

# Presentation and Management of Raised Intracranial Pressure

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**Objectives:** most imp lec u need to know in neurosurgery and most imp principle in anything has to do with brain; trauma, tumor, infection

- To learn what are the basics of ICP.
- What things that form ICP inside the brain.
- How you lower ICP.
- How you can identify raised ICP.

# Basics

## ■ Components of cranium

### ■ Normal components:

- Brain 1400 ml
- CSF 75-100 ml
- Blood 75ml

### ■ Abnormal components:

- Tumors
- hematoma

skull is like a rigid box and brain inside this box, which doesn't allow any expansion (any mass, tumor, infection, hematoma > pressure will be reflected on brain)

## ■ Monro-Kellie Doctrine

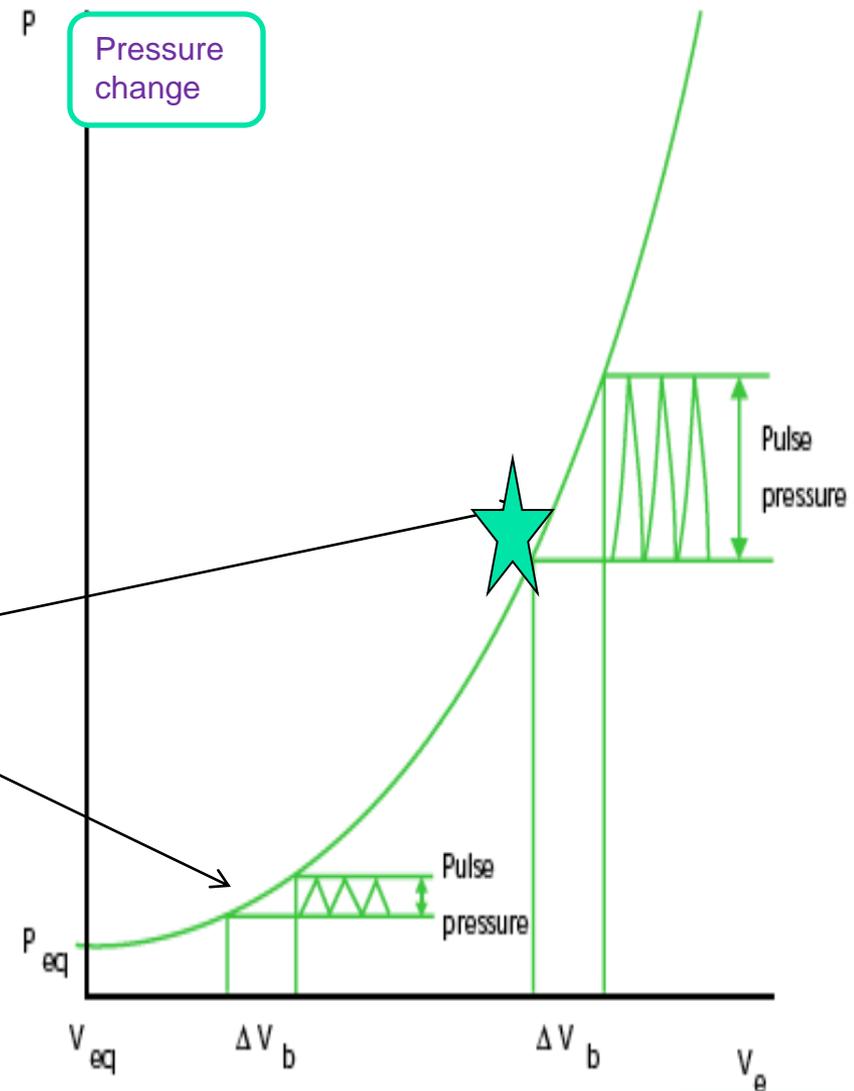
- These contents are incompressible, u can't compress water; blood, CSF
- Therefore, change in volume of the brain is associated with change in CSF or blood volume ( if there is increase of volume of brain > to compensate CSF volume has to decrease / veins inside brain has to shrink & push blood outside to compensate for the added volume from outside ;)

# Pressure-Volume

- Increase in volume in one compartment leads to change in volume in the other ones.
  - E.g. brain tumor ---> CSF volume ↓ then blood volume ↓
- For how long could this go on? Increase of volume can go on to a certain extent and then the brain can't take it anymore
  - actually, it differs from one person to another, e.g. if a small benign brain tumor starts growing and then reaches a phase of growing that the brain can't tolerate or accommodate "but some brains can".

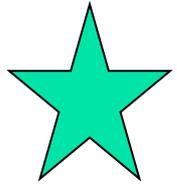
# Pressure-Volume relationship v. imp

- As much we increase the volume, the pressure will increase.
- First, a little increase in pressure with a little increase in volume.
- Then, with the same increase in volume there was a huge increase in pressure. “an increase in the volume a little bit can take the curve over”
- This is the characteristics of brain>> within a few minutes everything can change.
- Pt. will come with headache and vomiting and within a small increase in the volume the pressure was not tolerated and he had to go to emergency craniotomy.



# Notes

- As the volume increase > pressure will increase !
- Ex) by increasing volume by 1 > pressure increase by .7
- And then as volume goes up expansively until u reach point when u change volume by 1 > pressure increase by 3 ( this is how brain react)
- Pt has brain tumor complains of headache > why?  
From the increasing of pressure
- pt can come in stage when u see and examine him and then within minutes he collapse and become comatose why? b/c he just at edge of pressure volume relationship



## Notes

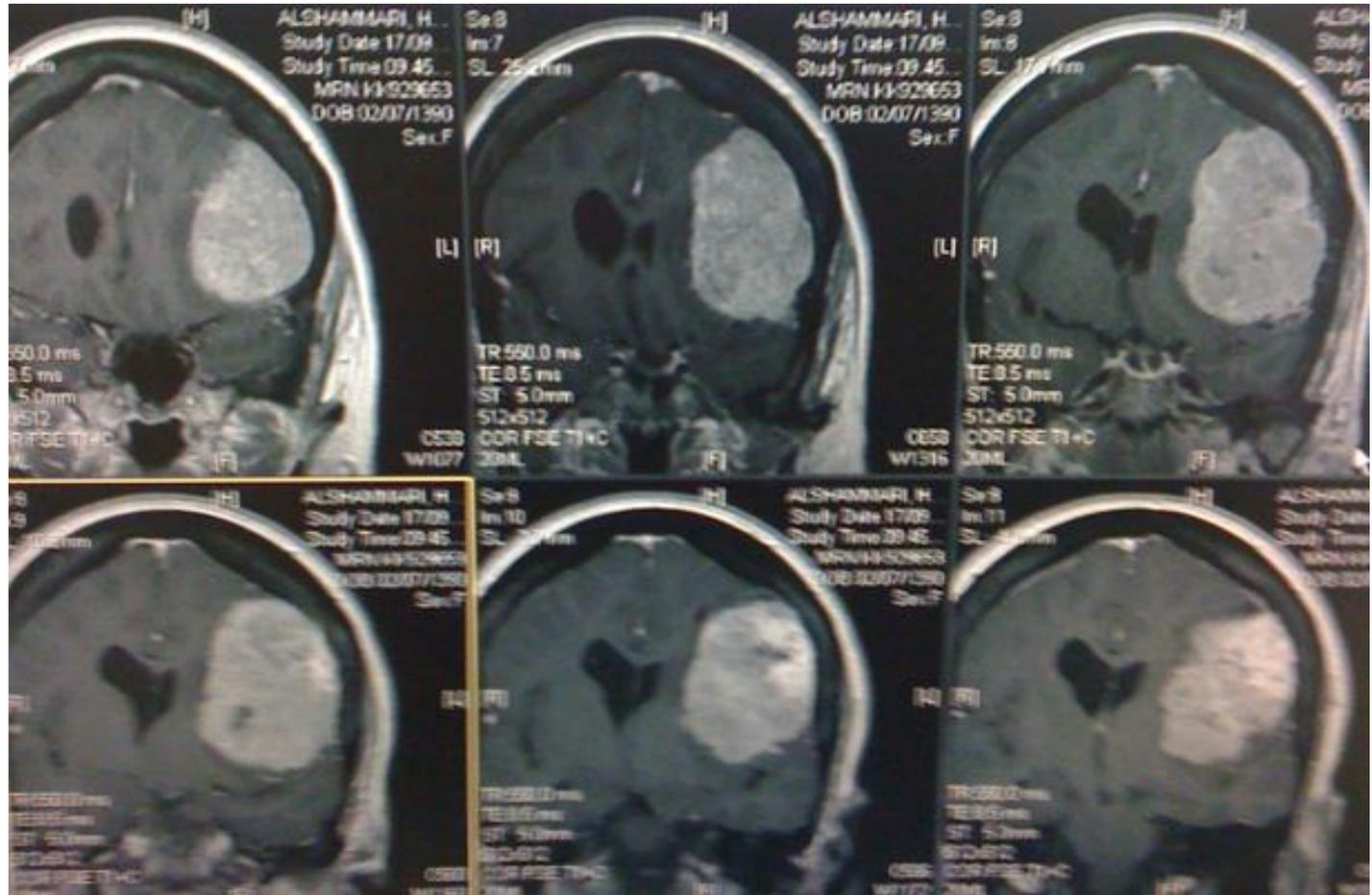
- So if pt has tumor that's growing and growing he has little headache & with time he has more headache , until he reach stage that he can't take it any more and come in emergency (at that stage where's his volume has increased to degree that the pressure in head can't take it anymore and any further increase in the volume of tumor will shoot up the pressure of brain which isn't a good thing )

# Can somebody walk around with a raised ICP?

tumors they came walking to the hospital

Yes, most pts. with brain

This person has brain tumor came complaining of numbness and mild weakness, **slow growing tumor!**

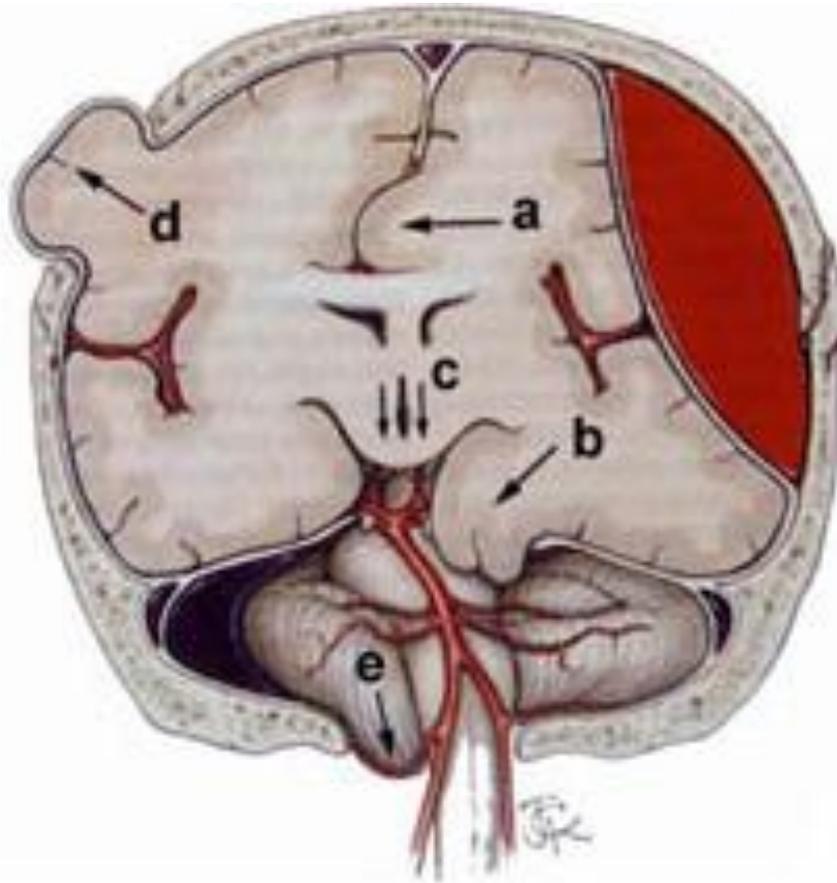


# Notes

- If Tumor that grows 1mm in year  $\gg$  v. small , brain gets a lot of time to accommodate , CSF gets a lot of time to change its absorption and production pattern, blood flow will change and has a lot of time to accommodate opposite to Sudden change which isn't tolerated well

# Raised ICP and brain shift

- Somebody with hematoma of brain ex) just got RTA ..
- An rapid increase in volume will shoot up pressure to expansional part of pressure volume curve of head (brain)
- If pressure increase significantly will push brain around “ looks to areas to escape “



- A) Cingulate herniation**
- B) Uncal herniation**
- C) Central herniation**
- D) Outside herniation**
- E) Tonsillar herniation**

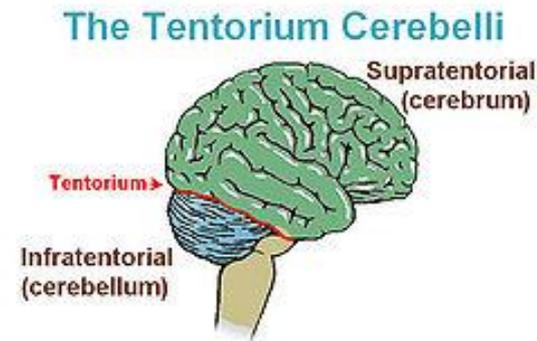
Herniations in the brain: the brain is actually under so much pressure and it will go to least resistance part in the brain.

# From the previous slide

- **Uncal herniation:** uncus is the most medial part of the temporal lobe so, it's the part that is going to herniate, if there's a lot of pressure uncus goes above the tentorium and compress brainstem giving the pt dilated pupil "3rd cranial nerve effected" , coma state , hemiplasia

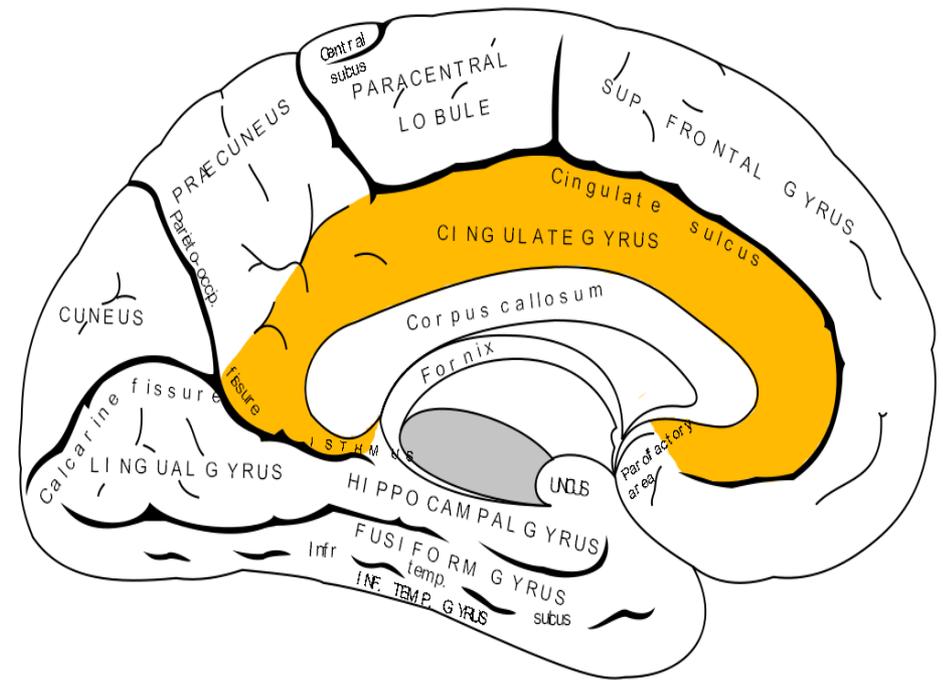
most common clinically seen

- **Central herniation:** a hematoma or mass compressing the upper part, it pushes the whole brain down through the tentorial opening.
- **Tonsillar herniation:** if there is massive increase in the ICP especially that around the cerebellum, the tonsil will come down to the foramen magnum and then it compresses the lower medulla where the centre of respiration is there and the pt will stop breathing. **This type is fatal**

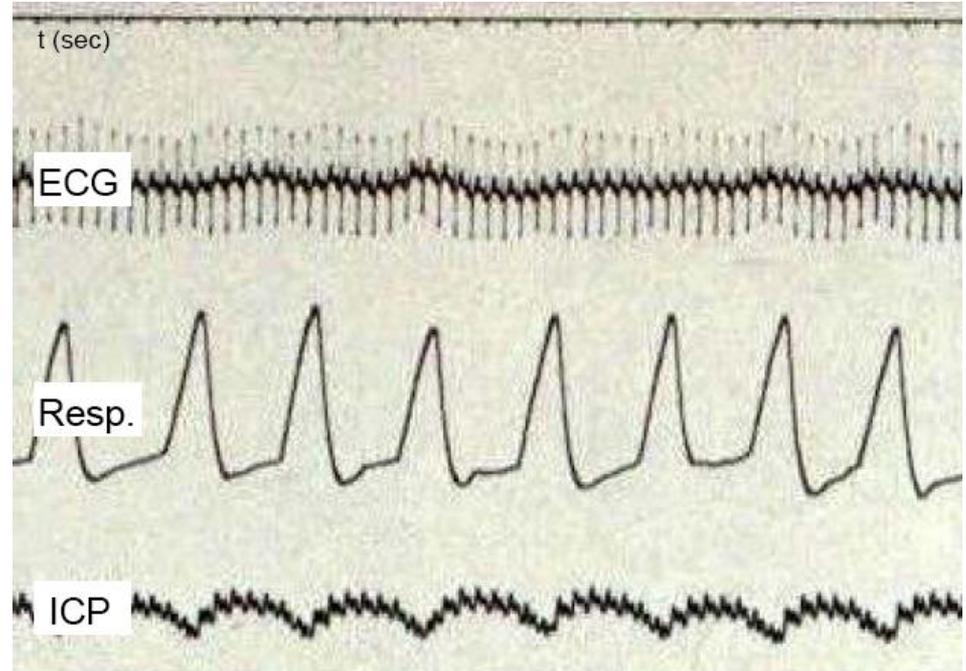
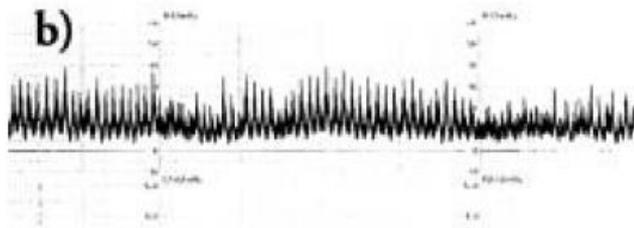
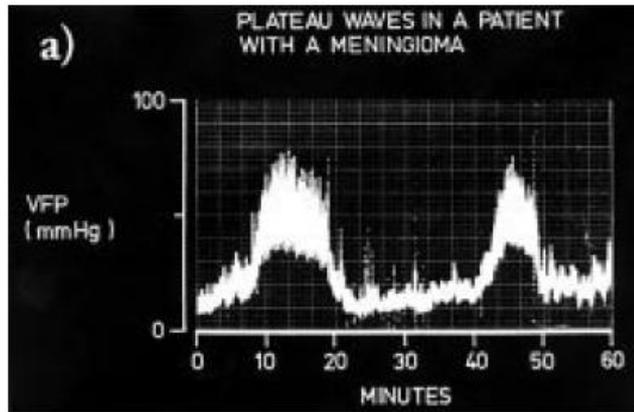


# Notes

- Cingulate herniation: subfalcine herniation, left brain that's compressed and push on the right one, goes under the falx cerebri to other side.
- Outside herniation: if there's skull fracture "pressure inside is so huge looking for easiest way to be out"



# ICP waveform



It's the same as the heart waveform and it gives the brain pulsation and this pulsation is what forms your ICP.

- Pulsation of heart > great vessel > internal carotid artery > brain  
"transmits into brain substance into pulsation" even S.C pulsate

# Normal ICP

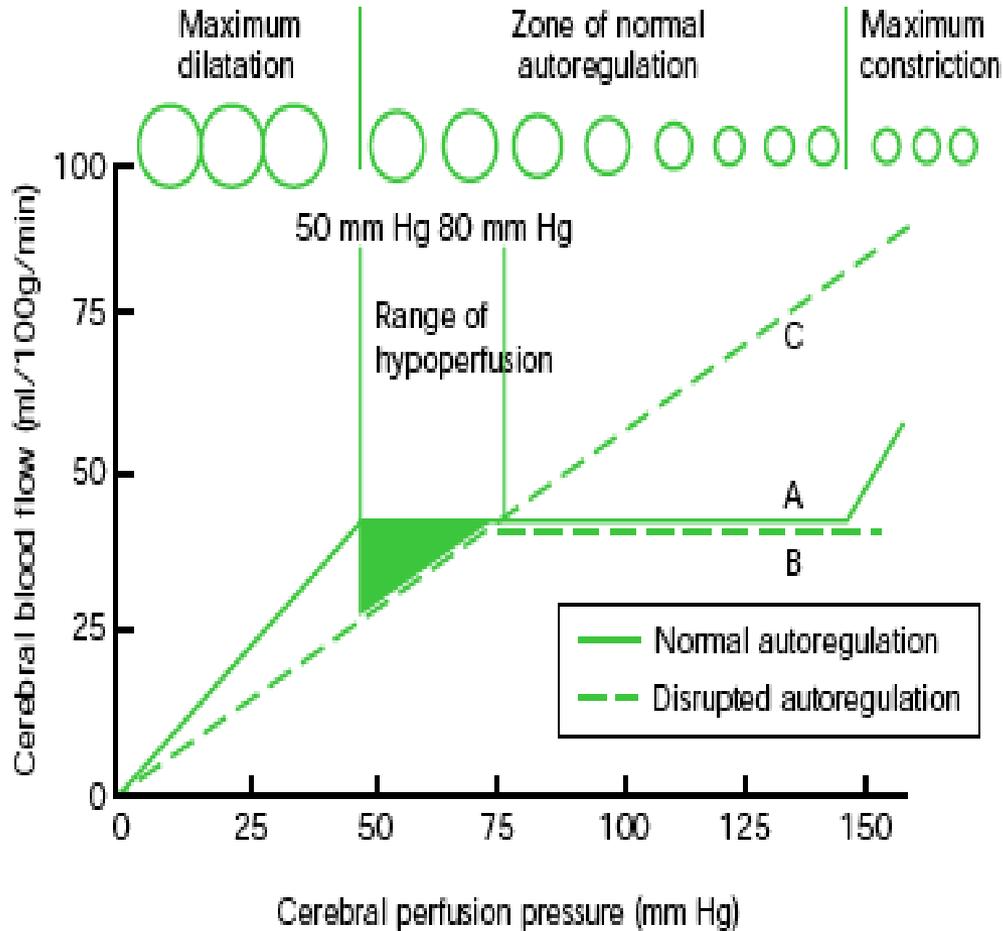
**Table 1** Normal intracranial pressure values

| Age group    | Normal range (mm Hg) |
|--------------|----------------------|
| Adults       | <10-15               |
| Children     | 3-7                  |
| Term infants | 1.5-6                |

In Infants their bones not fused yet > u can find infant with very large head ,, that' why they measure head circumference in pediatric follow up

- **Cerebral autoregulation** : when Bp is low ex) hypovolemic pt. the brain can't tolerate low blood come to it / when high Bp should brain take all this blood and bleed ? NO
  - Ability of cerebral vessels to maintain cerebral perfusion within strictly determined limits
    - Rise in SBP ----> Constriction of cerebral arteries
    - Low SBP ----> cerebral vessels dilate to accommodate, to keep u awake and able to judge ex) u r dehydrated> so u will go to drink water if brain collapse u can't protect ur self in this way
  - Loss of autoreglation: Change in cerebral blood flow with the change in BP

# Cerebral Autoregulation



Increase of pressure > increase of bl. Flow. ex) 25:25 , 50:50. 75: bl. Flow constant , until it reaches to extreme abnormal state then finally auto regulation fail

Disrupted autoregulation : BBB or vessels badly affected like bad hematoma , bad contusion of brain  
In that area increase pressure > will increase flow and this area can bleed inside.

# BP and CBF

v. critical if someone comes to ER with trauma and he losing a lot of bl. > brain can't survive without blood !

## ■ If ICP goes up, how does the brain get perfusion?

### ■ Process of autoregulation

### ■ $CPP = MAP - ICP$ “v. imp”

### ■ If:

- $MAP = 85 \text{ mmHg}$

- $ICP = 15 \text{ mmHg}$

- $CPP : 70 \text{ mmHg}$

- If:  $MAP : 50 \text{ mmHg}$   $ICP : 50 \text{ mmHg}$  >  $CPP : 0$  , no perfusion of brain !
- In trauma ABC : brain needs  $O_2$  , brain needs blood !
- $MAP$ : pressure comes from heart some of it goes to brain , blood pushed into skull and will face resistance of  $ICP$  (this area not empty and has + pressure )

CPP: Cerebral Perfusion Pressure

MAP: Mean Arterial Pressure 17

## Normal:

- CPP 50-140 mmHg
- In case of trauma with bad head injury > we put catheter in brain and measure ICP , also u have MAP> u want CPP to be around 70 , if it's around 40 then u rise BP or lower ICP !

- 20 year old man. Had car accident (MVC) as unrestrained driver.

He presented with BP 75/30, HR 125 bpm.  
Unconscious, with right hemiplegia.

What is going on? U think it's intracranial bleeding >b/c he's Unconscious, with right hemiplegia.

Another possibility is the patient has hematoma in the brain that's why he is with hemiplegia and he is bleeding somewhere in the body and because of that he is hypotensive and unconscious and he has high HR

How we deal with him in the emergency ?

1<sup>st</sup> ABC : A :check airway > intubation , B: breathing > chest tube C: external bleeding u want stop and 2<sup>nd</sup> !

2<sup>nd</sup> 2 larger I.V line to start fluid , blood > remember the brain will not survive if there is no bl.

3<sup>rd</sup> C.T to know why he is unconscious

# Possible Causes

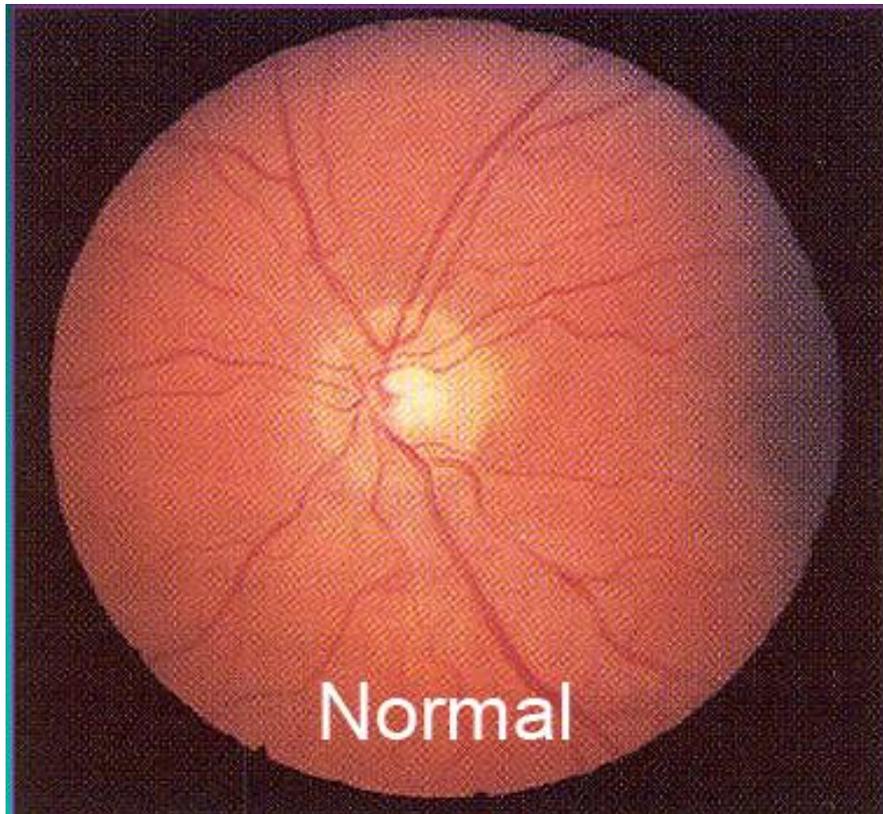
- **VITAMEN D** is vitamin D deficiency is a possible cause of raised ICP?? **NO**, it an abbreviation of **Vascular, Infection, Trauma, Autoimmune, Metabolic, Endocrine, Neoplastic, Drugs..**
- **Other:** classify according to major pathological criteria : infection , trauma, tumor
- **OR :** see table

**Table 2** Examples of causes of raised intracranial pressure

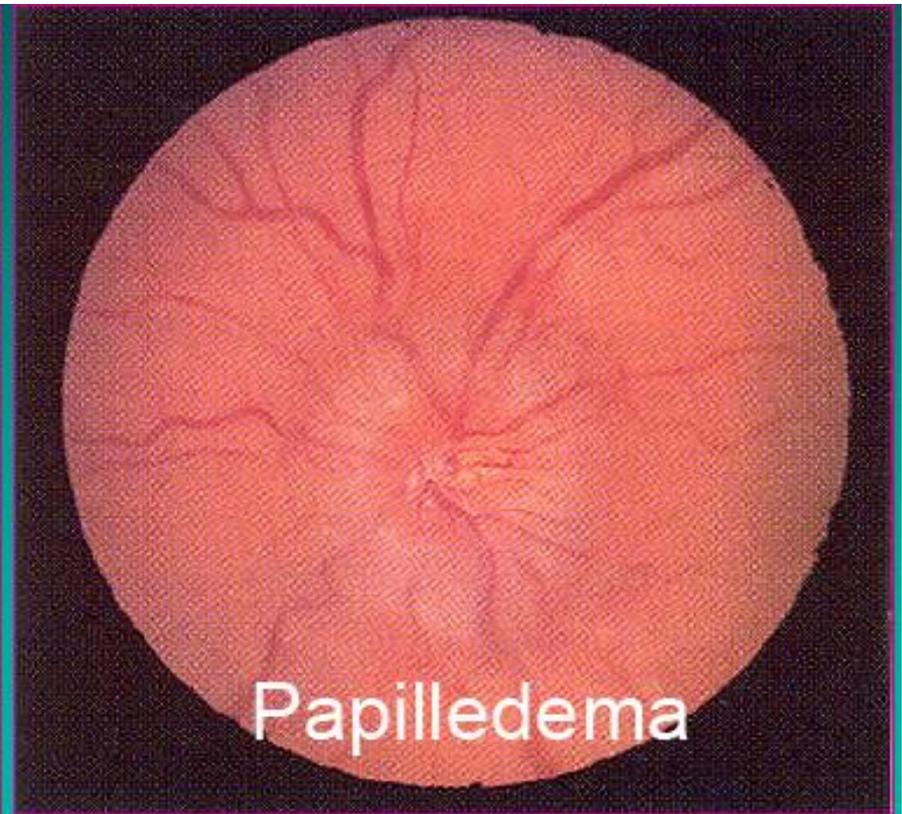
| Pathological process                | Examples  |
|-------------------------------------|---|
| Localised mass lesions              | Traumatic haematomas (extradural, subdural, intracerebral)<br>Neoplasms (glioma, meningioma, metastasis)<br>Abscess<br>Focal oedema secondary to trauma, infarction, tumour |
| Disturbance of CSF circulation      | Obstructive hydrocephalus<br>Communicating hydrocephalus  |
| Obstruction to major venous sinuses | Depressed fractures overlying major venous sinuses<br>Cerebral venous thrombosis  |
| Diffuse brain oedema or swelling    | Encephalitis, meningitis, diffuse head injury, subarachnoid haemorrhage, Reye's syndrome, lead encephalopathy, water intoxication, near drowning                            |
| Idiopathic                          | Benign intracranial hypertension  |

# Clinical Presentation of raised ICP

- Headache, vomiting, papilloedema **V.imp**
  - Headache
    - Early morning b/c pt laying flat during sleeping which u will increase venous return and amount of blood will reach brain increase opposite when pt upright gravity will take bl. down > so will lower ICP
    - Throbbing / Bursting
    - ↑ sneezing, coughing b/c it'll increase intrathoracic pressure prevent bl come down from head > increase ICP
  - Papilloedema
    - Reliable but may take several days **“happened only with chronic problems like with growing brain tumor.** So u will not see it in acute hematoma in ER **“no enough time to papilloedema”**
    - Associated fundal hge indicates acute and severe rise in ICP



Normal



Papilledema

- Blurred optic disk “ congested”
- Increase pressure in brain > veins within optic nerve becomes congested > whole optic nerve head becomes congested
- U see very large tortuous veins , elevated and floored optic disk margin
- In severe cases u find hemorrhages

# GCS

“**very imp** to asses the severity of coma (LOC) ,

- easier to communicate b/w physicians
- if pt has GCS 3 (lowest) > might be die within days different than somebody with GCS 14 admit to hospital for 2 days > so it easy to estimate prognosis

| Glasgow Coma Score                                 |  |  |
|--|--|--|
| Eye Opening (E)                                    | Verbal Response (V)  | Motor Response   |
| 4=Spontaneous<br>3=To voice<br>2=To pain<br>1=None | 5=Normal conversation<br>4=Disoriented conversation<br>3=Words, but not coherent<br>2=No words.....only sounds<br>1=None | 6=Normal<br>5=Localizes to pain<br>4=Withdraws to pain<br>3=Decorticate posture<br>2=Decerebrate<br>1=None |
|  |  | <b>Total = E+V+M</b>   |

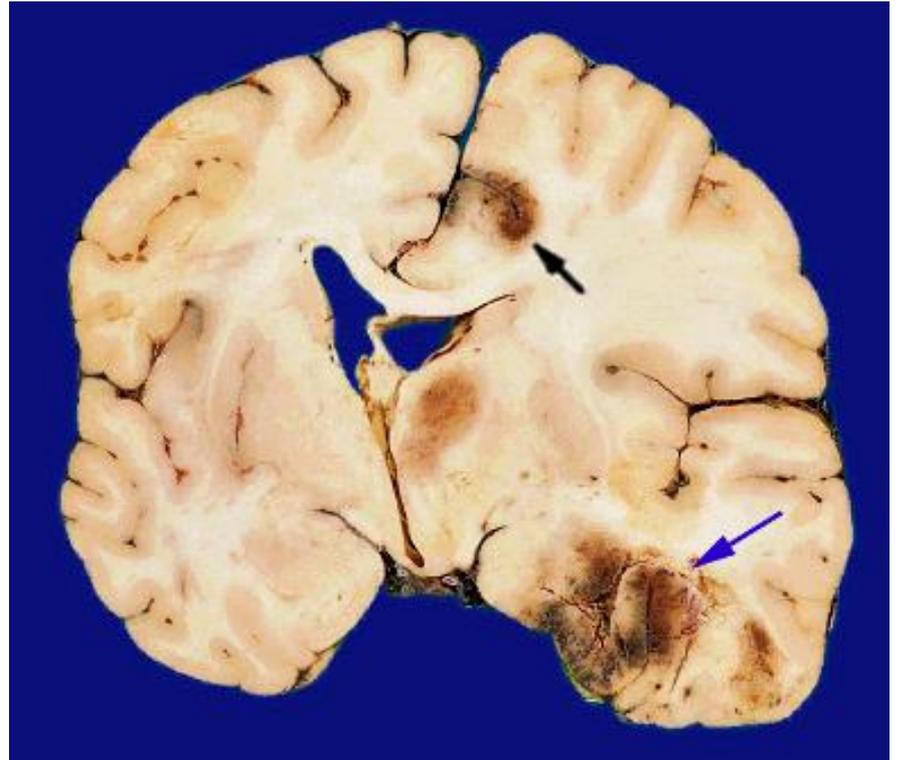
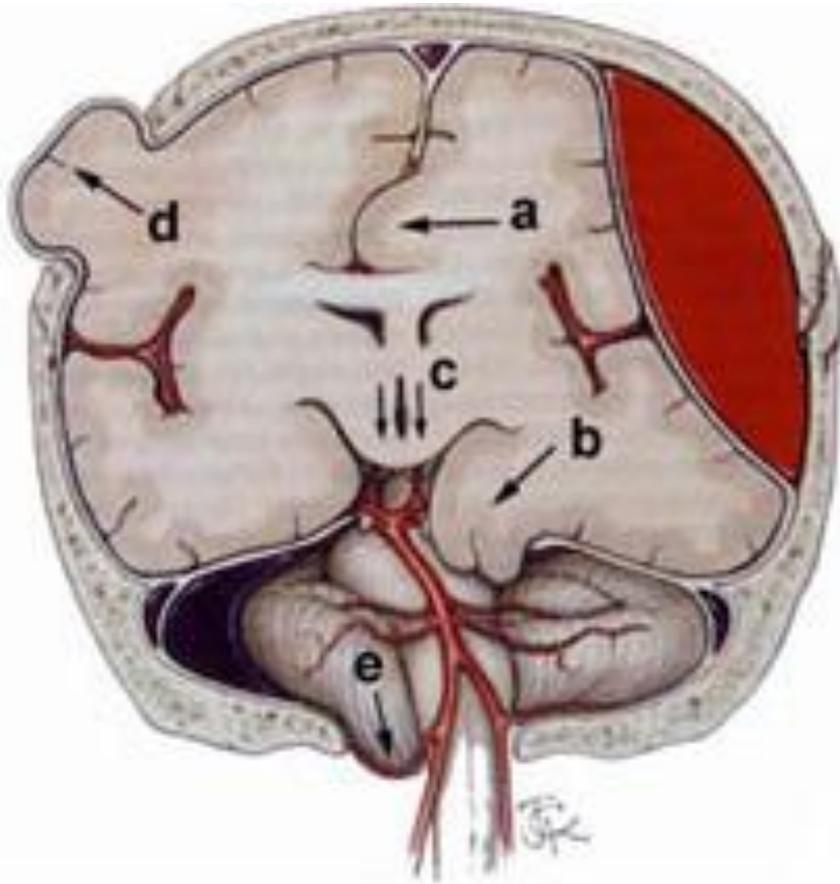
The patient takes 6 even he is with hemiplegia

## Decreased Level of Consciousness

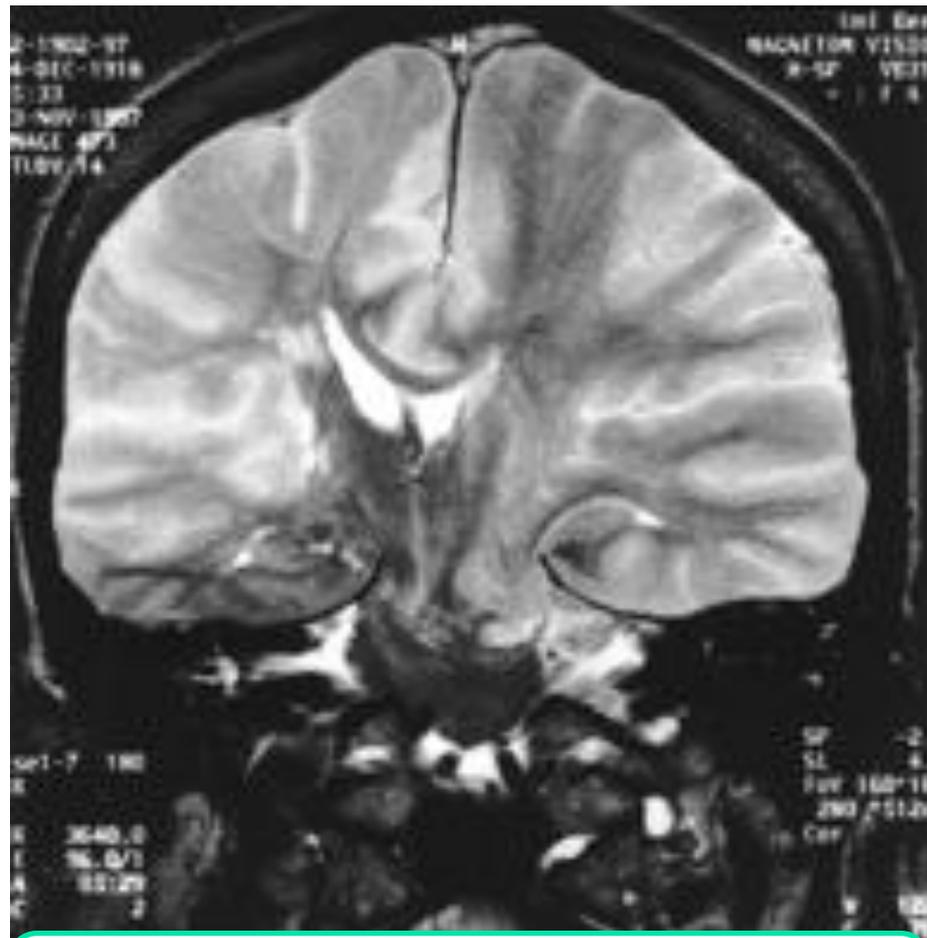
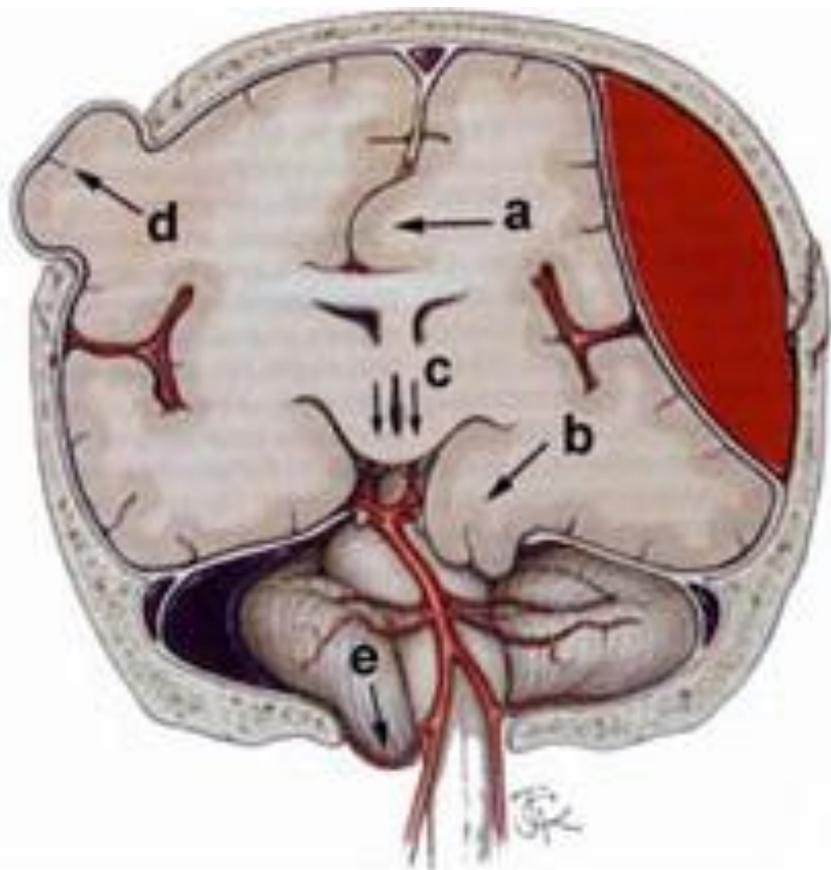
It's a coma score not a weakness score.

- When it comes to head injury there a classification of GCS:
- Mild GCS= 13 – 15
- Moderate GCS= 9 – 12
- Severe GCS= 3 – 8
- The lowest number in GCS is 3 and the highest number is 15

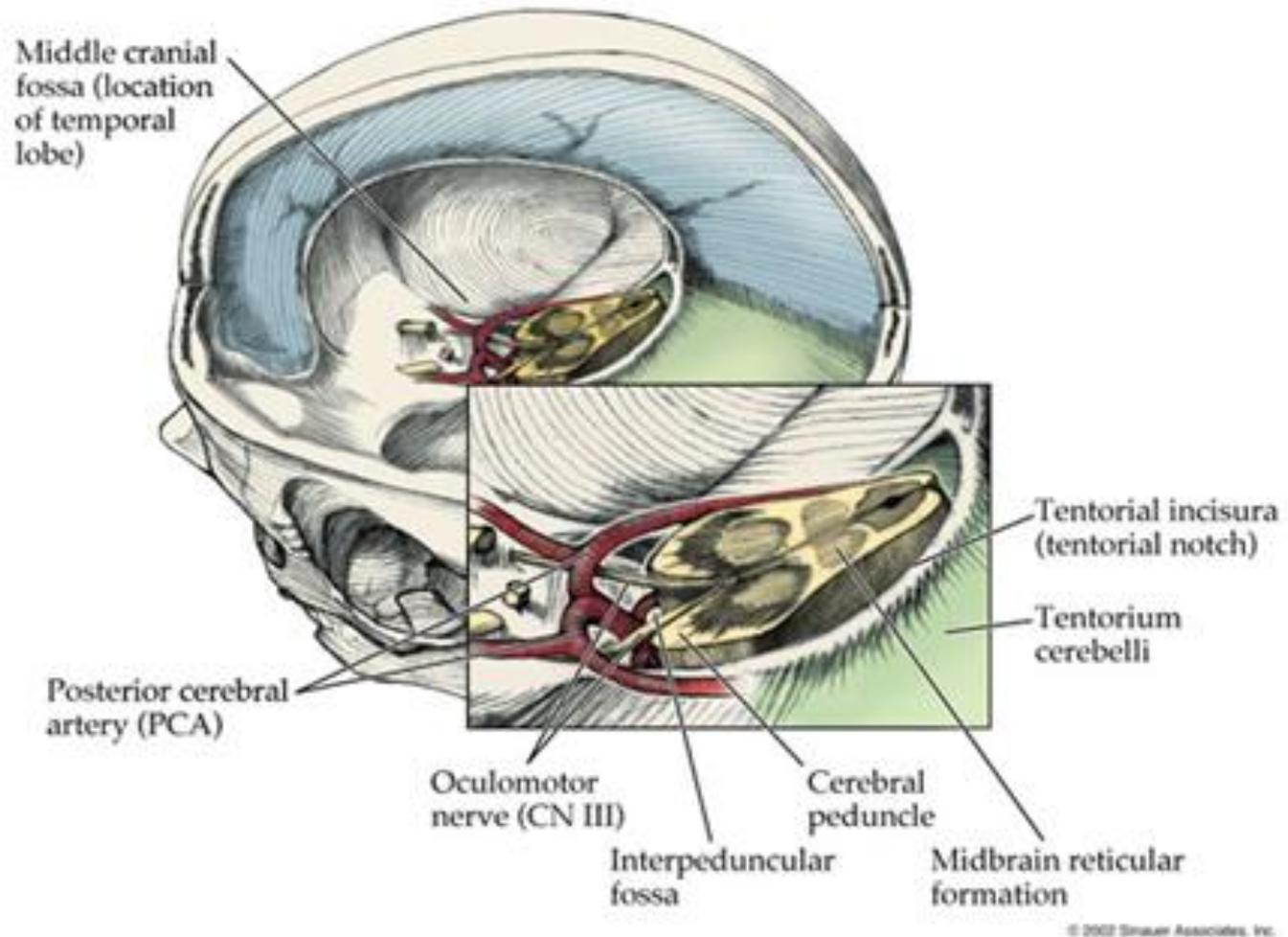
- In Neurological exam the most common signs :
  - Pupillary dilation
  - Hemiplegia (any weakness)
  - Cranial nerve deficit



- This pathological picture shows
- Cingulate herniation (subfalcine herniation) , central herniation , some Uncal herniation.
  - bl in temporal area , basal ganglia, frontal area.

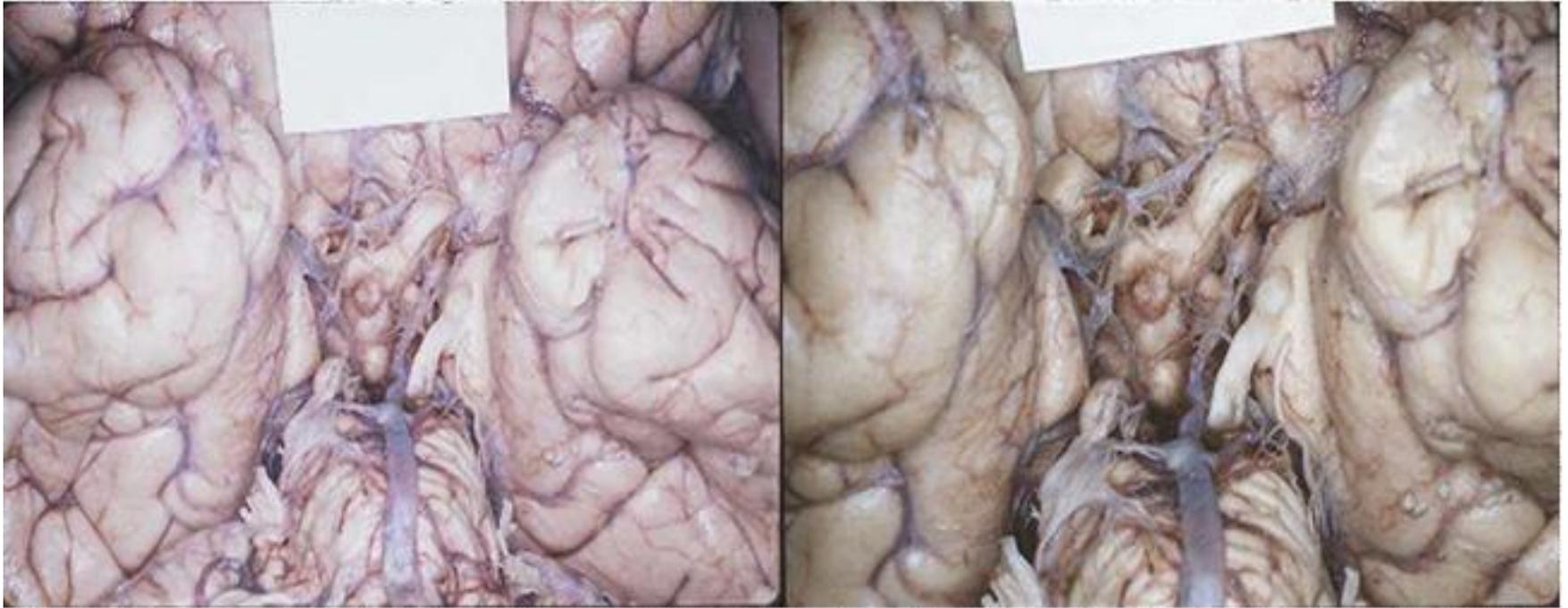


Coronal cut MRI shows u the same thing

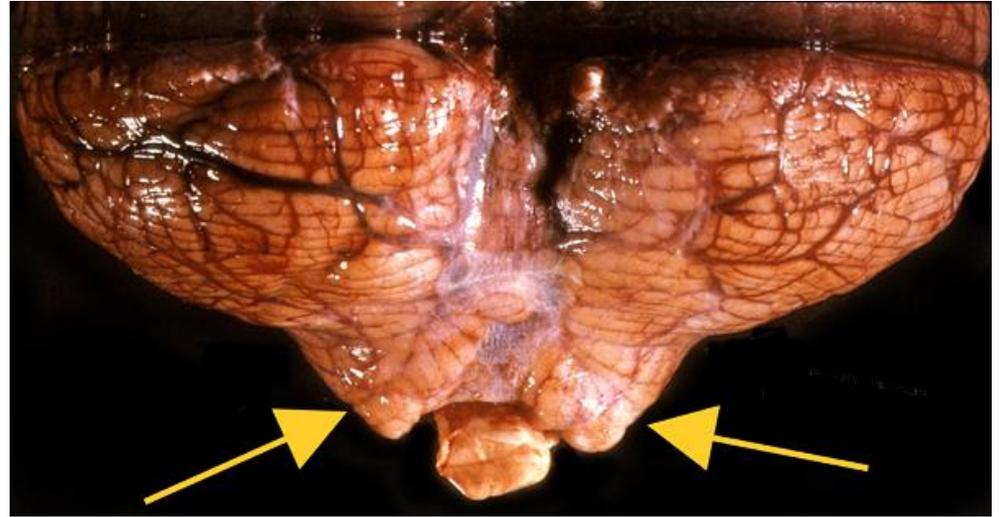
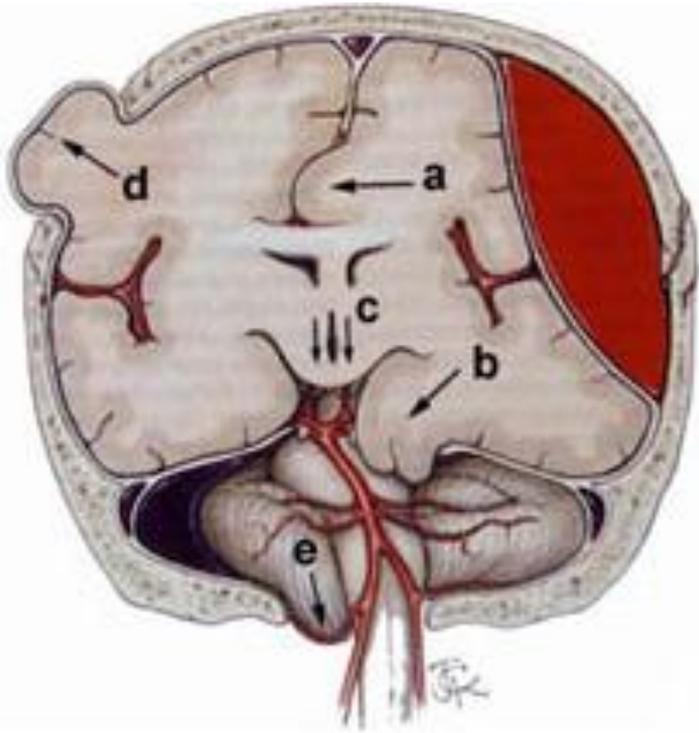


- The 3rd cranial nerve comes out from front of midbrain (next to tentorium) > so in beginning of herniation this nerve will be effected
- If there is a mass compressing the 3<sup>rd</sup> nerve So, ipsilateral pupil dilation and compression on the brain stem will give you contralateral hemiplasia "weakness".

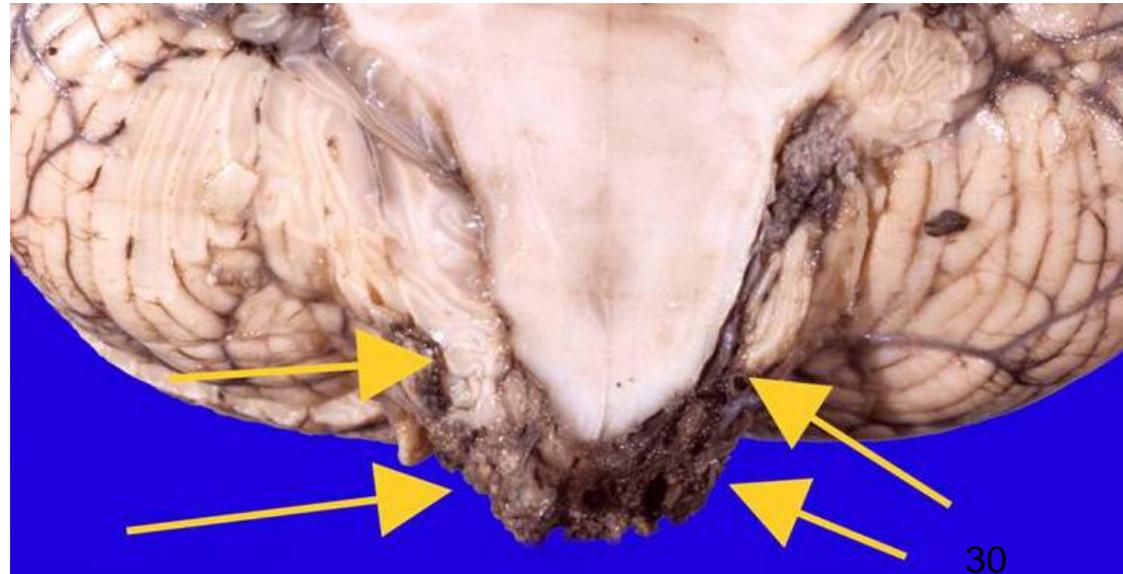
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Trans-tentorial herniation: - Ipsilateral dilated pupil  
- Contra-lateral weakness

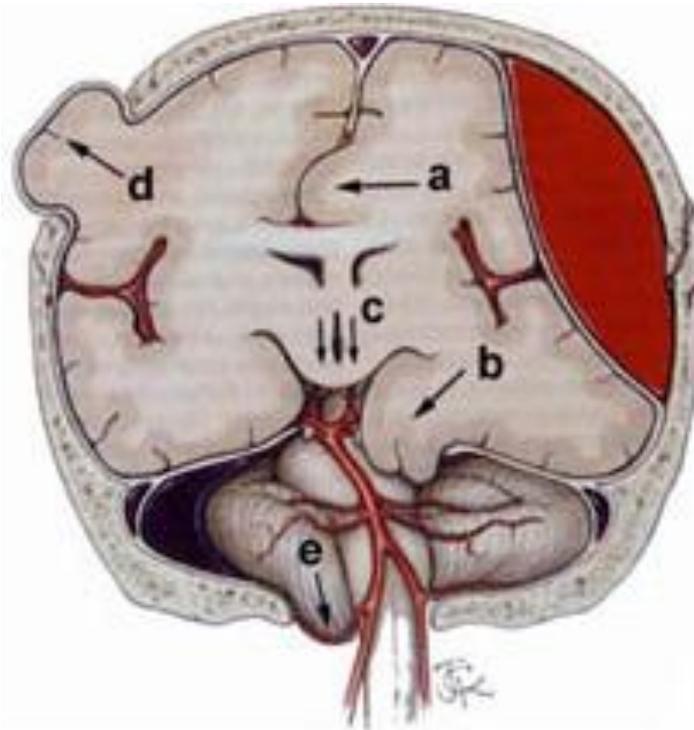


**Tonsillar herniation,**  
 tonsil comes down from  
 foramen magnum  
 and bone compress it >  
 make it flat .



# False localization

- Kernohan's notch



U used these signs to estimate clinically the side of bleeding but to know where is the bleeding exactly > CT scan

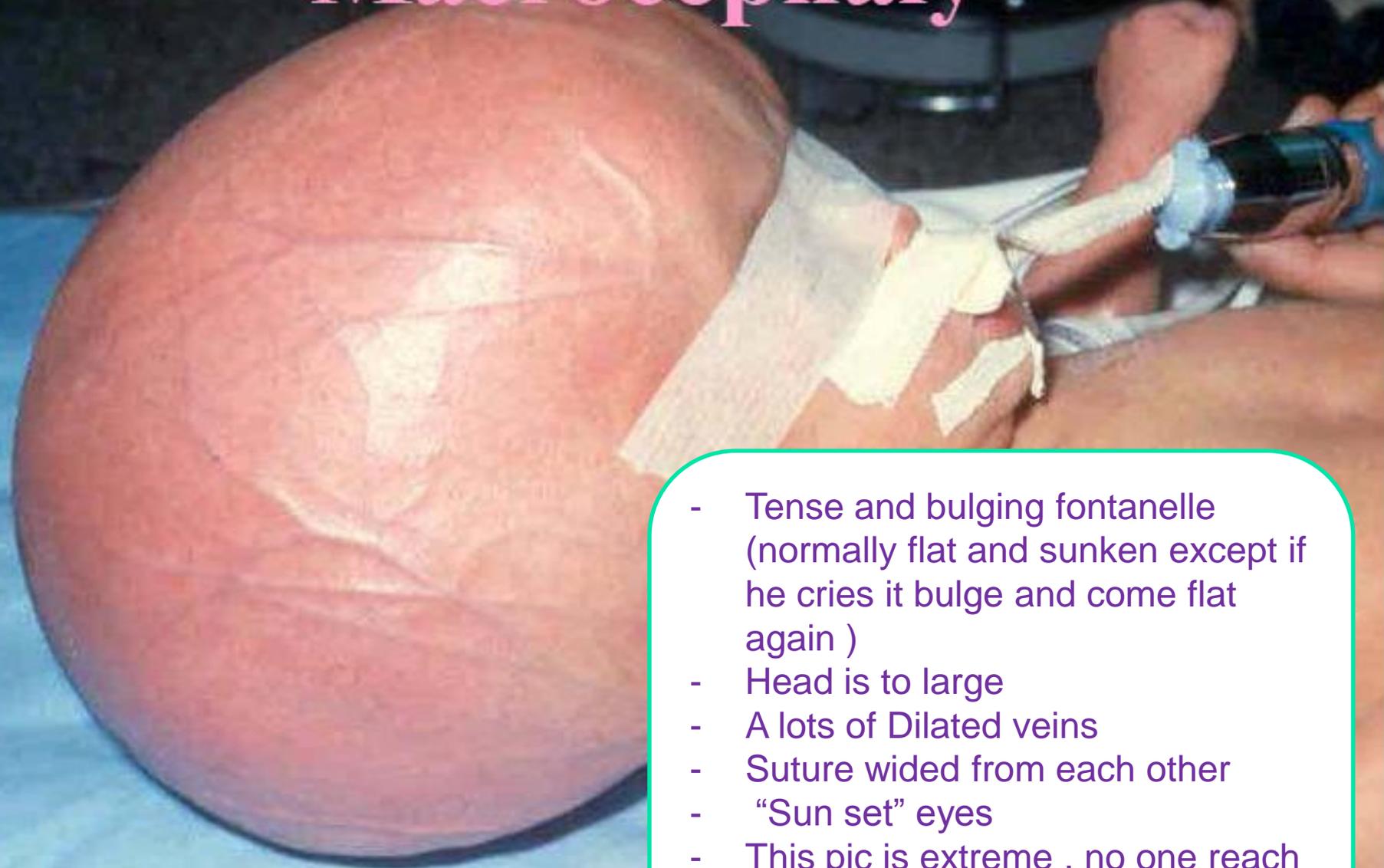
Simply, when there is a huge growing right side hematoma it will push the whole brain stem to the opposite side (so push the whole brainstem against the contralateral tentorium) and that may cause ipsilateral weakness and contra-lateral dilated pupil

- Systemic: reaction to increased ICP !
  - Raised BP (recall:  $CPP=MAP-ICP$ ) bl. Is pumping so high to compensate ( u rise MAP by rising systolic BP) if u drop his Bp u Kill him
  - Respiratory change:
    - Cheyne-Stokes breathing: not seen in every case
      - Oscillating periods of apnea-tachypnea ( stop breathing > suddenly breathing fast > again suddenly stop breathing.. Etc)
      - Respiratory centers compromise

# Raised ICP in infants results in: skull here isn't skull it can accommodate

- Widened sutures
- Increased Head circumference
- Dilated head veins
- “Sun set” eyes “his eyes always looking down”

# Macrocephaly



- Tense and bulging fontanelle (normally flat and sunken except if he cries it bulge and come flat again )
- Head is too large
- A lot of Dilated veins
- Suture widened from each other
- “Sun set” eyes
- This pic is extreme , no one reach this !

# Investigations

- URGENT CT head
  - NO Lumbar Puncture until you do at least the CT
    - Some one has headache, vomiting?
      - Look in his eyes > has Papilleodema or not !
      - If he has also fever > oh let's do LP to R/O meningitis ? No , before R/o meningitis 1- Papilleodema 2- do CT
- b/c this fever can be abscess in brain not meningitis
- Or he has meningitis that cause abscess
- Why? b/c If u take CSF from back and there's high pressure in brain > herniate tonsil > pt can stop breathing !

# What is the treatment of high ICP?

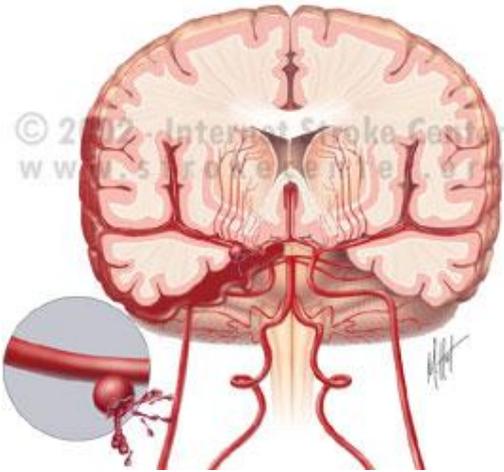
## ■ General measures:

- Head elevation (30 degrees) to help with VR
- No neck compression to relief veins
- Mannitol for patients who have decreased LOC (or Furosemide) will increase osmotic pressure in vessel & suck fluid from intracellular
- Steroids (Dexamethazone) for tumors (a lot of edema around of tumor)
- Hyperventilation: controlled to PCO<sub>2</sub> 35-40 mmHg >a lot of hyperventilation > wash out Co<sub>2</sub> > shrink bl vessels ( decrease the amount of bl reaching brain ! )
- Sedation, muscle relaxants >decrease metabolic rate
- Hypothermia > decrease metabolic rate
- Barbiturates: terminal option > u put brain in complete relaxation !

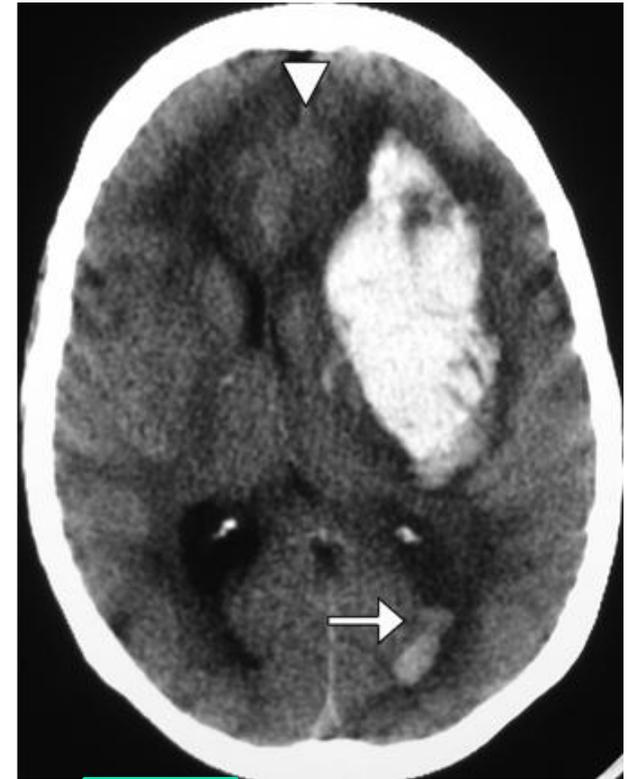
# What is the treatment of high ICP?

- Specific treatment:
  - Depends on the cause
    - VITAMEN D remember stands for what?

# Vascular - SAH / ICH



SAH , sylvian  
fissure fill of blood

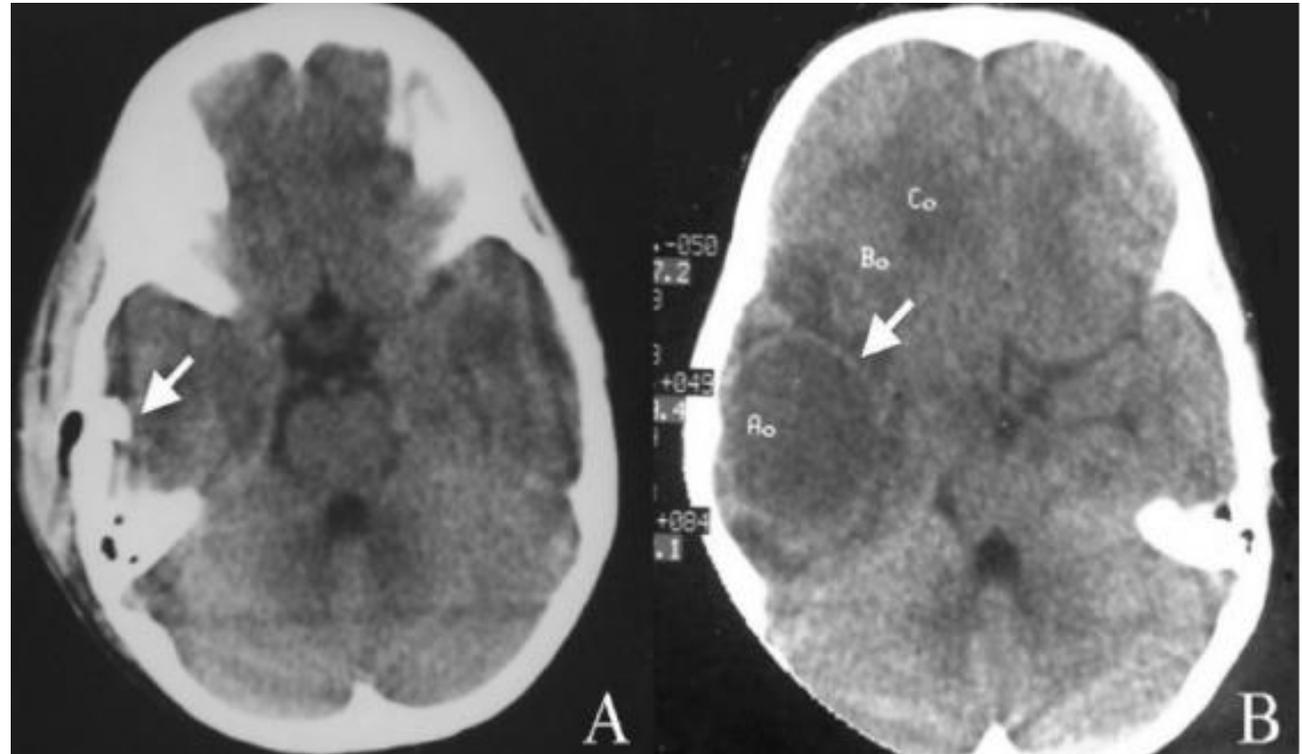


ICH

Axial CT of brain  
White > bl.

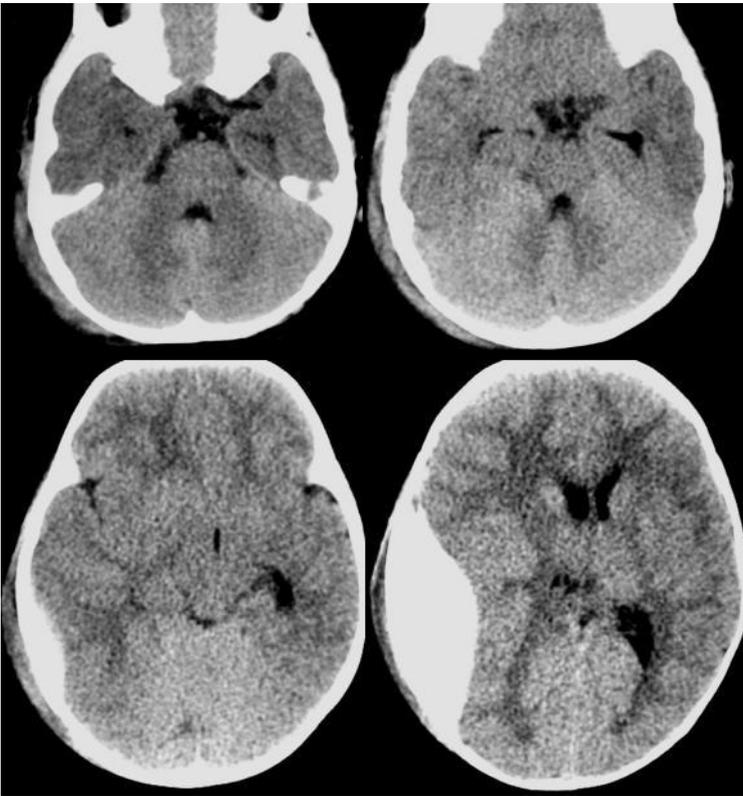
# Infection - Abscess

- Rounded space
- In pt w drug abuse or immune suppressed, with sinusitis, OM
- sustained infection that when u give contrast >enhanced pic (big collection of pus)



# Trauma

- Localized



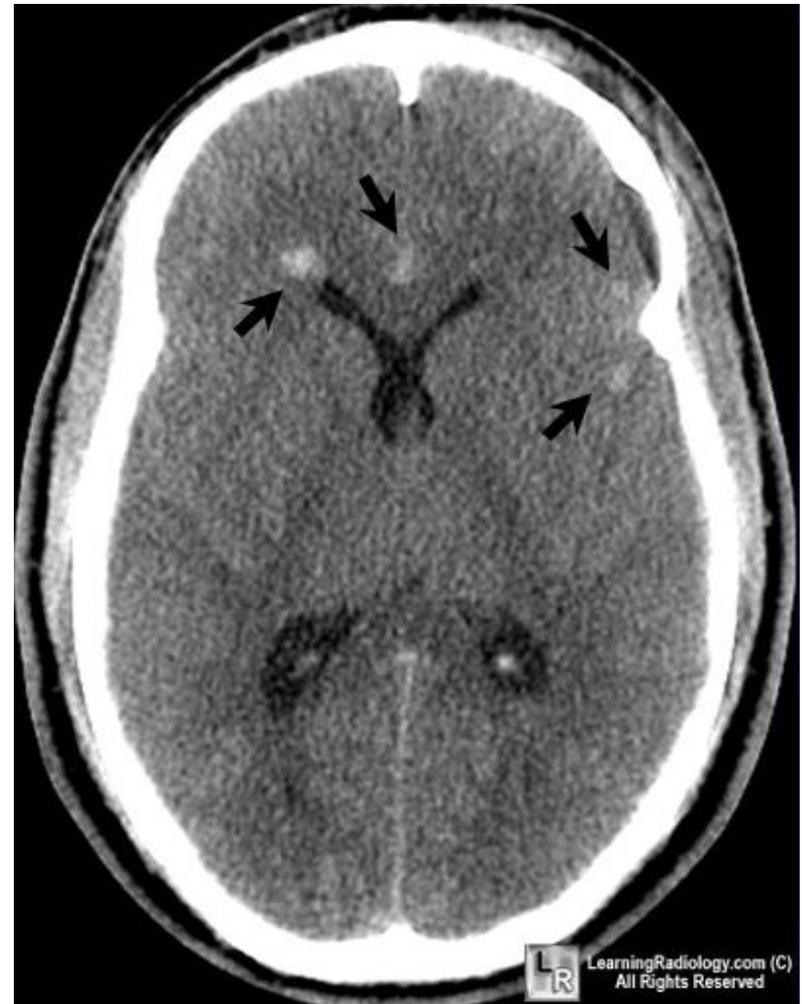
Epidural Hematoma



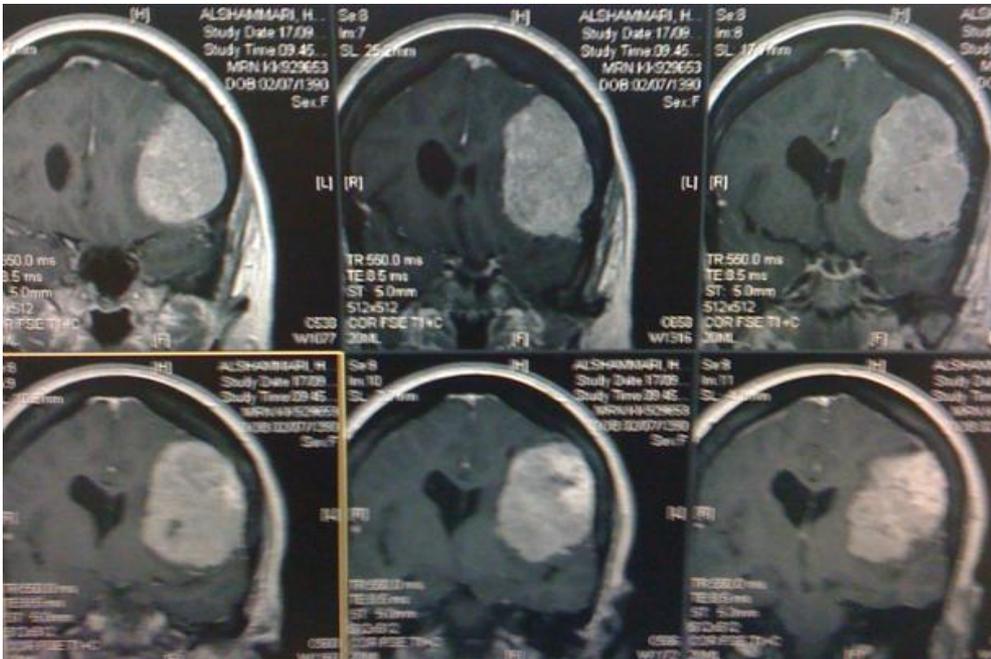
Subdural Hematoma,  
compress brain, subfalcine herniation +  
temporal herniation

# Trauma

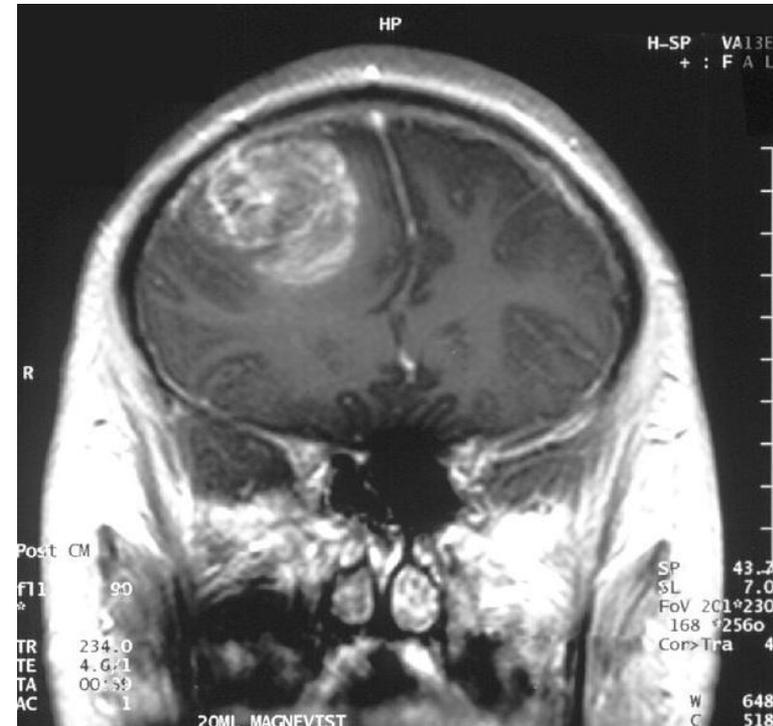
- Diffuse
- Sever shaking of head > cut of Fx  
> Salt and pepper appearance of  
blood scattered around in brain



# Tumor midline shift to other side, edema around it

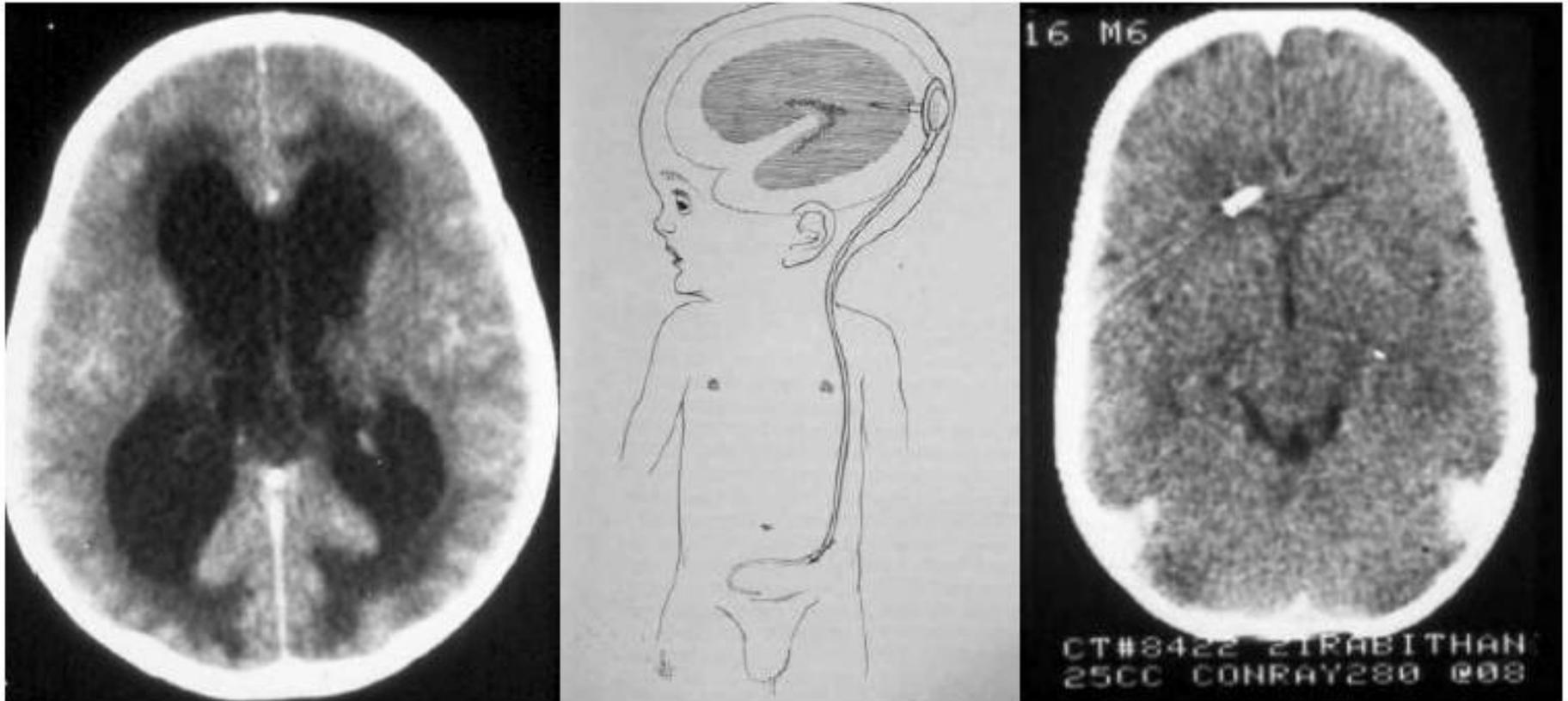


Meningioma



Glioblastoma Multiforme

# Hydrocephalus

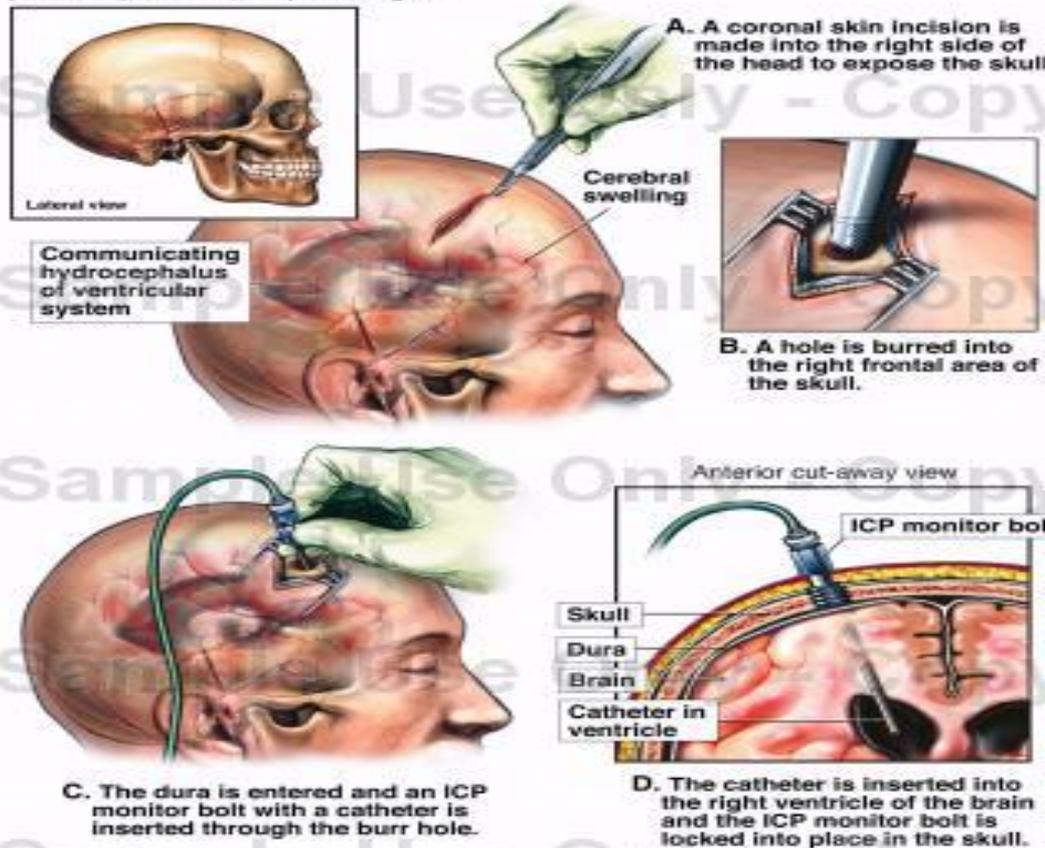


Treated with shunt , ventricles enlarged , diffusion of CSF into brain substance

# Can we monitor ICP?

## Brain Surgery - Ventriculostomy and Placement of Intracranial Pressure (ICP) Monitor Bolt

Multiple comminuted skull fractures involving the occipital bone, mastoid bone, squamous part of temporal bone, and parietal region



Catheter pass in brain substance to give pressure  
Or ventricle : give pressure and suck fluid