



# Semeiotica encefalo

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## Metodiche di studio

TC



sostanza bianca

sostanza grigia

liquor

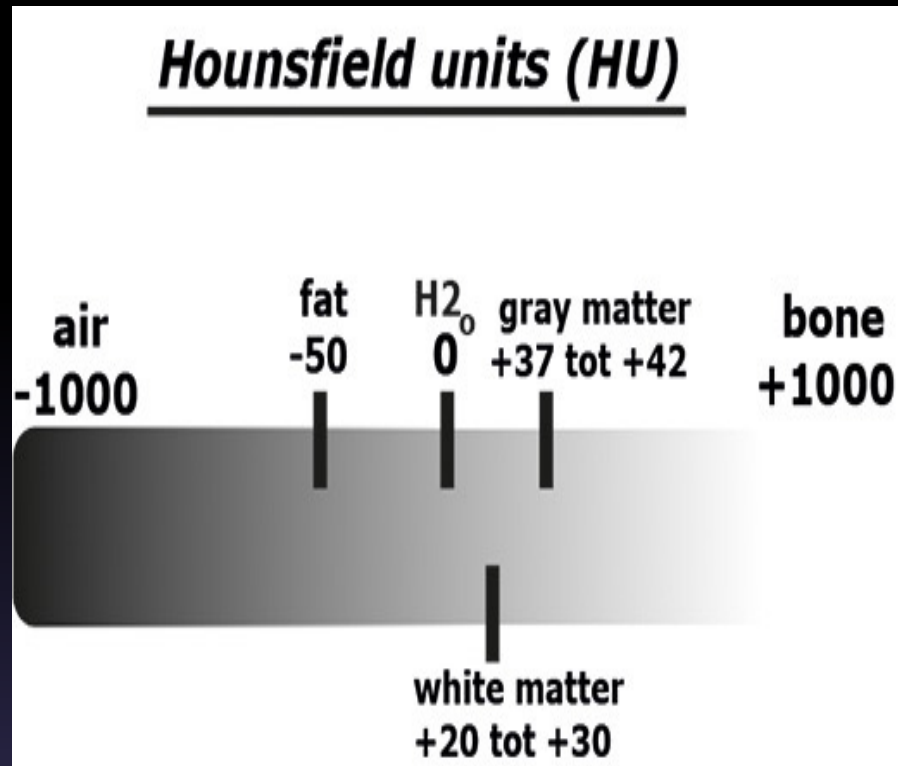
vasi

RM



meningi

osso



. Hounsfield unit (HU) scale.

## Normal anatomy

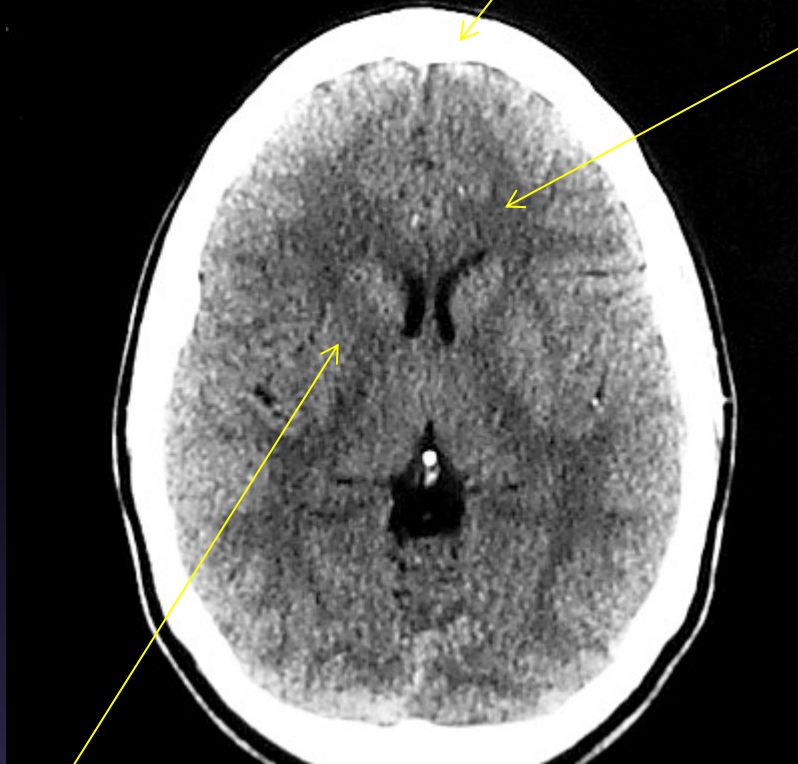
### Brain parenchyma

The brain surface consists of gyri (ridges) and sulci (grooves).

The gray matter is at the outside of the brain parenchyma. Gray matter is somewhat denser on CT than white matter. This is because white matter (as opposed to gray matter) contains the fatty substance myelin

**osso**

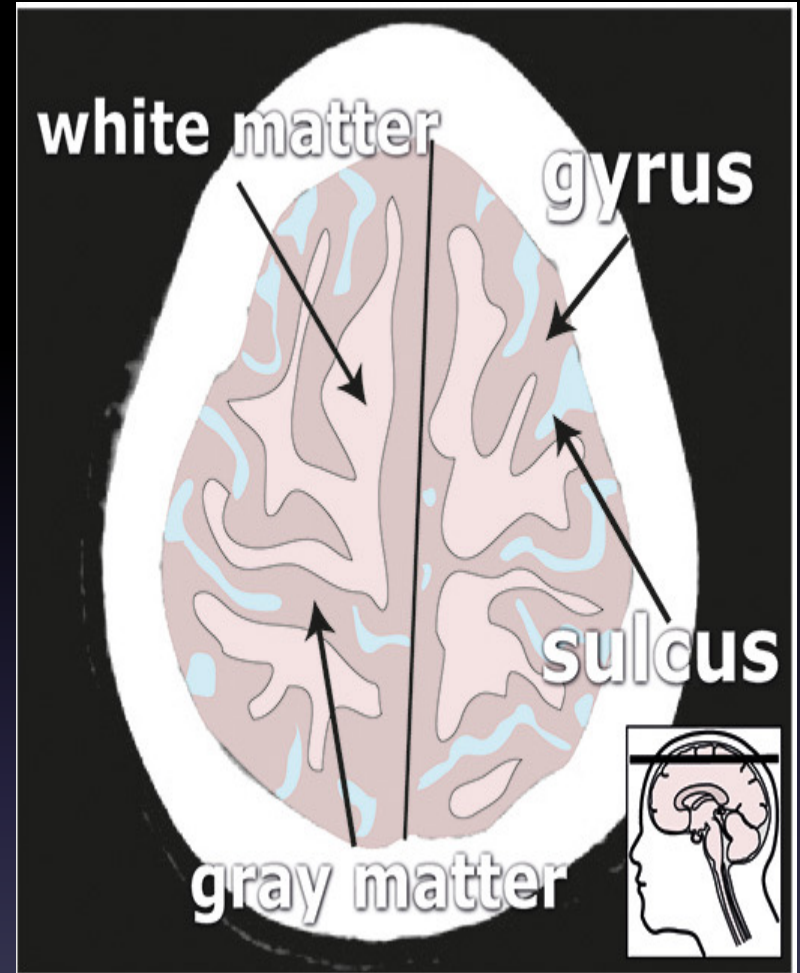
**Sostanza bianca**



**Sostanza grigia**

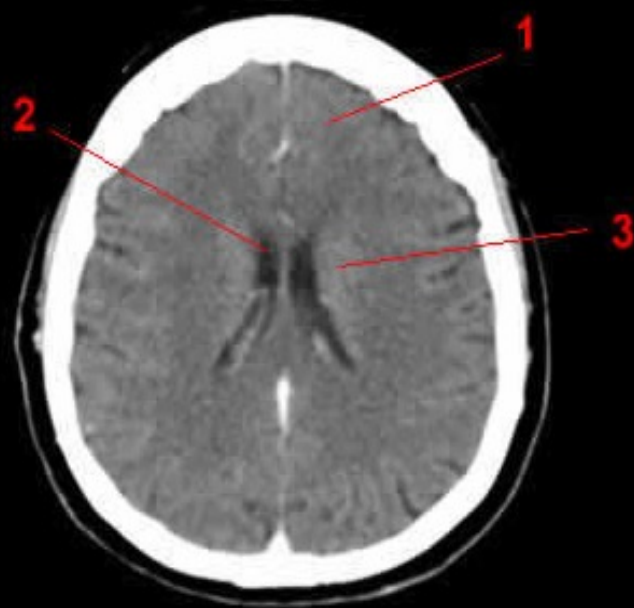
**liquor**





TC

Normal brain anatomy in the transversal plane



info-radiologie.ch

### Tomografia assiale computerizzata cerebrale - Image 6

Ricostruzione assiale. 1, Giro frontale superiore. 2, Ventricoli laterali. 3, Nucleo caudato.



info-radiologie.ch

### Tomografia assiale computerizzata cerebrale - Image 5

Ricostruzione assiale. 1, Nucleo caudato. 2, Braccio anteriore della capsula interna. 3, Nucleo lenticolare. 4, Seno sagittale inferiore. 5, Seno sagittale superiore. 6, Scissura interemisferica / falce del cervello. 7, Talamo. 8, Ventricoli laterali. 9, Corpo calloso.



**Tomografia assiale computerizzata cerebrale - Image 4**  
 Ricostruzione assiale. 1, Cellule etmoidali. 2, Bulbo oculare. 3, Nervo ottico. 4, Verme. 5, Mesencefalo. 6, Circonvoluzioni temporali



**Tomografia assiale computerizzata cerebrale - Image 3**  
 Ricostruzione assiale. 1, Bulbo oculare. 2, Seno sfenoidali. 3, Lobo temporale destro. 4, Cellule mastoidee. 5, Ponte. 6, IV ventricolo. 7, Emisferi cerebellari.

- l'immagine RM è formata dalla rappresentazione grafica, in una matrice di punti più o meno chiari o scuri, dell'intensità del segnale di risonanza raccolto dall'apparecchio per ciascun punto della regione esaminata

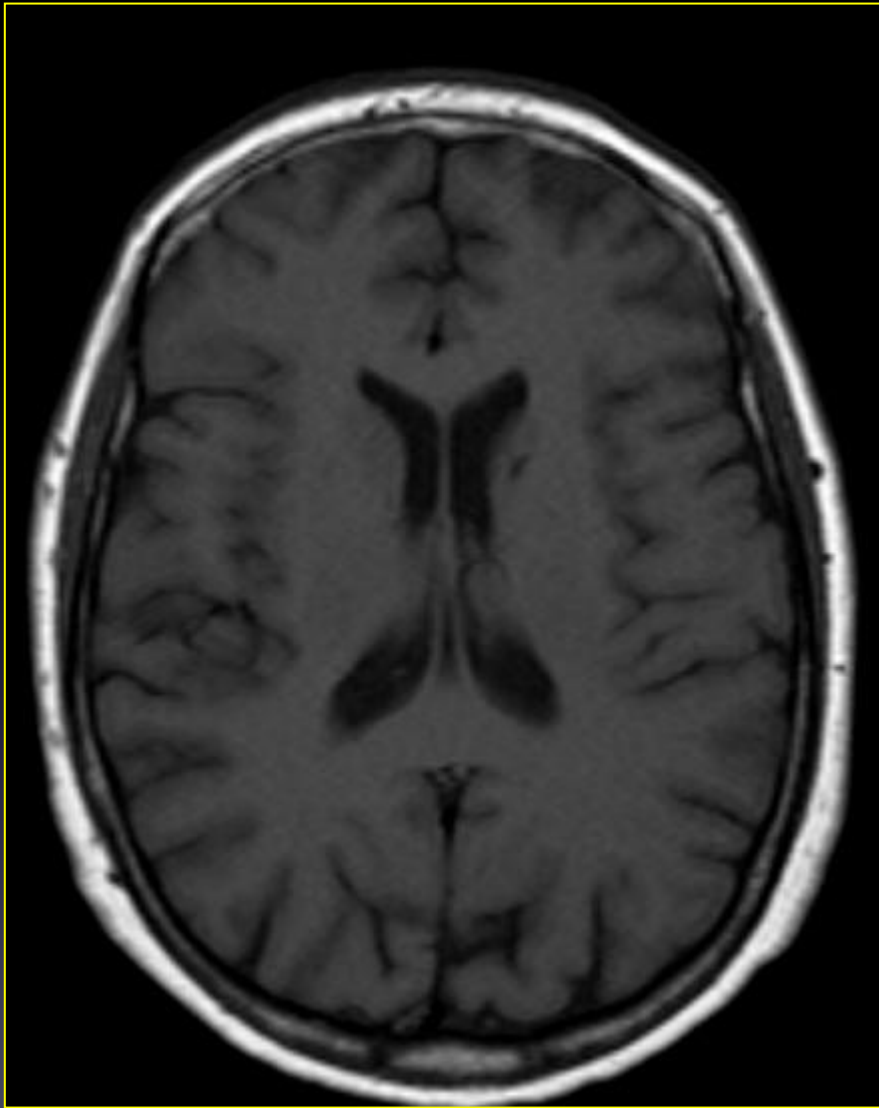
- Per convenzione sono rappresentati bianchi i punti dotati di segnale più intenso mentre appaiono neri i punti a segnale scarso o assente

In RM si parla unicamente di punti o strutture a segnale più o meno intenso

- Iperintenso (bianco)
- Ipointenso (nero)
- Isointenso (intermedio)

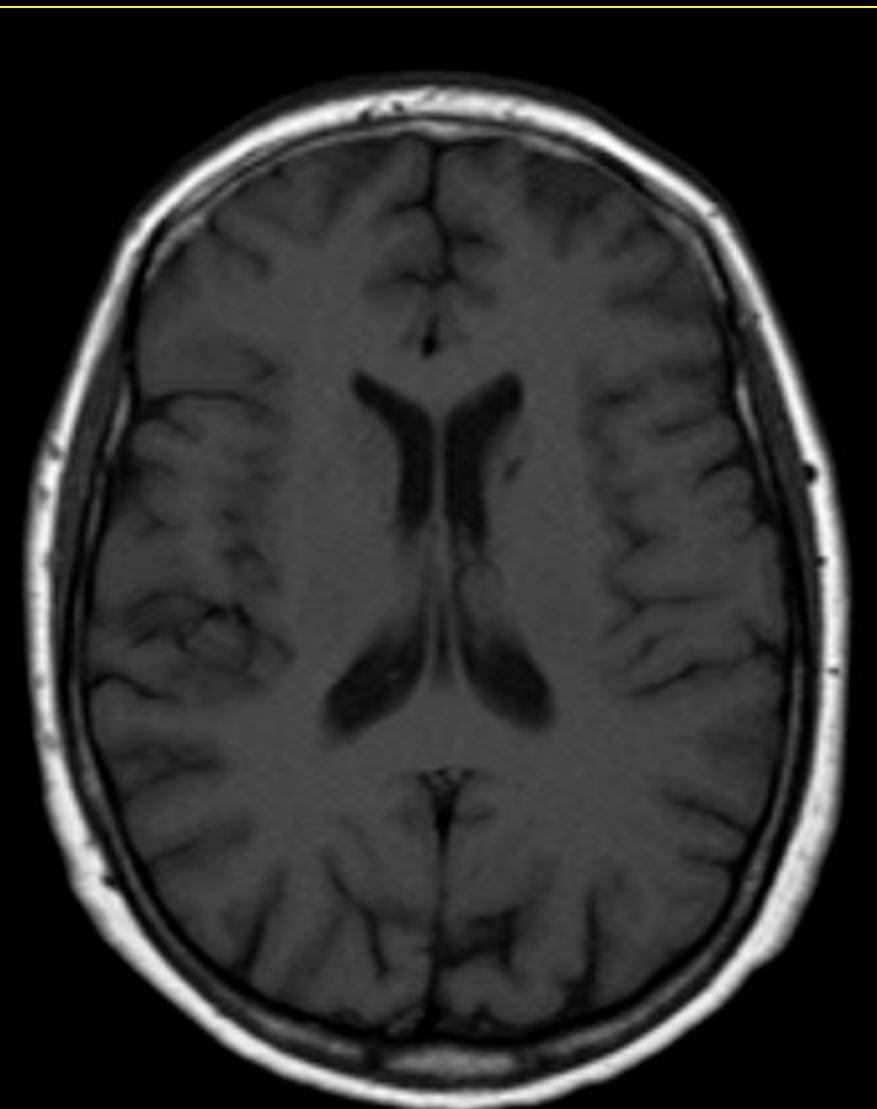
I liquidi limpidi (liquor, raccolte sierose, o ematiche, urina) hanno un segnale ipointenso in T<sub>1</sub> e iperintenso in T<sub>2</sub>



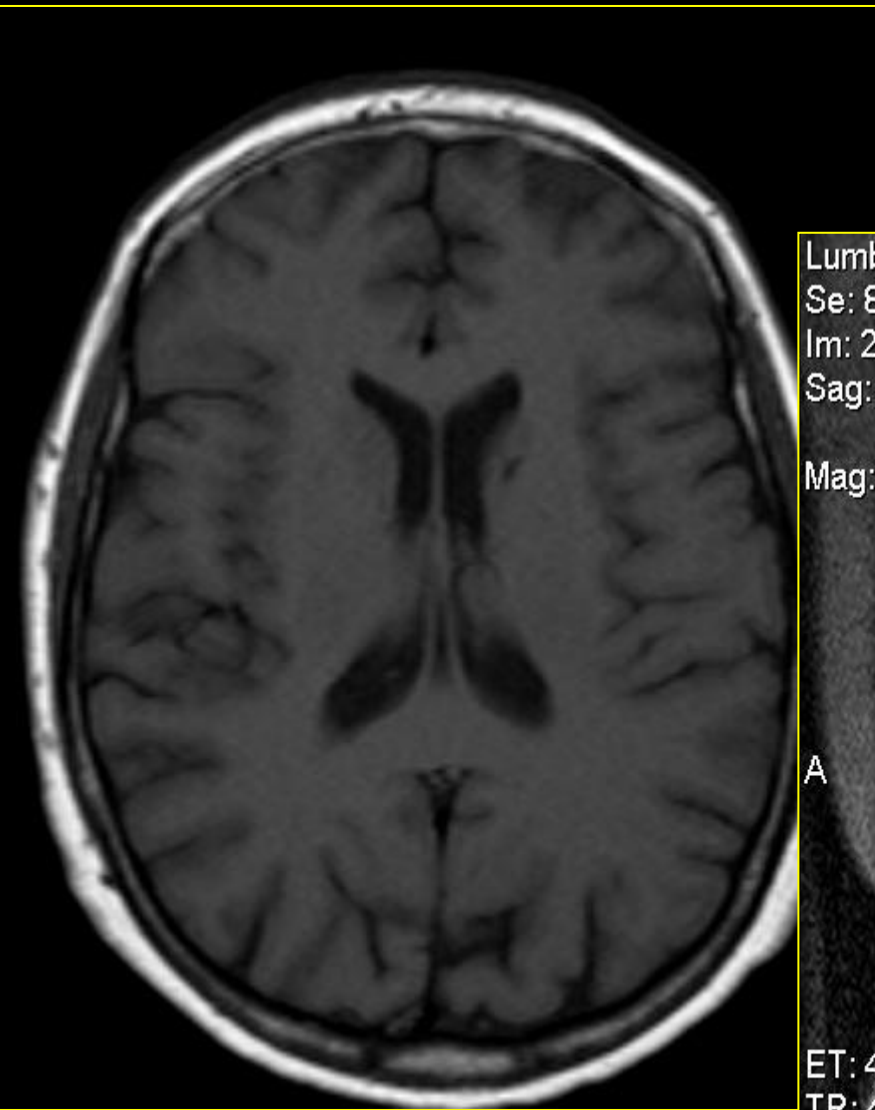


- I parenchimi hanno valori di T<sub>1</sub> e T<sub>2</sub> a livelli intermedi della scala, variabili a seconda del loro contenuto cellulare, idrico e adiposo
- In generale generano un segnale di intensità intermedia in T<sub>1</sub> e T<sub>2</sub>, in relazione al contenuto idrico, e iperintenso in DP in relazione al contenuto cellulare

- Saranno quindi più o meno grigi in T<sub>1</sub> e T<sub>2</sub> e chiari in densità protonica



- Il grasso : iperintenso in T<sub>1</sub> e T<sub>2</sub>
- la sostanza bianca encefalo: piu' iperintensa in T<sub>1</sub> della sostanza grigia



Lumbar T1W/TSE  
Se: 801/9  
Im: 2/11  
Sag: L10.4 (COI)

Mag: 1.2x

A

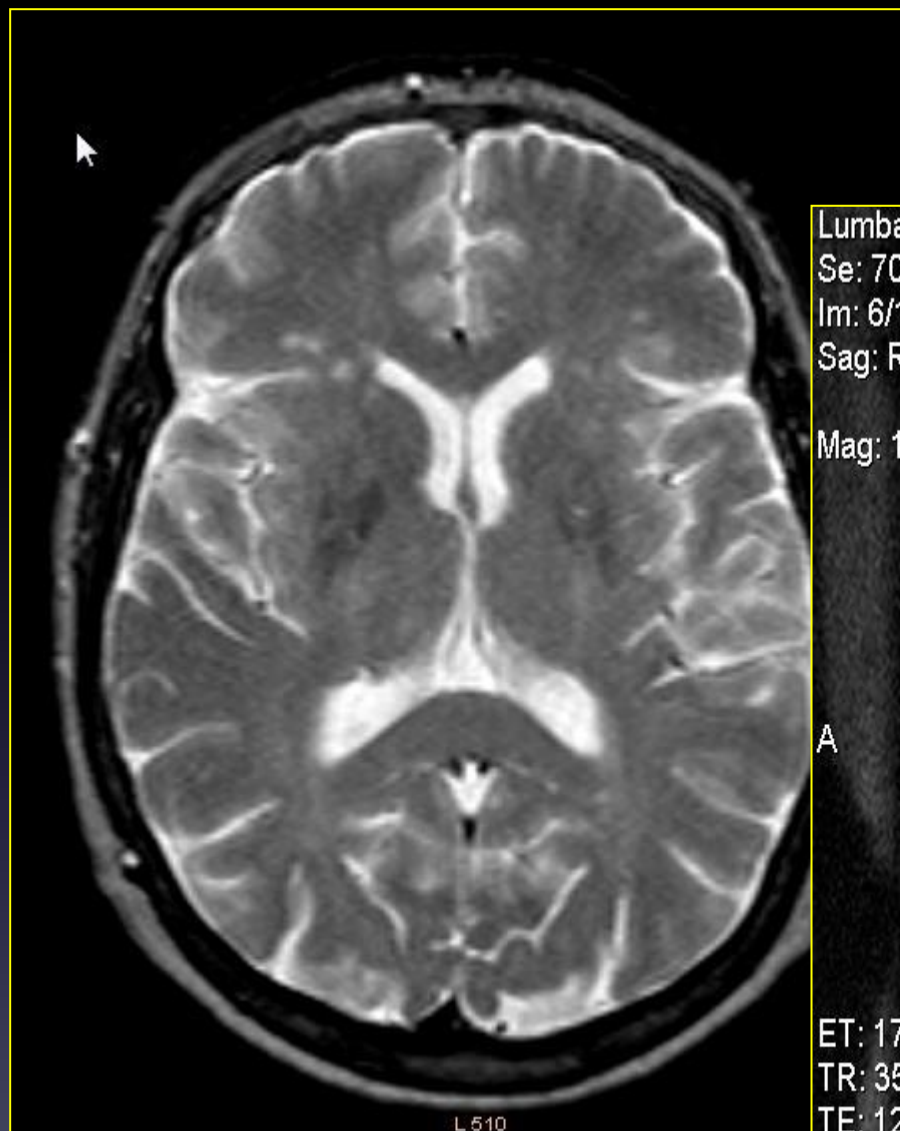
ET: 4  
TR: 400.0  
TE: 11.0  
Syn-spine  
4.0thk/0.4sp  
Lin:DCM / Lin:DCM / Id:ID

1928 Mar 12 M 532/RM  
Acc: 532/09  
2009 Mar 13  
Img Tm: 10:51:00.92

512 x 512

F





Lumbar T2W/TSE

Se: 701/9

Im: 6/11

Sag: R7.2 (COI)

Mag: 1.2x

1928 Mar 12 M 532/RM

Acc: 532/09

2009 Mar 13

Img Tm: 10:46:38.29

512 x 512

A

P

ET: 17

TR: 3500.0

TE: 120.0

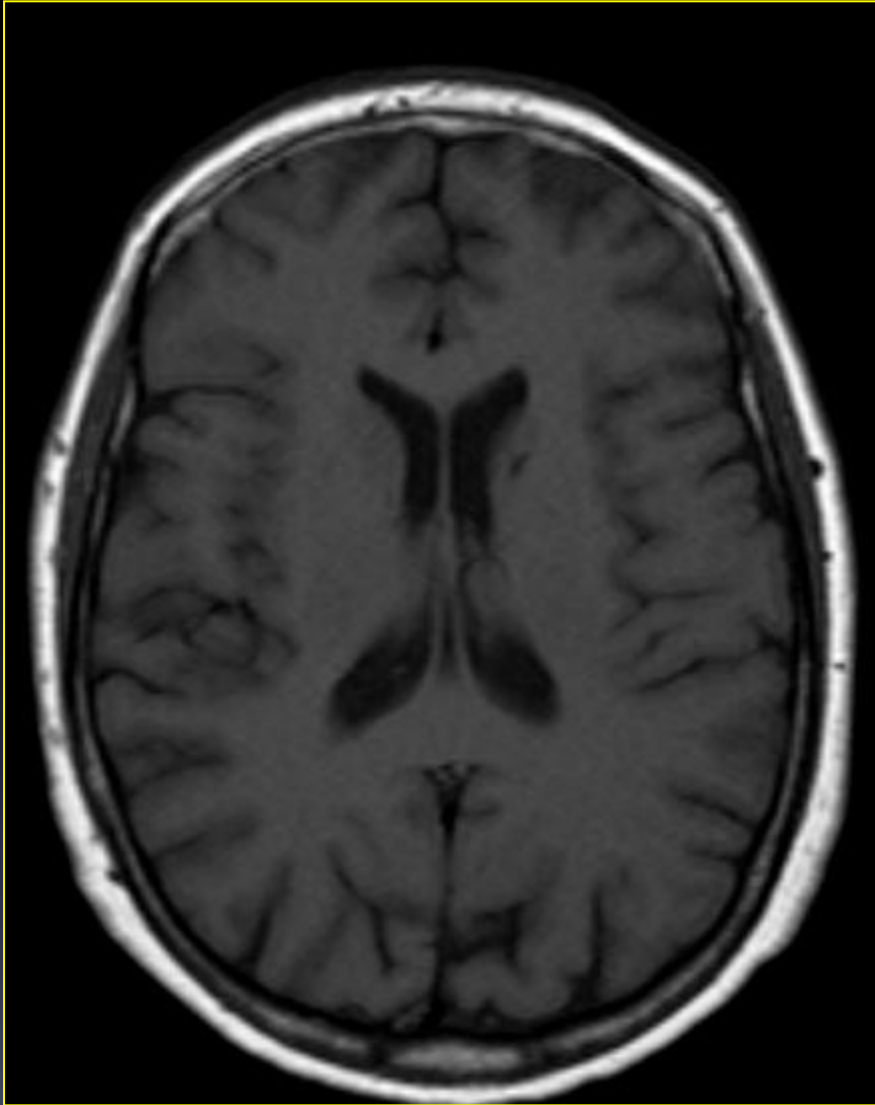
Syn-spine

4.0thk/0.4sp

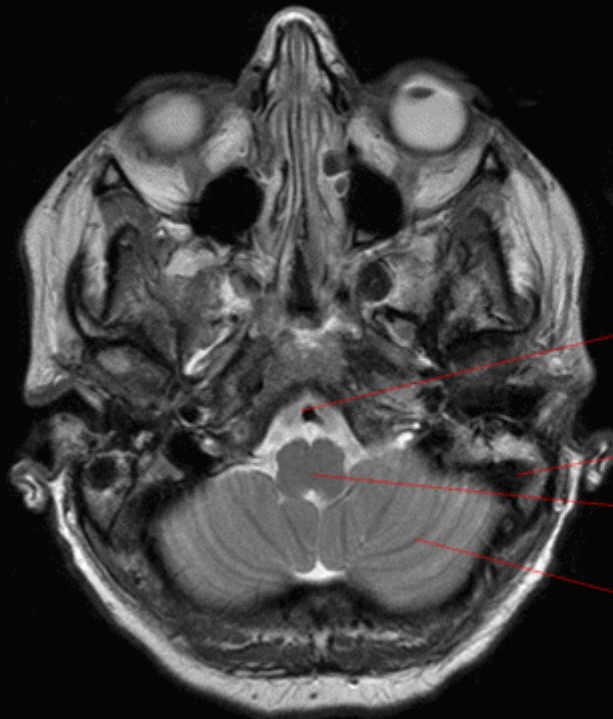
Lin:DCM / Lin:DCM / Id:ID



L'osso compatto, la corticale ossea e tutte le strutture solide cristalline (calcoli, calcificazioni) appaiono ipointensi in T<sub>1</sub> e in T<sub>2</sub>



## Brain Axial T2

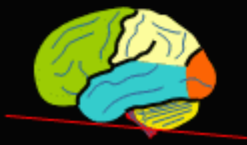


Basilar artery

Sigmoid sinus

Medulla Oblongata

Cerebellum



## Brain Axial T2



Internal carotid artery

Superior temporal gyrus

Meckel's cave

CN VII and VIII

Pons

Transverse sinus

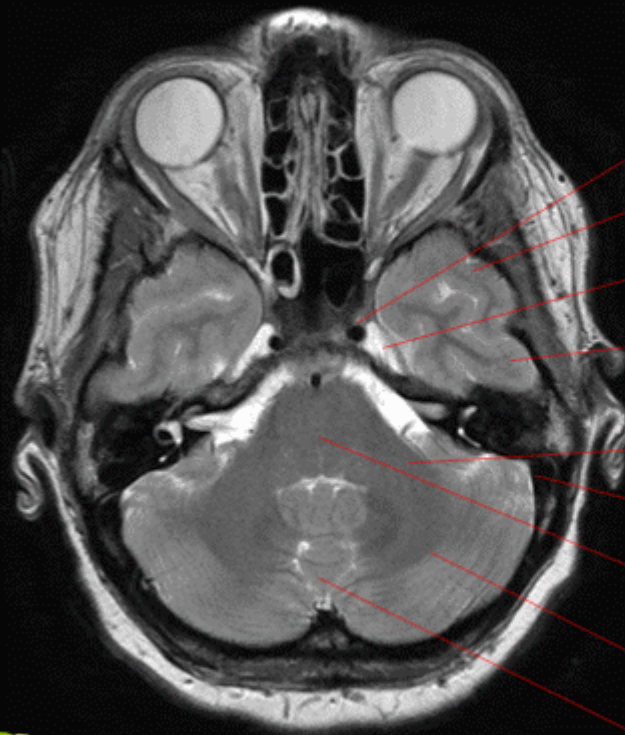
Medulla Oblongata

Cerebellum

Vermis



## Brain Axial T2



Internal carotid artery

Superior temporal gyrus

Meckel's cave

Inferior temporal gyrus

Middle cerebellar  
peduncle

Transverse sinus

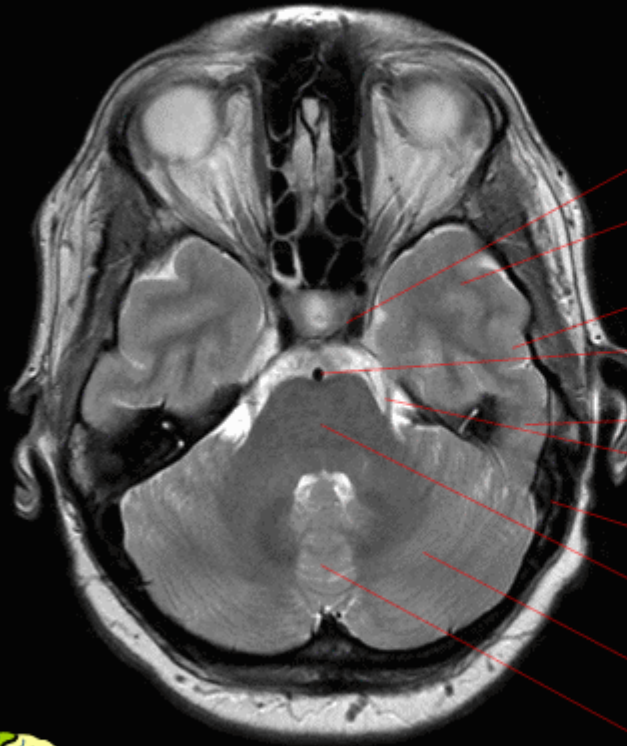
Pons

Cerebellum

Vermis

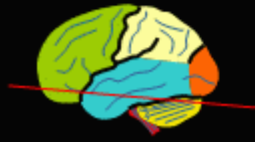
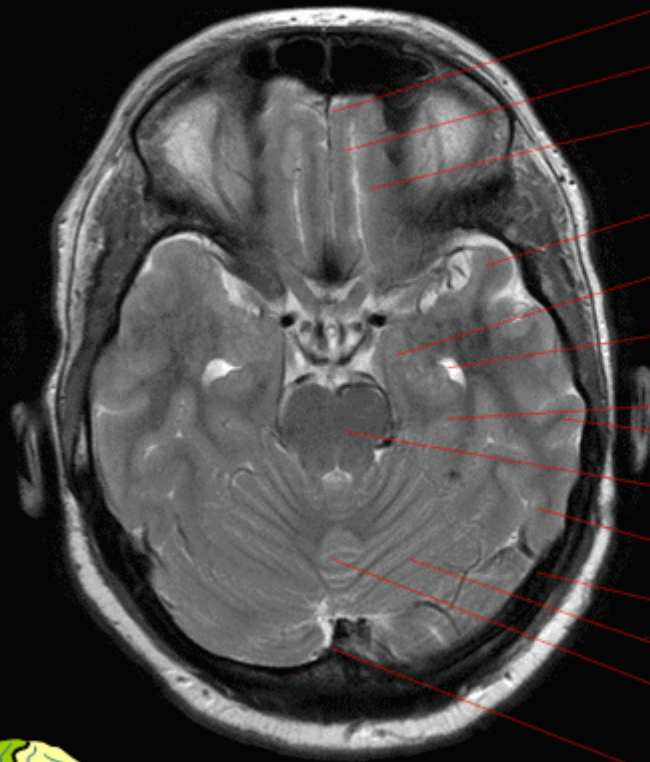


## Brain Axial T2



- Internal carotid artery
- Superior temporal gyrus
- Middle temporal gyrus
- Basilar artery
- Inferior temporal gyrus
- CN V
- Transverse sinus
- Pons
- Cerebellum
- Vermis

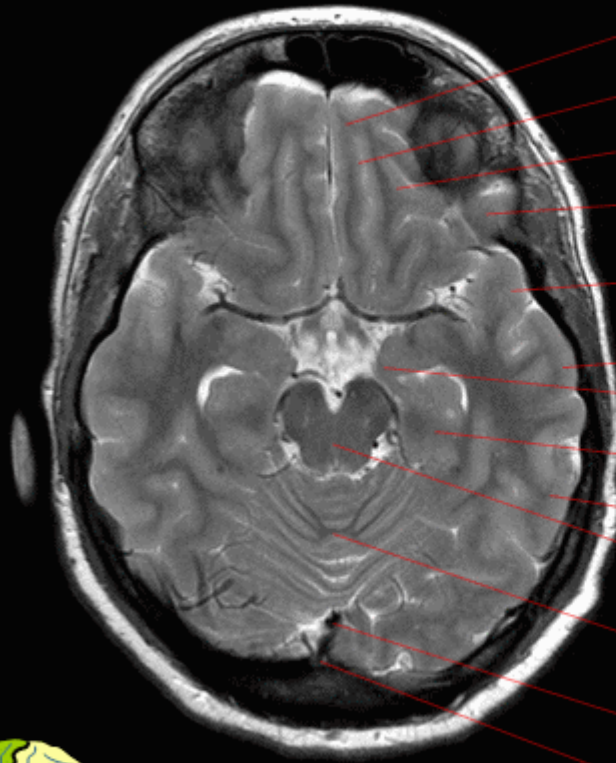
## Brain Axial T2



- Gyrus rectus
- Olfactory sulcus
- Orbital gyrus
- Superior temporal gyrus
- Uncus
- Temporal horn of lateral ventricle
- Parahippocampal gyrus
- Middle temporal gyrus
- Pons
- Inferior temporal gyrus
- Transverse sinus
- Cerebellum
- Vermis
- Confluence of sinuses (Torcula herophili)



## Brain Axial T2



Gyrus rectus

Olfactory sulcus

Orbital gyrus

Inferior frontal gyrus

Superior temporal gyrus

Middle temporal gyrus

Uncus

Parahippocampal gyrus

Inferior temporal gyrus

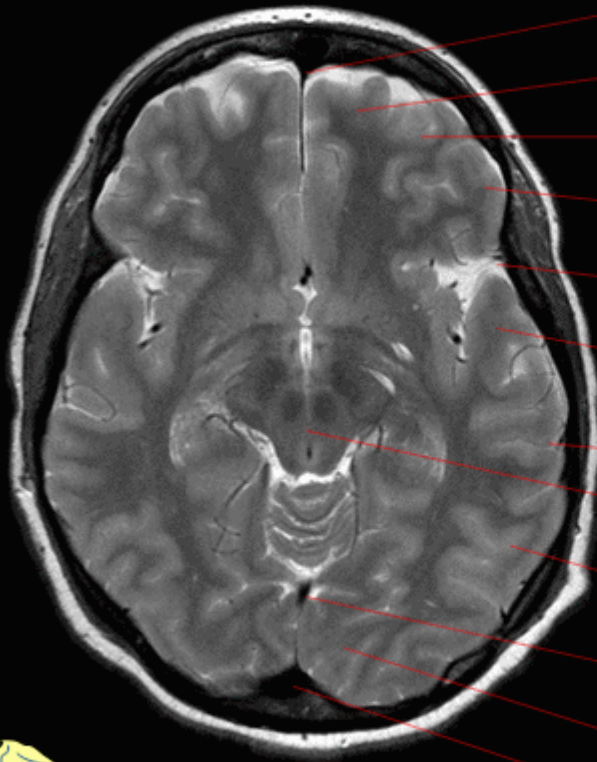
Midbrain

Vermis

Straight sinus

Superior sagittal sinus

## Brain Axial T2



Superior sagittal sinus

Superior frontal gyrus

Middle frontal gyrus

Inferior frontal gyrus

Lateral sulcus

Superior temporal gyrus

Middle temporal gyrus

Midbrain

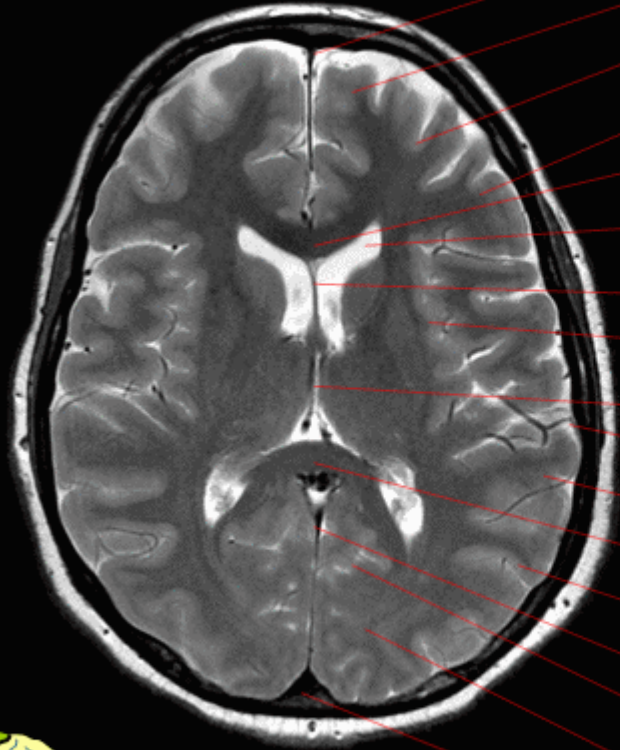
Inferior temporal gyrus

Straight sinus

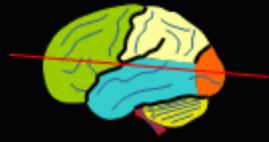
Occipital lobe

Superior sagittal sinus

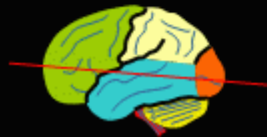
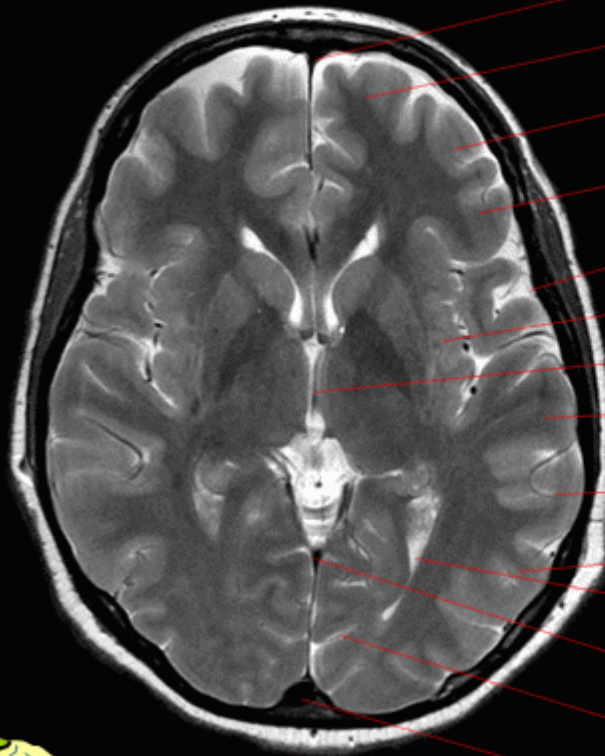
## Brain Axial T2



- Superior sagittal sinus
- Superior frontal gyrus
- Middle frontal gyrus
- Inferior frontal gyrus
- Genu of corpus callosum
- Frontal horn of lateral ventricle
- Septum pellucidum
- Insula
- Third ventricle
- Lateral sulcus
- Superior temporal gyrus
- Splenium of corpus callosum
- Middle temporal gyrus
- Straight sinus
- Parietooccipital sulcus
- Occipital lobe
- Superior sagittal sinus

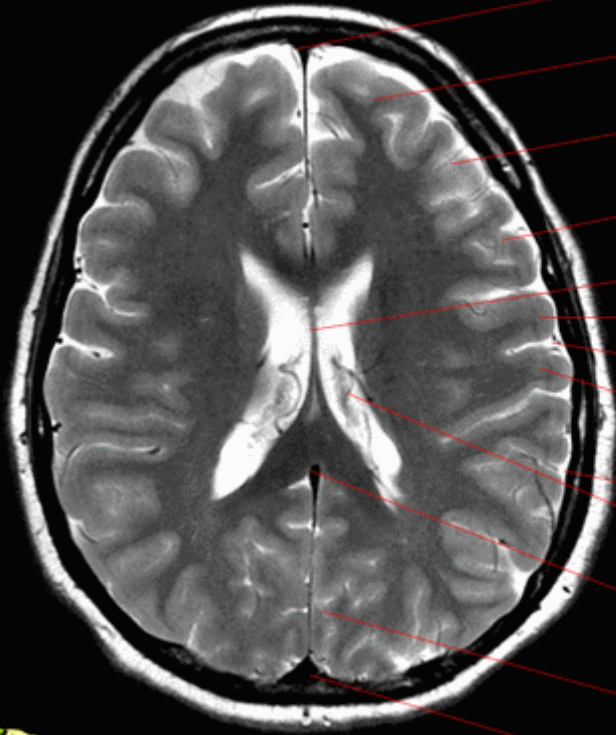


## Brain Axial T2



- Superior sagittal sinus
- Superior frontal gyrus
- Middle frontal gyrus
- Inferior frontal gyrus
- Lateral sulcus
- Insula
- Third ventricle
- Superior temporal gyrus
- Middle temporal gyrus
- Inferior temporal gyrus
- Occipital horn of lateral ventricle
- Straight sinus
- Calcarine sulcus
- Superior sagittal sinus

## Brain Axial T2



Superior sagittal sinus

Superior frontal gyrus

Middle frontal gyrus

Inferior frontal gyrus

Septum pellucidum

Precentral gyrus

Central sulcus

Postcentral gyrus

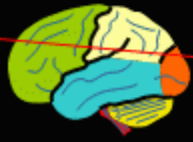
Lateral sulcus

Choroid plexus

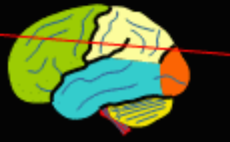
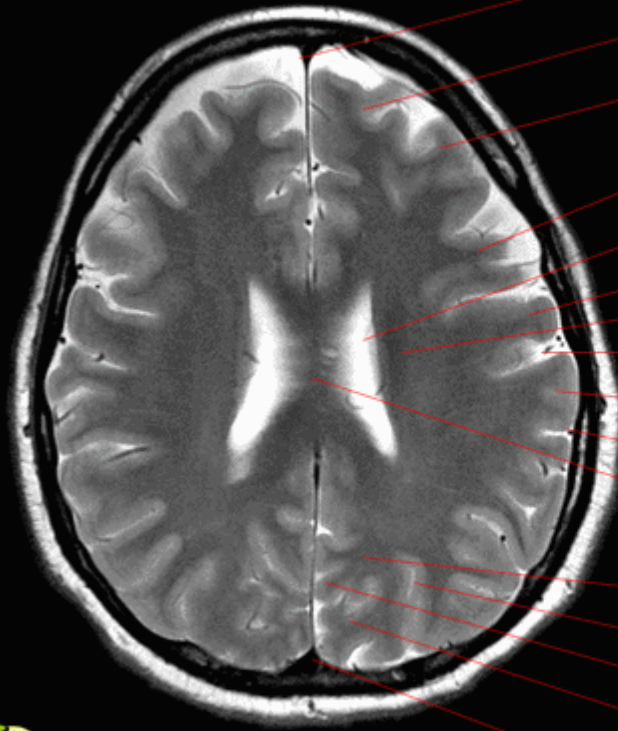
Inferior sagittal sinus

Parietooccipital sulcus

Superior sagittal sinus



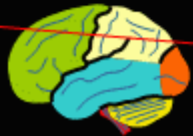
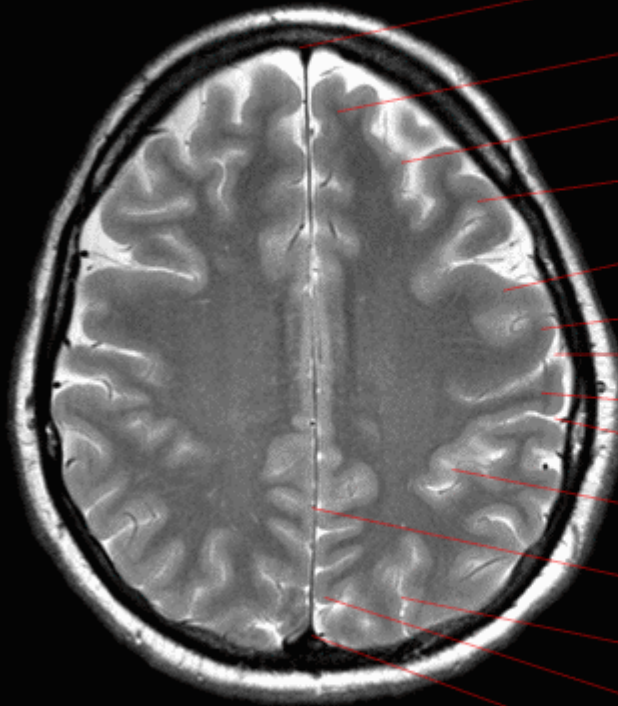
## Brain Axial T2



- Superior sagittal sinus
- Superior frontal gyrus
- Middle frontal gyrus
- Inferior frontal gyrus
- Body of lateral ventricle
- Precentral gyrus
- Corona radiata
- Central sulcus
- Postcentral gyrus
- Postcentral sulcus
- Body of corpus callosum
- Precuneus
- Intraparietal sulcus
- Parietooccipital sulcus
- Cuneus
- Superior sagittal sinus

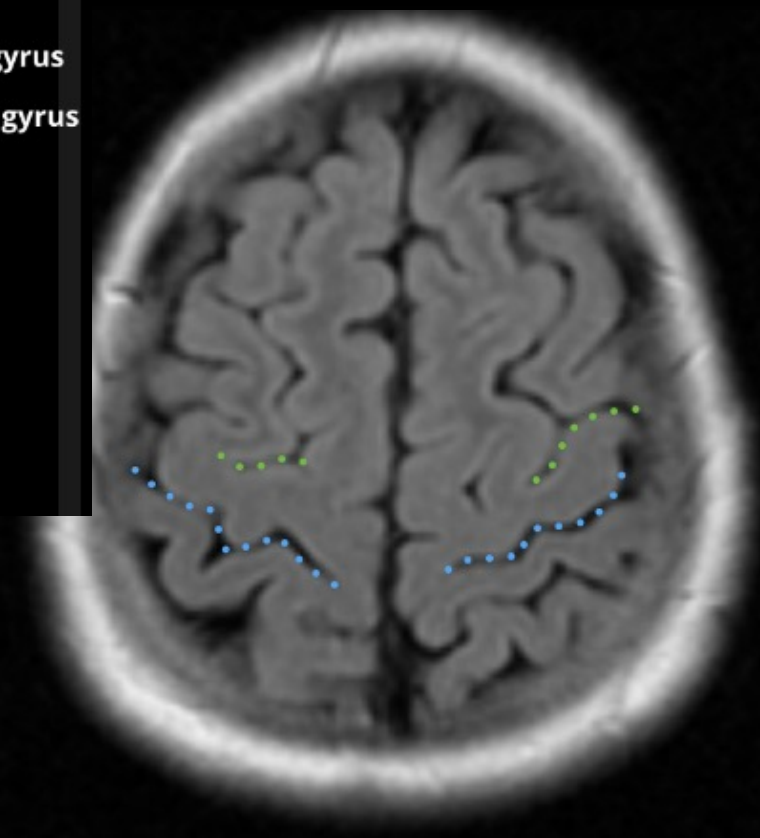
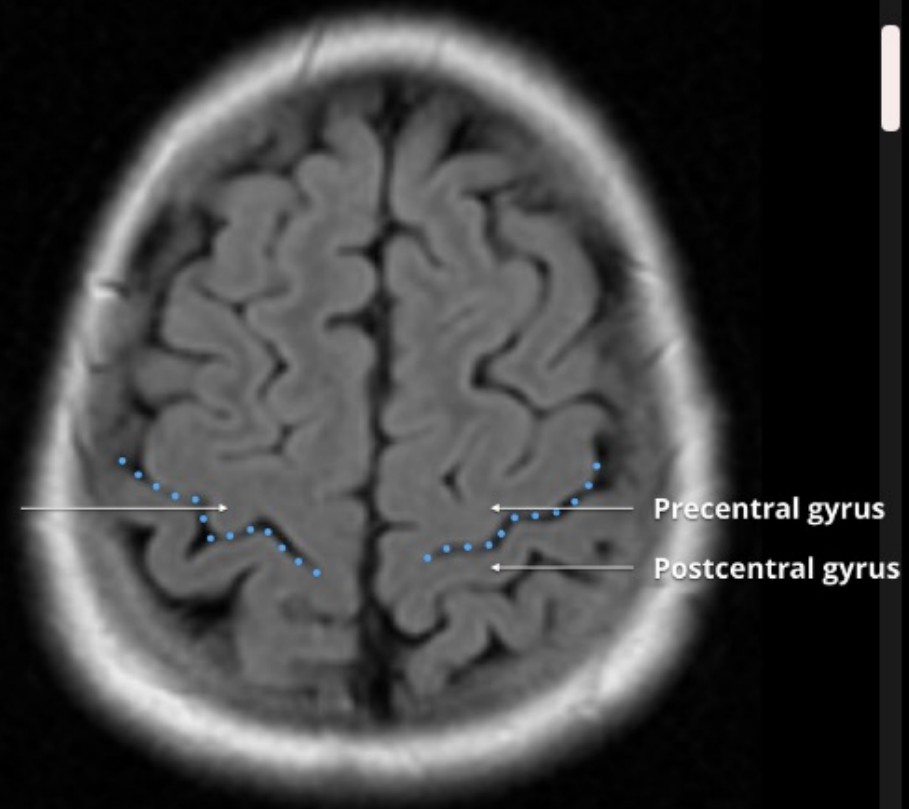


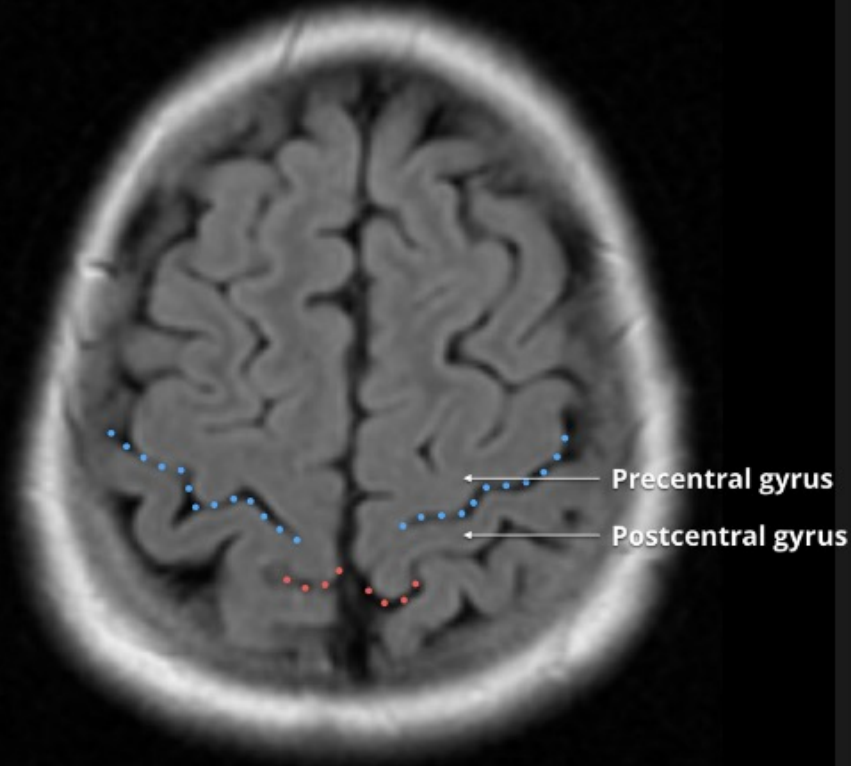
## Brain Axial T2



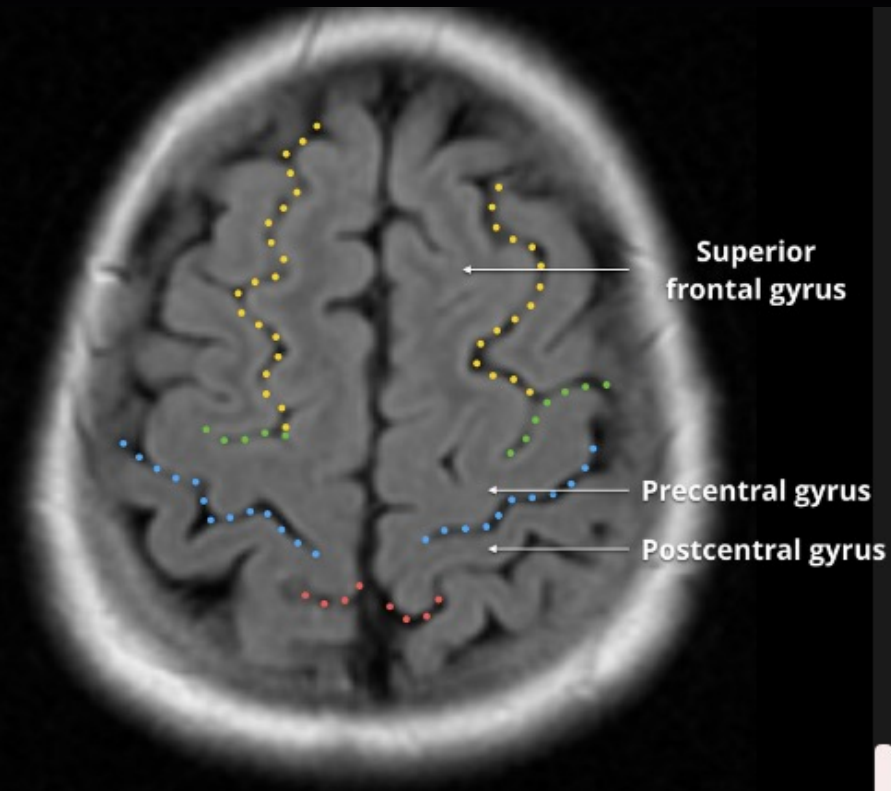
- Superior sagittal sinus
- Superior frontal gyrus
- Superior frontal sulcus
- Middle frontal gyrus
- Inferior frontal gyrus
- Precentral gyrus
- Central sulcus
- Postcentral gyrus
- Postcentral sulcus
- Intraparietal sulcus
- Interhemispheric fissure
- Intraparietal sulcus
- Parietooccipital sulcus
- Superior sagittal sinus







Central sulcus and Marginal sulcus



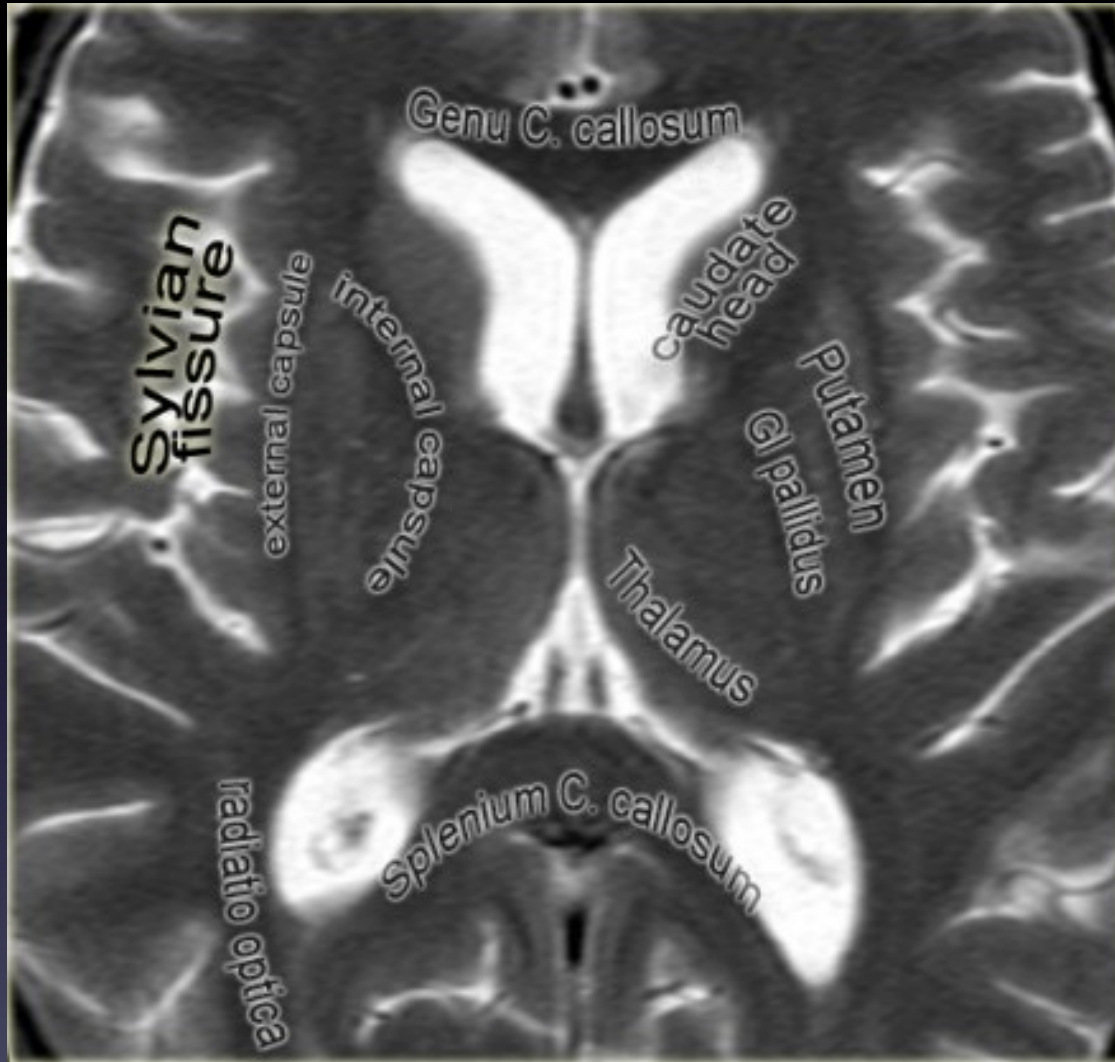
Central sulcus, Marginal sulcus, Precentral sulcus and Superior Frontal sulcus



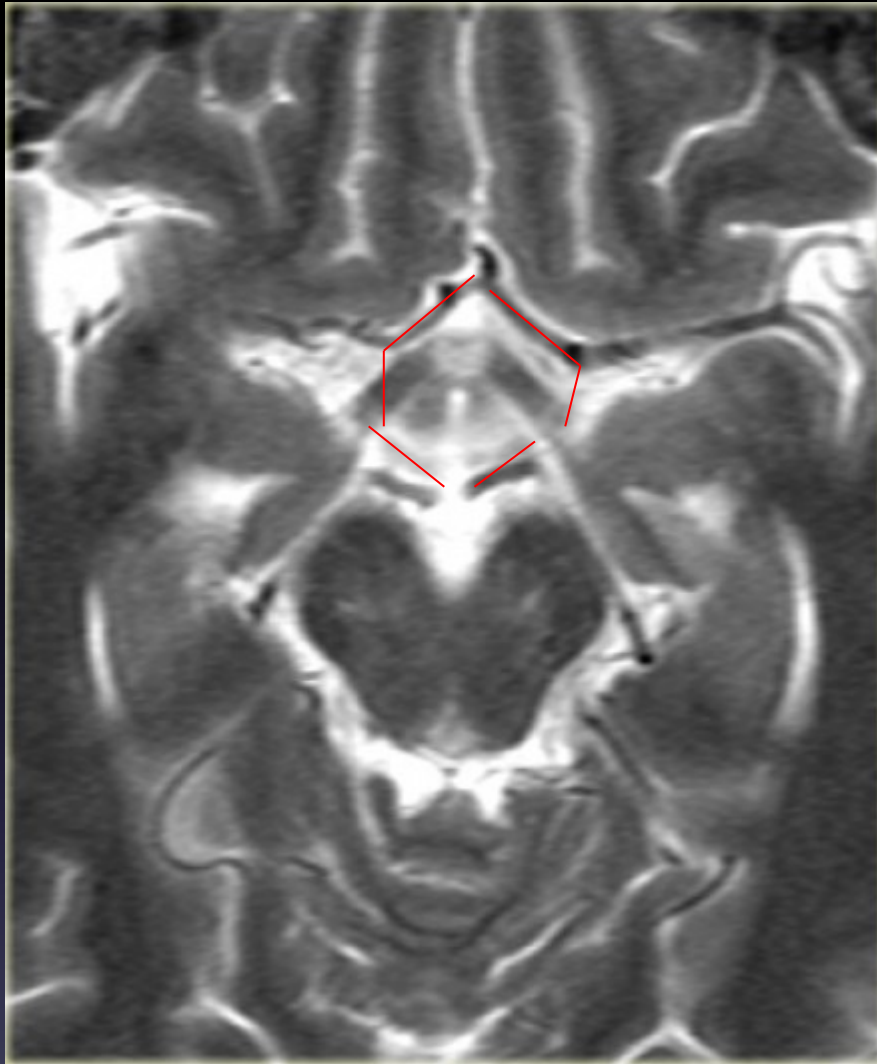
## Brain Sagittal T1

- Superior sagittal sinus
- Frontal lobe
- Parietal lobe
- Corpus callosum
- Precuneus
- Parieto-occipital fissure
- Cuneus
- Calcarine sulcus
- Lingual gyrus
- Straight sinus
- Cerebellum
- Brainstem
- Straight gyrus
- Spinal cord

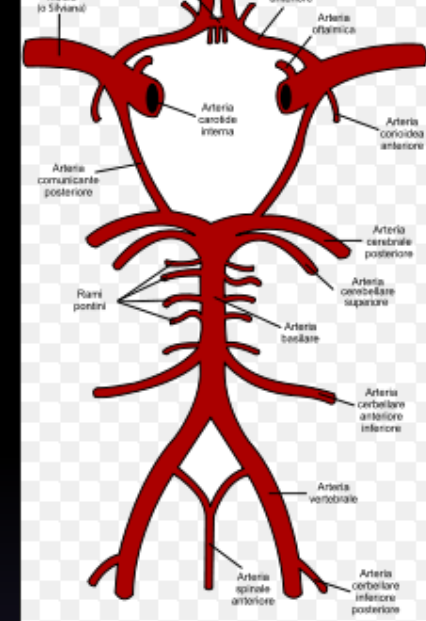
# Basal ganglia







## Circle of Willis



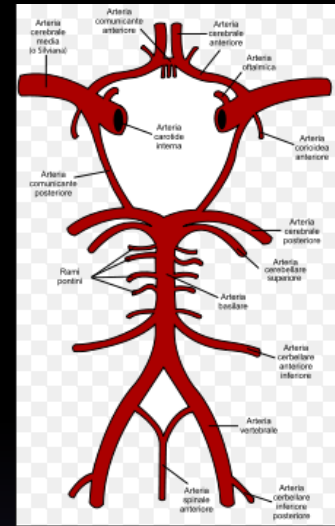
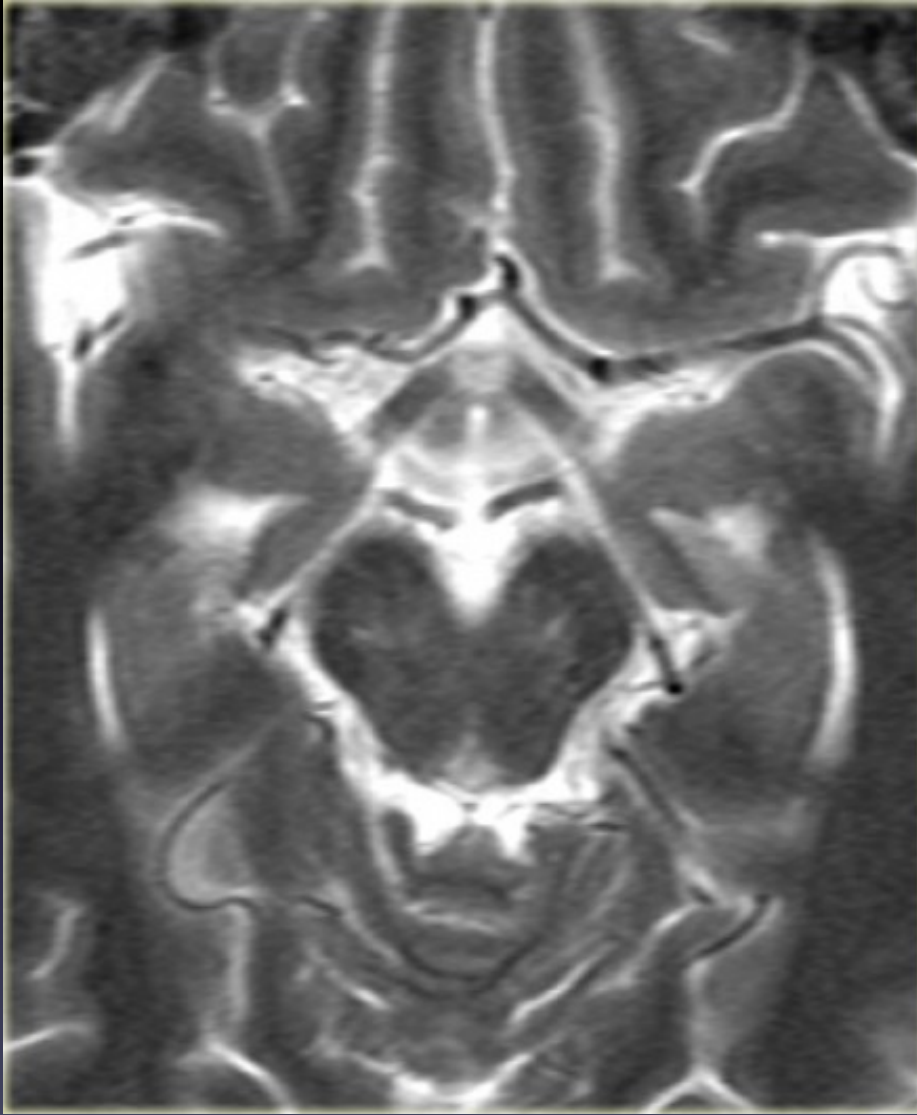
- **A1-segment**  
Anterior cerebral artery from carotid bifurcation to anterior communicating artery gives rise to the medial lenticulostriate arteries.
- **A2-segment**  
Part of anterior cerebral artery distal to the anterior communicating artery.
- **Cisterna ambiens**  
Also called ambient cistern is a cistern of the subarachnoid space between the posterior end of the corpus callosum and the superior surface of the cerebellum.

♂



♂





## P1-segment

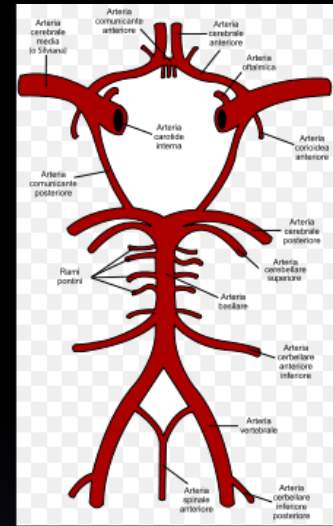
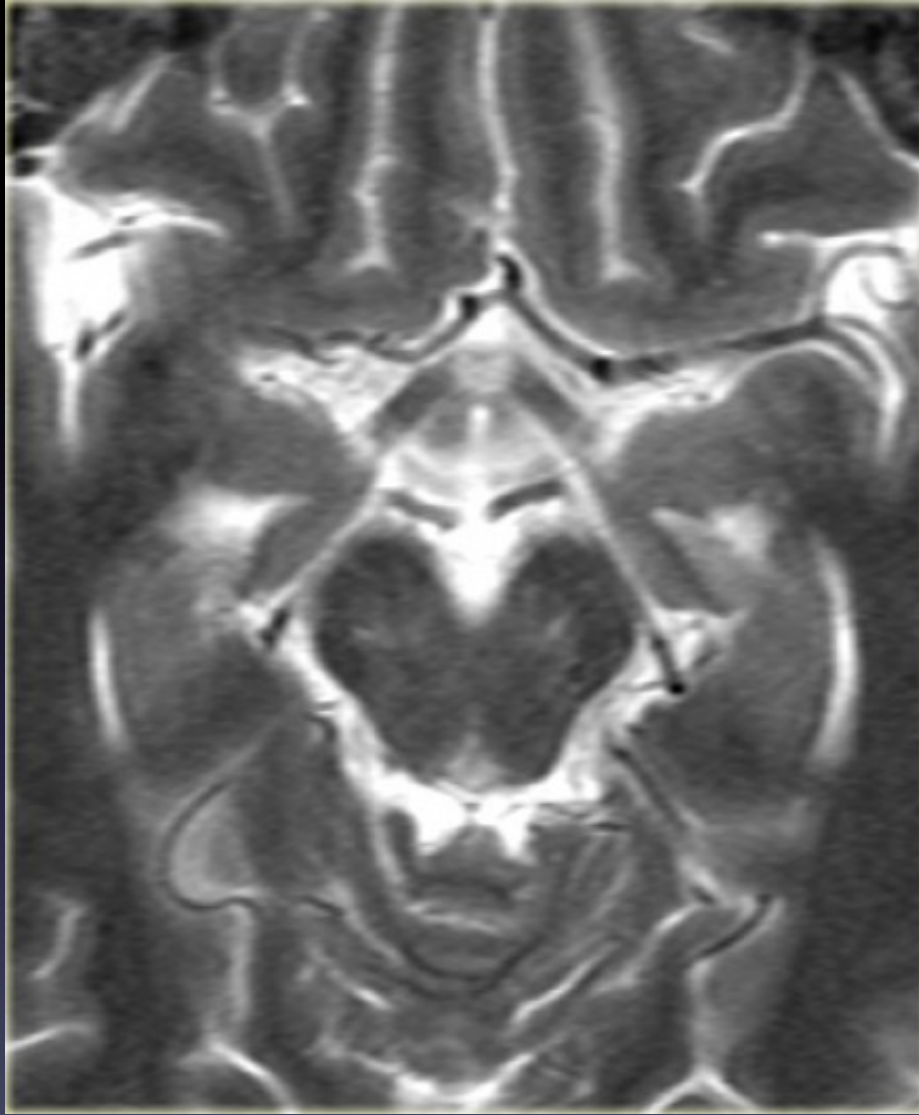
Part of the posterior cerebral artery proximal to the posterior communicating artery.

The posterior communicating artery is between the carotid bifurcation and the posterior cerebral artery)

## P2-segment

Part of the posterior cerebral artery distal to the posterior communicating artery

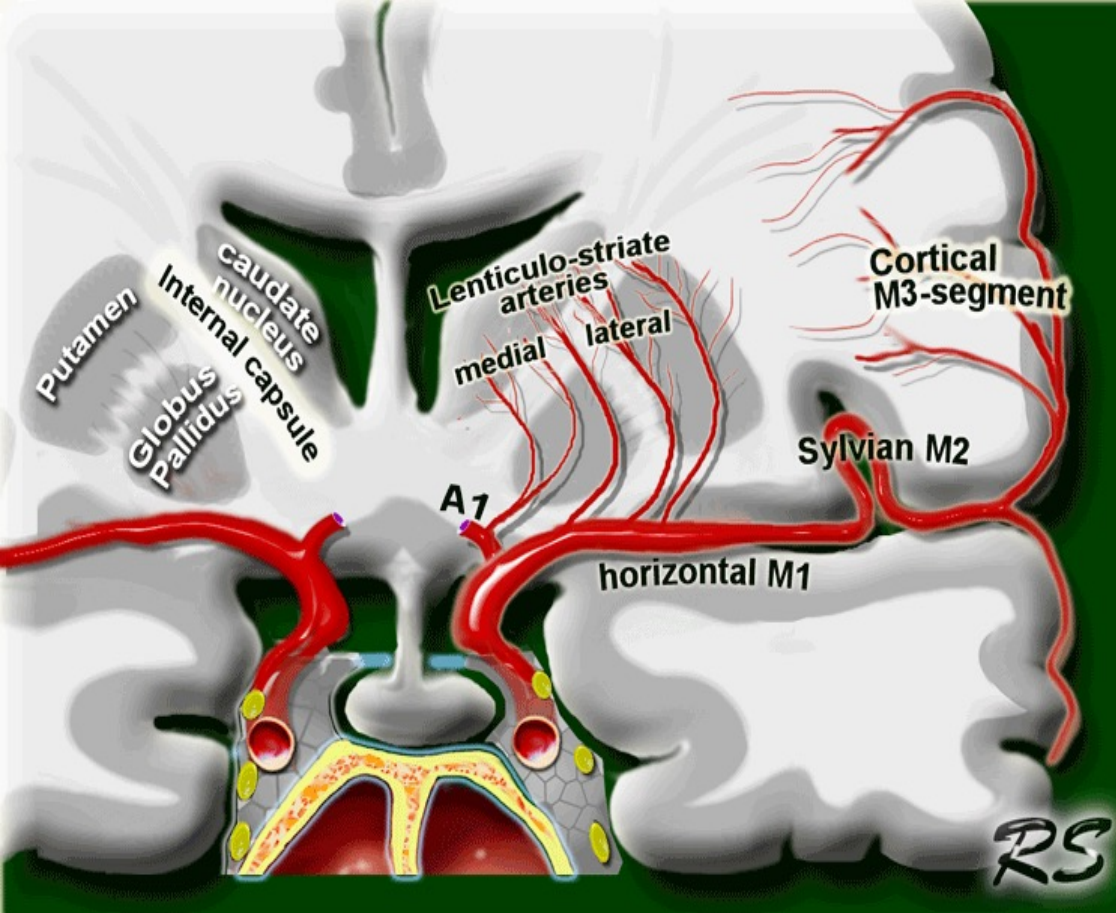




## M<sub>1</sub>-segment

Horizontal part of the middle cerebral artery which gives rise to the lateral lenticulostriate arteries which supply most of the basal ganglia.

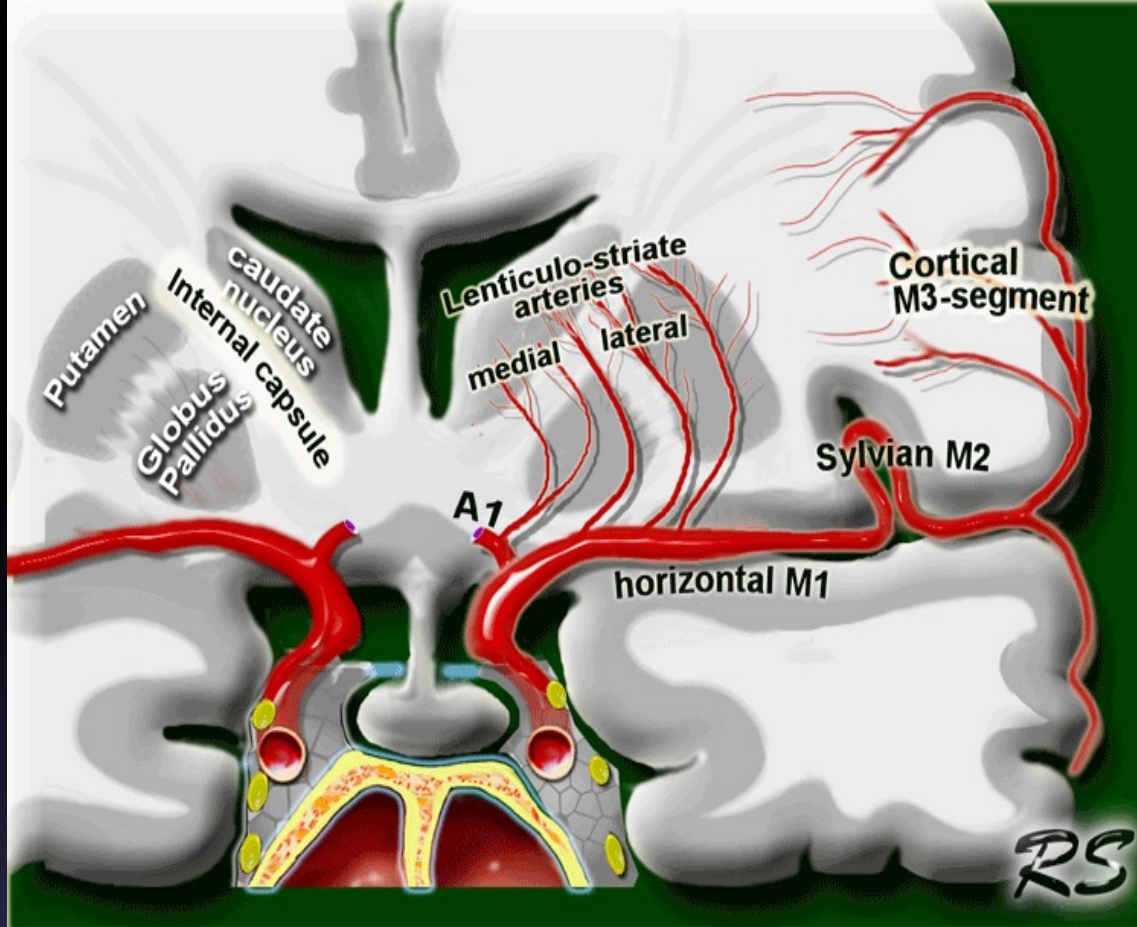
The M<sub>2</sub>-segment is the part in the sylvian fissure and the M<sub>3</sub>-segment is the cortical segment.



### Horizontal M1-segment

gives rise to the *lateral* lenticulostriate arteries which supply part of head and body of caudate, globus pallidus, putamen and the posterior limb of the internal capsule.

Notice that the *medial* lenticulostriate arteries arise from the A1-segment of the anterior cerebral artery.



### **Sylvian M2-segment**

Branches supply the temporal lobe and insular cortex (sensory language area of Wernicke), parietal lobe (sensory cortical areas) and inferolateral frontal lobe

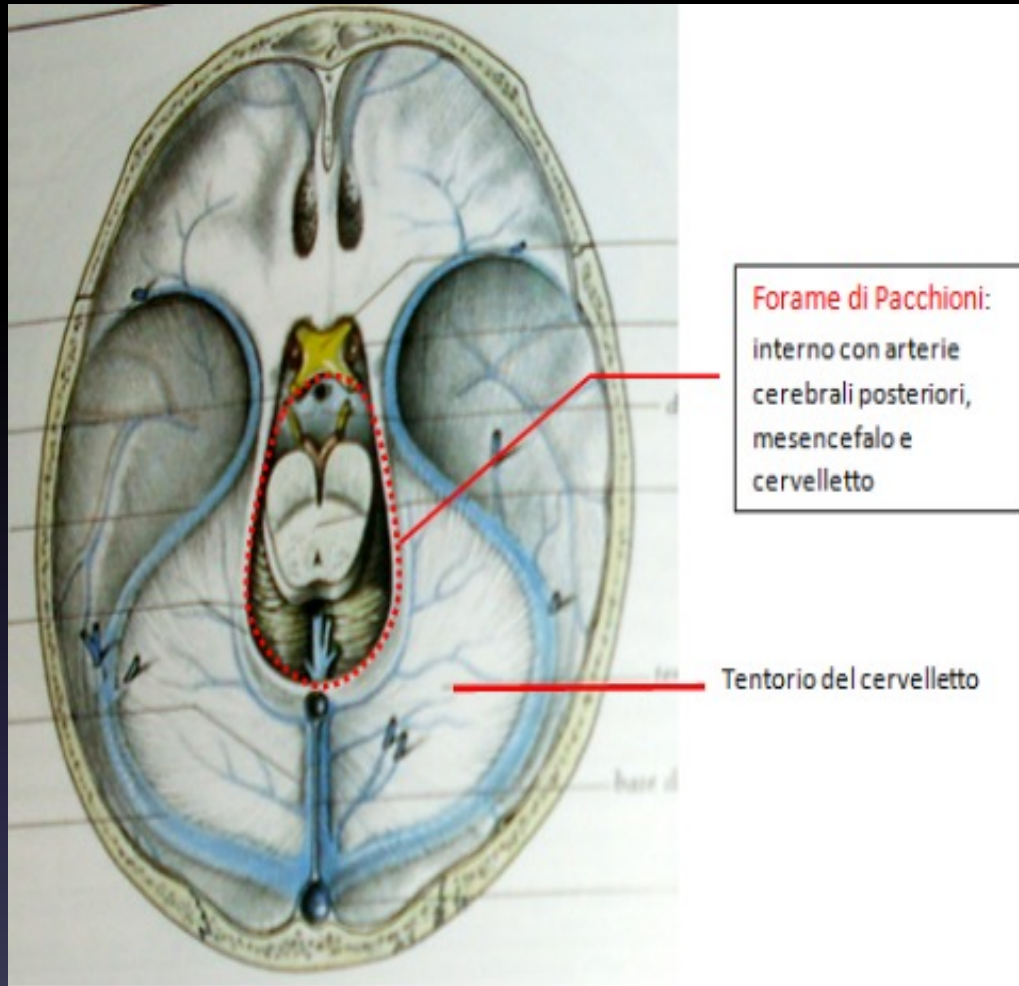
### **Cortical M3-segment**

Branches supply the lateral cerebral cortex

# TUMORI CEREBRALI

# TUMORI ENDOCRANICI

- SOPRATENTORIALI
  - SOTTOTENTORIALI
  - INTRA-ASSIALI
  - EXTRA-ASSIALI
- 
- TUMORI PRIMITIVI
  - TUMORI SECONDARI



- il tentorio cerebellare separa la fossa cranica posteriore dagli emisferi cerebrali

- Intrassiali: originano e si sviluppano nel tessuto encefalico
- Extrassiali: si sviluppano al di fuori del tessuto cerebrale



# TUMORI INTRASSIALI

- Tumori astrocitari: pilocitico, astrocitoma, a. anaplastico, glioblastoma multiforme
- Oligodendrogliali: oligodendroglioma
- T. ependimali e pl. coriodei: ependimoma, papilloma dei plessi, carcinoma dei plessi
- T. pineali
- T. neuronali: gangliocitoma
- T. scarsam. differenziati- embrionari: gliomatosi, medulloblastoma
- Linfoma primitivo
- T. vascolari: emangioblastoma
- T. a cellule germinali: teratoma
- Metastasi

# ASTROCITOMA

- PIU' FREQUENTE DEI NEUROGLIALI
- PIU' FREQUENTE IN ETA' PEDIATRICA
- SEDI: TRONCO ENCEFALICO (> FREQUENZA), POI EMISFERI CEREBELLARI E VERME
- RARO NELL'ADULTO
- PER LO PIU' PILOCITICO, FORME FIBRILLARI E ANAPLASTICHE IN NEUROFIBROMATOSI
- RM: LESIONI SOLIDE DISOMOGENEE
- MDC: VARIABILE

# TUMORI INTRASSIALI SOTTOTENTORIALI

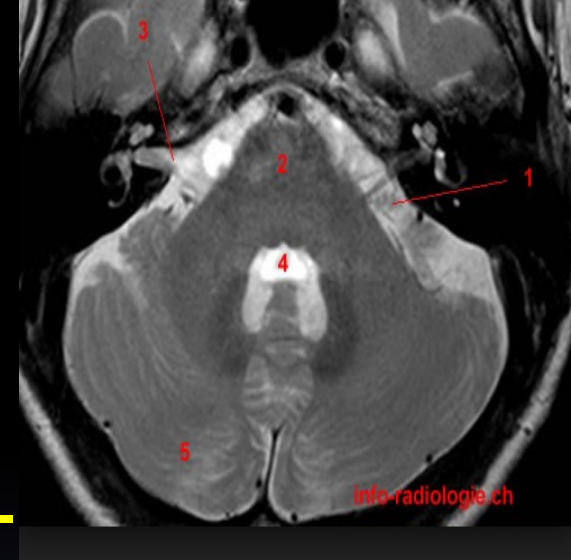
- NELL'ADULTO SONO PIU' RARI (25-30%) DEI TUMORI ENDOCRANICI, RISPETTO ALL'ETA' PEDIATRICA (50%)
- I PIU' COMUNI SONO METASTASI, MOLTO PIU' RARE LE ALTRE FORME

# **TUMORI EXTRASSIALI**

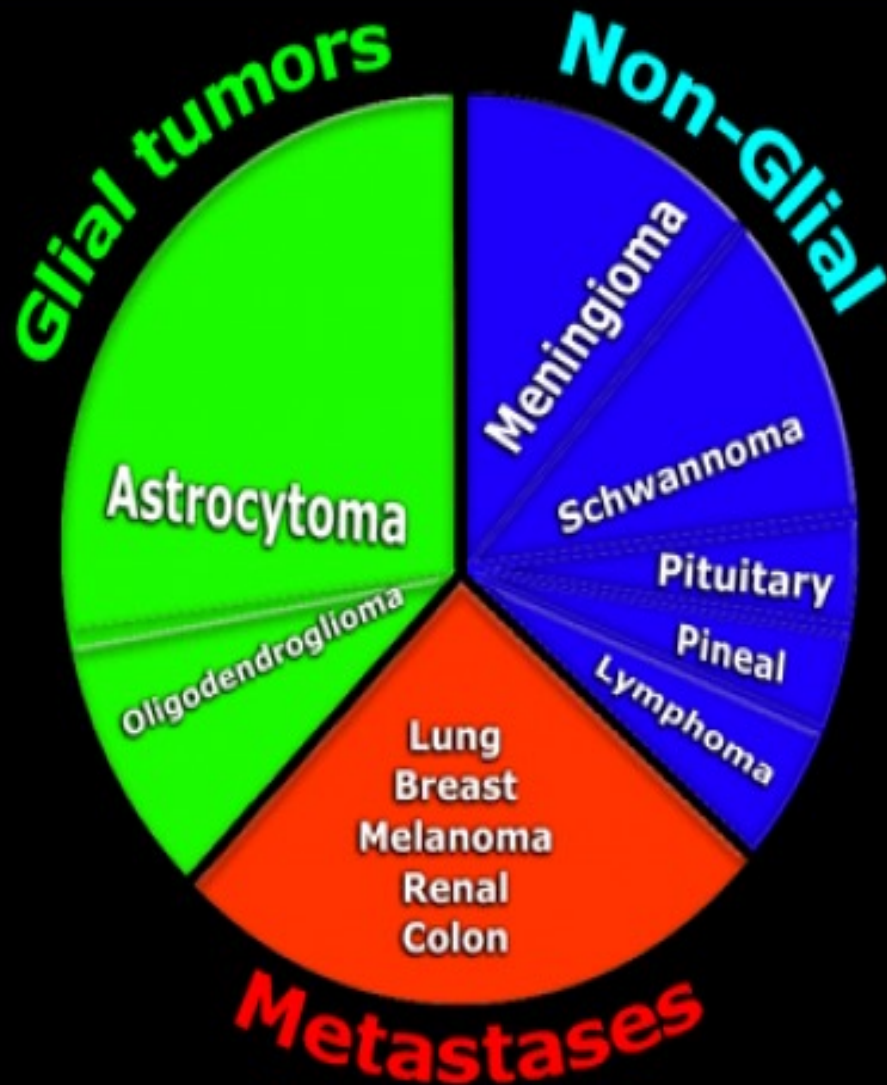
- **I TUMORI EXTRASSIALI ENDOCRANICI, A DIFFERENZA DI QUELLI INTRAASSIALI SONO GENERALMENTE DI NATURA BENIGNA E PER LA LORO SEDE SONO MOLTO SPESSO SUSCETTIBILI DI TERAPIA CHIRURGICA RADICALE.**

# TUMORI E PSEUDOTUMORI DELL'APC

- SCHWANNOMI (85-90%)
- MENINGIOMI (3-7%)
- EPIDERMIOIDI E DERMIOIDI (2-6%)
- EPENDIMOMA IV VENTRICOLO (1-2%)
- GRANULOMA COLESTERINICO (1%)
- CISTI ARACNOIDEE E LIPOMI (< 1%)
- PARAGANGLIOMA (< 1%)



# Incidence of CNS tumors



Glioma is a non-specific term indicating that the tumor originates from glial cells like astrocytes, oligodendrocytes, ependymal and choroid plexus cells.

Astrocytoma is the most common glioma and can be subdivided into the low-grade pilocytic type, the intermediate anaplastic type and the high grade malignant glioblastoma multiforme (GBM).

GBM is the most common type (50% of all astrocytomas).

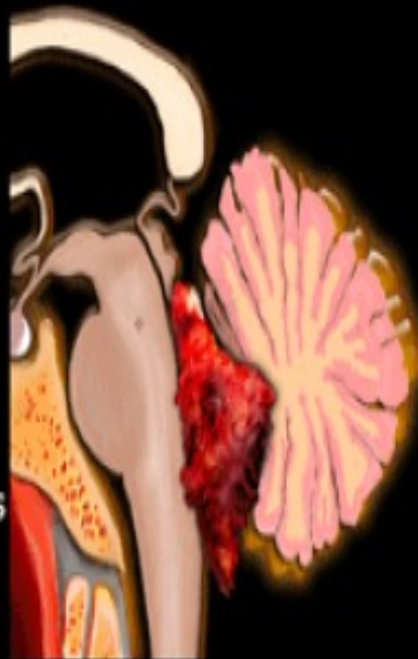
The non-glial cell tumors are a large heterogeneous group of tumors of which meningioma is the most common.

# Brain Tumor - Systematic Approach



## Analysis of a Potential Brain Tumor

- Age of the patient
- Localization
  - Intra- vs Extra-axial
  - What Compartment
  - Midline crossing
- CT and MR Characteristics
  - Calcification, Fat, Cystic
  - T1, T2, DWI
- Contrast Enhancement
- Effect on surrounding structures
  - Mass effect - Edema
- Solitary - Multiple
- Pseudotumor ?



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When we analyze a potential brain tumor, there are many questions that need to be answered:

Since different tumors occur in different **age** groups we first of all need to know the age of the patient.

# Age distribution

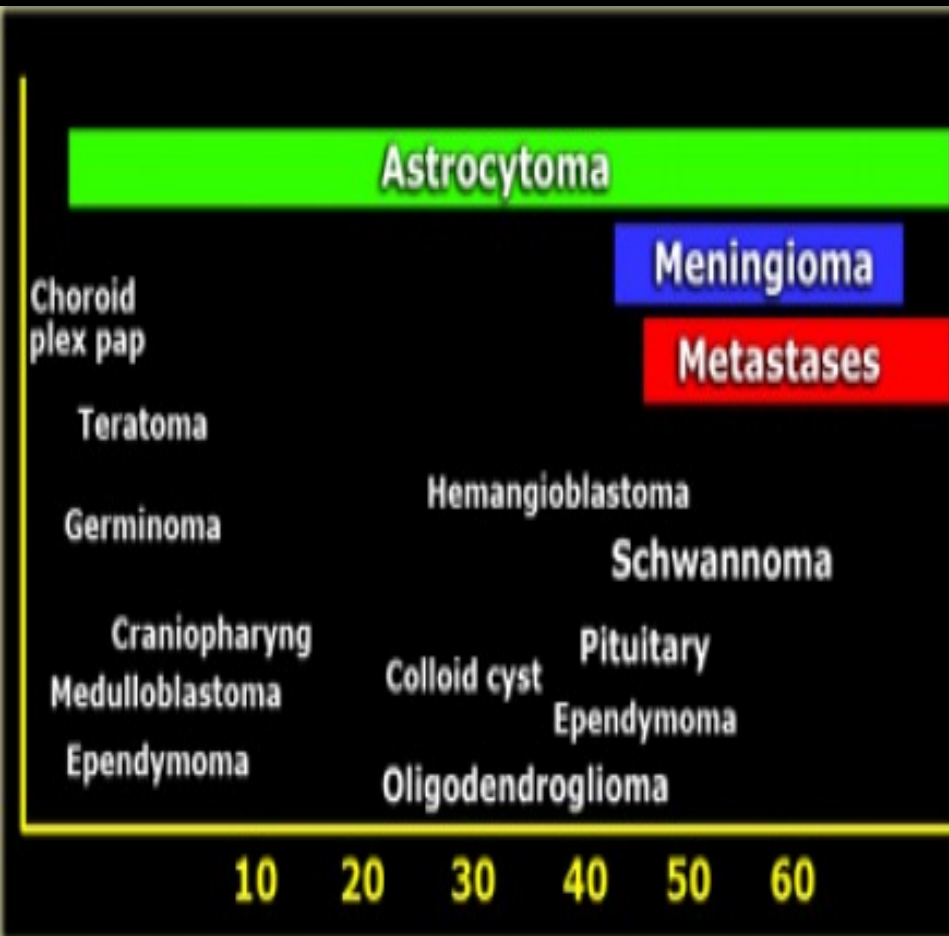
The age of the patient is an important factor for the differential diagnosis.

In the first decade medulloblastomas, astrocytomas, ependymomas, craniopharyngeomas and gliomas are most common, while metastases are very rare.

In adults about 50% of all CNS lesions are metastases.

Other common tumors in adults are astrocytomas, glioblastoma multiforme, meningiomas, oligodendrogliomas, pituitary adenomas and schwannomas.

Astrocytomas occur at any age, but glioblastoma multiforme is mostly seen in older people.



## Common Intra-Axial Tumors in Pediatric

### Supratentorial:

Astrocytoma  
Pleomorphic xanthoastro (PXA)  
PNET  
DNET  
Ganglioglioma

### Infratentorial:

Juvenile Pilocytic Astro  
PNET (Medulloblastoma)  
Ependymoma  
Brainstem Astrocytoma

Although cancer is rare in children, brain tumors are the most common type of childhood cancer after leukemia and lymphoma. Most of the tumors in children are located infratentorially.

## Common Intra-Axial Tumors in Adult

### Supratentorial:

**Metastases ++**

Gliomas (25%)

- Fibrillary Astrocytoma
- Anaplastic Astrocytoma
- Glioblastoma Multiformi
- Oligodendroglioma

### Infratentorial:

**Metastases ++++**

Hemangioblastoma

metastases are by far the most common.

It is important to realize that 50% of metastases are solitary.

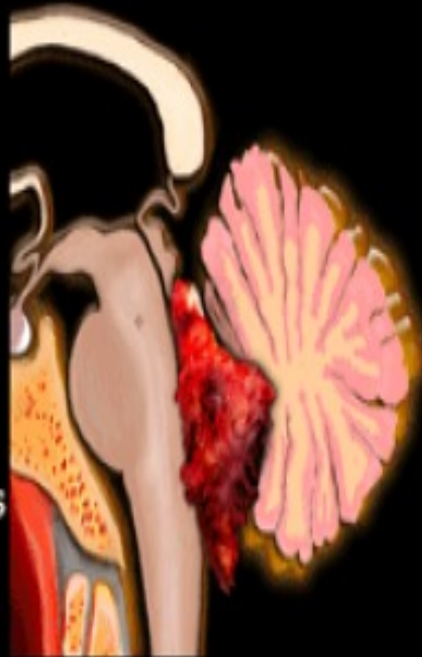
Particularly in the posterior fossa, metastases should be in the top 3 of the differential diagnostic list.

Hemangioblastoma is an uncommon tumor, but it is the most common primary intra-axial tumor in the adult.

Supratentorially, metastases are also the most common tumors, followed by gliomas.

# Analysis of a Potential Brain Tumor

- Age of the patient
- Localization
  - Intra- vs Extra-axial
  - What Compartment
  - Midline crossing
- CT and MR Characteristics
  - Calcification, Fat, Cystic
  - T1, T2, DWI
- Contrast Enhancement
- Effect on surrounding structures
  - Mass effect - Edema
- Solitary - Multiple
- Pseudotumor ?



Next we need to know where the lesion is **located** - is it intra- or extra-axial and in what anatomical compartment does it lie? Is it located in the sellar or pontocerebellar region for example?

# Tumor spread

## Signs of Extra-Axial Location

---

- ✓ CSF cleft
- ✓ Displaced subarachnoid vessels
- ✓ Cortical gray between mass and white matter
- ✓ Displace and expand subarachnoid space
- ✓ Broad Dural base
- ✓ Bony reaction

There is a CSF cleft (yellow arrow).

The subarachnoid vessels that run on the surface of the brain are displaced by the lesion (blue arrow).

There is gray matter between the lesion and the white matter (curved red arrow).

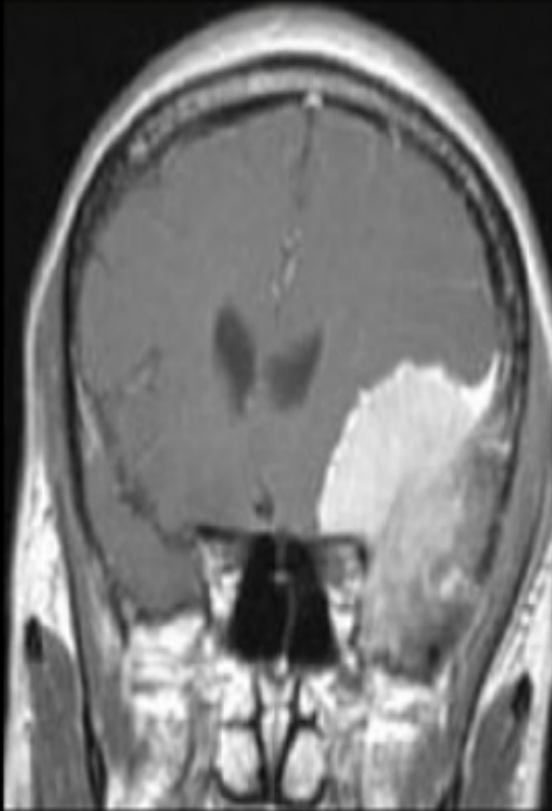
The subarachnoid space is widened because growth of an extra-axial lesion tends to push away the brain.

All these signs indicate that this is a typical extra-axial tumor.

In the region of the CPA 90% of the extra-axial tumors are schwannomas.





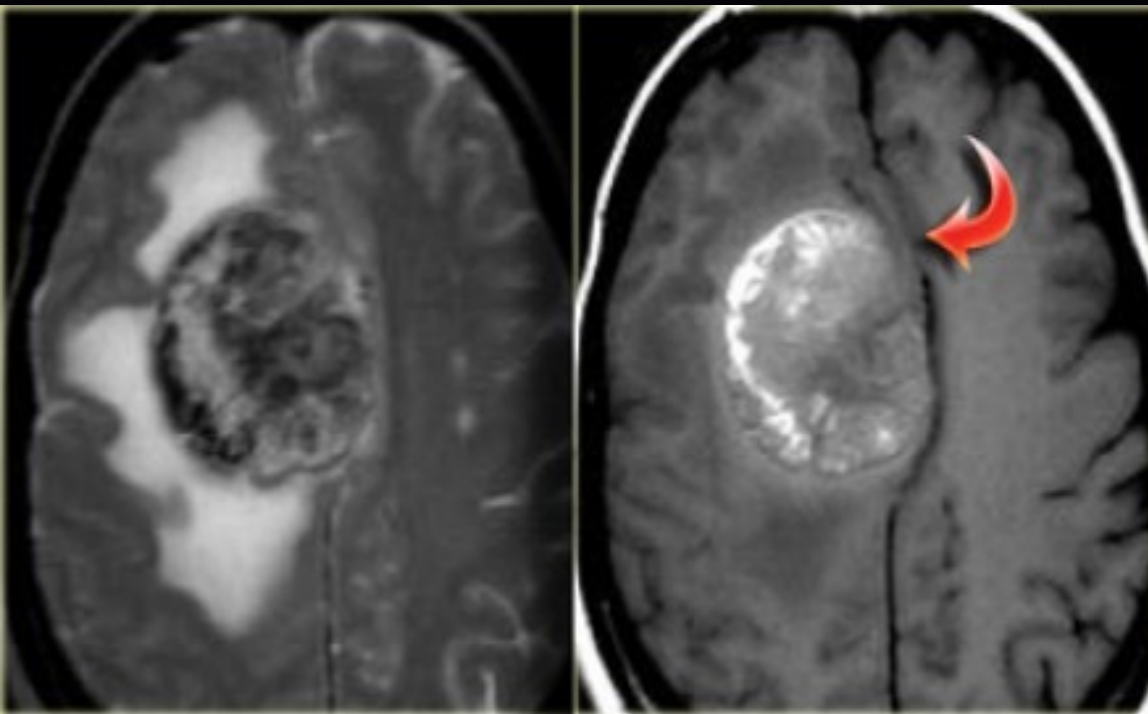


Another sign of an extra-axial origin is a broad **dural base** or a dural tail of enhancement as is typically seen in meningiomas.

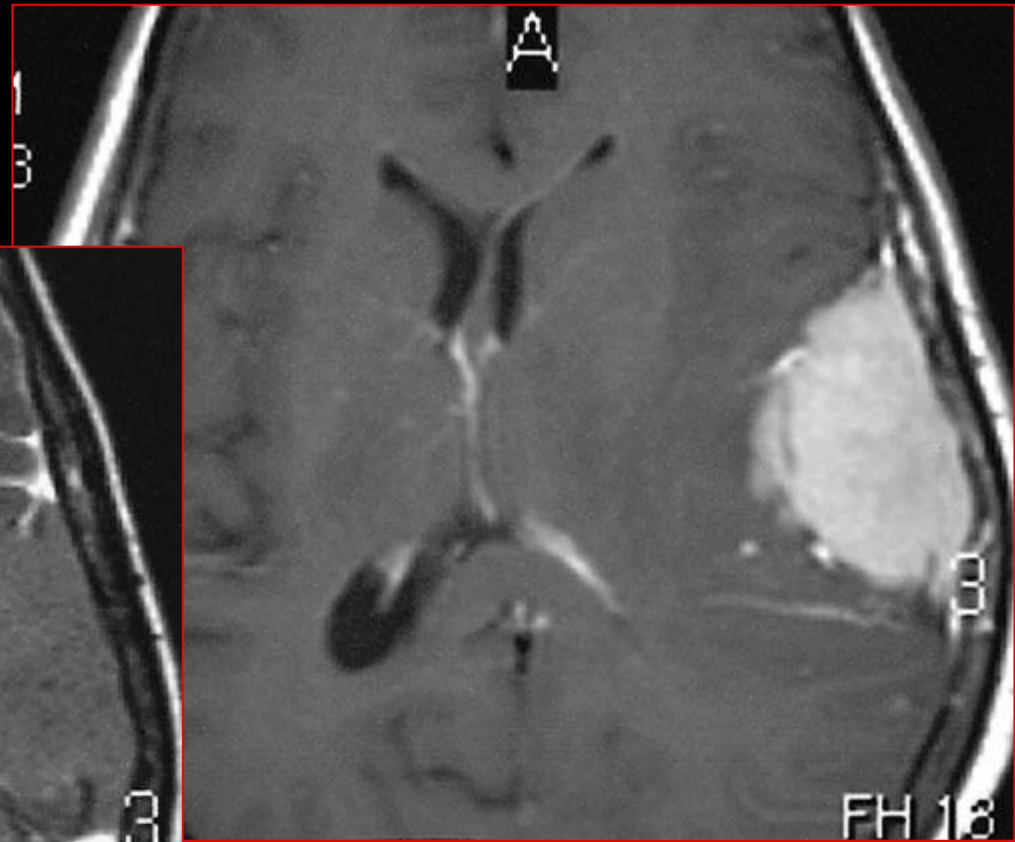
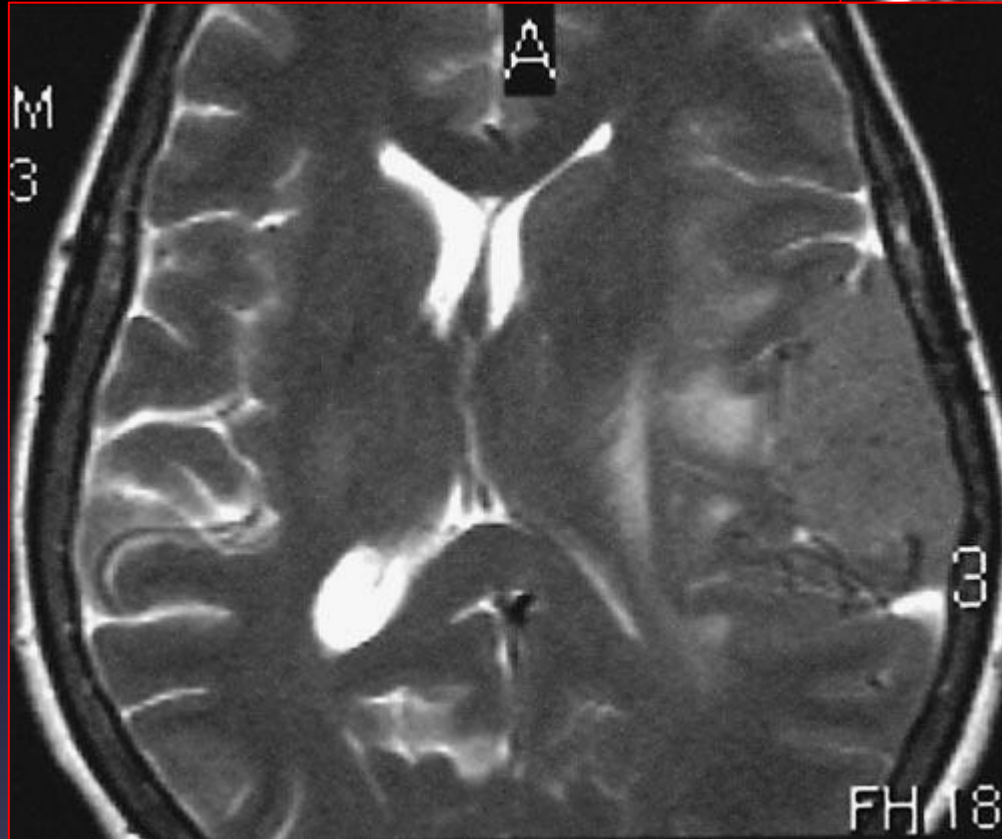
This may also occur in other extra-axial tumors, but it is less common. Another sign of an extra-axial origin are bony changes. **hyperostosis** in the adjacent bone and the lesion enhances homogeneously. Extra-axial tumors are not derived from brain tissue and do not have a blood-brain-barrier, so most of them enhance homogeneously.

## Intra- vs Extra-axial

However, there is gray matter on the anteromedial and posteromedial side of the lesion (red arrow). This indicates that the lesion is intra-axial

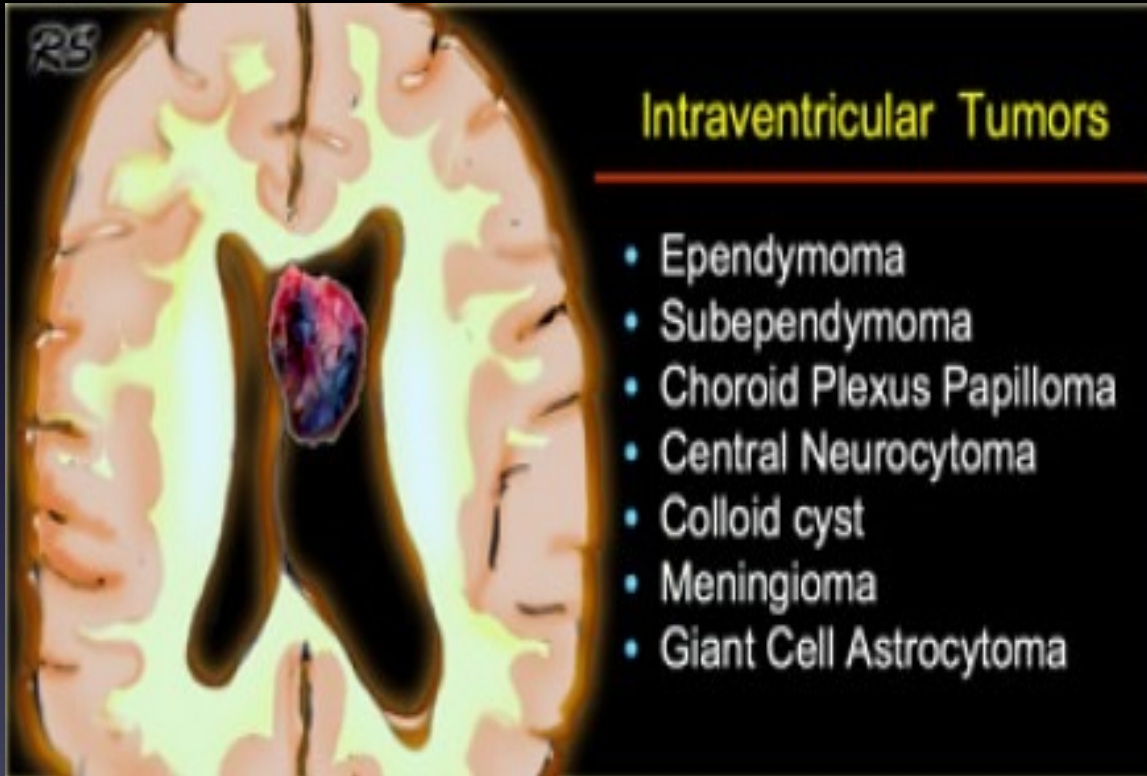


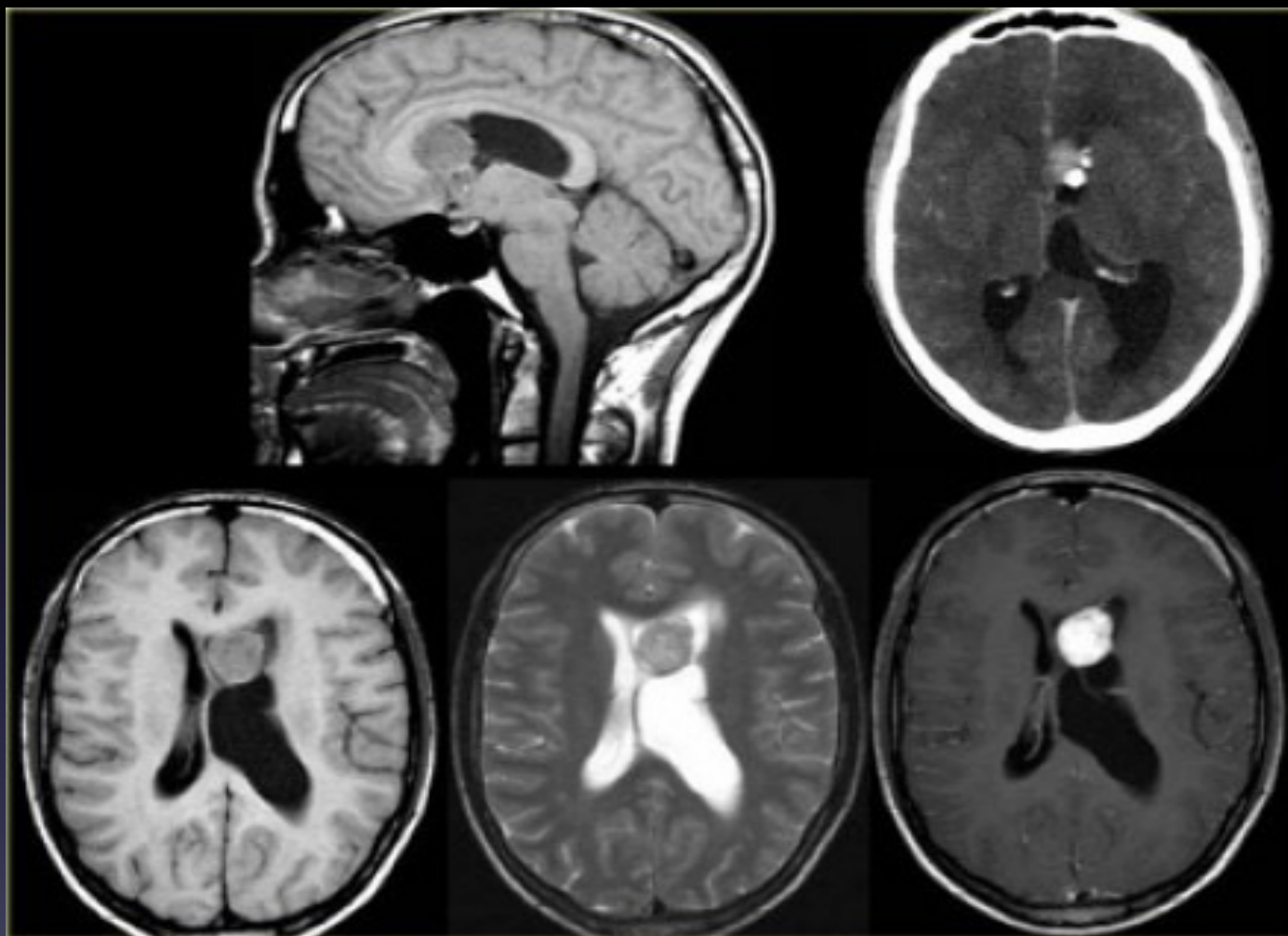
If the lesion was extra-axial the gray matter should have been pushed away. This proved to be a melanoma metastasis.



MENINGIOMA

# Intraventricular





# LOCAL SPREAD

- Another important consideration is the effect on the surrounding structures.

Primary brain tumors often have less mass effect for their size than you would expect, due to their infiltrative growth.

This is not the case with metastases and extra-axial tumors like meningiomas or schwannomas, which have more mass effect due to their expansive growth.



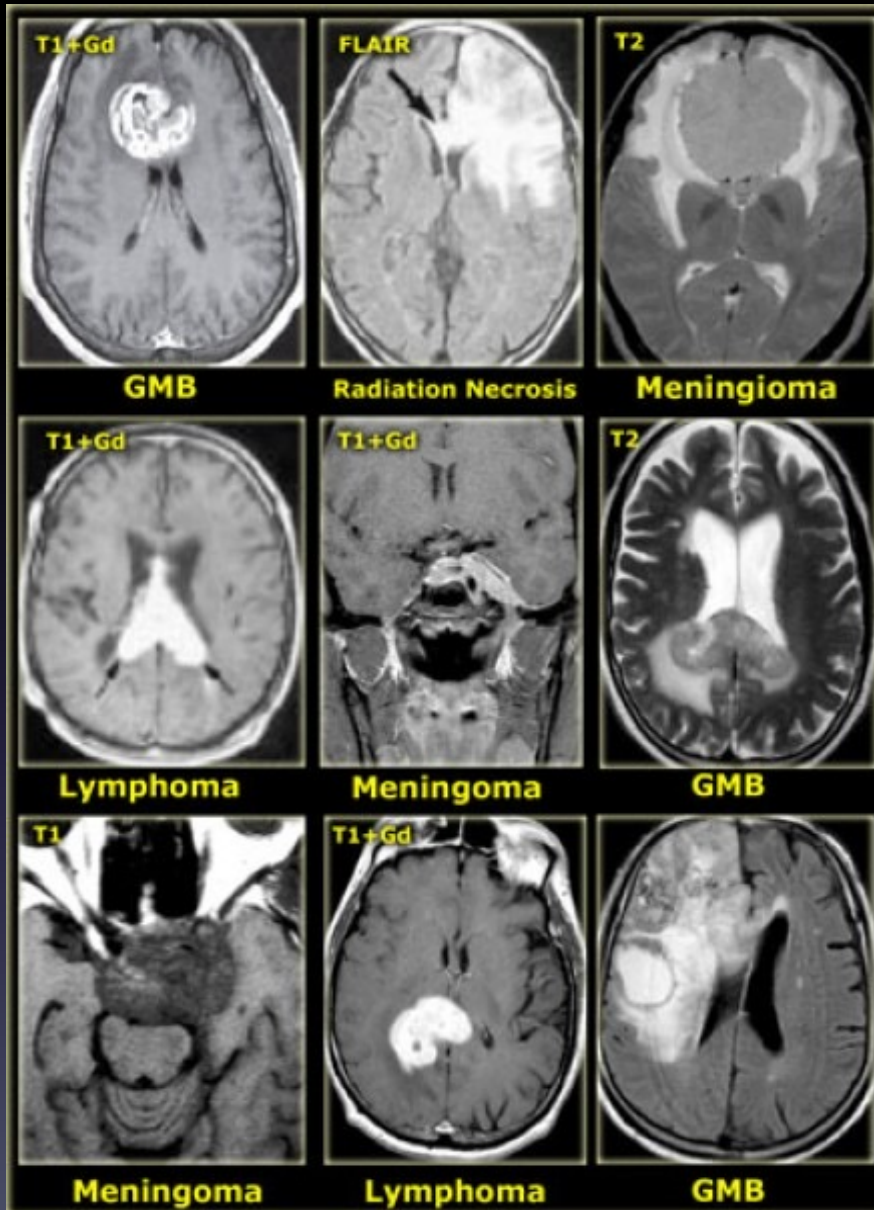


On the left is an image of a diffusely infiltrating intra-axial tumor occupying most of the right hemisphere with only a minimal mass effect.

This is typical for the infiltrative growth seen in primary brain tumors.

There is no enhancement so this would probably be a low-grade astrocytoma





## Midline crossing

The ability of tumors to cross the midline limits the differential diagnosis

## Analysis of a Potential Brain Tumor

- Age of the patient
- Localization
  - Intra- vs Extra-axial
  - What Compartment
  - Midline crossing
- CT and MR Characteristics
  - Calcification, Fat, Cystic
  - T1, T2, DWI
- Contrast Enhancement
- Effect on surrounding structures
  - Mass effect - Edema
- Solitary - Multiple
- Pseudotumor ?



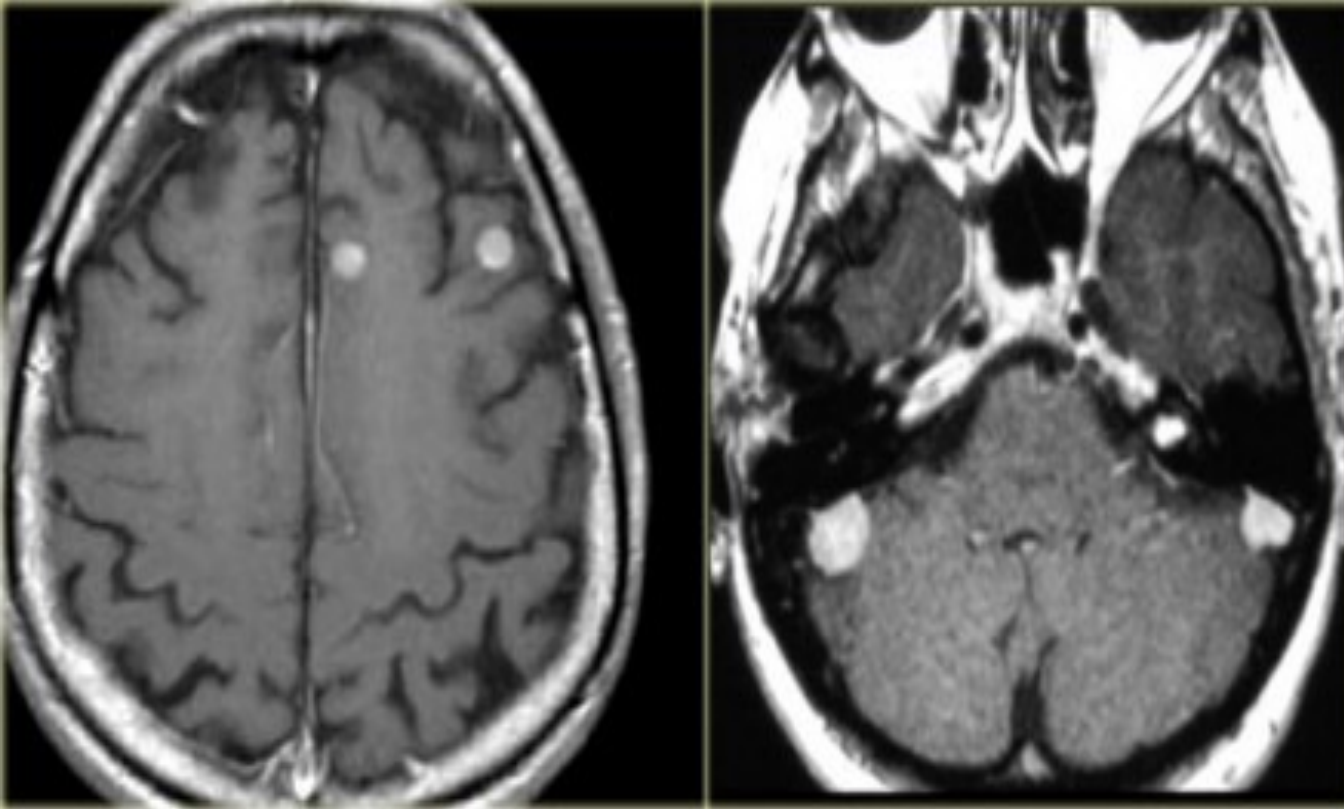
RS

On CT and MR: tissue characteristics like calcifications, fat, cystic components, contrast enhancement and signal intensity on T1WI, T2WI and DWI.

Therefore high signal intensity on T1WI or low signal on T2WI can be an important clue to the diagnosis.

Is it a **solitary** mass or is there multi-focal disease?

Finally we have to consider the possibility that we are dealing with a lesion that simulates a tumor - like an abscess, MS-plaque, vascular malformation, aneurysm or an infarct with luxury perfusion.

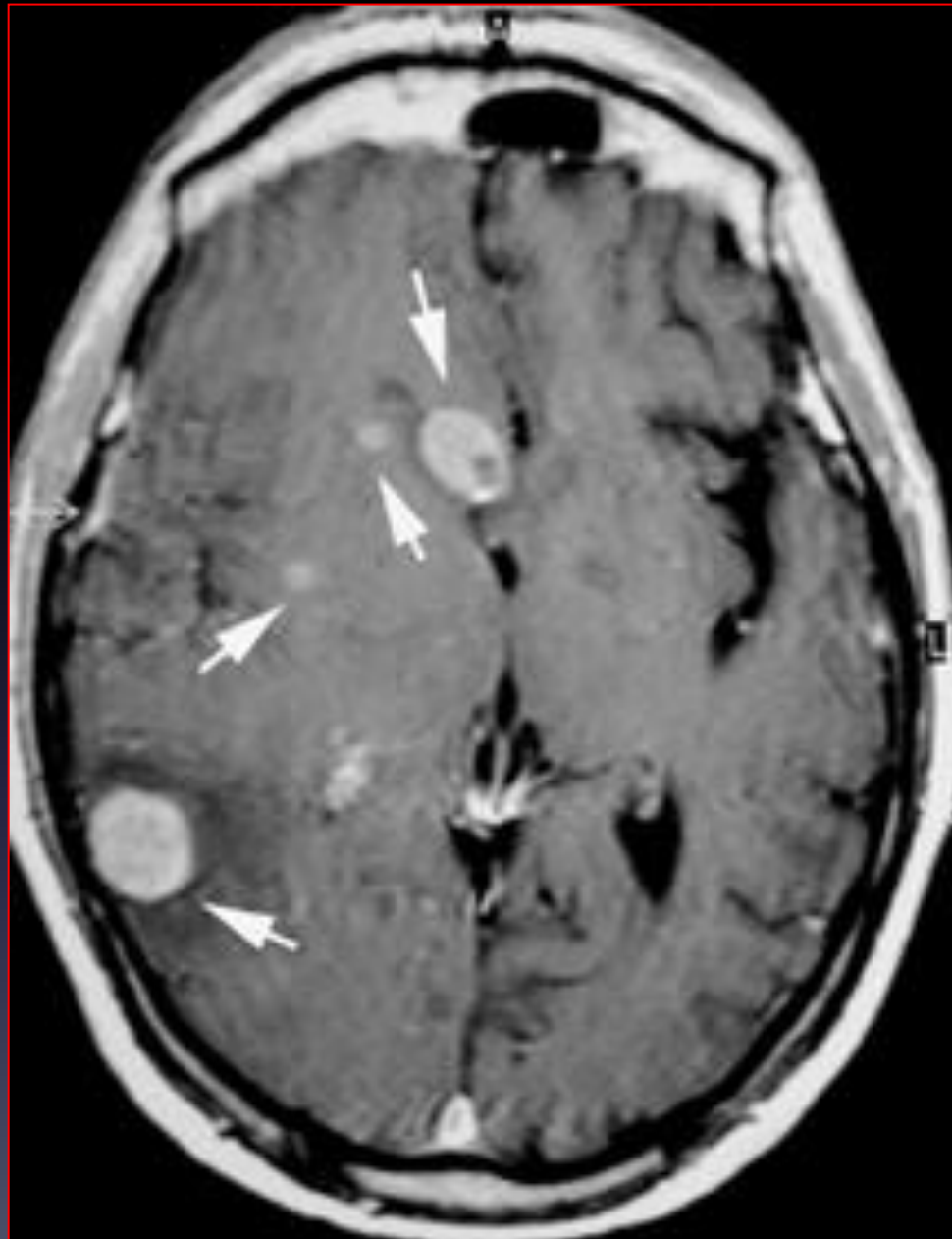


## Multifocal disease

Multiple tumors in the brain usually indicate metastatic disease.

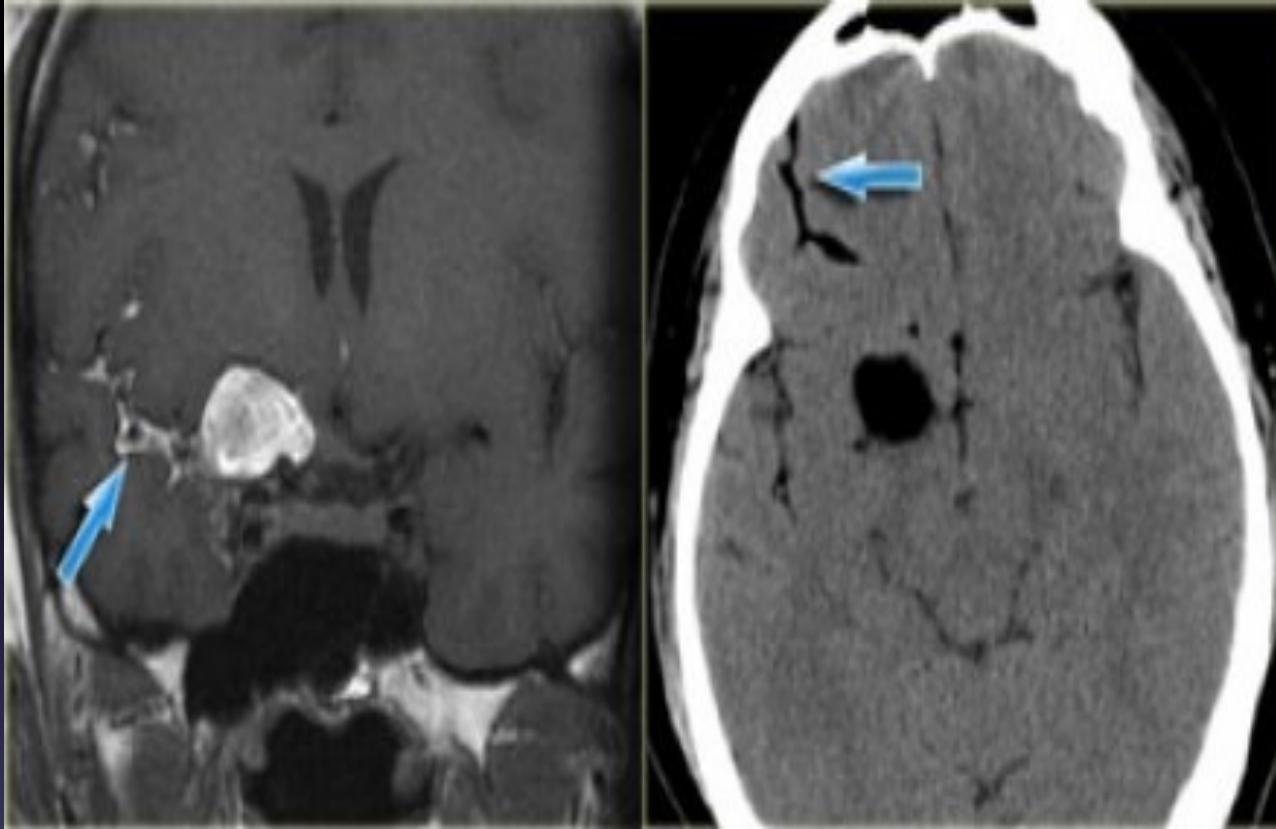
Primary brain tumors are typically seen in a single region, but some brain tumors like lymphomas, multicentric glioblastomas and gliomatosis cerebri can be multifocal.

Meningiomas and schwannomas can be multiple, especially in neurofibromatosis type II.



METASTASI

# CT and MR Characteristics



**Fat - Calcification - Cyst - High density**

- Fat within a tumor is seen in lipomas, dermoid cysts and teratomas.

Some tumors can have a high density on CT.

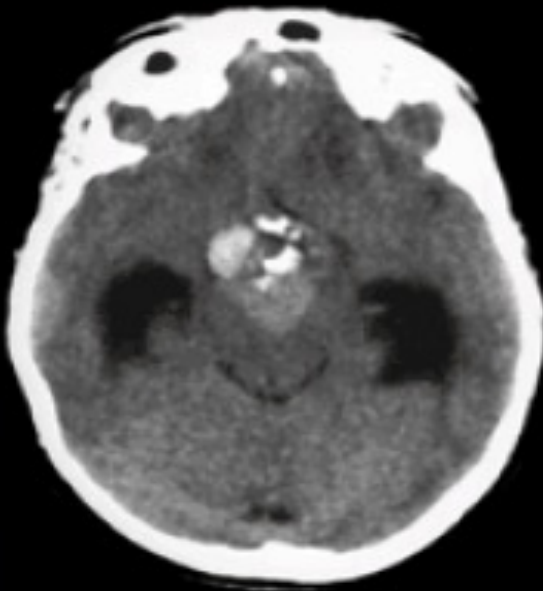
This is typically seen in lymphoma, colloid cyst and PNET-MB (medulloblastoma)



# Calcification

Calcification is seen in many CNS tumors :

## Calcifications



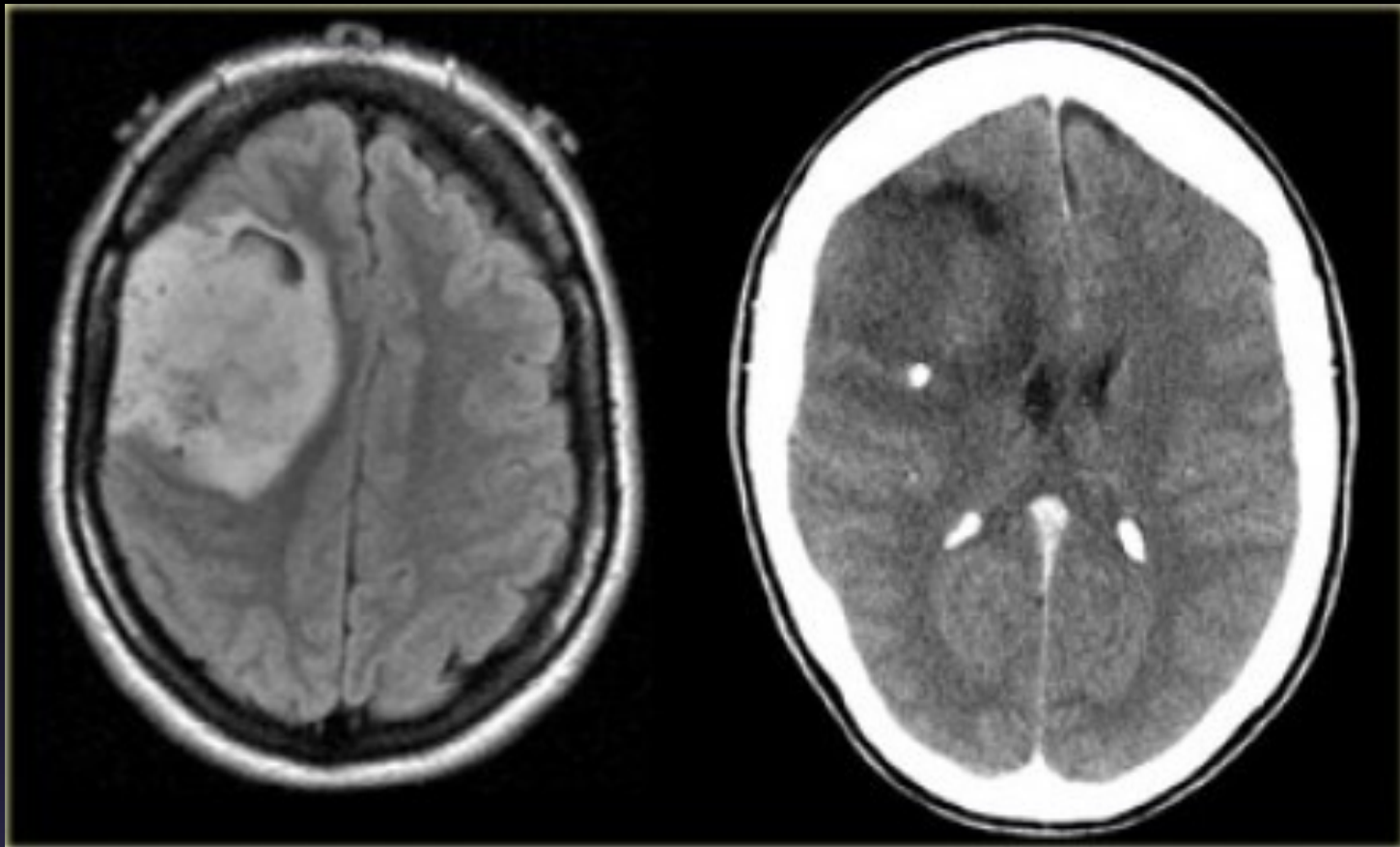
### Intra-axial tumors:

- Astrocytomas (20%)
- Oligodendrogliomas (90%)
- Metastases
- Ependymoma (50%)
- Choroid plexus papilloma (25%)
- Ganglioglioma (40%)

### Extra-axial tumors:

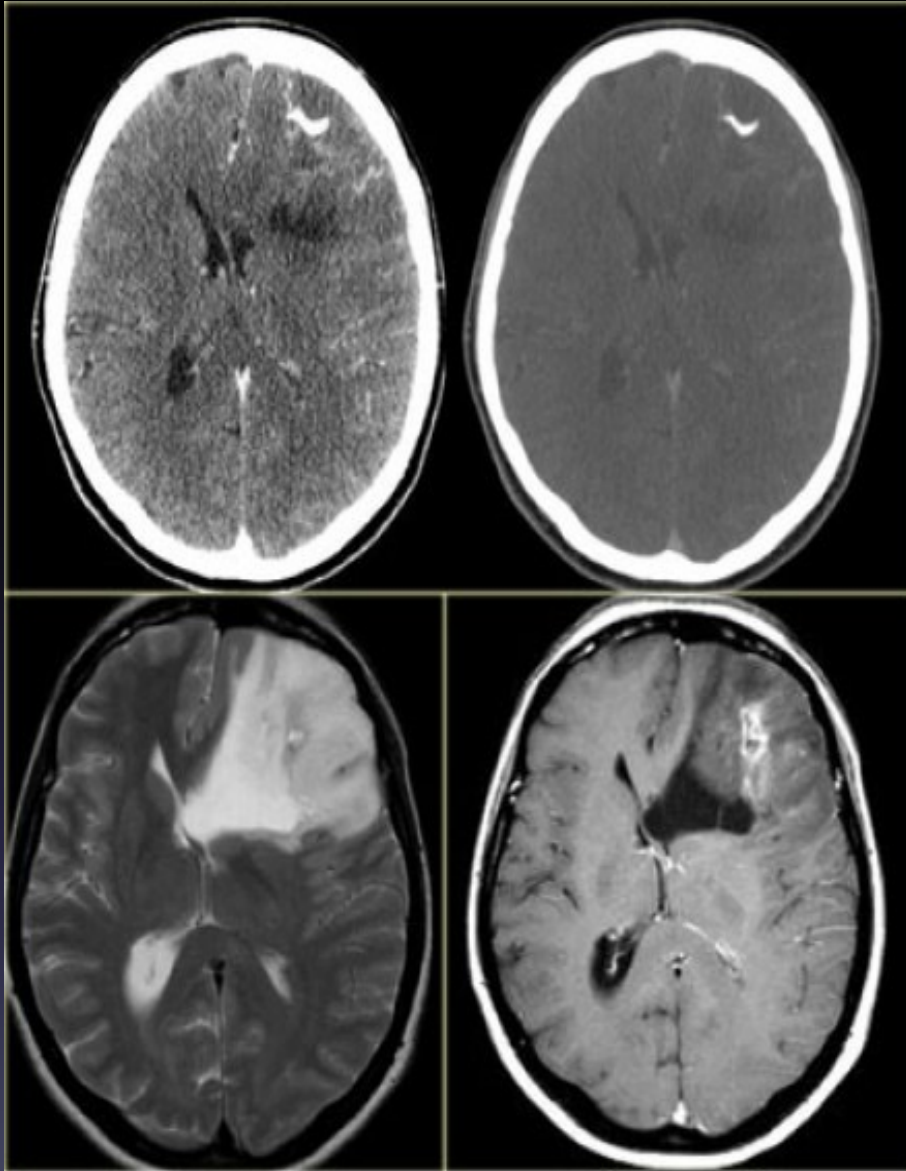
- Meningiomas (25%)
- Craniopharyngeomas (90%)
- Chordomas
- Chondrosarcomas





tumor with a small calcification.  
The calcification is not appreciated on the MR images, but is easily seen on CT.  
The calcification and the extension of the tumor to the cortex are very typical for an oligodendroglioma.

## CALCIFICAZIONI



The CT shows a mass with calcifications, which extends all the way to the cortex. Although this is a large tumor there is only limited mass effect on surrounding structures, which indicates that this is an infiltrating tumor.

The most likely diagnosis is oligodendroglioma. The differential diagnosis includes a malignant astrocytoma or a glioblastoma

# Cistic or solid ?



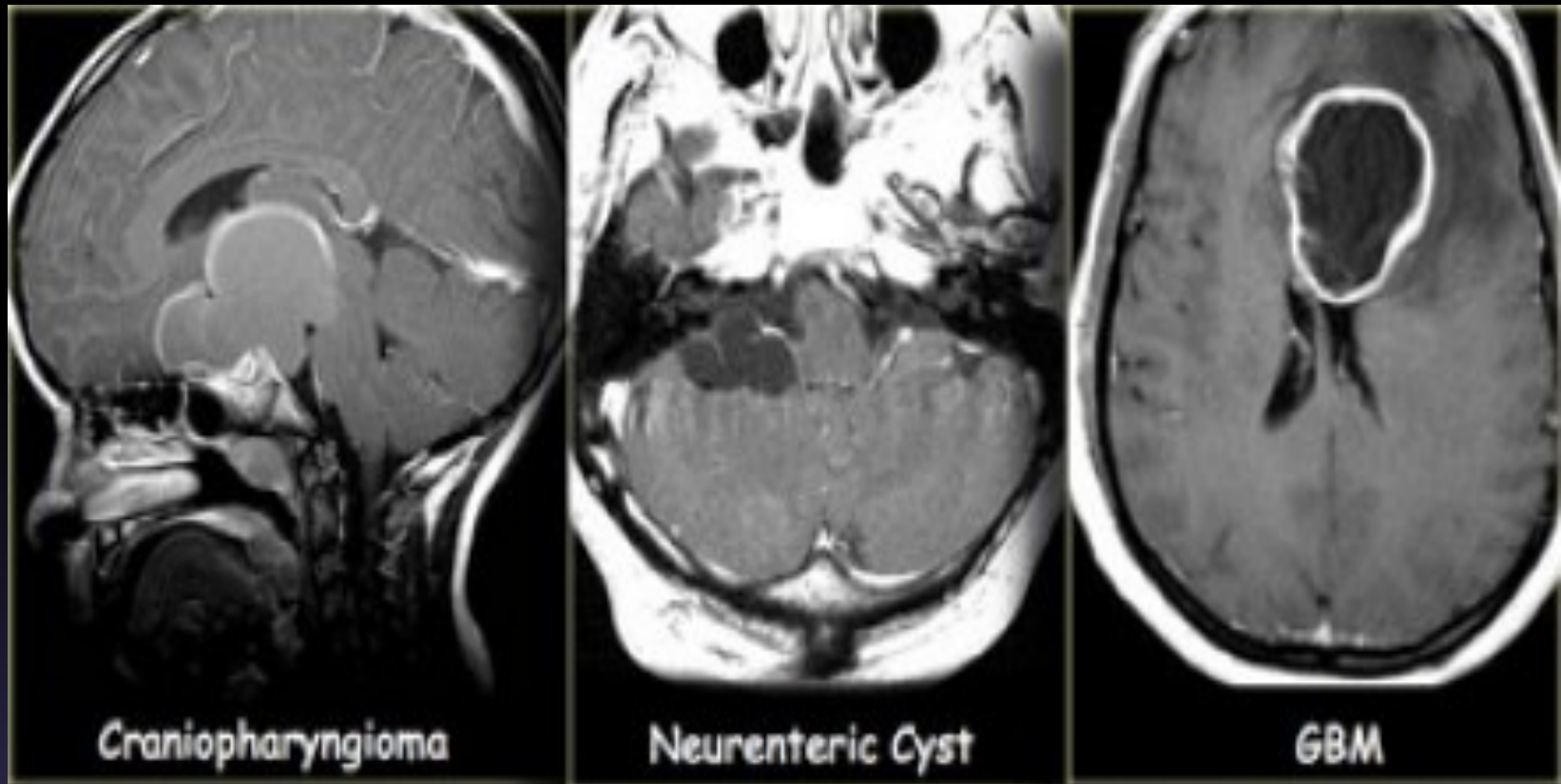
- TC: densità- pattern di enhancement
- RM: segnale della lesione rispetto al liquor
  - > Componente liquida > segnale
  - > Componente solida < segnale

## Cistic or solid ?

Even enlarged perivascular spaces of Virchow Robin can simulate a tumor.

In order to determine whether a lesion is a cyst or cystic mass look for the following characteristics:

- Morphology
- Fluid/fluid level
- Content usually isointense to CSF on T<sub>1</sub>, T<sub>2</sub> and FLAIR
- DWI: restricted diffusion

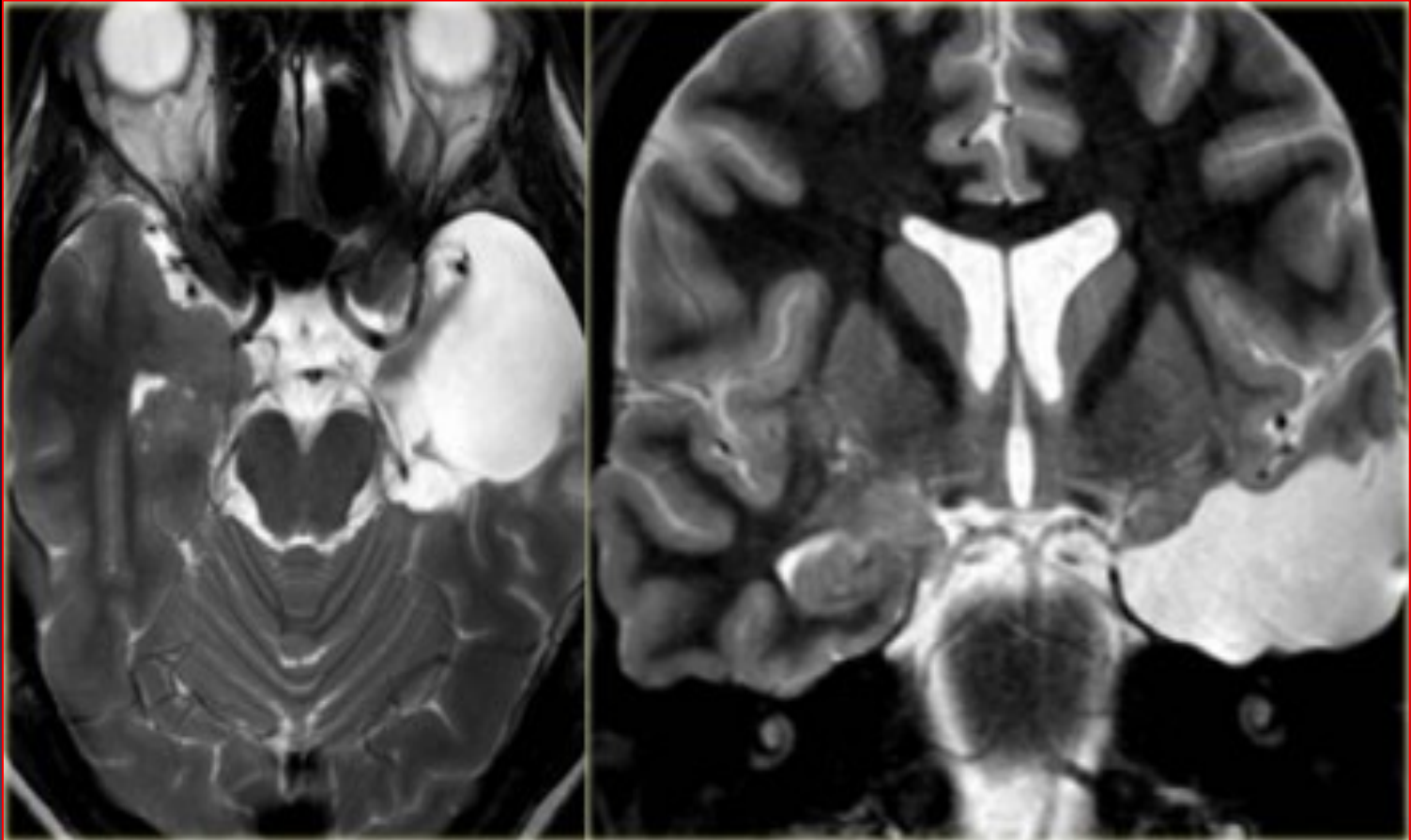


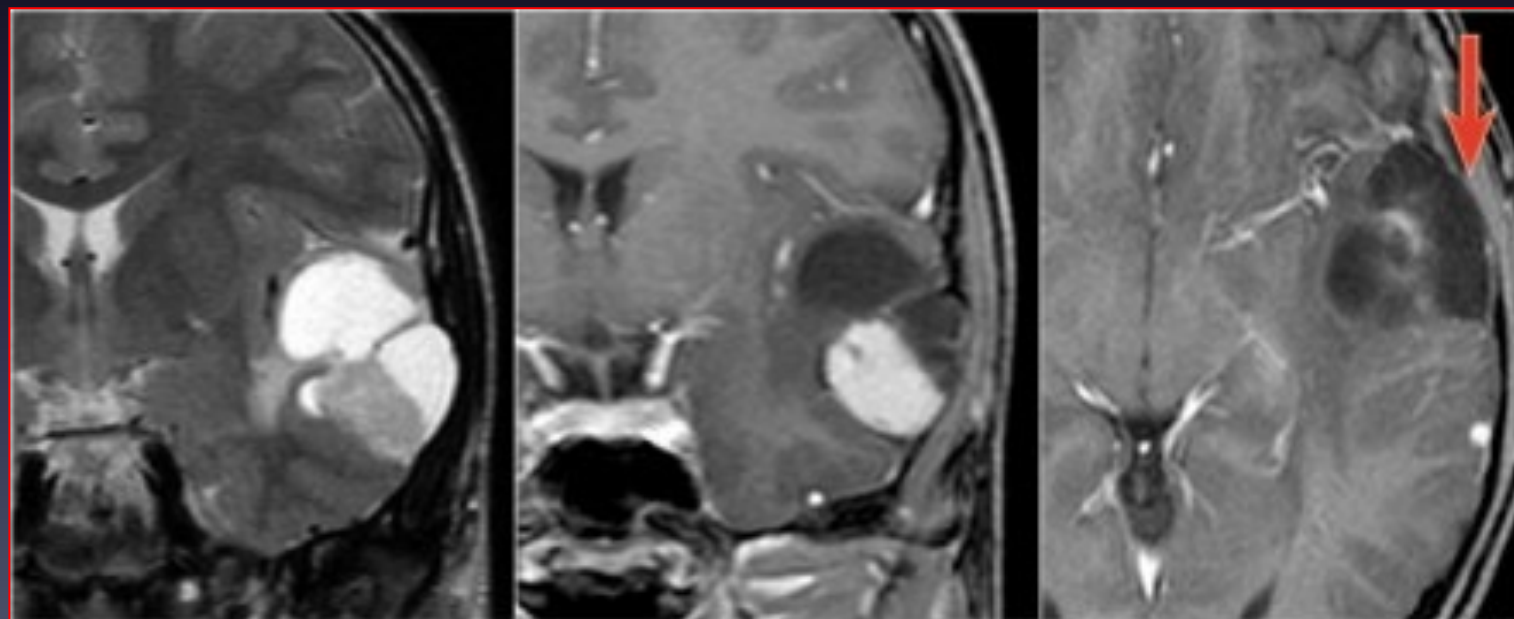
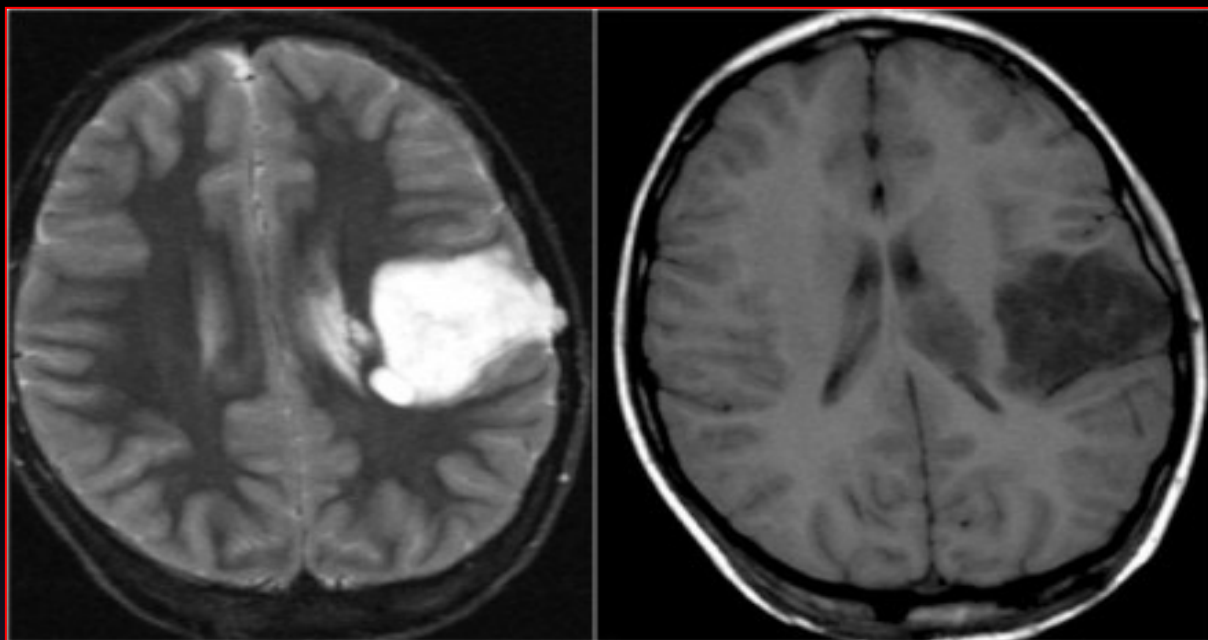
### **Cystic or Solid ?**

There are many cystic lesions that can simulate a CNS tumor.

These include epidermoid, dermoid, arachnoid, neuroenteric and neuroglial cysts.

# Cisti aracnoidea







# Enhancement: meaning

## **Blood brain barrier**

The brain has a unique triple layered blood-brain barrier (BBB) with tight endothelial junctions in order to maintain a consistent internal milieu.

Contrast will not leak into the brain unless this barrier is damaged.

Enhancement is seen when a CNS tumor destroys the BBB.

# Enhancement

## Contrast Enhancement

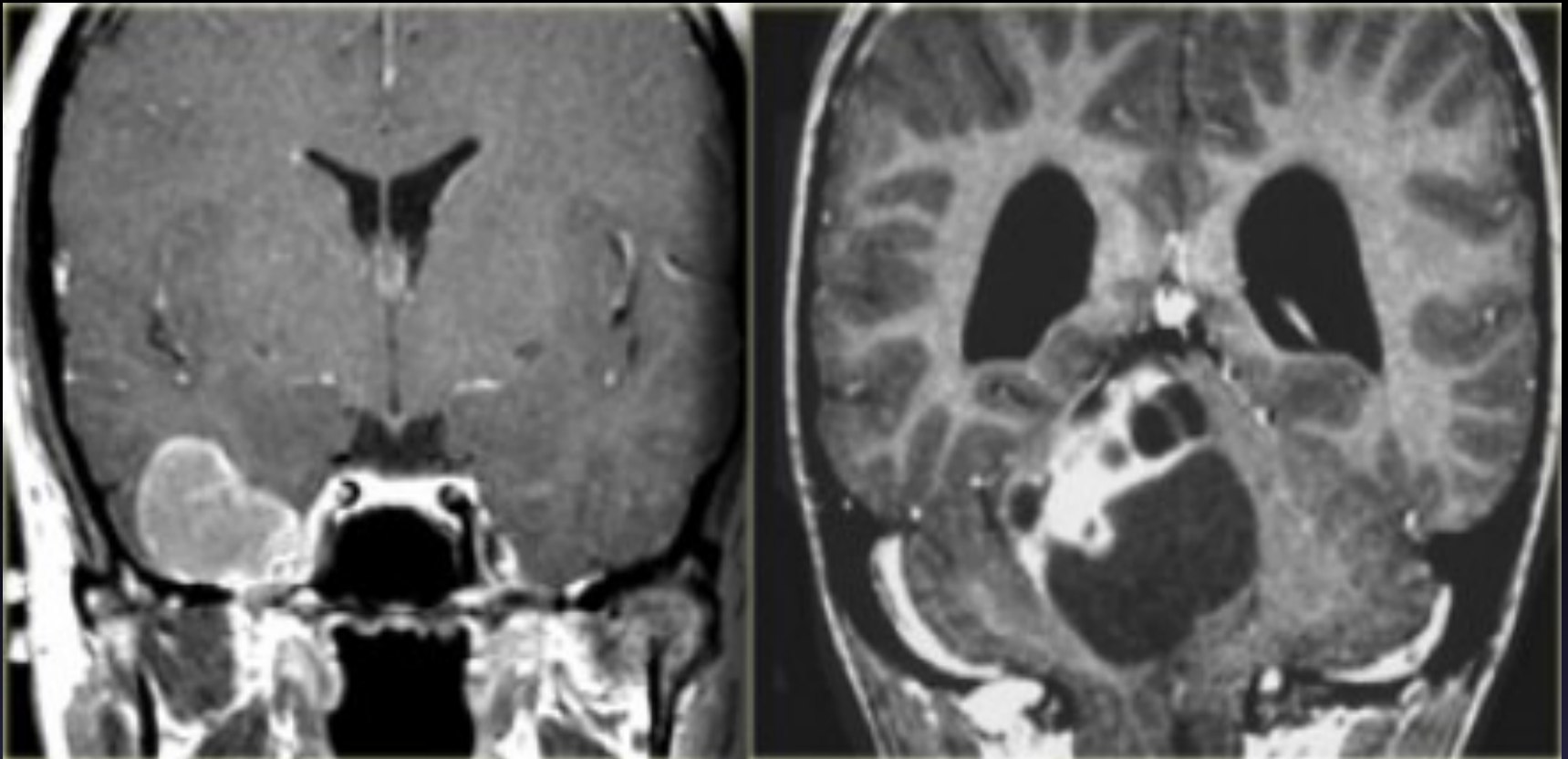
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- Extra-axial tumors: Meningioma, Schwannoma
- High grade gliomas
- Low grade gliomas: ganglioglioma, pilocytic astrocytoma
- Lymphoma
- Metastases
- Non-tumoral: infection, abscess, MS, infarction

# Enhancement: meaning

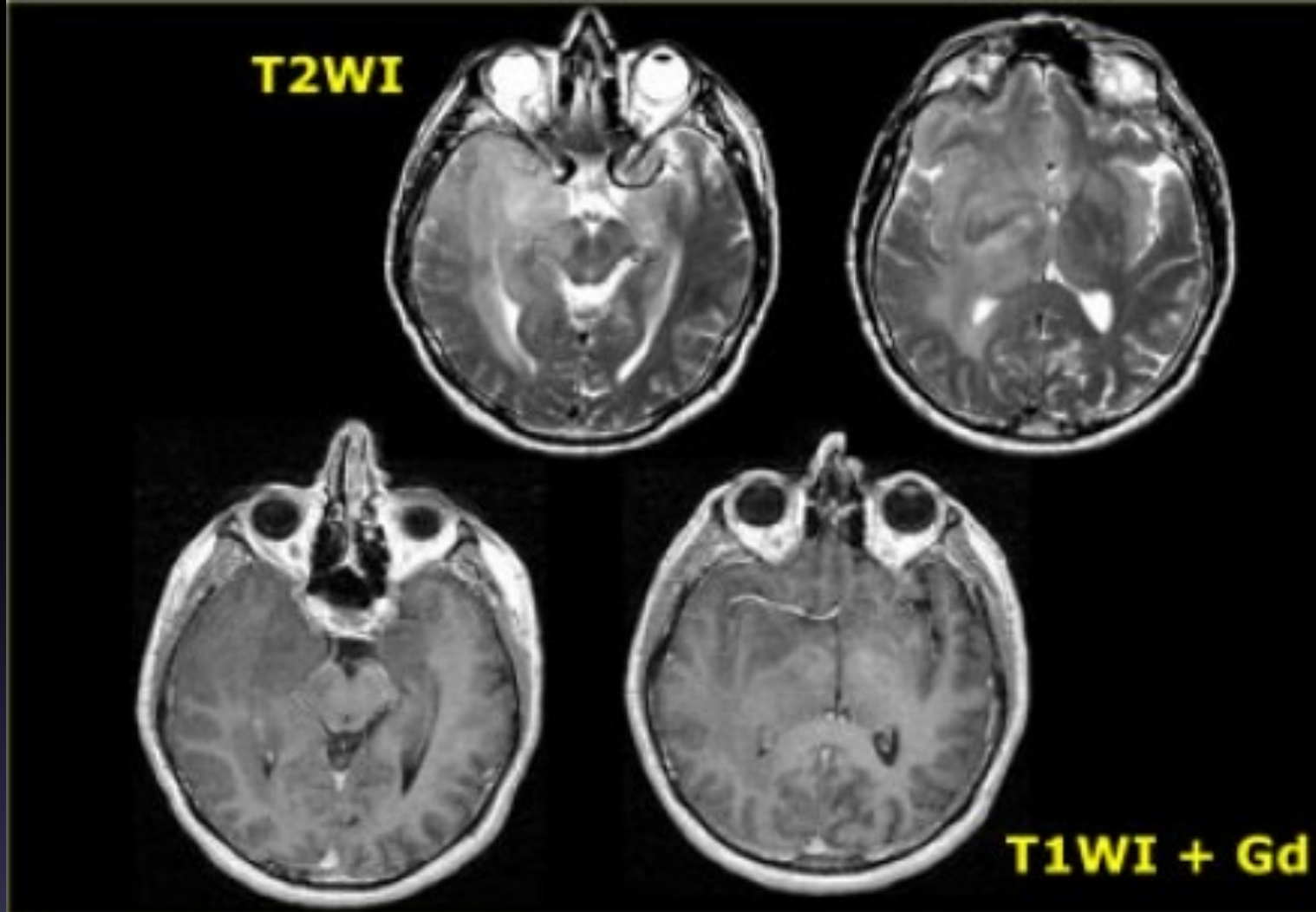
Contrast enhancement cannot visualize the full extent of a tumor in cases of infiltrating tumors, like gliomas.

The reason for this is that tumor cells blend with the normal brain parenchyma where the blood brain barrier is still intact. Tumor cells can be found beyond the enhancing margins of the tumor and beyond any MR signal alteration - even beyond the area of edema



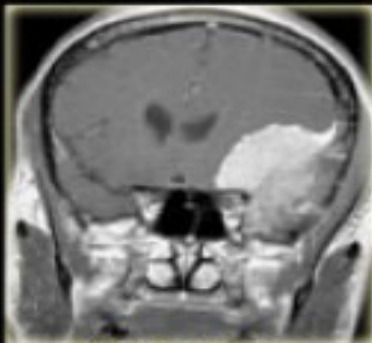
In gliomas - like astrocytomas, oligodendrogliomas and glioblastoma multiforme - enhancement usually indicates a higher degree of malignancy.

Therefore when during the follow up of a low-grade glioma the tumor starts to enhance, it is a sign of malignant transformation. Gangliogliomas and pilocytic astrocytomas are the exceptions to this rule: they are low-grade tumors, but they enhance vividly



temporal lobe and involves the cortex.

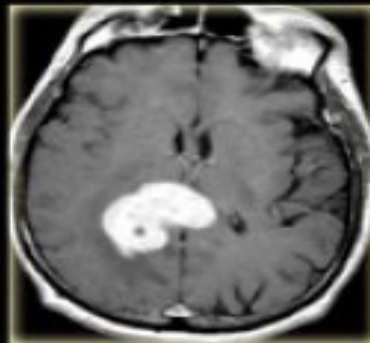
Although there is massive infiltrative growth involving a large part of the right cerebral hemisphere, there is only minimal mass effect.



**Meningioma**



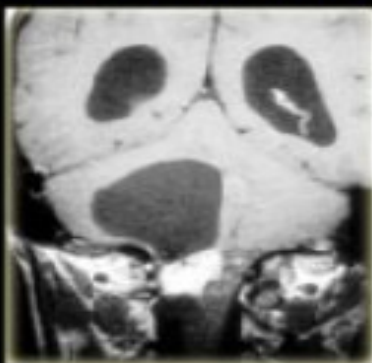
**Schwannoma**



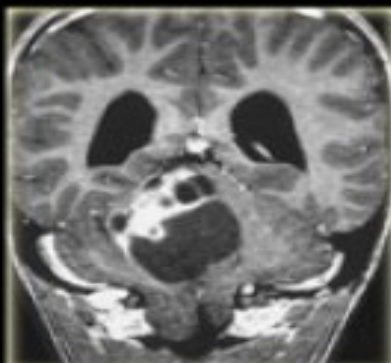
**Lymphoma**



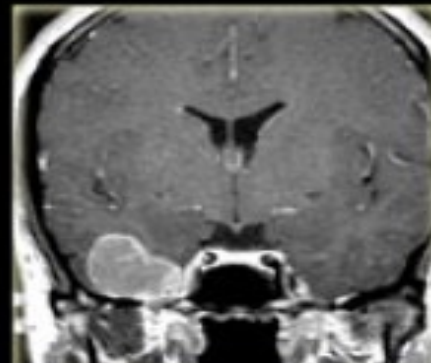
**Choroid Pl. Papilloma**



**Hemangioblastoma**

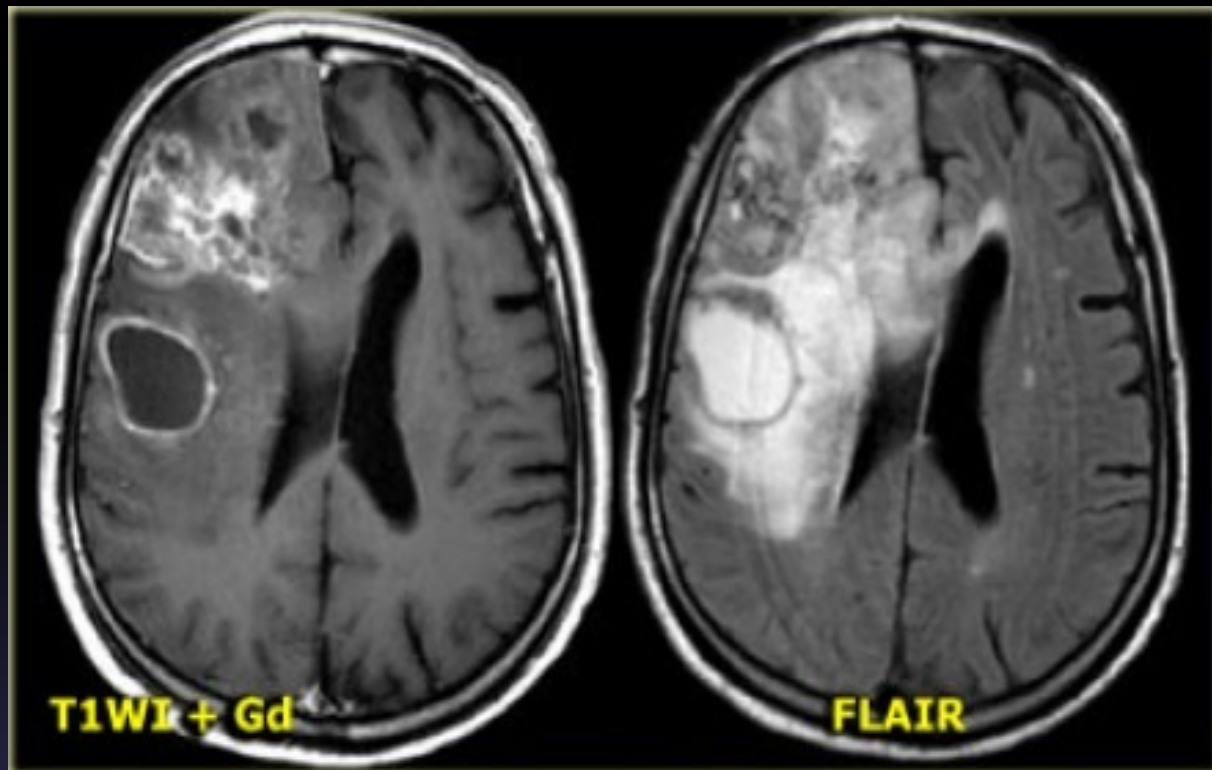


**Pilocytic Astrocytoma**



**Ganglioglioma**

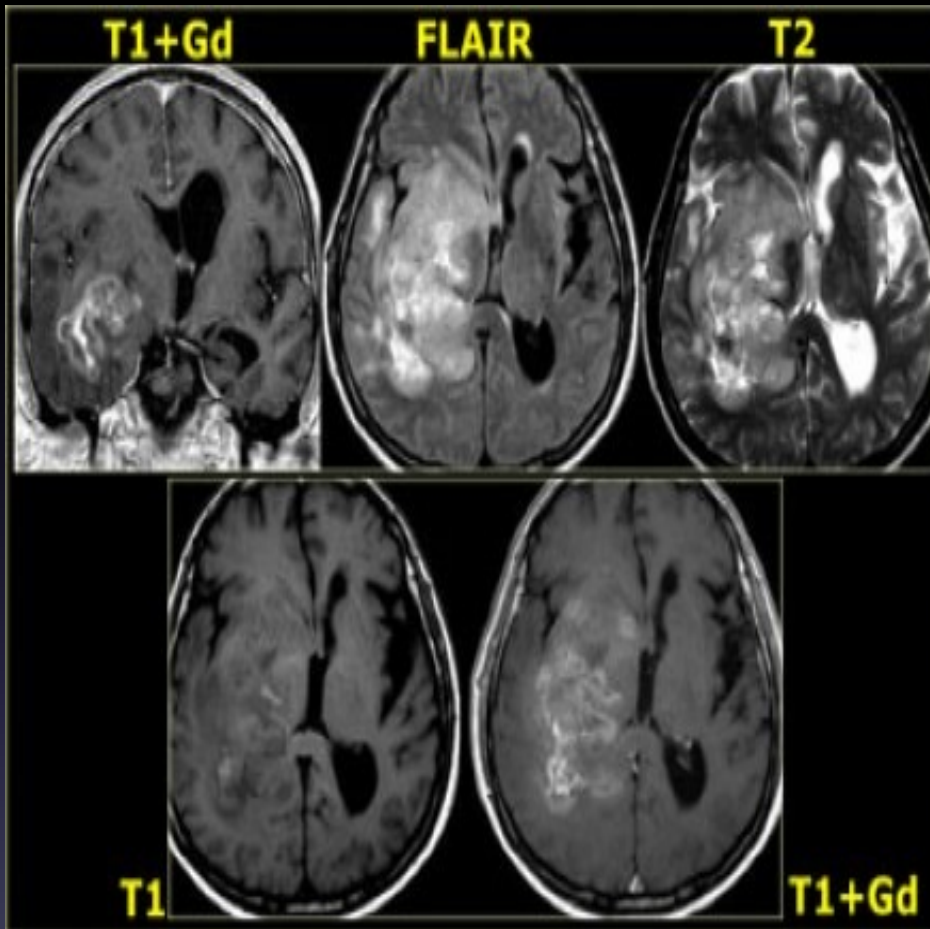
**Homogeneous enhancement**



**Patchy enhancement** can be seen in:

- Metastases
- Oligodendroglioma
- **Glioblastoma multiforme**
- Radiation necrosis





## Patchy enhancement

On the left are images of a tumor located in the right hemisphere. Although is a large tumor, the mass-effect is limited.

This indicates that there is marked infiltrative growth, a characteristic typical for gliomas. Notice the heterogeneity on both T2WI and FLAIR.

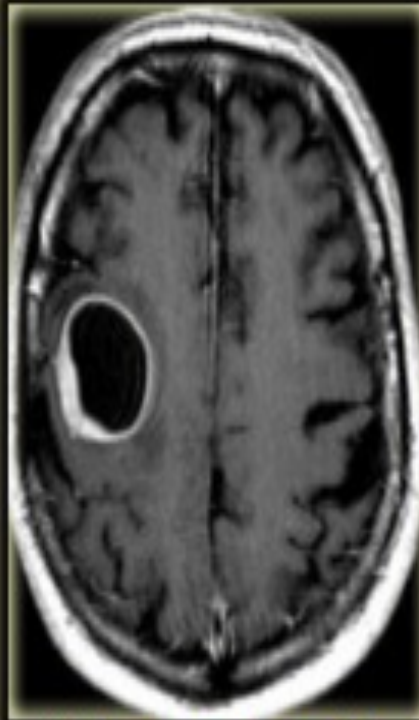
There is patchy enhancement

All these findings are typical for a GBM.

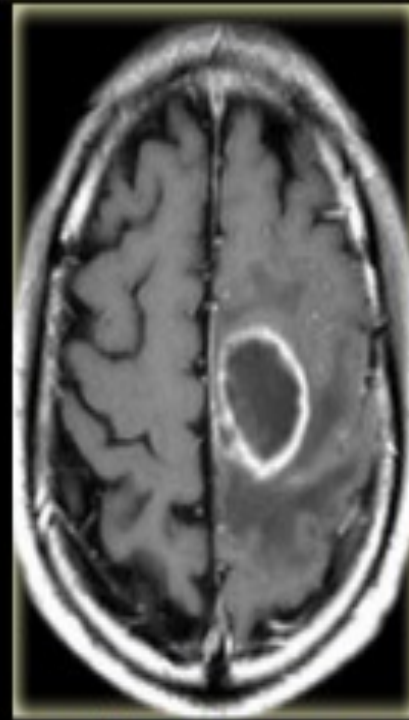
Virtually no other tumor behaves in this way

## Ring Enhancement

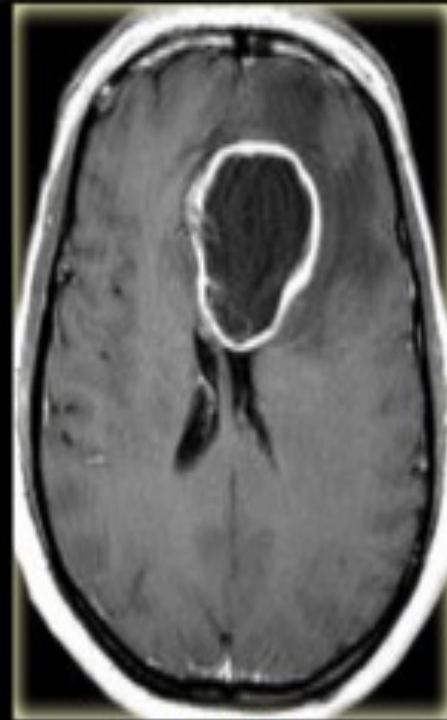
Metastases  
Glioblastoma  
Abscess, I  
Multiple sclerosis  
Chronic hematoma



**Metastasis**



**Abscess**



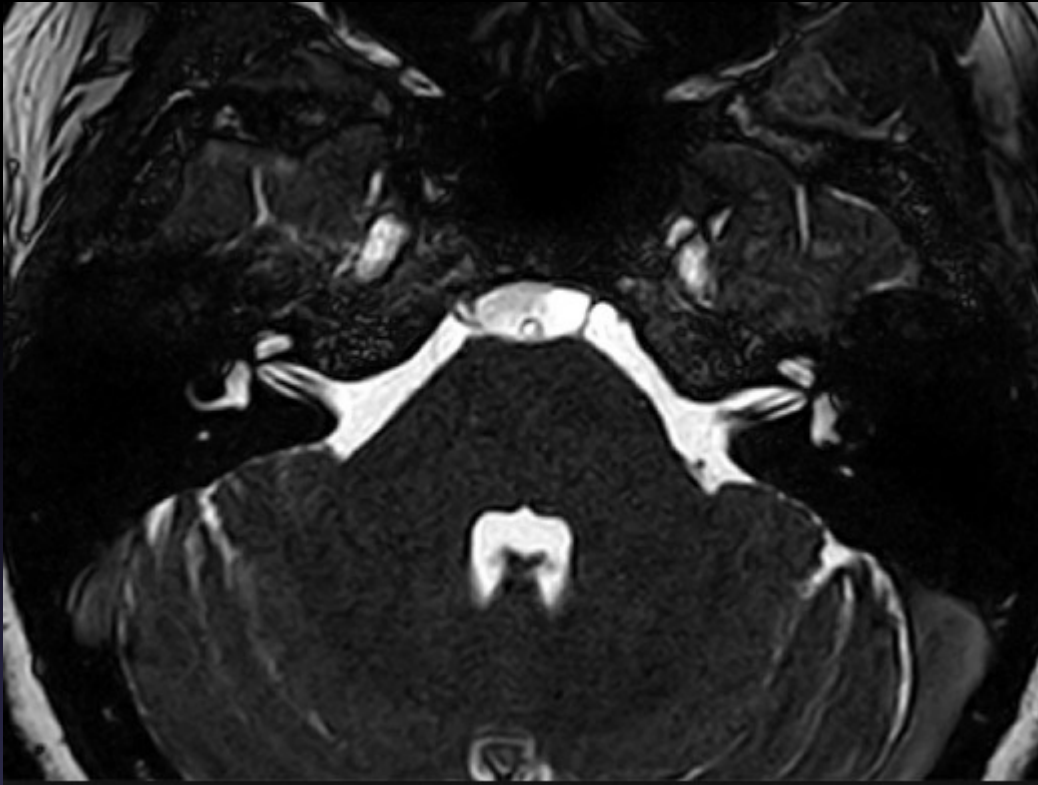
**GMB**

## Ring enhancement

Ring enhancement is seen in metastases and high-grade gliomas.

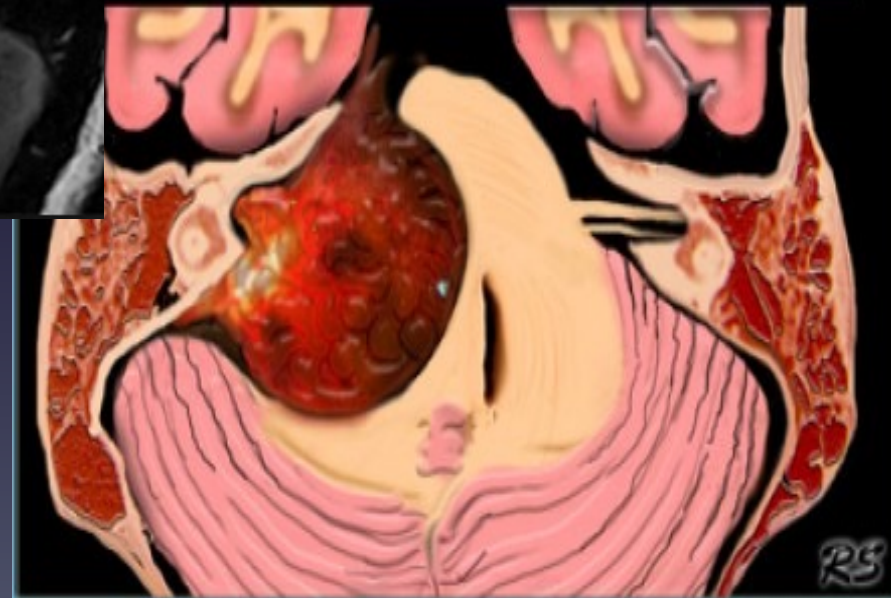
It is also seen in non-tumorous lesions like abscesses, some MS-plaques and sometimes in an old hematomas

# Cerebello-pontine angle



## Common CP Angle Tumors

- Schwannoma
- Meningioma
- Epidermoid
- Arachnoid Cyst
- Paraganglioma
- Metastasis





# LESIONI TRAUMATICHE

# TC

- Preferibile in condizioni d'urgenza (pazienti non collaboranti, trauma cranico, ictus)
- Indispensabile nell'analisi di strutture ossee e nella ricerca di piccole calcificazioni
- Buona risoluzione di contrasto: s. bianca, s. grigia, spazi liquorali
- Limiti: valutazione FCP, ipofisi

# RM

- Tecnica fondamentale nello studio della patologia cranio-encefalica e vertebro-midollare
- Non radiazioni ionizzanti (campi magnetici radiofrequenze)
- Multiparametrica: elevata risoluzione di contrasto
- Approccio multiplanare
- Studio dei fluidi in movimento: Angio-RM
- Sequenze convenzionali, veloci, FLAIR
- RM funzionale: diffusione, perfusione, spettro-RM, BOLD (Blood Oxygen Level Dependent)



# TC:limiti

difficoltà a rilevare :

- ❑ lesioni di piccole dimensioni in prossimità delle strutture ossee
- ❑ microemorragie
- ❑ mal valutabile il tronco encefalico
- ❑ molti artefatti in fossa cranica posteriore

# RM:limiti

- intrinseci:

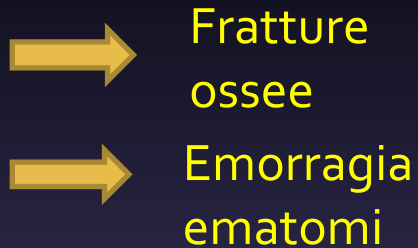
*controindicazione assoluta per soggetti portatori di corpi estranei metallici o elettronici*

- semeiologici:

*minore sensibilità della TC nell'individuazione di fratture e sanguinamenti recenti*

# Protocollo traumi

In acuto:



TC

- In fase subacuta-

cronica



RM

# TC: Patologia emorragica

TC: indispensabile in acuto

- Sangue: raccolta **iperdensa**: legata al coefficiente di assorbimento della componente proteica dell'emoglobina
- La densità decresce progressivamente fino a scomparire intorno alla 3-4 settimana



# **RM: Patologia emorragica**

- Ioni paramagnetici nei prodotti del catabolismo dell'Hb
- Datazione dell'emorragia: ossiHb, desossiHb, metaHb intra ed extracellulare, emosiderina
- Miglior dimostrazione delle cause legate all'emorragia

L'aspetto del sangue in RM e' variabile in relazione all'eta' del sanguinamento

Un ematoma puo' avere 5 stadi:

Iperacuto (ossiemo globina intracellulare)

iso sia in T1 che in T2

Acuto 1-2 giorni deossiemo globina intracellulare

T2 ipo

T1 iso

Subacuta precoce 2-7 giorni metaemo globina intracellulare

T1 iso -> iper

T2 ipo

subacuta tardiva (10-30 giorni) metaemo globina extracellulare

T1 iper

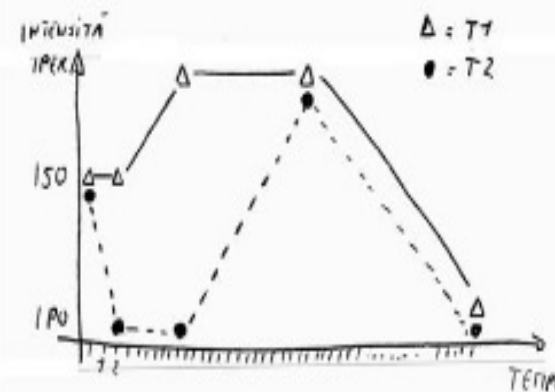
T2 iper

Cronico, emosiderina intracellulare

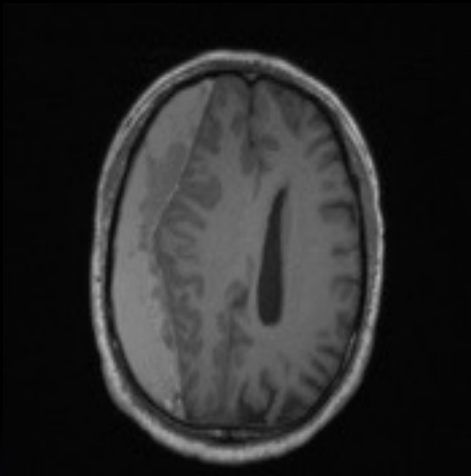
T1 ipo

T2 ipo

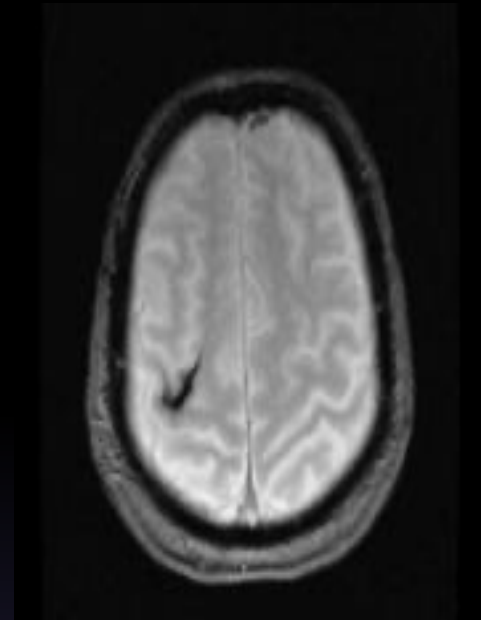
# Sangue coagulato



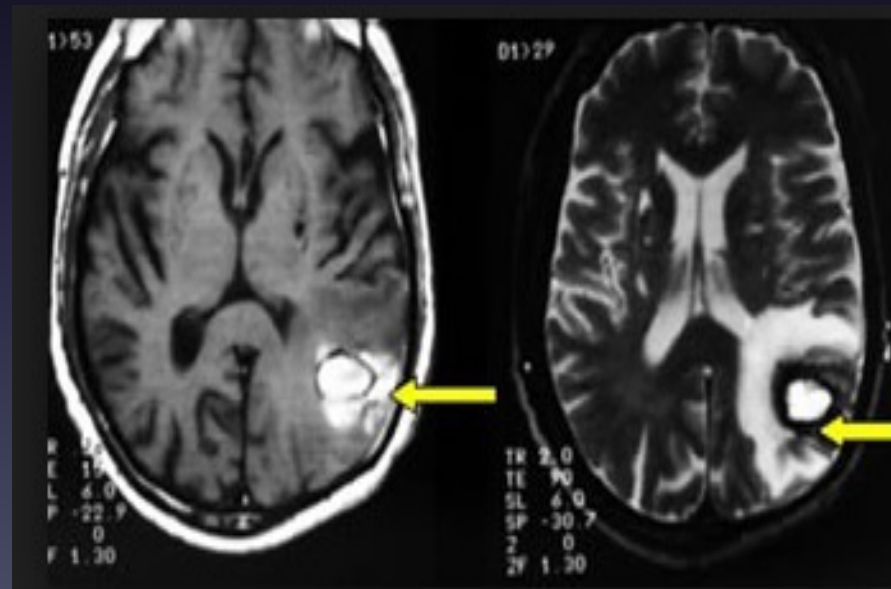




subacute subdural haematoma

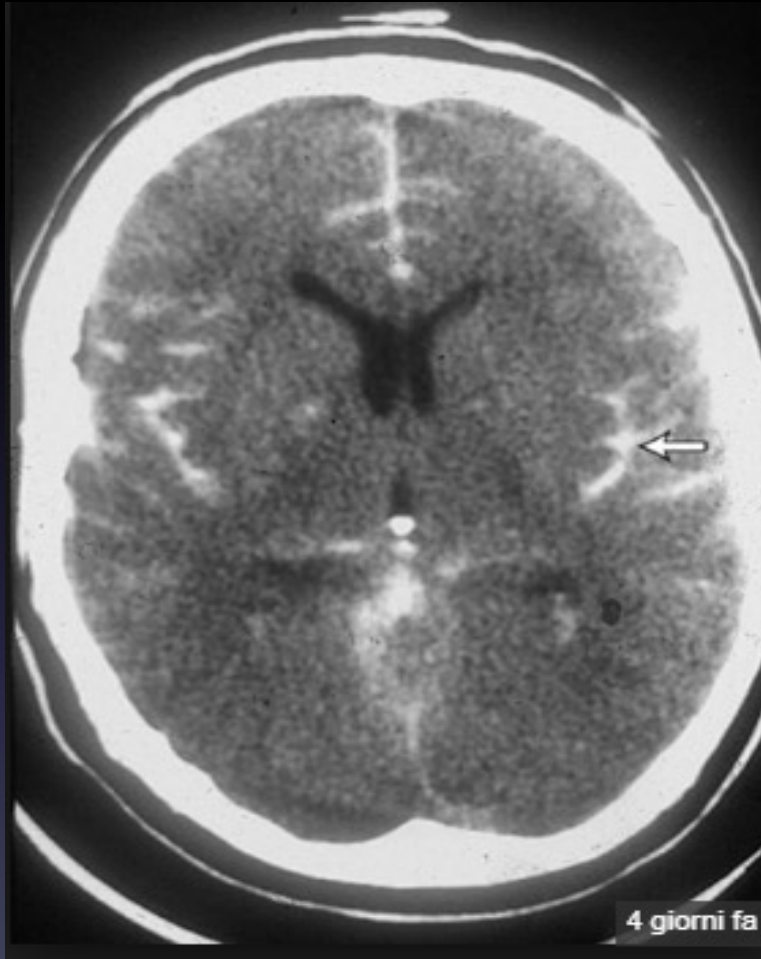


chronic



# Emorragia subaracnoidea

- ❑ **Sanguinamento legato alla rottura di piccole vene corticali che attraversano lo spazio subaracnoideo**
- ❑ **Clinicamente :**
  - di per sé poco significativa, è frequente nel trauma cranico severo, di solito associata a contusioni parenchimali emorragiche**



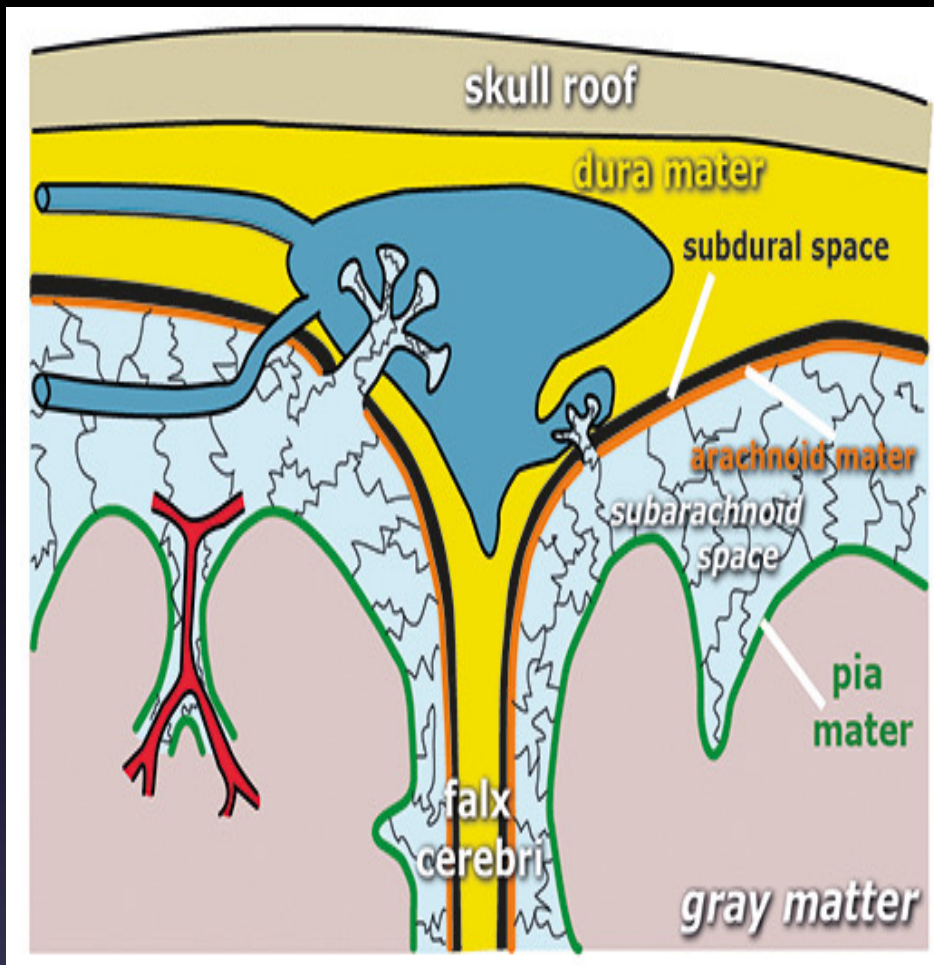
**IPERDENSITA' TRA I SOLCHI  
IN SEDE INTEREMISFERICA**



**VIE DI DIFFUSIONE:**

- ☐ Spazi meningei
- ☐ Spazi liquorali

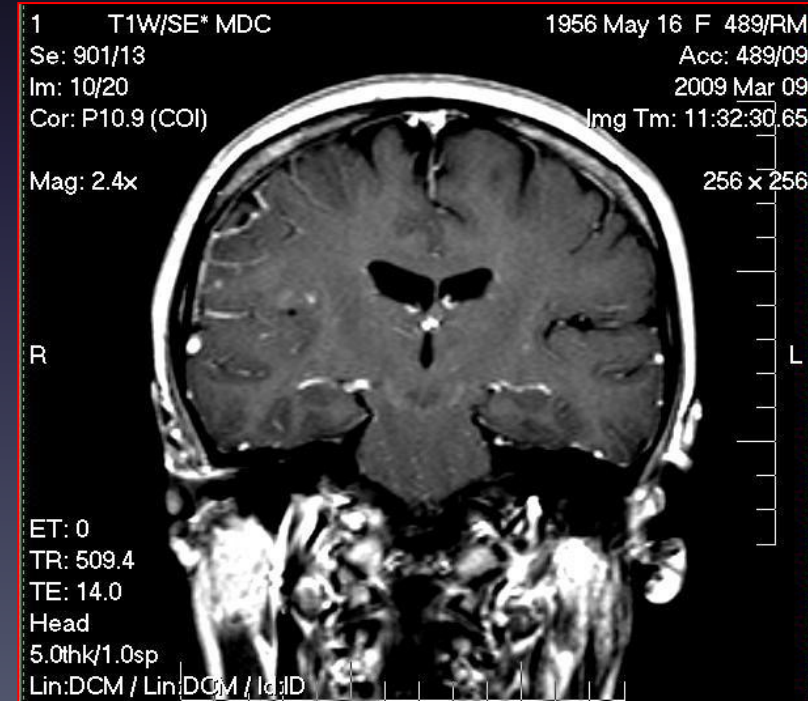
## Meningeal spaces



## Meninges

The brain is covered from inside out by the pia mater, the arachnoid mater, the dura mater and the skull roof

Figure Normal anatomy of the cerebral meninges.



# Ventricular system

- Cerebrospinal fluid (CSF), is produced in the choroid plexus, located in the ventricles. The CSF circulates from the ventricles (through the 3rd ventricle & the aqueduct) to the 4th ventricle. The CSF then flows through the foramina to the subarachnoid space over the convexity of the brain and around the spinal cord. Resorption takes place in the venous sinus (through the arachnoid granulation).

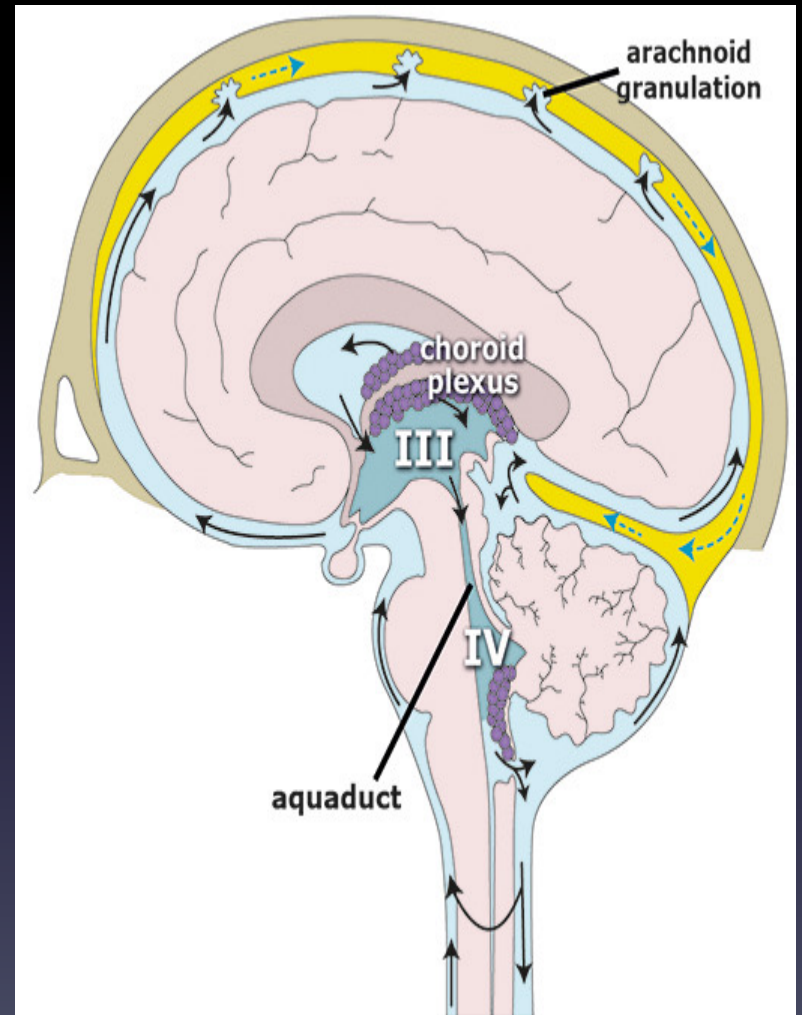
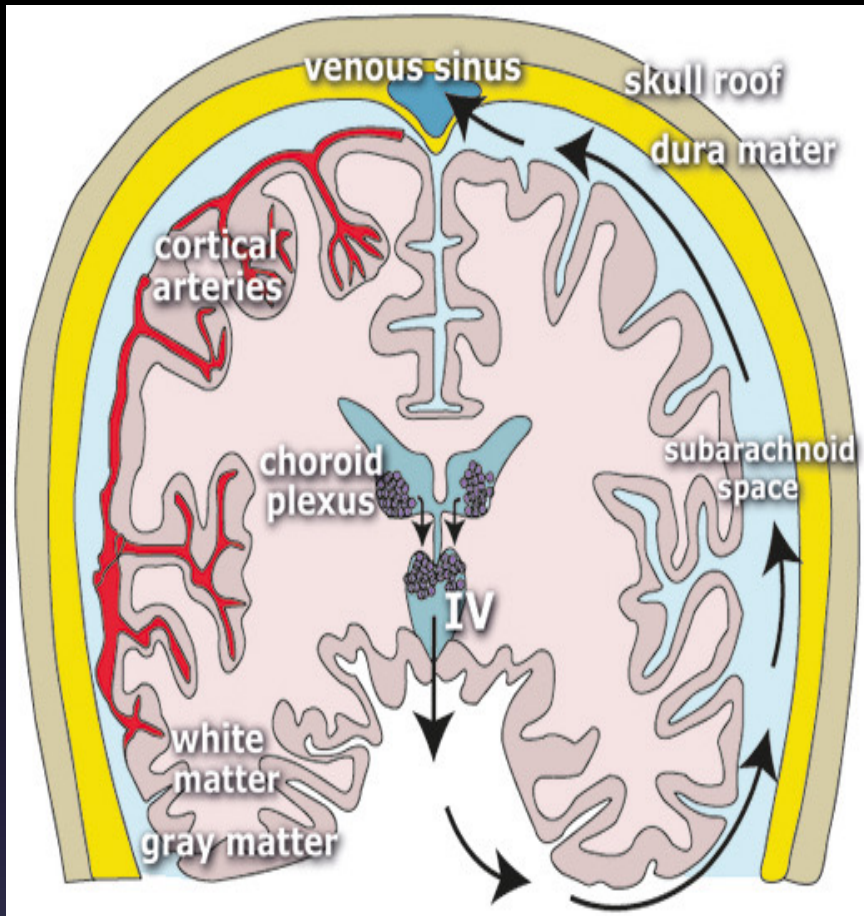


Figure. Circulation of the cerebrospinal fluid in the coronal plane (a) and sagittal plane (b).



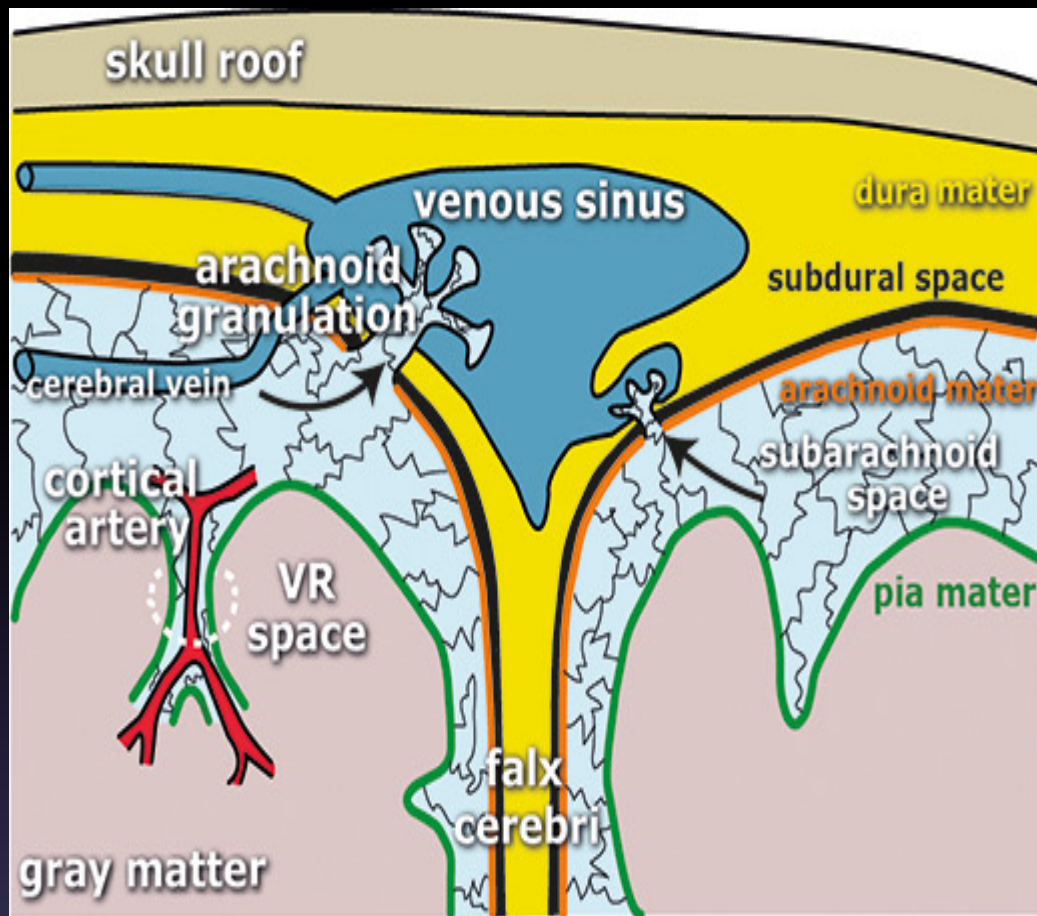
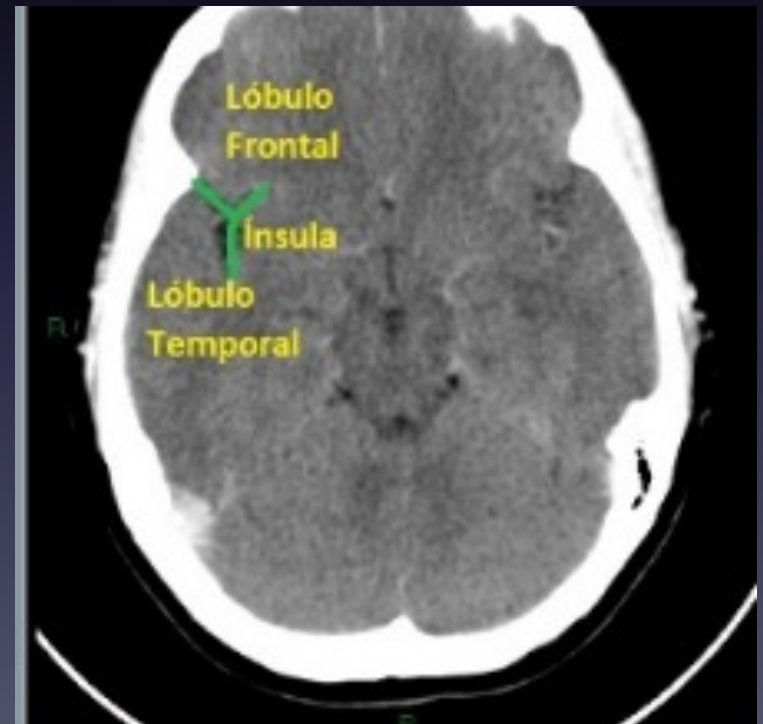
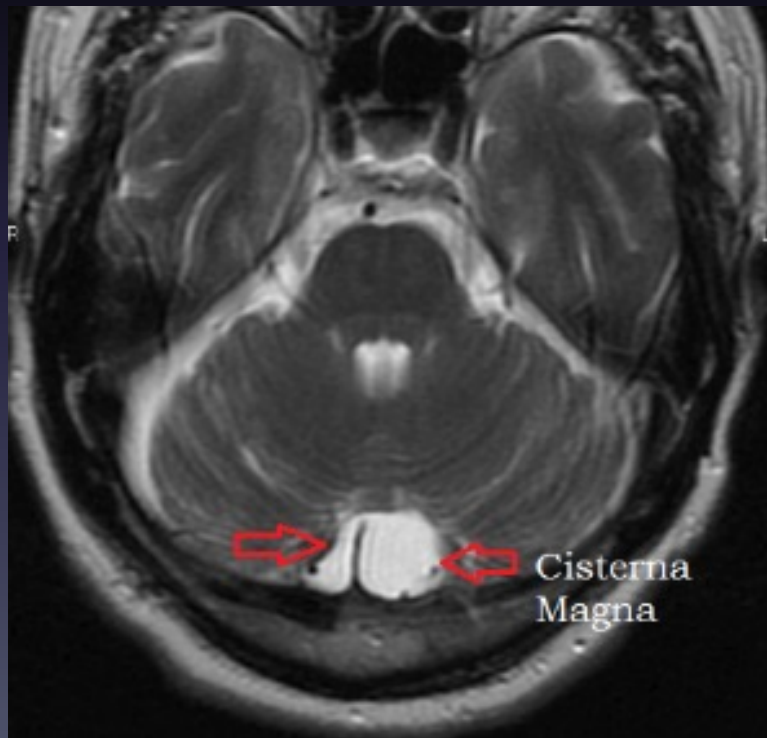
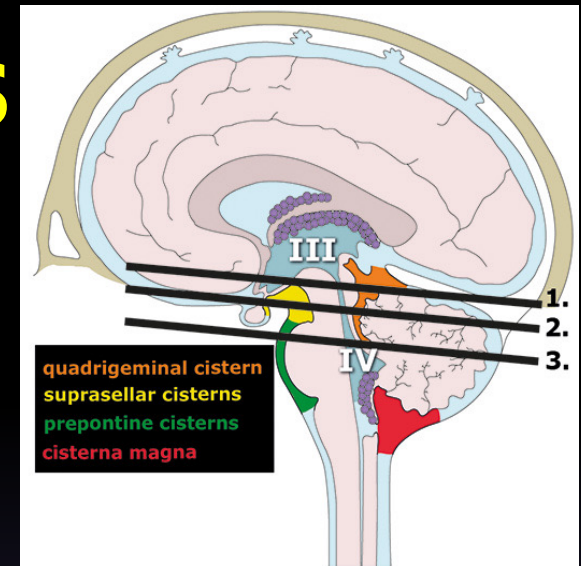


Figure Resorption of CSF through the arachnoid granulation in the venous sinus.

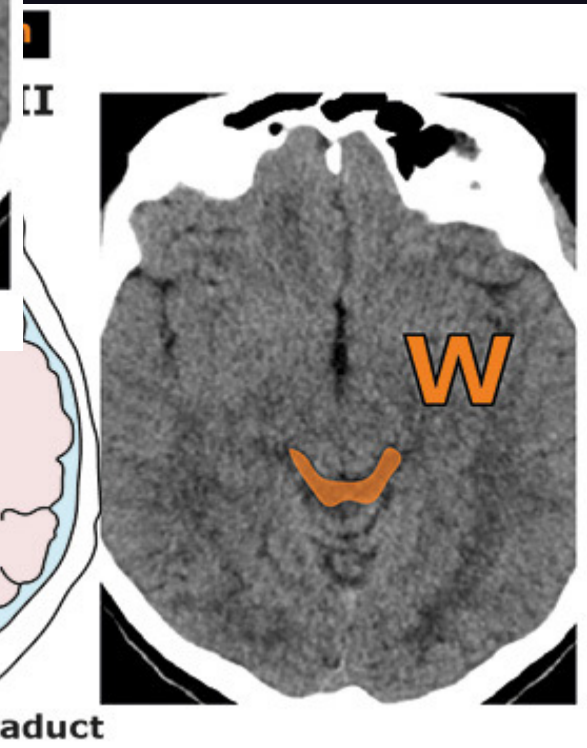
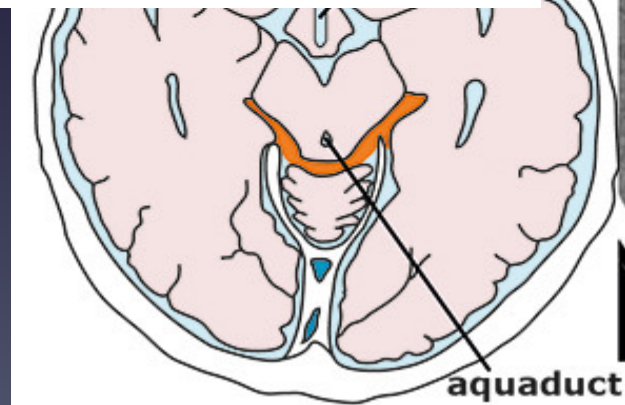
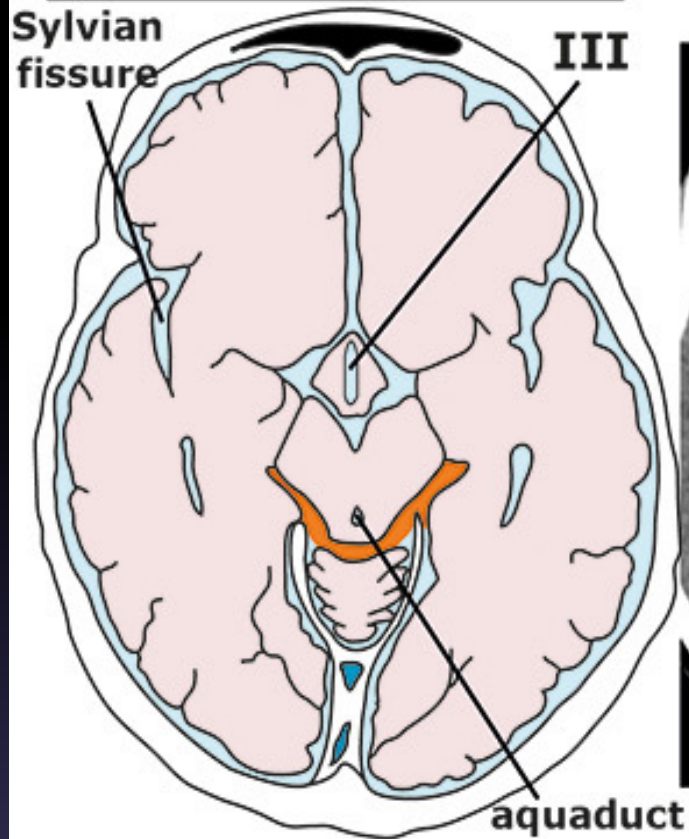


# Subarachnoid cisterns

Sylvian fissure; space between the temporal and frontal lobes.  
quadrigeminal cistern (transversal W shape).  
suprasellar cisterns (transversal pentagon/5-sided shape).  
prepontine cisterns (transversal moon shape).  
cisterna magna (cerebellomedullaris).

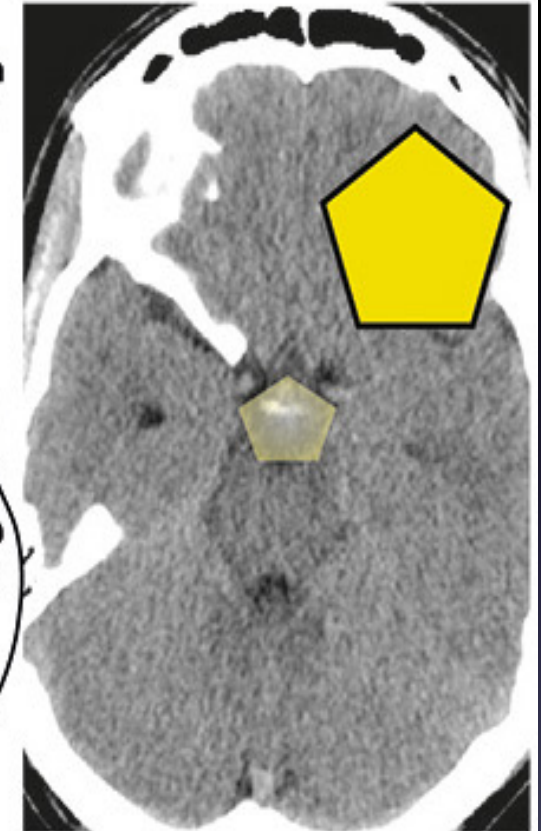
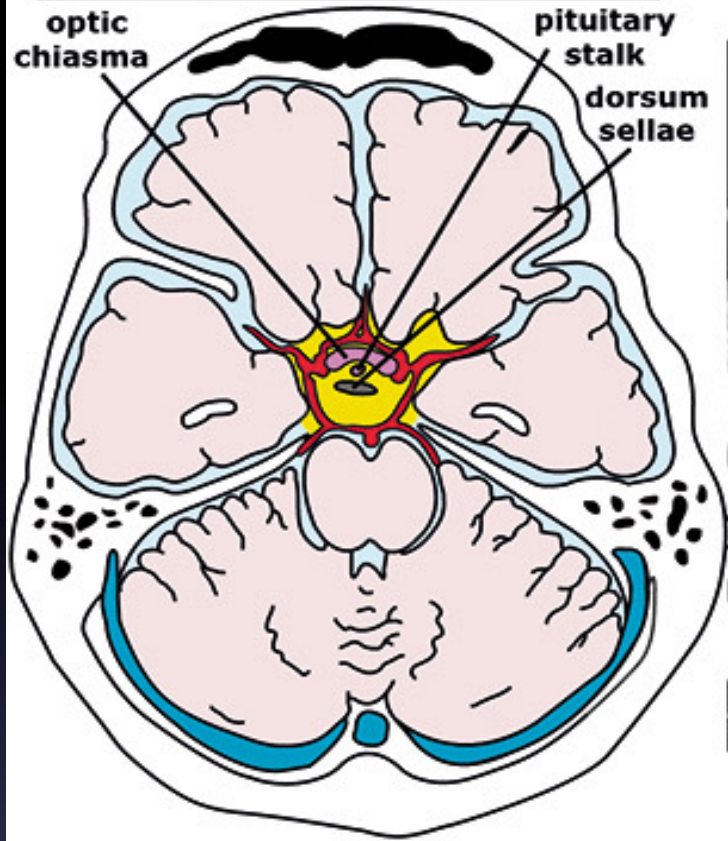


## 1. quadrigeminal cistern



Quadrigeminal cistern: w shape

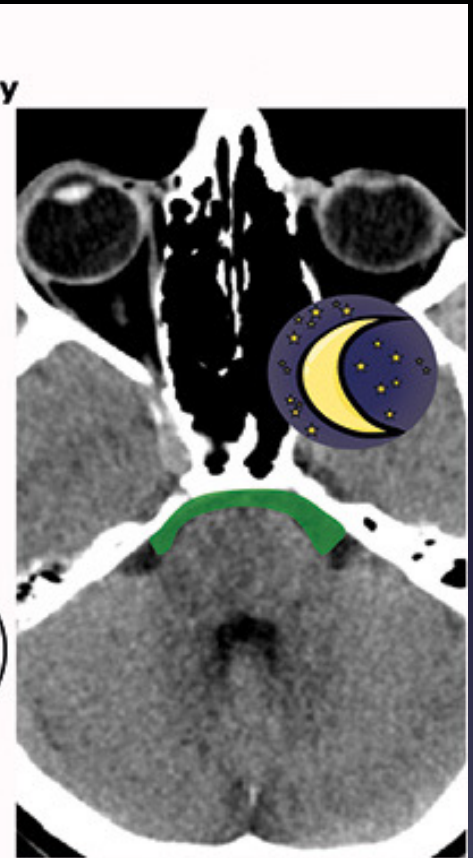
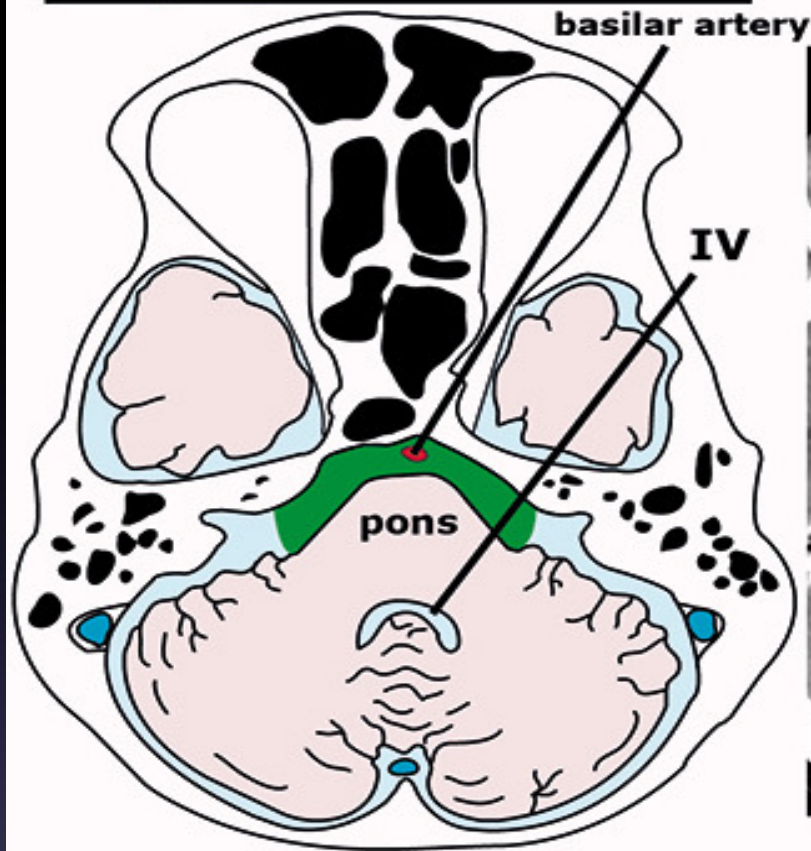
## 2. suprasellar cistern



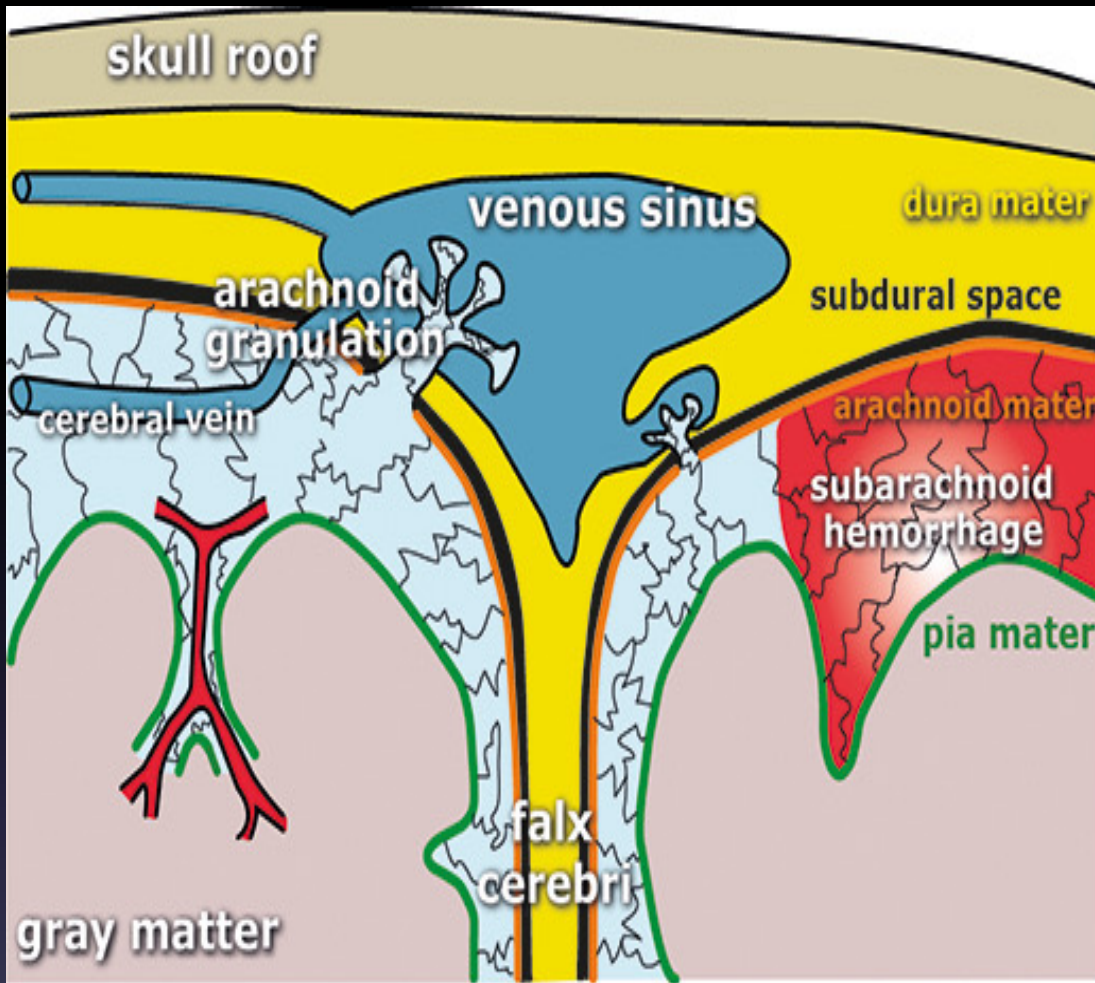
Suprasellar cistern (pentagon) in the transversal plane.



### 3. prepontine cisterns



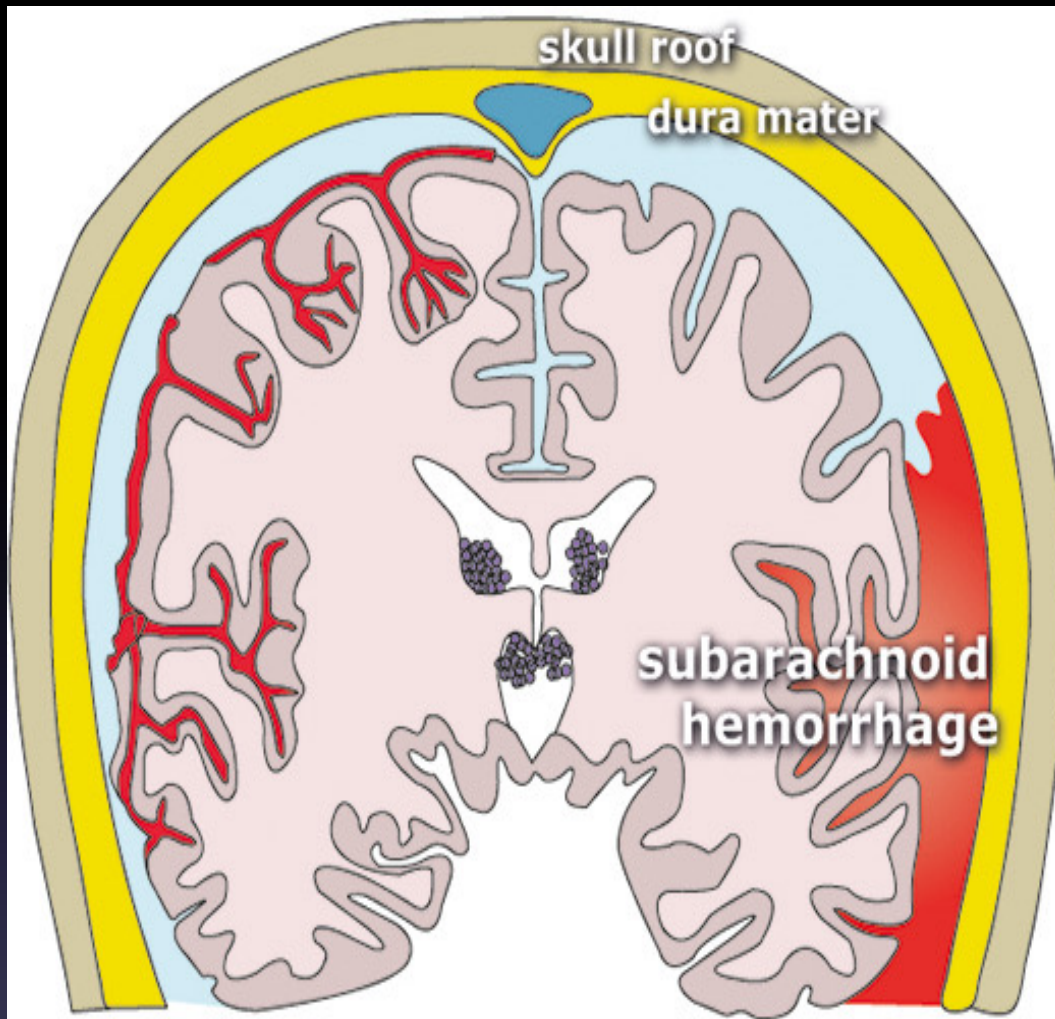
Prepontine cisterns (moon shape) in the transversal plane. Fourth ventricle (IV).



## **Subarachnoid hemorrhage:**

In a subarachnoid hemorrhage, the blood is located in the subarachnoid spaces.

Figure: The blood is located between the pia mater and the arachnoid mater.



The subarachnoid spaces include the basal cisterns (= space around the brain stem), the Sylvian fissure, the cerebral sulci, the intraventricular space and the interhemispheric fissure

Figure. Brain in the coronal plane. The subarachnoid hemorrhage follows the gyri sulci pattern and spreads out over the left convexity.

# Subarachnoid hemorrhage spread

Characteristic on a CT without contrast

- subarachnoid blood in the basal cisterns, Sylvian fissure and along the cerebral convexity.
- intraventricular blood with possibly a blood-fluid level in the posterior horn of the lateral ventricle



Figure Subarachnoid blood in the prepontine cisterns (hyperdense obliteration of the moon shape).

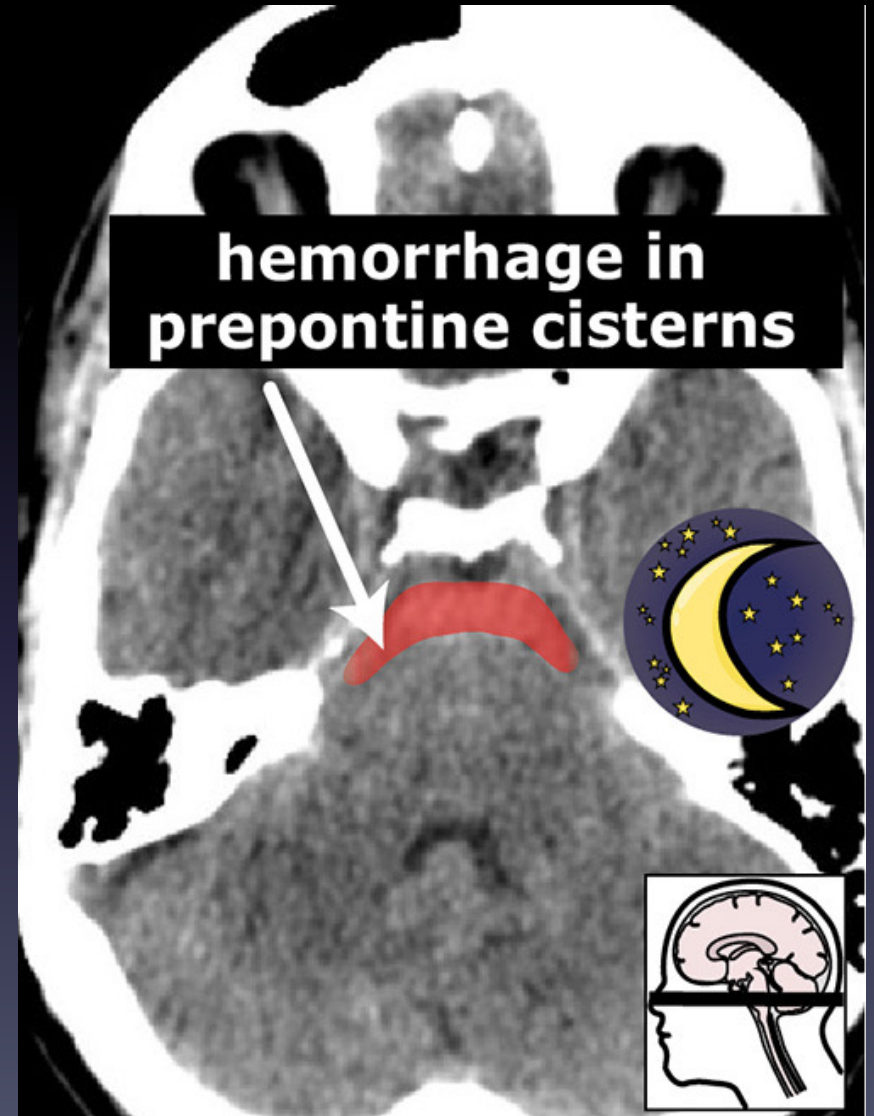
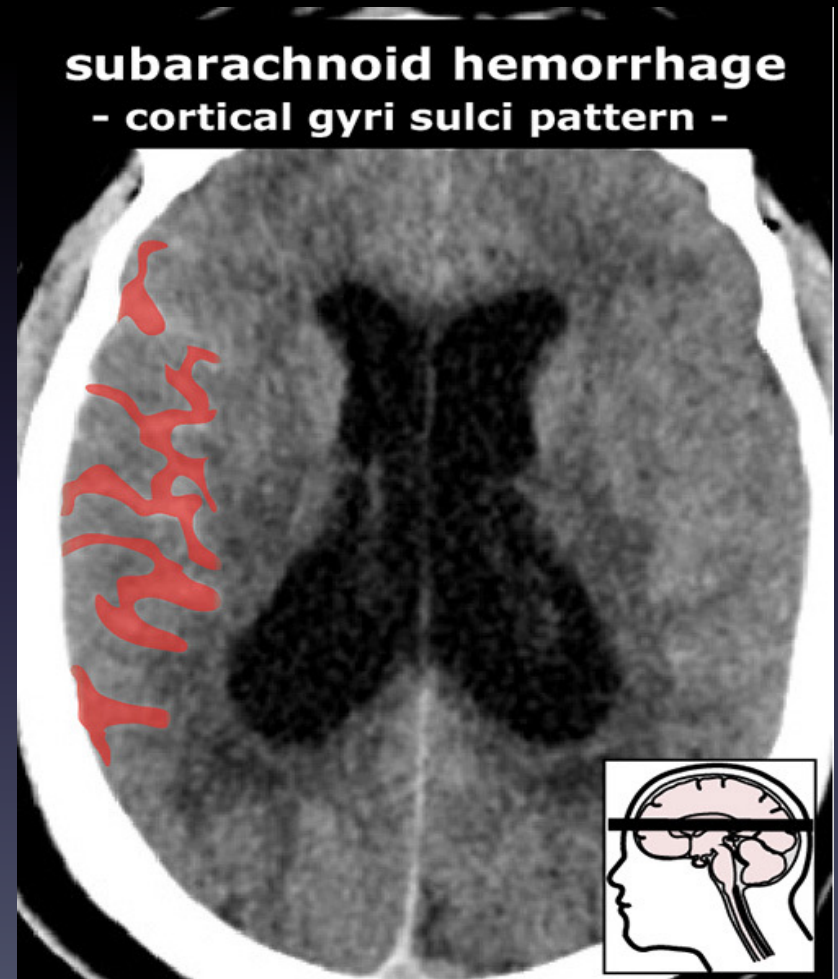


Figure Blood along the right cerebral convexity. The blood follows the cortical gyri sulci pattern, characteristic of subarachnoid blood



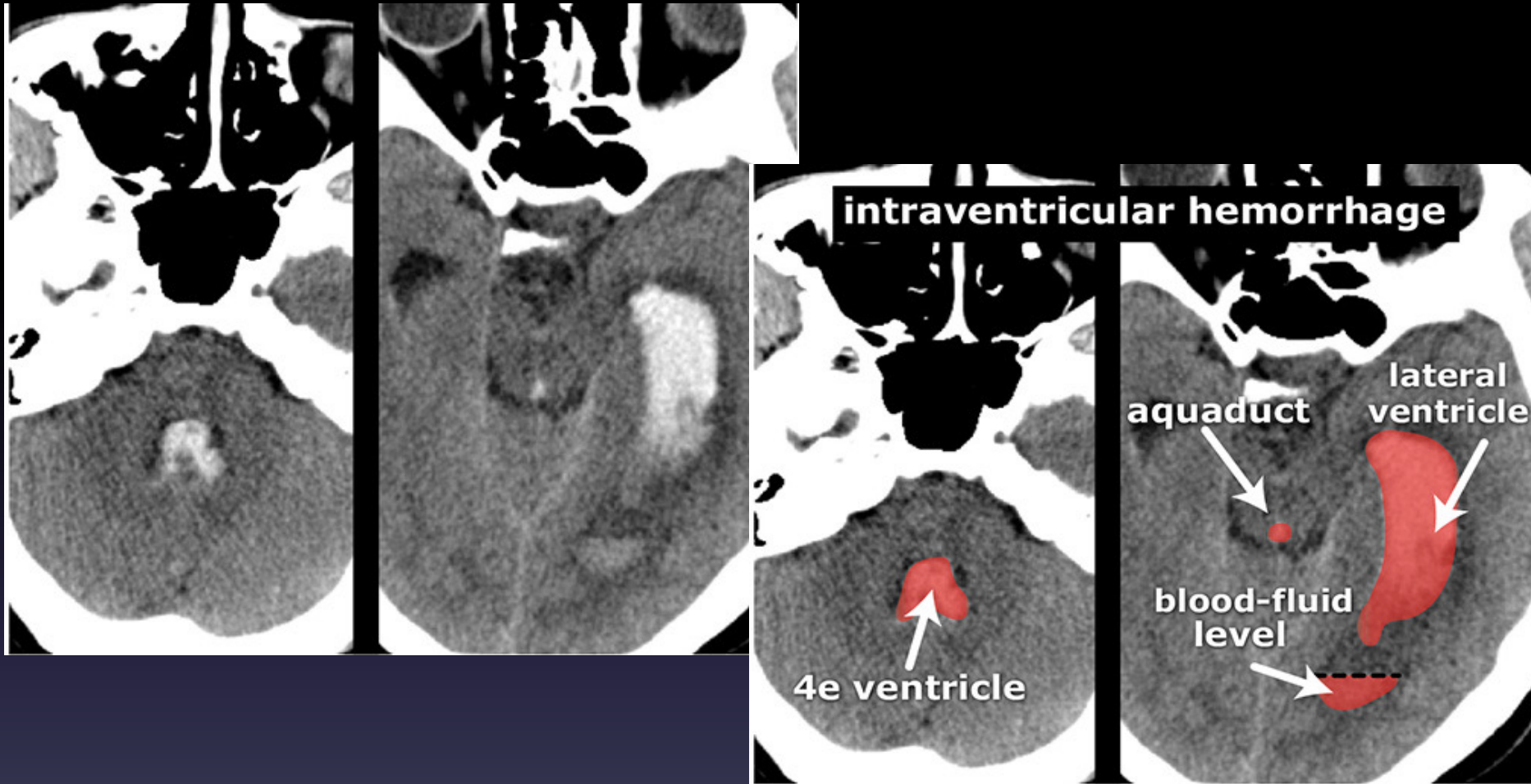


Figure Extensive intraventricular blood in the left lateral ventricle, the aqueduct and the 4th ventricle

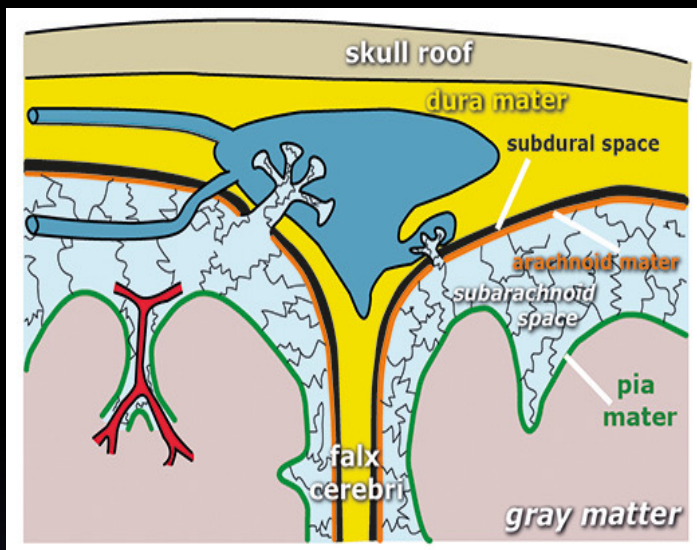
Comment:

The sensitivity of the CT depends on the amount of blood and the time of scanning. The first 48 hours have good sensitivity to detect subarachnoid blood. Sensitivity then diminishes rapidly ( $< 50\%$  after 1 week). This is due to the relatively quick resorption of the subarachnoid blood.

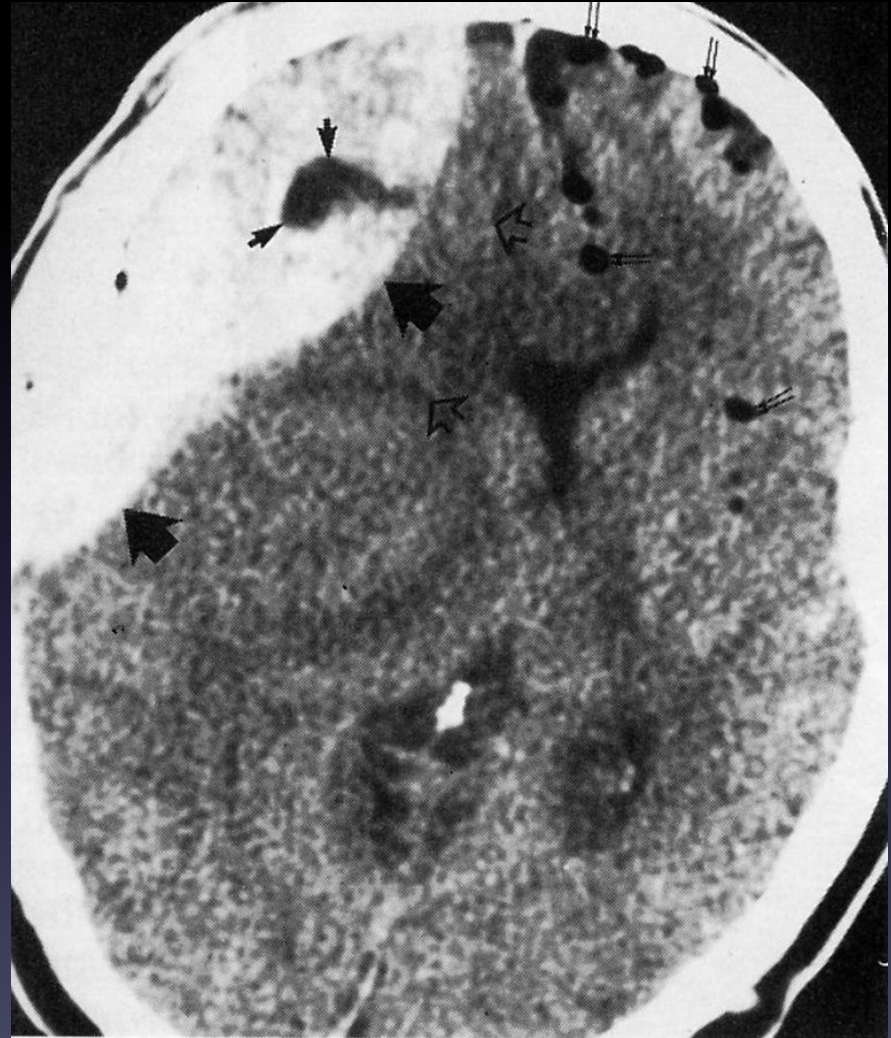
# Ematoma extradurale

- ❑ Sanguinamento tra la dura madre ed il tavolato interno del cranio
- ❑ Nell'85% dei casi si associa a frattura





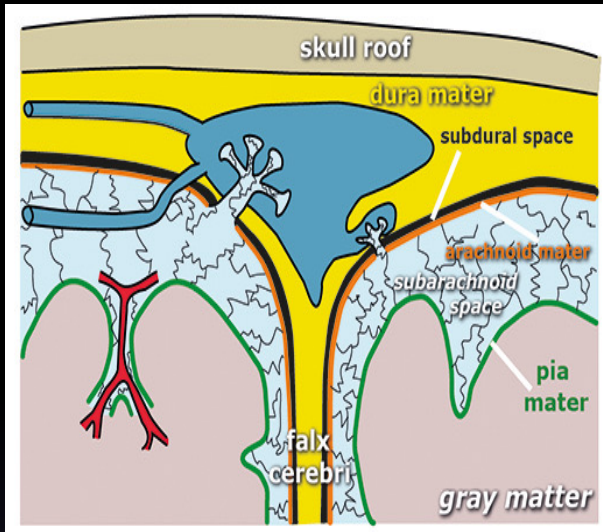
**raccolta a forma  
di lente  
biconvessa,  
iperdensa,  
adiacente alla  
teca cranica**



# Ematoma subdurale

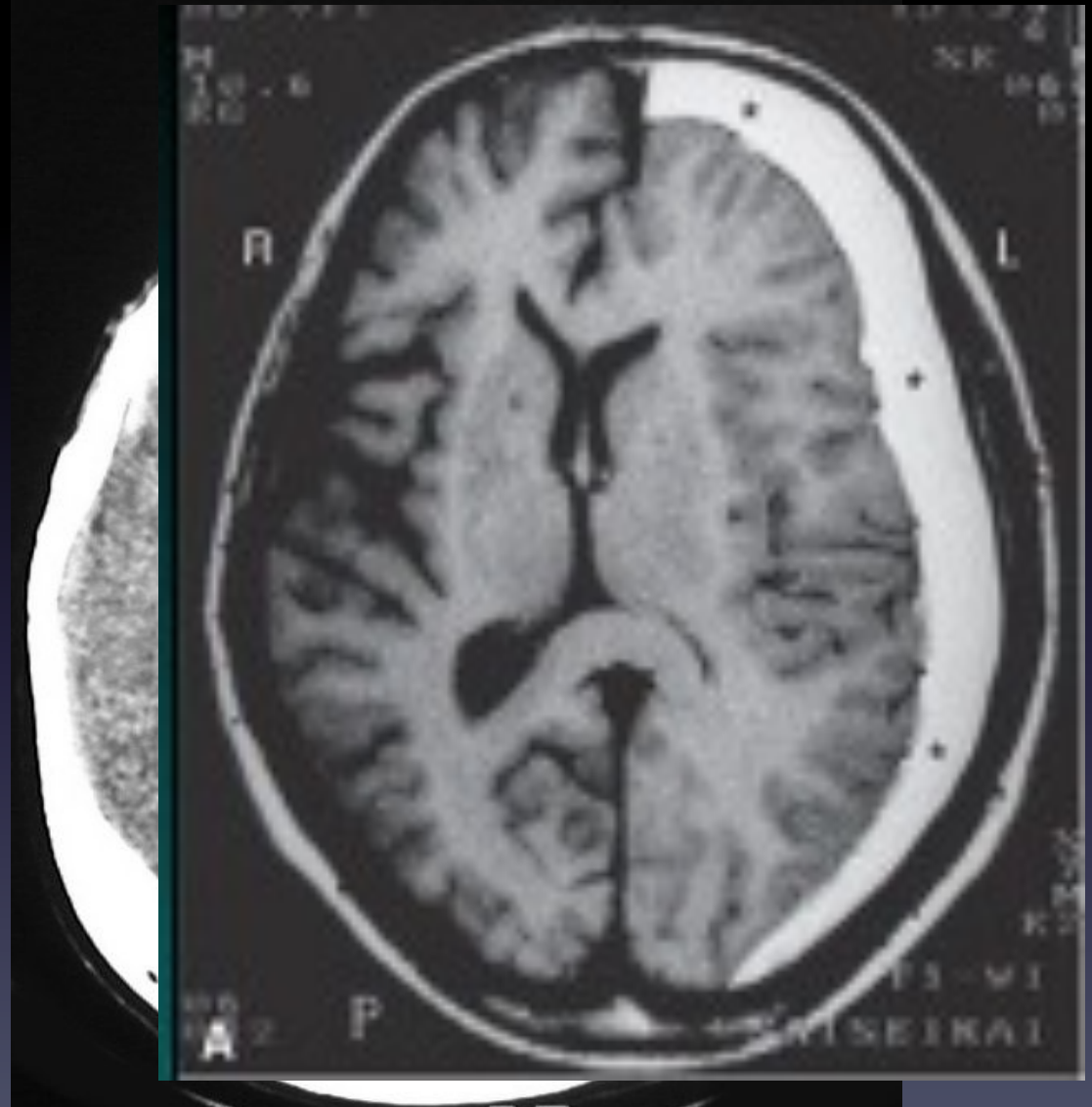
- ❑ Sanguinamento tra la dura madre e l'aracnoide
- ❑
  - acuto (insorge entro 24 h)
  - subacuto( tra 2-10 gg )
  - cronico

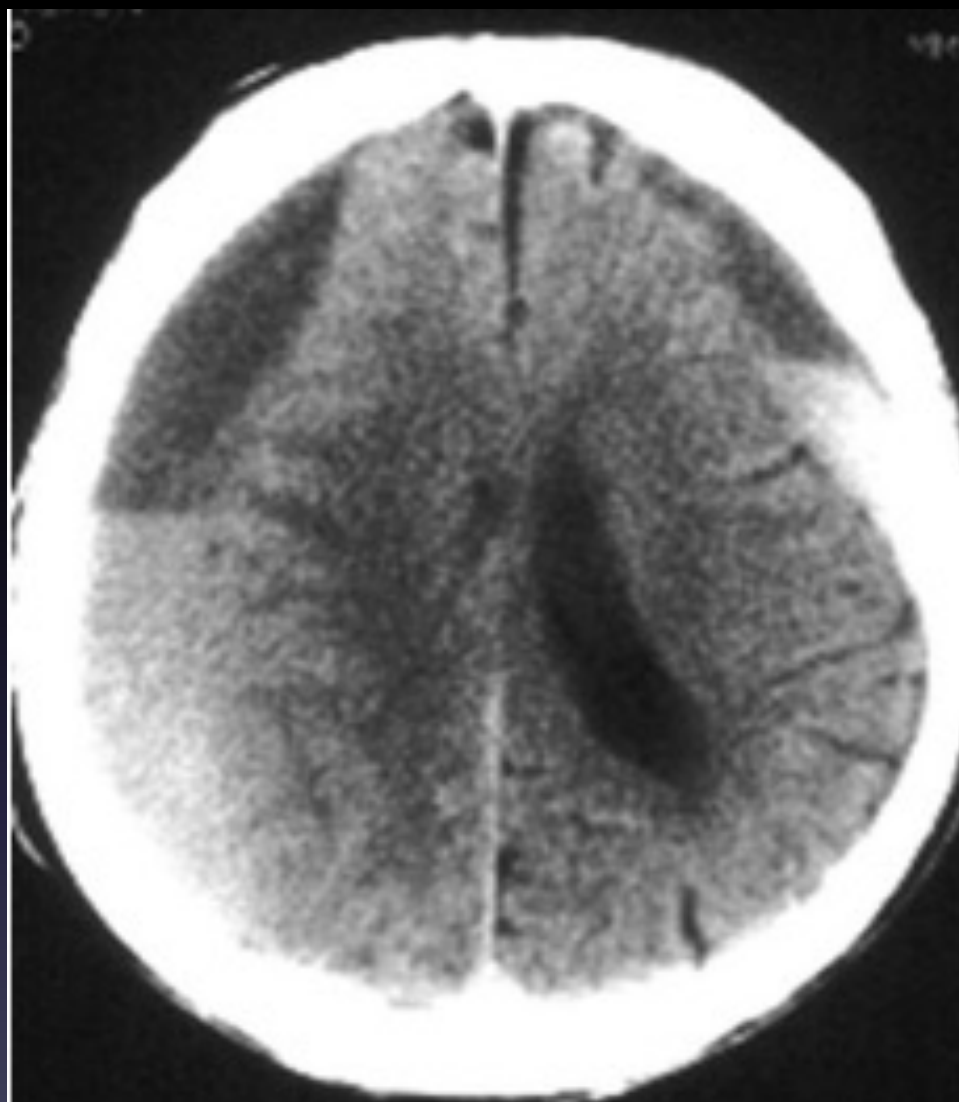




**raccolta  
falciforme, iuxta-  
ossea, iperdensa**

Fase acuta





Ematoma subdurale cronico

# **Lesione vascolare**

**ISCHEMICO**

**o**

**EMORRAGICO**

**condizioni, queste, non sempre differenziabili clinicamente, ma individuabili con la TC.**

# **STROKE: ETIOLOGIA E FREQUENZA**

<b>Ischemia cerebrale</b>	<b>80-85%</b>
<b>Emorragia primaria intracranica</b>	<b>15%</b>
emorragia ipertensiva	
angiopatia amiloidea	
malformazioni vascolari	
miscellanea (tumori, farmaci, diatesi emorragica)	
<b>Emorragia subaracnoidea non traumatica</b>	<b>5%</b>
aneurismi	
SAH non aneurismatica	
<b>Trombosi venosa cerebrale</b>	<b>1%</b>
occlusione dei seni venosi	
trombosi venosa corticale isolata	

# STROKE ISCHEMICO

- Trombotico

- Embolico

80% dei casi di Stroke

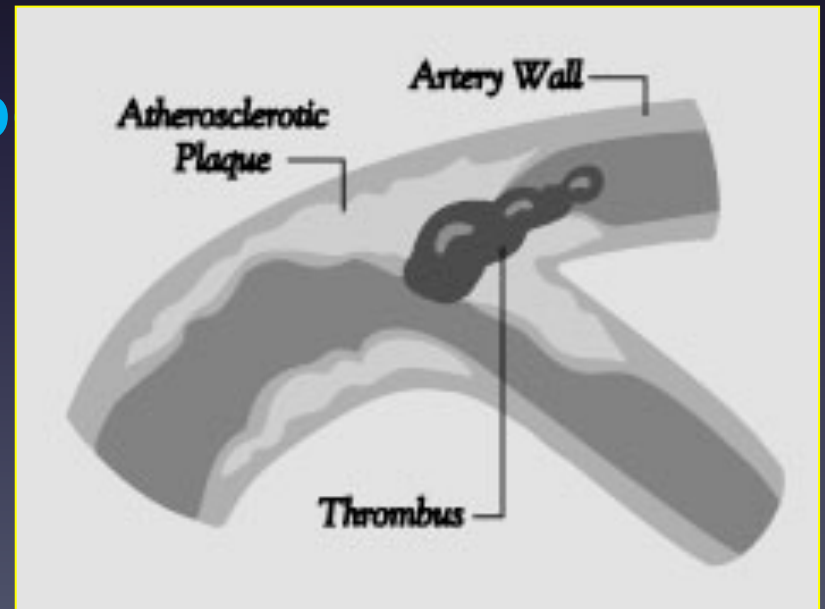
- Emodinamico

# TIPI DI STROKE ISCHEMICO

2 tipi

## STROKE TROMBOTICO

- formazione del coagulo ematico avviene dentro il cervello (trombo)
- responsabile del 50% di tutti gli strokes



# Stroke trombotico

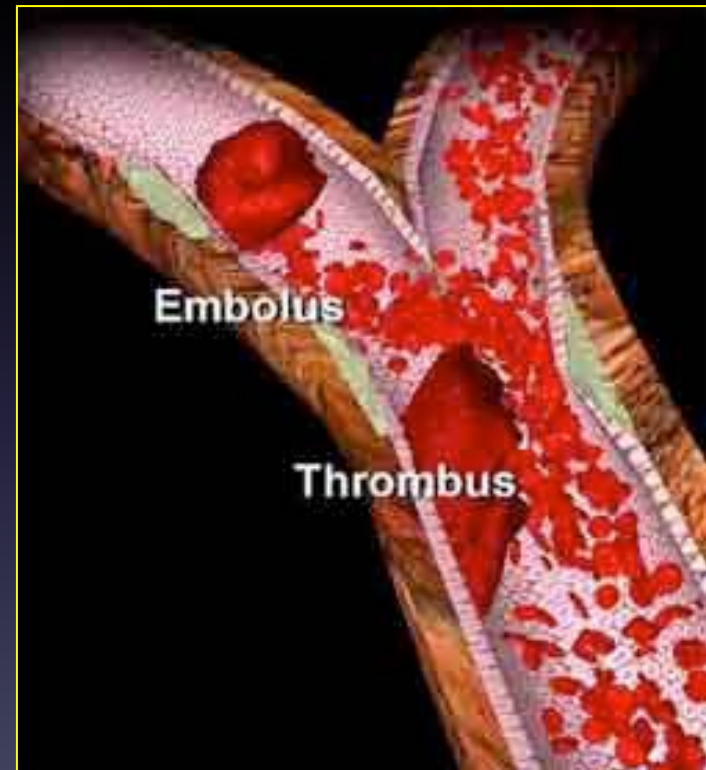
- Uno stroke trombotico si verifica quando il coagulo di sangue si sviluppa in una delle arterie del cervello o in quelle che direttamente lo riforniscono e cresce fino a diventare abbastanza grande da bloccare la circolazione



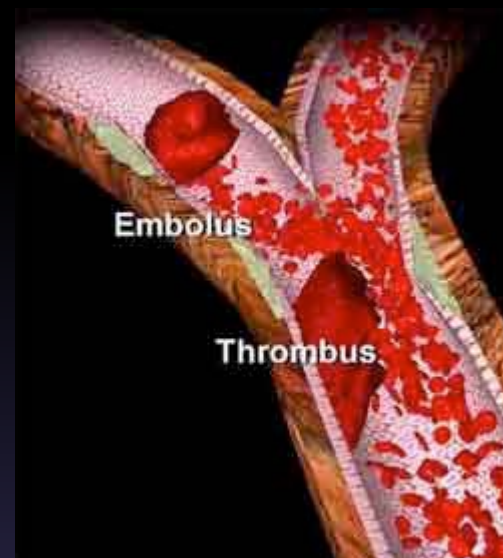
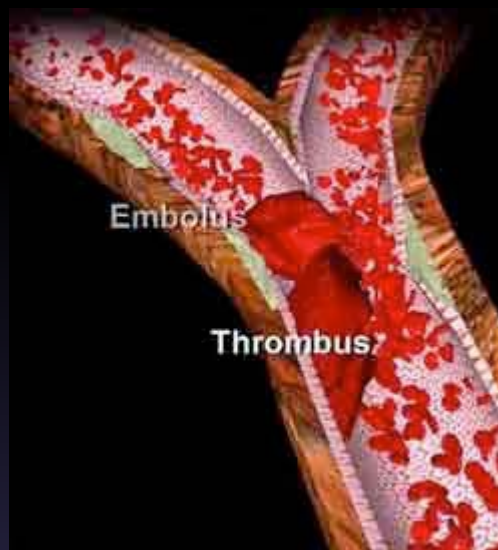
# Stroke trombotico

Cause:

- – Arteriosclerosis
- – Hypothyroidism
- – Oral contraceptives
- – Sickle cell disease
- – Coagulation disorders



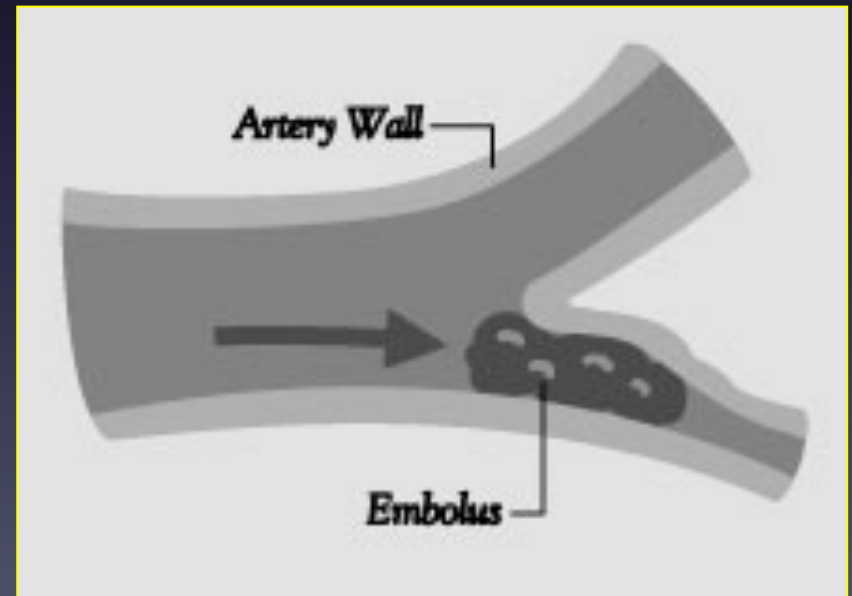
# Stroke trombotico



- Può essere il trombo stesso a bloccare il flusso
- Un embolo si può staccare dal trombo e provocare il blocco del flusso secondariamente

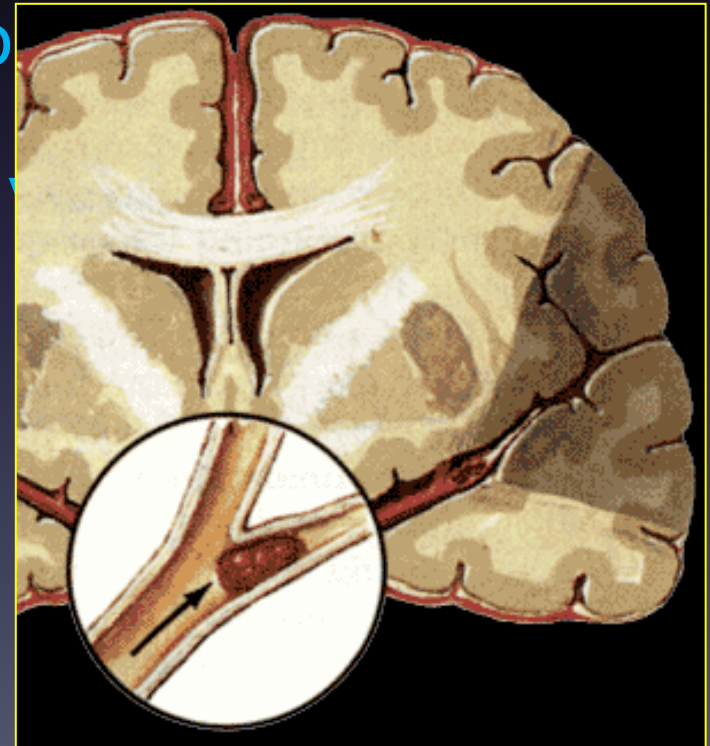
# STROKE EMBOLICO

- formazione del coagulo ematico (embolo) avviene in una qualunque parte del corpo che non sia il cervello e tramite la circolazione arriva al cervello ove si blocca.
- responsabile del 30% di tutti gli strokes

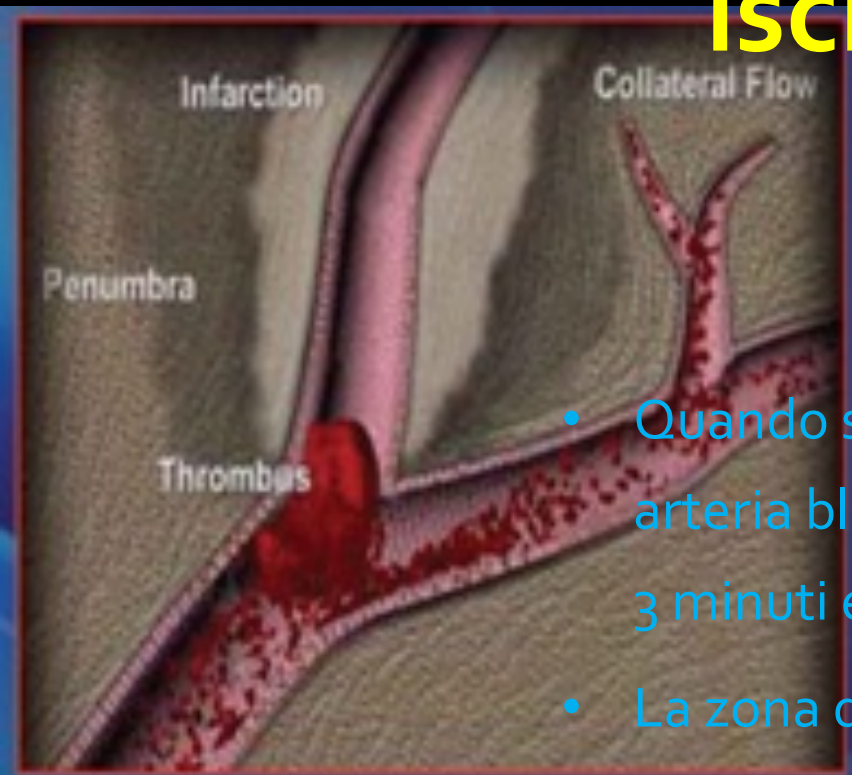


# Stroke Embolico

Una volta nel cervello l' embolo  
passa in vasi sempre più piccoli  
blocca la dove il diametro del  
inferiore al suo diametro



# Progressione dello stroke ischemico



- Quando si verifica uno stroke i neuroni riforniti dall'arteria bloccata muoiono in un tempo variabile tra i 3 minuti e le 2 ore.
- La zona dove è presente la morte cellulare è quella di **INFARTO**
- Altre cellule che si trovano in una zona periferica sono lese ma non muoiono subito poichè vi sono dei circoli collaterali che vicariano parzialmente: zona di **PENOMBRA**

# Progressione dello stroke ischemico

- La sopravvivenza nell' area di penombra ischemica può durare numerose ore, ma alla fine se non si pone rimedio anche la zona di penombra ischemica diventa irrecuperabile

# Ictus

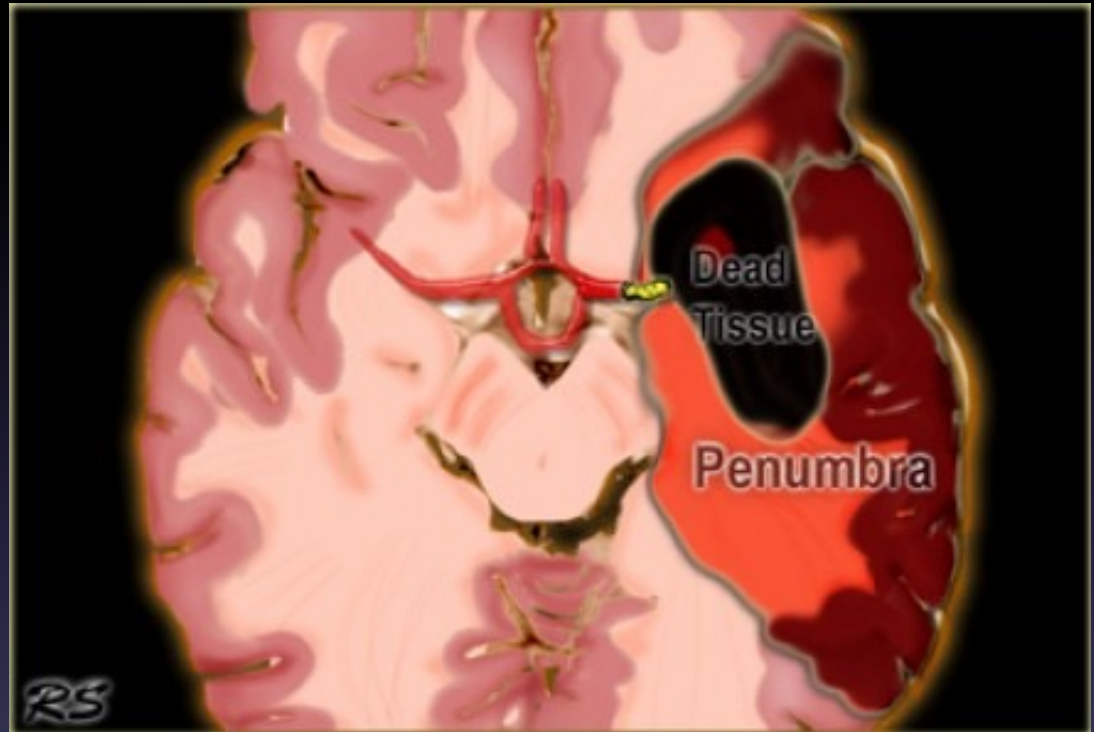
The goal of imaging in a patient with acute stroke is:

- Exclude hemorrhage
- Differentiate between irreversibly affected brain tissue and reversibly impaired tissue (dead tissue versus tissue at risk)
- Identify stenosis or occlusion of major extra- and intracranial arteries



# Lesione ischemica

- TC
- RM



Penumbra: Occlusion of the MCA with irreversibly affected or dead tissue in black and tissue at risk or penumbra in red

La metodica di elezione per  
lo studio dello stroke è la  
**TC**

# TC

- ❑ immediata diagnosi differenziale tra evento ischemico ed emorragico
- ❑ eventuale individuazione di patologie (neoplasie, ematomi subdurali cronici) che possono clinicamente mimare uno stroke.

## Vantaggi

- ❑ rapidità di esecuzione
- ❑ buona diffusione territoriale delle apparecchiature

# Stroke ischemico

- Fase **iperacuta** (2-6 ore) (TC, RM seq. convenzionali, diffusione, perfusione, spettroscopia)
- Fase **acuta** (8-12 ore)
- Fase **subacuta** (3-14 giorni)
- Fase **cronica** (dopo 20-30 giorni)

- CT has the advantage of being available 24 hours a day and is the gold standard for hemorrhage. Hemorrhage on MR images can be quite confusing. On CT 60% of infarcts are seen within 3-6 hrs and virtually all are seen in 12-24 hours. The overall sensitivity of CT to diagnose stroke is 64% and the specificity is 85%.

## **CT early signs**

---

- hypo attenuating brain tissue
- obscuration of lentiform nucleus
- dense MCA sign
- “insular ribbon” sign
- loss of sulcal effacement

**Nelle prime  
6 ore:**



- ❑ reperto TC nei limiti della norma
- ❑ nel 25% iperdensità dell'arteria cerebrale media





6 h

### Hypo attenuating brain tissue

The reason we see ischemia on CT is that in ischemia cytotoxic edema develops as a result of failure of the ion-pumps.

These fail due to an inadequate supply of ATP.

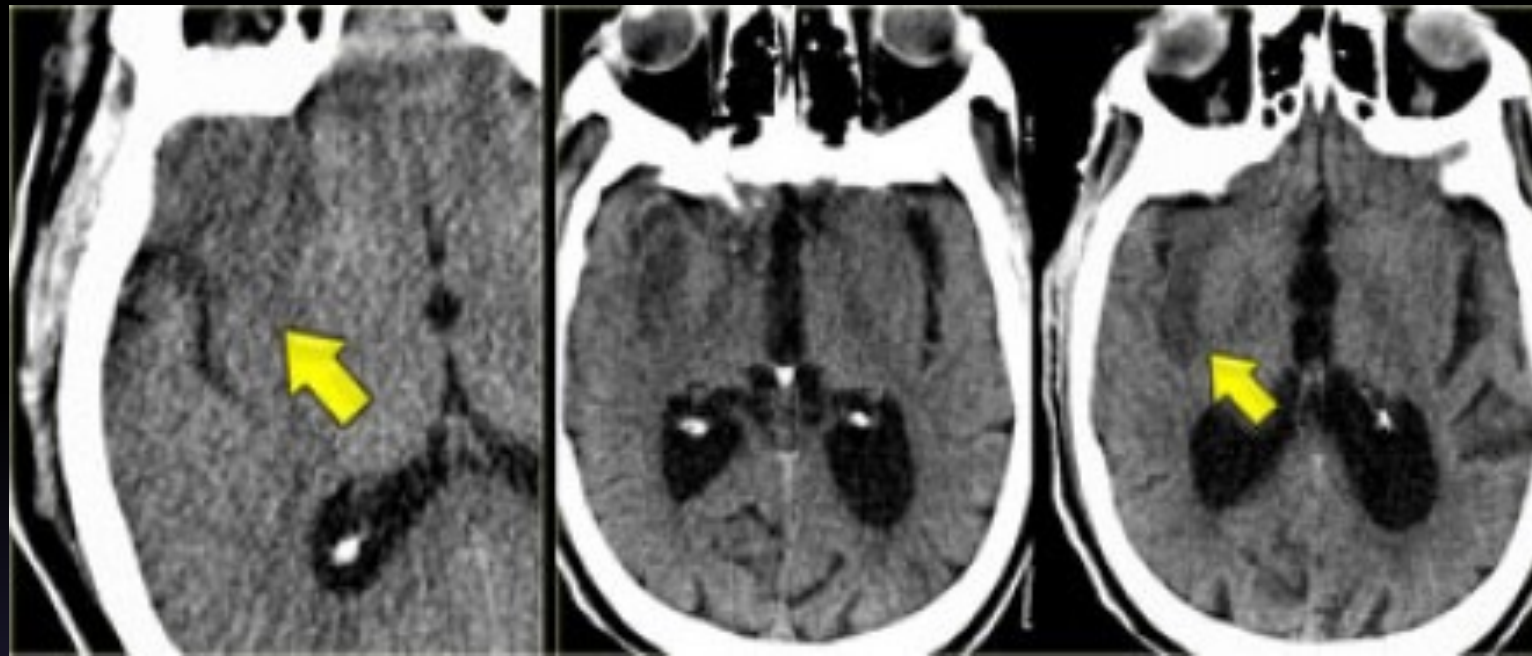
An increase of brain water content by 1% will result in a CT attenuation decrease of 2.5 HU.

- On the left a patient with hypoattenuating brain tissue in the right hemisphere.  
The diagnosis is infarction, because of the location (vascular territory of the middle cerebral artery (MCA) and because of the involvement of gray and white matter, which is also very typical for infarction

hypoattenuation appearing within six hours is highly specific for irreversible ischemic brain damage

- Patients who present with symptoms of stroke and who demonstrate hypodensity on CT within first six hours were proven to have larger infarct volumes, more severe symptoms, less favorable clinical courses and they even have a higher risk of hemorrhage. Therefore whenever you see hypodensity in a patient with stroke this means bad news.

No hypodensity on CT is a good sign !



## Insular Ribbon sign

This refers to hypodensity and swelling of the insular cortex. It is a very indicative and subtle early CT-sign of infarction in the territory of the middle cerebral artery.

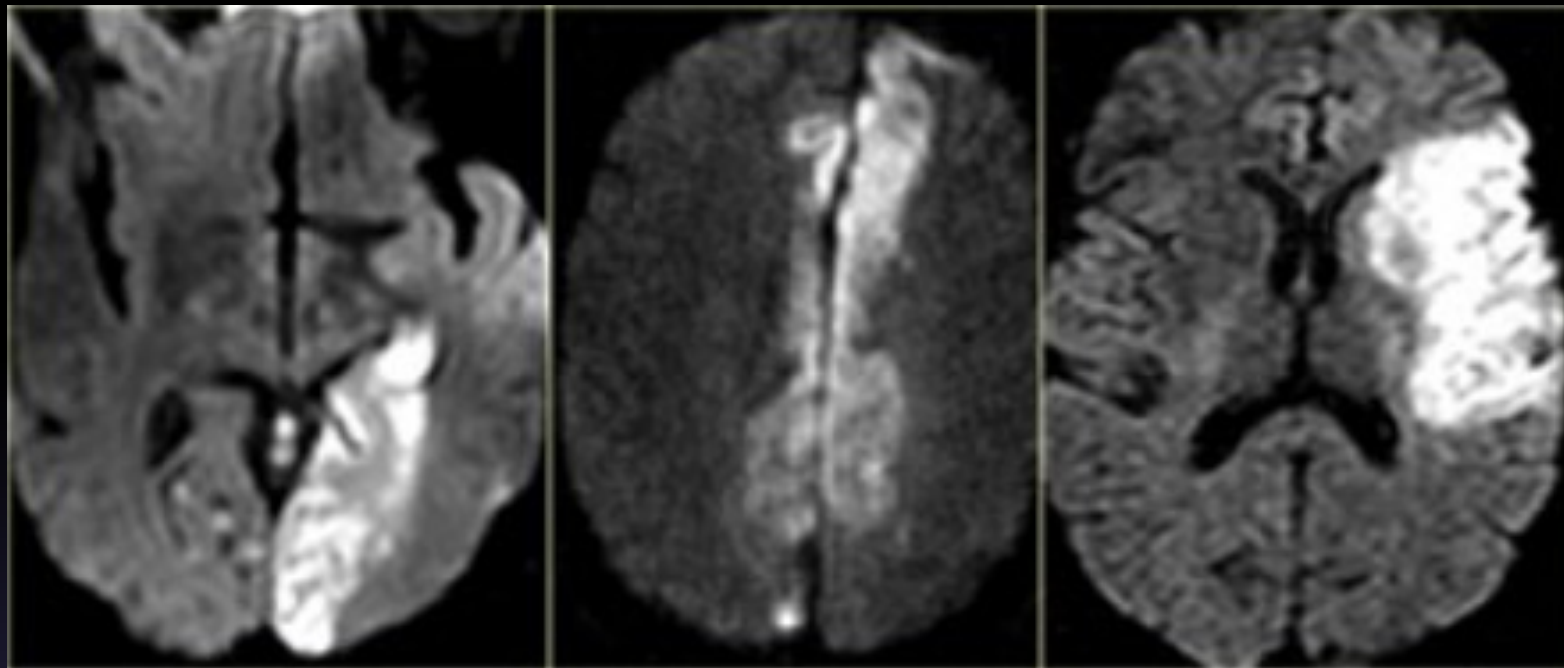
This region is very sensitive to ischemia because it is the furthest removed from collateral flow.

It has to be differentiated from herpes encephalitis.



### **Dense MCA sign**

This is a result of thrombus or embolus in the MCA.  
On the left a patient with a dense MCA sign.  
On CT-angiography occlusion of the MCA is visible.



RM

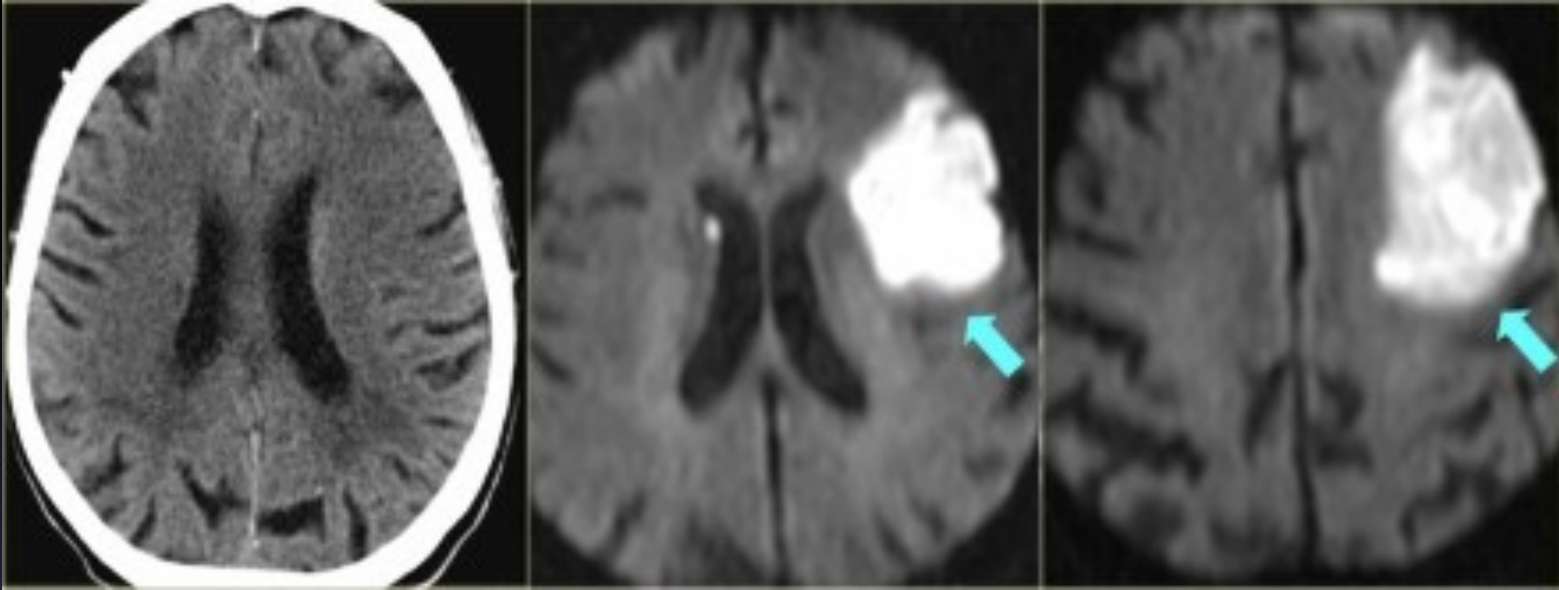
DWI in posterior, anterior and middle cerebral infarction

### Diffusion Weighted Imaging (DWI)

DWI is the most sensitive sequence for stroke imaging. DWI is sensitive to restriction of Brownian motion of extracellular water due to imbalance caused by cytotoxic edema.

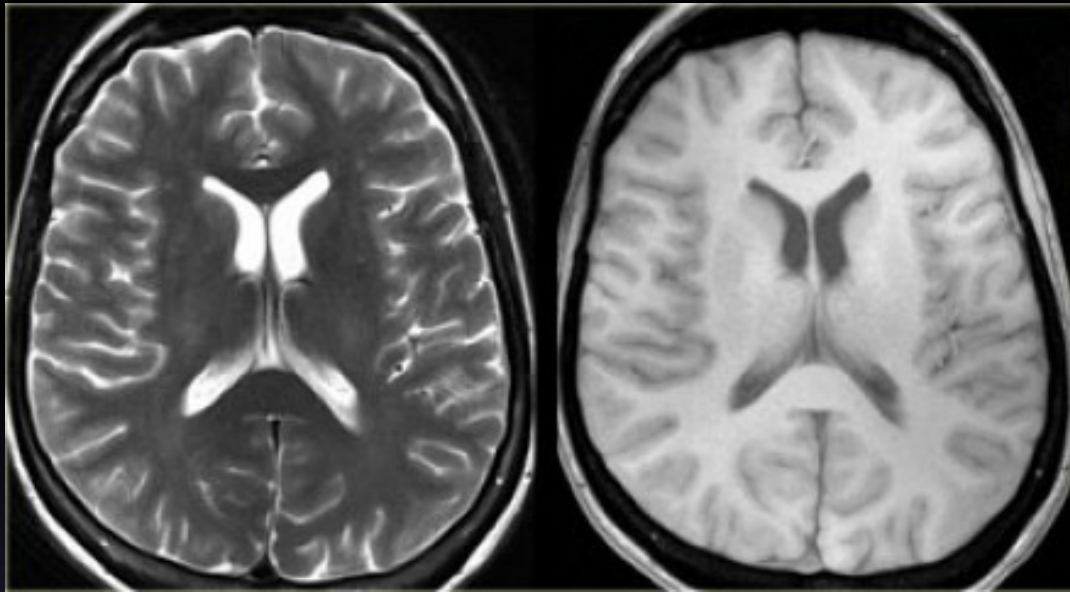
Normally water protons have the ability to diffuse extracellularly and loose signal.

High intensity on DWI indicates restriction of the ability of water protons to diffuse extracellularly.

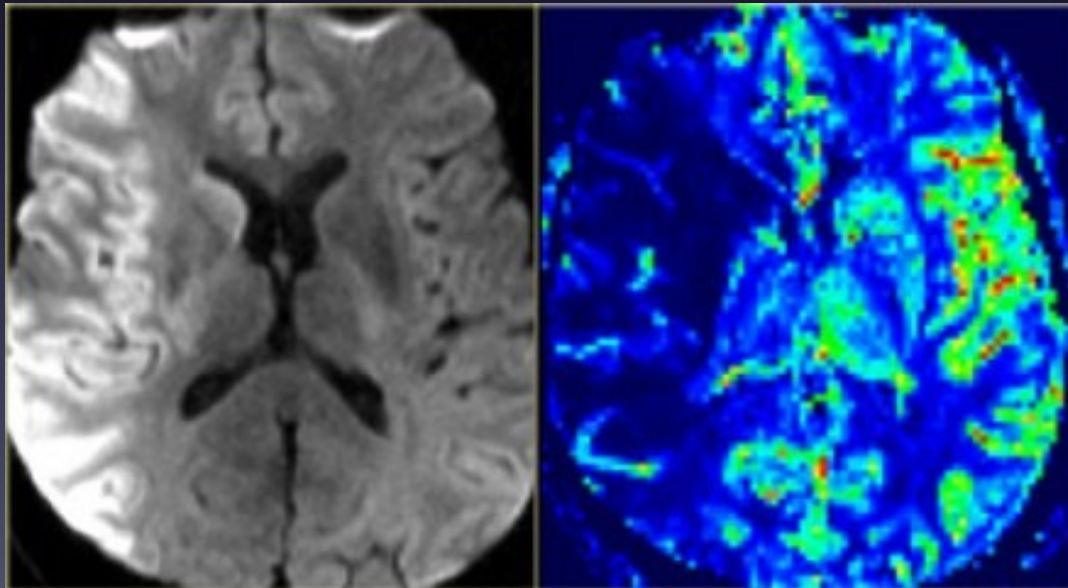


There is some hypodensity and swelling in the left frontal region with effacement of sulci compared with the contralateral side





1 hour after onset of symptoms



Large area with restricted diffusion in territory of the right middle cerebral artery



# FASE ACUTA

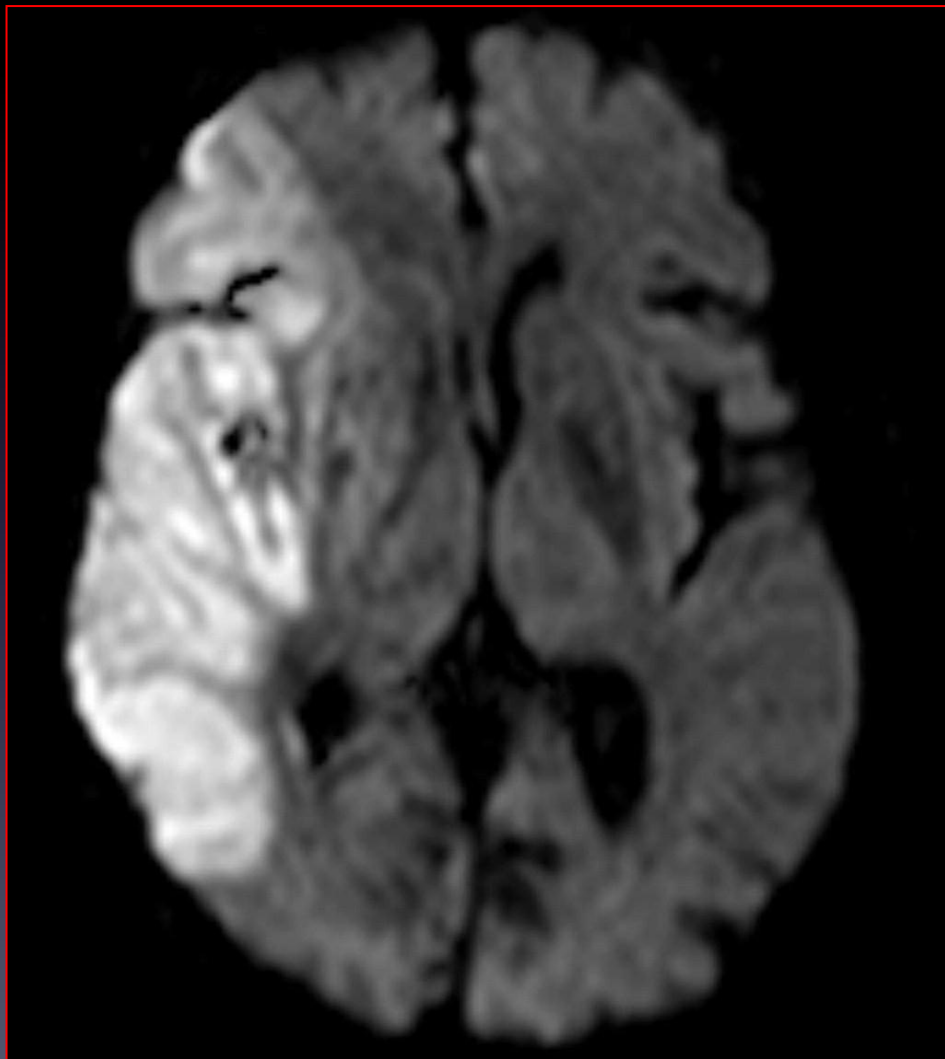
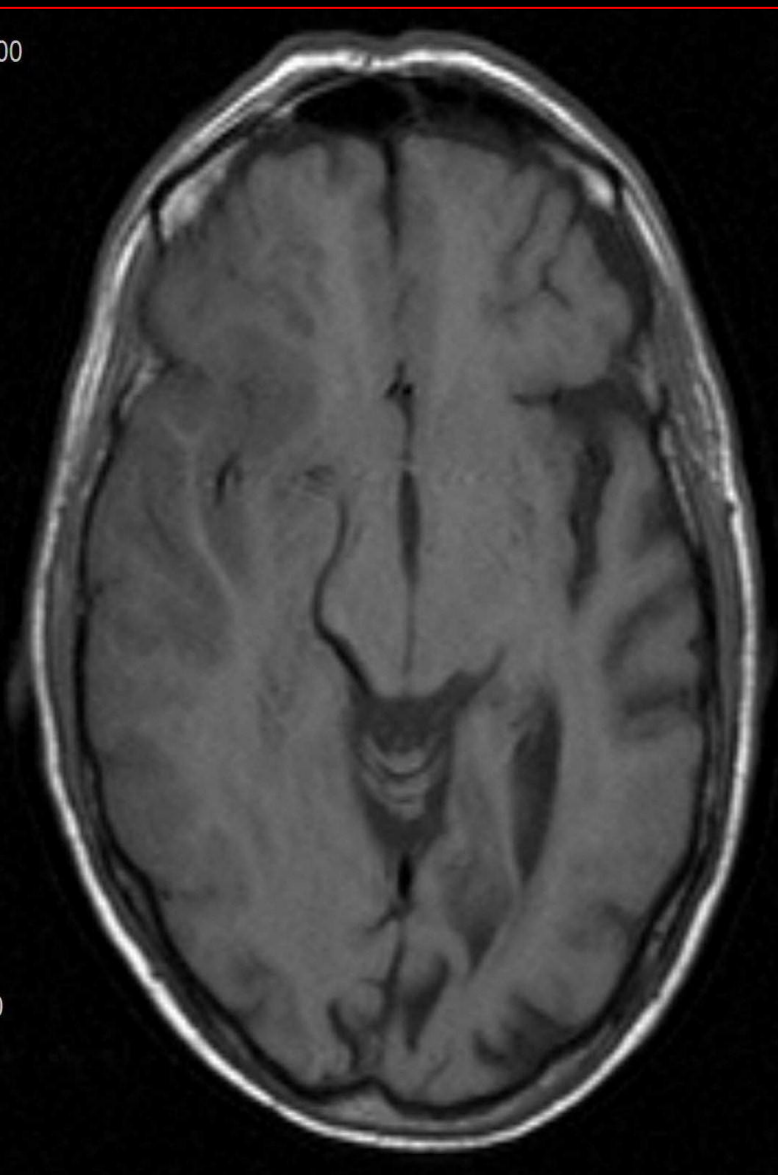
- TC: ipodensità dell'area ischemica
- T1: Rigonfiamento corticale
- DP, T2, FLAIR: iperintensità focale
- Spettroscopia: incremento del lattato; riduzione N-acetilaspartato (deplezione neuronale)
- Diffusione: riduzione coefficiente di diffusione
- Perfusion: decremento curva segnale/tempo

**entro 12-24 ore:**

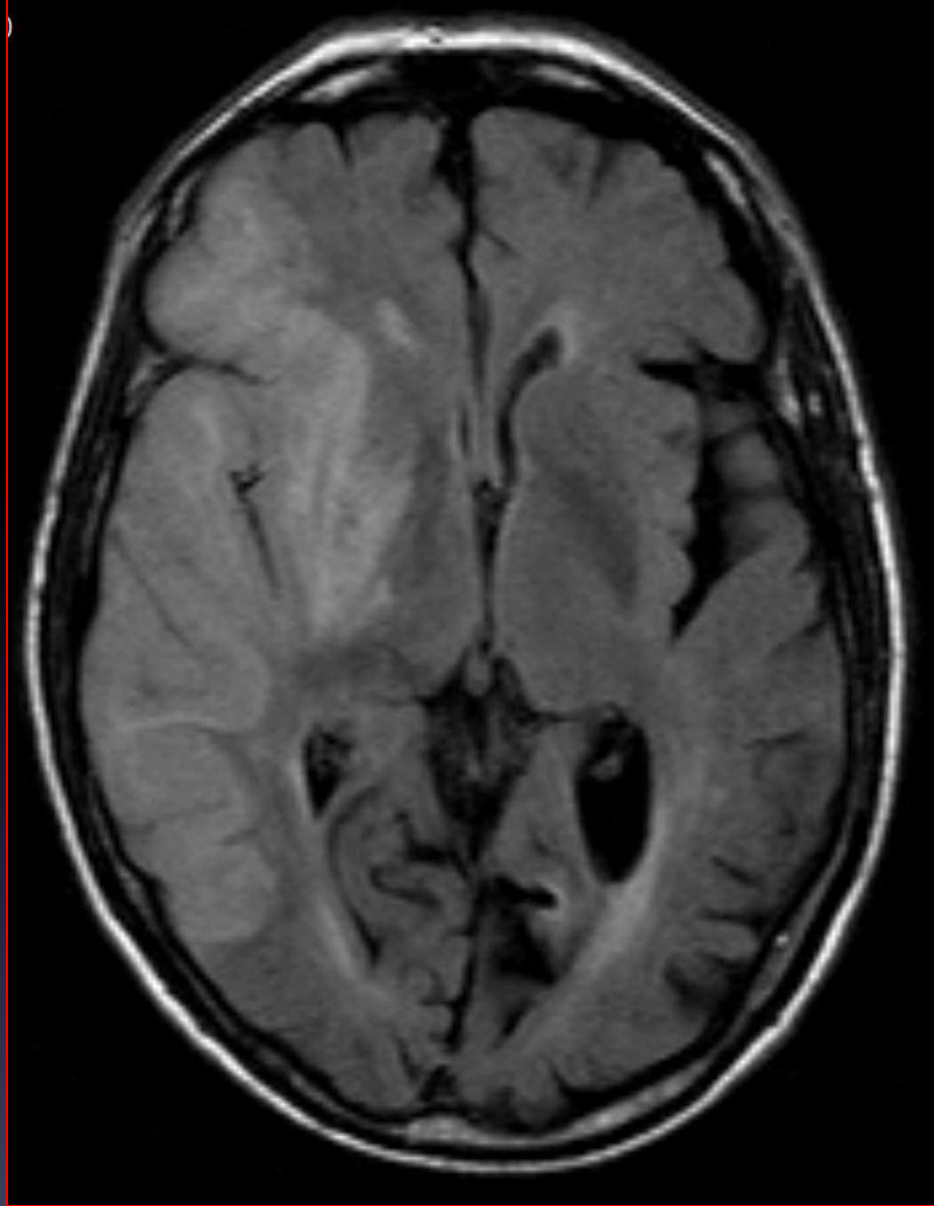
- ❑ sfumata ipodensità del territorio coinvolto**
- ❑ ridotta apprezzabilità dell'interfaccia  
sostanza bianca-sostanza grigia**
- ❑ iniziale spianamento dei solchi locoregionali**

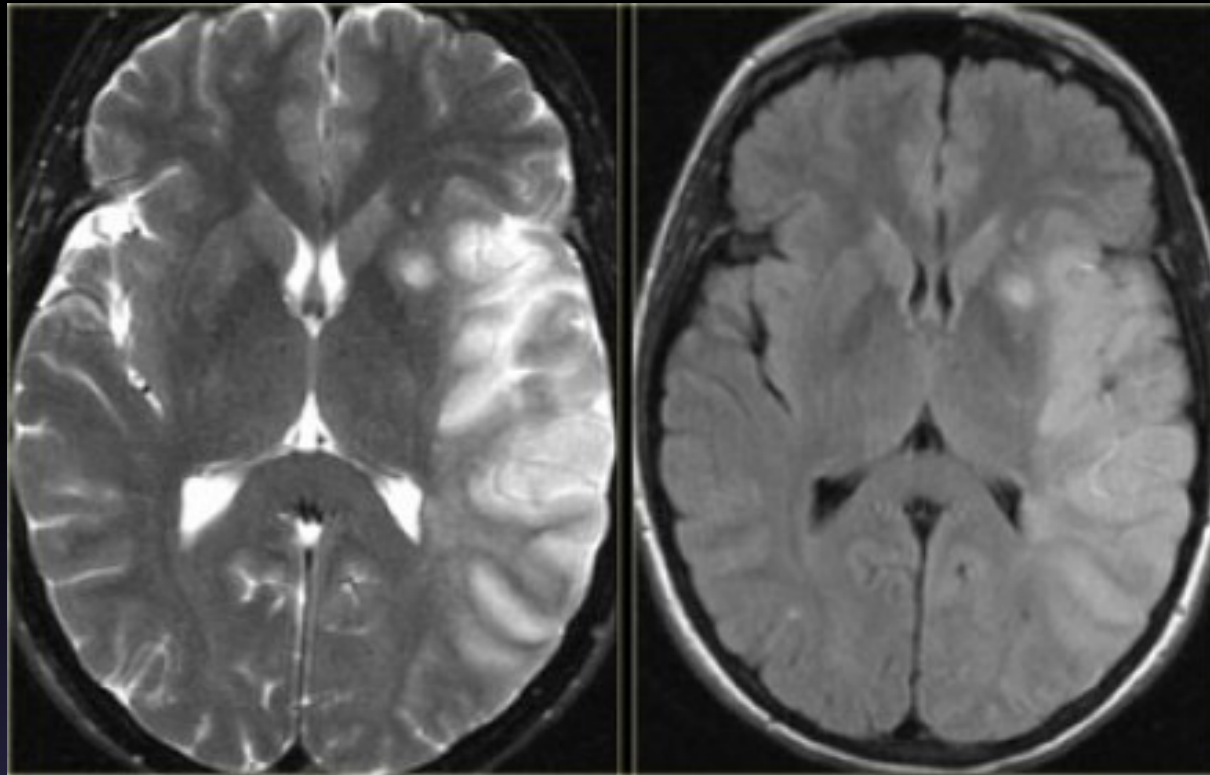












**Hyperintensity on MR = irreversible ischemic brain damage**

On PD/T2WI and FLAIR infarction is seen as high SI.  
These sequences detect 80% of infarctions before 24 hours.  
They may be negative up to 2-4 hours post-ictus!

On the left T2WI and FLAIR demonstrating hyperintensity in the territory of the middle cerebral artery.  
Notice the involvement of the lentiform nucleus and insular cortex.

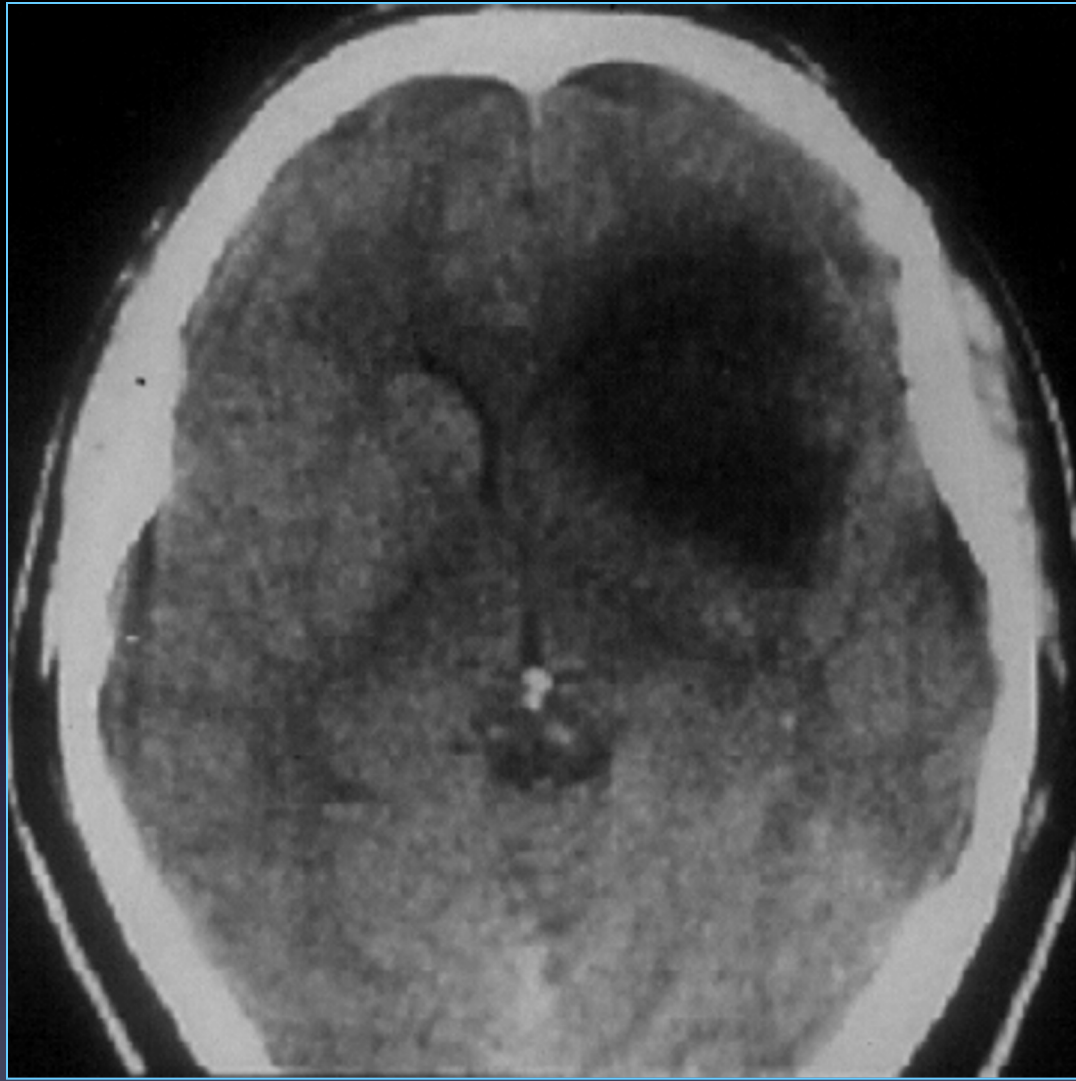


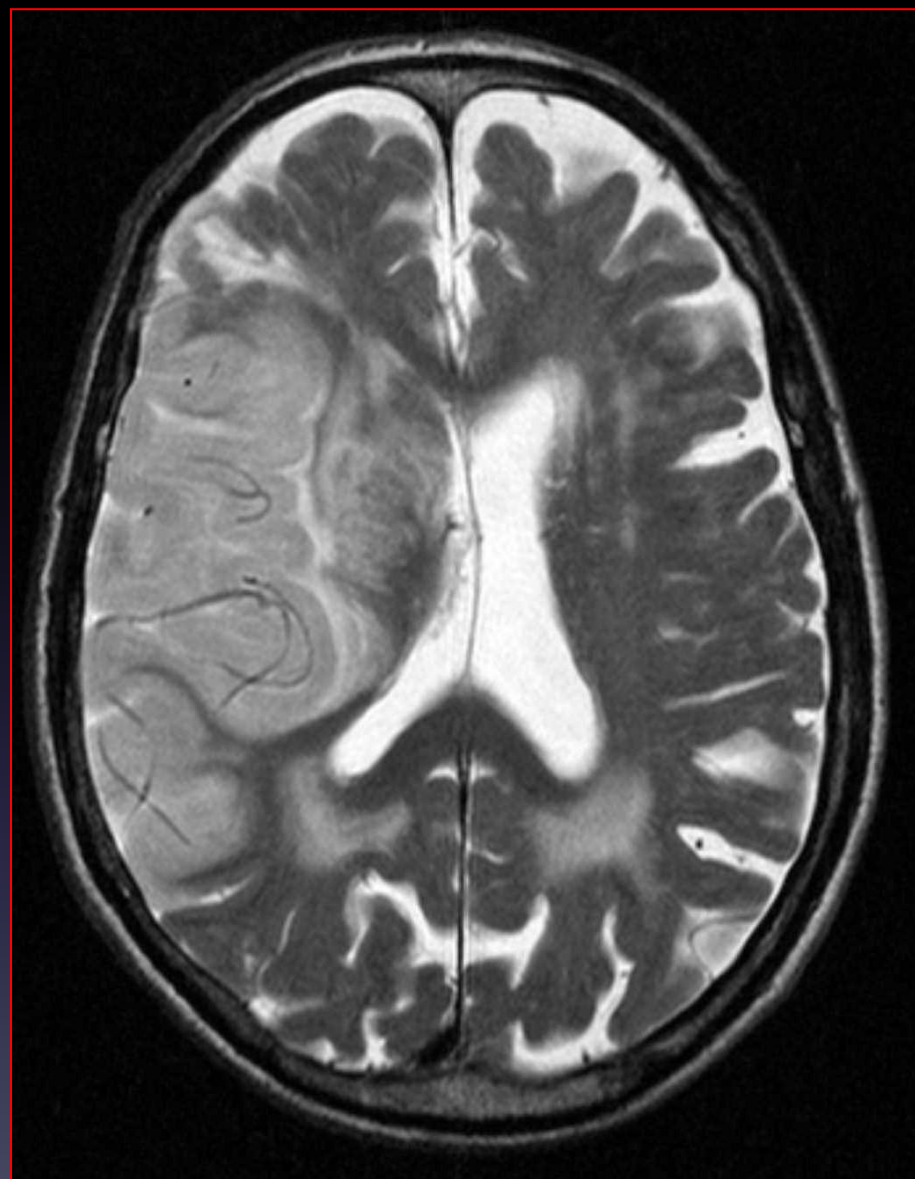
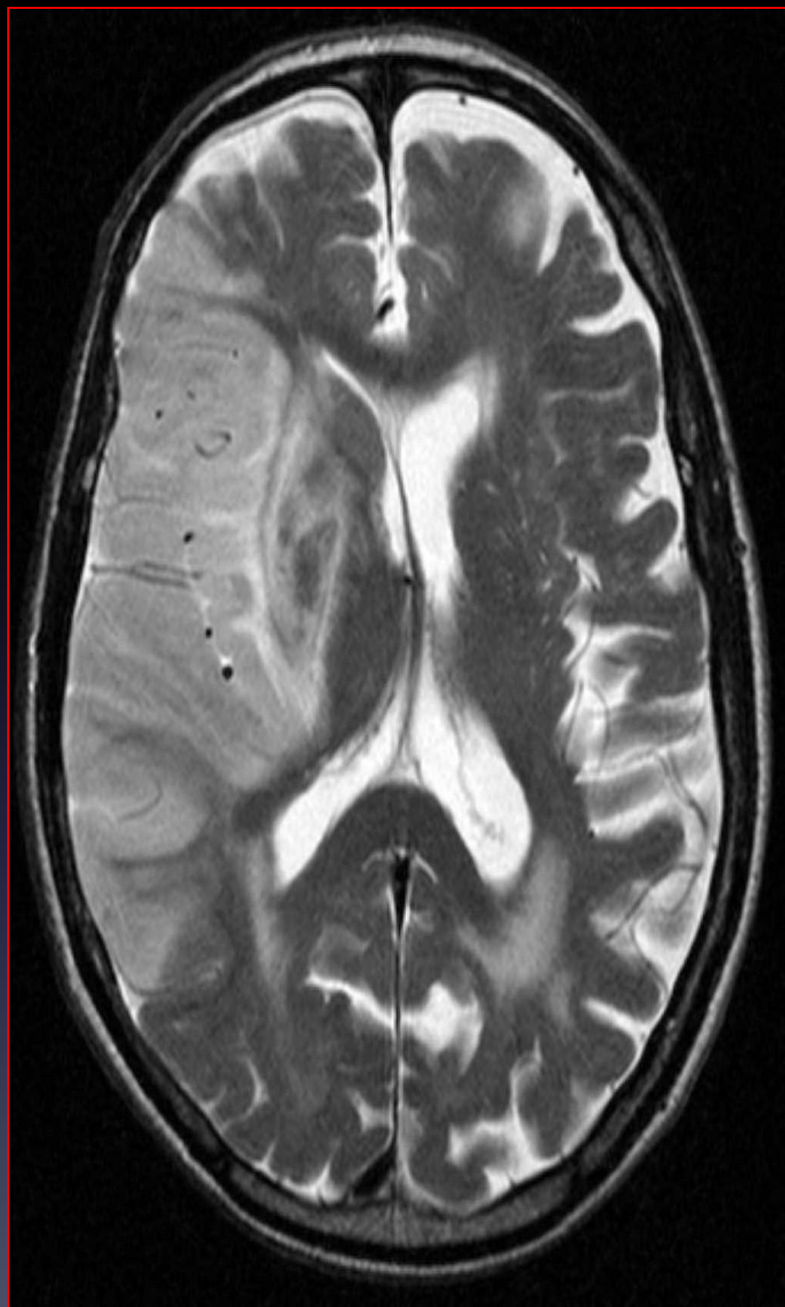
High signal on conventional MR-sequences is comparable to hypodensity on CT.  
It is the result of irreversible injury with cell death.  
So hyperintensity means BAD news: dead brain.

- 3-14 giorni: alterazioni di segnale più evidenti
- Edema; effetto compressivo
- Impregnazione diffusa dopo mdc

## FASE SUBACUTA

- **Ipodensità sempre più marcata**
- **T1, DP, T2 e FLAIR: alterazione di segnale ben evidente \ prese di contrasto in T1**
  - T1 → ipo
  - DP\T2\FLAIR → iper
- **T1: infarcimento emorragico**





# Fase cronica

- 20-30 giorni : risoluzione edema, riassorbimento tessuto necrotico; esiti gliotico-malacici
- Nessuna impregnazione dopo mdc

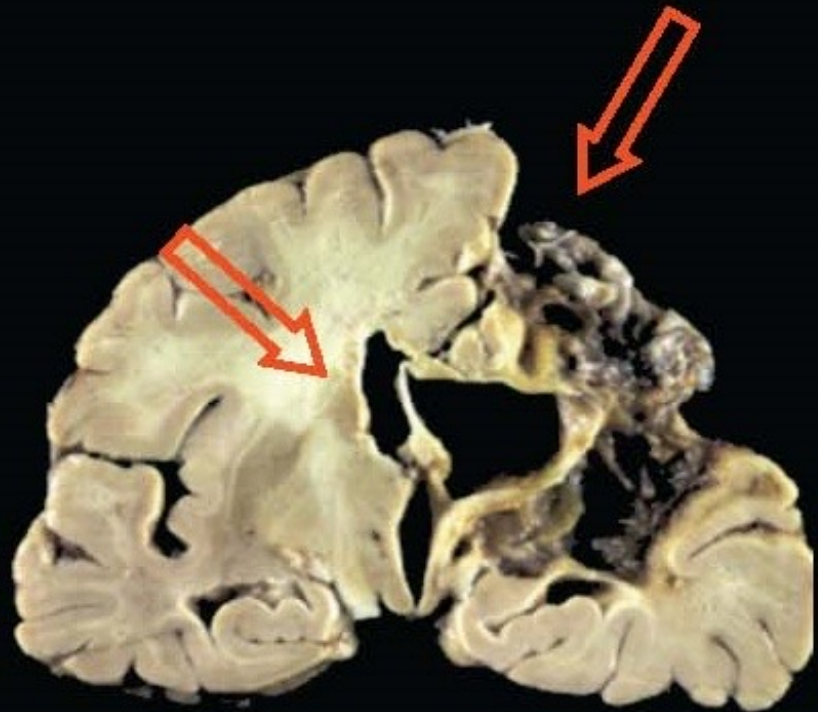


## FASE CRONICA

- TC: Segnale simil-liquorale
- RM: Segnale simil-liquorale
- Segni di atrofia focale (ampliamento spazi liquorali)

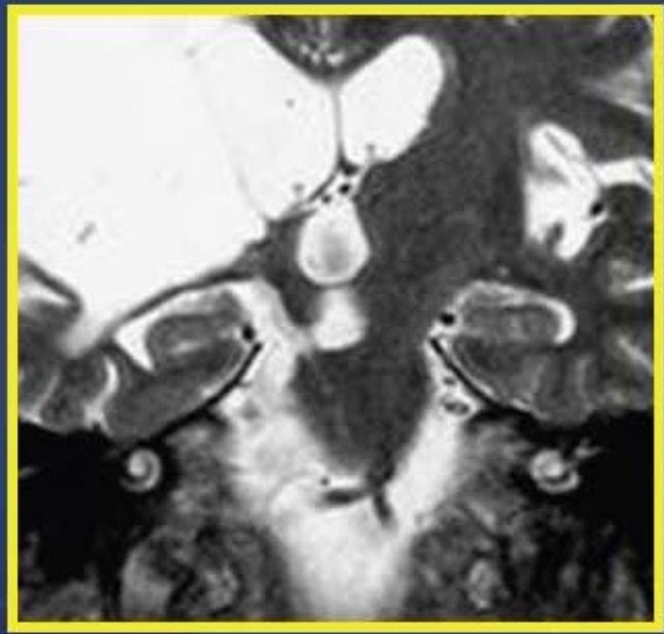
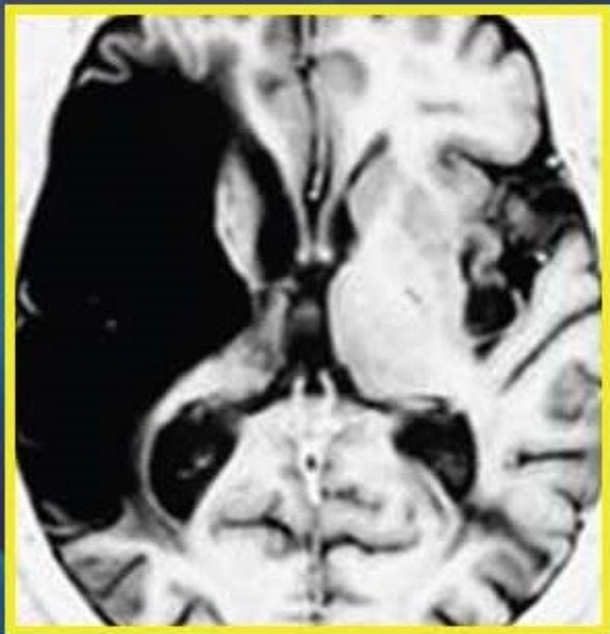


## Stroke ischemico di lunga data : TC

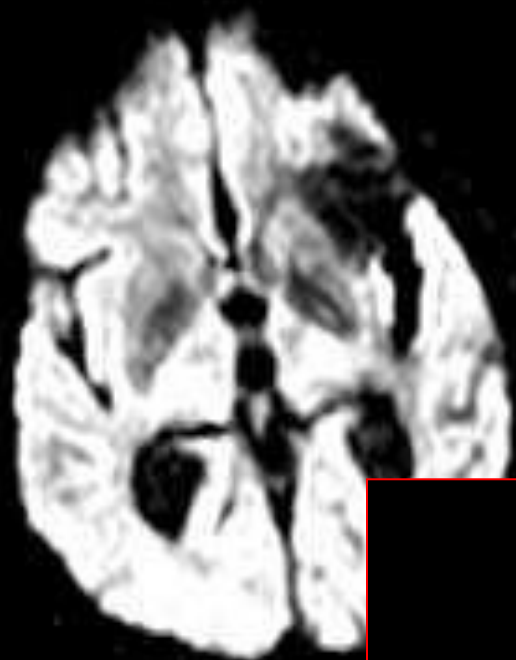


# Stroke Ischemico di lunga data

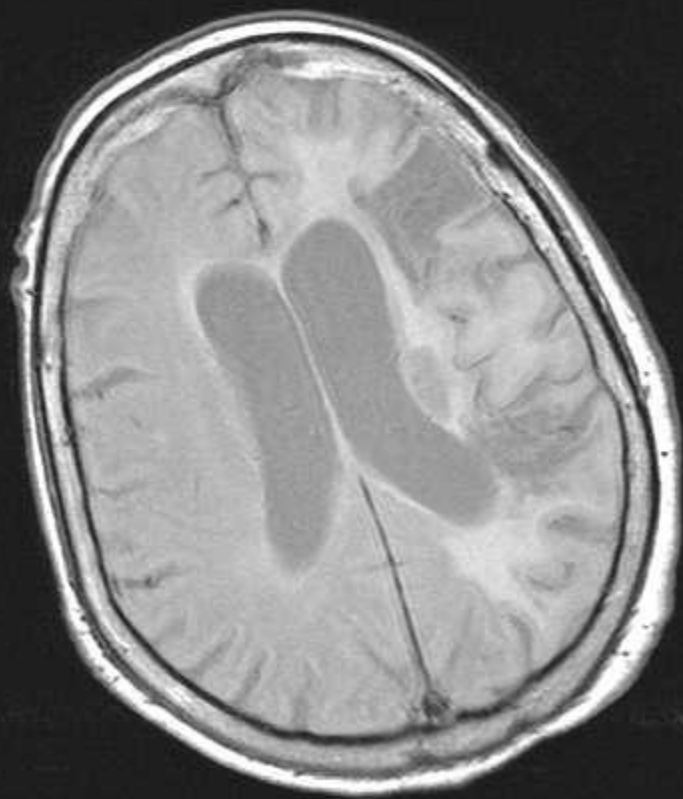
- Poromalacia
- Gliosi perilesionale
- Degenerazione Walleriana



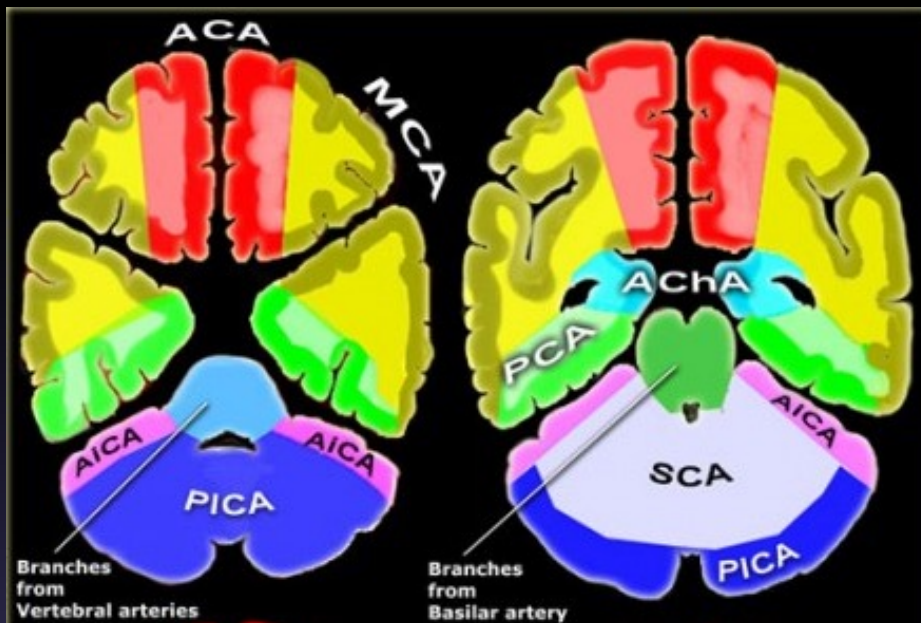




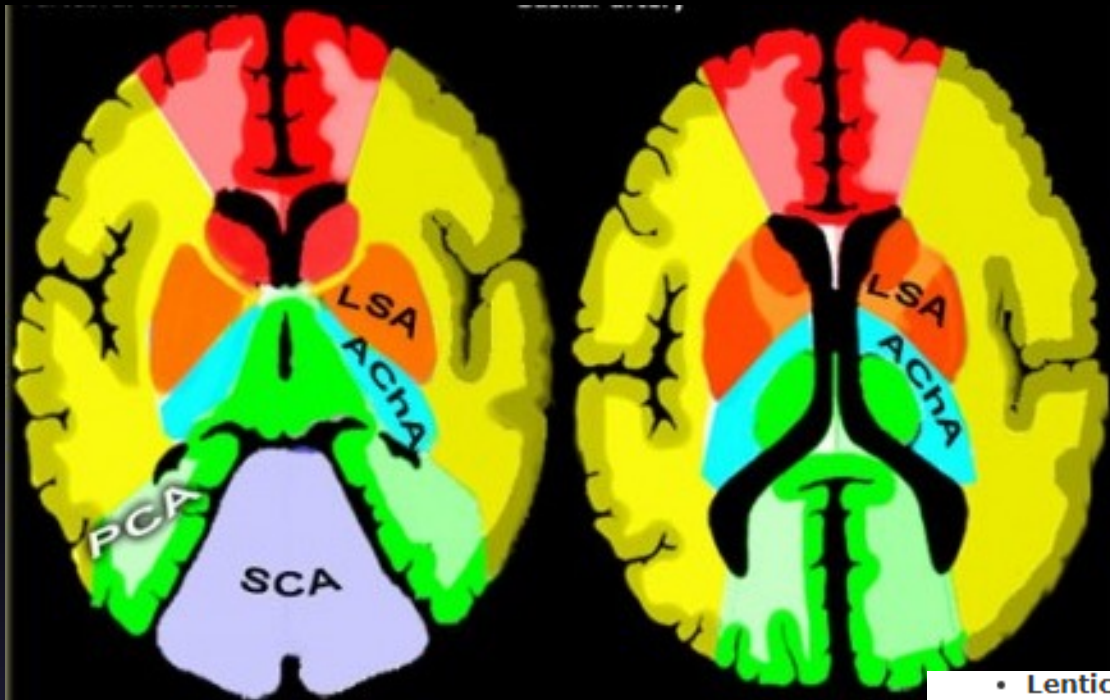




# Vascular territories of the cerebrale arteries



- **Posterior Inferior Cerebellar Artery (PICA in blue)**  
The PICA territory is on the inferior occipital surface of the cerebellum and is in equilibrium with the territory of the AICA in purple, which is on the lateral side (1). The larger the PICA territory, the smaller the AICA and viceversa.
- **Superior Cerebellar Artery (SCA in grey)**  
The SCA territory is in the superior and tentorial surface of the cerebellum.
- **Branches from vertebral and basilar artery**  
These branches supply the medulla oblongata (in blue) and the pons (in green).
- **Anterior Choroideal artery (AChA in blue))**  
The territory of the AChA is part of the hippocampus, the posterior limb of the internal capsule and extends upwards to an area lateral to the posterior part of the cella media.



- **Lenticulo-striate arteries**

The *lateral* LSA's (in orange) are deep penetrating arteries of the middle cerebral artery (MCA). Their territory includes most of the basal ganglia. The *medial* LSA's (indicated in dark red) arise from the anterior cerebral artery (usually the A1-segment). Heubner's artery is the largest of the medial lenticulostriate arteries and supplies the anteromedial part of the head of the caudate and anteroinferior internal capsule.

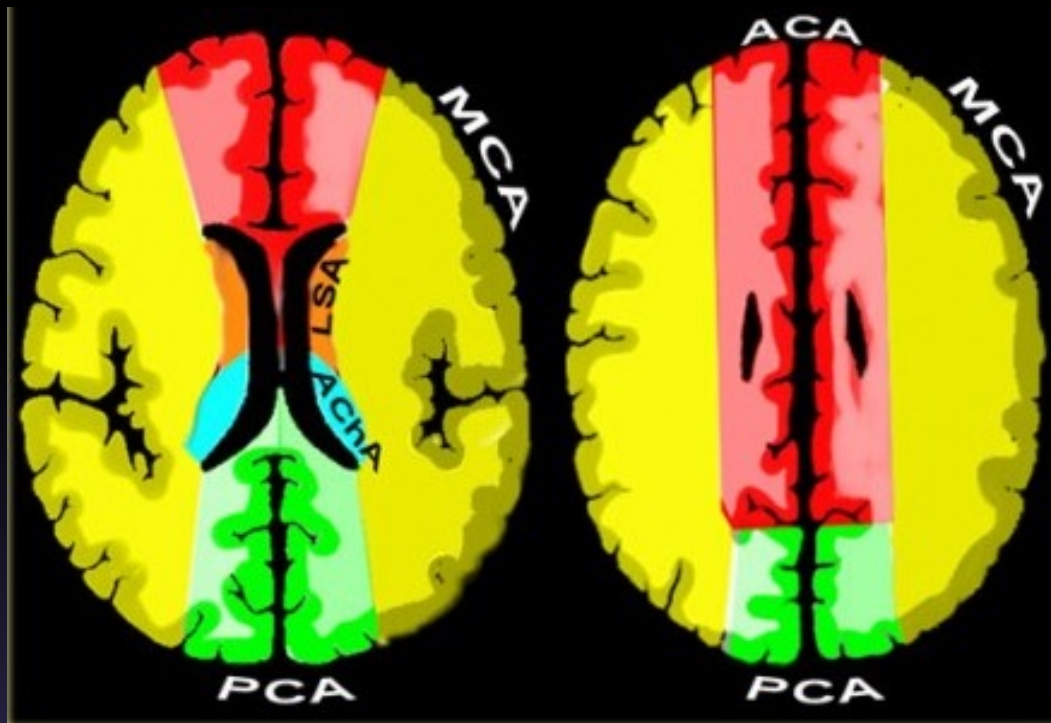
- **Anterior cerebral artery (ACA in red)**

The ACA supplies the medial part of the frontal and the parietal lobe and the anterior portion of the corpus callosum, basal ganglia and internal capsule.

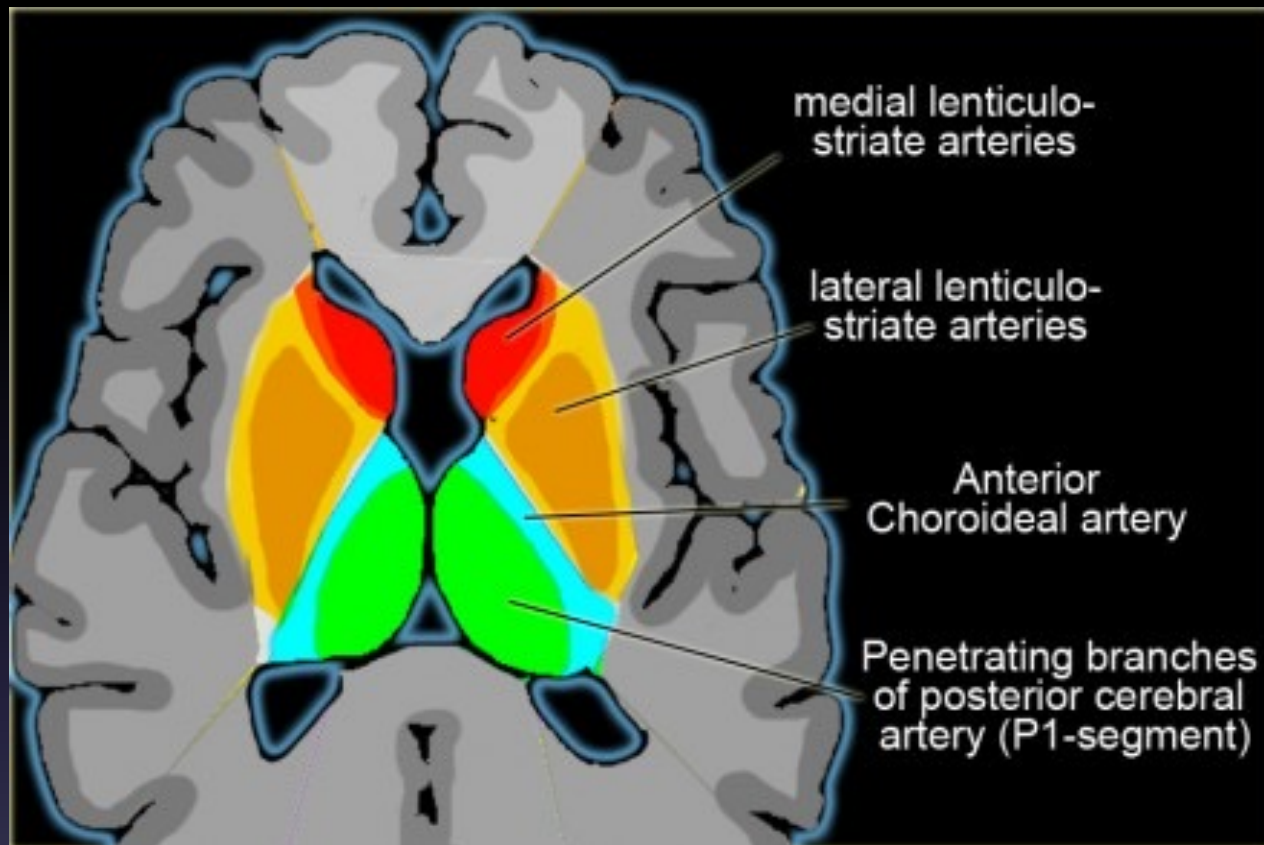
- **Middle cerebral artery (MCA in yellow)**

The cortical branches of the MCA supply the lateral surface of the hemisphere, except for the medial part of the frontal and the parietal lobe (anterior cerebral artery), and the inferior part of the temporal lobe (posterior cerebral artery).

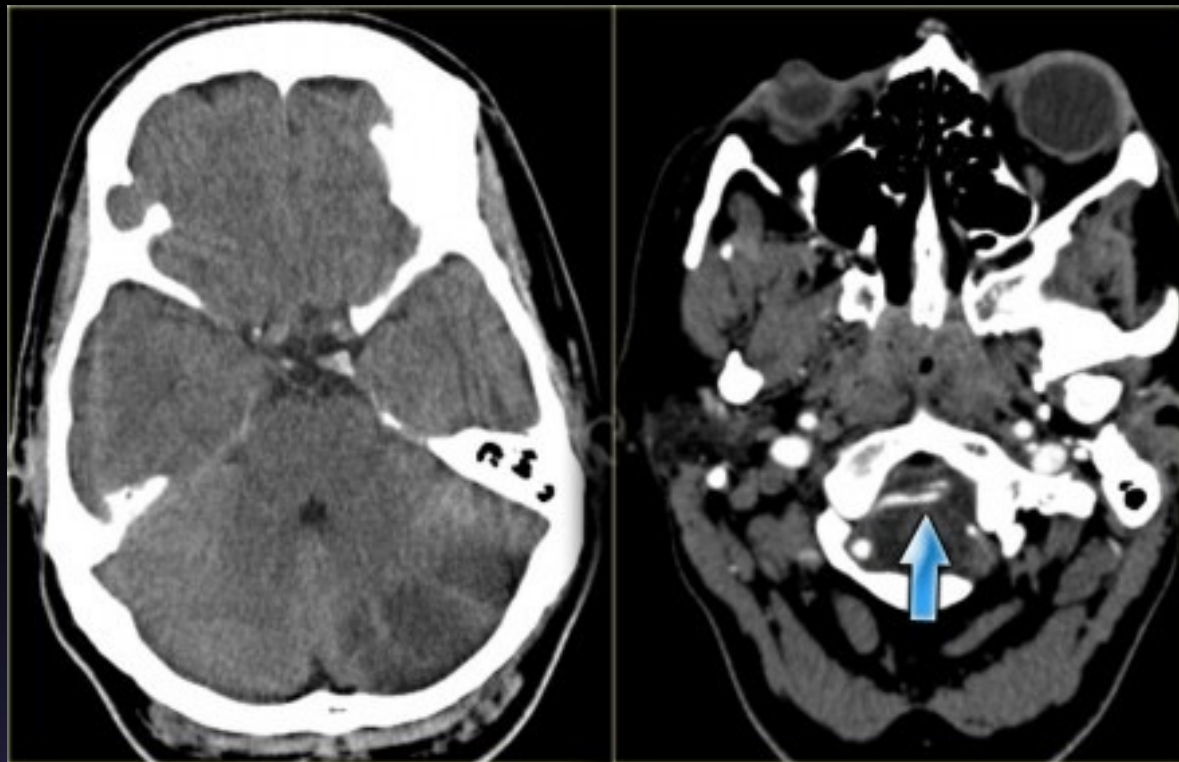




- Posterior cerebral artery (PCA in green)**  
 P1 extends from origin of the PCA to the posterior communicating artery, contributing to the circle of Willis. Posterior thalamoperforating arteries branch off the P1 segment and supply blood to the midbrain and thalamus. Cortical branches of the PCA supply the inferomedial part of the temporal lobe, occipital pole, visual cortex, and splenium of the corpus callosum.

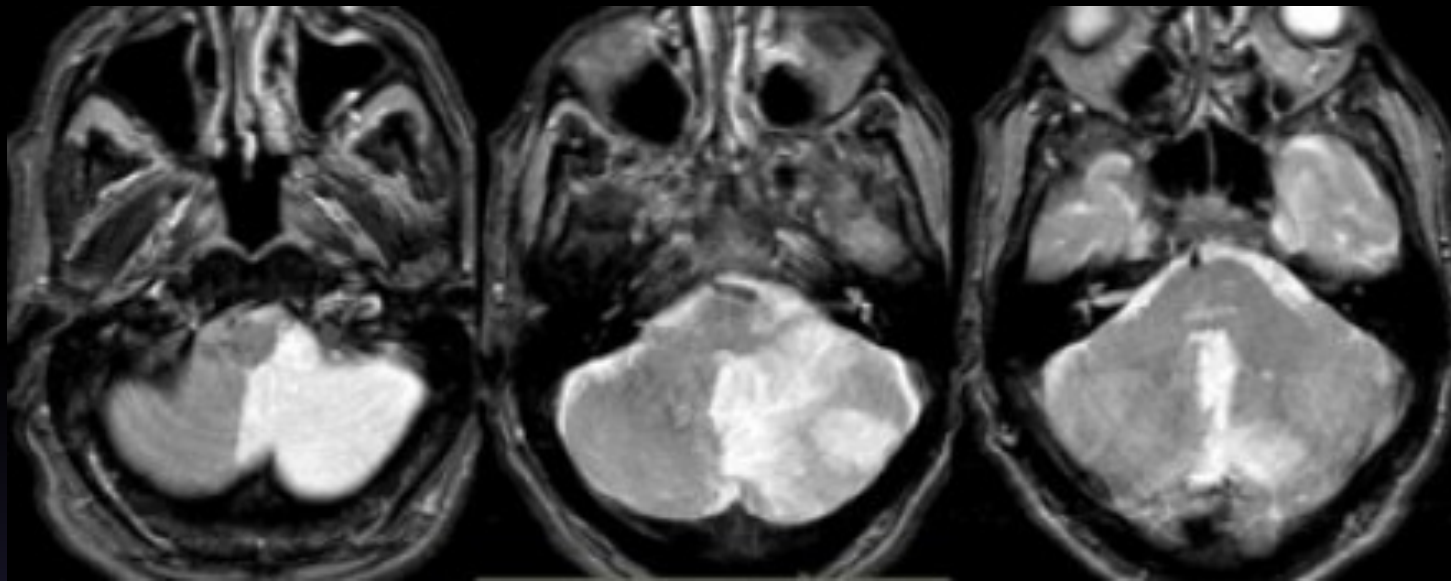


On the left a detail to illustrate the vascular supply to the basal ganglia.



## PICA

On the left CT-images of a left-sided PICA-infarction.  
Notice the posterior extension.  
The infarction was the result of a dissection (blue arrow).



On the left MR-images of a left-sided PICA-infarction. In unilateral infarcts there is always a sharp delineation in the midline because the superior vermian branches do not cross the midline, but have a sagittal course. This sharp delineation may not be evident until the late phase of infarction. In the early phase, edema may cross the midline and create diagnostic difficulties.

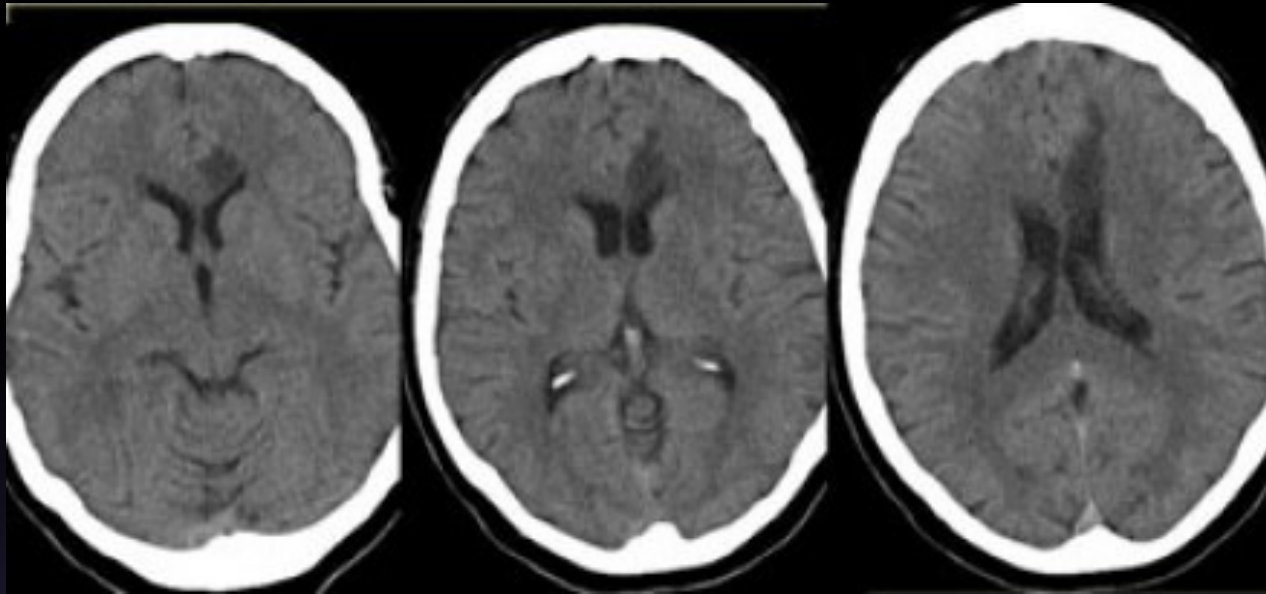
Infarctions at pontine level are usually paramedian and sharply defined because the branches of the basilar artery have a sagittal course and do not cross the midline. Bilateral infarcts are rarely observed because these patients do not survive long enough to be studied, but sometimes small bilateral infarcts can be seen.



### SCA

On the left MR-image of a cerebellar infarction in the region of the superior cerebellar artery and also in the brainstem in the territory of the PCA.

Notice the limitation to the midline.

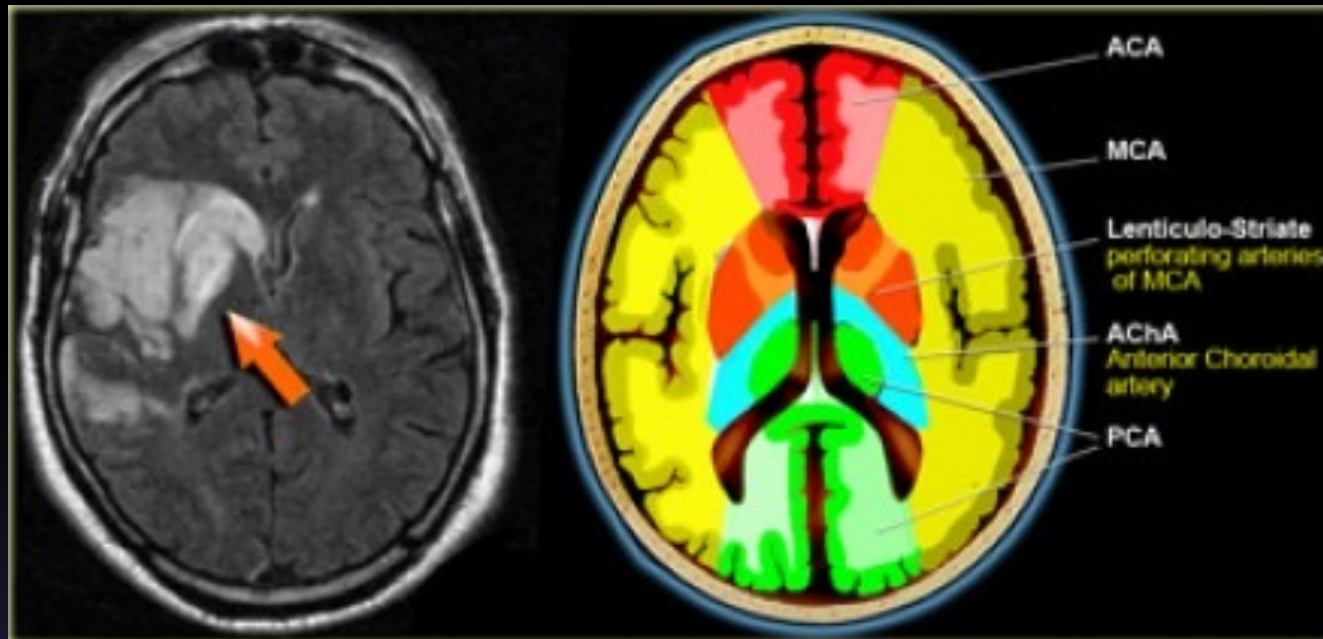


## ACA

Anterior cerebral artery:

- A1 segment: from origin to anterior communicating artery and gives rise to medial lenticulostriate arteries (inferior parts of the head of the caudate and the anterior limb of the internal capsule).
- A2 segment: from anterior communicating artery to bifurcation of pericallosal and callosomarginal arteries.
- A3 segment: major branches (medial portions of frontal lobes, superior medial part of parietal lobes, anterior part of the corpus callosum).





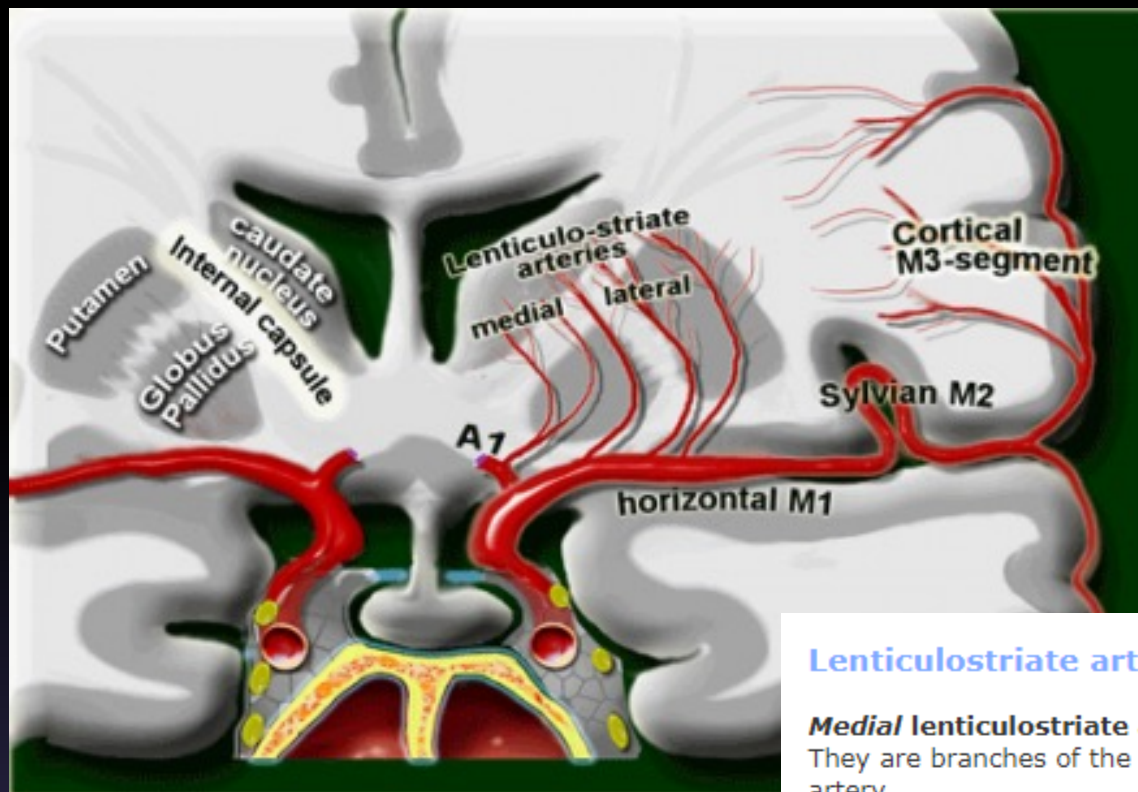
## Middle cerebral artery

The MCA has cortical branches and deep penetrating branches, which are called the lateral lenticulo-striate arteries.

The territory of the lateral lenticulo-striate perforating arteries of the MCA is indicated with a different color from the rest of the territory of the MCA because it is a well-defined area supplied by penetrating branches, which may be involved or spared in infarcts separately from the main cortical territory of the MCA.

On the left a T2W-image of a patient with an infarction in the territory of the middle cerebral artery (MCA).

Notice that the lateral lenticulo-striate perforating arteries of the MCA are also involved (orange arrow).



## Lenticulostriate arteries

### **Medial lenticulostriate arteries**

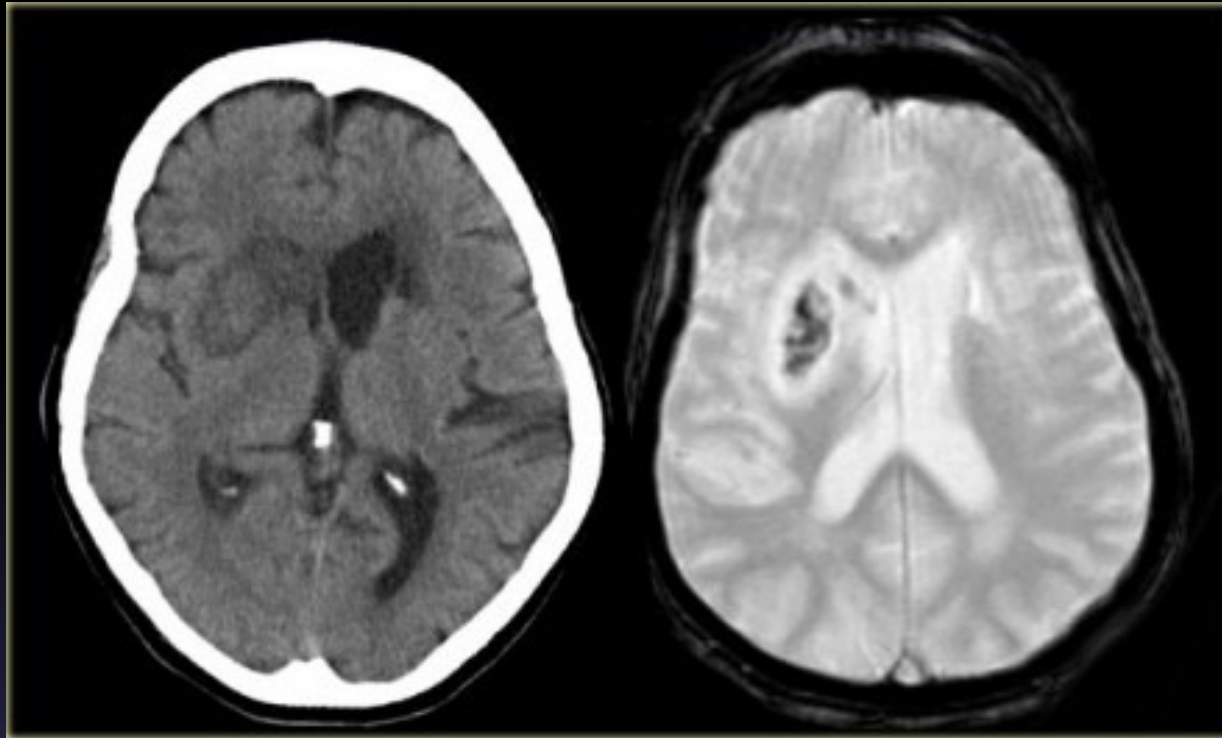
They are branches of the A1-segment of the anterior cerebral artery.

They supply the anterior inferior parts of the basal nuclei. They also supply the anterior limb of the internal capsule together with the recurrent artery of Huebner, which also is a branch of the anterior cerebral artery.

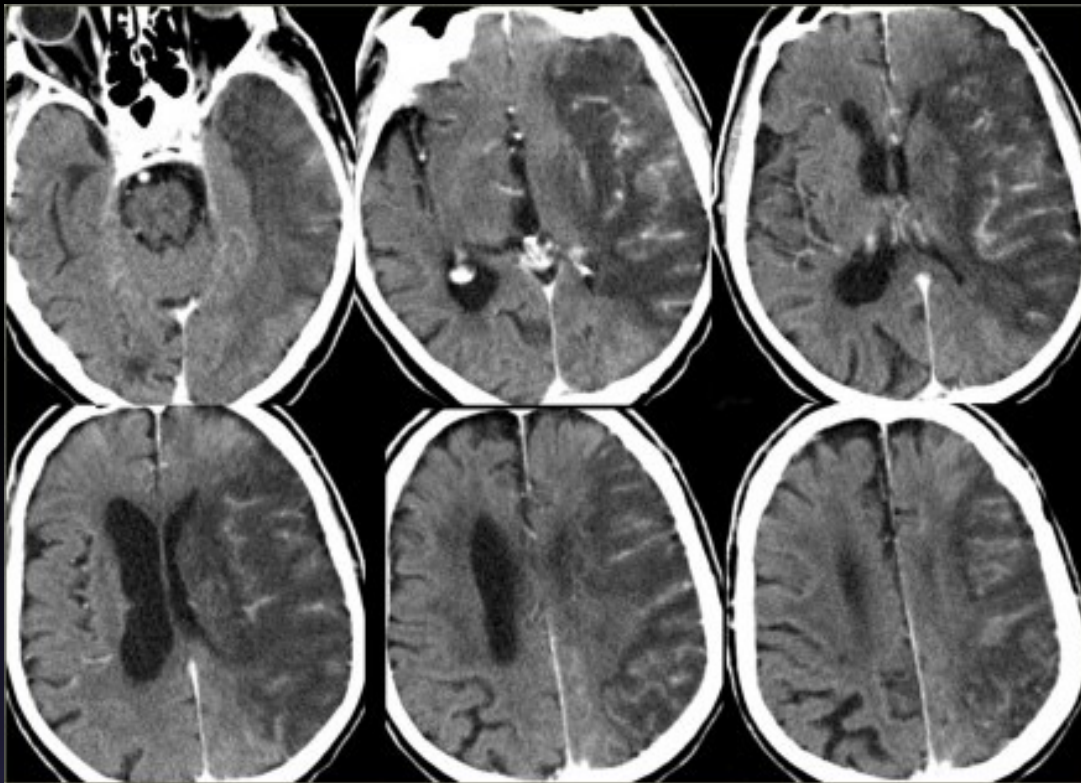
### **Lateral lenticulostriate arteries**

They are branches of the horizontal M1-segment of the middle cerebral artery.

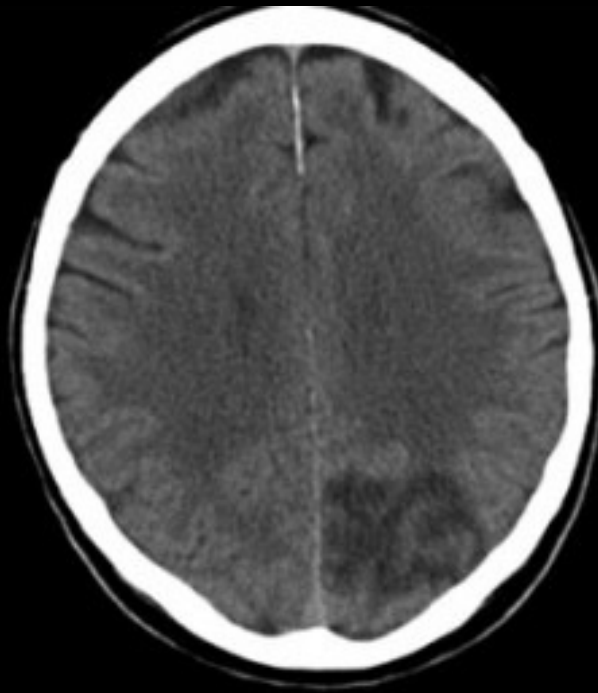
They supply the superior part of the head and the body of the caudate nucleus, most of the globus pallidus and putamen. They also supply the anterior limb of the internal capsule and parts of the posterior limb of the internal capsule, which is largely supplied by the [anterior choroidal artery](#).



On the left images of a hemorrhagic infarction in the area of the deep perforating lenticulostriate branches of the MCA.



On the left enhanced CT-images of a patient with an infarction in the territory of the middle cerebral artery (MCA). There is extensive gyral enhancement (luxury perfusion).



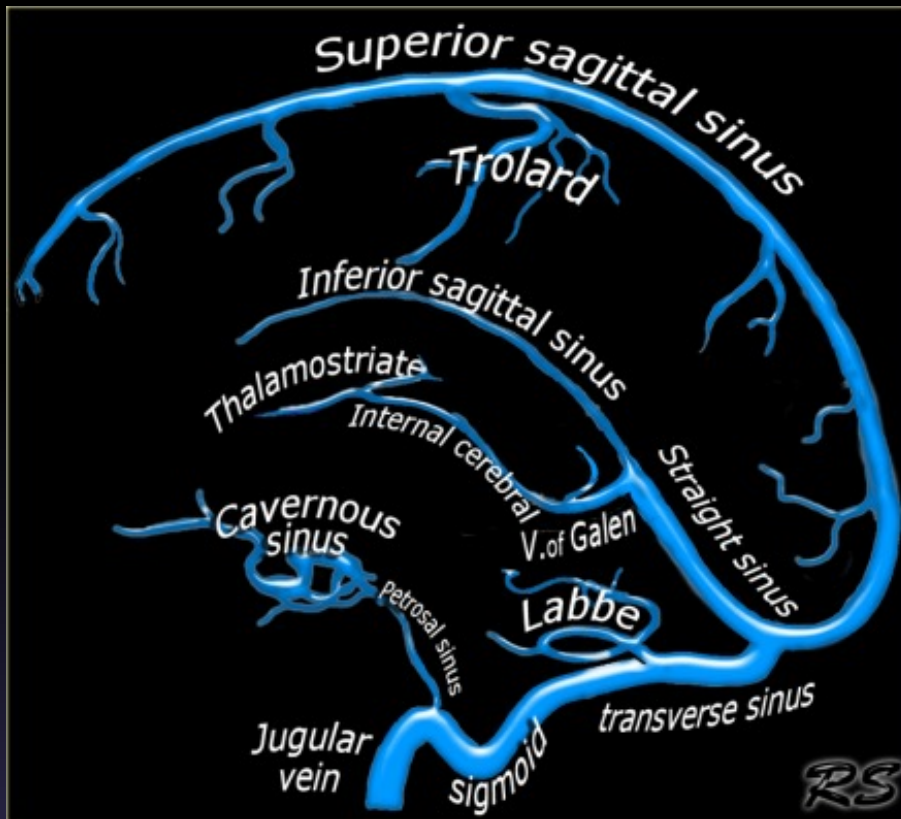
### Posterior cerebral artery (PCA)

Deep or proximal PCA strokes cause ischemia in the thalamus and/or midbrain, as well as in the cortex. Superficial or distal PCA infarctions involve only cortical structures (4).

On the left a patient with acute vision loss in the right half of the visual field.

The CT demonstrates an infarction in the contralateral visual cortex, i.e left occipital lobe.

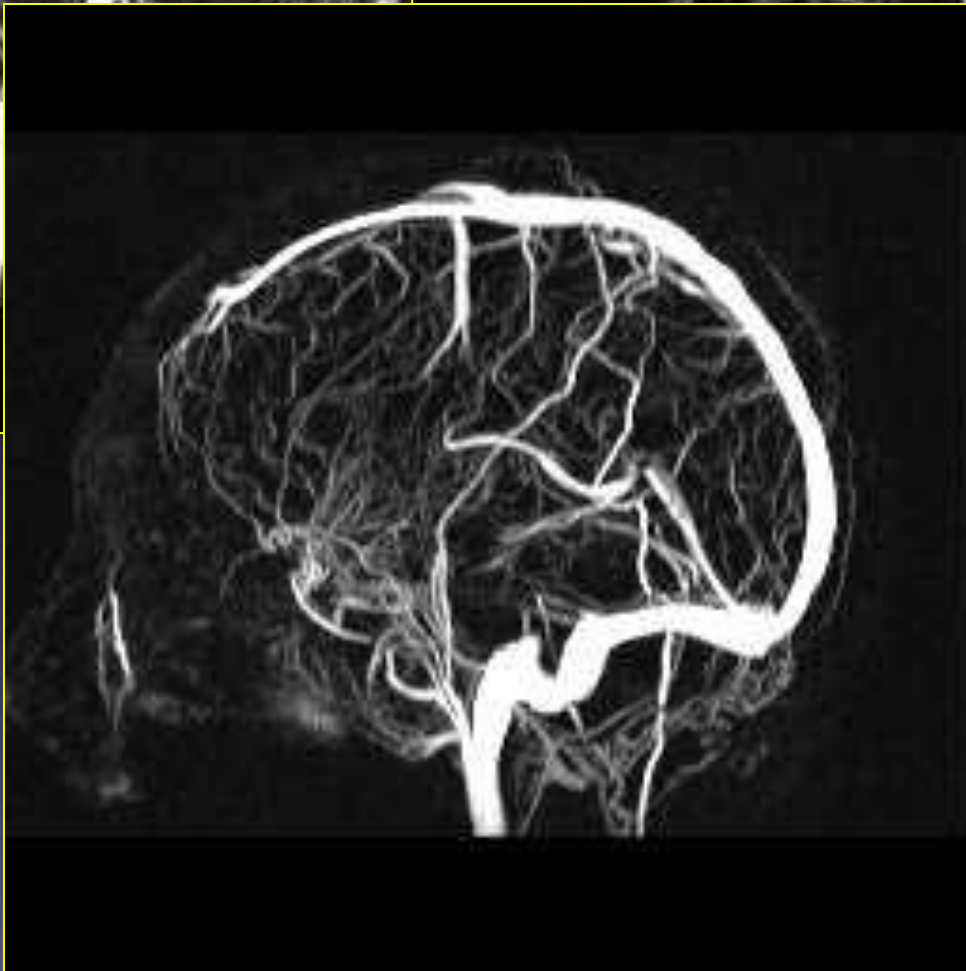
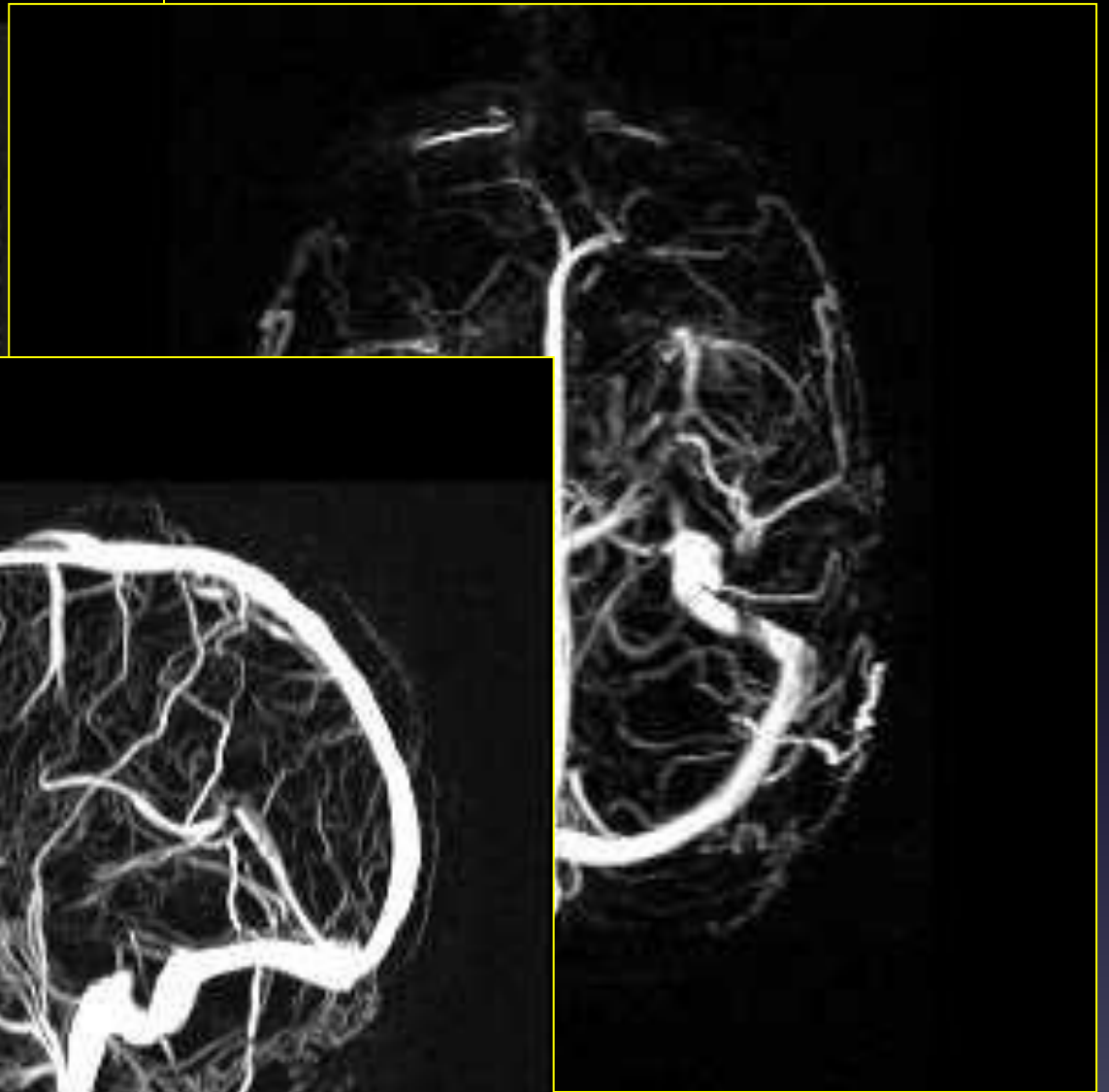


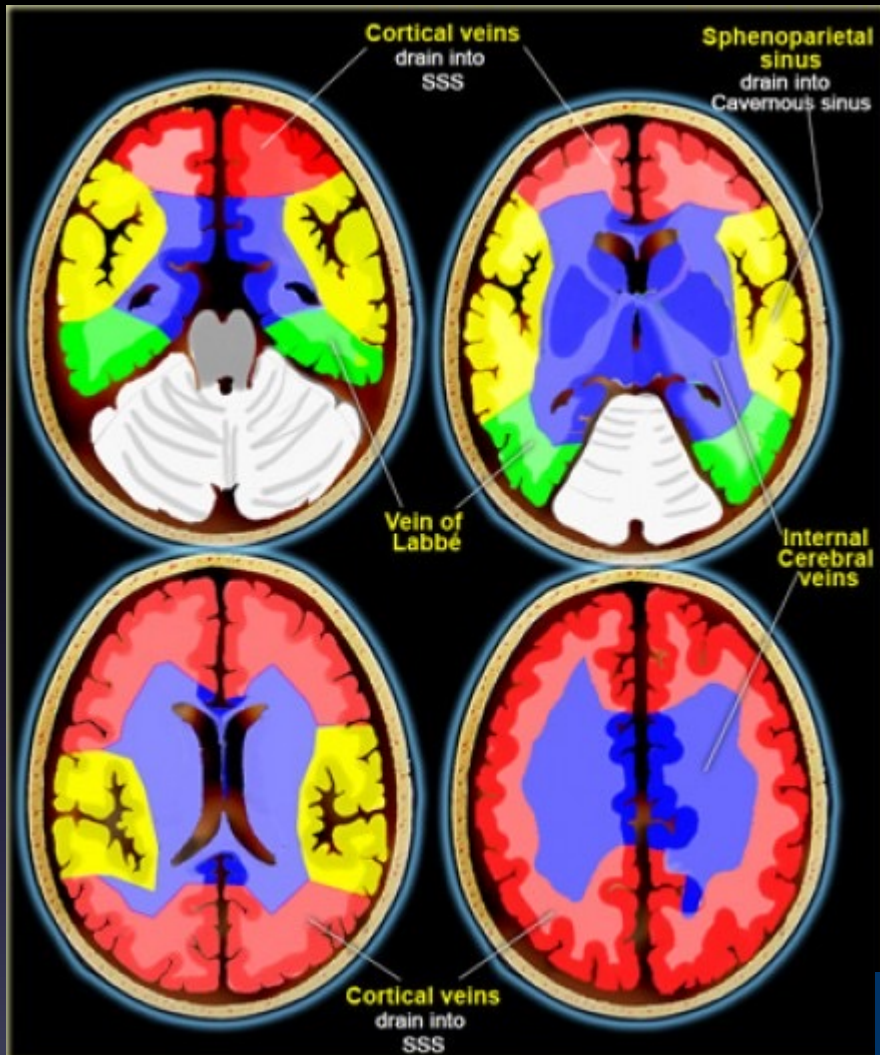


Cerebral venous thrombosis is located in descending order in the following venous structures:

- Major dural sinuses:  
Superior sagittal sinus, transverse, straight and sigmoid sinuses.
- Cortical veins:
  - Vein of Labbe, which drains the temporal lobe.
  - Vein of Trolard, which is the largest cortical vein that drains into the superior sagittal sinus.
- Deep veins:  
Internal cerebral and thalamostriate veins.
- Cavernous sinus.







## Cerebral Venous territory

There is great variation in the territories of venous drainage. The illustrations on the left should be regarded as a rough guide.

## When to think of venous thrombosis

Direct sign of thrombus	Dense clot sign
	Cord sign
	Empty delta
	Loss of normal flow void on MR
Venous infarction	Bilateral - <i>parasagittal</i> <i>bithalamic</i>
	Temporal lobe infarction
	Cortical edema or hemorrhage
	Peripheral lobar hemorrhage
Clinically	Seizures
	Headache
	Loss of consciousness

## When to think of venous thrombosis

Venous thrombosis has a nonspecific presentation and therefore it is important to recognize subtle imaging findings and indirect signs that may indicate the presence of thrombosis.

Although these findings are often present on initial scans, they are frequently detected only in retrospect.

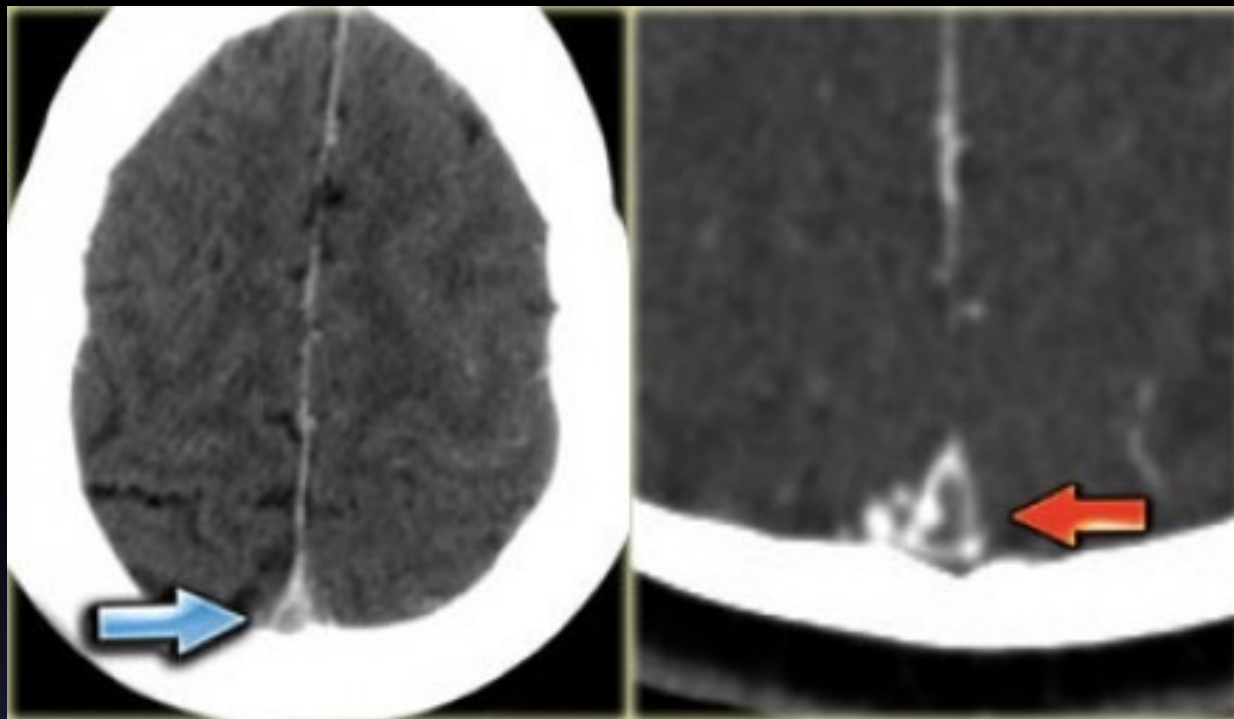
Clinically patients with venous thrombosis often present with seizures, which is not a symptom in patients with an arterial infarction.

On a routine non-enhanced MR or CT you should think of the possibility of venous thrombosis when you see:

- Direct signs of a thrombus
- Infarction in a non-arterial location, especially if it is bilateral and hemorrhagic
- Cortical or peripheral lobar hemorrhage
- Cortical edema



Dense clot sign  
Direct visualization of a clot  
in the cerebral veins on a  
non enhanced CT scan



### Empty delta sign

The empty delta sign is a finding that is seen on a contrast enhanced CT (CECT) and was first described in thrombosis of the superior sagittal sinus.

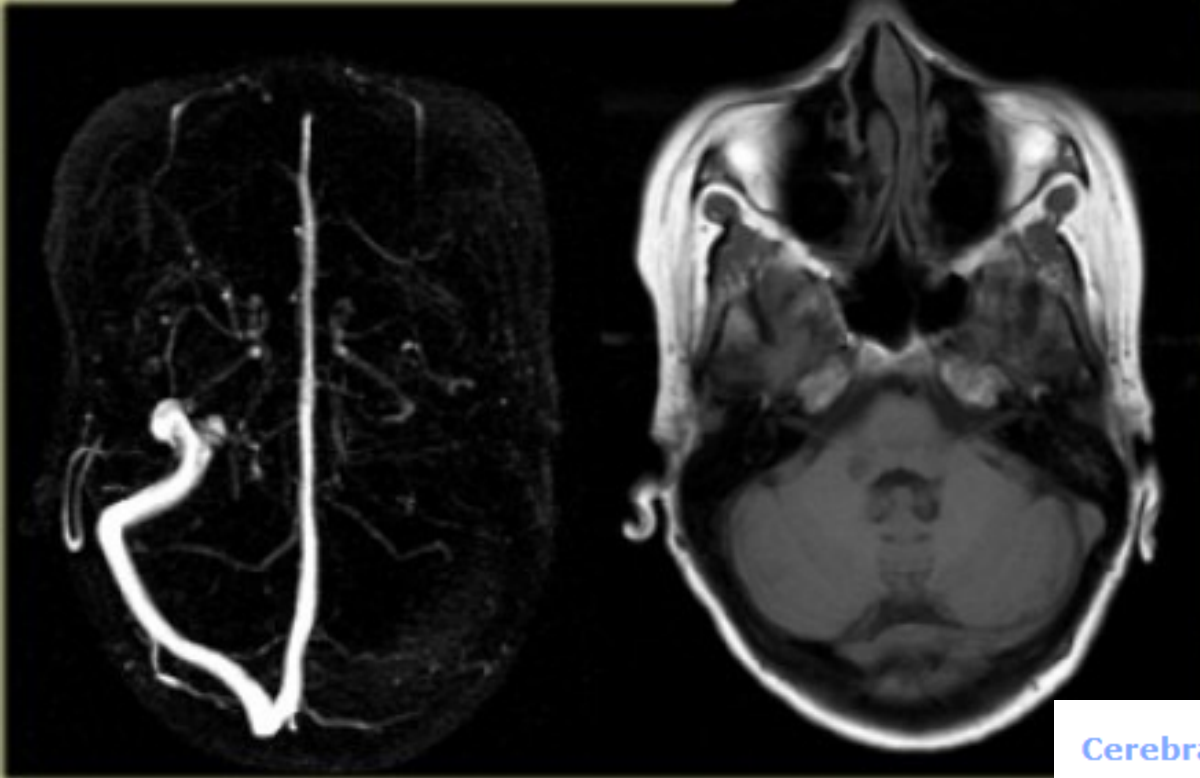
The sign consists of a triangular area of enhancement with a relatively low-attenuating center, which is the thrombosed sinus.

The likely explanation is enhancement of the rich dural venous collateral circulation surrounding the thrombosed sinus, producing the central region of low attenuation.

In early thrombosis the empty delta sign may be absent and you will have to rely on non-visualization of the thrombosed vein on the CECT.

The sign may be absent after two months due to recanalization within the thrombus.





### Cerebral venous thrombosis

Cerebral venous thrombosis results from occlusion of a venous sinus and/or cortical vein and usually is caused by a partial thrombus or an extrinsic compression that subsequently progresses to complete occlusion (7).

Dehydration, pregnancy, a hypercoagulable state and adjacent infection (eg, mastoiditis) are predisposing factors.

Cerebral venous thrombosis is an elusive diagnosis because of its nonspecific presentation.

It often presents with hemorrhagic infarction in areas atypical for arterial vascular distribution.

Imaging plays a key role in the diagnosis.

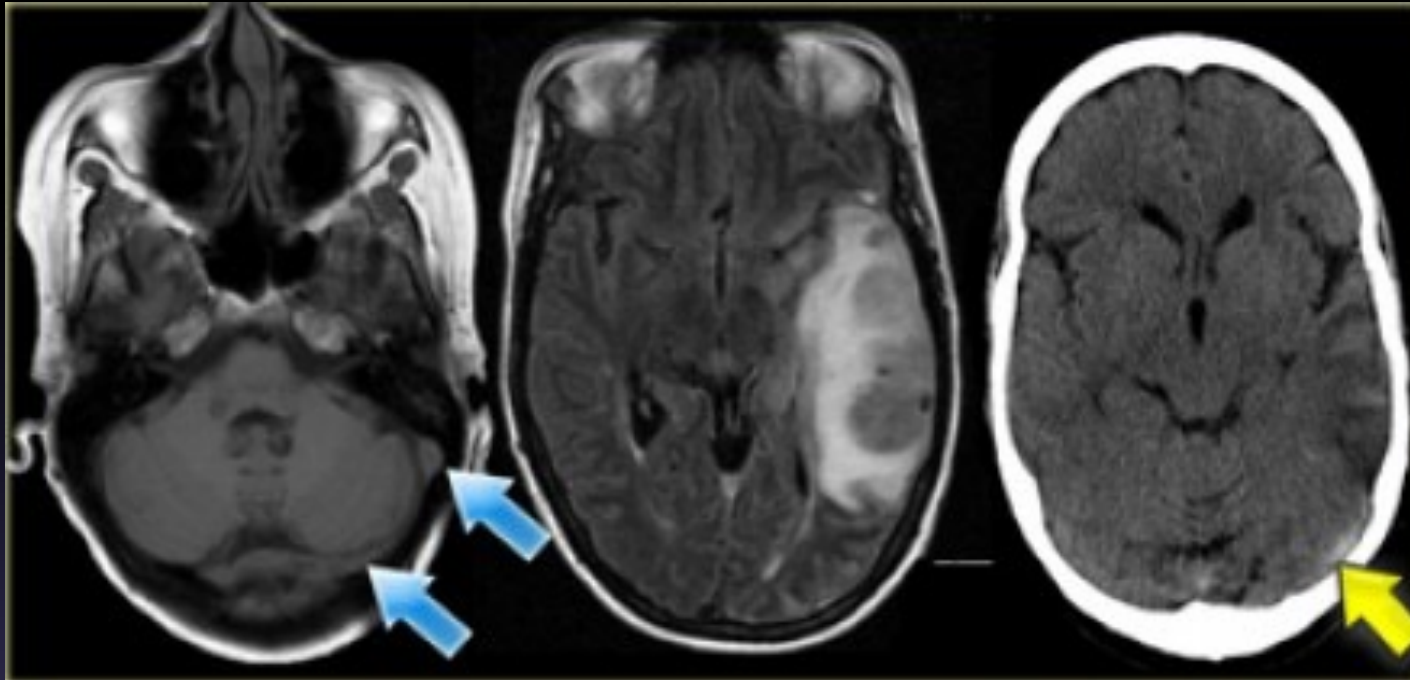
On the far left a MRA with non-visualization of the left transverse sinus.

Since the venous anatomy is variable, this can be due to absence of the transverse sinus or thrombosis.

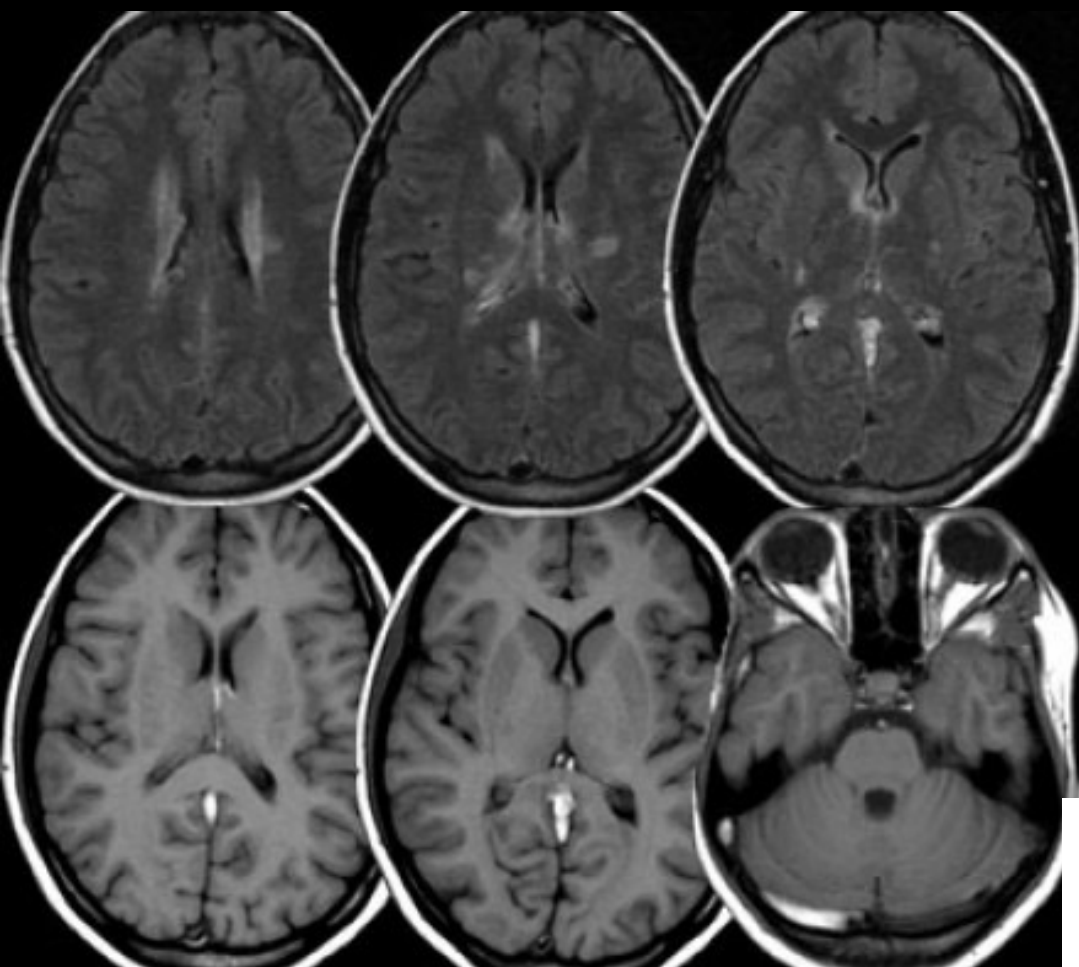
The T1W-image on the right clearly demonstrates, that there is a transverse sinus on the left, so the MRA findings are due to thrombosis.

Continue with next images.





On the left the CT nicely demonstrates the dense thrombosed transverse sinus (yellow arrow). The FLAIR image demonstrates the venous infarction in the temporal lobe.



### **Thrombosis of deep cerebral veins**

The clinical presentation of thrombosis of the deep cerebral venous system are severe dysfunction of the diencephalon, reflected by coma and disturbances of eye movements and pupillary reflexes.

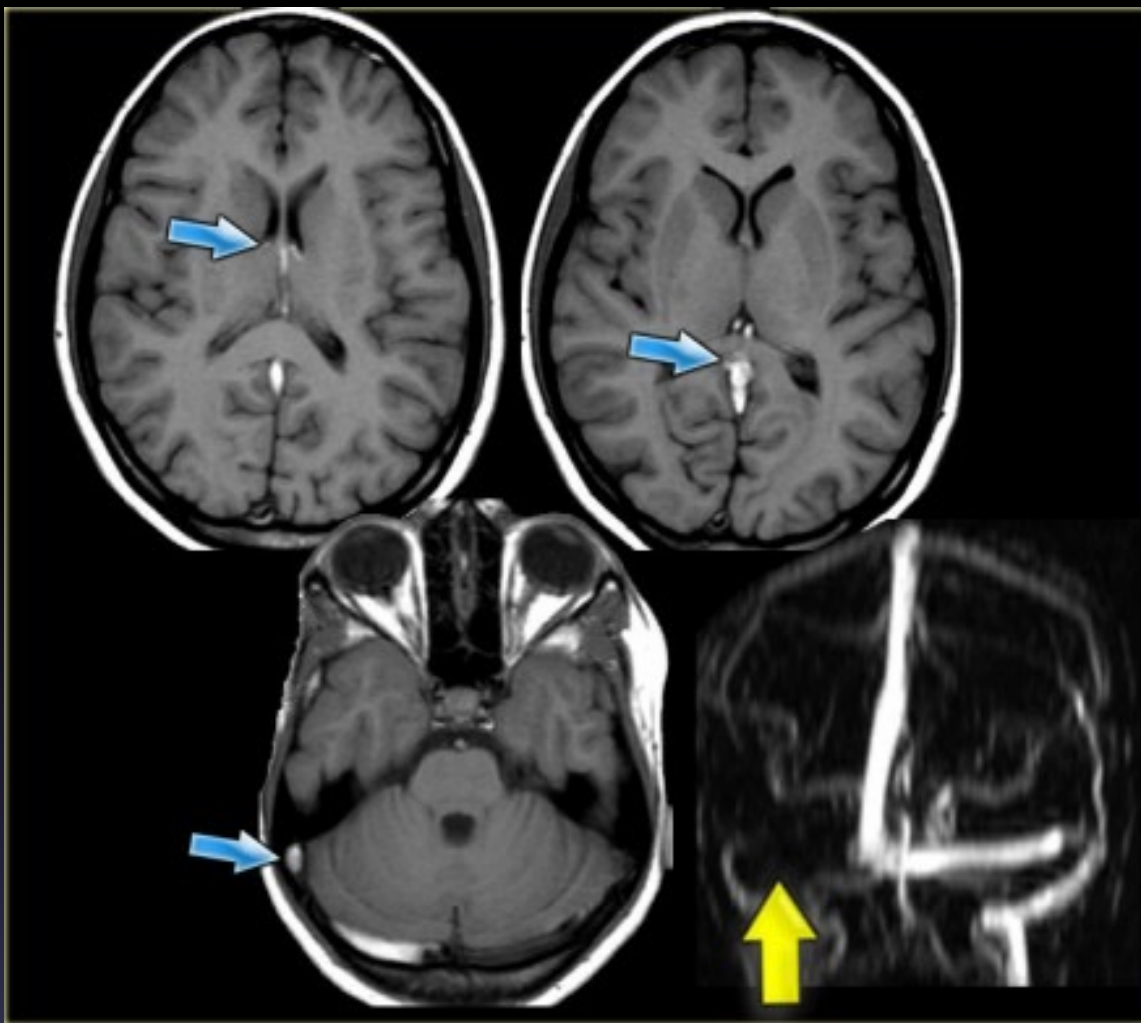
Usually this results in a poor outcome.

However, partial syndromes without a decrease in the level of consciousness or brainstem signs exist, which may lead to initial misdiagnoses.

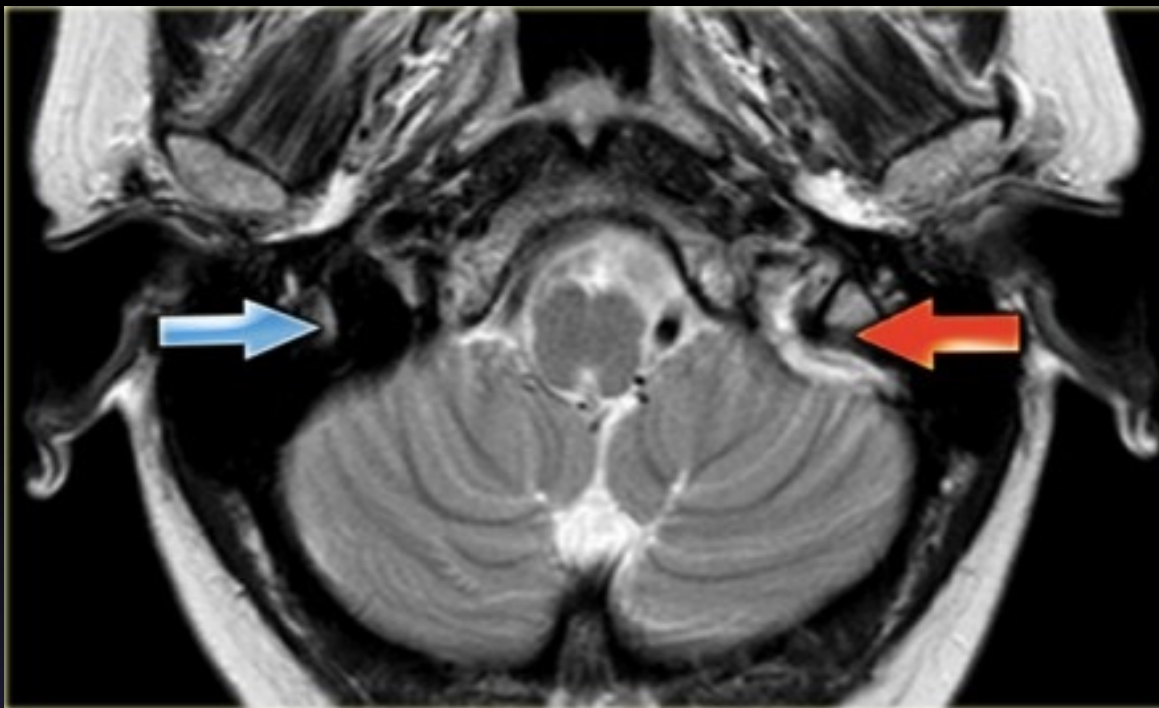
Deep cerebral venous system thrombosis is an underdiagnosed condition when symptoms are mild and should be suspected if the patient is a young woman, if the lesions are within the basal ganglia or thalamus and especially if they are bilateral.

On the left images of a patient with deep cerebral vein thrombosis.

Notice the bilateral infarctions in the basal ganglia.



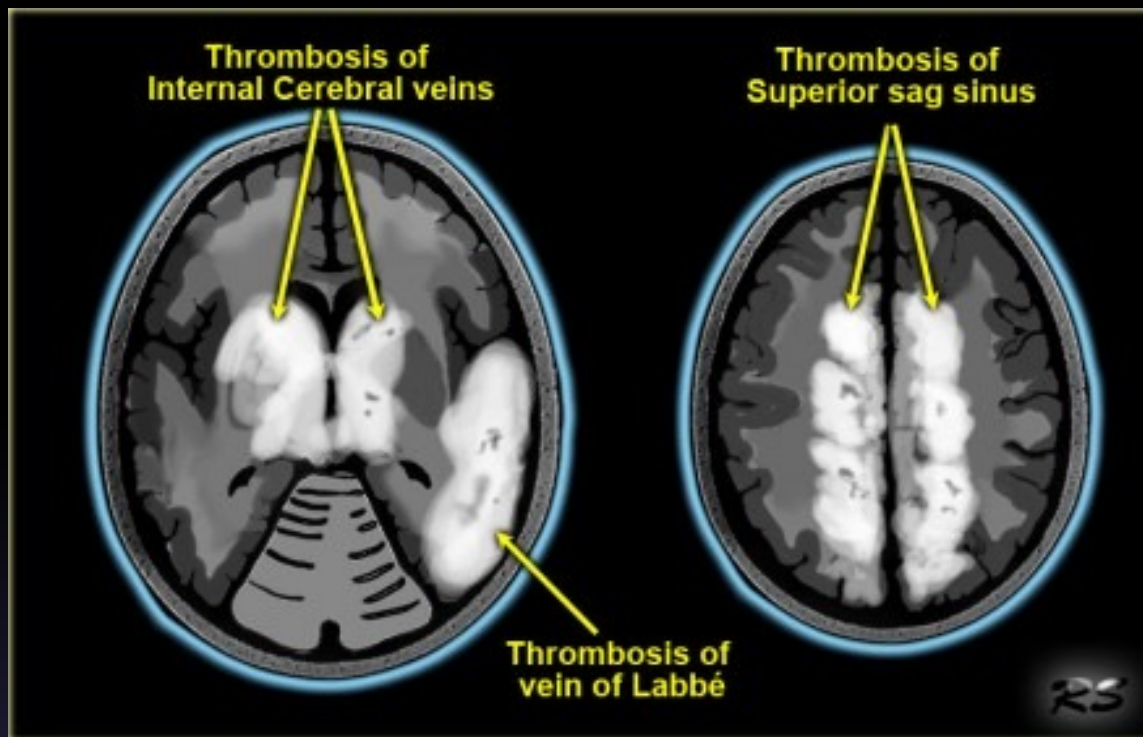
There is absence of flow void in the internal cerebral veins, sinus rectus and right transverse sinus (blue arrows). On the MRA the right transverse sinus is not visualized.



### **Absence of normal flow void on MR**

On spin-echo images patent cerebral veins usually will demonstrate low signal intensity due to flow void. Flow voids are best seen on T2-weighted and FLAIR images, but can sometimes also be seen on T1-weighted images. A thrombus will manifest as absence of flow void. Although this is not a completely reliable sign, it is often one of the first things, that make you think of the possibility of venous thrombosis. The next step has to be a contrast enhanced study.

On the left a T2-weighted image with normal flow void in the right sigmoid sinus and jugular vein (blue arrow). On the left there is abnormal high signal as a result of thrombosis (red arrow).



### Venous infarction

The other sign that can help you in making the diagnosis of unsuspected venous thrombosis is venous infarction. Venous thrombosis leads to a high venous pressure which first results in vasogenic edema in the white matter of the affected area.

When the process continues it may lead to infarction and development of cytotoxic edema next to the vasogenic edema. This is unlike in an arterial infarction in which there is only cytotoxic edema and no vasogenic edema.

Due to the high venous pressure hemorrhage is seen more frequently in venous infarction compared to arterial infarction.

Since we are not that familiar with venous infarctions, we often think of them as infarctions in an atypical location or in a non-arterial distribution.

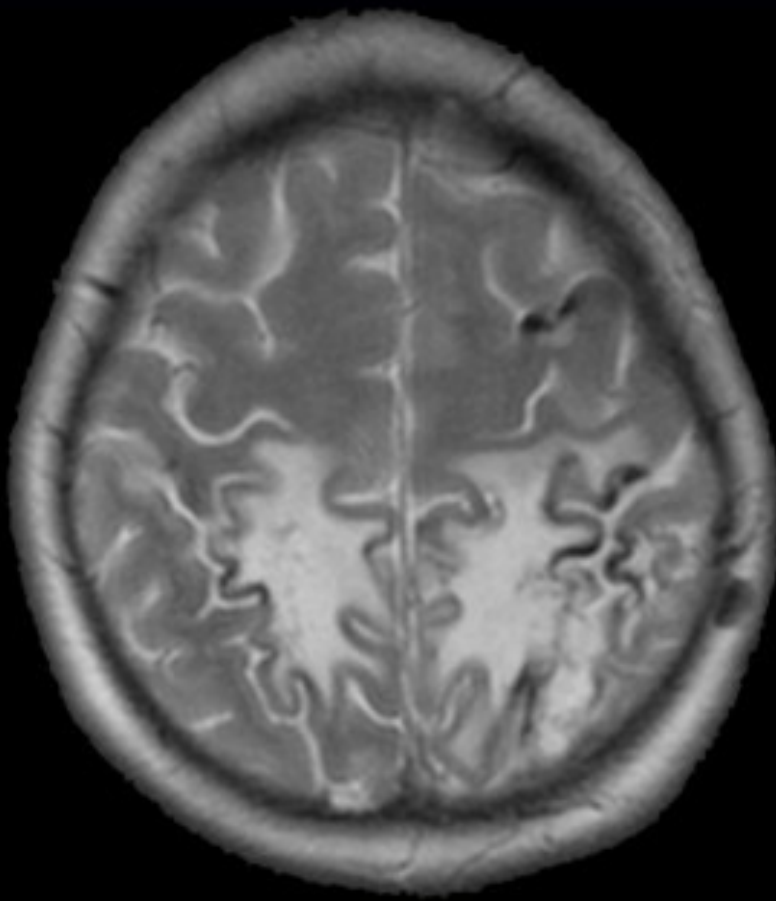
However venous infarctions do have a typical distribution, as shown on the left.

- Venous infarcts are often bilaterale in the midline and hemorrhagic

Since many veins are midline structures, venous infarcts are often bilateral.

This is seen in thrombosis of the superior sagittal sinus, straight sinus and the internal cerebral veins.





### **Venous infarction (2) - Superior sagittal sinus thrombosis**

The most frequently thrombosed venous structure is the superior sagittal sinus.

Infarction is seen in 75% of cases.

The abnormalities are parasagittal and frequently bilateral. Hemorrhage is seen in 60% of the cases.

On the left bilateral parasagittal edema and subte hemorrhage in a patient with thrombosis of the superior sagittal sinus.

