

# Neuroimaging

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brain



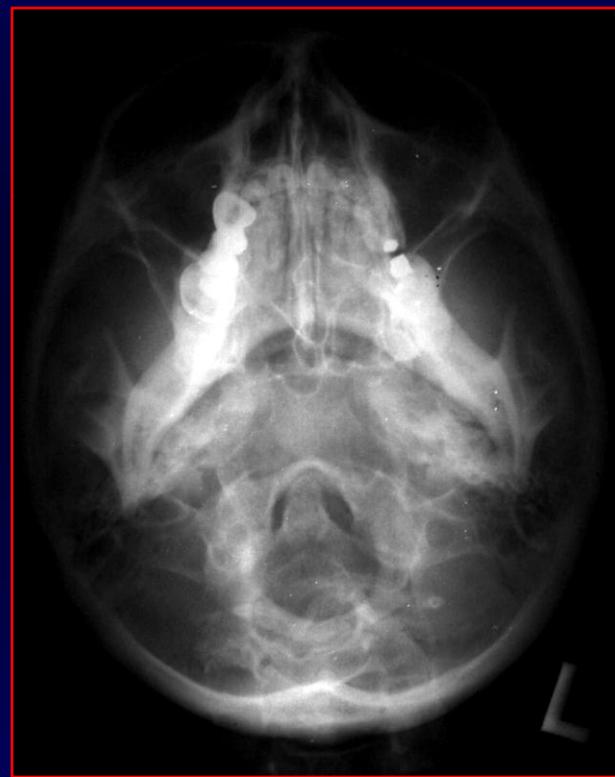
# Brain imaging methodology

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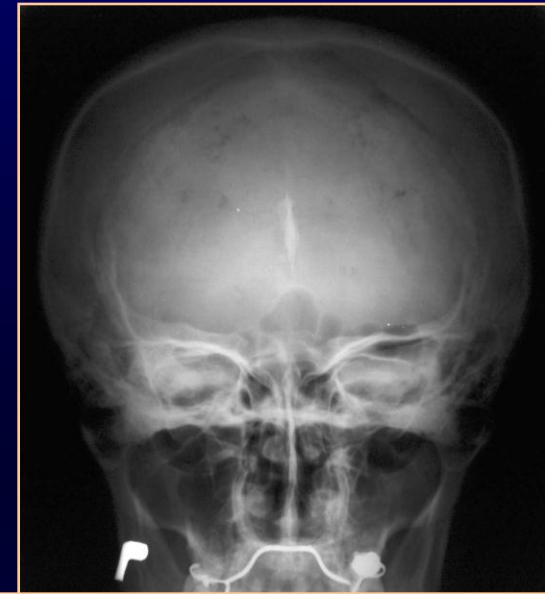
- Plain x-ray of skull
- Computed tomography – CT
  - traditional („normal” CT)
  - angio-CT
  - perfusion techniques
- Magnetic resonance – MR
  - standard techniques
  - angio-MR
  - perfusion, diffusion, spectroscopy
  - functional & molecular MR
- Ultrasound
  - Doppler US imaging
  - pediatric trans-fontanelle US
- Angiography - DSA



**Skull – plain x-ray**  
still useful after head trauma

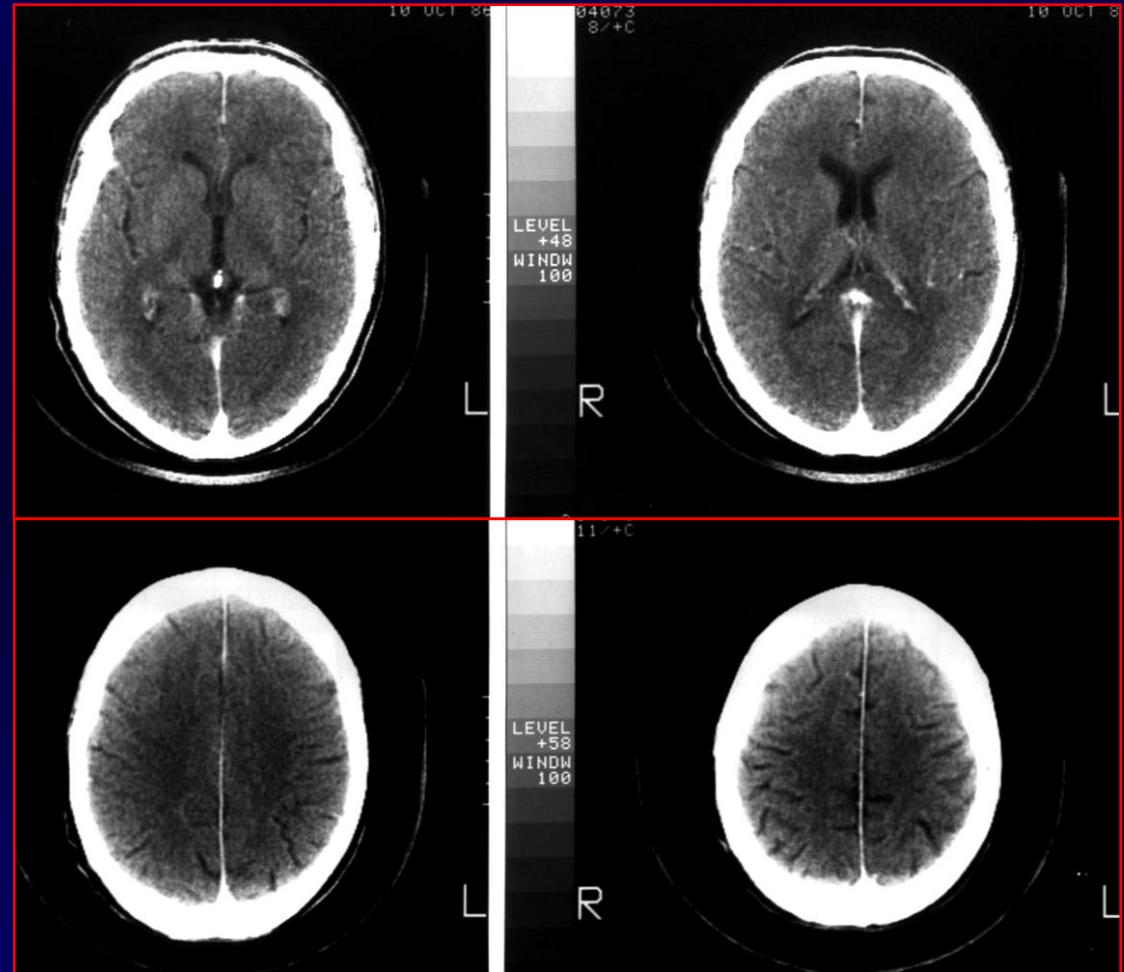
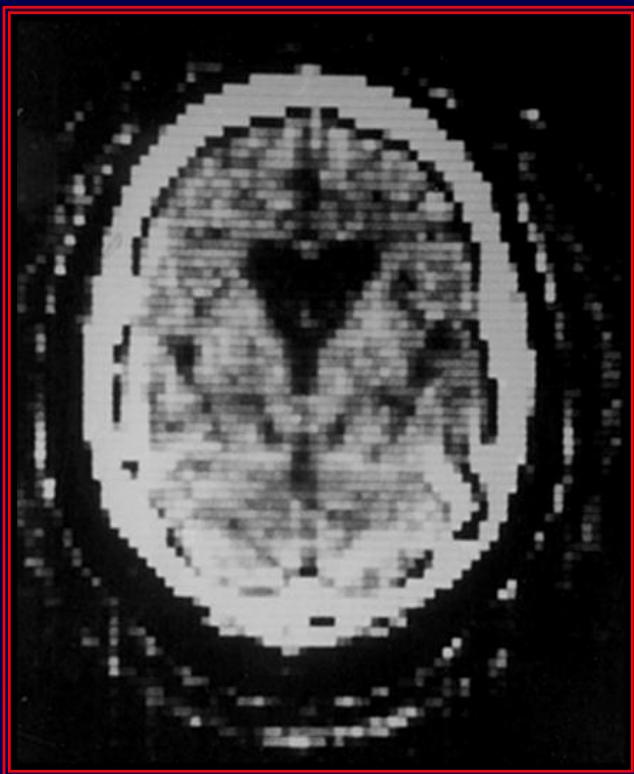


# Intracranial calcifications on plain x-ray



# Computed Tomography

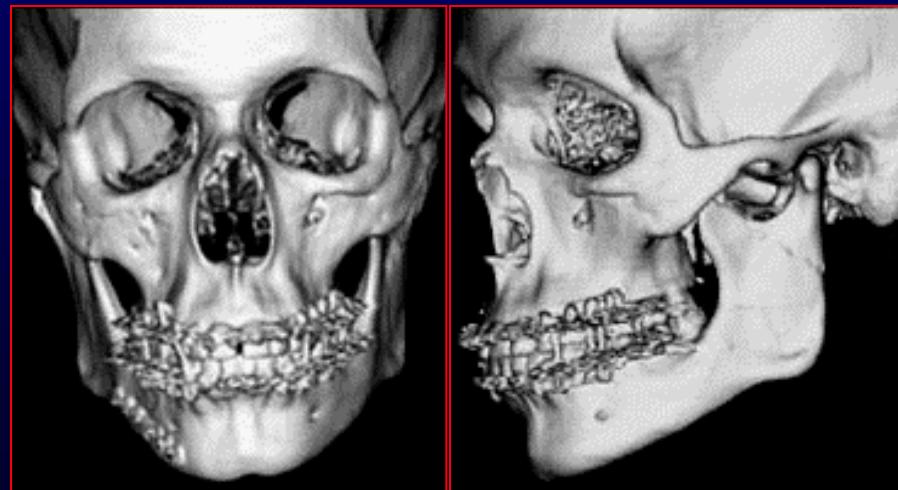
## revolution in brain imaging



# Nowadays CT

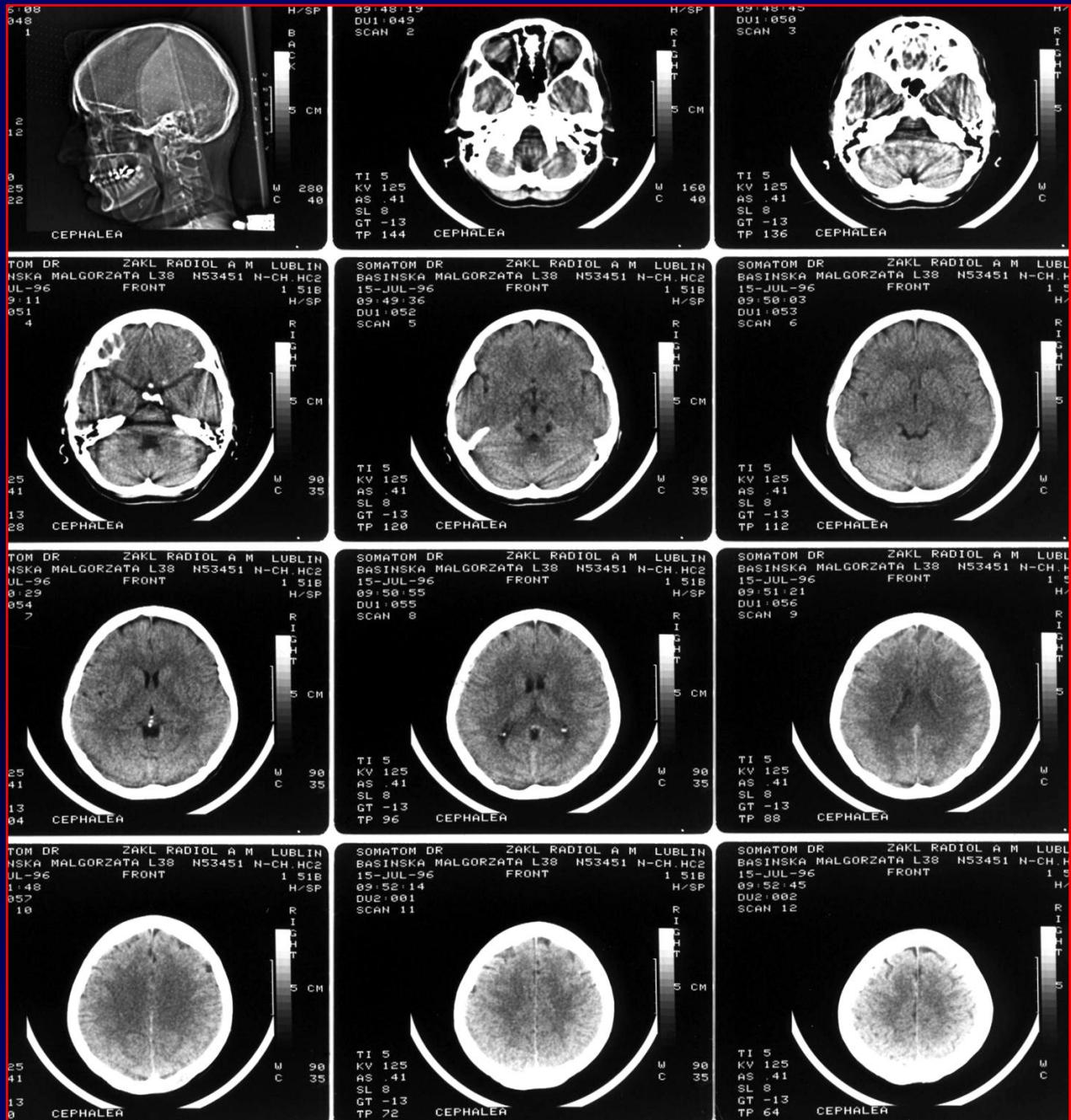


# CT – 3D reconstructions



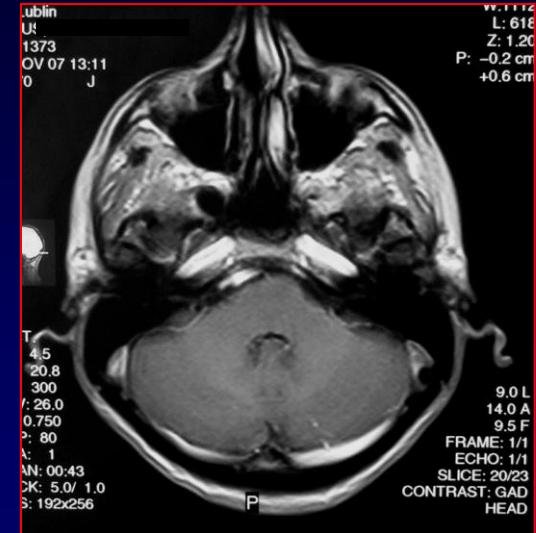
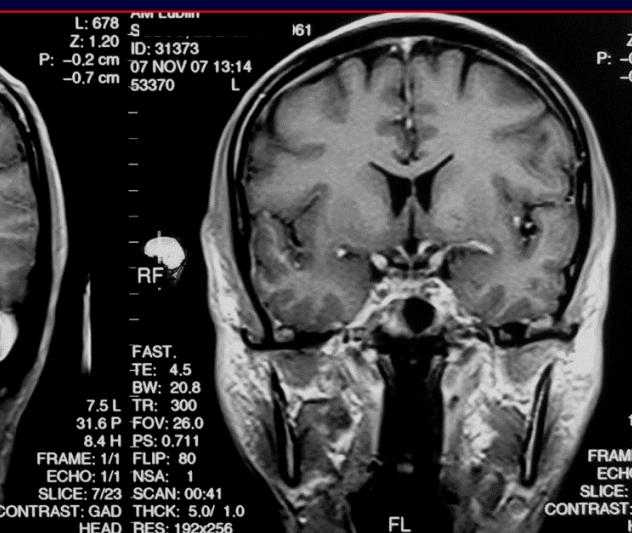
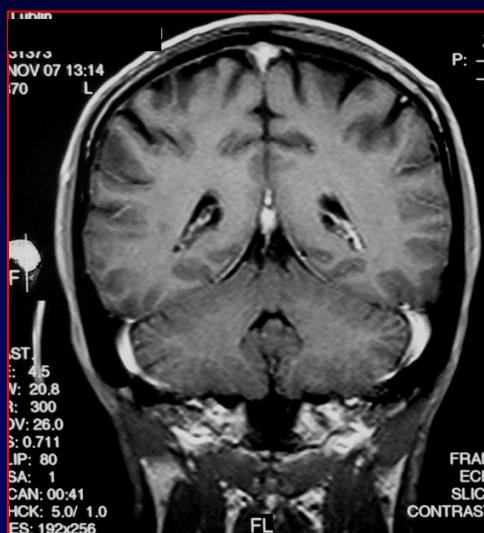
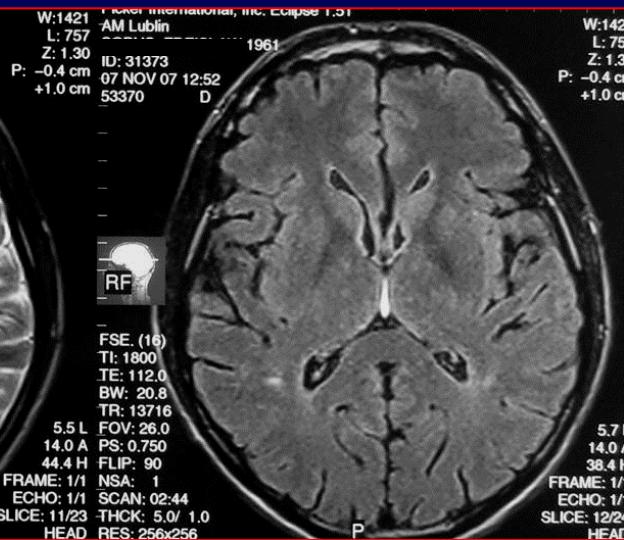
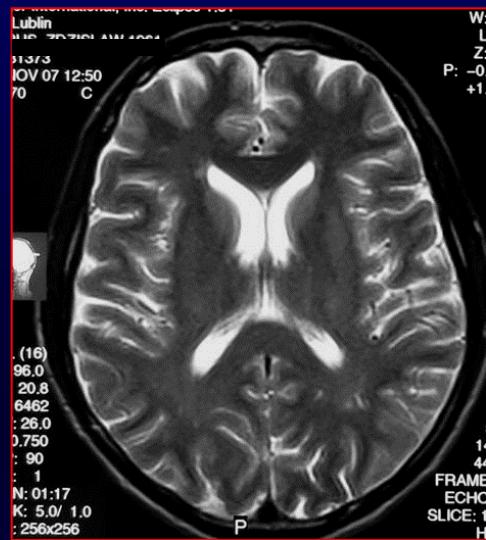
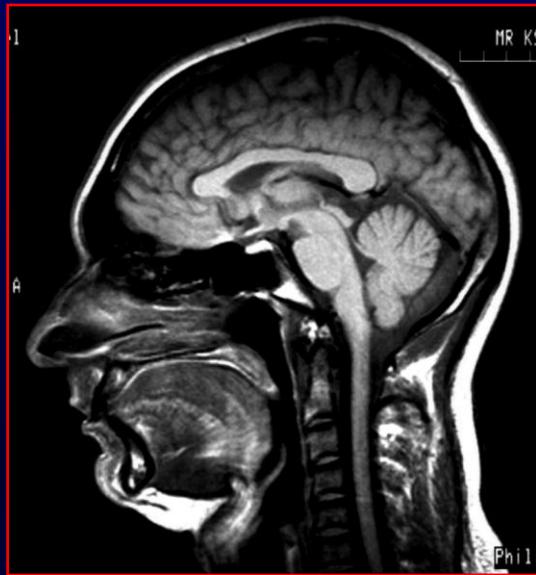
# CT

## any drawbacks?

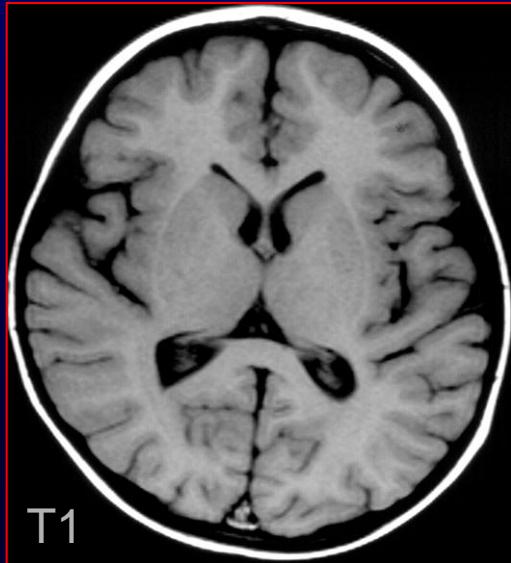


# MRI - magnetic resonance imaging

## high spatial resolution images in every plane



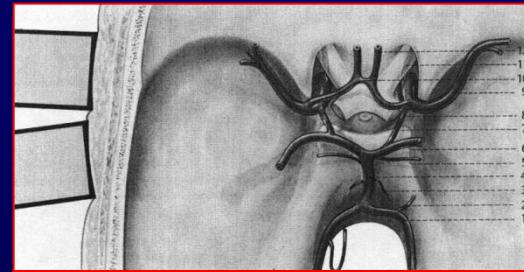
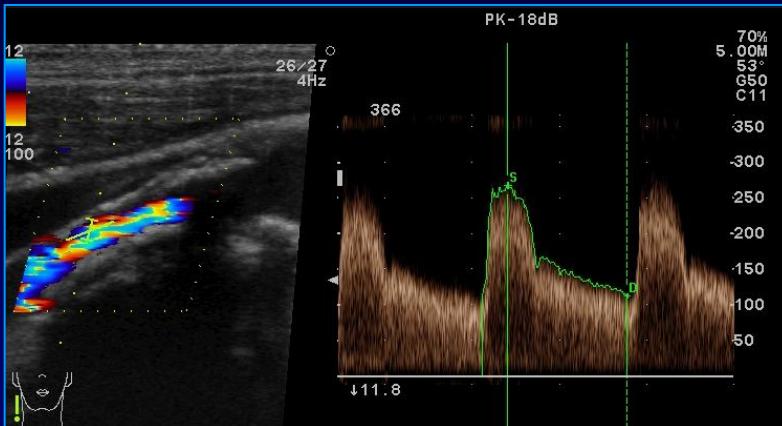
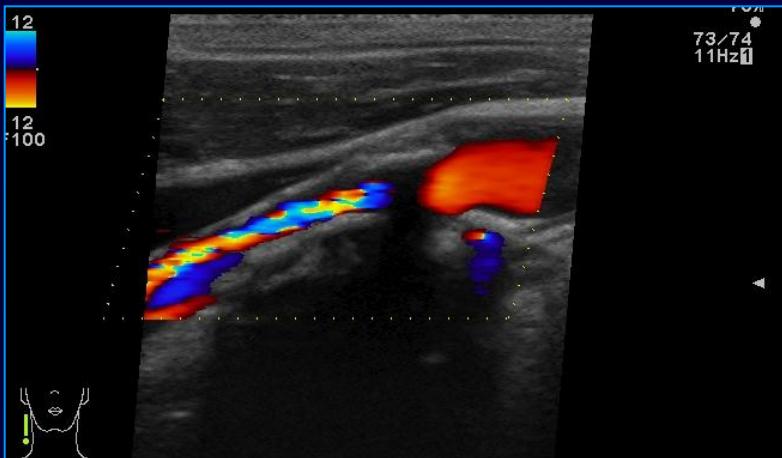
# MRI different sequences of images



# Ultrasonography

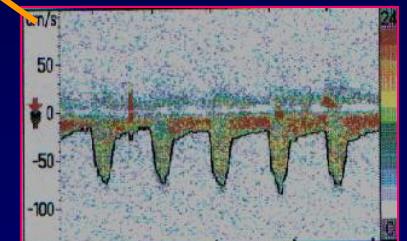
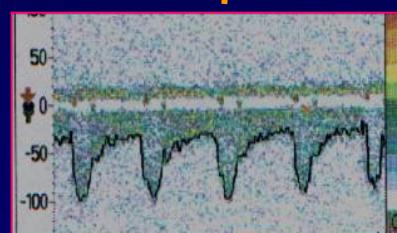
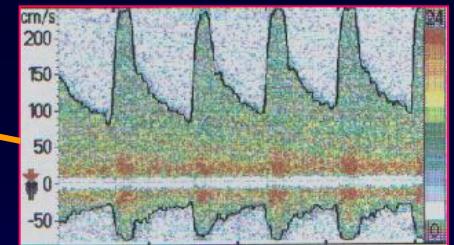
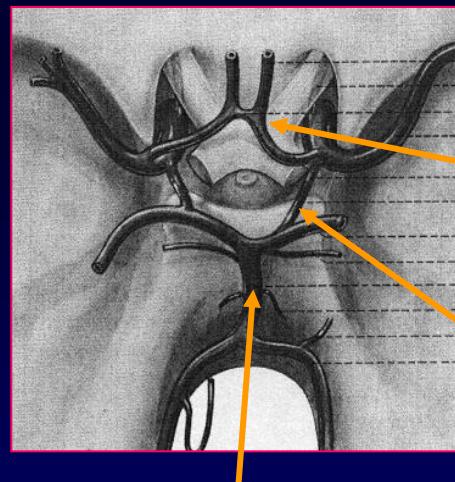
## Duplex Doppler US

evaluation of extracranial  
carotid & vertebral arteries

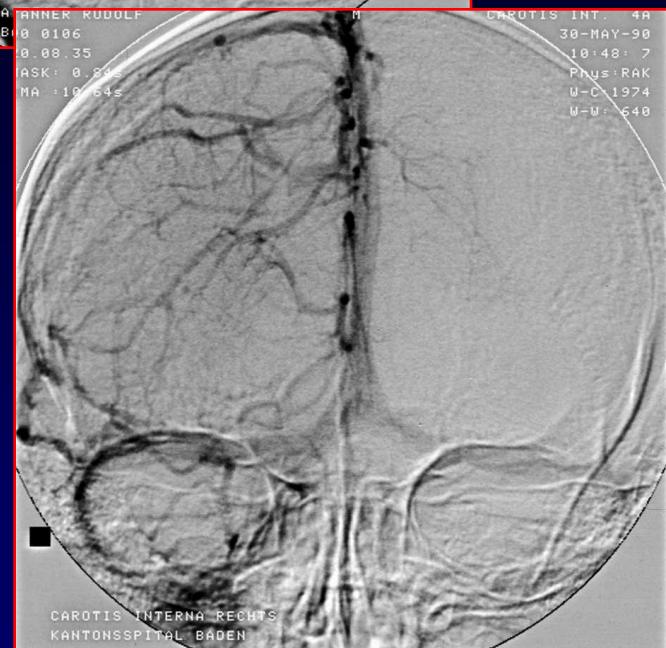
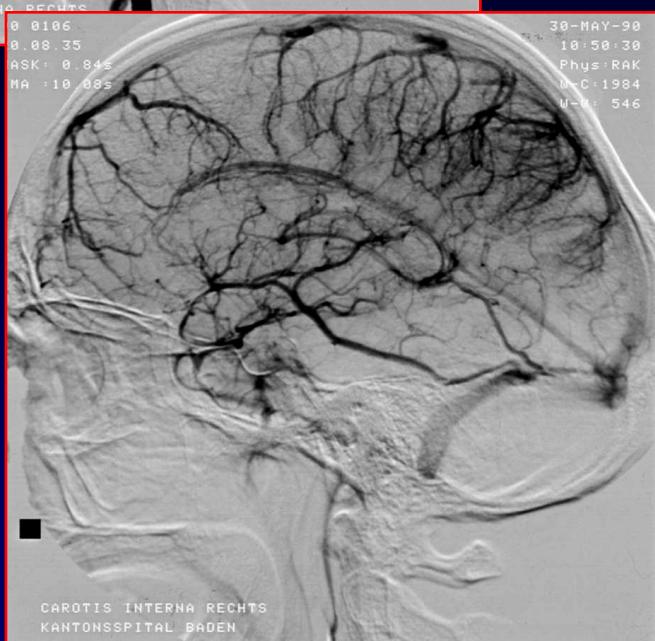


## Transcranial Doppler – TCD

- arterial spasm
- collateral circulation
- a-v malformations

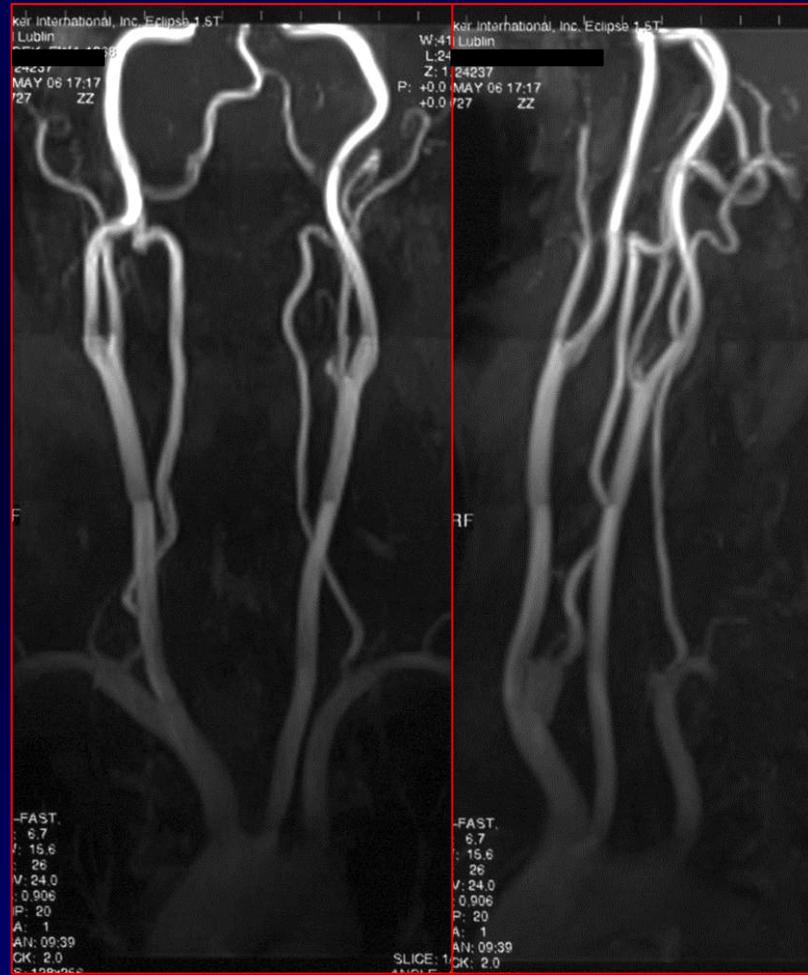


# Digital subtraction angiography DSA

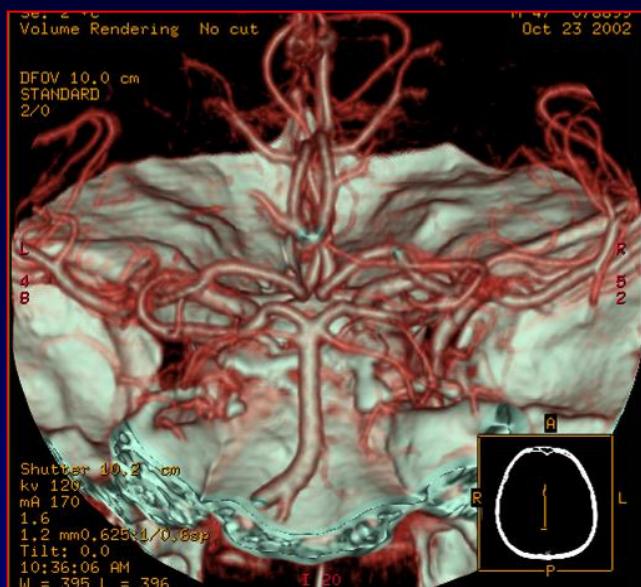


# Non-invasive angiography

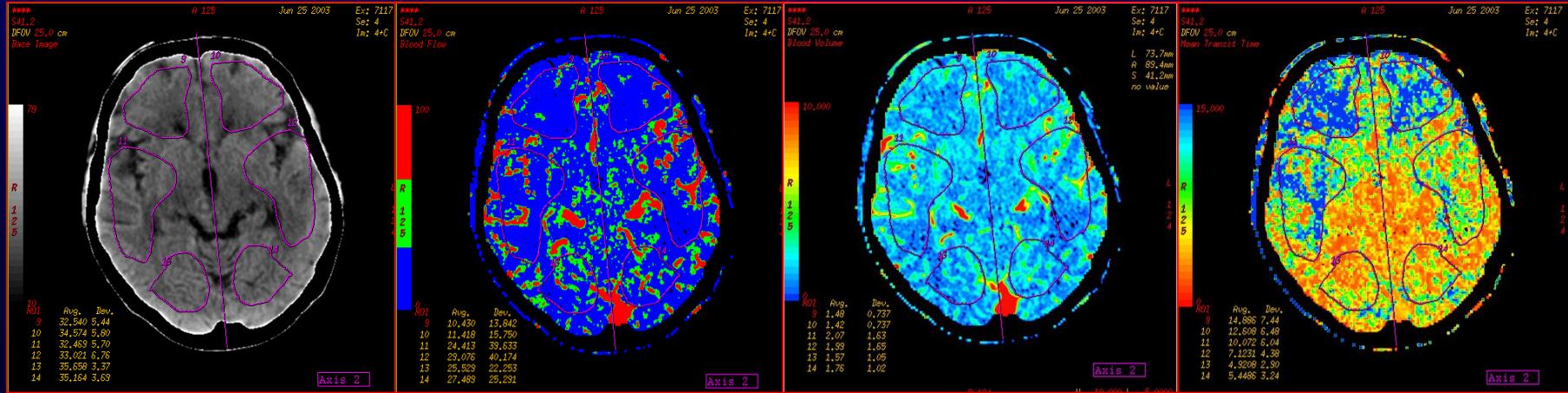
## angio-MR



# angio - CT



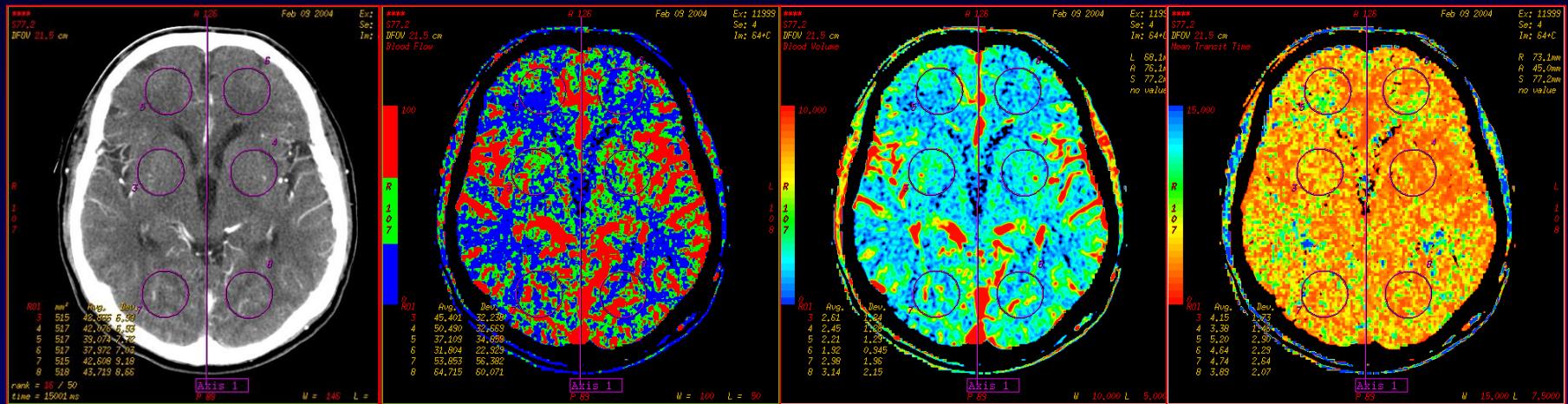
# Perfusion imaging - CT



CBF

CBV

MTT

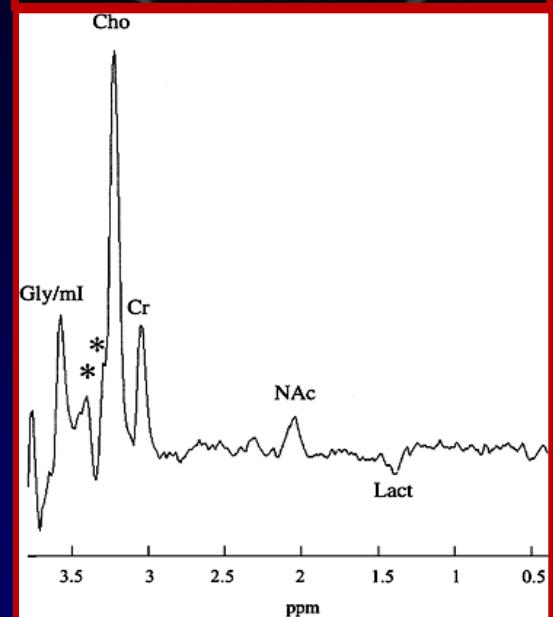
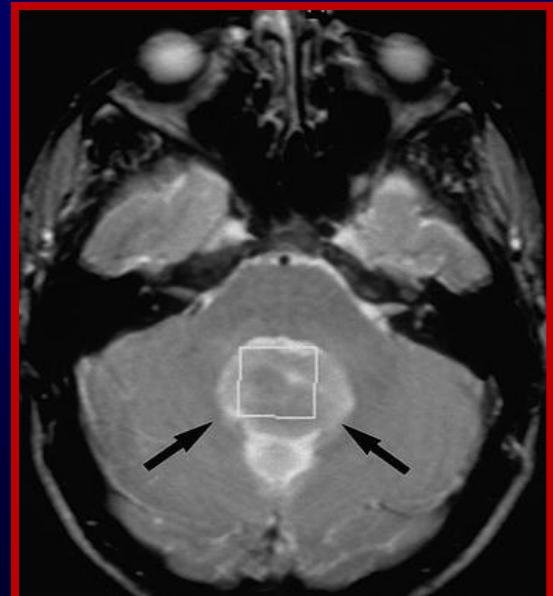
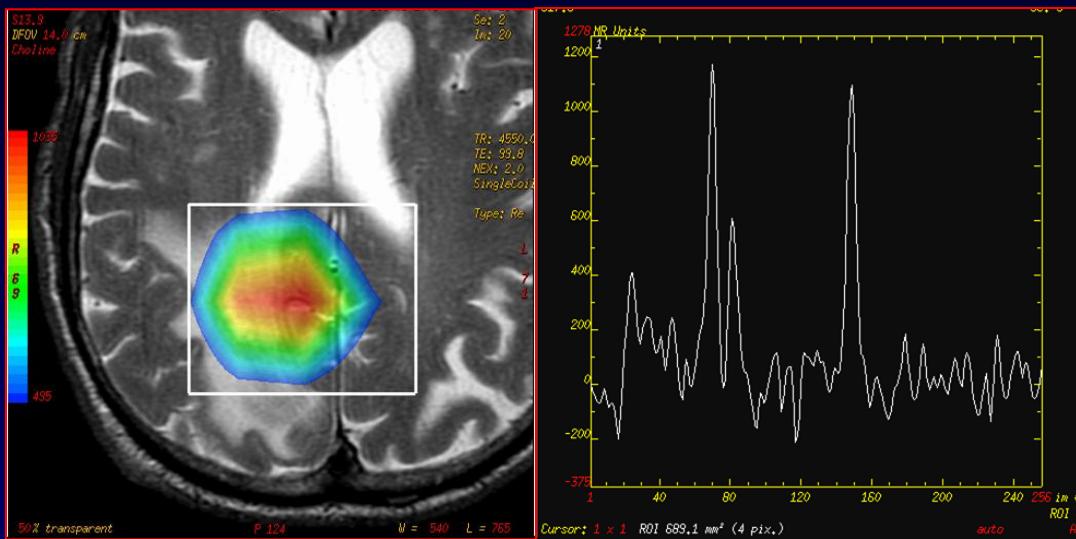


# MR spectroscopy

is shows presence of particular metabolites  
in a volume of interest - VOI

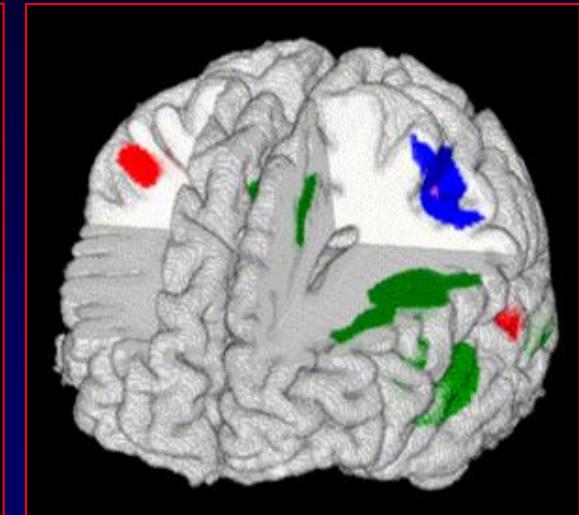
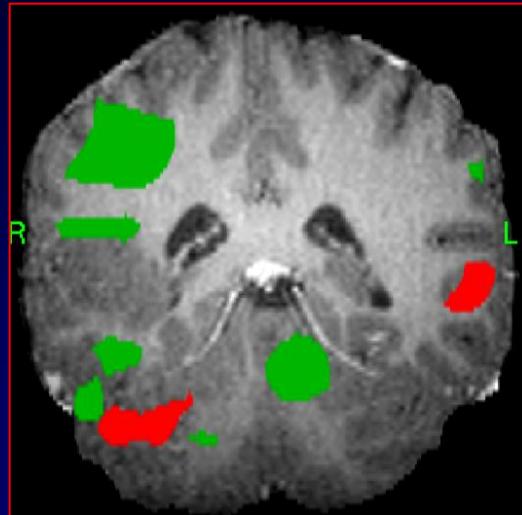
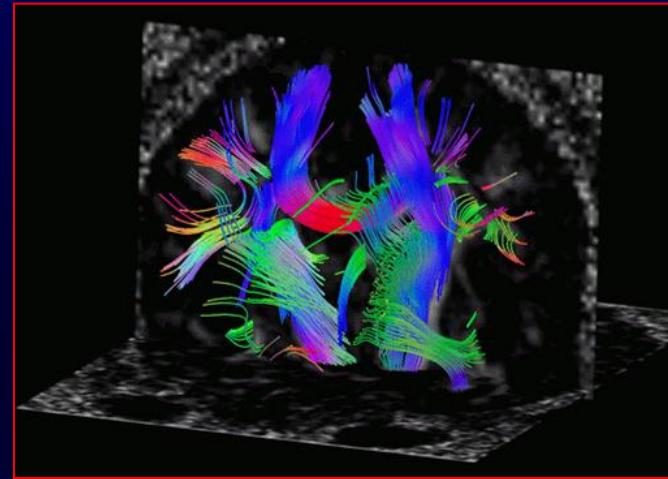
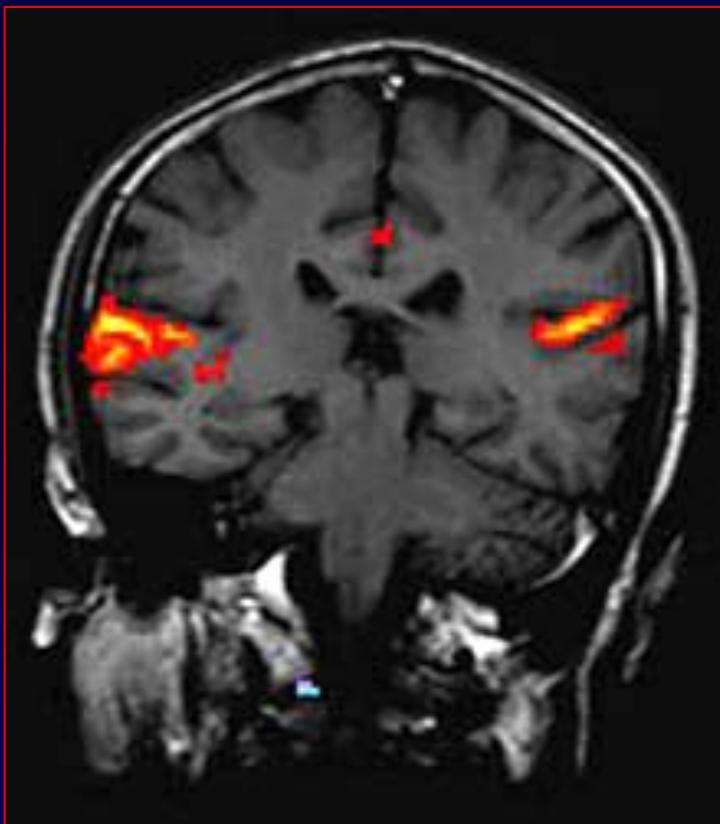


different metabolites  
for different pathologies



# MR functional & molecular imaging

it shows which part of a brain reacts for particular impulse



# 1. Congenital CNS defects

## developmental anomalies

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Very heterogenic group of disorders

selected examples below



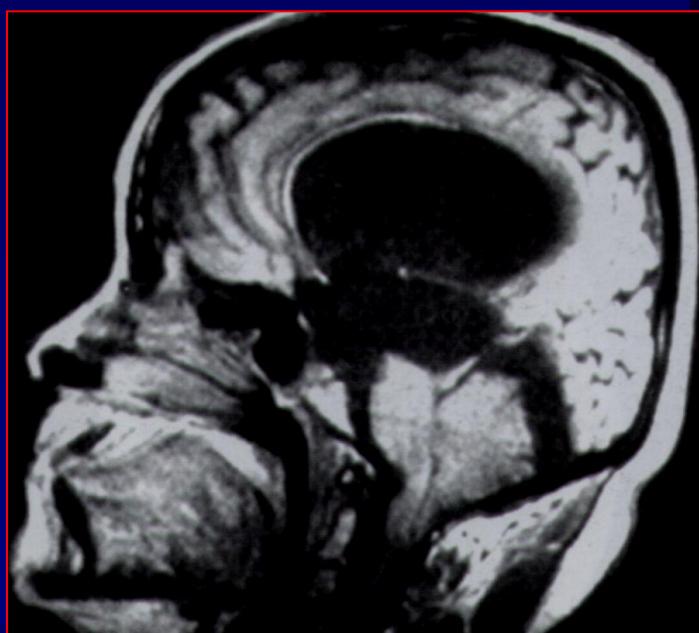
Type I



## Chiari Malformations

- cerebellar tonsils ectopy
- decrease of fluid reserve in a posterior fossa
- hydrocephalus in type II
- meningo-cerebral hernia in type III

Type II

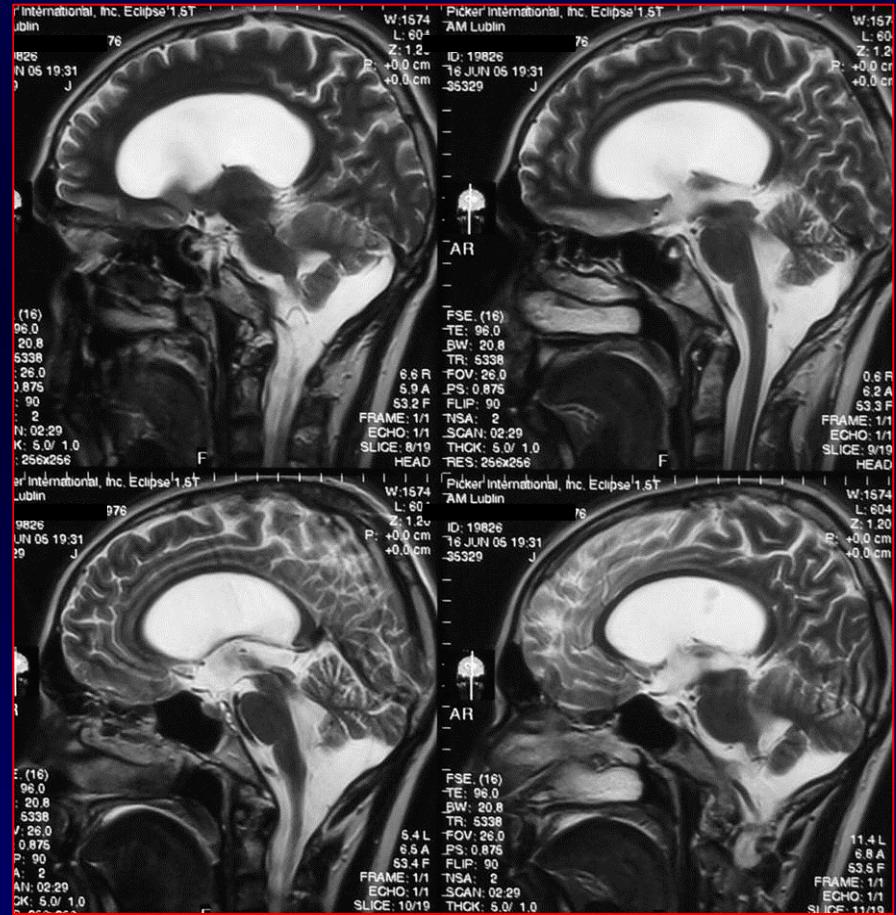
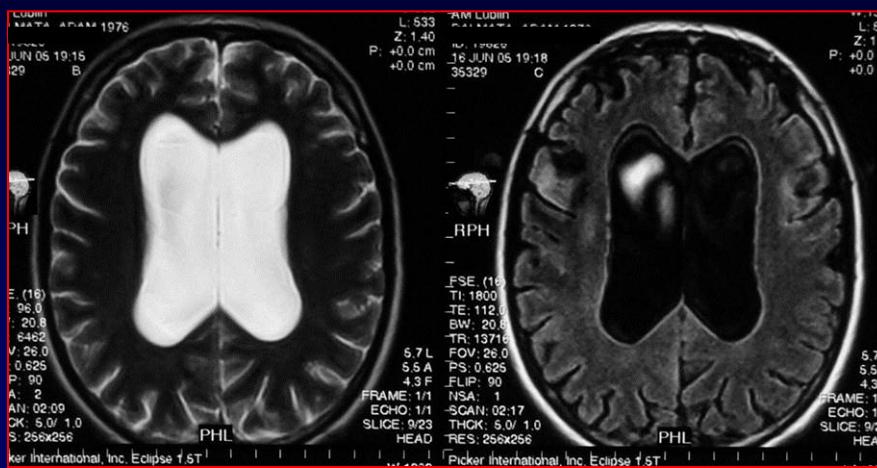
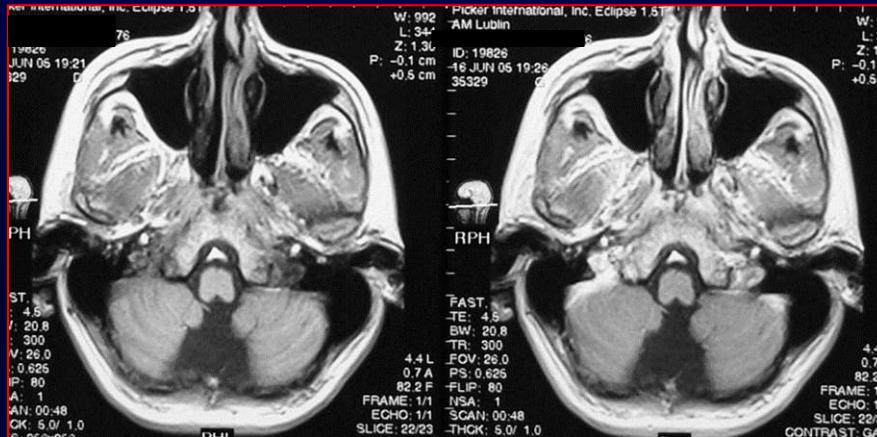


Type III



# Dandy-Walker Syndrome

- agenesis or hypoplasia of vermis cerebelli
- cystis in posterior fossa (dilated IV ventricle )
- hydrocephalus 80%



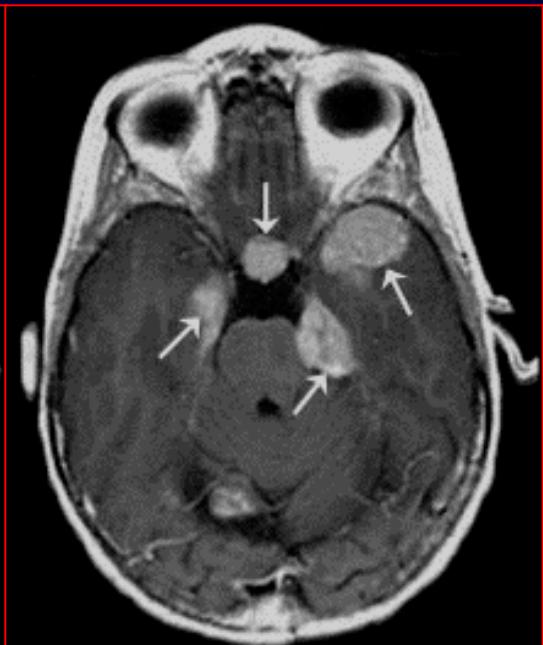
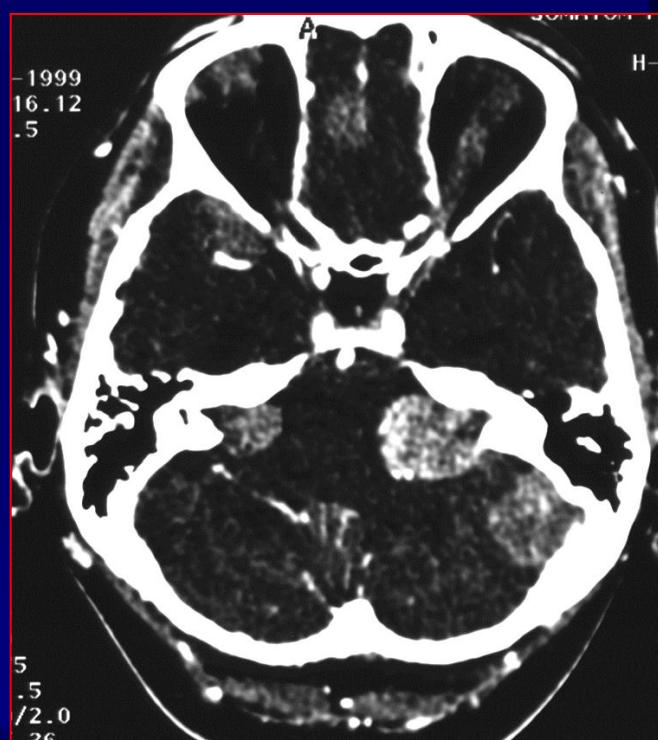
# Neurofibromatosis

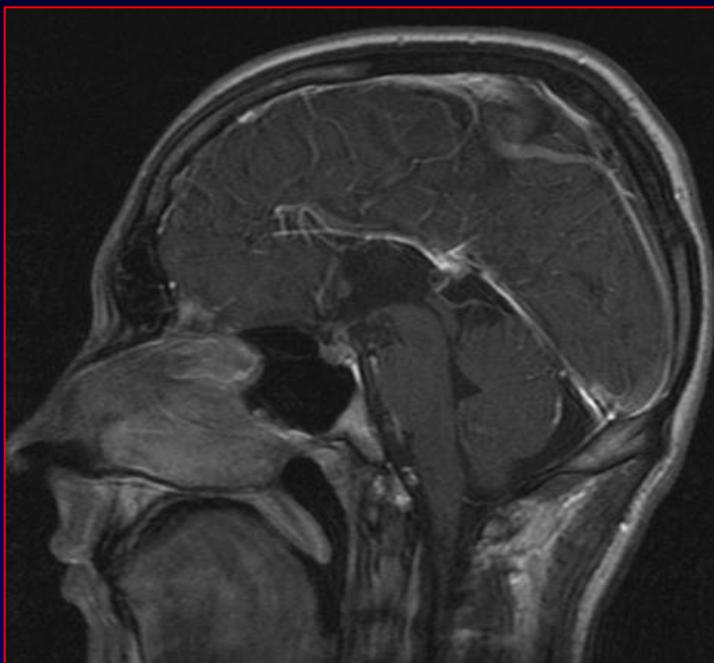
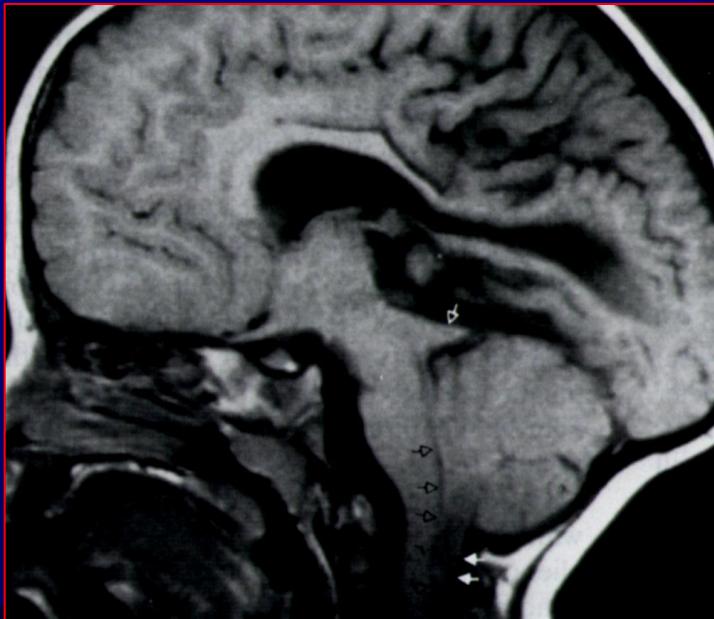
type I peripheral

Recklinghausen disease

- skin hyperpigmentations
- subcutaneous nodules (neurinomas, neurofibromas)
- CNS tumors - 15-20%
- intracranial neurinomas and/ or meningiomas (multiple)

type II central



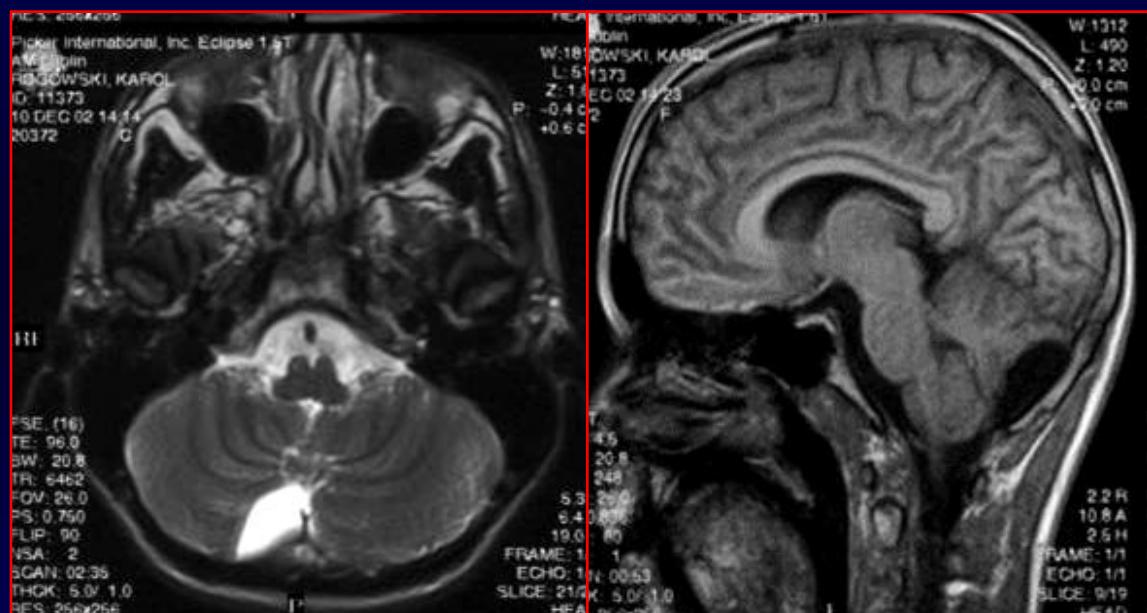
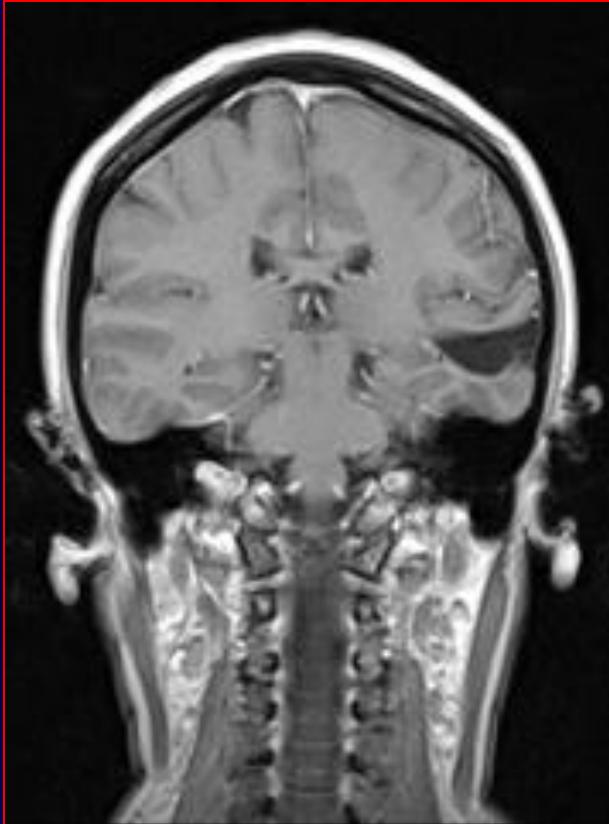


## Corpus callosum anomalies

solitare or with other anomalies



# Meningeal Cysts intracranial



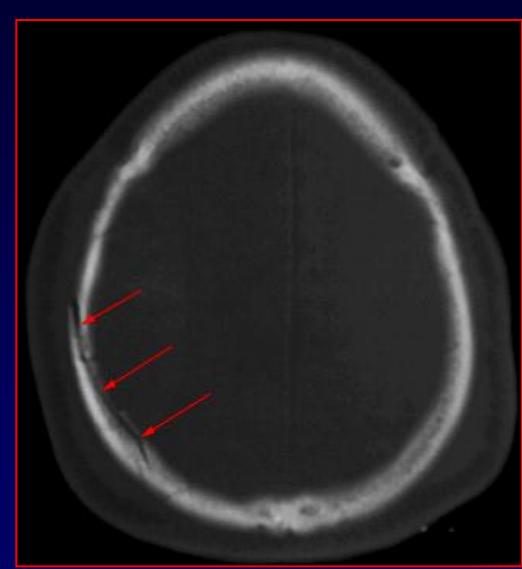
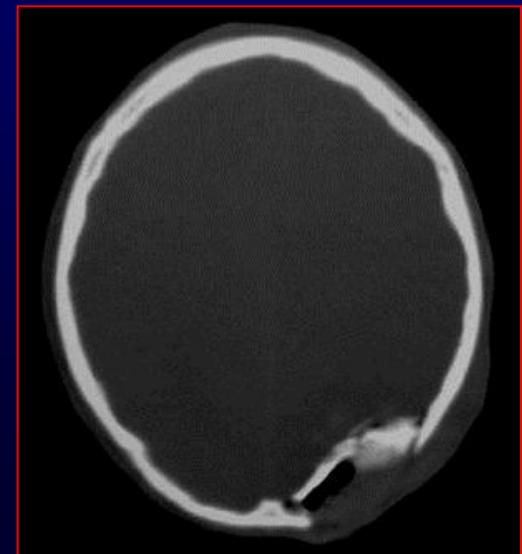
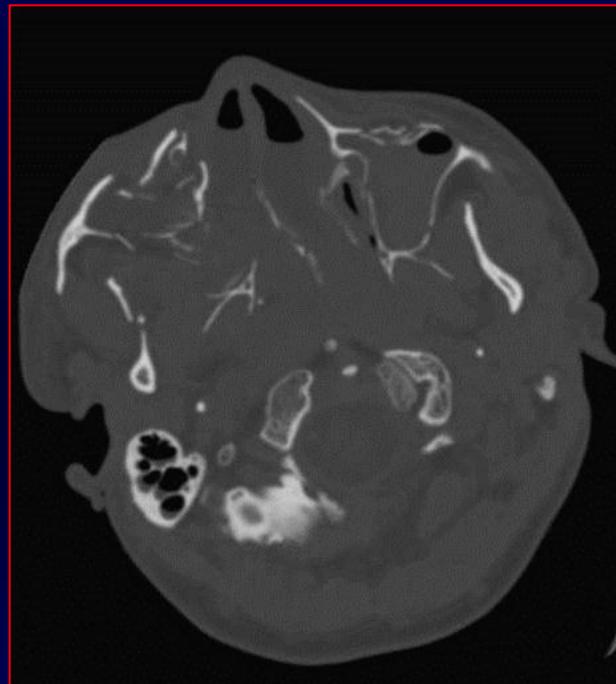
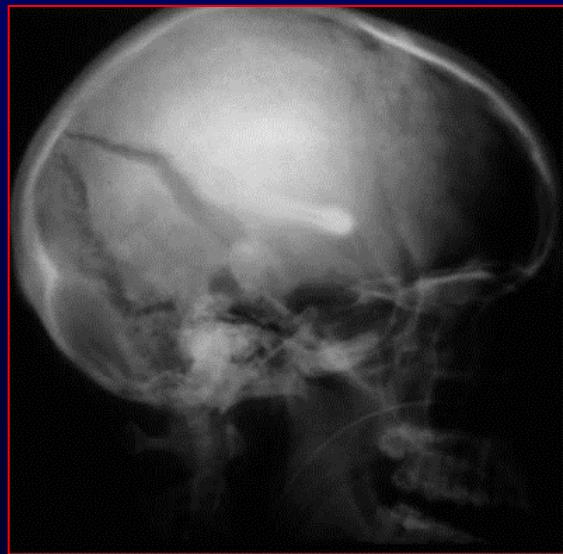
## 2. Skull and cerebral trauma

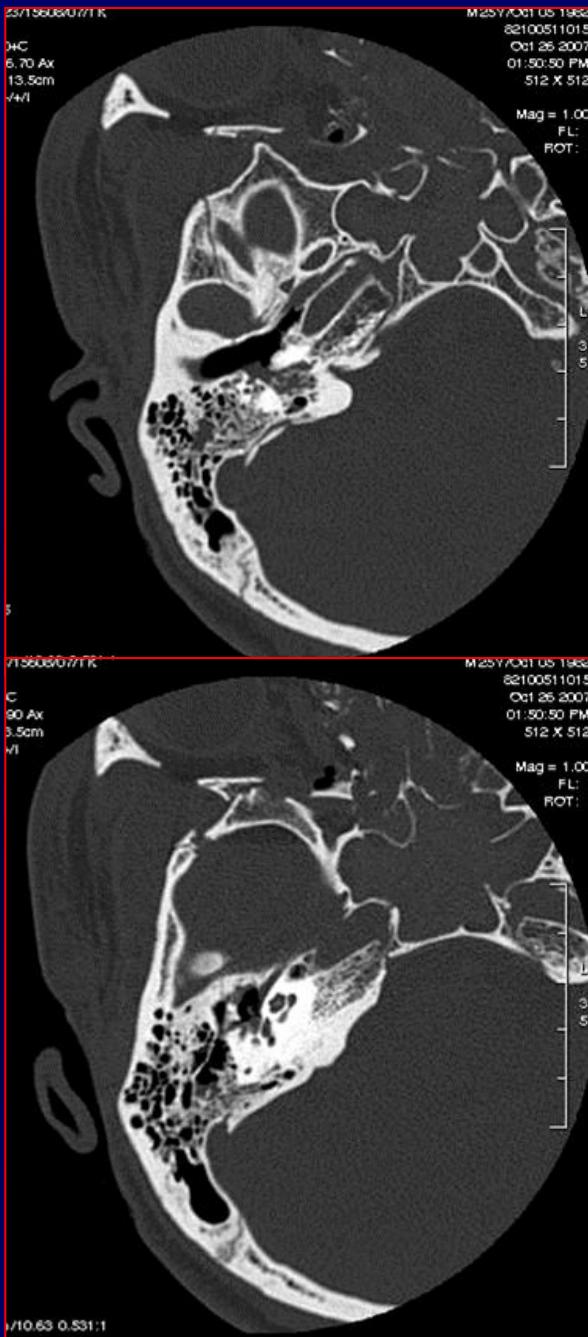
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- **bone fractures**
- **para-cerebral hematomas**
  - epidural
  - subdural
- **intra-cerebral hematomas**
- **cerebral contusion / laceration**

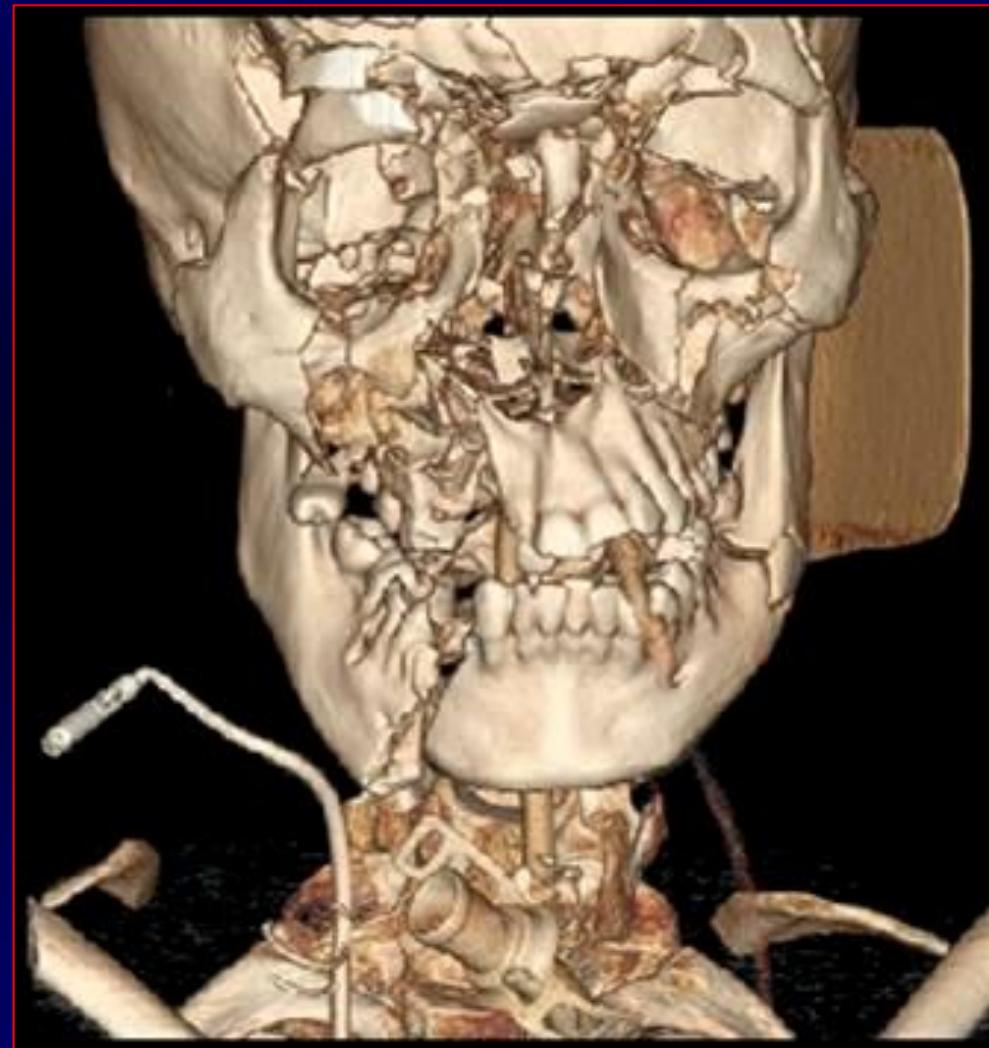
**brain oedema**

## Skull bone fractures





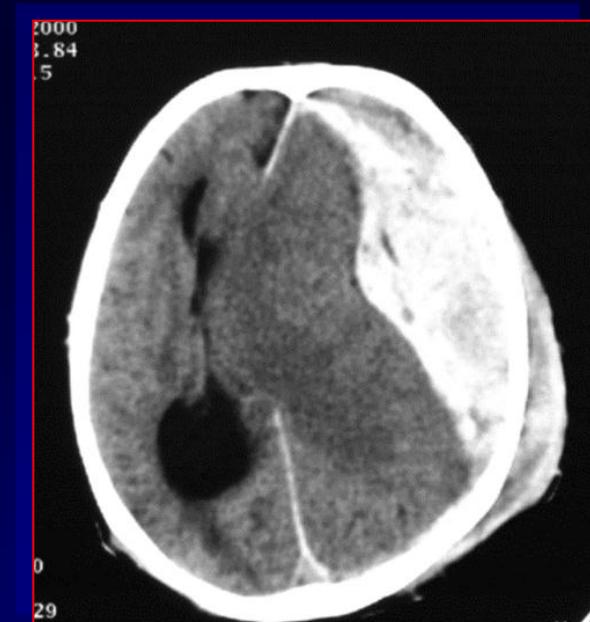
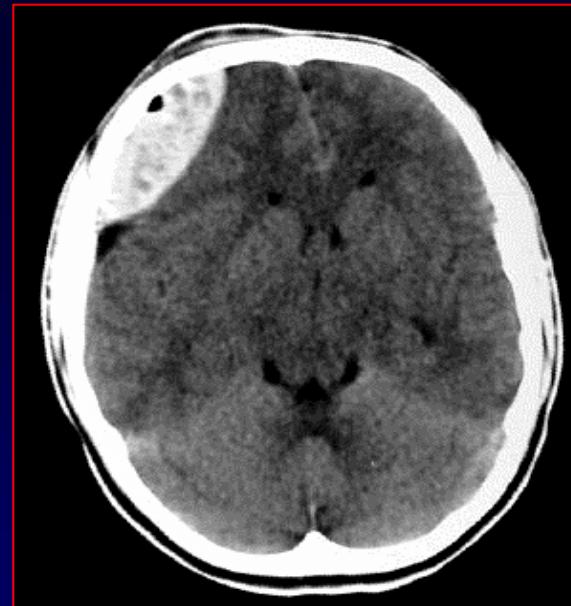
## Skull bone fractures





## Epidural hematoma

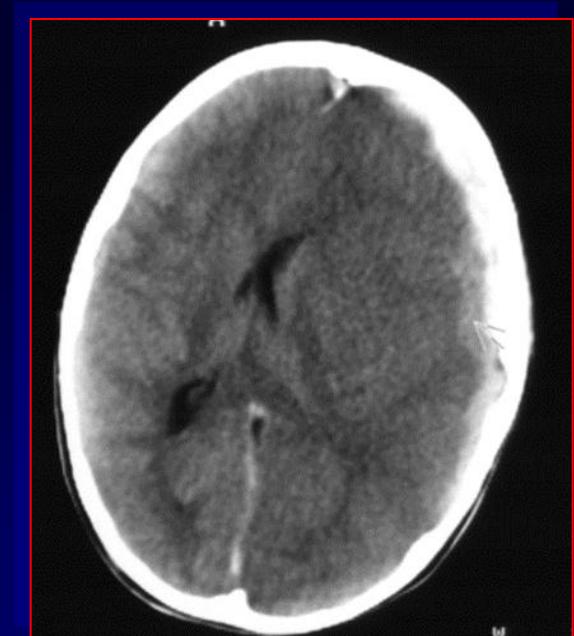
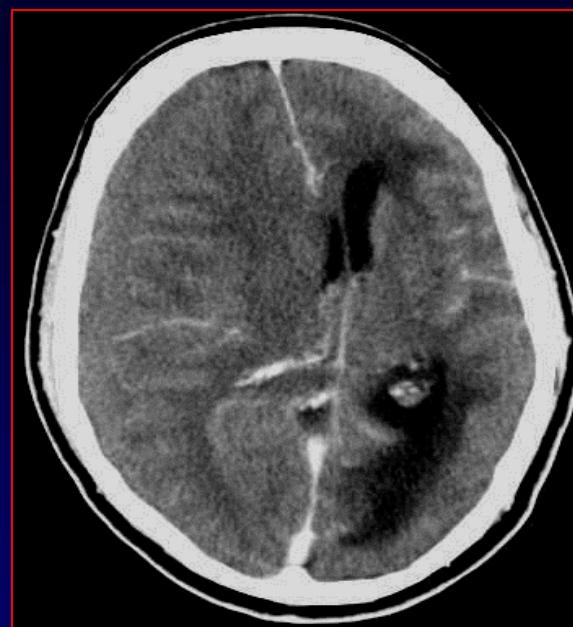
- meningeal artery rupture
- venous sinus rupture
- rupture of dural veins





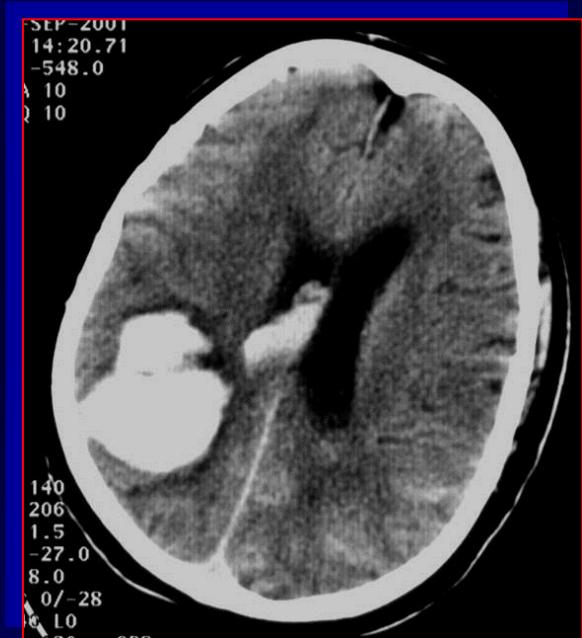
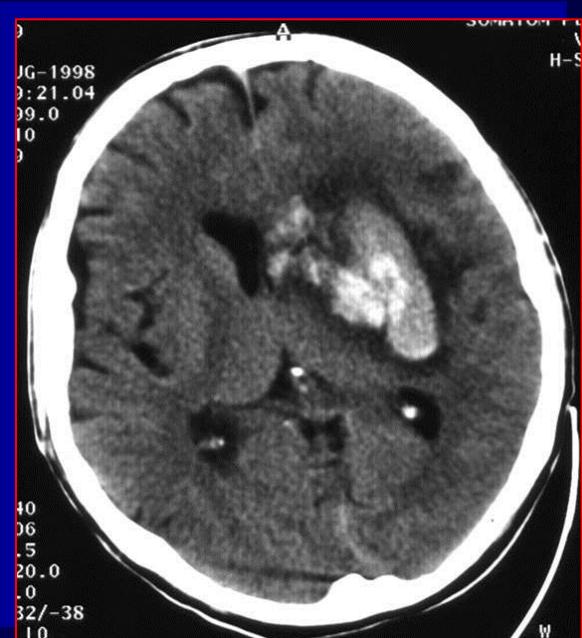
## Subdural hematoma

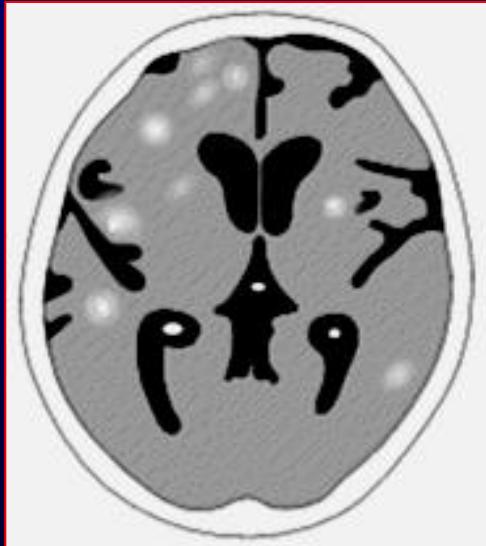
- superficial brain veins rupture



# Intracerebral hematomas

## post-traumatic

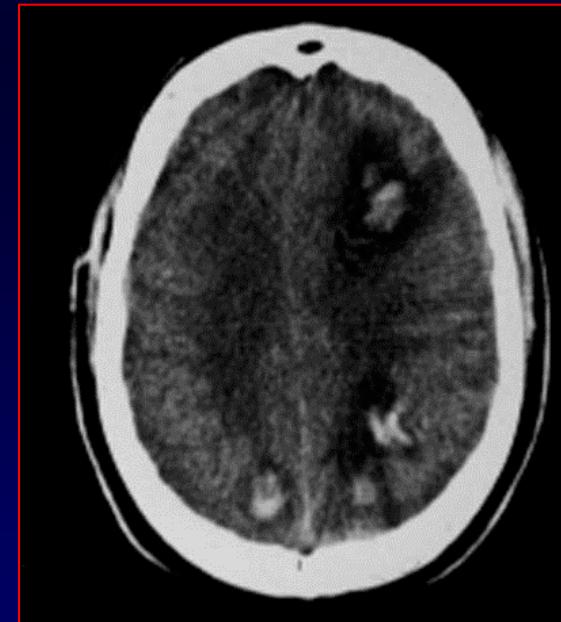
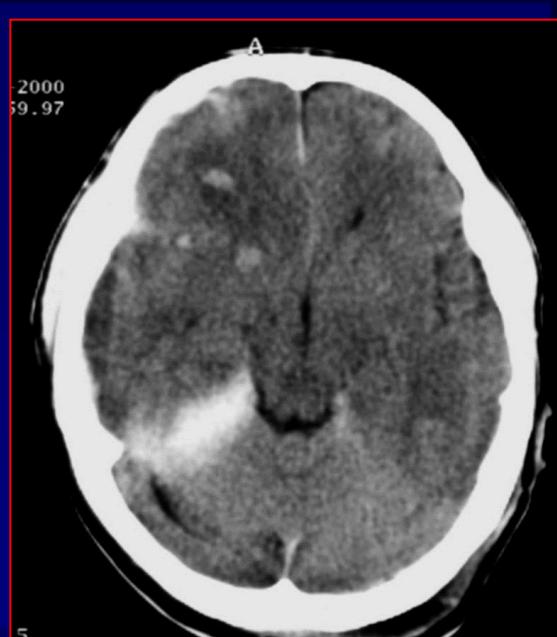
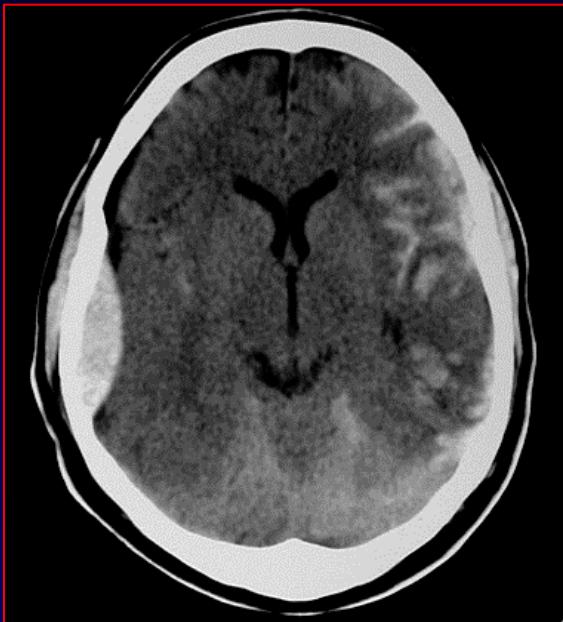




## Cerebral contusion

*contusio cerebri*

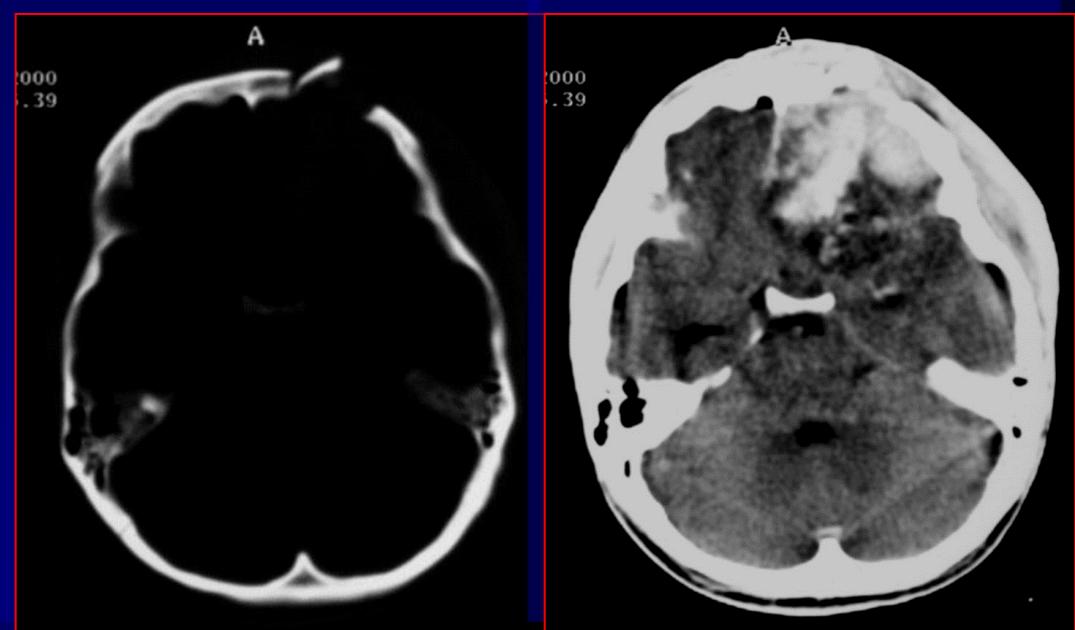
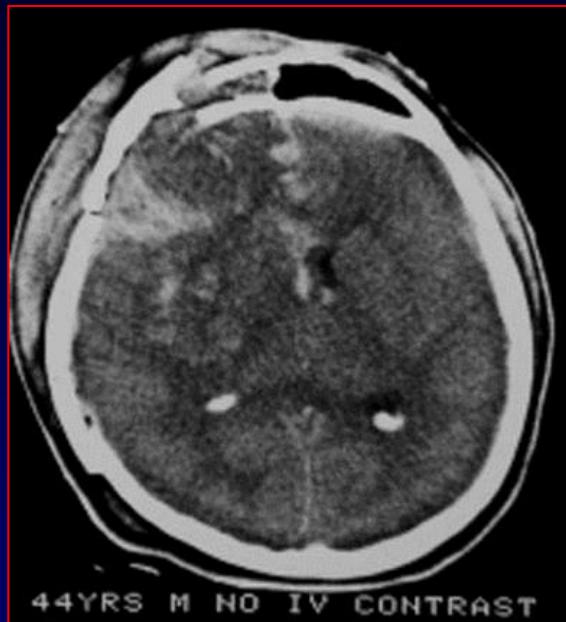
different imaging features

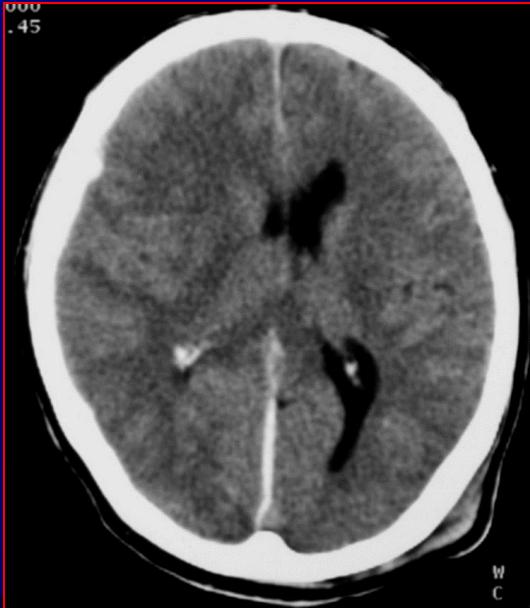




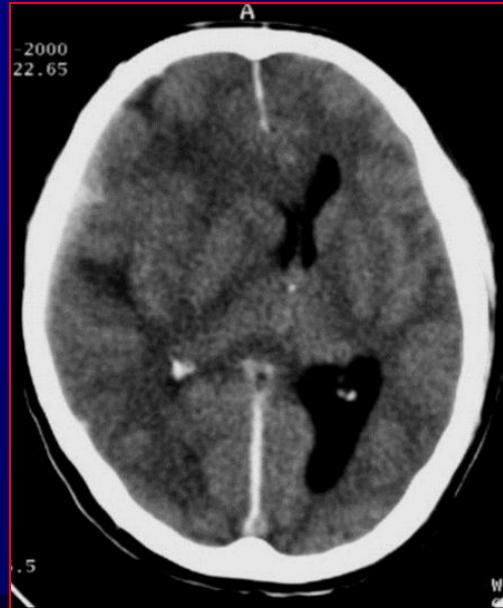
## Cerebral laceration

*laceratio cerebri*

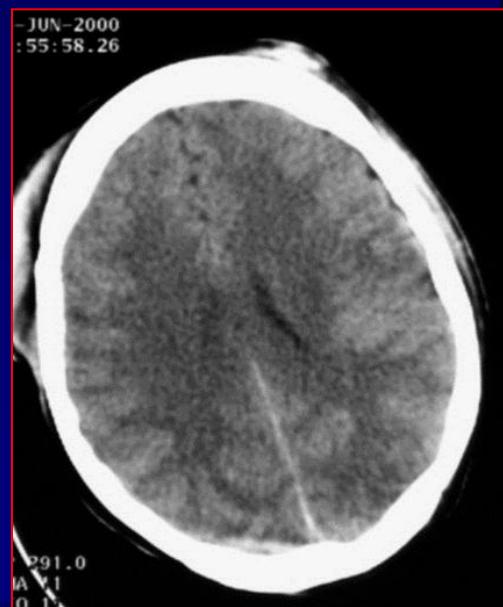




## Cerebral edema



local  
or  
general



### 3. vascular CNS diseases

#### strokes

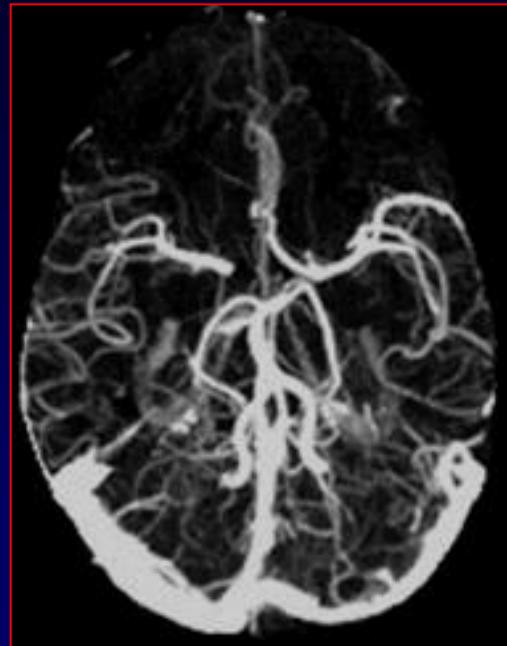
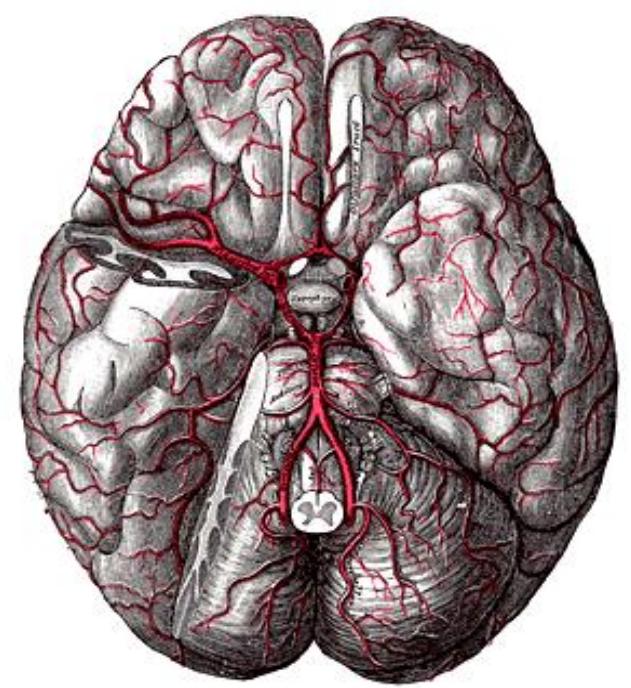
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##### **hemorrhagic:**

- subarachnoid hemorrhage (SAH)
- intracerebral hemorrhage  
(pos-traumatic, atherosclerosis, arterial hypertension)

##### **ischemic:**

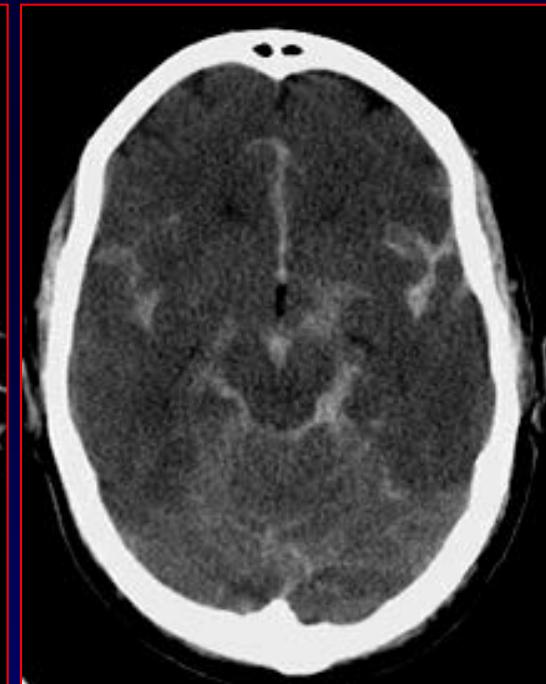
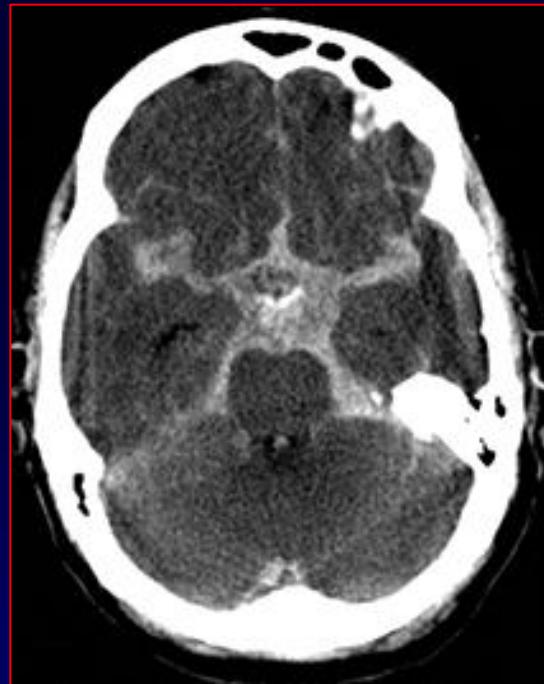
- embolic / thrombotic
  - cardiogenic embolism
  - arterial thrombosis (intracerebral)
- atherosclerosis of extracranial antebrain arteries



## Hemorrhagic stroke

subarachnoid hemorrhage

- intracranial aneurysms
- cerebral a-v malformations
- intracerebral hemangiomas



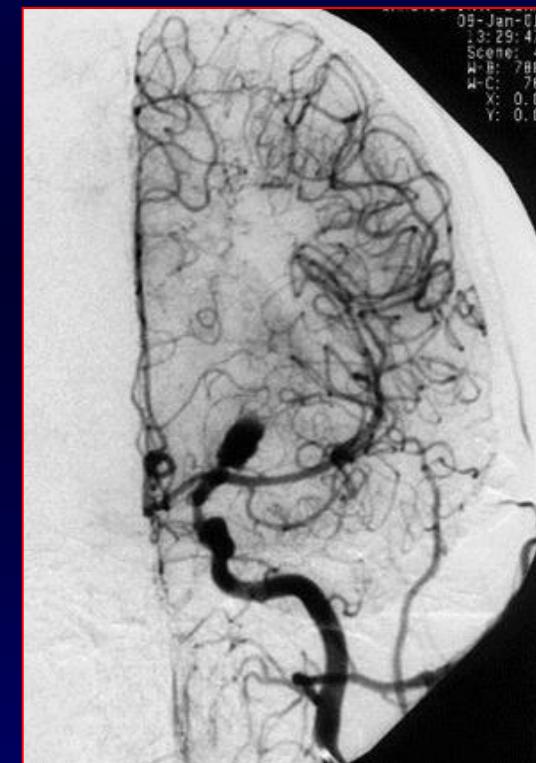
# Intracranial aneurysms

most frequent  
on anterior communicating arteries

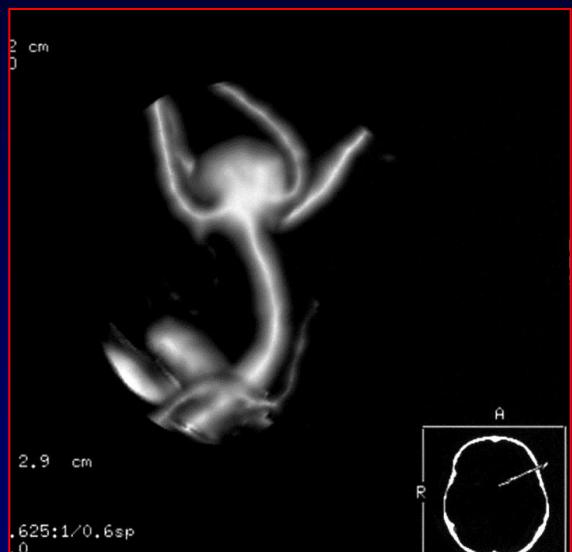


# Intracranial aneurysms

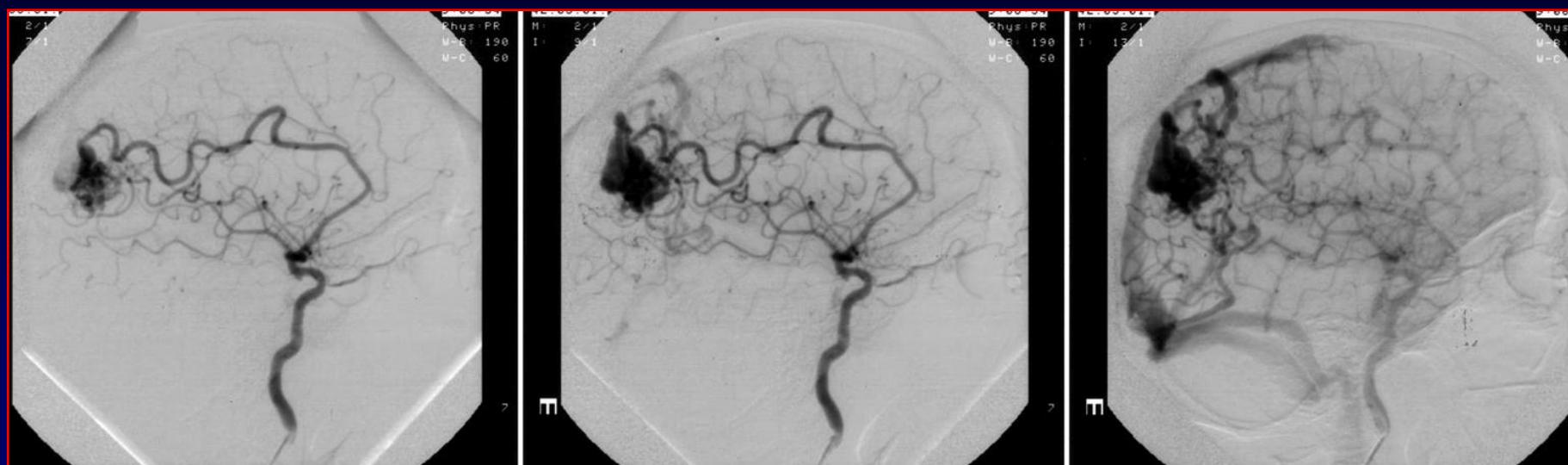
- on middle cerebral artery
- on internal carotid artery



# Basilar artery aneurysms

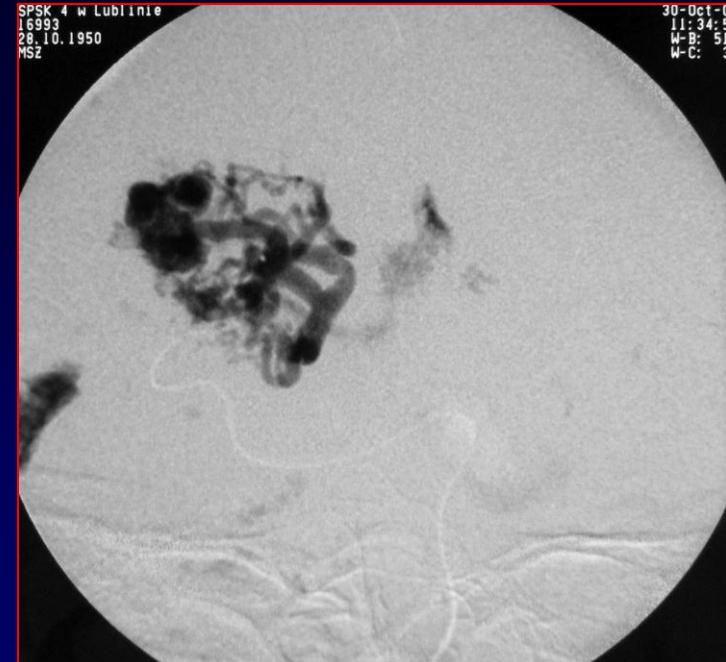


# Arterio-Venous brain hemangioma





## A-V hemangioma in infratentorial location with venous "aneurysm"





# Hemorrhagic stroke

## a-v hemangioma

### Intracerebral hemorrhage



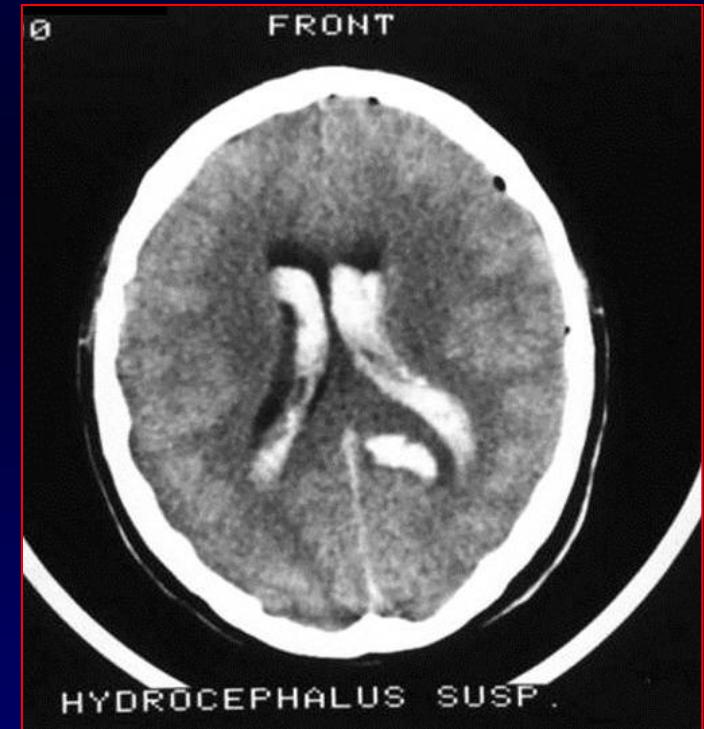
# Hemorrhagic stroke

intracerebral hemorrhage

idiopathic / spontaneous  
arterial hypertension

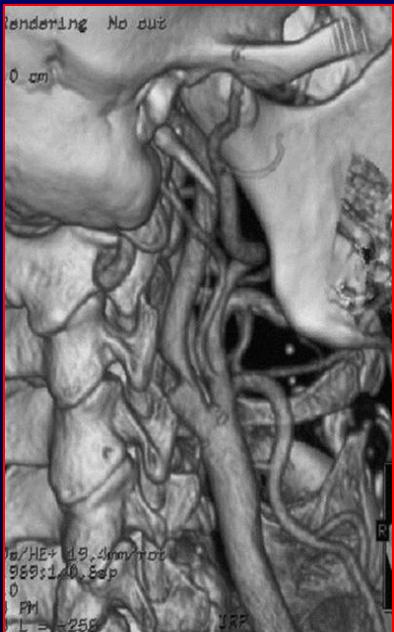


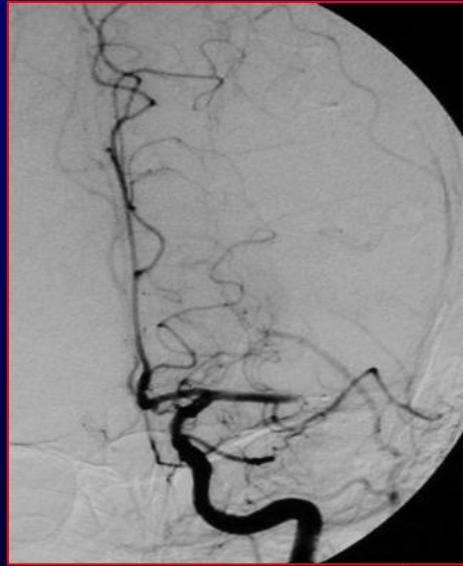
intra-ventricular



# Ischemic stroke

stenosis or occlusion  
of extracranial or intracranial arteries

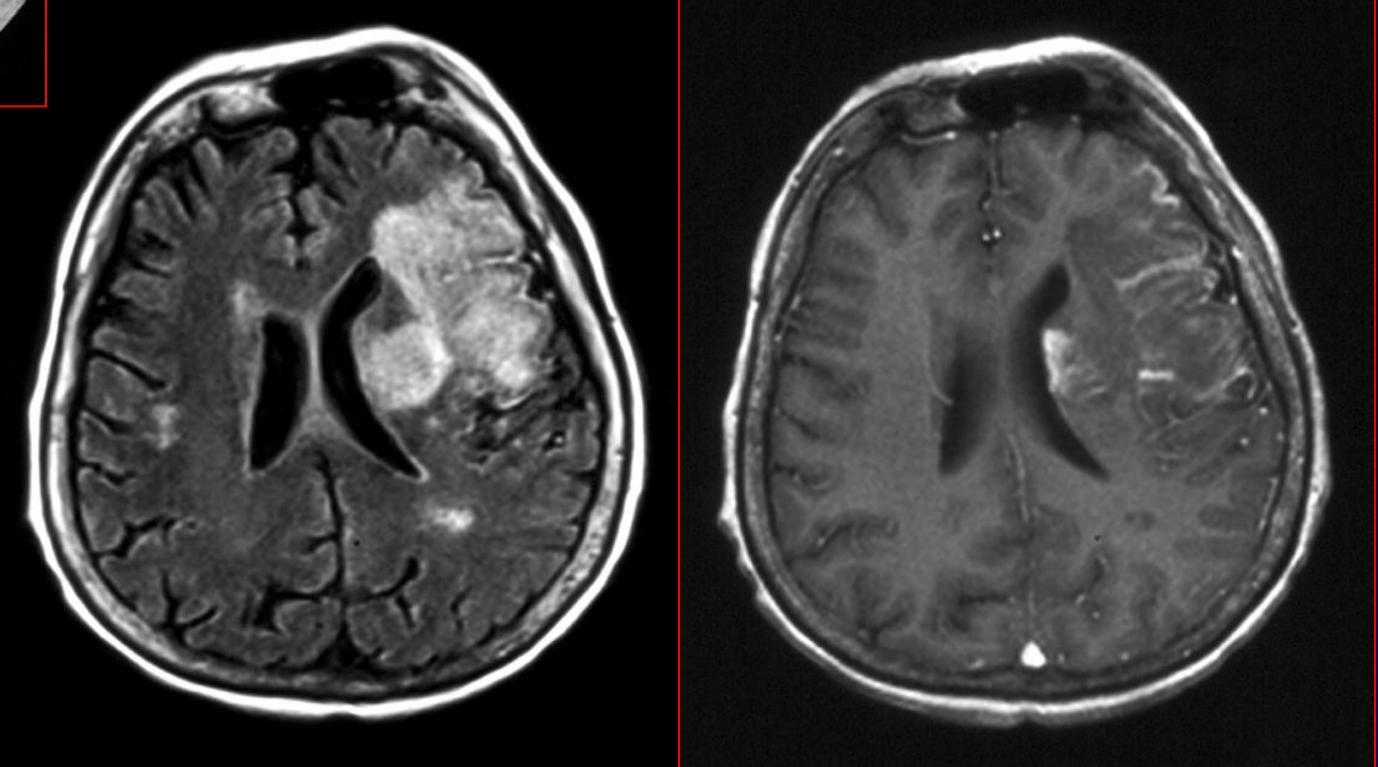


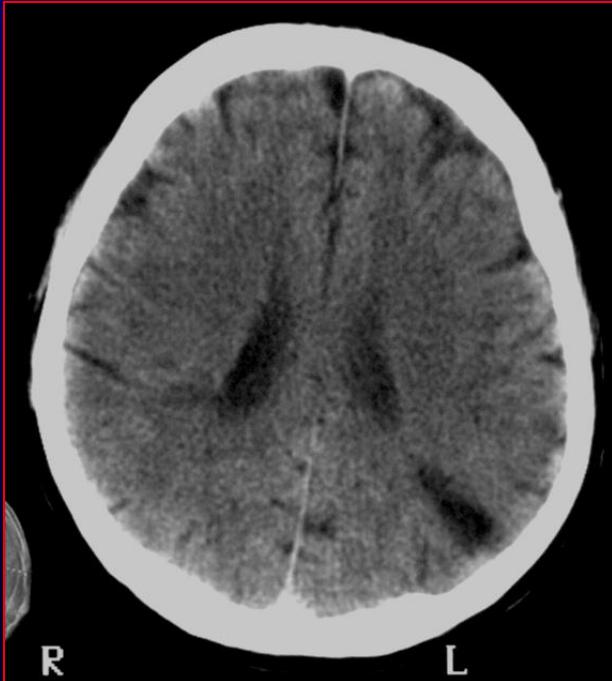


## Ischemic stroke

left brain hemisphere infarction

caused by MCA occlusion (embolic?)





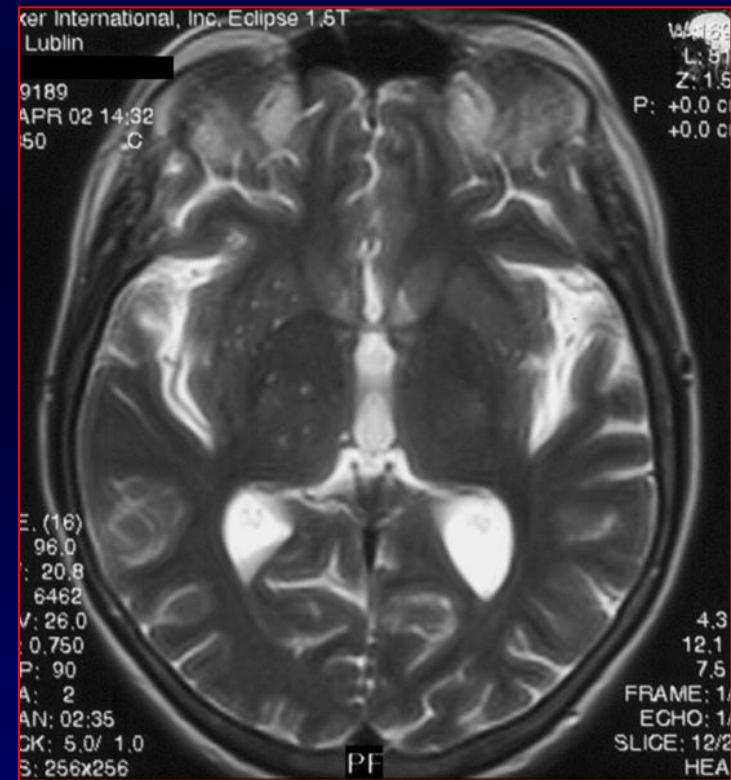
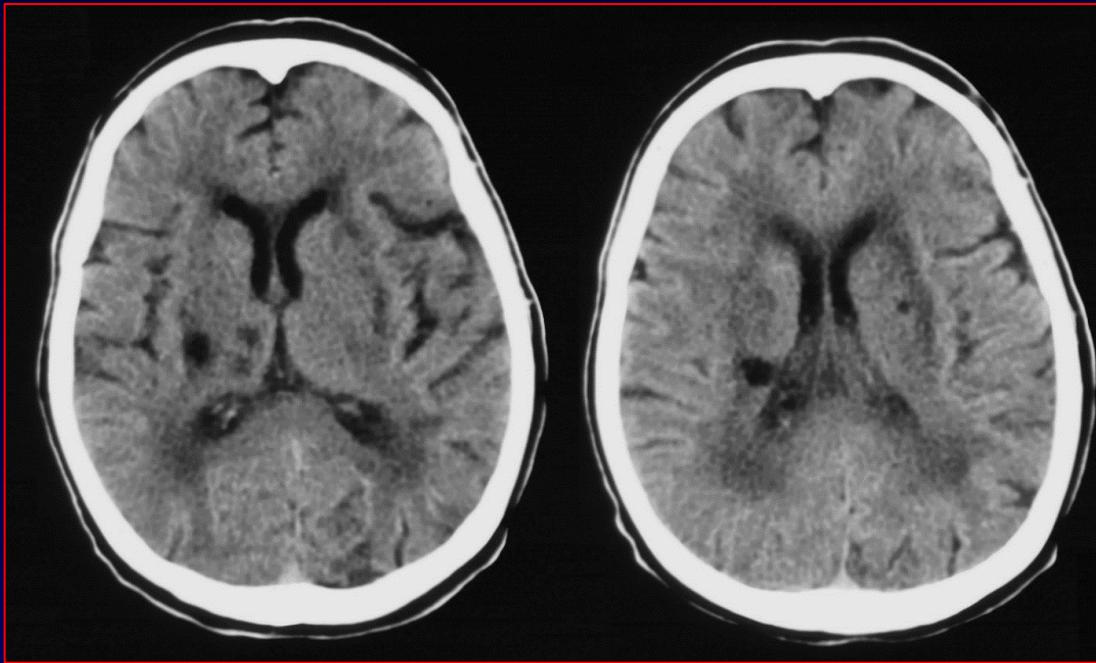
## Ischemic stroke hemodynamic stroke



"border-line brain infarct"

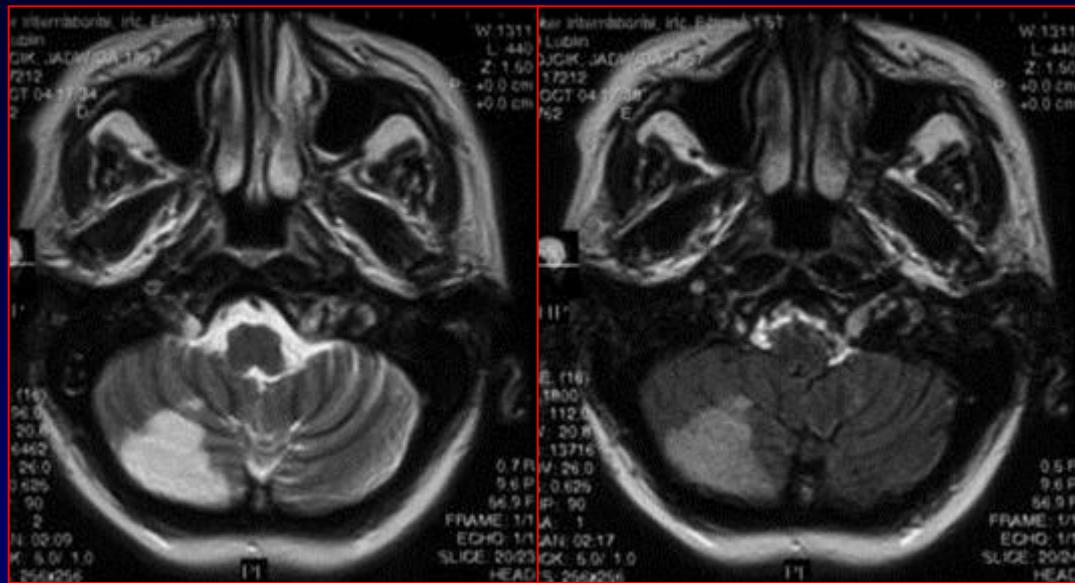
# Ischemic stroke      lacunar stroke

most frequently embolic –  
cardiogenic or debris from atherosclerotic plaques



# Cerebellar infarction

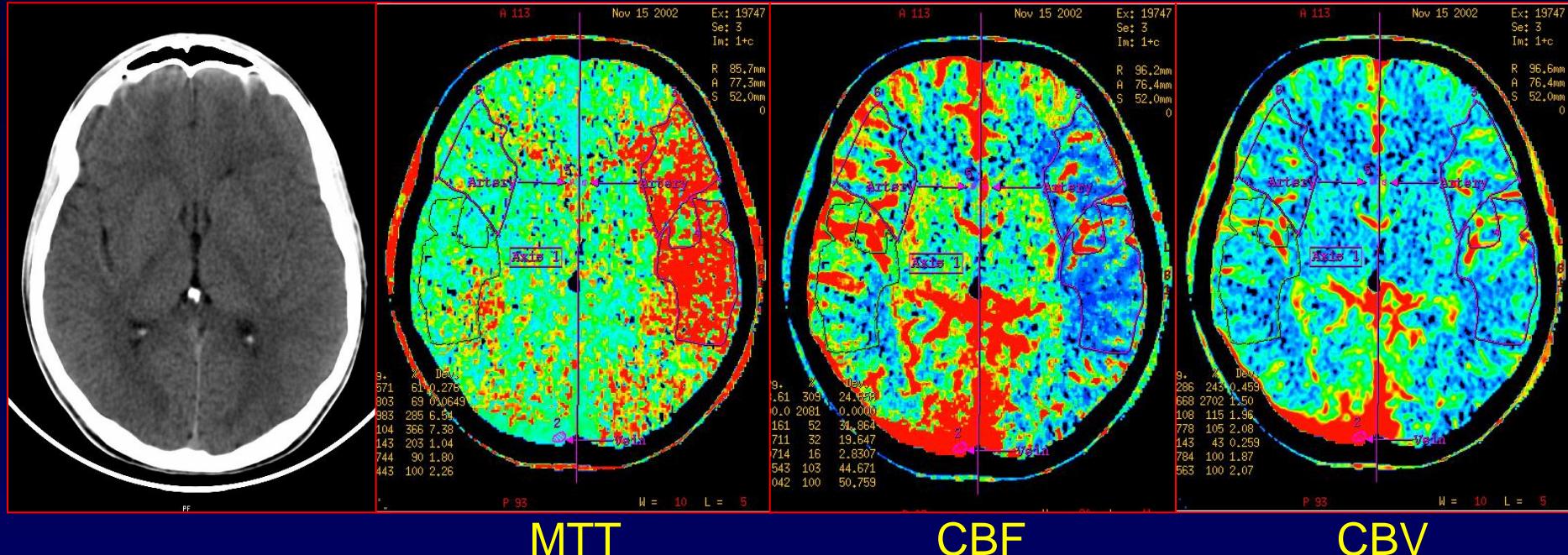
vertebro-basilar  
circulation defect



# Brain perfusion – CT or MR

it shows hypoperfusion zones

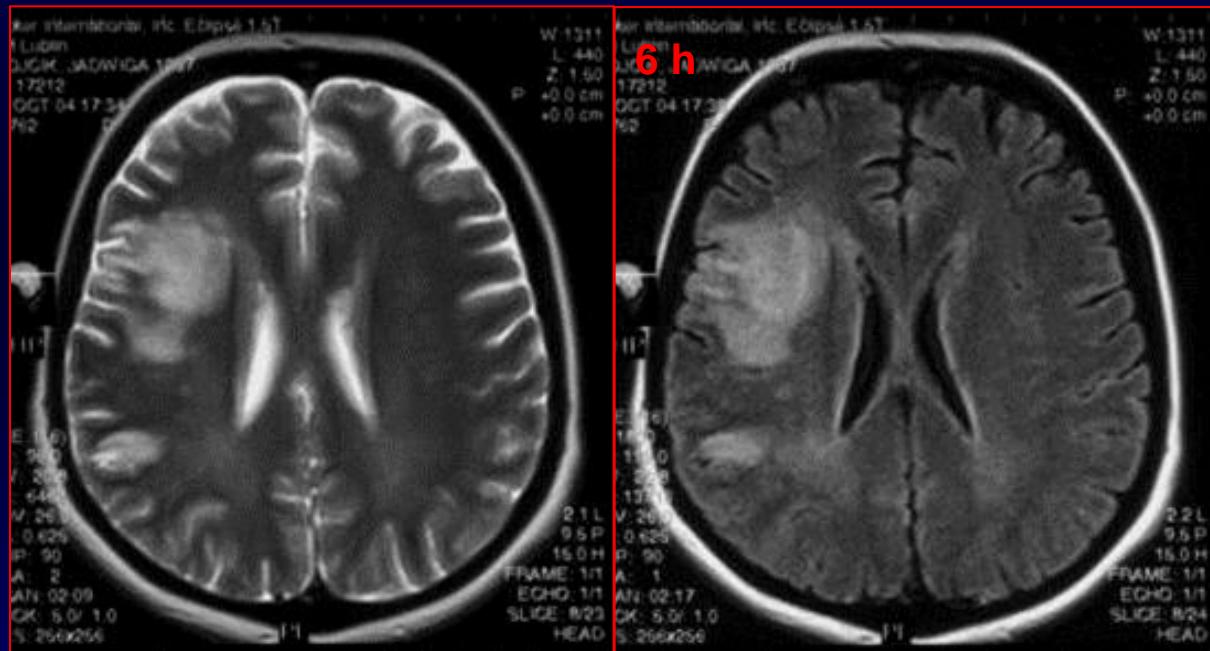
- in imminent stroke – pre-symptomatic
- in completed stroke – symptomatic

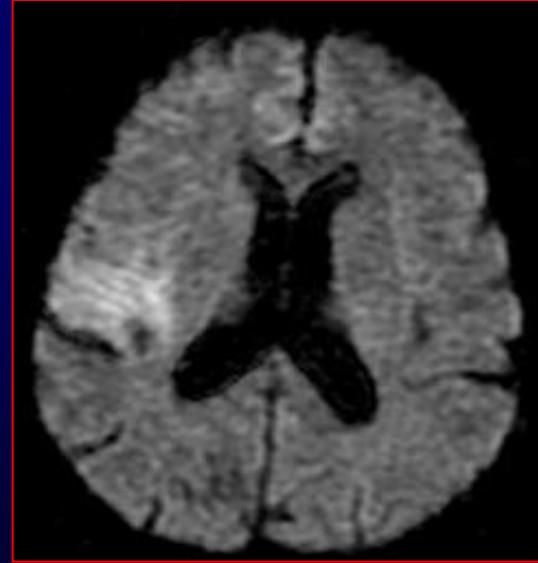
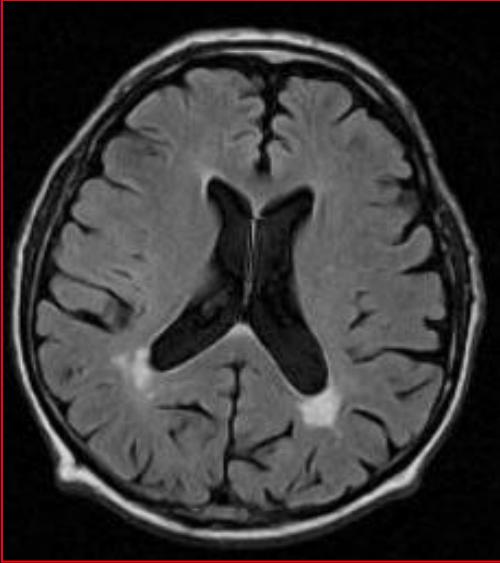


# Ischemic stroke

time is crucial

therapeutic window for trombolysis is 4-6 h



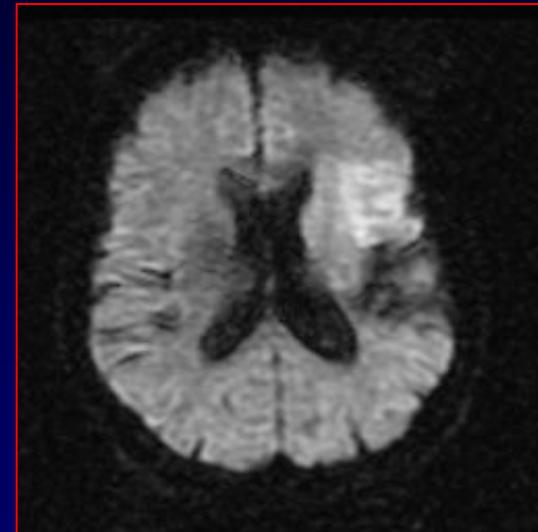
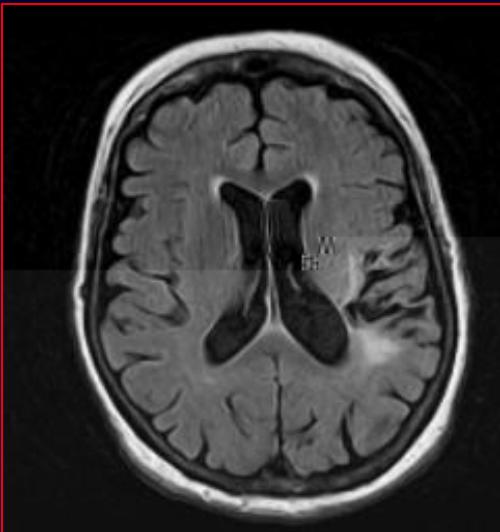


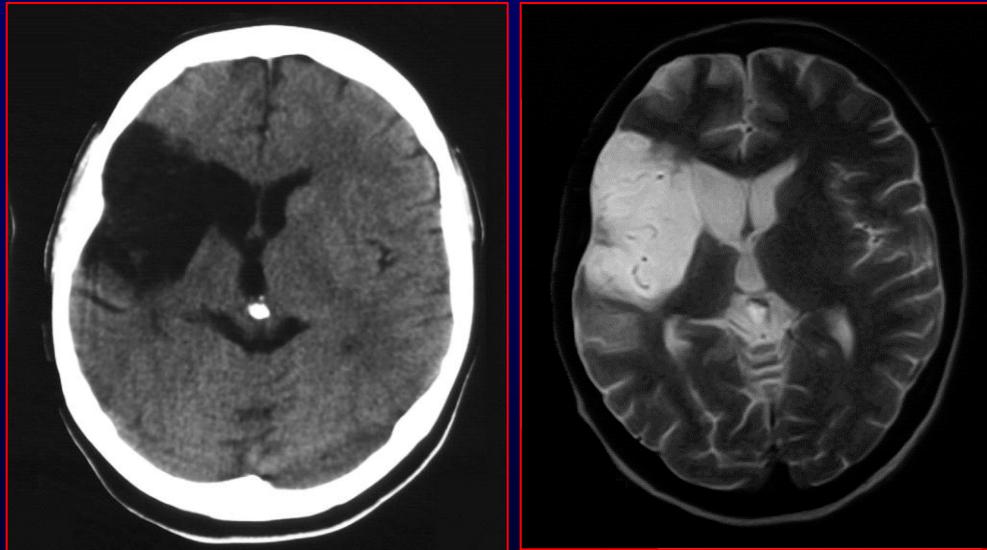
FLAIR

## Dyfusion MR - DWI

may show ischemic area after 2 hours

DWI

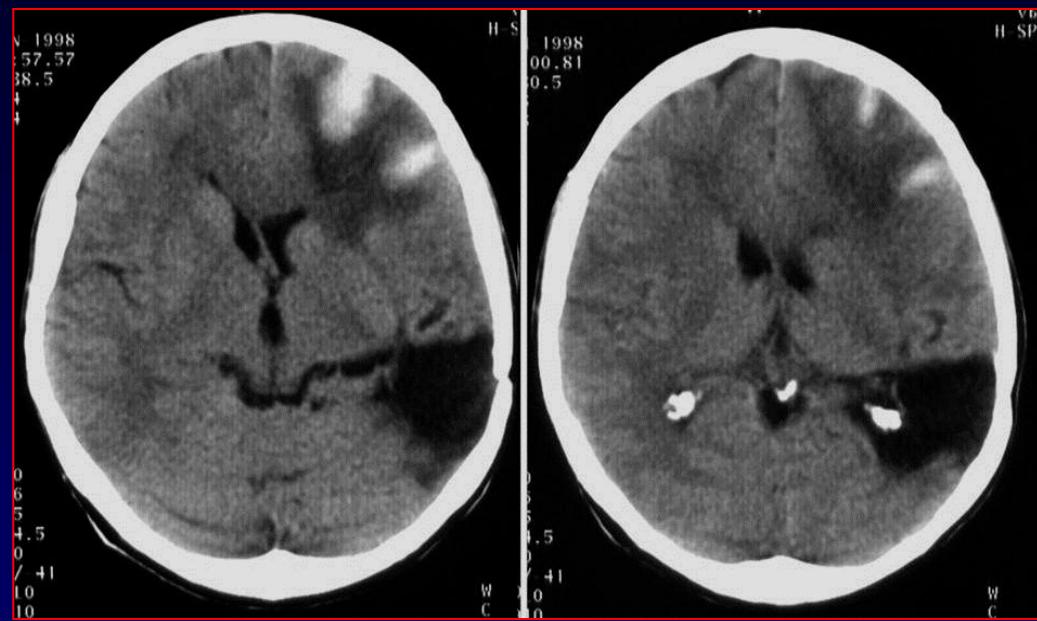




**"old" ischemic stroke**  
cerebral malacia  
in the MCA area

**"old" infarct**  
(hemodynamic , "border zone")

**and recent,  
hemorrhagic stroke**  
in the area of ACA



## **4. Intracranial tumors** (basic classification)

---

### **Neuroepithelial tumors (gliomas):**

- astocytoma
- oligodendrogloma
- ependymoma
- GBM

### **Meningeal tumors:**

- meningioma
- meningiosarcoma

### **Parasellar tumors**

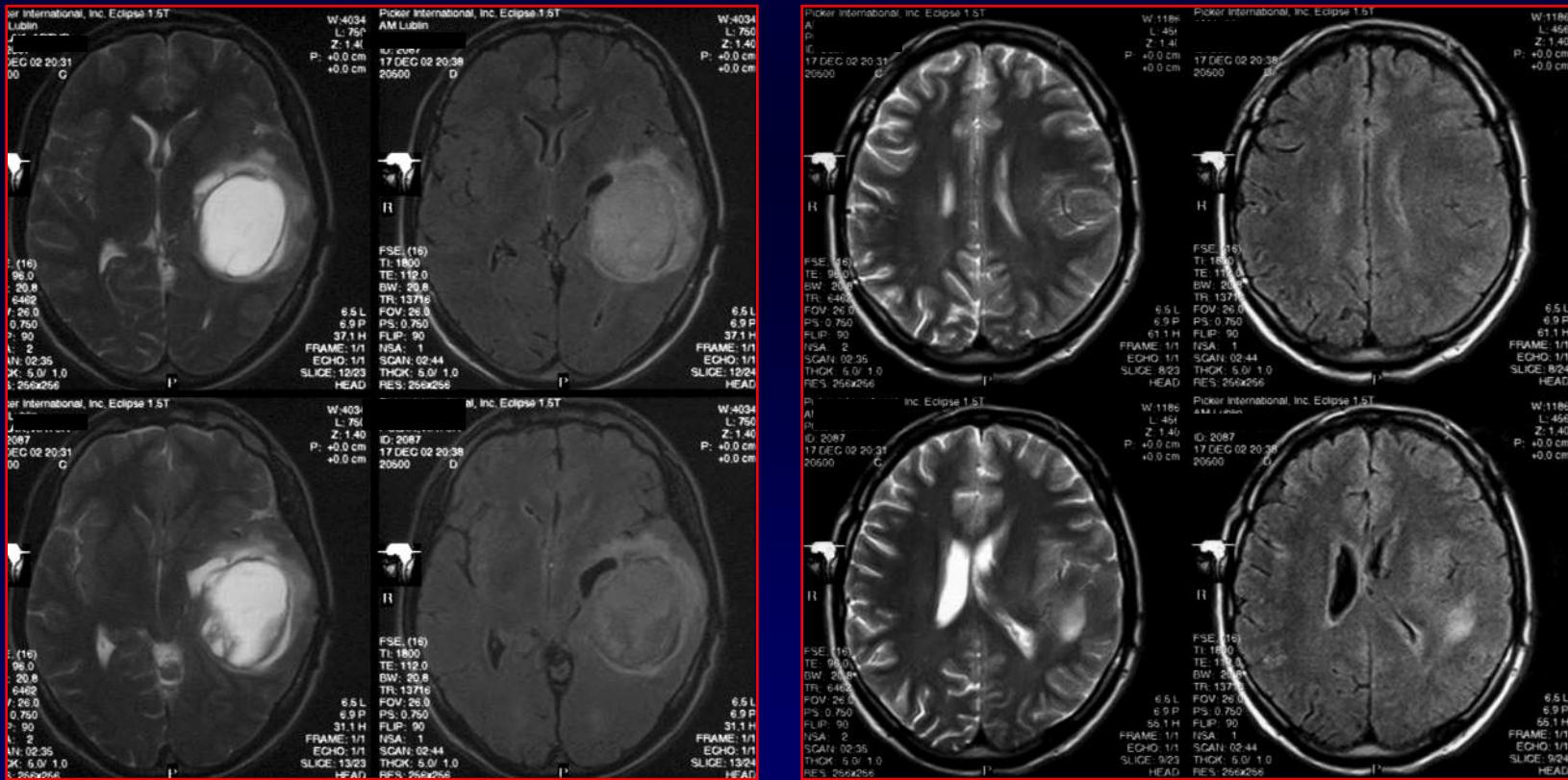
- pituitary adenoma
- craniopharyngioma

### **Cranial nerves tumors**

- neurinoma, schwannoma
- neurofibroma

# Gliomas – wide variety of images, different malignancy (I<sup>o</sup>-IV<sup>o</sup> acc. WHO)

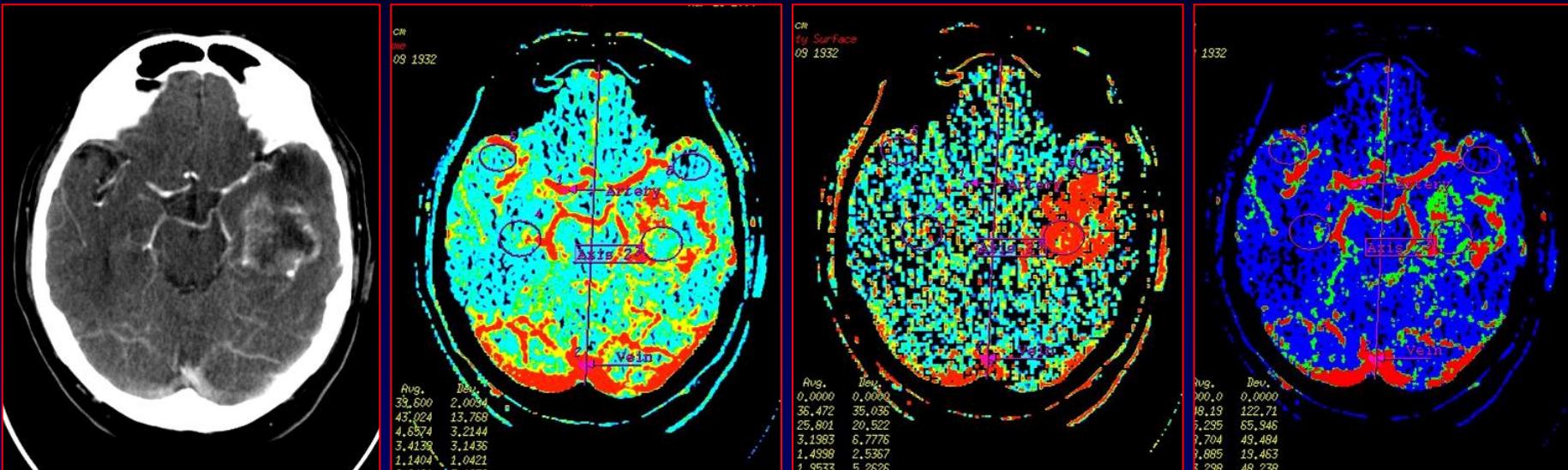
- most frequent - astrocytoma II<sup>o</sup>
- astrocytoma pilocyticum I<sup>o</sup>
- anaplastic astrocytoma III<sup>o</sup>
- GBM IV<sup>o</sup>
- oligodendroglioma, ependymoma II<sup>o</sup>
- 25 % (of all gliomas)
- 6-8%
- 5-10%
- 10-18%
- 10-12%

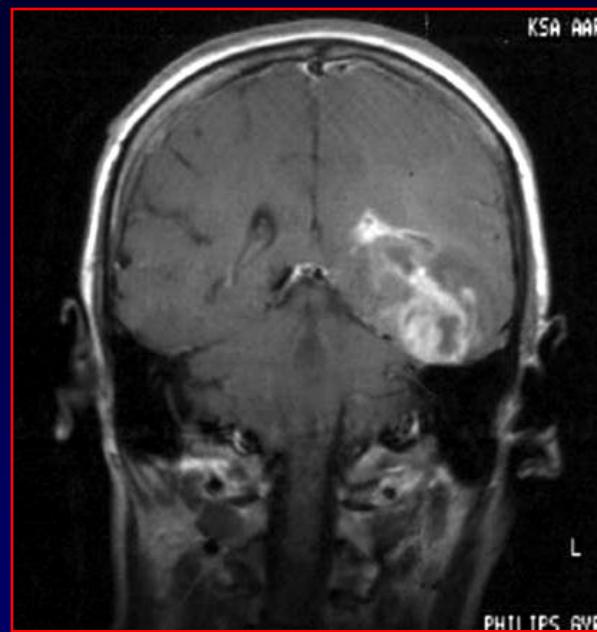
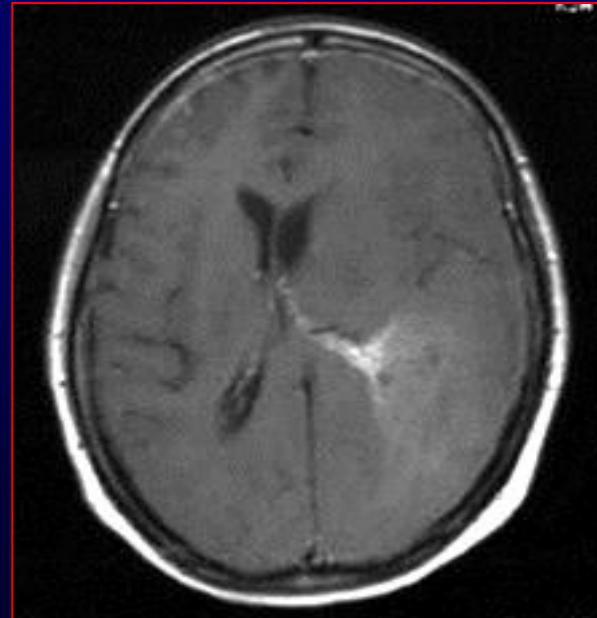
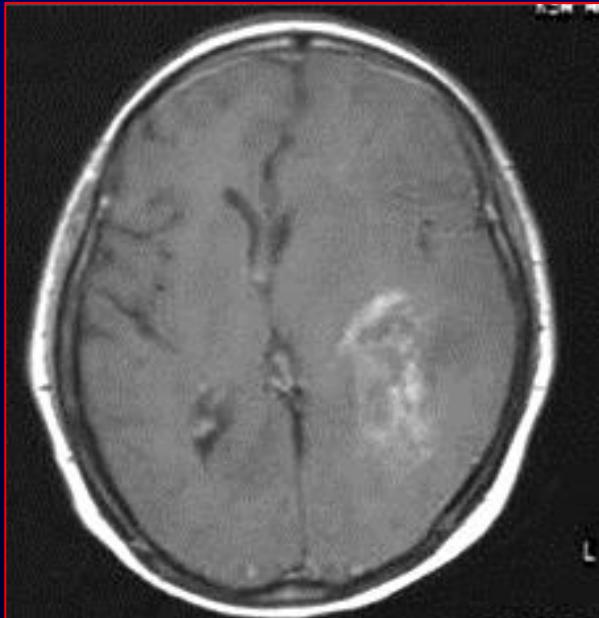




## Malignant brain tumors

are hypervascularized





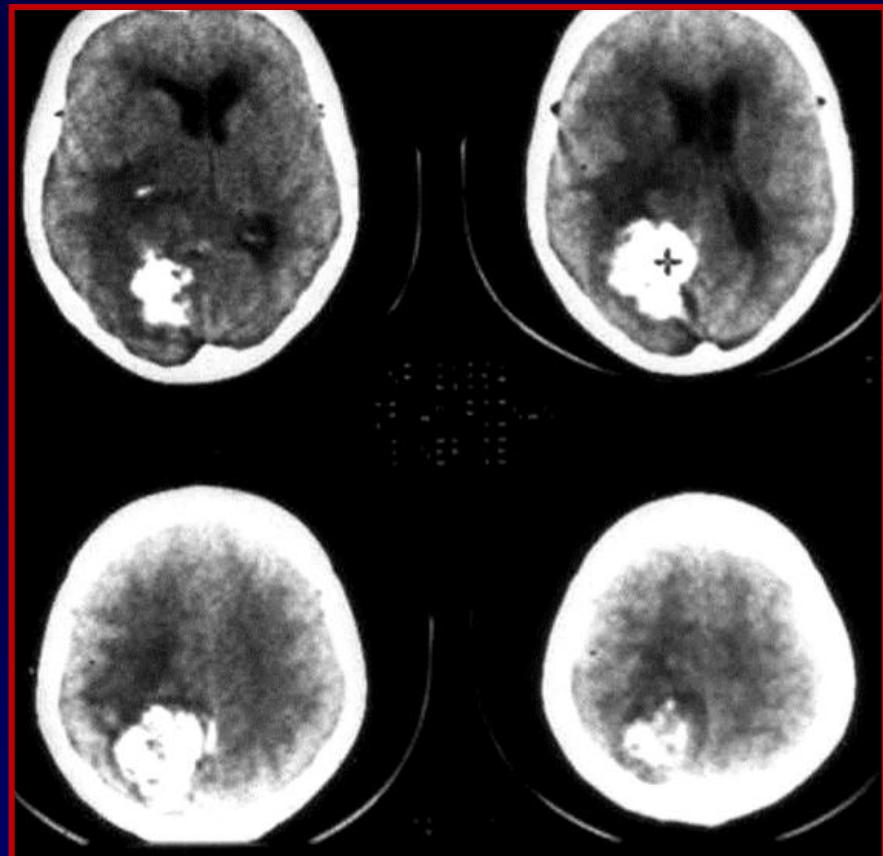
## Anaplastic astrocytoma

- infiltrating growth
- mass effect

# Oligodendroglioma

characteristic calcifications  
in a mass of a tumor

well seen in CT

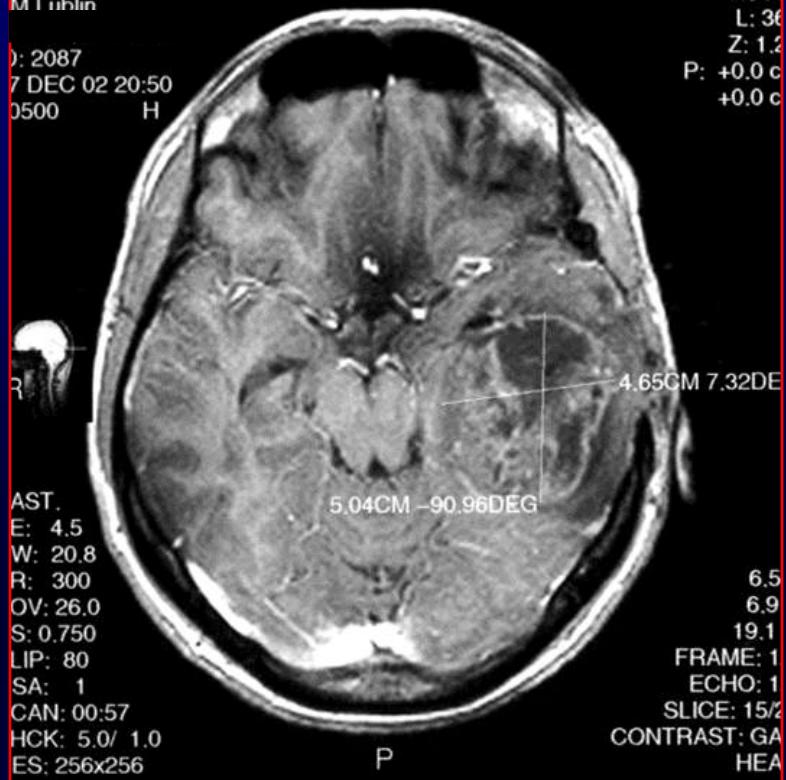


icker International, Inc. Eclipse 1.5T

M Lubin

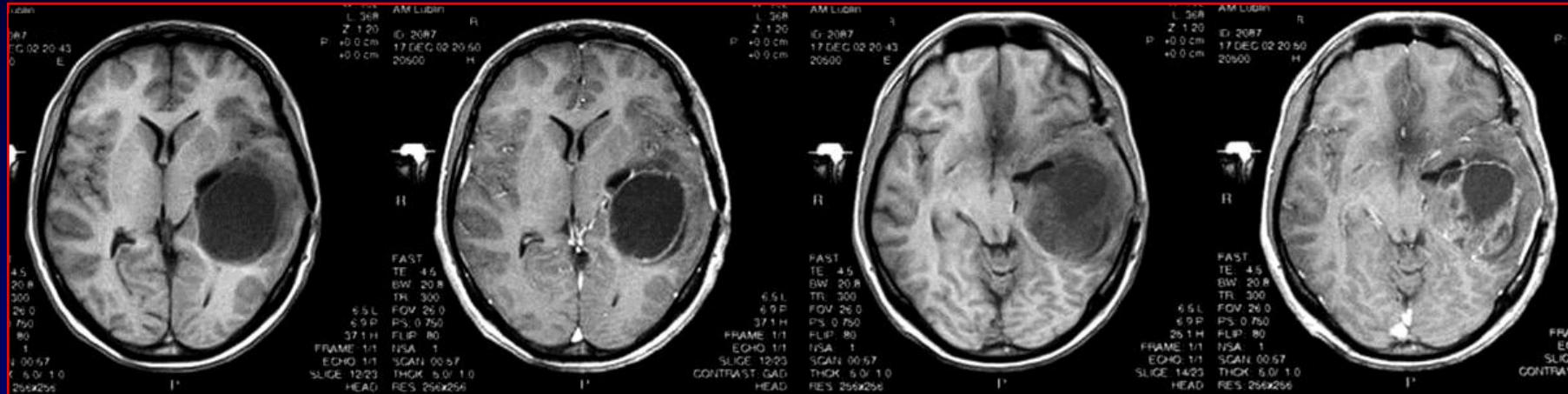
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7 DEC 02 20:50  
0500 H

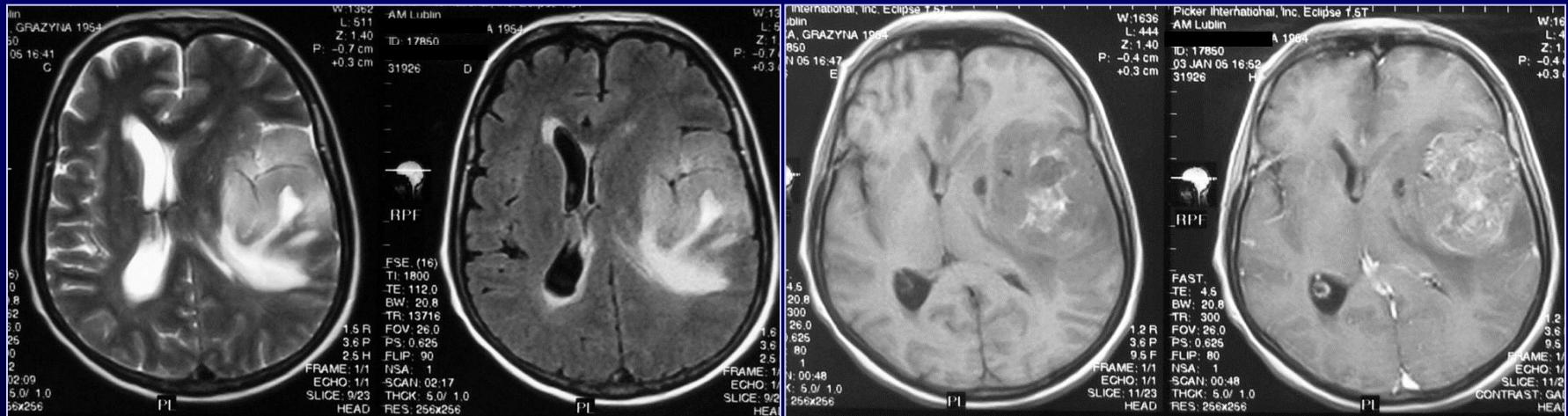
W: 90  
L: 36  
Z: 1.2  
P: +0.0 cm  
+0.0 cm



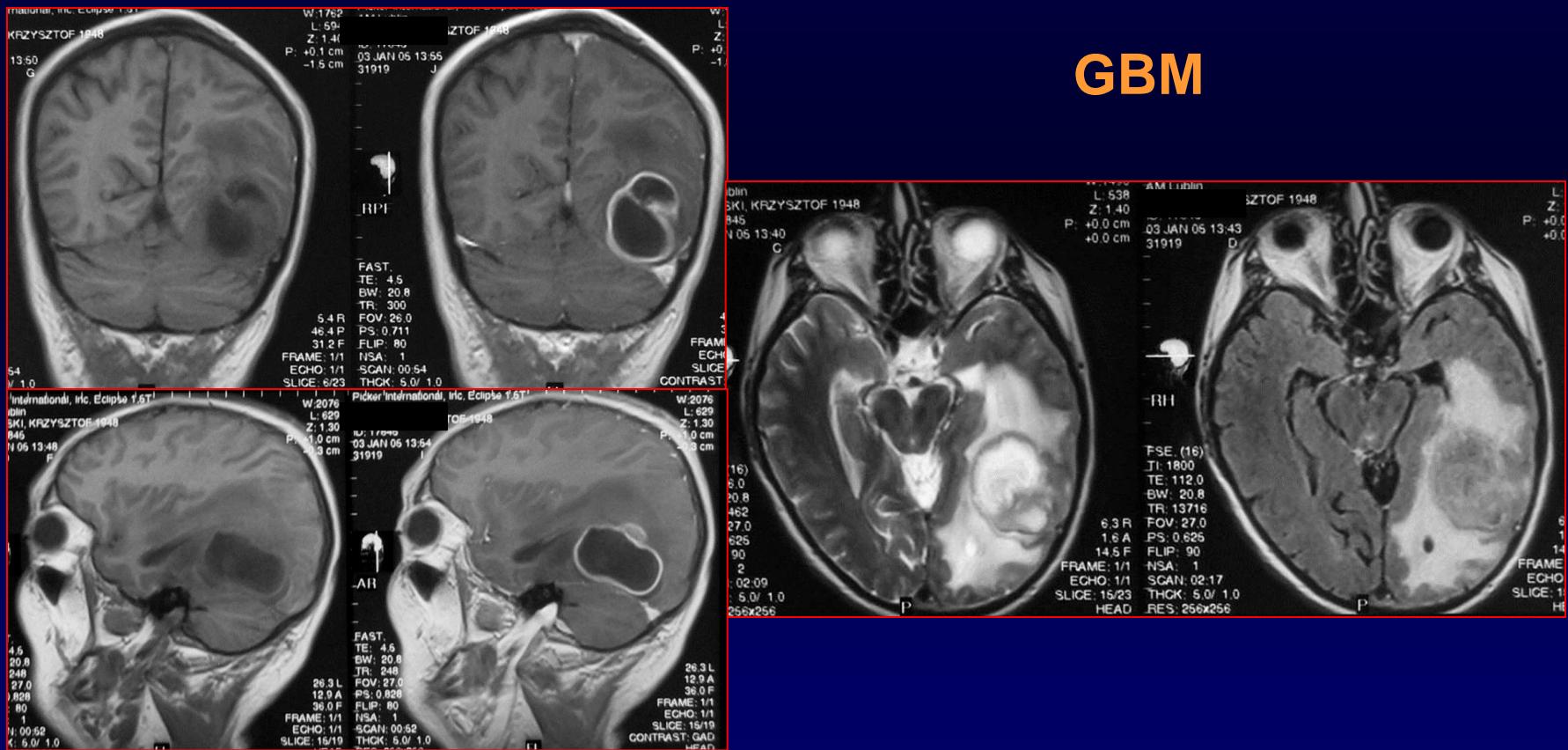
G B M

glioblastoma multiforme





# GBM



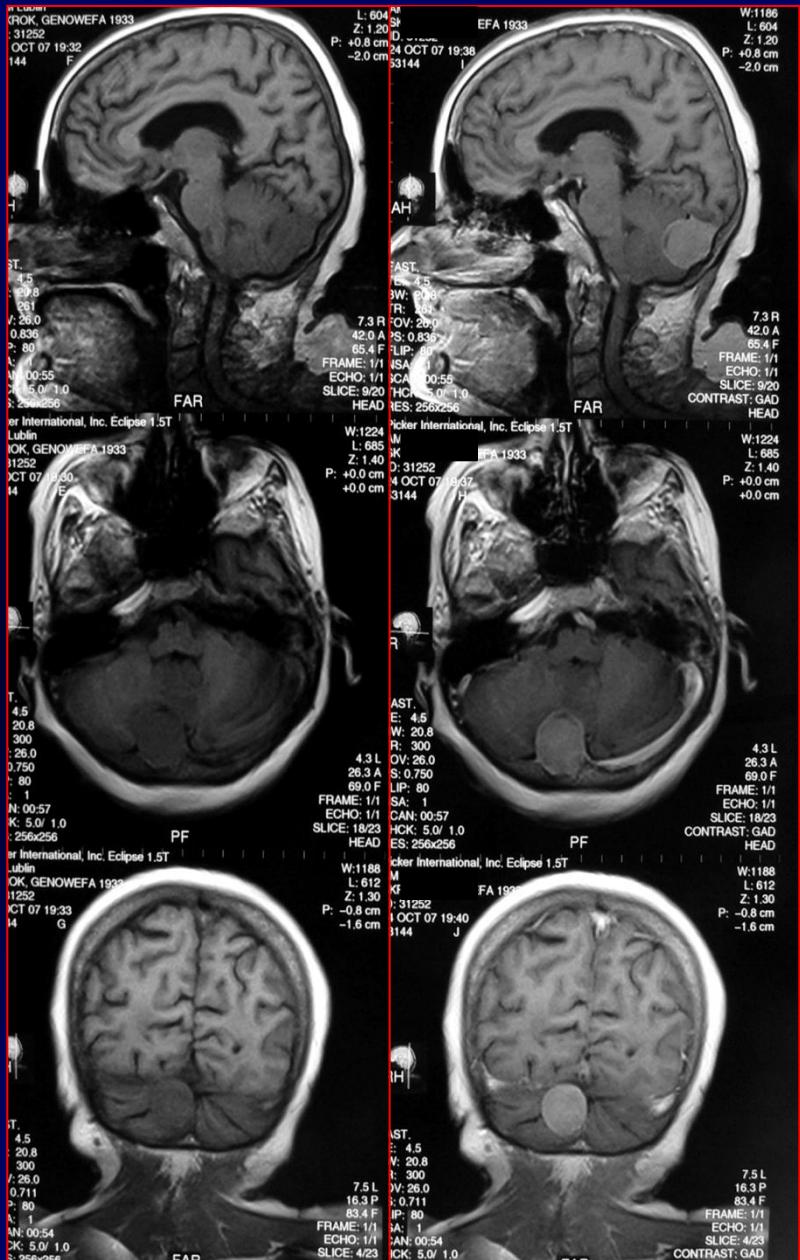
# Meningiomas

most frequent benign  
intracranial tumors



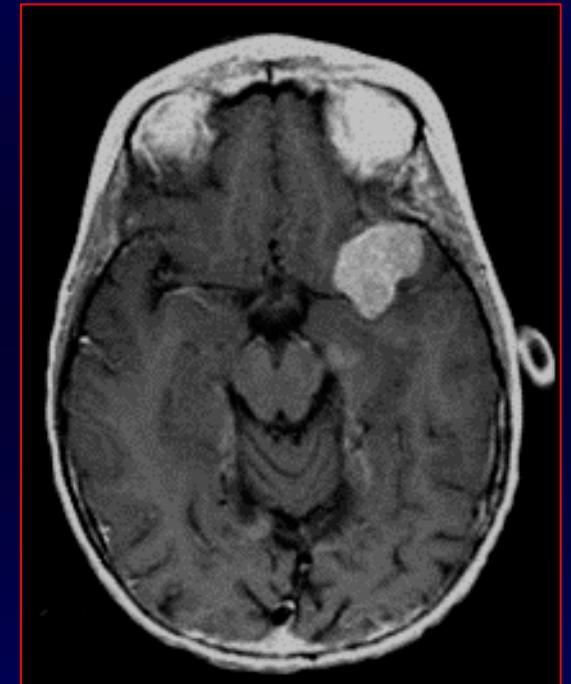
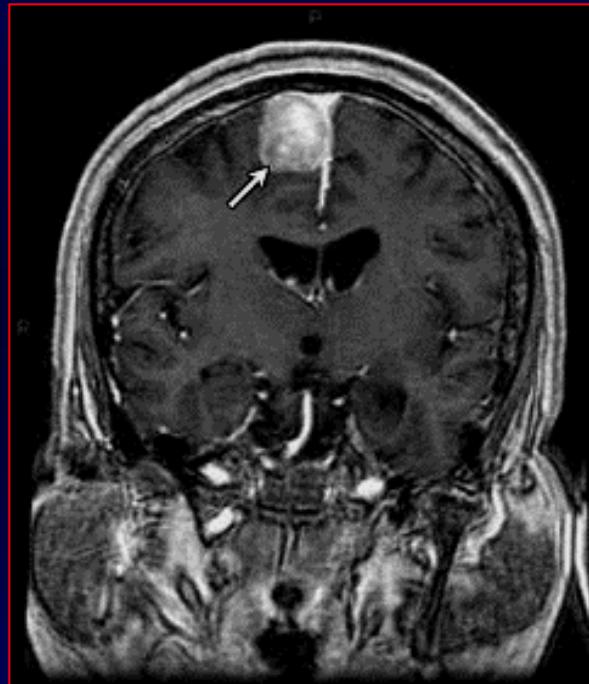
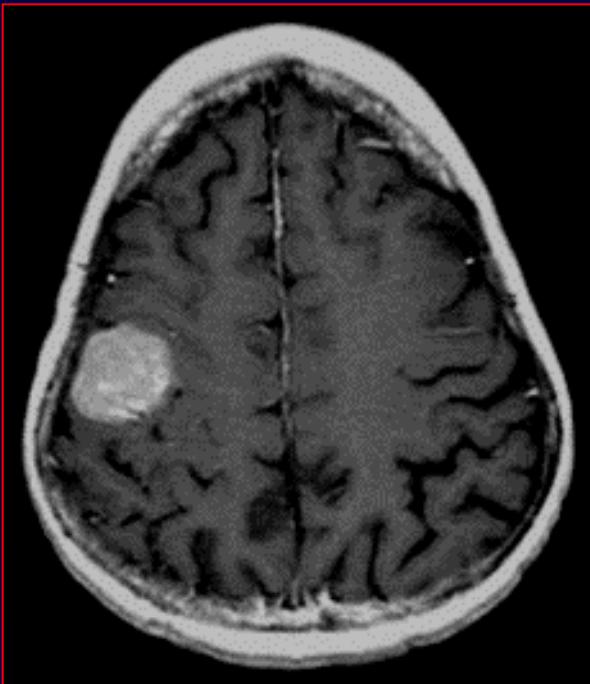
# Meningiomas

typical images / features – MR



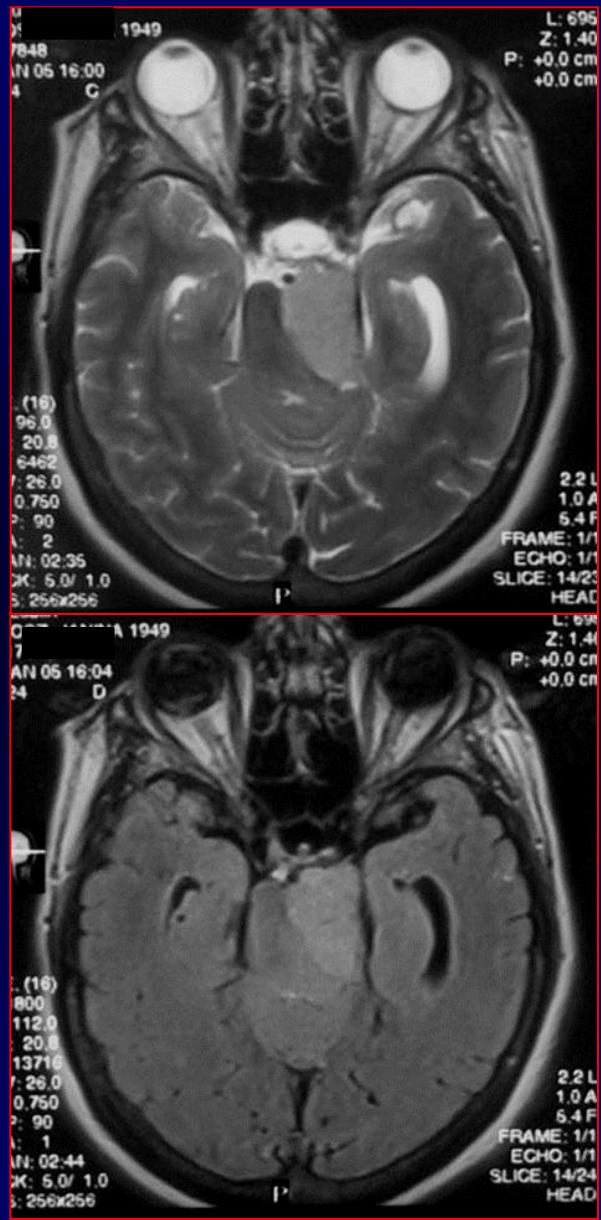
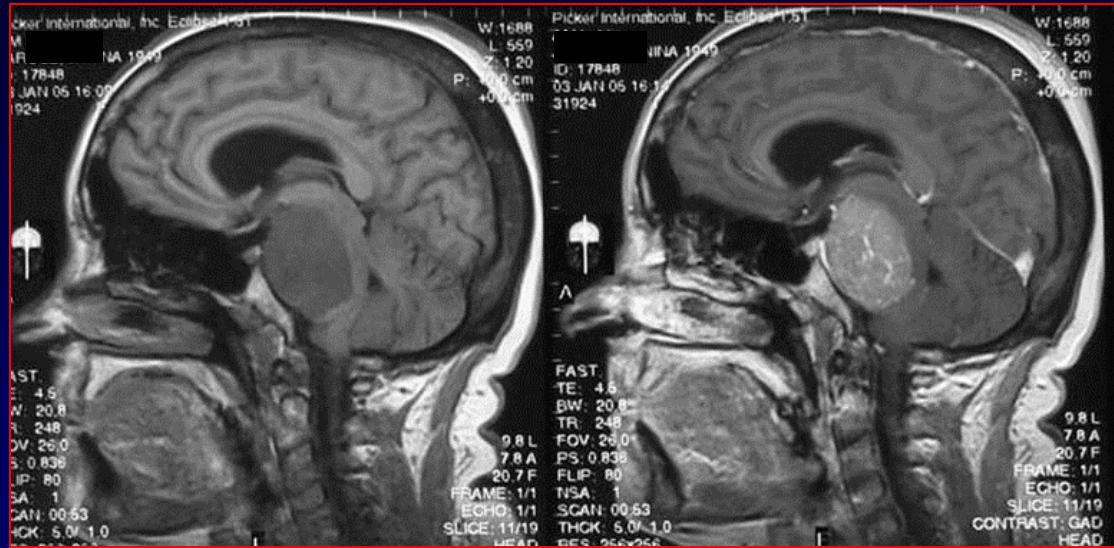
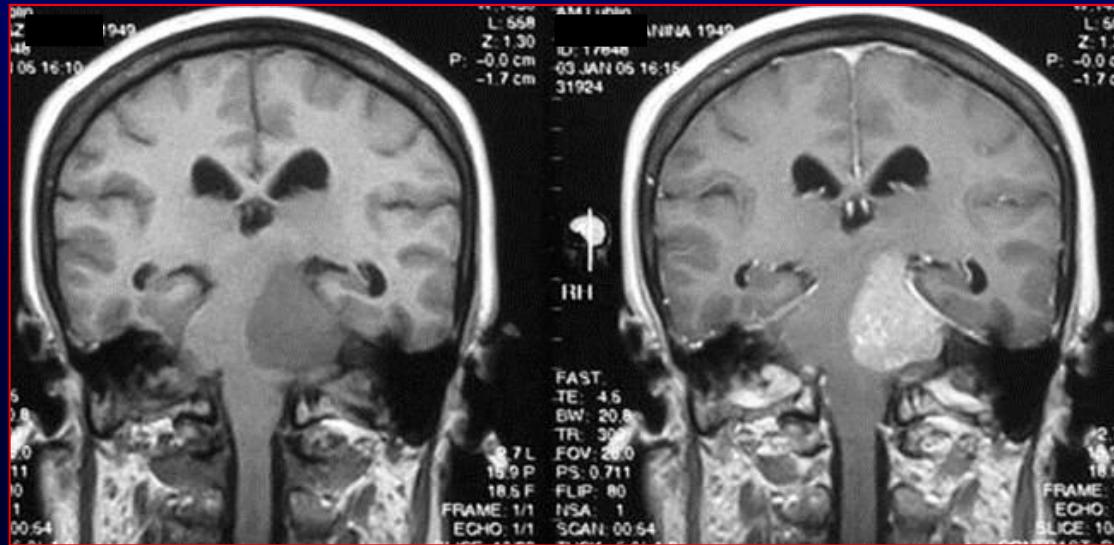
# Multiple meningiomas

proved genetic predisposition



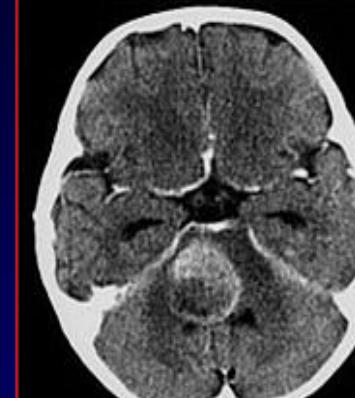
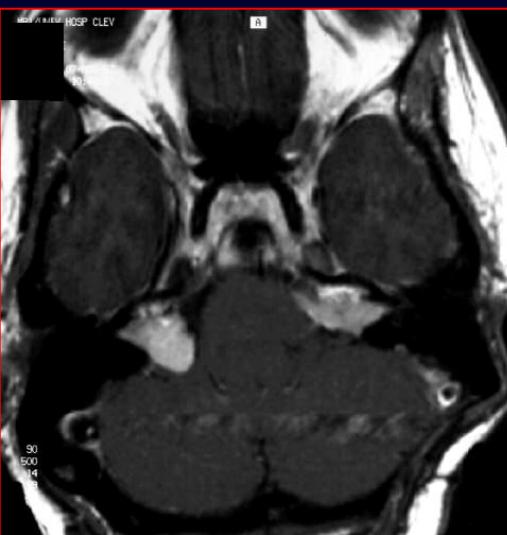
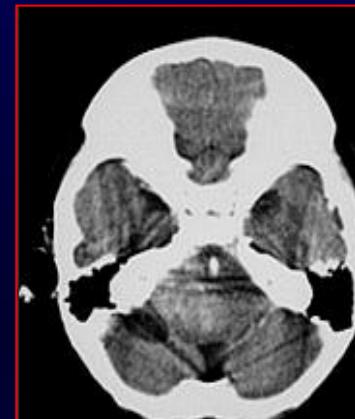
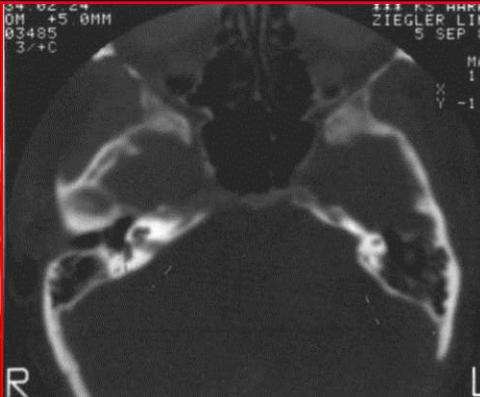
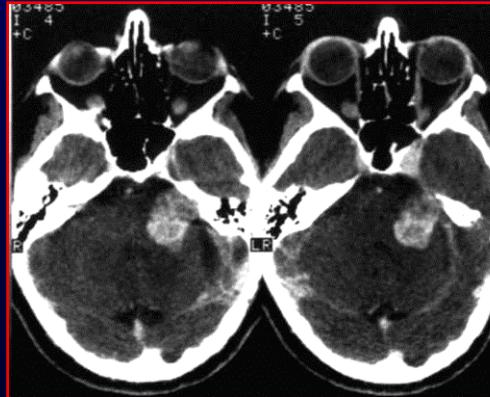
# cerebello-pontine angle tumors

*meningioma*

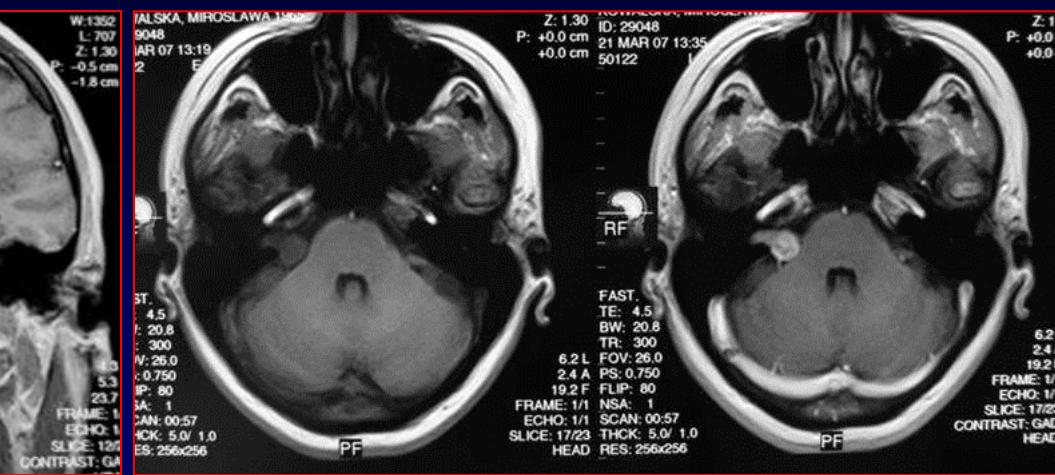
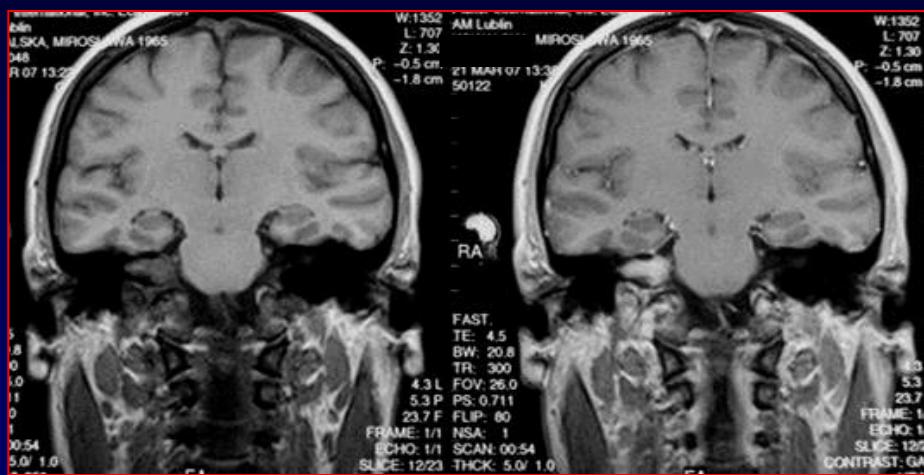
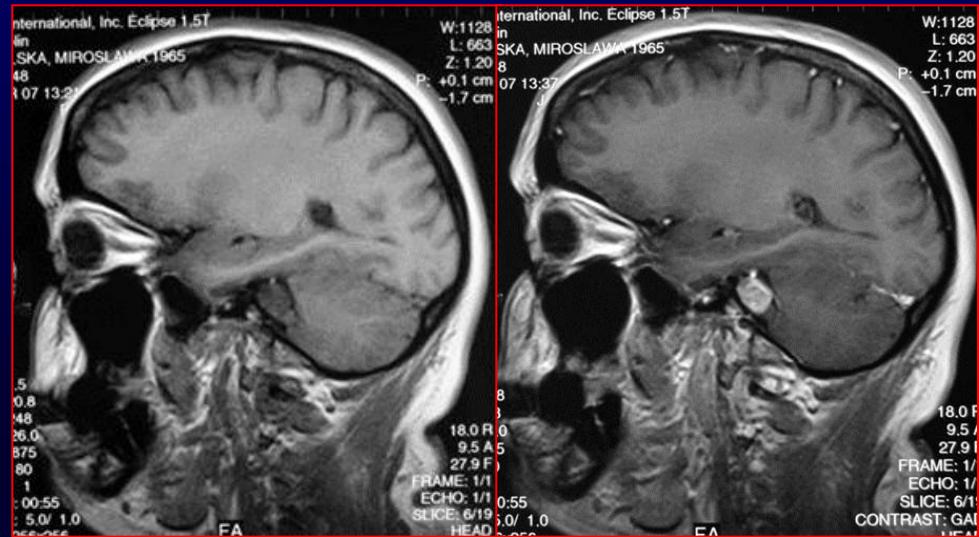


# cerebello-pontine angle tumors

*meningiomas, N. VIII neurinomas*



# N. VIII neurinoma (schwannoma)



# Intra- and para-sellar tumors

- frequent
  - pituitary macroadenoma & meningioma
- seldom
  - neurinoma, craniopharingioma & meta
- occasional
  - chordoma, glioma, ca, iuvenile fibroma

- mass effect (compression)
- general symptoms
  - ex. optic chiasm
  - ex. endocrinologic disorders

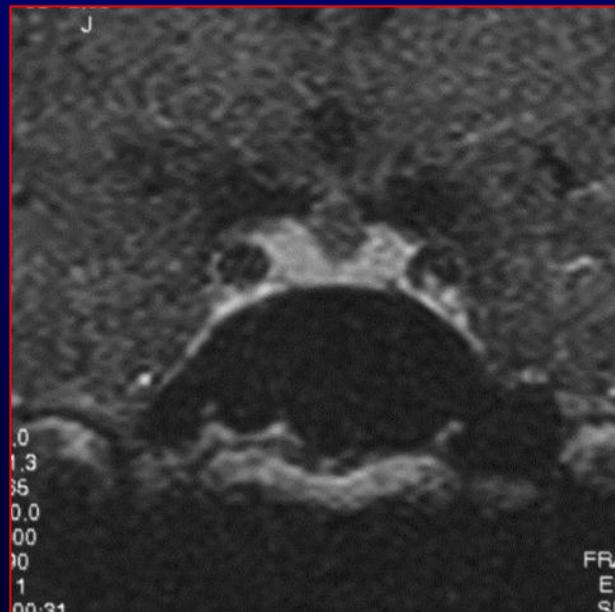
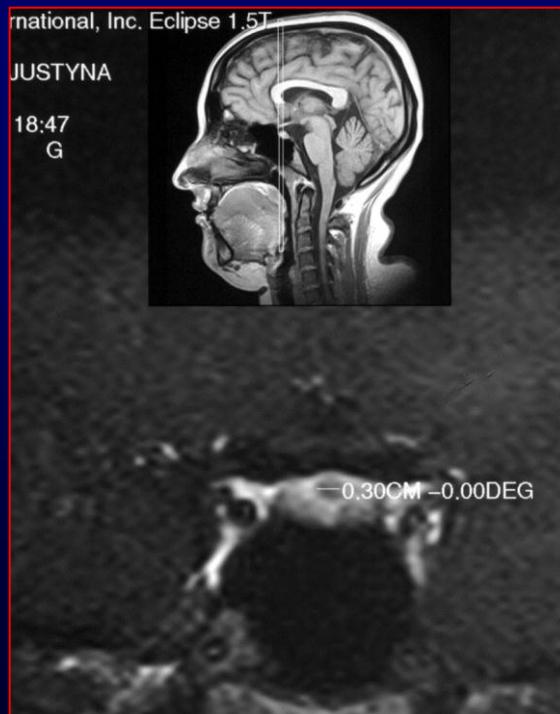


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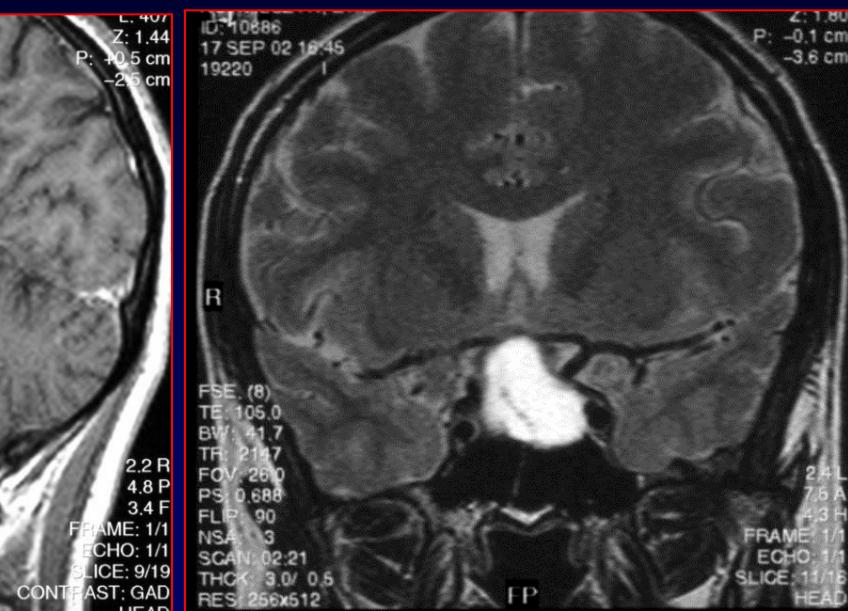
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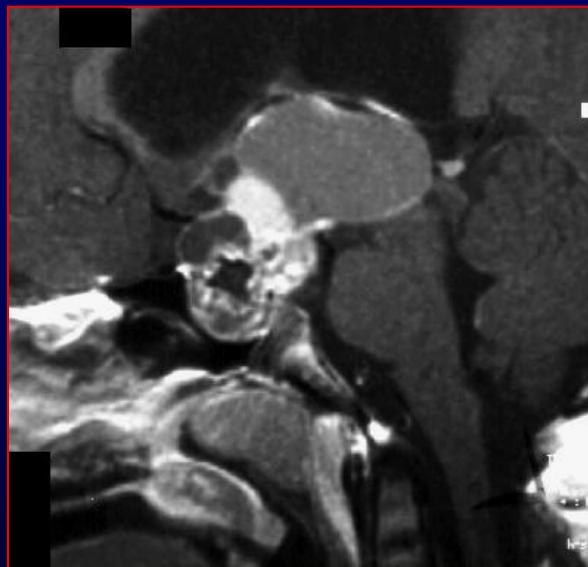
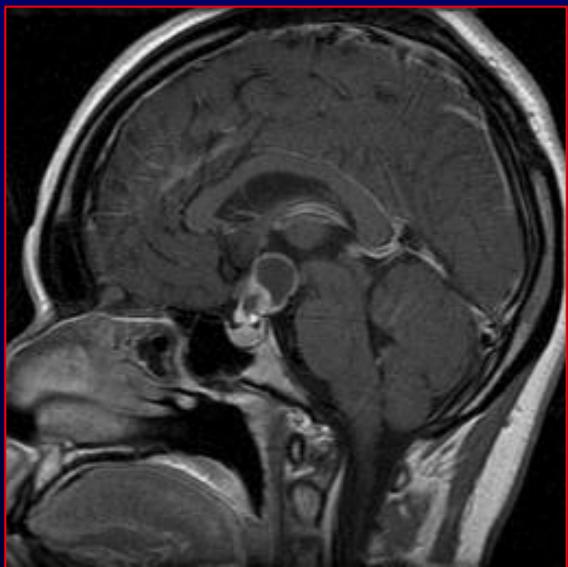
G



## Microadenoma *prolactinoma*

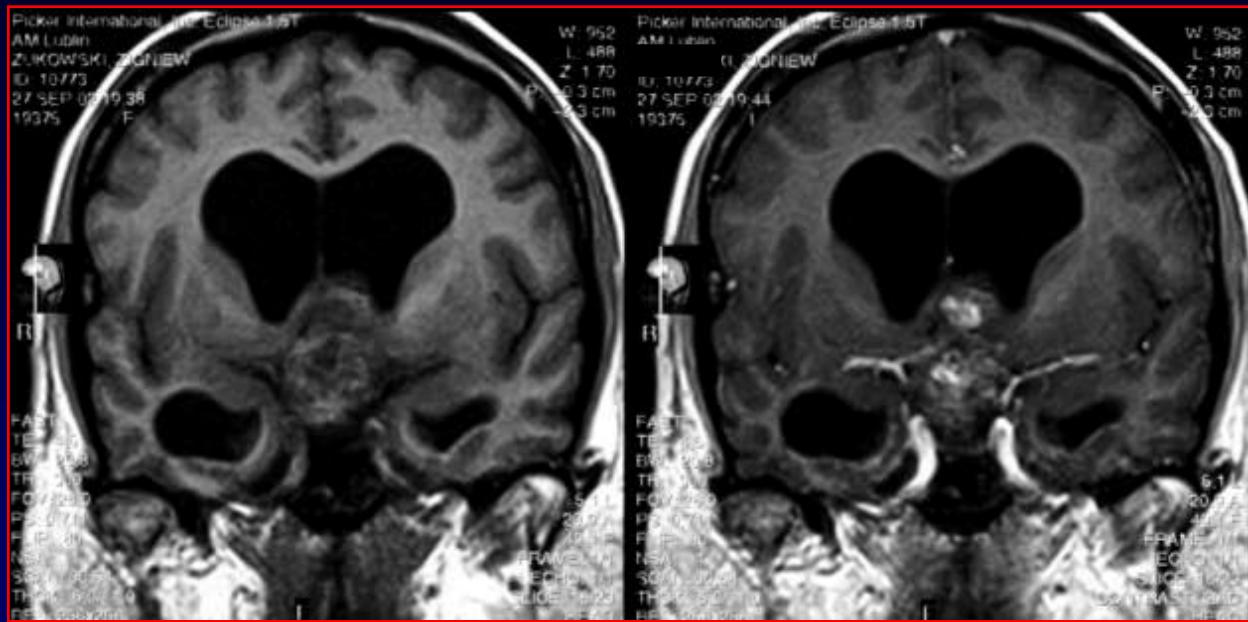
### Cystic adenoma





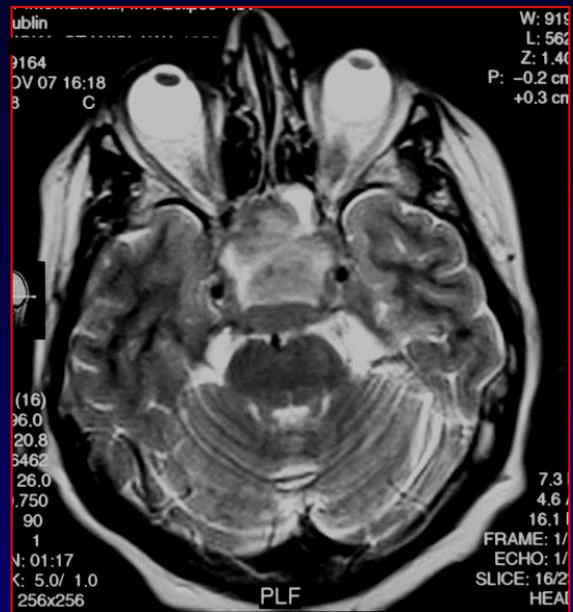
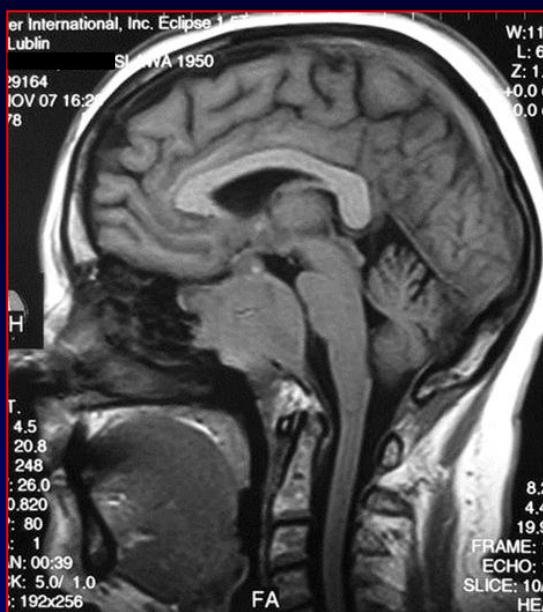
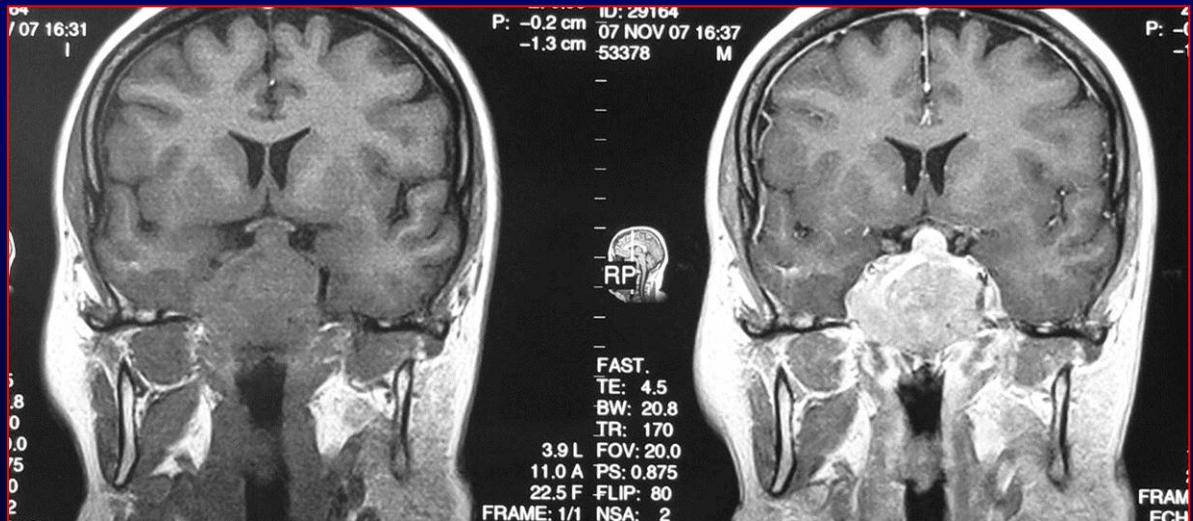
craniopharyngioma

Meta from  
bronchial ca



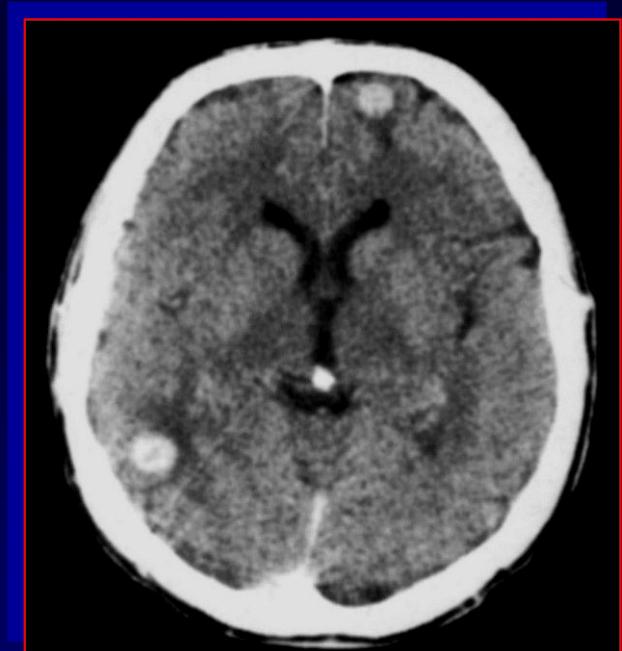
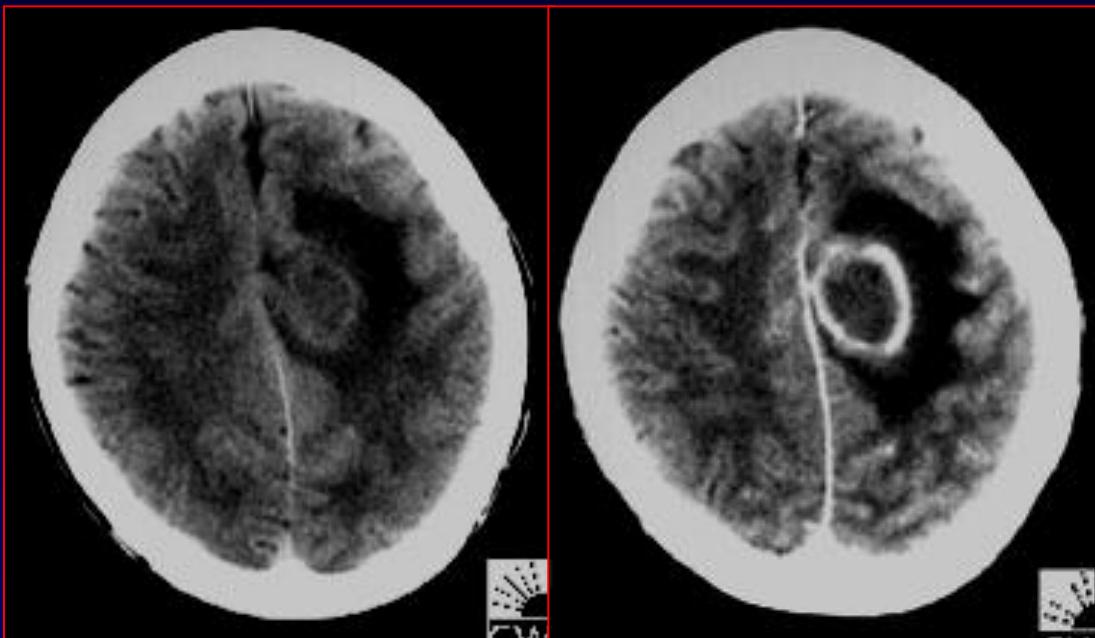
# juvenile fibroma

*fibroma juvenile*

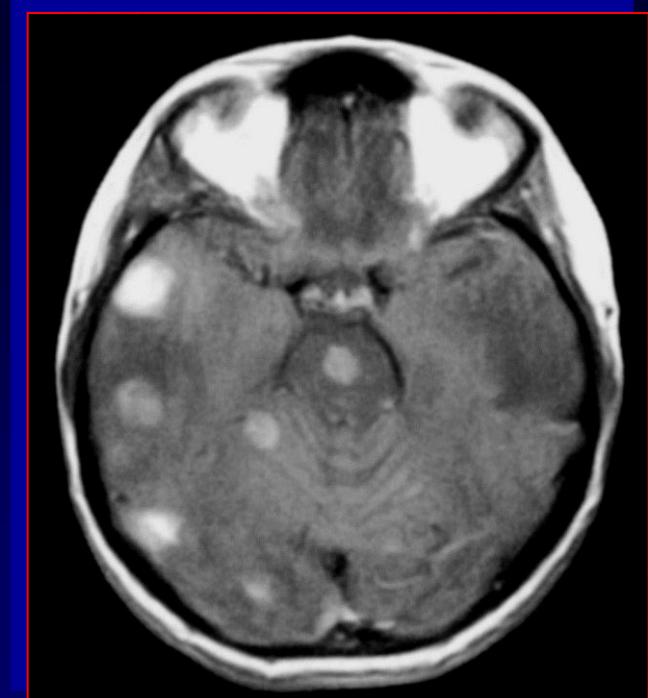
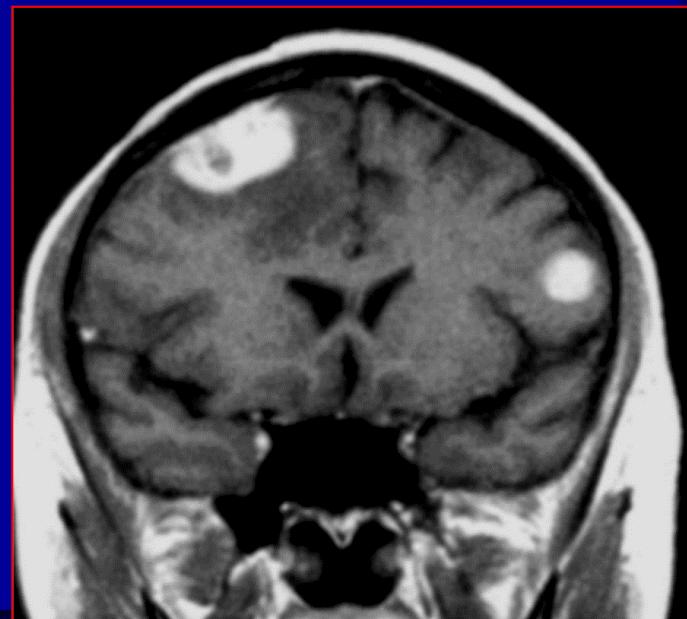


## Metastases to the brain

- 60-70% multiple
- 80% supratentorial location
- strong contrast enhancement
- broad surrounding edema
- mass effect

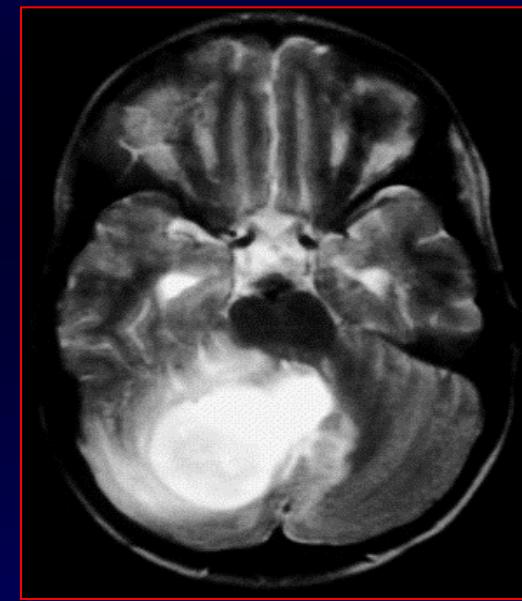
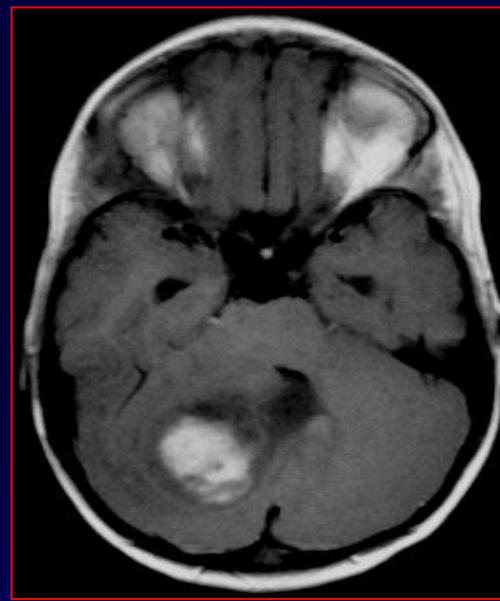
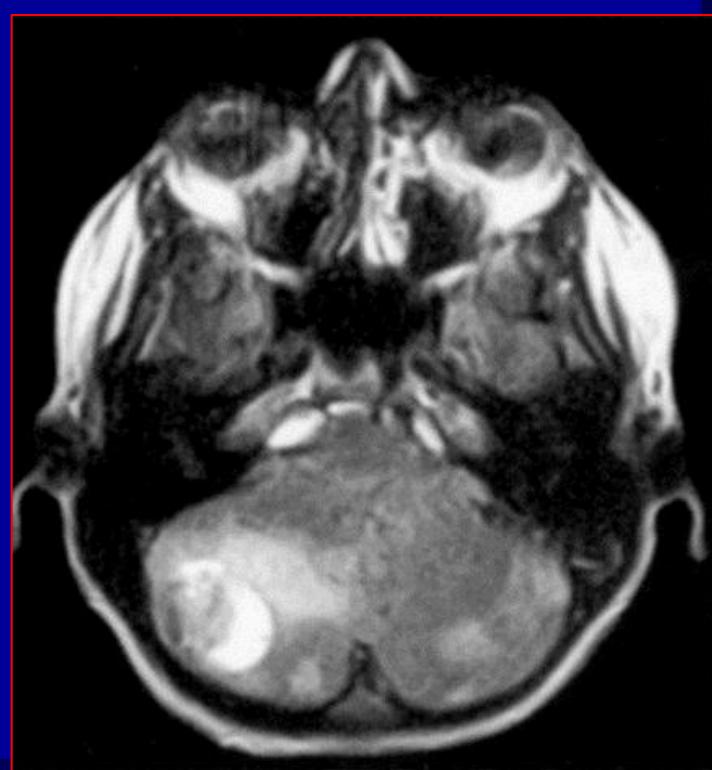


## Meta ad cerebri

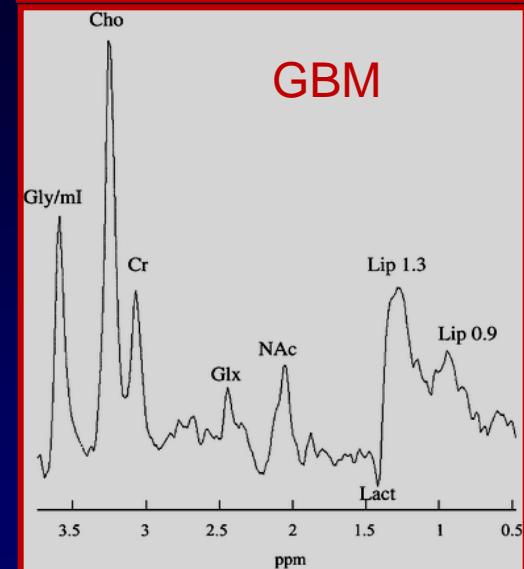
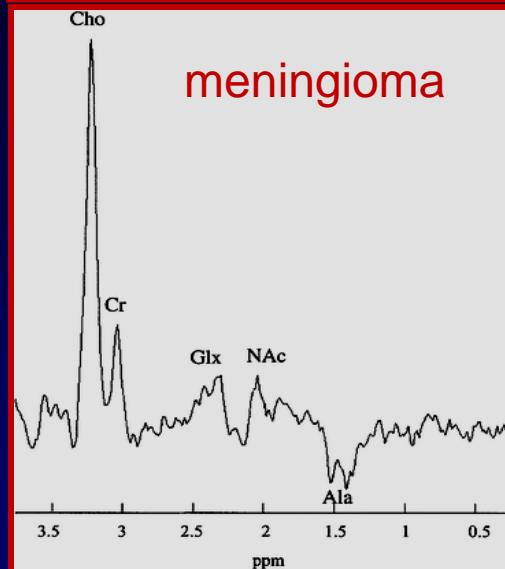
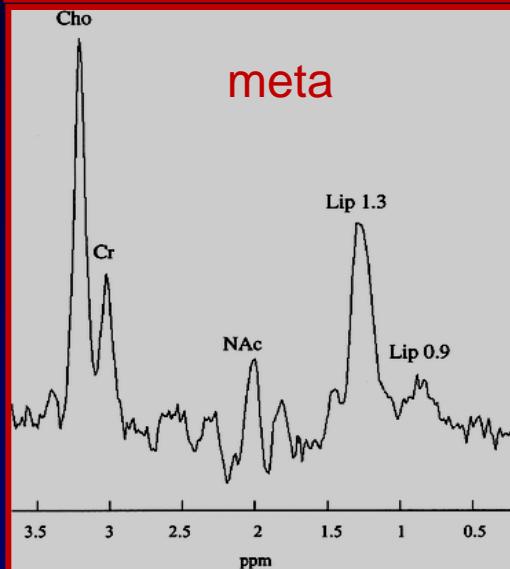
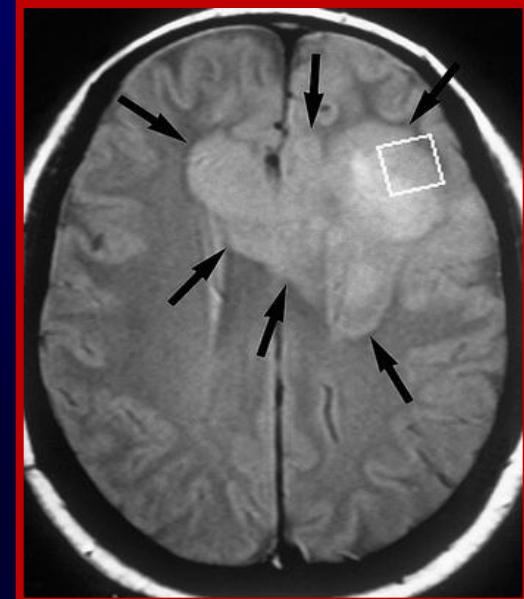
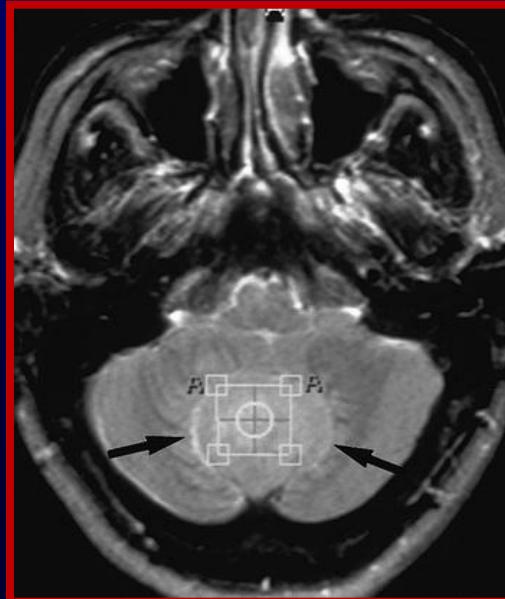
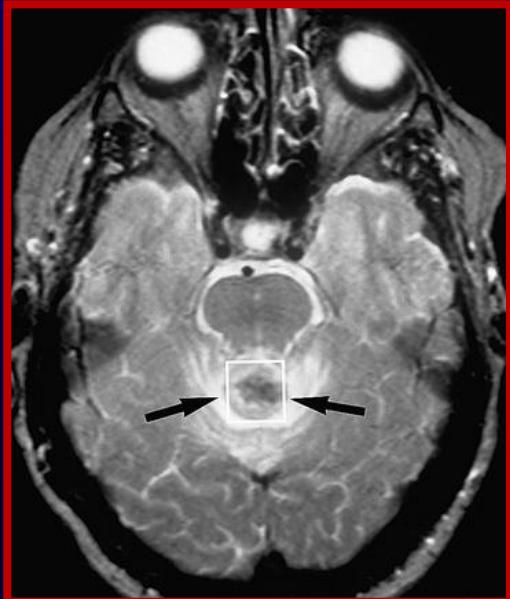


# Metastases to cerebellum

infratentorial metastases – approx. 20%



# MR spectroscopy may differentiate brain tumors – better than biopsy ???



## 5. Other selected brain diseases

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### Inflammatory CNS diseases

#### White matter diseases (acquired):

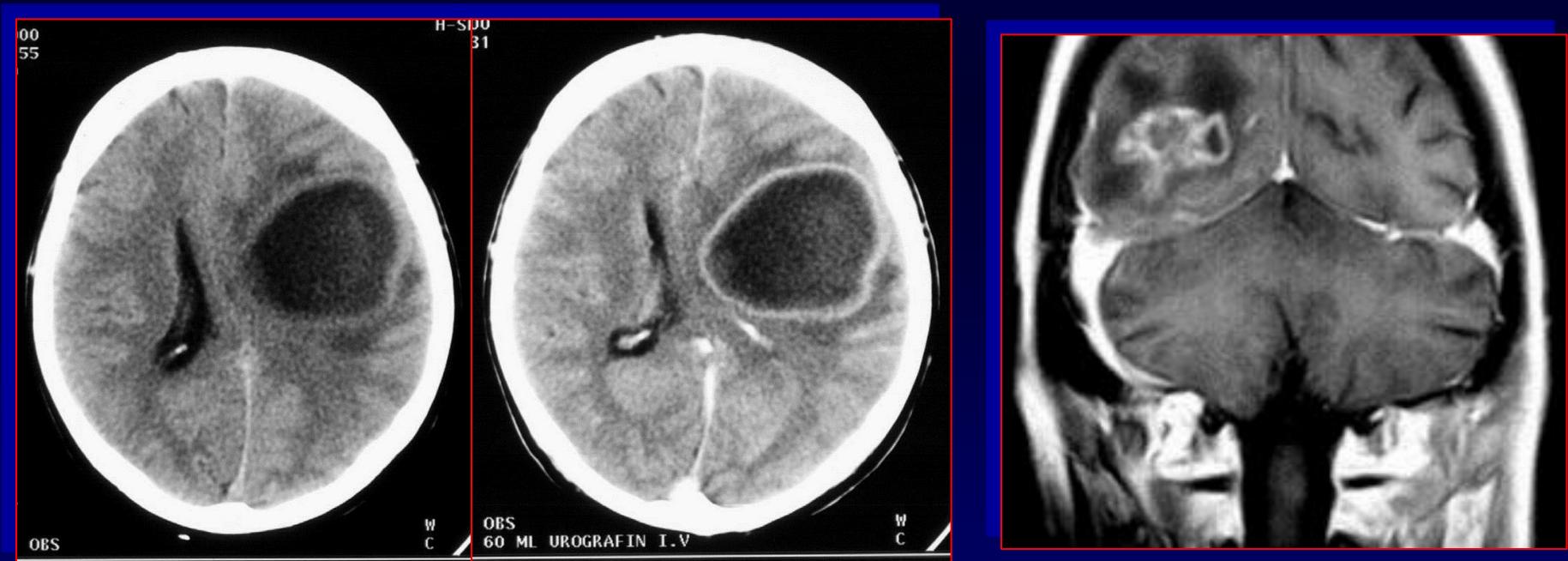
- multiple sclerosis (MS)
- other demyelination (seldom)

#### Dementive syndromes (examples):

- brain tissue atrophy
- Alzheimer disease

# Brain abscess – imaging / general symptoms / anamnesis

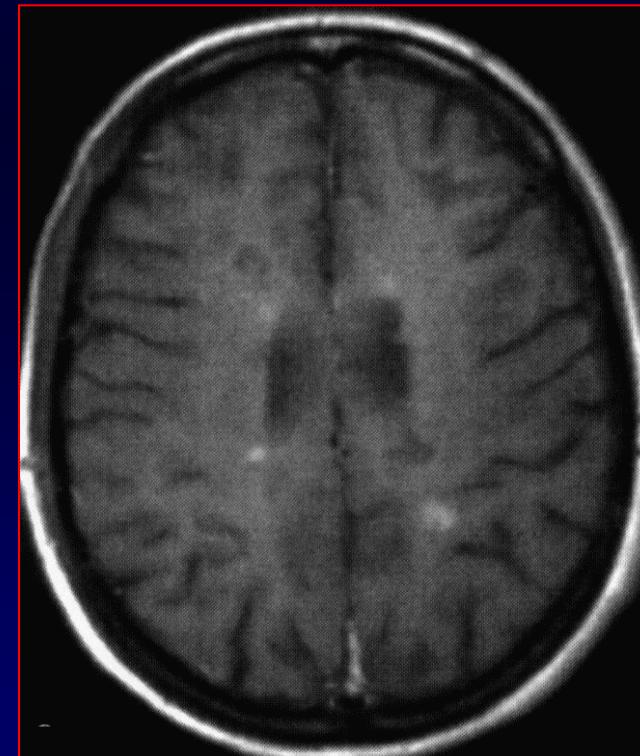
- different images in time – dynamic process
- abscess capsule – contrast enhancement
- mass effect
- healing – glia scar



# multiple abscess/ brain inflammation

## examples

- tbc, neuroborreliosis
- toxoplasmosis
- cysticercosis, echinococcosis
- mycotic inflammation ex.candidiasis

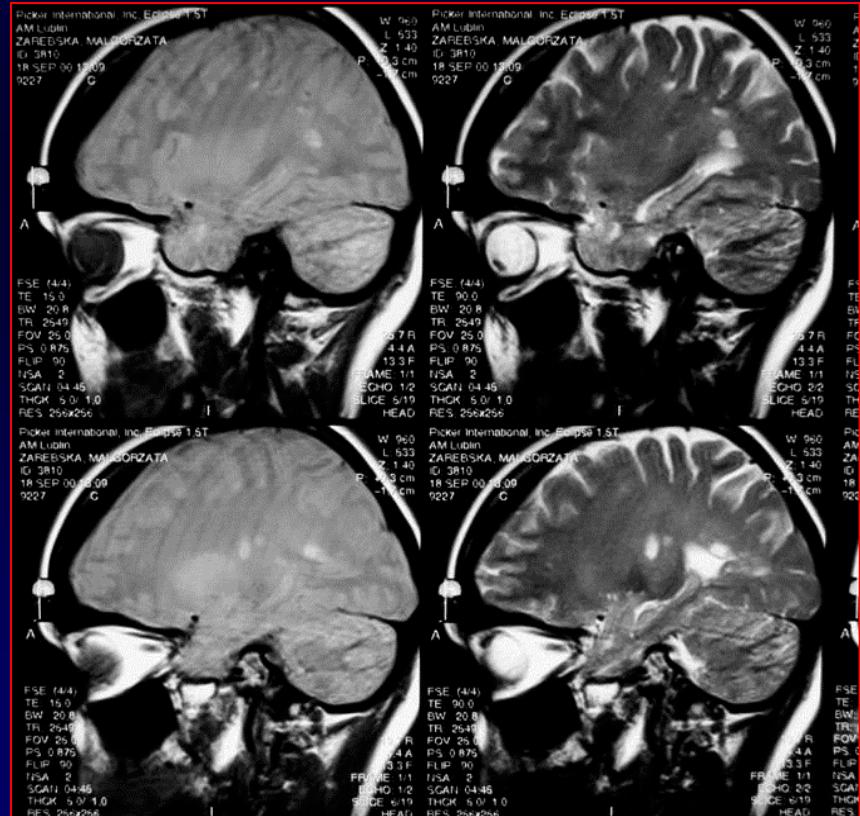
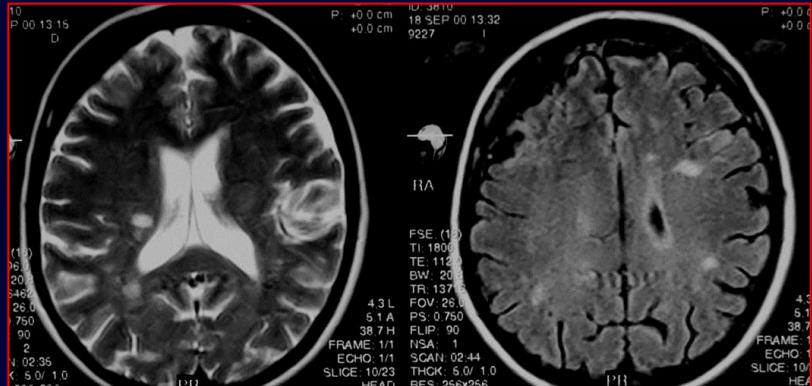
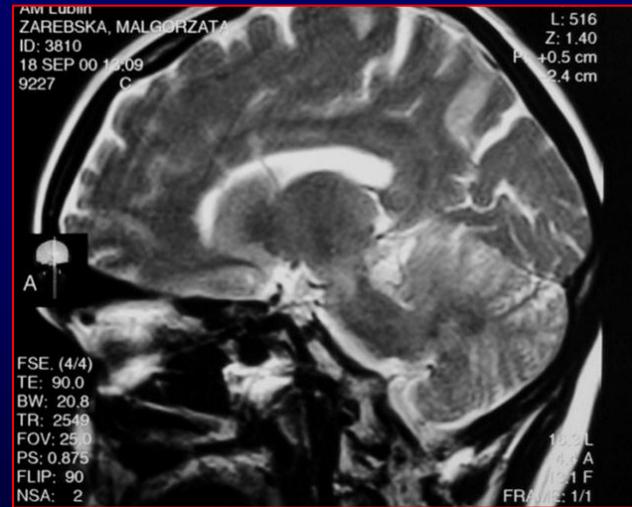


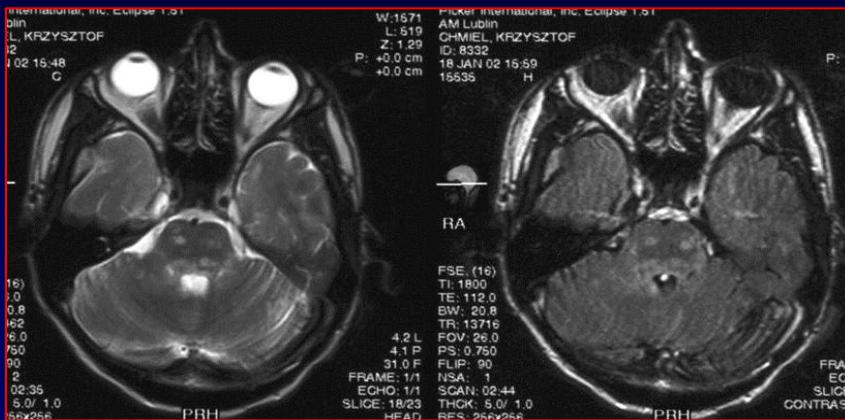
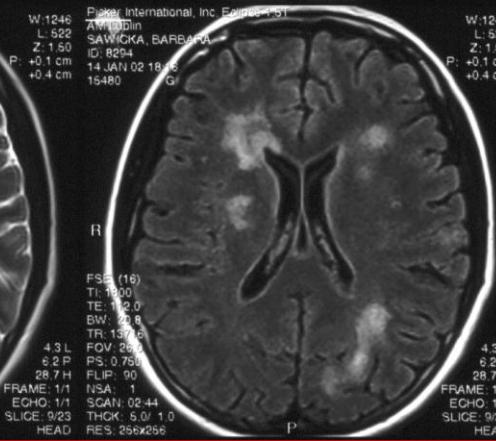
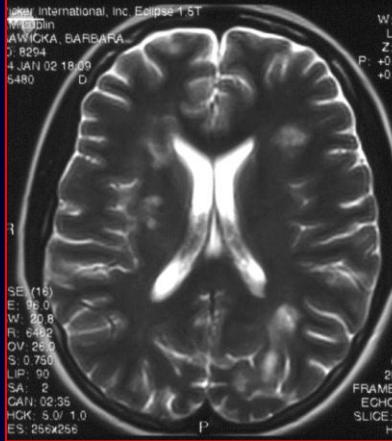
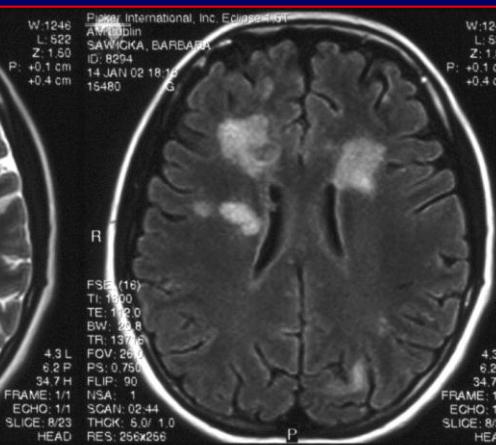
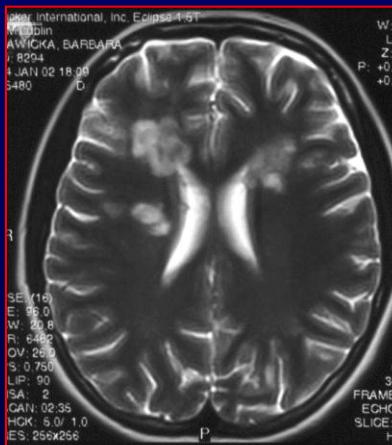
# Multiple sclerosis

## demyelinization „plaques”

(at least 3 plaques – typical shape & localization)

- hemispheric white matter, periventricular
- corpus callosum, brain stem
- cerebellum, spinal bulb, cervical spine





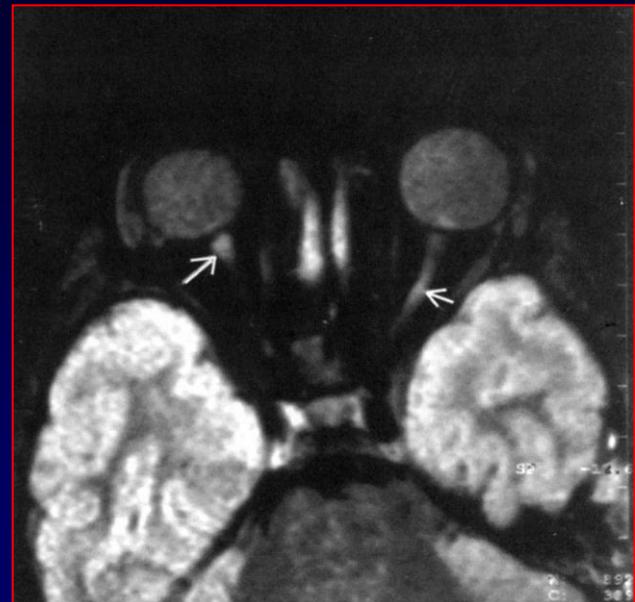
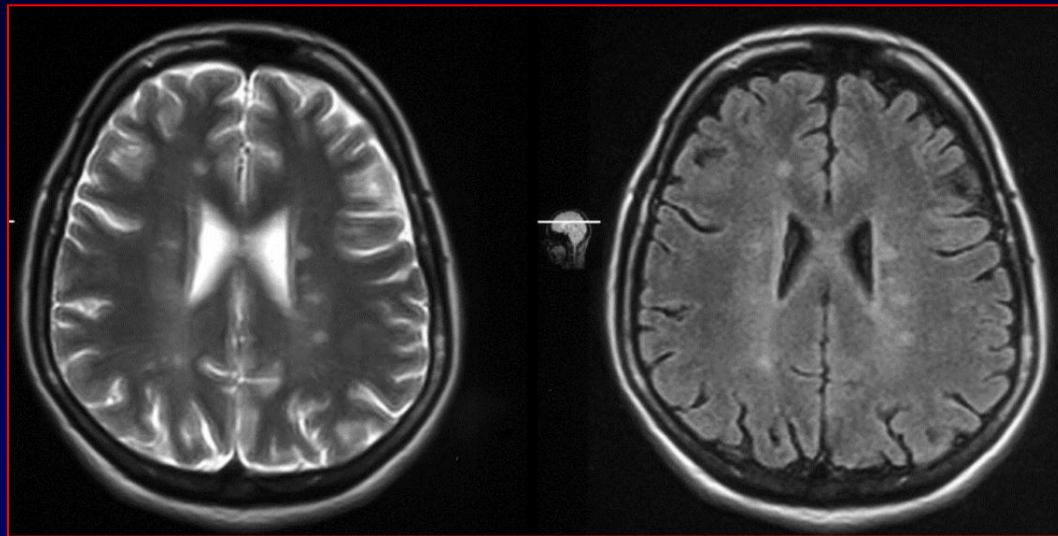
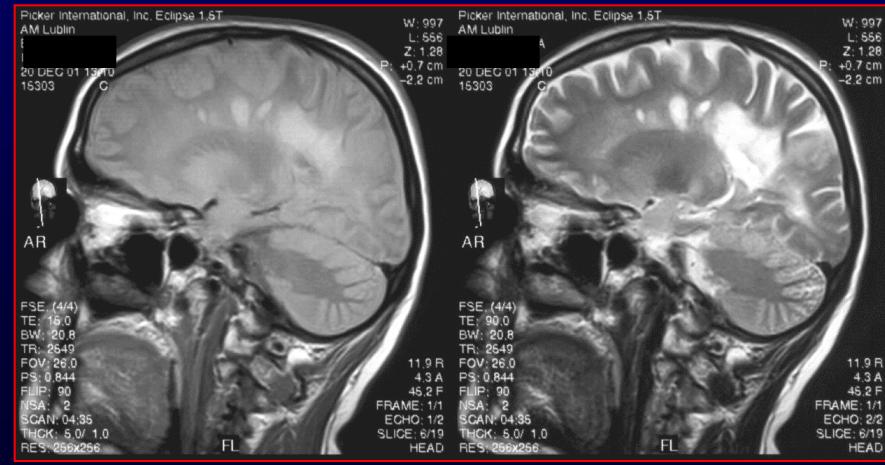
# MS – multiple plaques

- periventricular
- in brain stem
- in cervical spine



# MS

- plaques in corpus callosum  
 - "neuritis retrobulbaris"



# Brain tissue atrophy

- relatively frequent after 70 y.o. – senile atrophy
- more peri-brain fluid space
- broadening of ventricular system

52 y.o. male



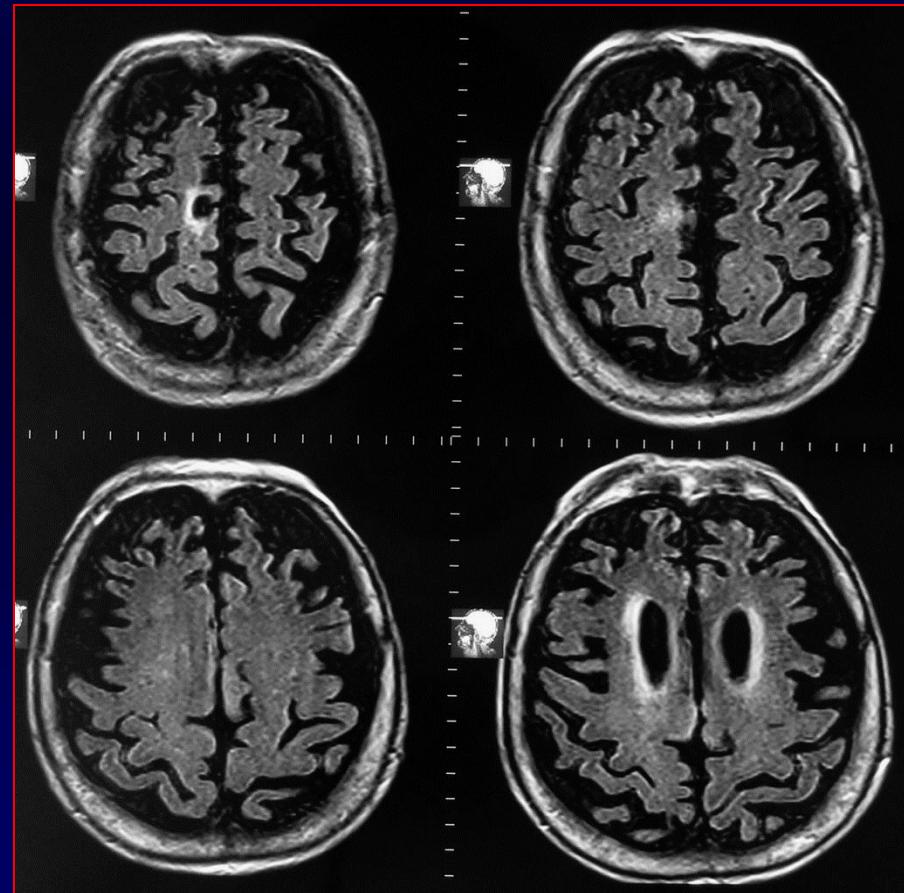
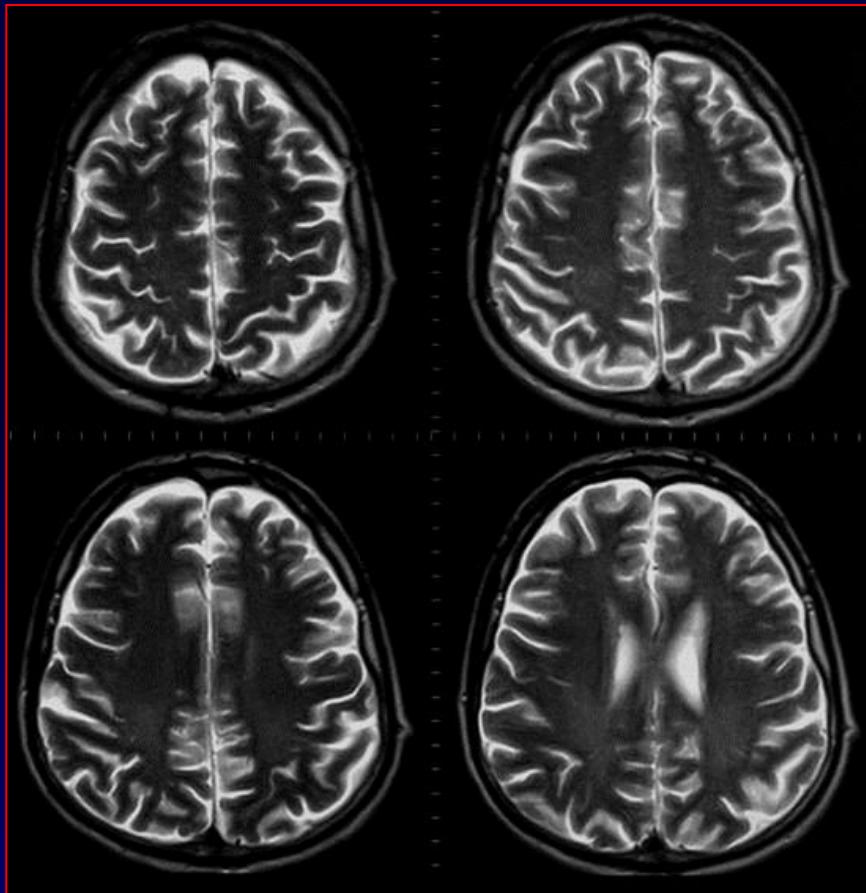
50 y.o. male



# **Brain tissue atrophy**

relation: brain tissue / peri-brain fluid

- subjective assessment (measurements?)
- degree of atrophy is not proportional to dementia



# Alzheimer disease

- brain atrophy (temporal lobes)
- leukoaraiosis
- malation patches in white matter

