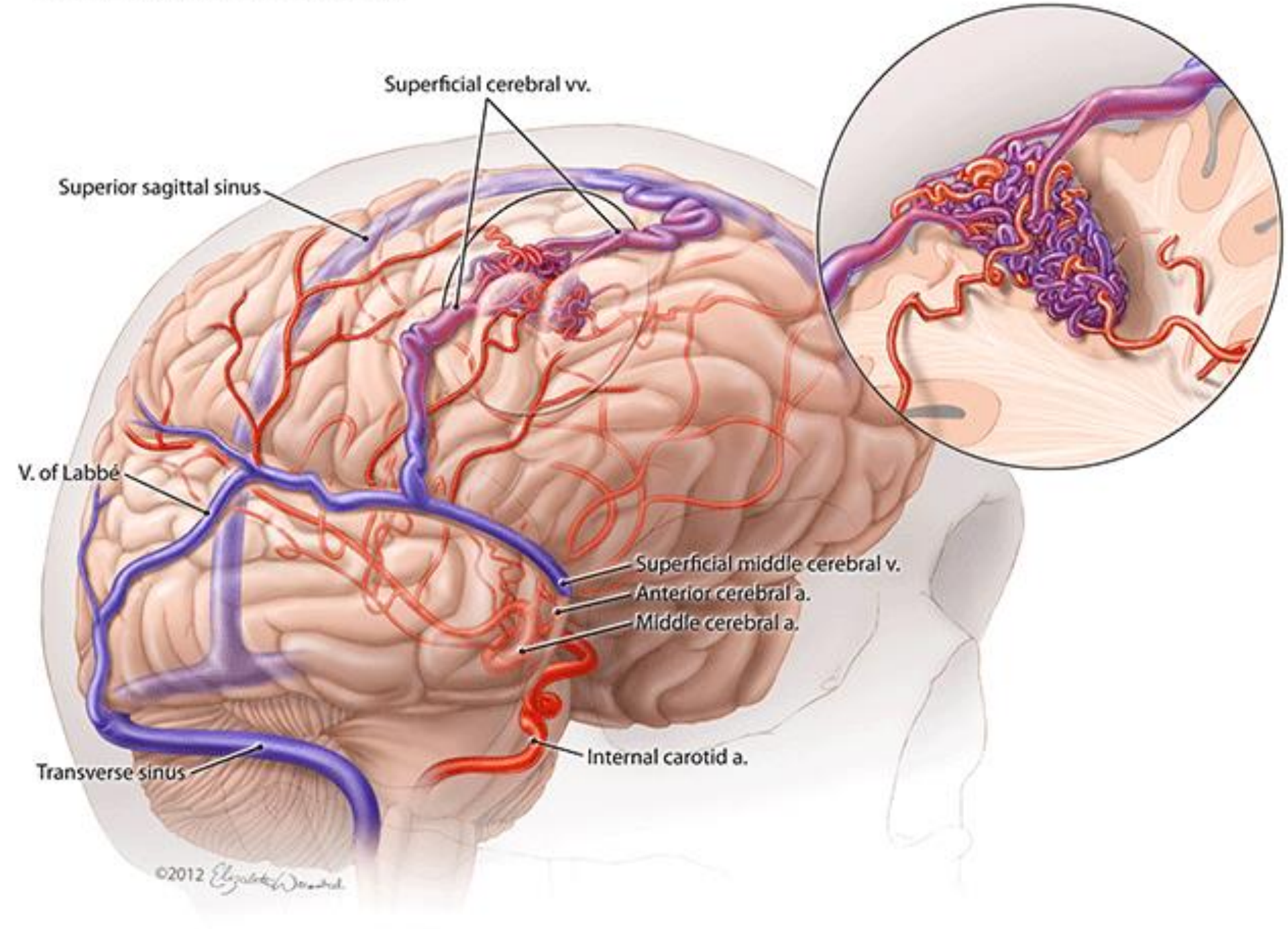
A) Артериальная
B) Артериовенозная фистулезная
C) Артериовенозная рацемозная (75%)
D) Артериовенозная микромальформация
E) Артериовенозная кавернозная (11%)
F) Телеангиоэктазия
G) Венозная

Spetzler-Martin (1986)




Cerebral Cavernous Malformation
(Cortex)
Parietal lobes
Frontal lobe
Corpus callosum
Internal capsule
Lateral ventricle
Caudate nucleus
Globus pallidus
Putamen
Occipital lobes
Temporal lobe
Cavernous malformation in the internal capsule
Cavernous malformation in the right frontal lobe
©2012

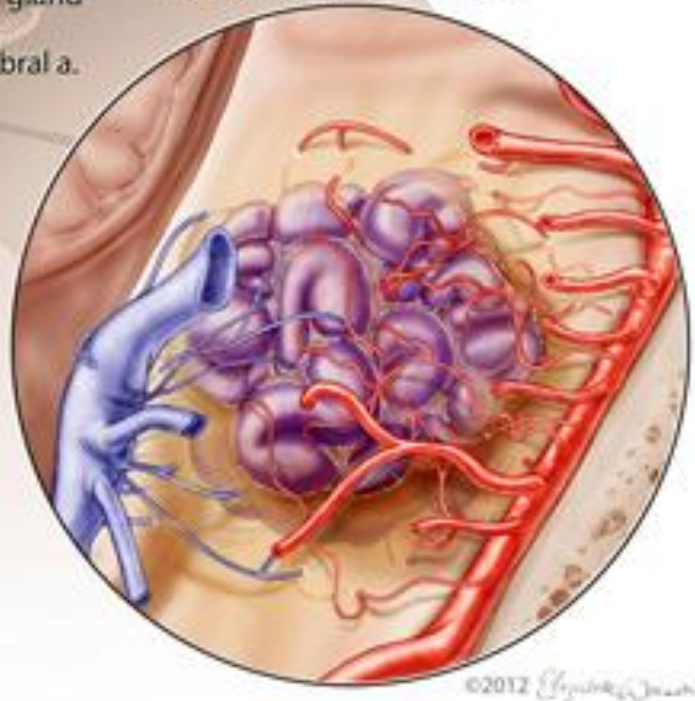
Arteriovenous Malformation

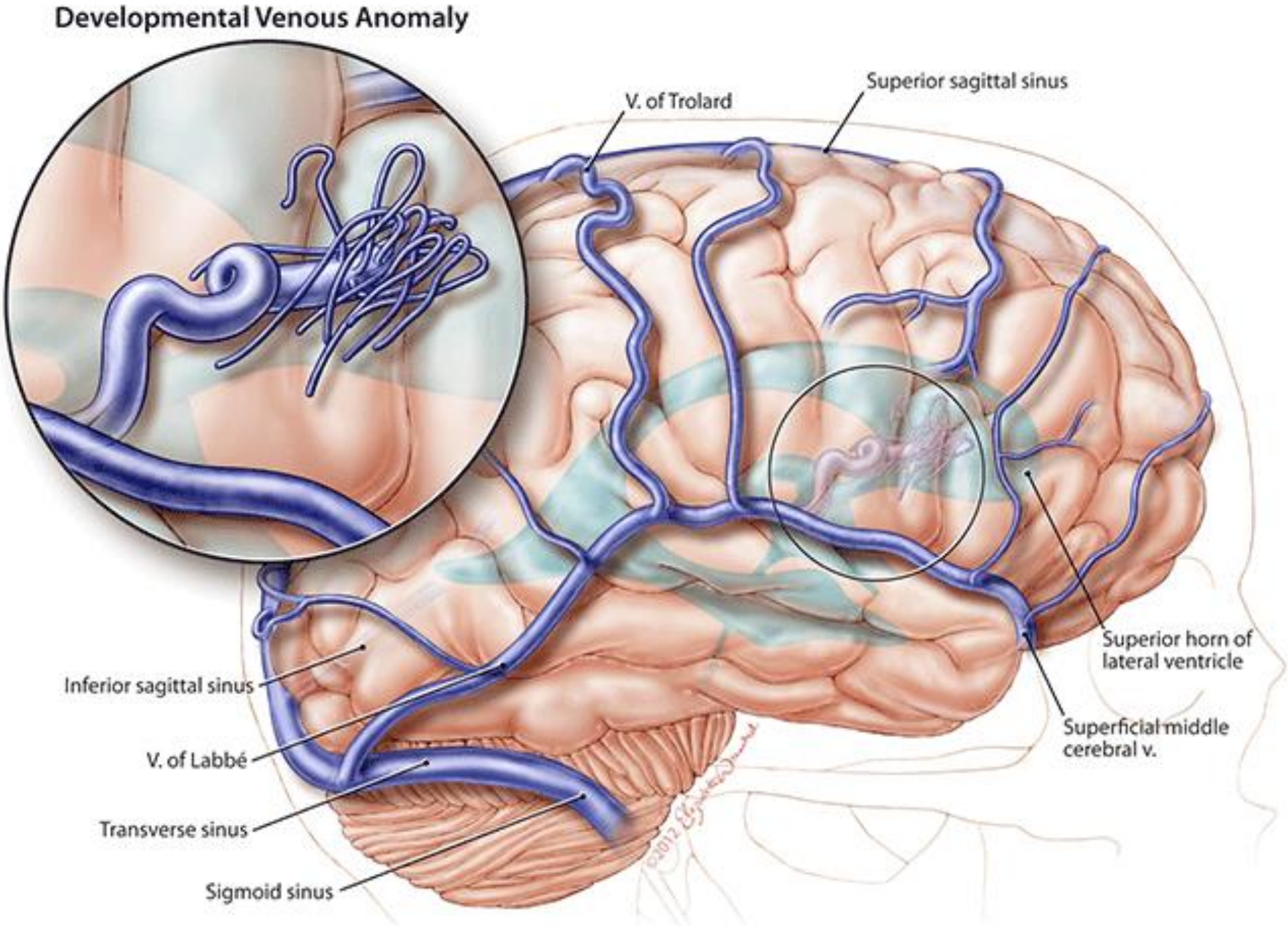


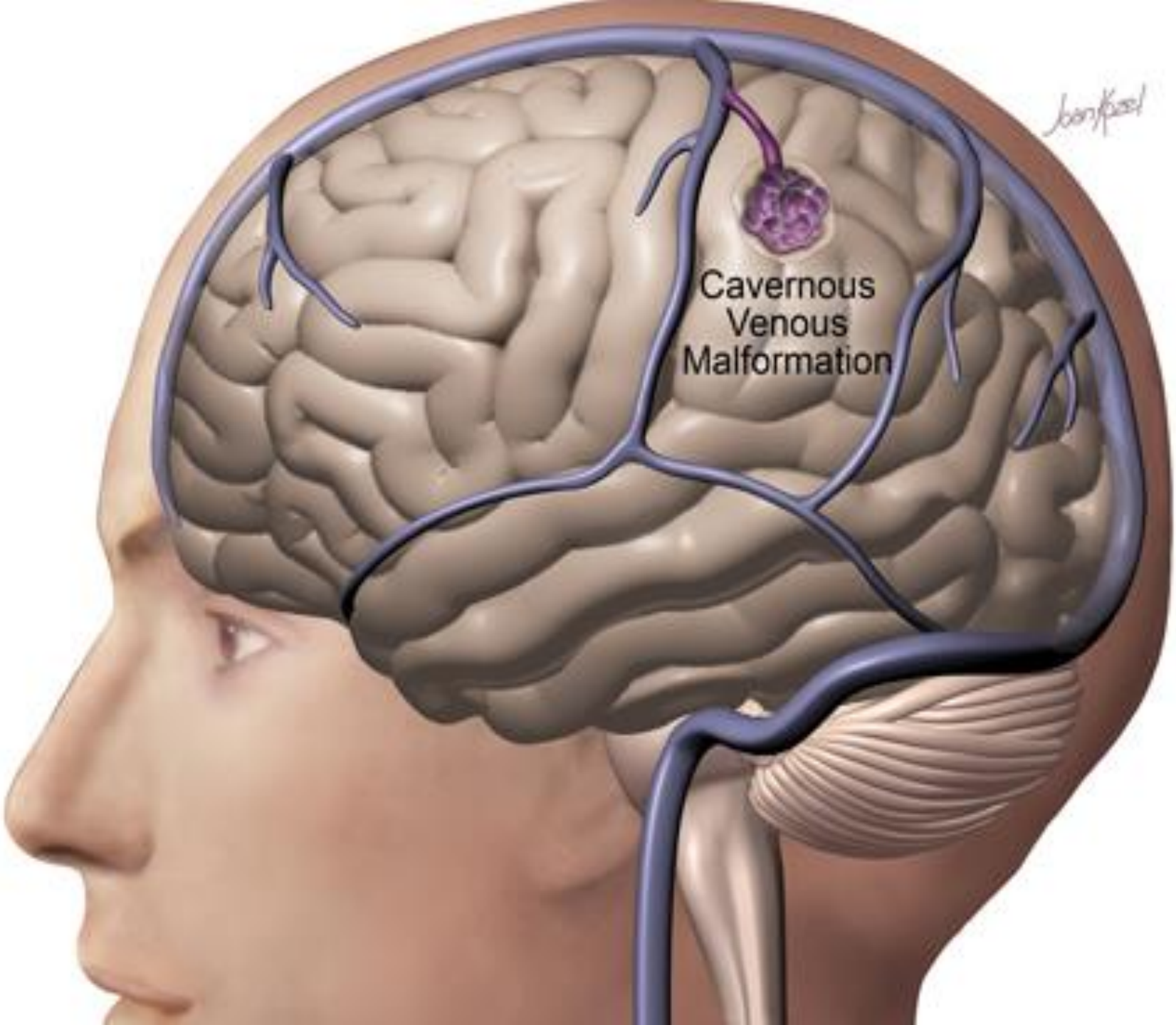
Cerebral Cavernous Malformation (Brainstem)

Fornix
Thalmus
Pineal gland
Cerebellum
Pons
Caudal cerebellar peduncular v.
Medulla oblongata
Posteromedian medullary v.
Corpus callosum
Anterior commisure
Optic chiasm
Pituitary gland
Posterior cerebral a.
Superior cerebellar a.
Basilar a.
Vertebral a.

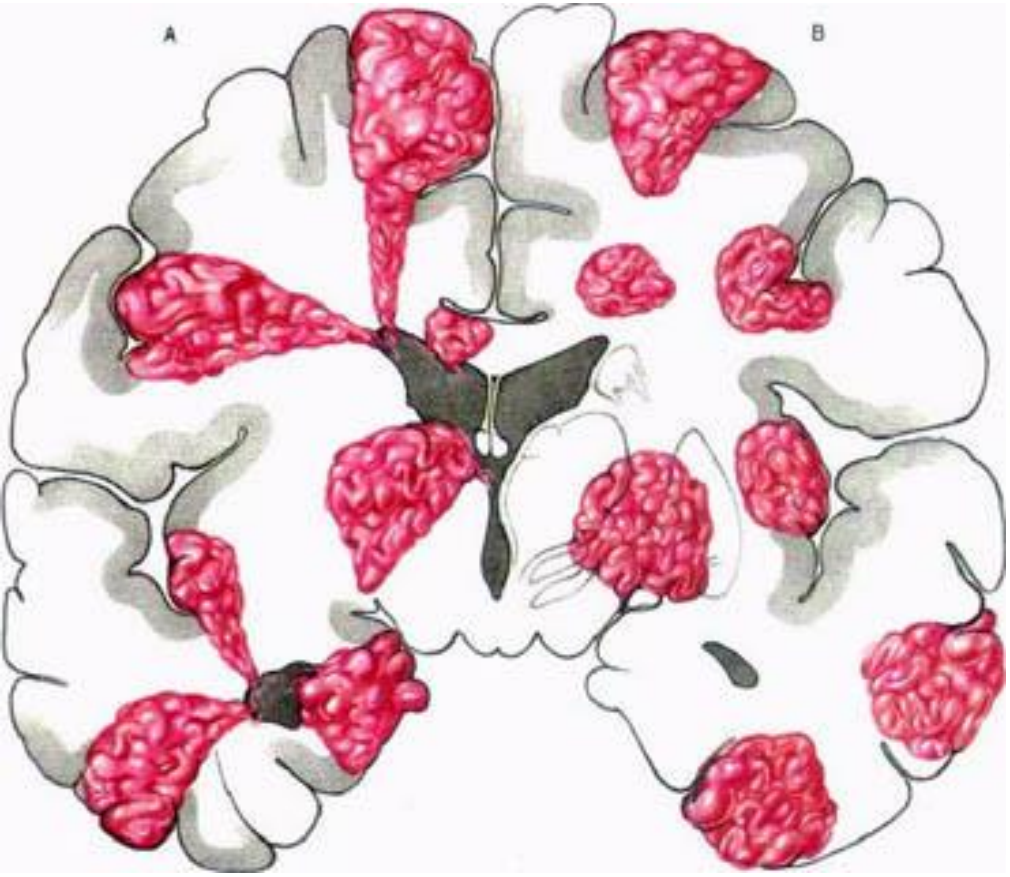
Cavernous malformation in the pontomedullary juncation

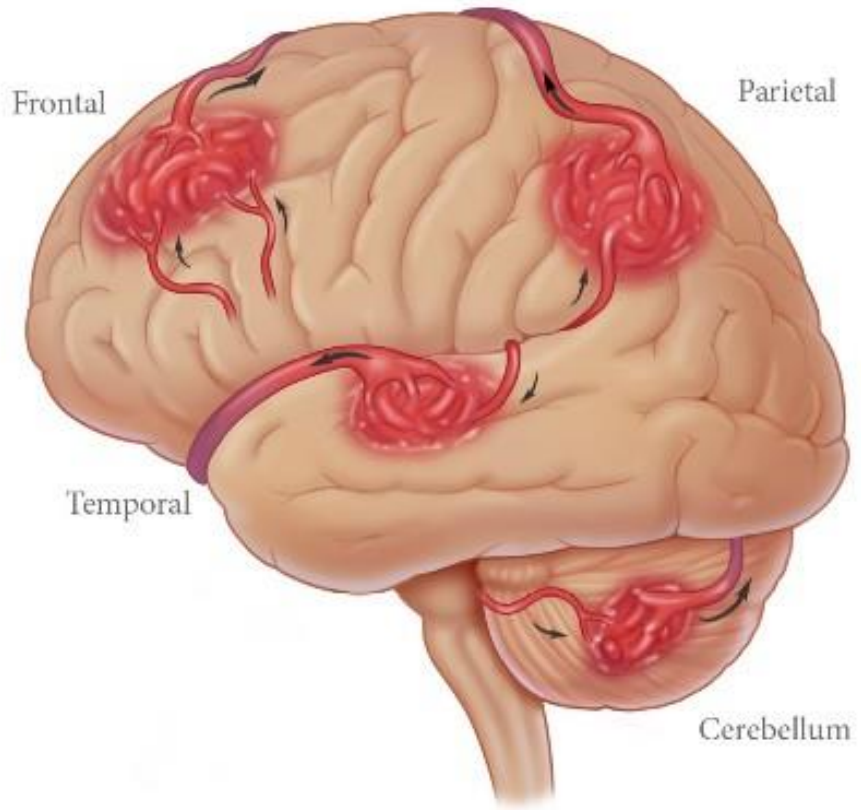


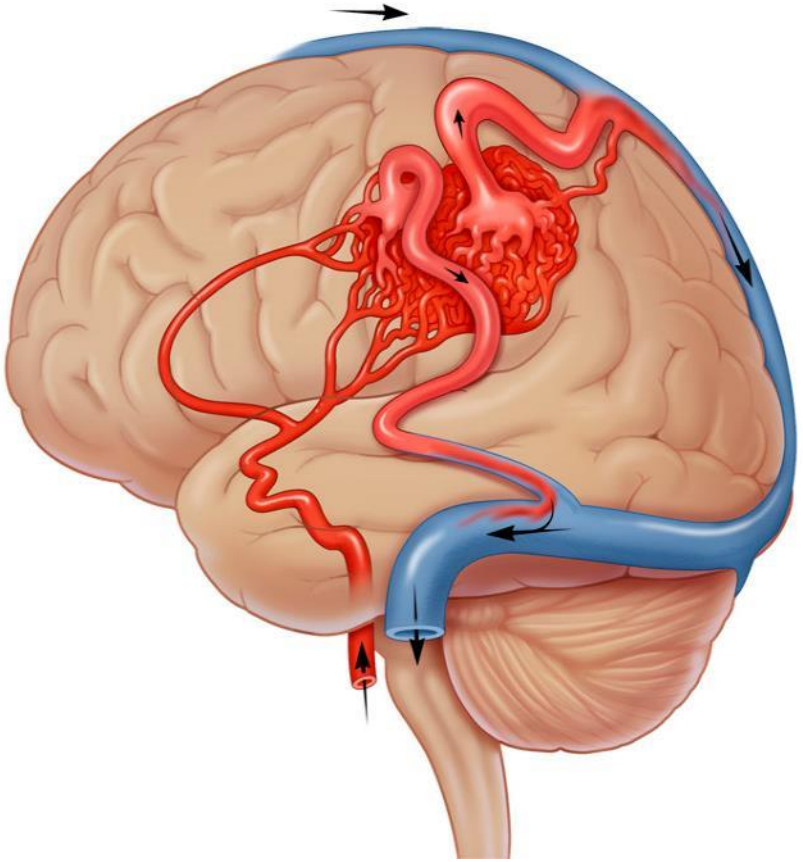

Developmental Venous Anomaly
V. of Trolard
Superior sagittal sinus
Superior horn of lateral ventricle
Superficial middle cerebral v.
Inferior sagittal sinus
V. of Labbé
Transverse sinus
Sigmoid sinus

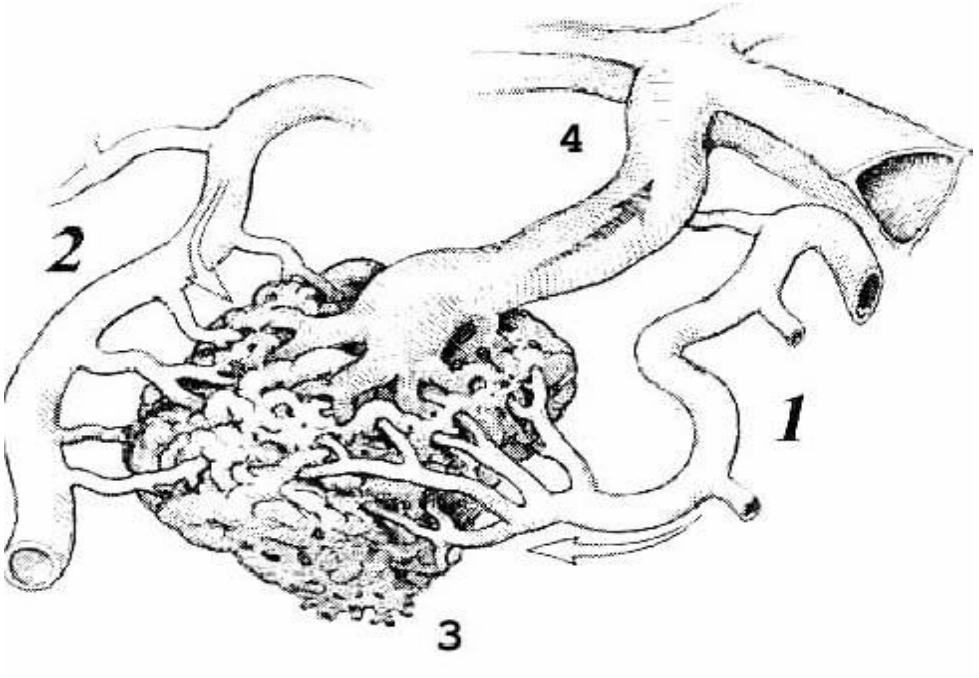

Cavernous
Venous
Malformation

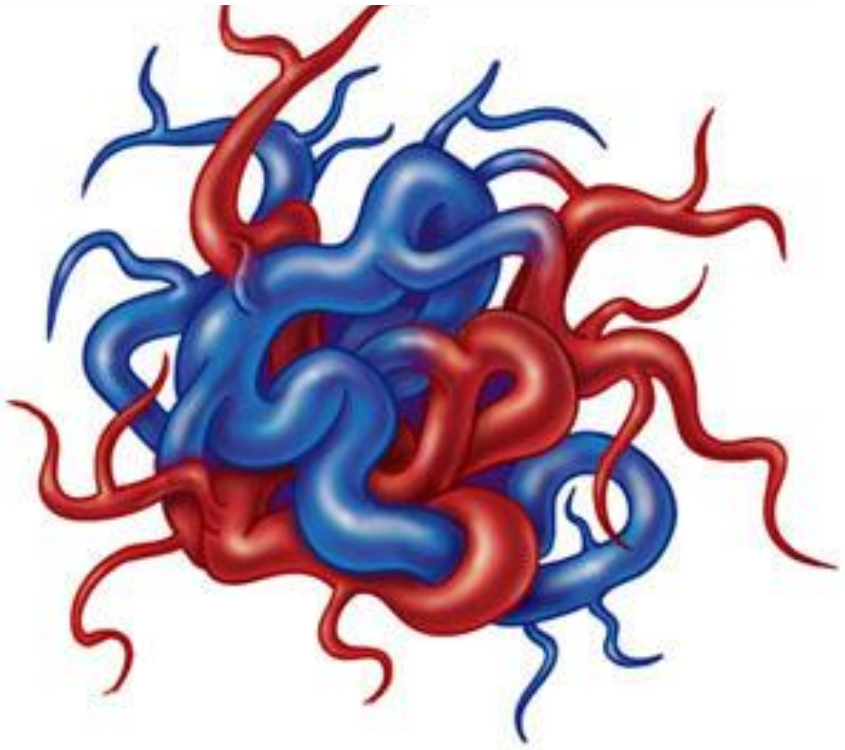
Localization AVM



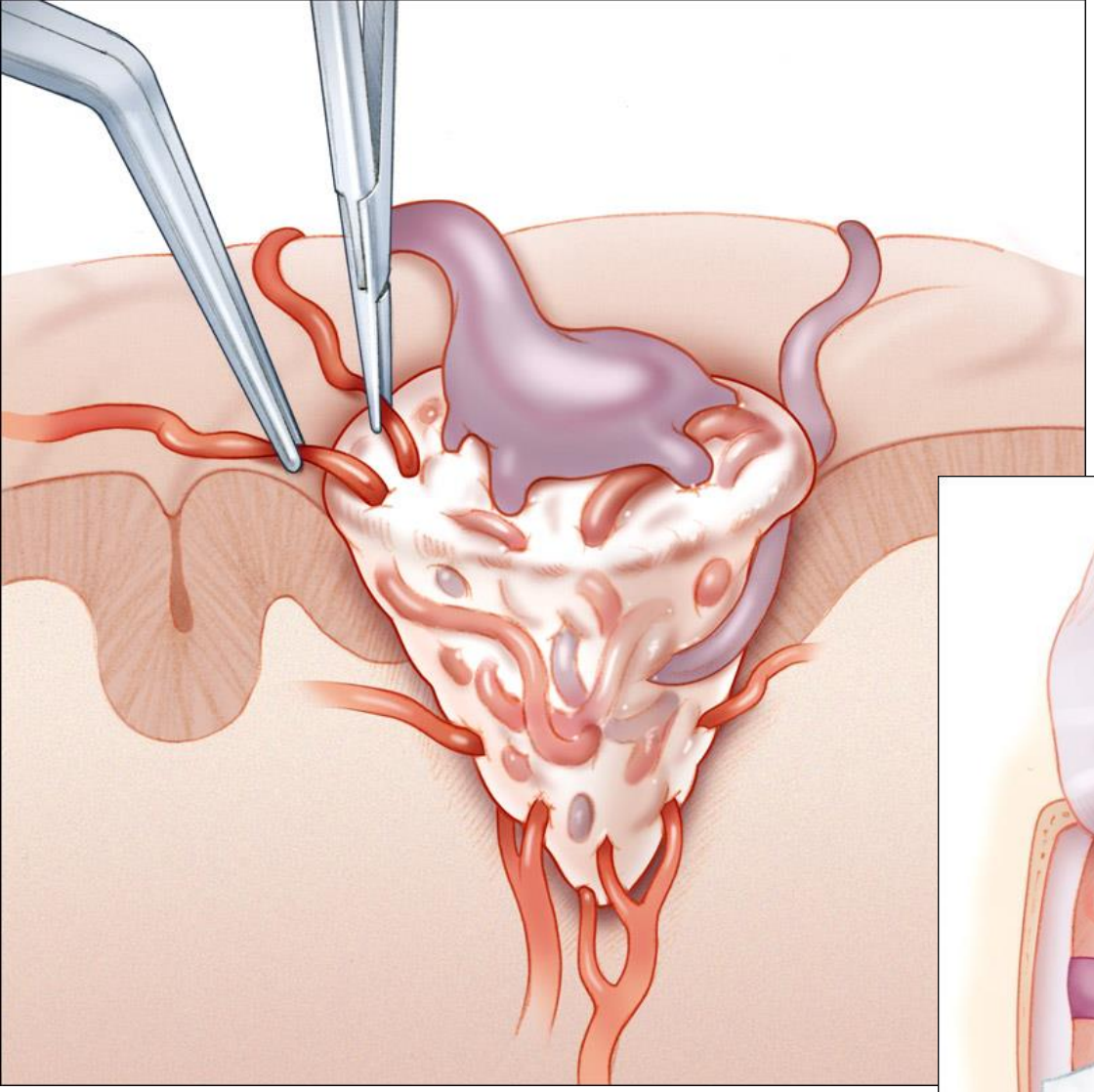


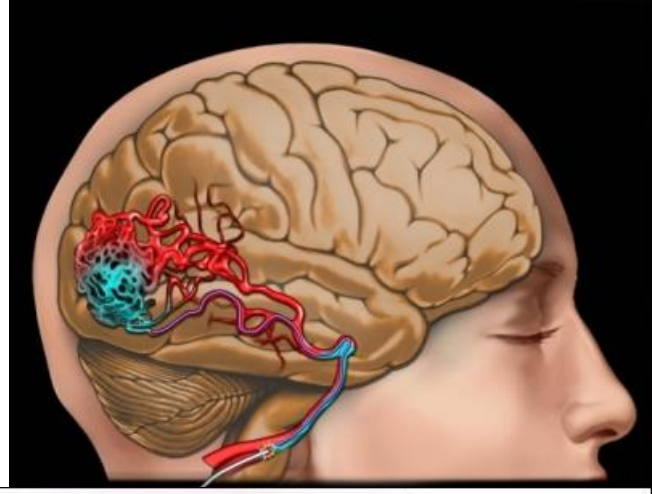


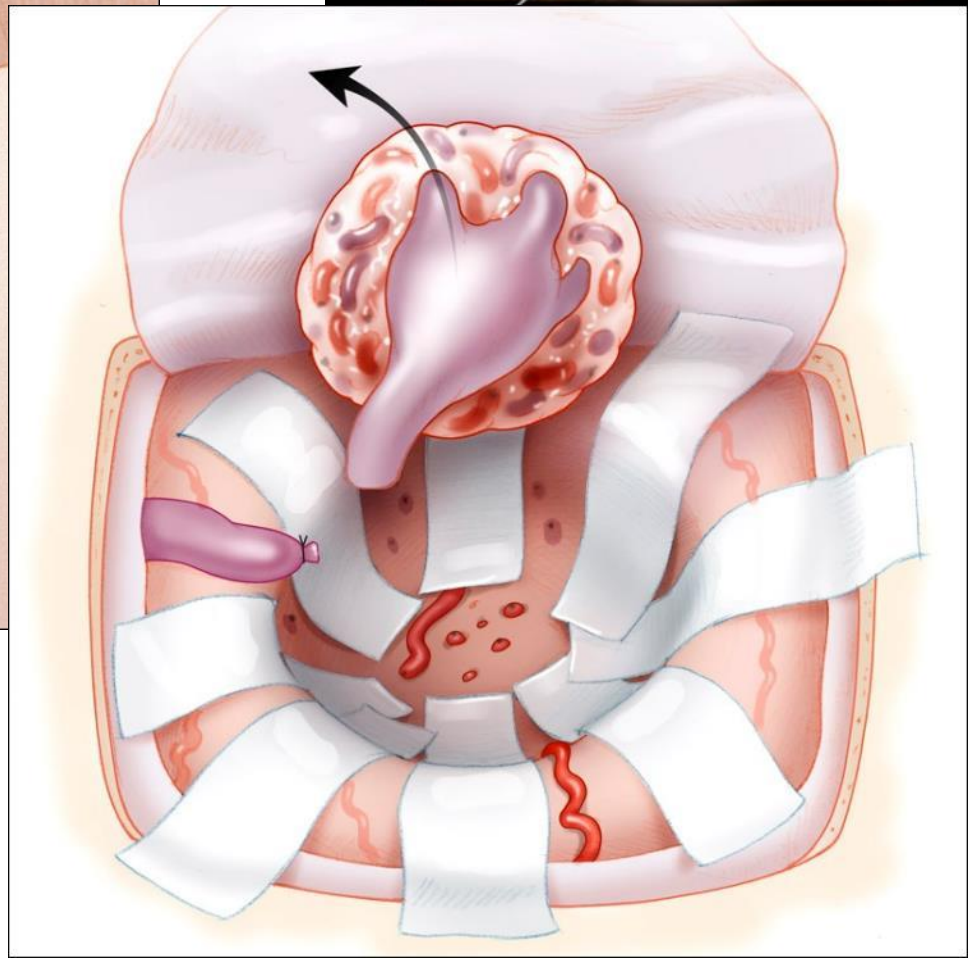




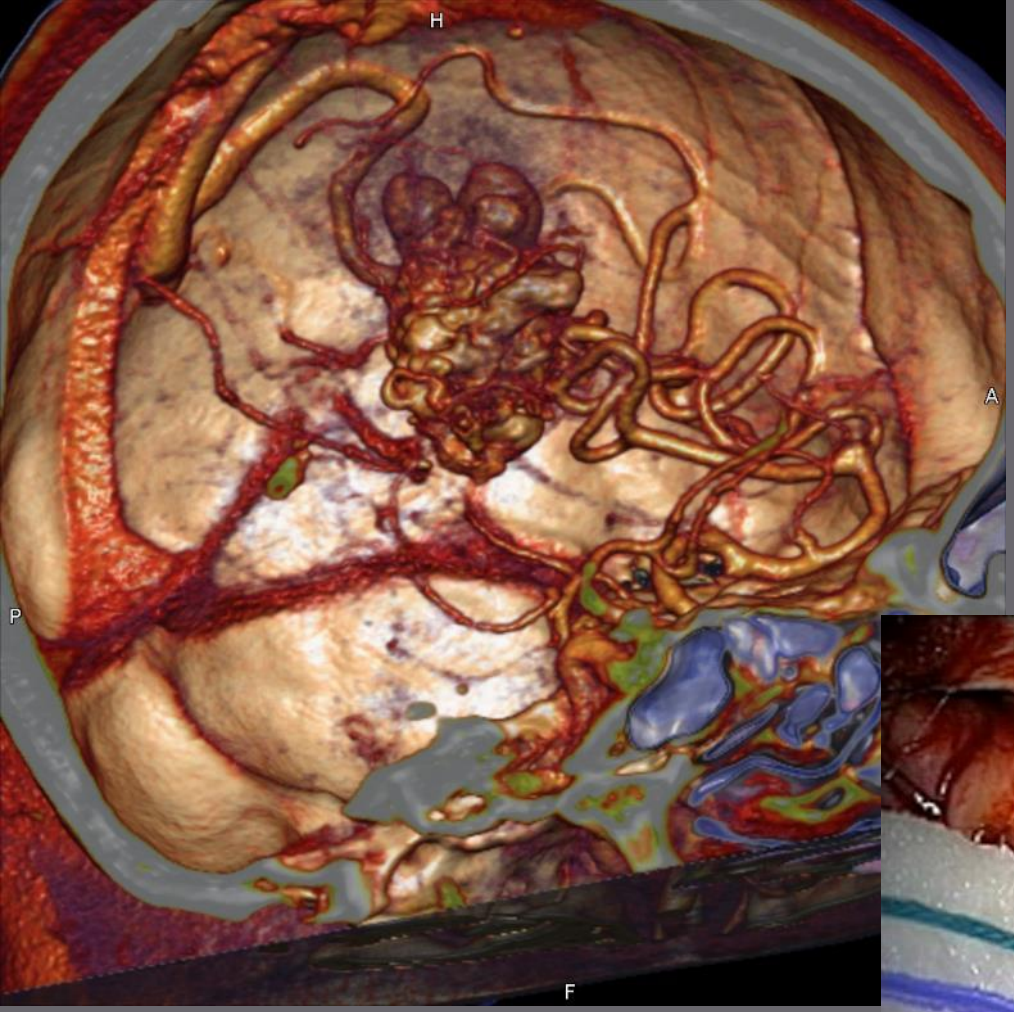
Эндоваскулярное выключение артериовенозных мальформаций сосудов головного мозга с использоваием клея для артериальных сосудов ПВА (поли-винил-алкоголь кополимер)

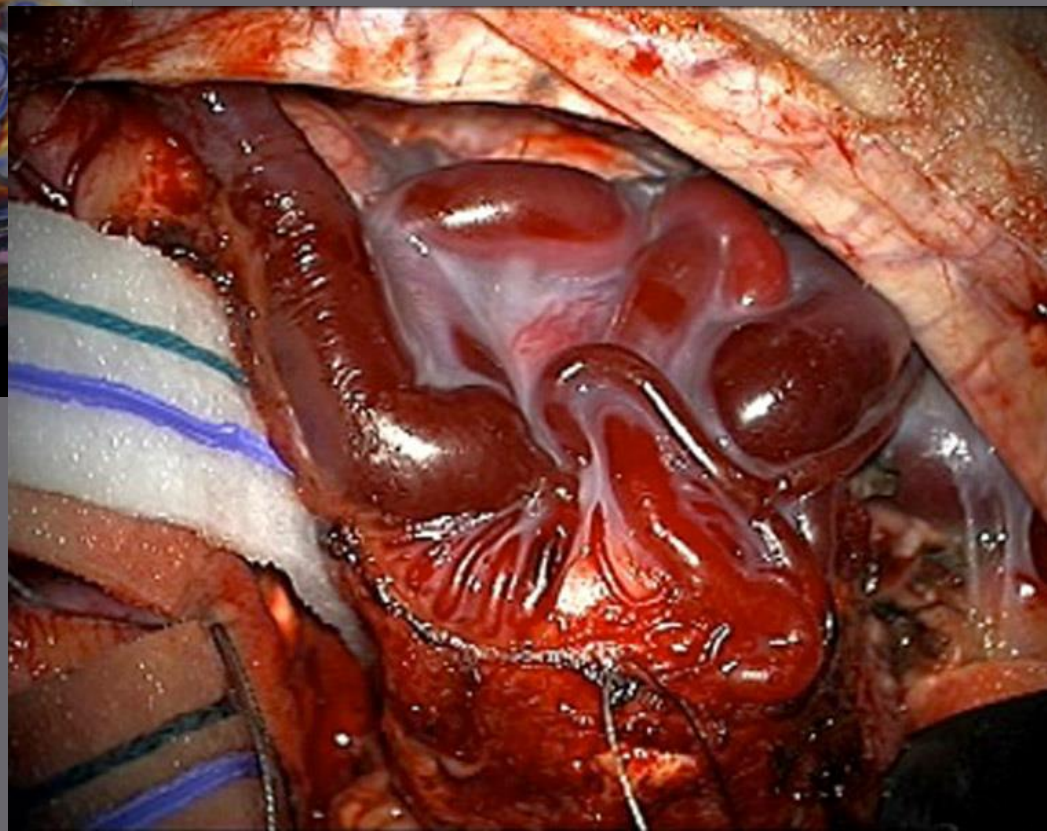


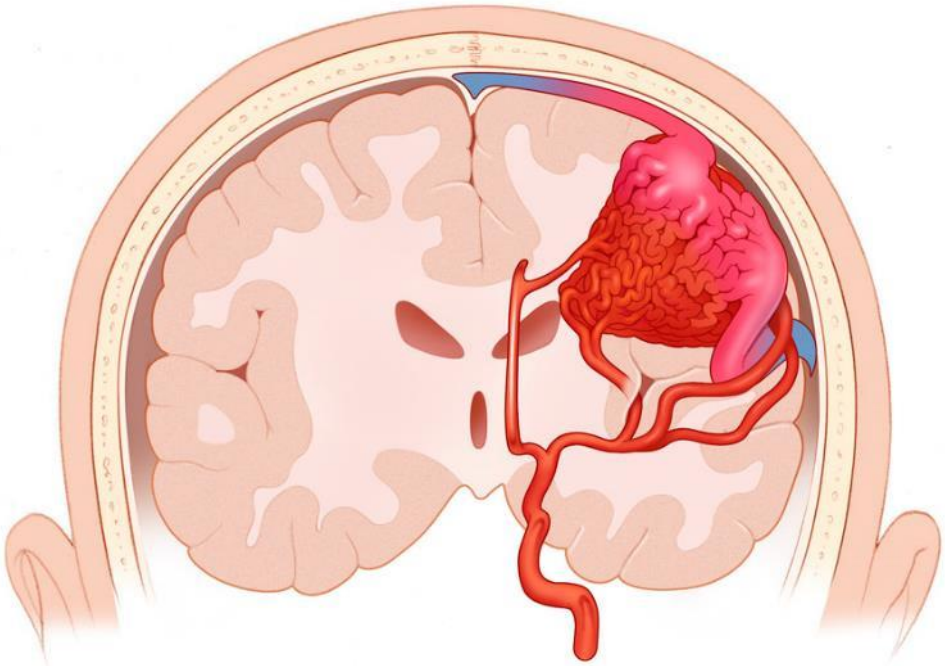




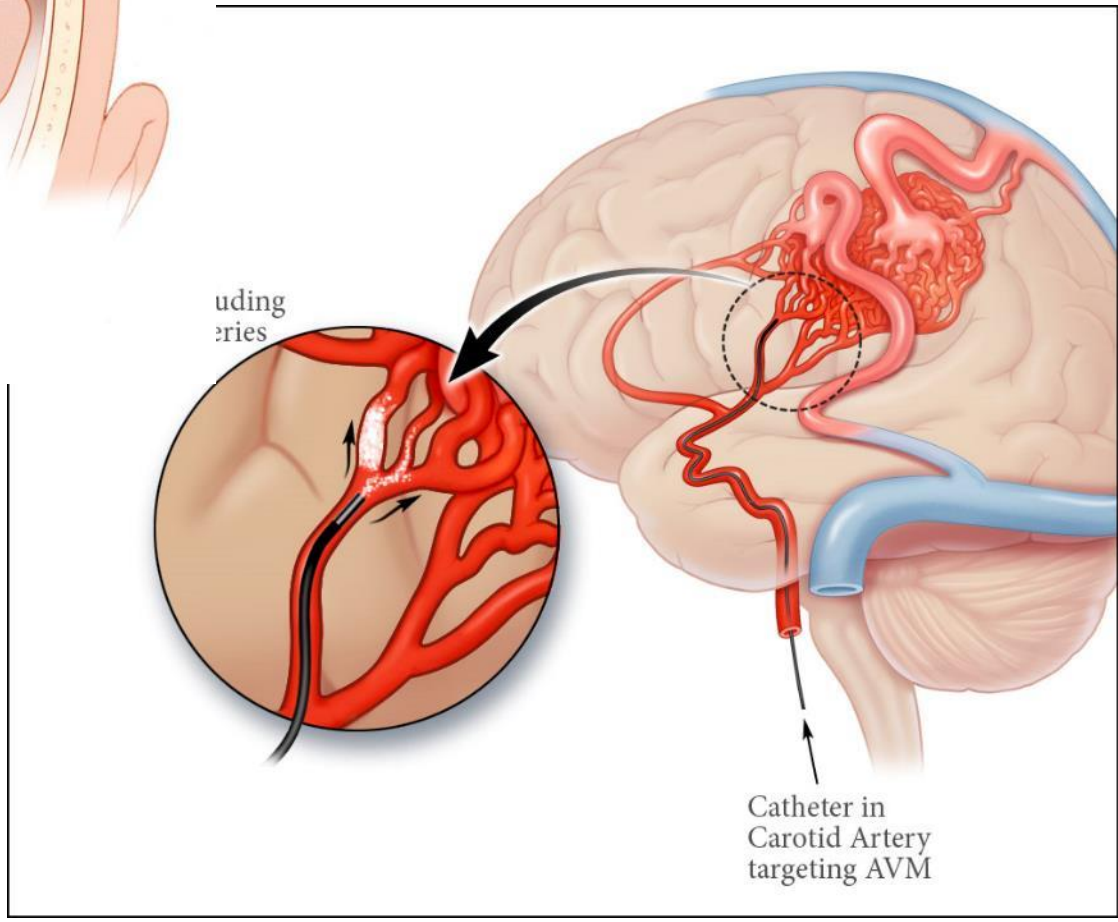
Surgery AVM


H
A
P
F

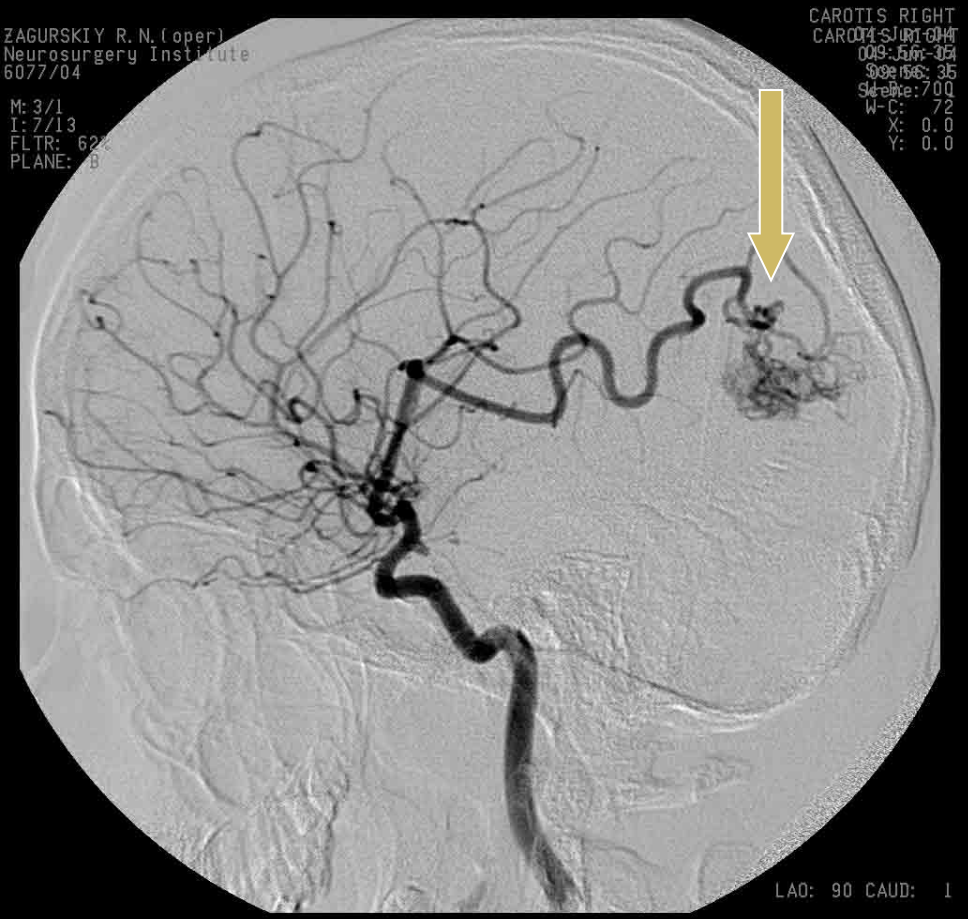




Endovascular embolization AVM



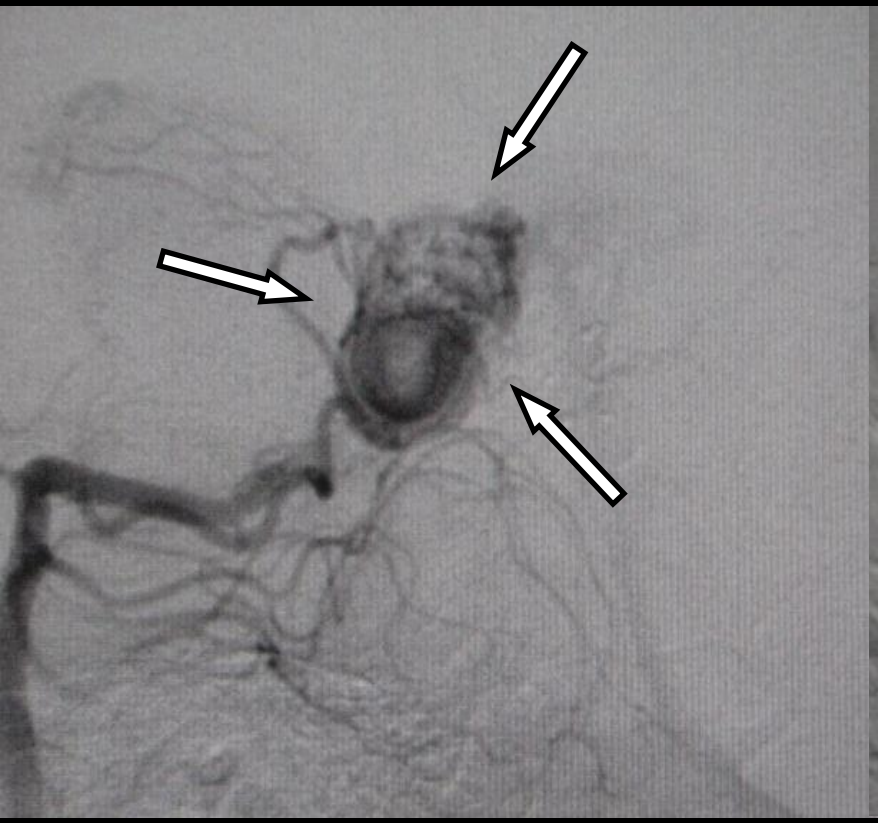
Артериовенозная мальформация в бассейне правой задней мозговой артерии



До операции

После операции

Артериовенозная мальформация теменно-затылочной области слева



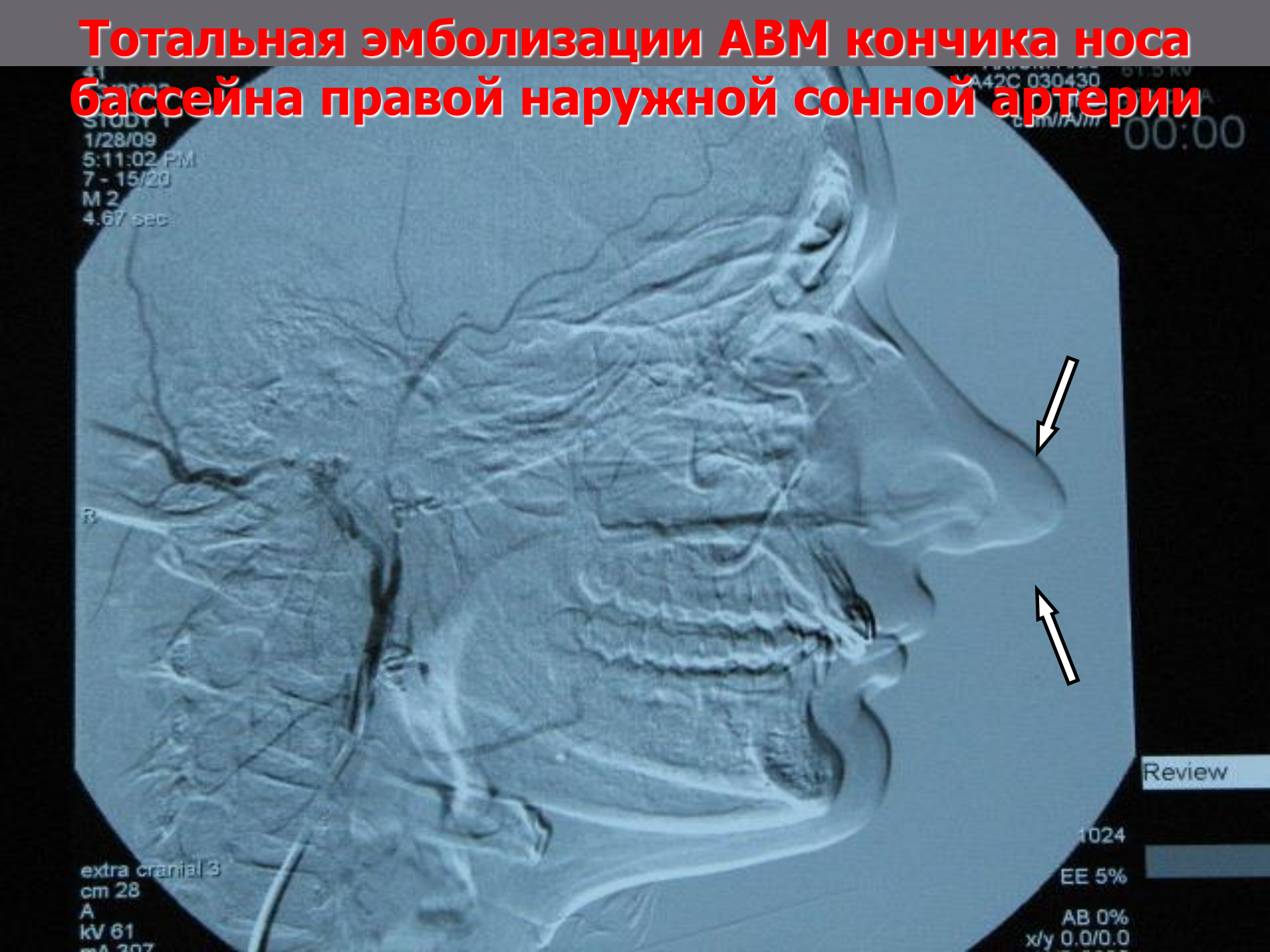
До операции

После операции

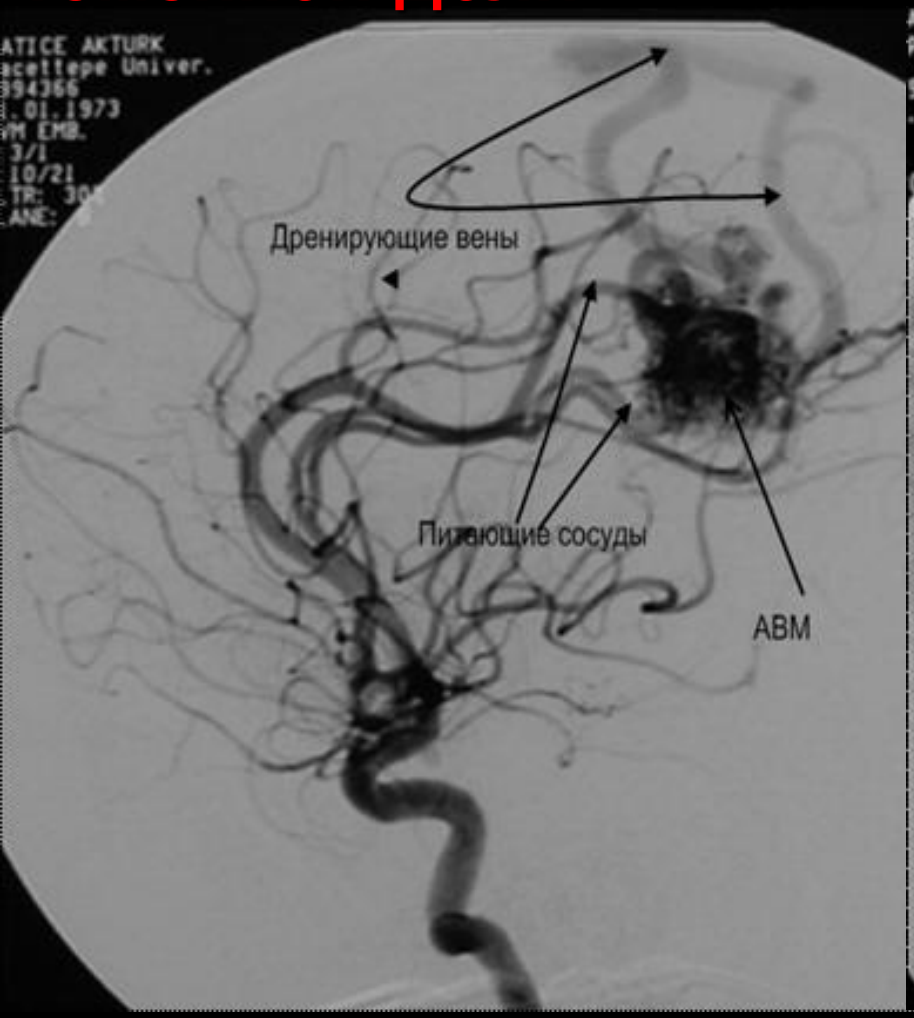
Артериовенозная мальформация кончика носа бассейна правой наружной сонной артерии

Промежуточный этап эмболизации АВМ носа бассейна правой наружной сонной артерии

Тотальная эмболизации АВМ кончика носа бассейна правой наружной сонной артерии

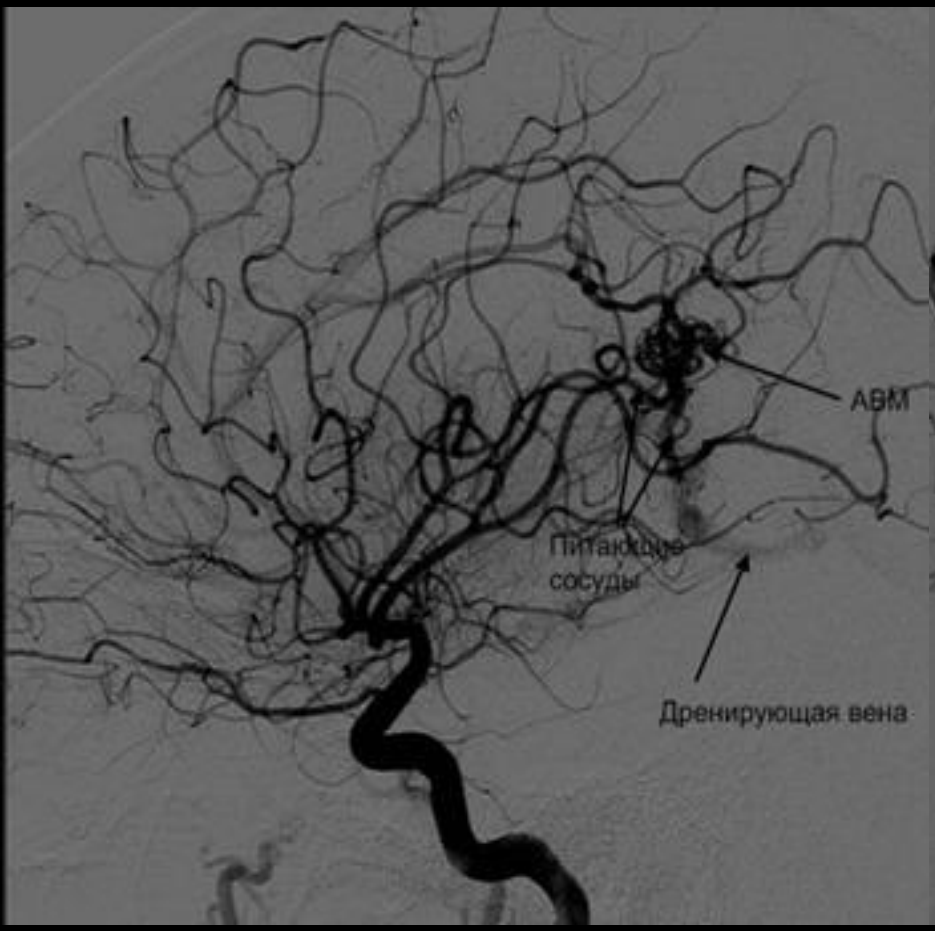


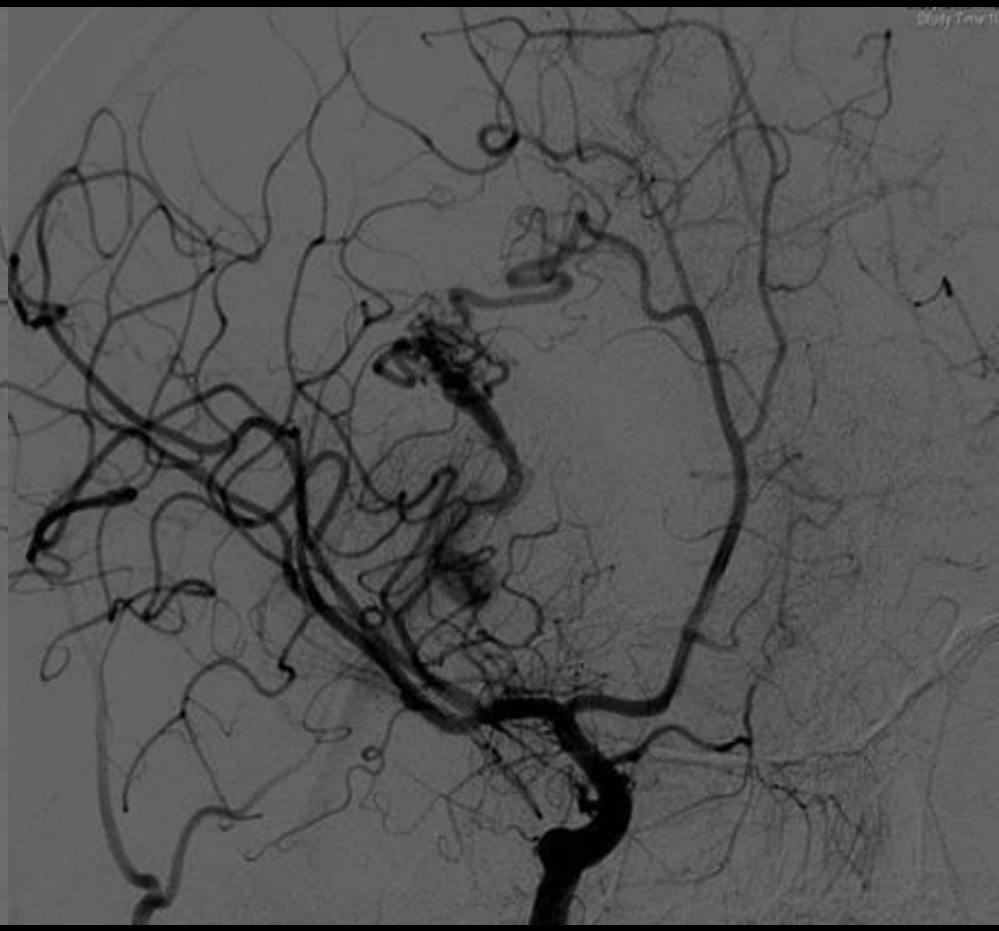
Клинический пример: операция при АВМ теменной доли



Первичная ангиография Полная окклюзия АВМ

АВМ мозолистого тела справа до эмболизации

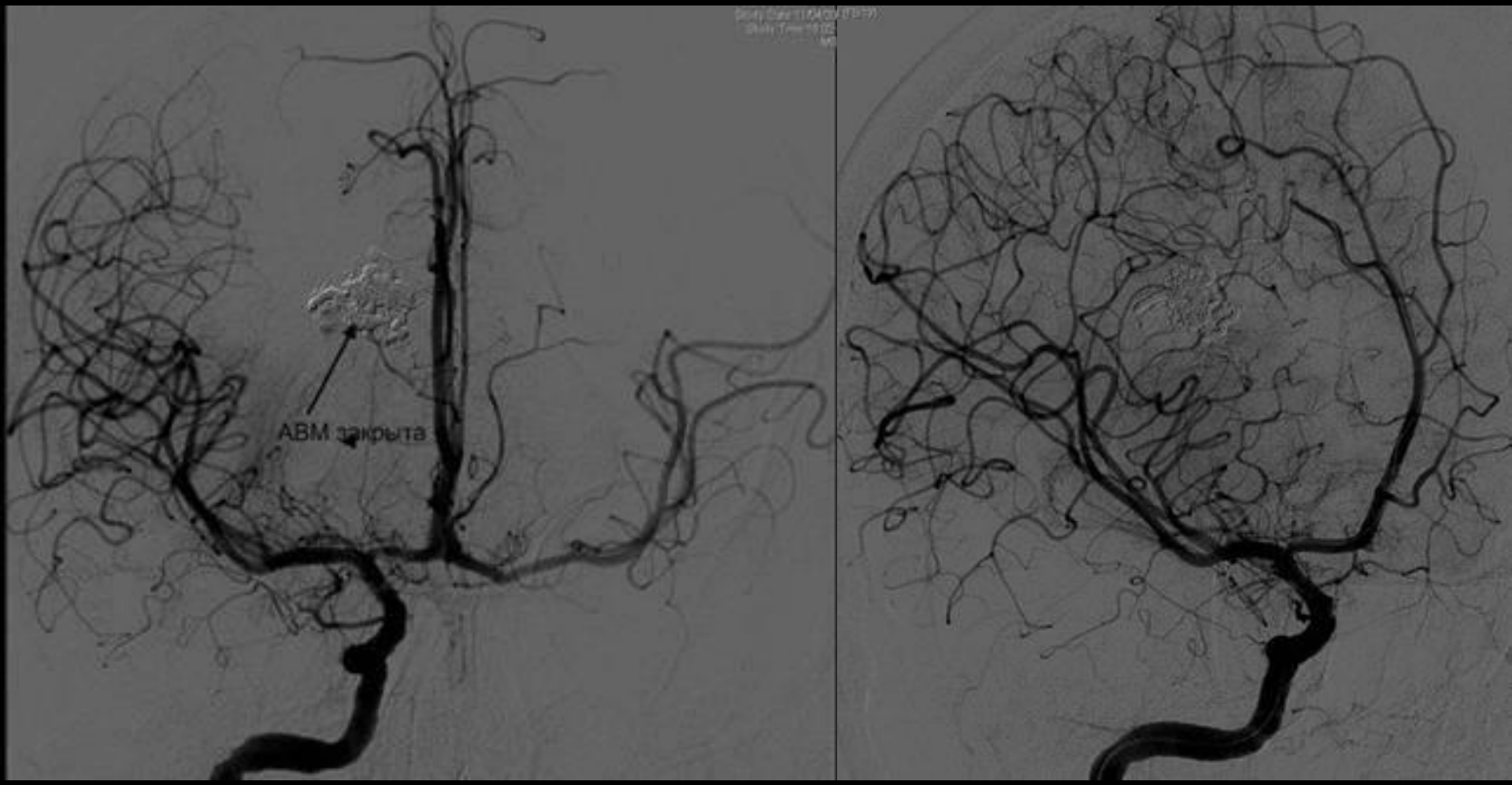




Боковая проекция

Полуаксиальная проекци

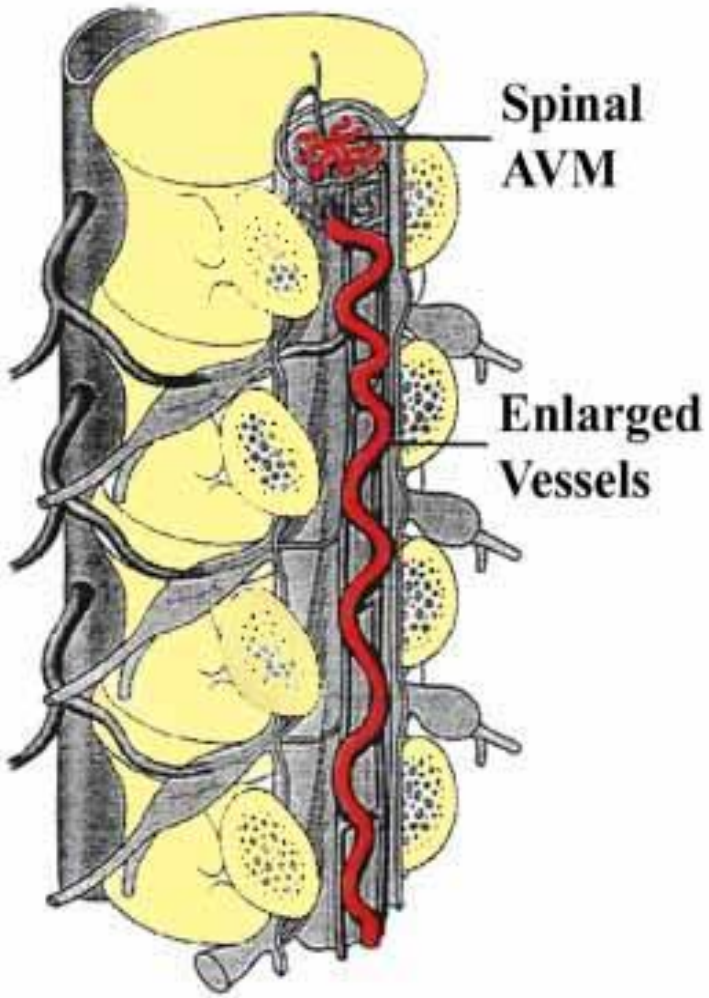
АВМ мозолистого тела справа после эмболизации

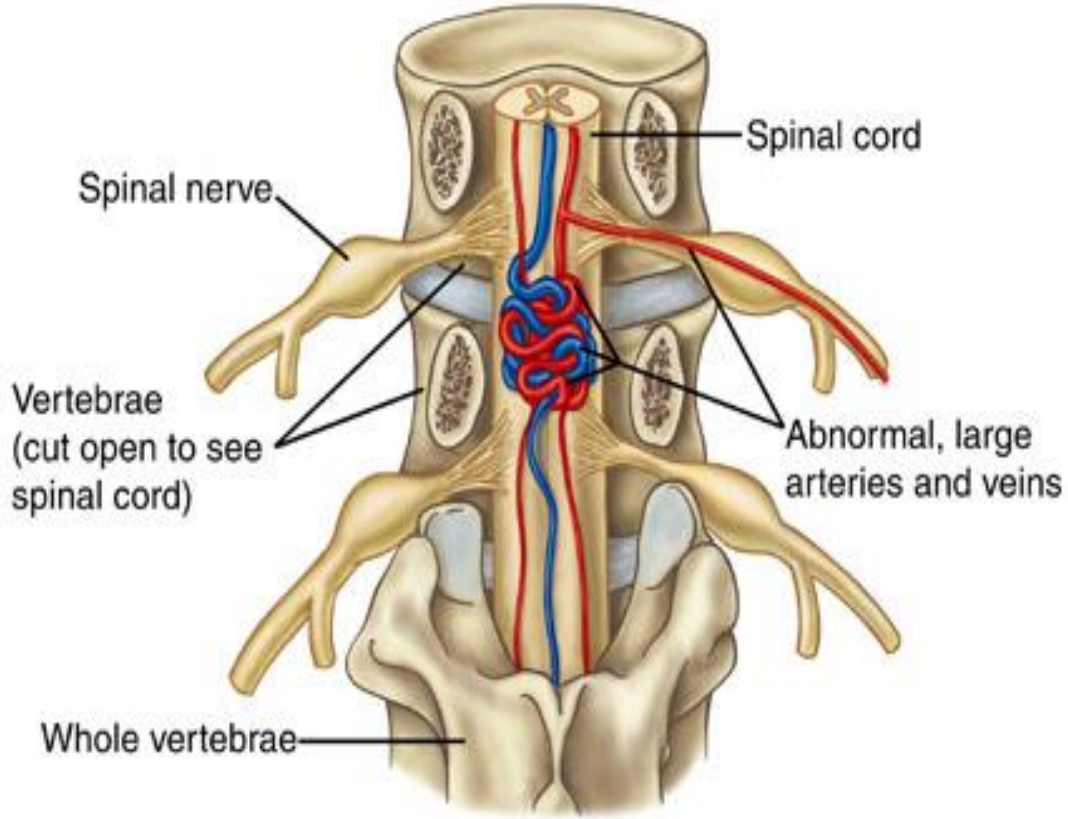


Боковая проекция

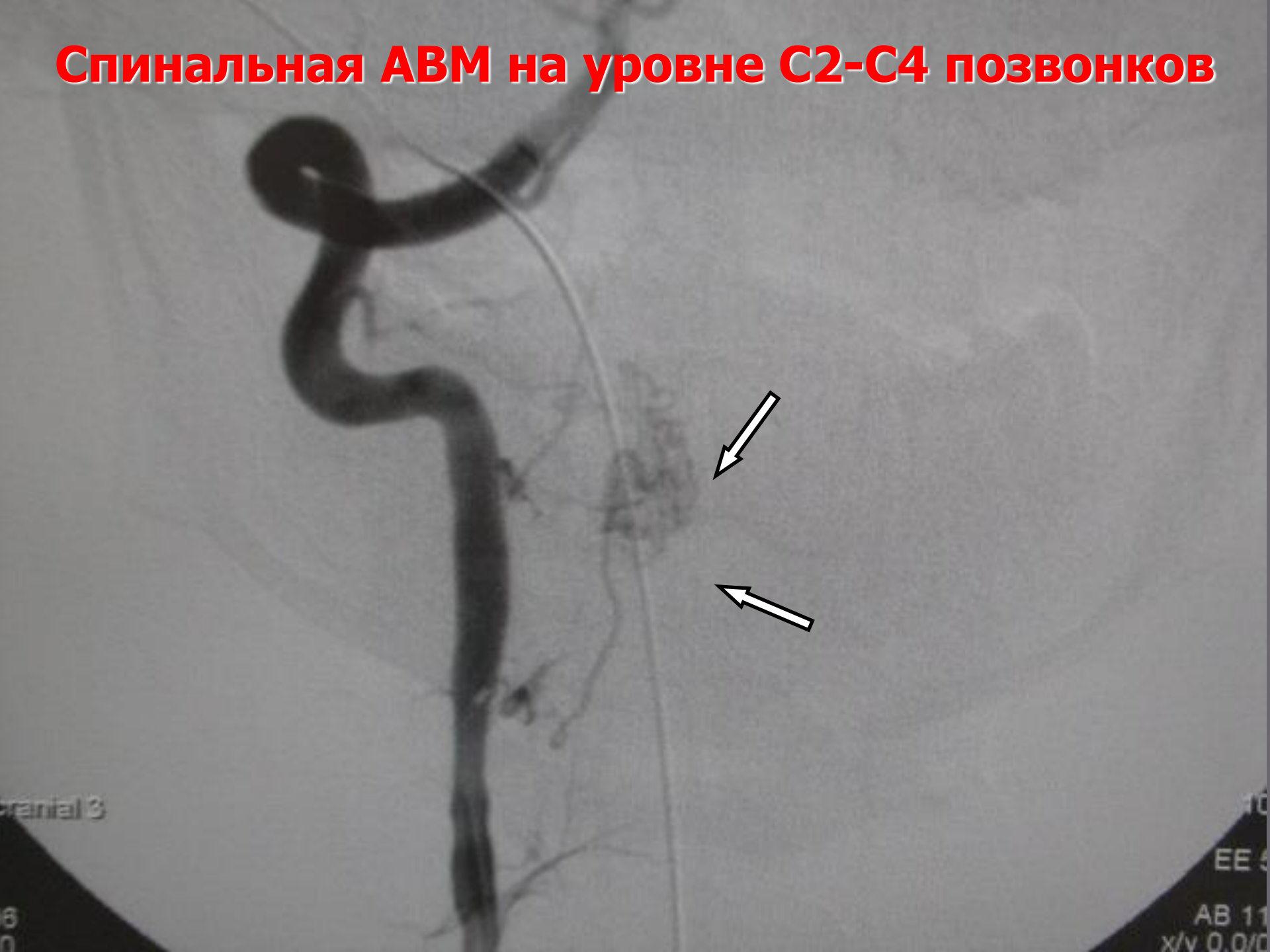
Полуаксиальная проекц

Спинальные мальформации





Спинальная АВМ на уровне С2-С4 позвонков



Состояние после эндоваскулярной эмболизации спинальной АВМ на уровне С2-С4 позвонков


THANK YOU!