

Increased intracranial pressure, hydrocephalus

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Aim of this presentation is, to elucidate

- Definition of ICP: its measurement and determinants
- Hemodynamics of cerebral circulation
- Herniation syndromes
- Diagnostic groups with increased ICP
- Disturbances of CSF circulation (hydrocephalus and treatment modalities)

Intracranial Pressure

- Definition: pressure exerted by intracranial volume of:
 - Brain
 - Blood
 - CSF
- Normal ICP: 5-15 mm Hg.
- Increased ICP: >20 mm Hg.

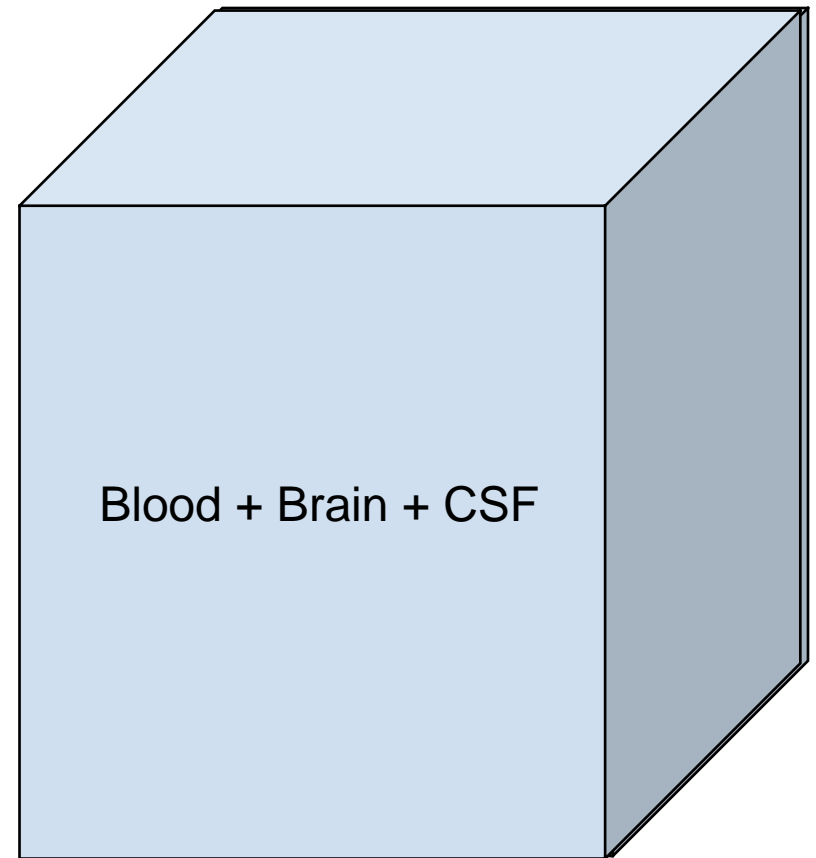
“Monro-Kellie doctrine”

- The skull is basically a rigid structure. Since its contents - brain, blood and cerebrospinal fluid (CSF) - are incompressible, an increase in one constituent or an expanding mass within the skull results in an increase in intracranial pressure (ICP).
- Skull is rigid (except in infants where \uparrow ICP causes sutural diastasis)
- **Intracranial Contents**
 1. Brain (80%)
 2. Blood (10%)
 3. Cerebrospinal Fluid (10%)



Monro-Kellie Hypothesis

- If the volume of one compartment increases, the volume of one or both of the other compartments decreases in order to maintain intracranial balance of volumes
- If the compensatory mechanism of volume-shift becomes exhausted, ICP inherently rises



Intracranial compliance

- Ability to accommodate increase in volume without a corresponding increase in pressure
- BUT at critical point: small change in volume = large change in pressure

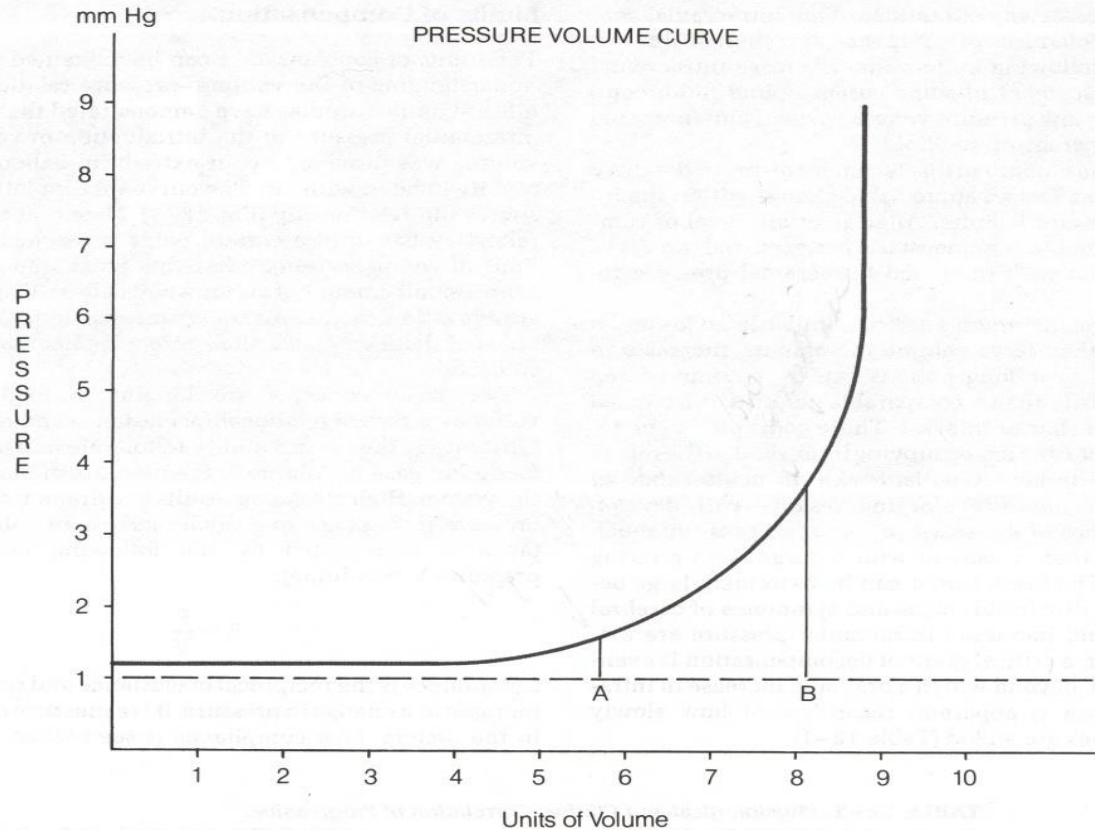


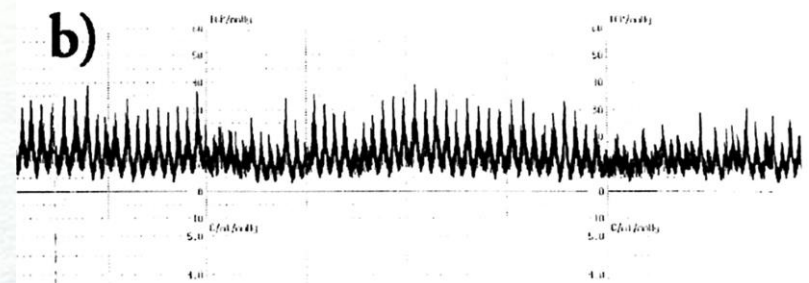
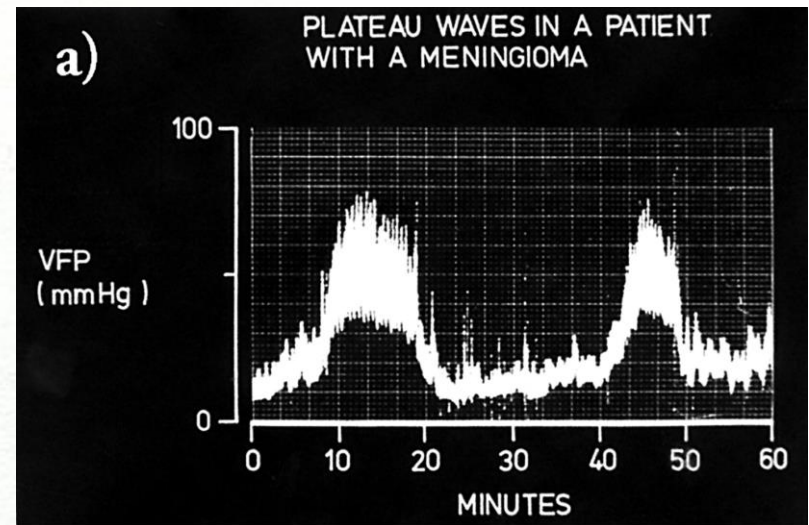
FIG. 12-1. Pressure volume curve. To point "A", addition of volume has little effect on pressure (high compliance); after that point, there is a dramatic increase in response to addition of volume, especially from point "B" onward (low compliance).

Intracranial pressure-volume relationship



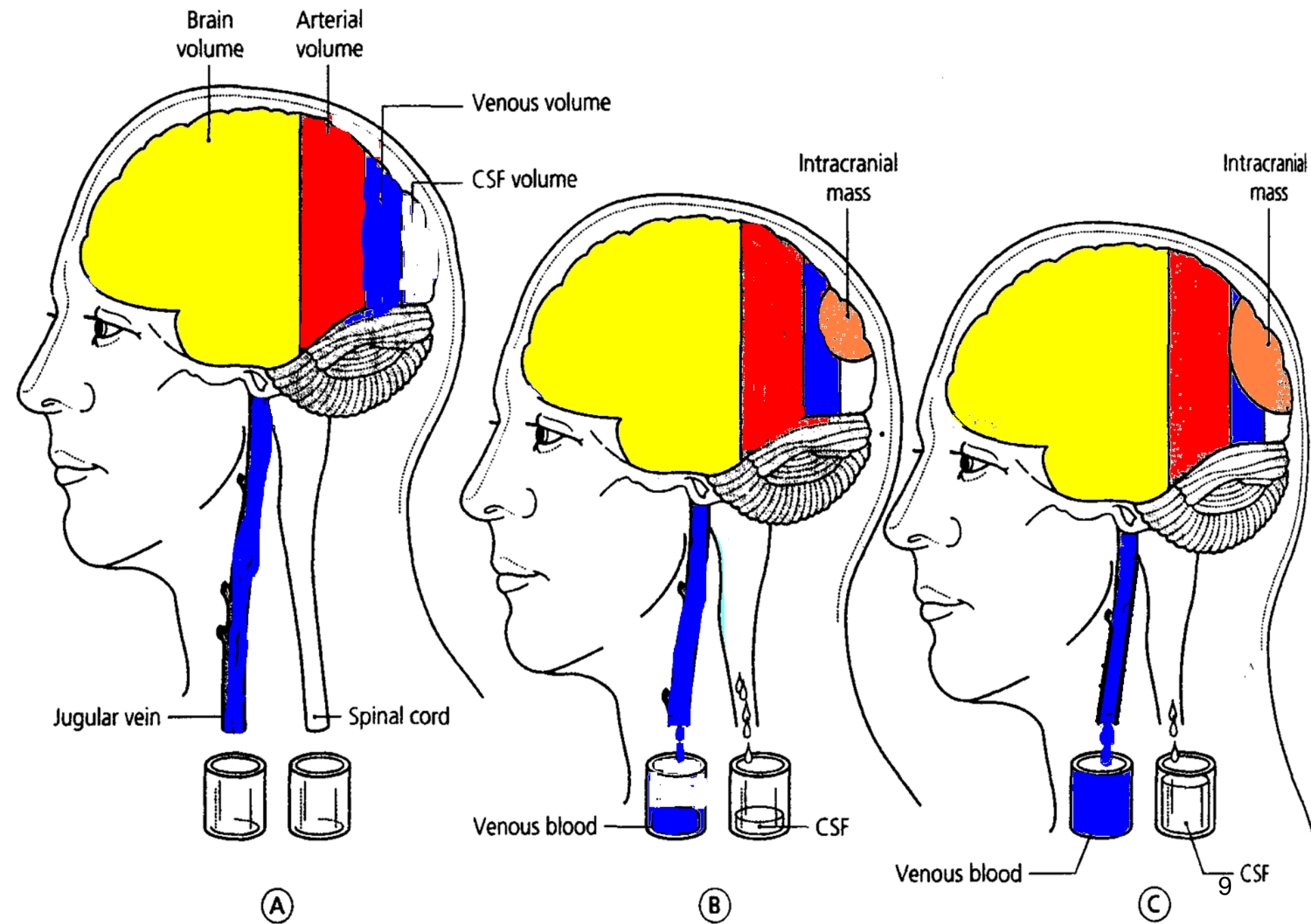
critical volume

Intracranial volume V



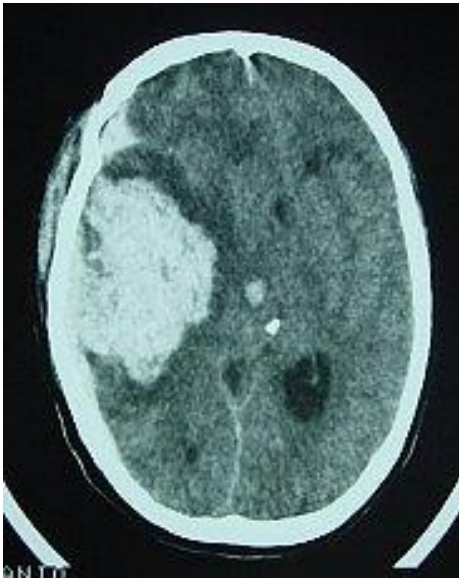
IICP—compensatory mechanisms

- 1. Blood displaces - (venous system)
 - 2. CSF displaces - (spinal reservoir)
 - 3. Brain displaces - herniation syndromes.
-
- *Our aim is to augment compliance before brain displaces.*



IICP: Etiologies

1. Increase in “brain” volume
 - i. Space-occupying lesion (eg. Hematomas, tumours, abscesses)
 - ii. Cerebral edema (eg. Tumor, stroke)



Hematoma

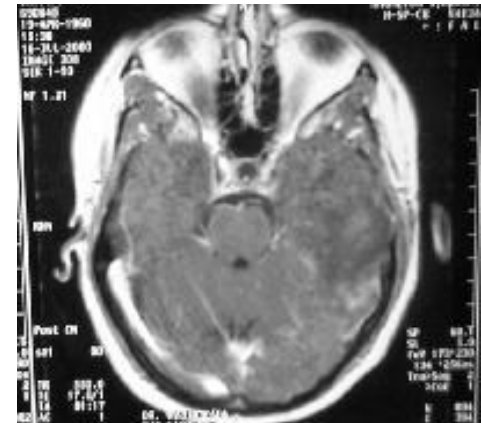
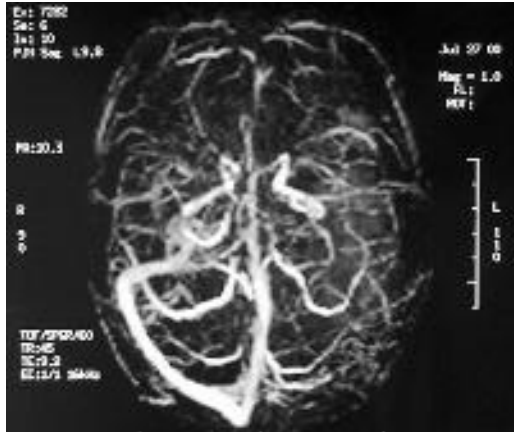


Tumour/
Edema

IICP: Etiologies (space occupying lesions)

2. Increase in blood volume

- i. Obstruction of venous outflow → edema, hemorrhage
- ii. Hyperemia (status epilepticus, post AVM surgery)
- iii. Hypercapnia ($\uparrow \text{CO}_2$)
- iv. Hypoxia



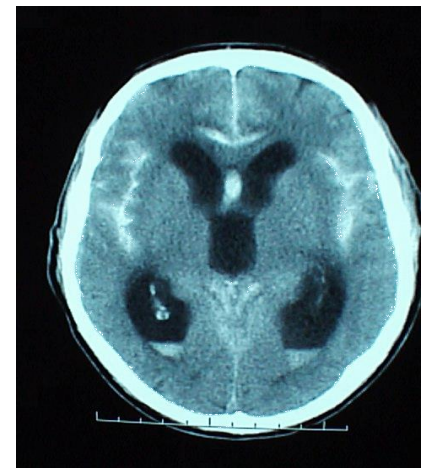
Venous Sinus Thrombosis

IICP: Etiologies (space occupying lesions)

3. Increase in CSF
 - i. Increase CSF production (eg. Choroid plexus papilloma)
 - ii. Decreased CSF absorption (Communicating hydrocephalus)
 - iii. Obstruction of CSF flow (Obstructive hydrocephalus)



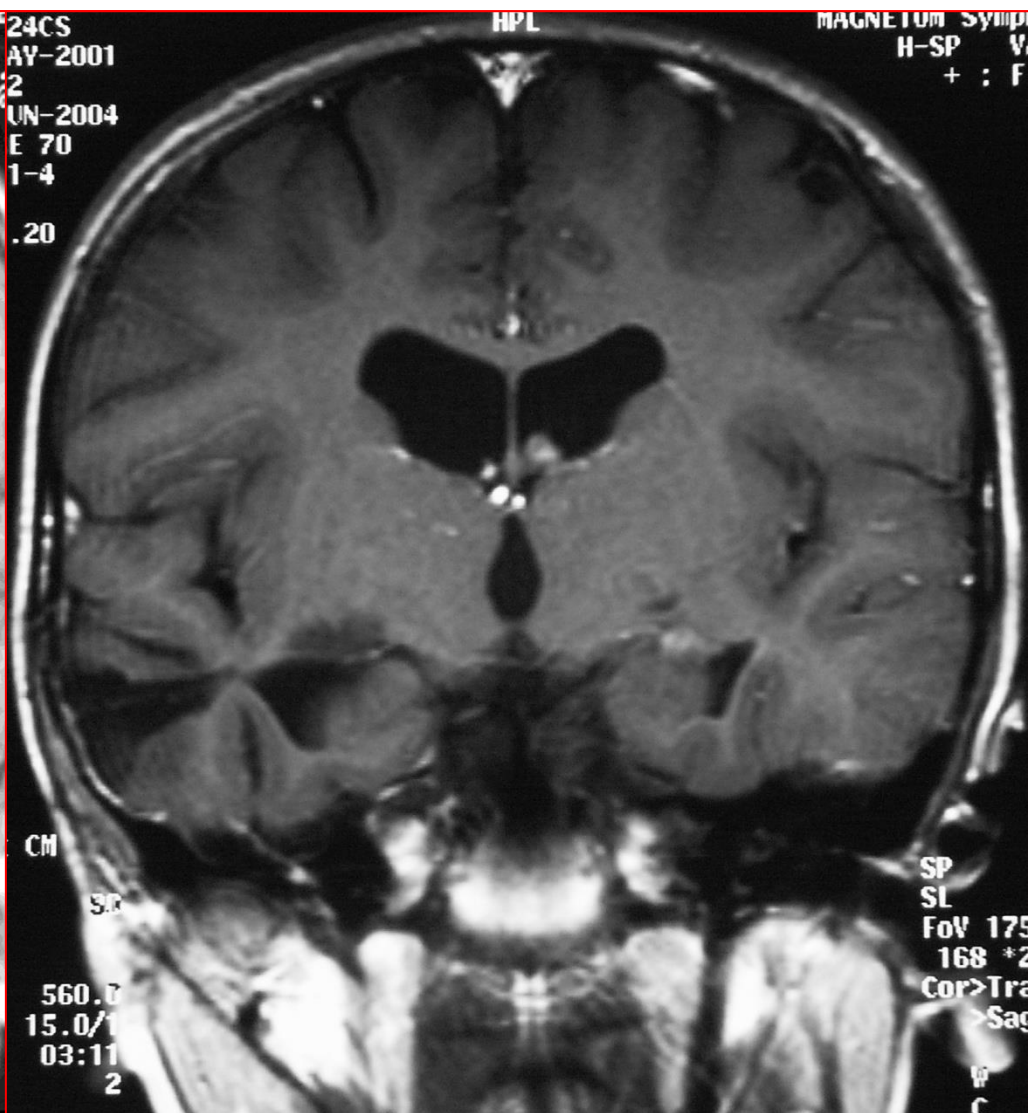
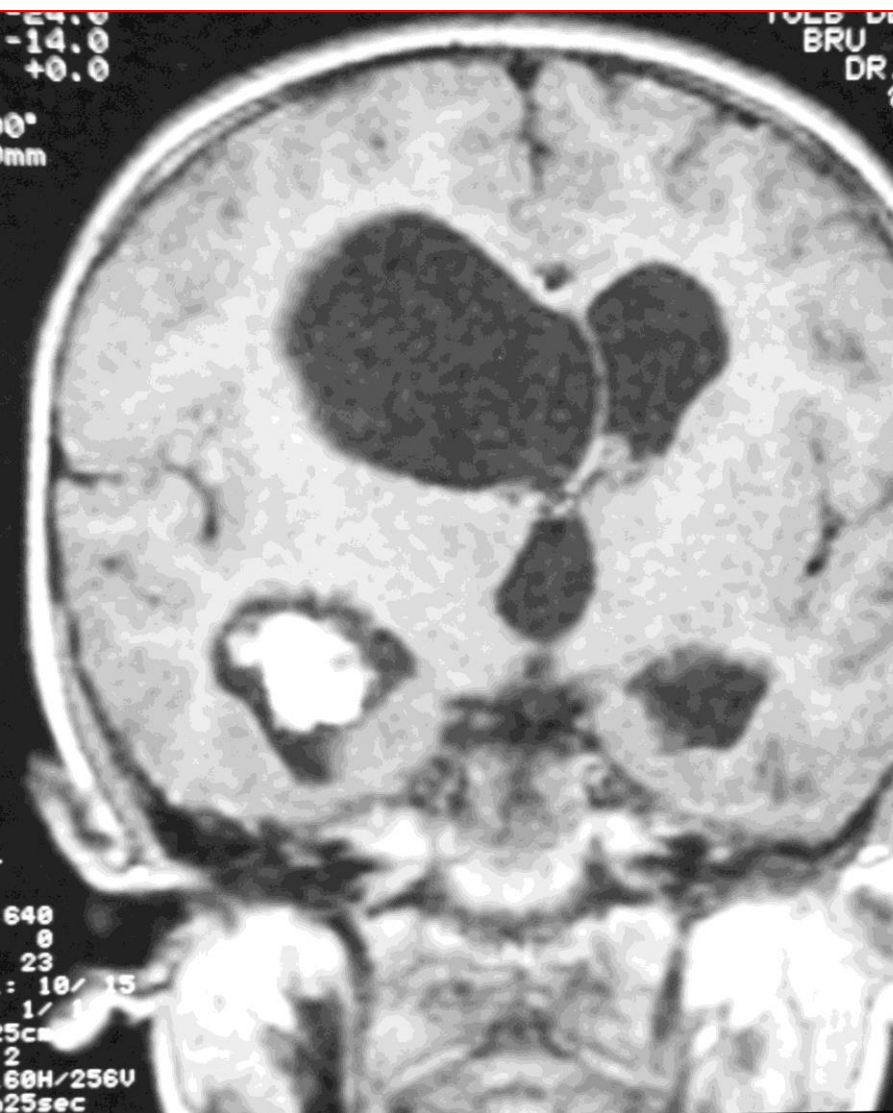
Obstructive

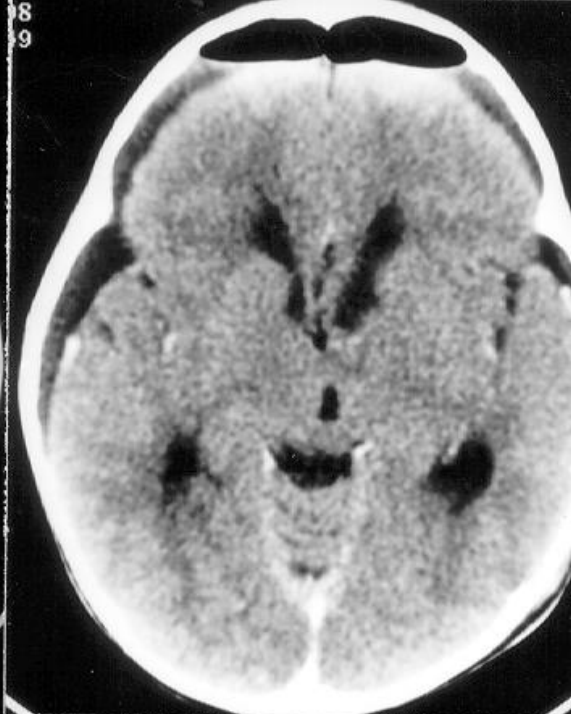


Communicating

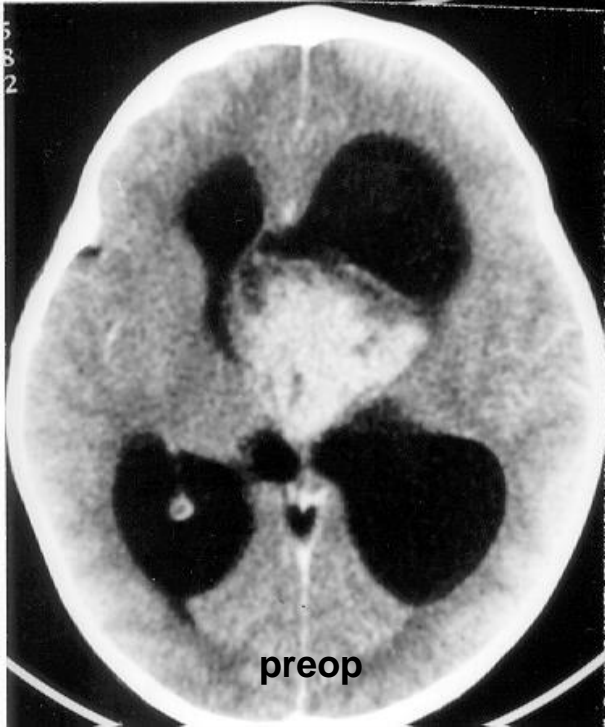
1yM Choroid plexus papilloma

3 years after surgery





Intraventricular A1
with blocade of the
foramen of Monro
M 32y



preop



postop

- **Brain Water/Edema:**

cerebral oedema = an excess of brain water

Types of brain edema:

1- Vasogenic: *excess fluid (protein rich)*

passes

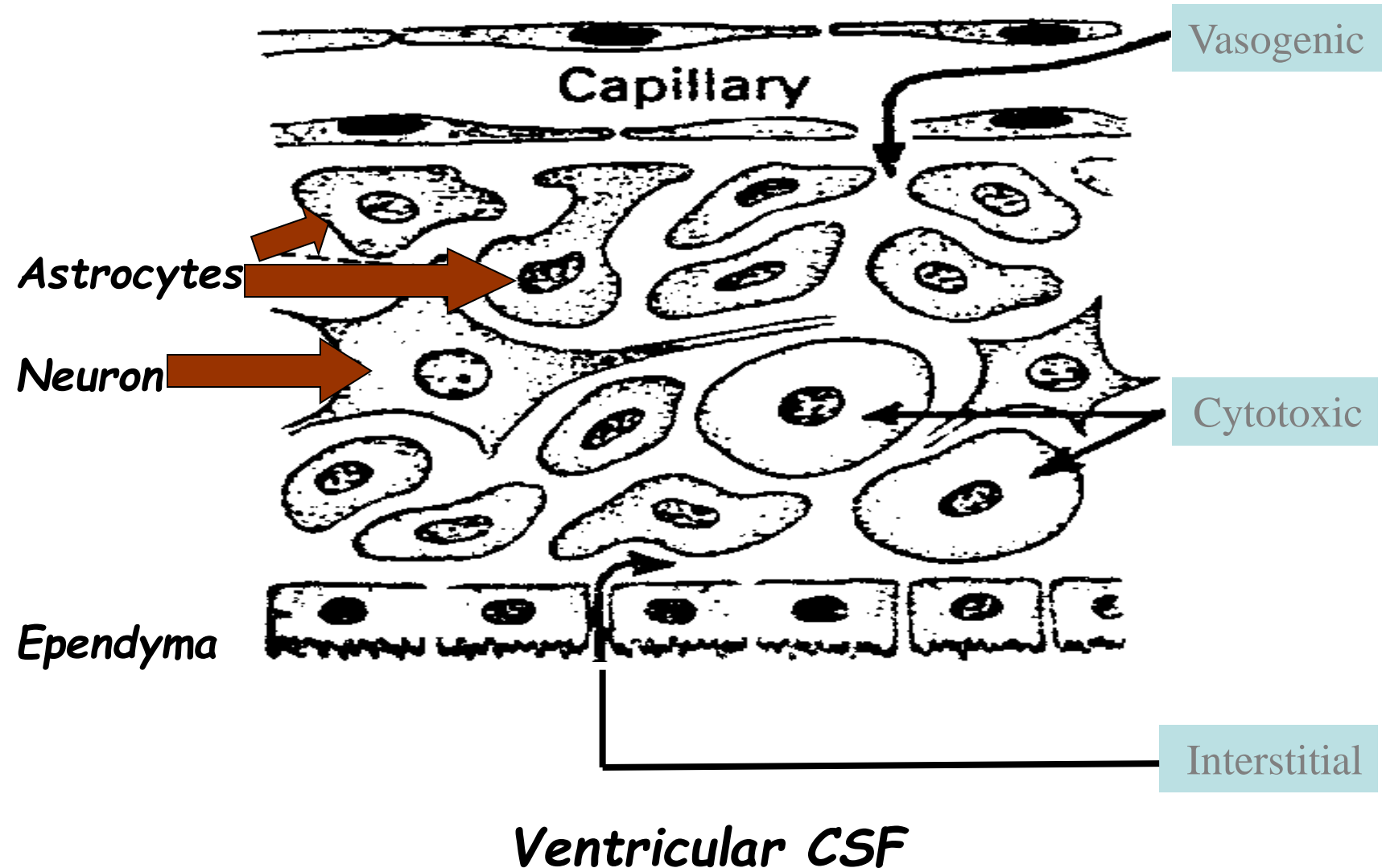
through damaged vessel walls to the extracellular space - especially in the white matter. The extracellular fluid gradually infiltrates throughout normal brain tissue towards the ventricular CSF and this drainage route may aid clearance. E.g. adjacent to tumor, abscess

2- Cytotoxic: *fluid accumulates within cells – neurons and glia i.e. intracellular. e.g. **toxic or metabolic states.***

3- Interstitial: *when obstructive hydrocephalus develops, CSF is forced through to the extracellular space especially in the periventricular white matter.*

* **With ischemic damage**, as cell metabolism fails, intracellular Na^+ and Ca^{++} increase and the cells swell i.e. **cytotoxic edema**. Capillary damage follows & **vasogenic edema**

Types of brain edema:



Measuring ICP

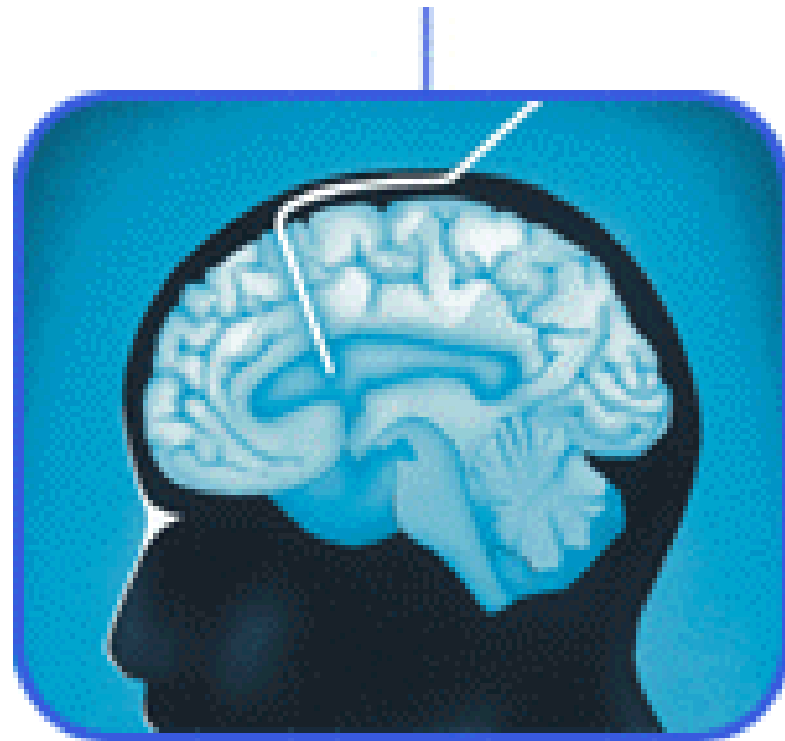


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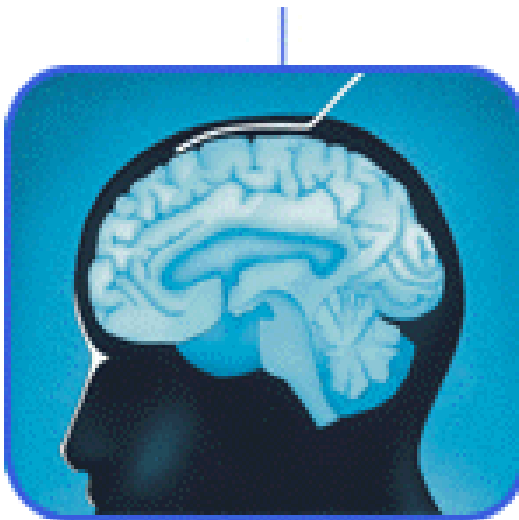
Measuring ICP 1

1. Ventricular catheter (EVD)

- accurate readings
- therapeutic option to drain CSF
- can measure compliance
- *need external transducer, frequent leveling



Measuring ICP 2

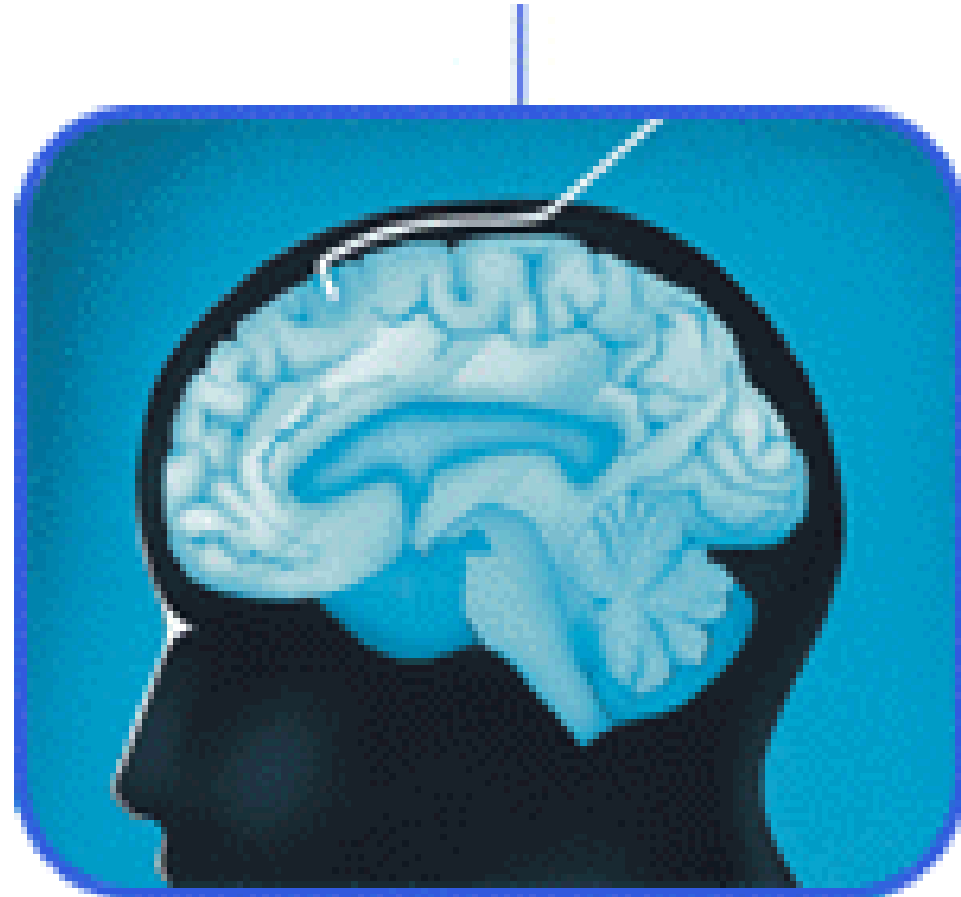


2. Epidural, subdural or subarachnoid catheter or bolt
 - Can place if ventricles collapsed, no penetration of brain required
 - *Tend to dampen, fail to transduce
 - *No access to drain CSF

Measuring ICP 3

3. Parenchymal catheter

- Transducer on fibreoptic catheter
- eliminates need to level a transducer
- *Unable to drain CSF, need to penetrate brain
- *concern re “drift”: cannot rezero while in situ

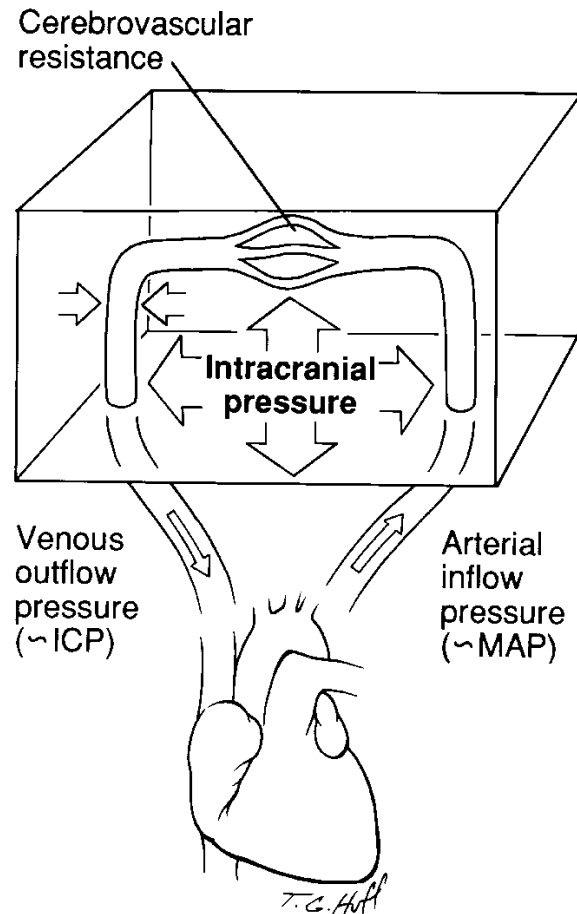


ICP monitoring in the ICU



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Cerebral Blood Flow (CBF)



CPP = Arterial inflow – Venous inflow

= MAP – ICP

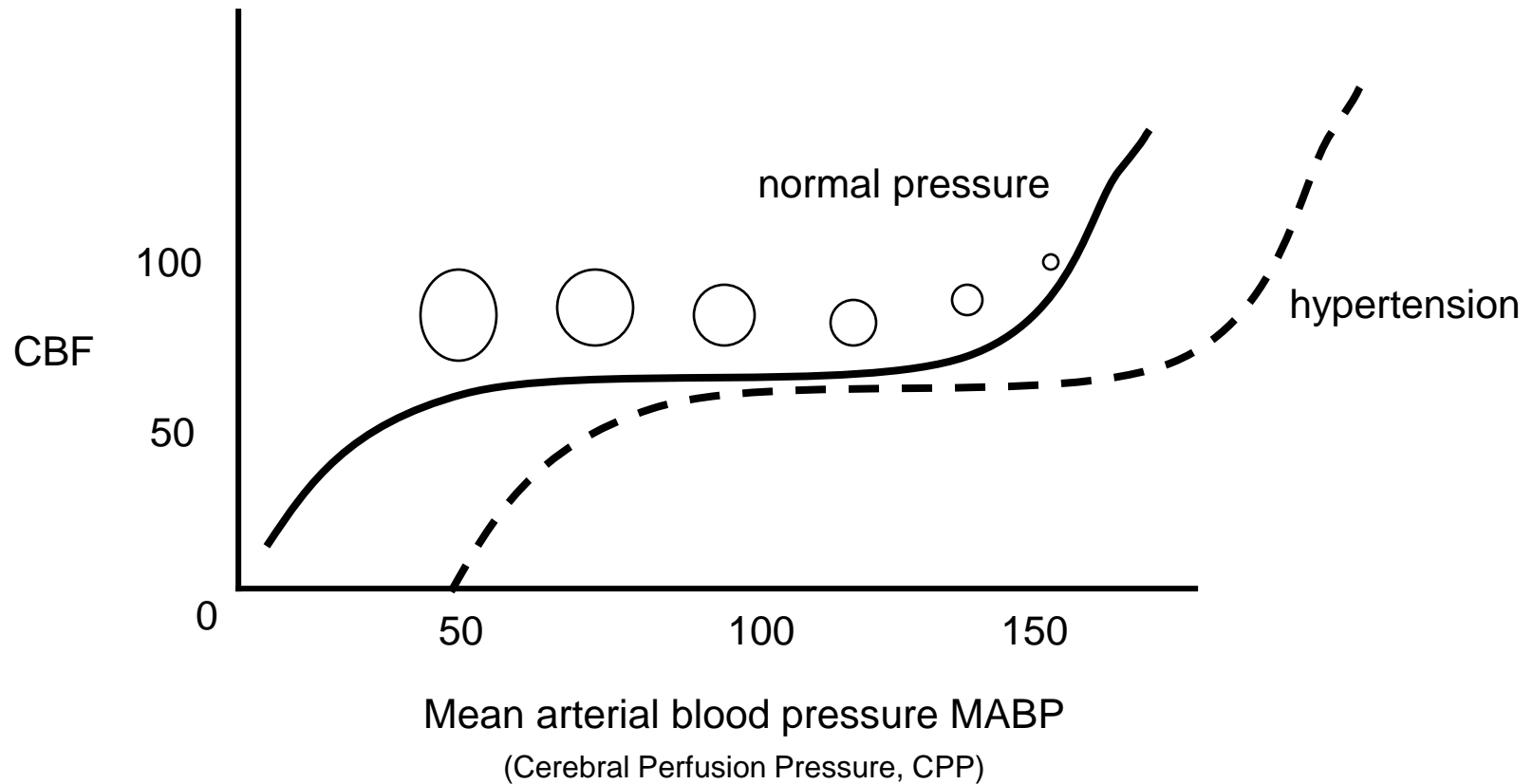
CBF * CVR = MAP - ICP

CBF = (MAP – ICP) / CVR

- **normal = 40-60 ml/100gm/min**
- **Symptoms = 20-30 ml/100gm/min**
- **EEG = 16-20 ml/100gm/min**
- **Na-K = 10-12 ml/100gm/min**
- **Complete = <10 ml/100gm/min**

Regulation of CBF 1

Autoregulation



Regulation of cerebral blood flow 2

Chemical regulation

- CO_2 is the most effective determinant of CBF
(PaCO_2)
- O_2 PaO_2 (<60mmHg) results in vasodilation, PaO_2 (>400mmHg) causes vasoconstriction
- pH ↓ (acidosis) elicits vasodilation, pH(alkalosis) elicits vasoconstriction

Signs & Symptoms of ↑ICP

SYMPTOMS

- Headache
- Nausea
- Vomiting (morning)
- Blurred vision
- Diplopia

SIGNS

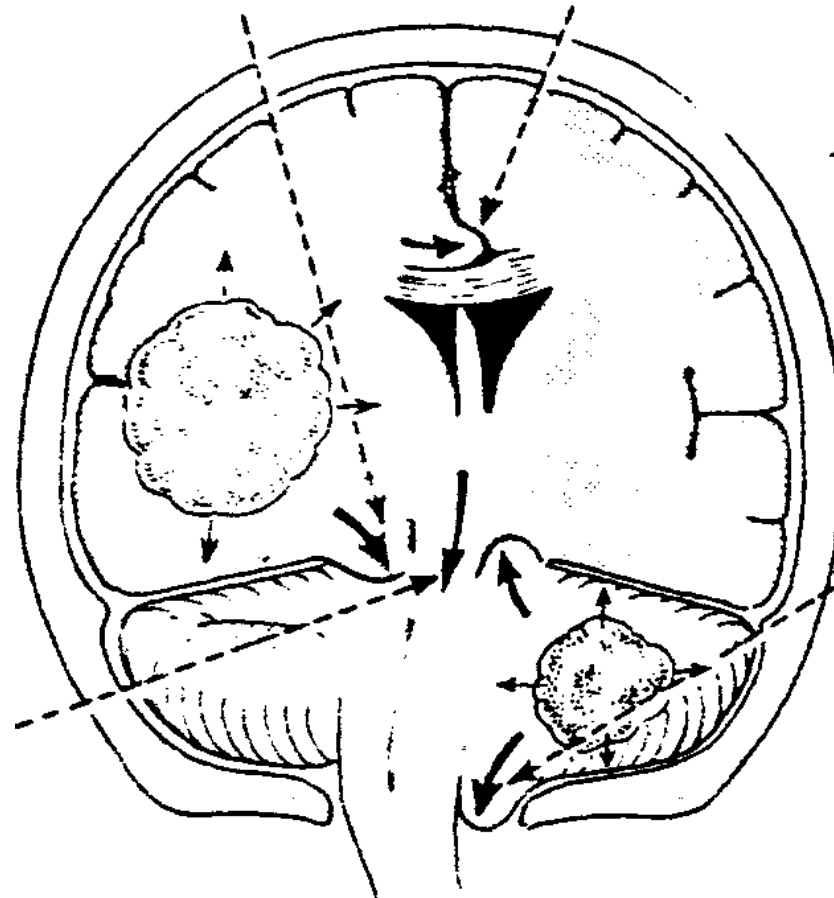
- Progressive focal deficit
- Deterioration in LOC
- VI Nerve palsy
- Papilledema
- Pupillary changes-size, reactivity
- Abnormal posturing
- Changes in vital signs
 - Bradycardia
 - Arterial HTN

Types of Brain Shift

Tentorial herniation (lateral).

Subfalcine herniation

Tentorial herniation
(central).



Tonsillar herniation.

NB: Unchecked lateral tentorial herniation leads to central tentorial and tonsillar herniation, associated with progressive brain stem dysfunction from midbrain to medulla.

Management of ↑ ICP (brain)

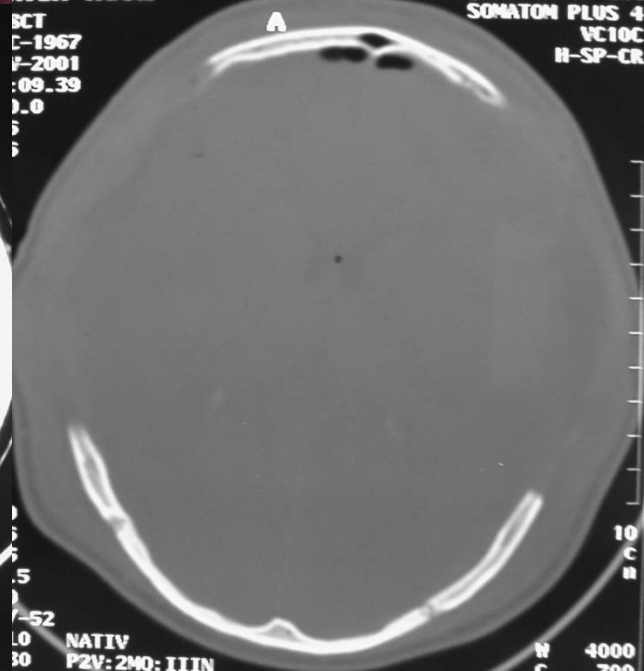
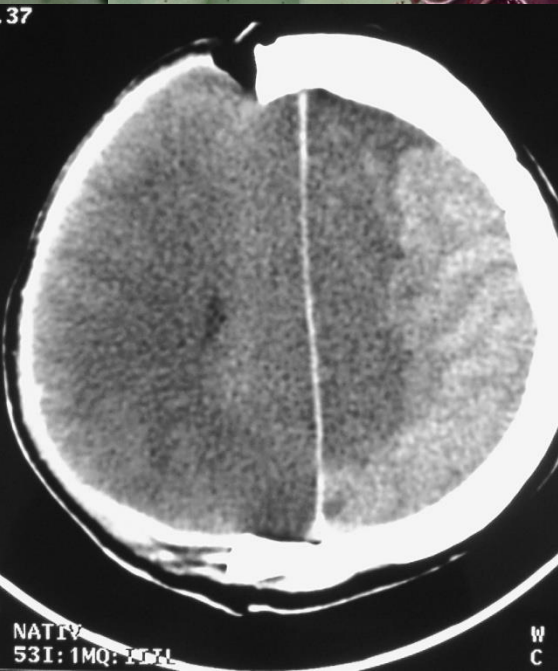
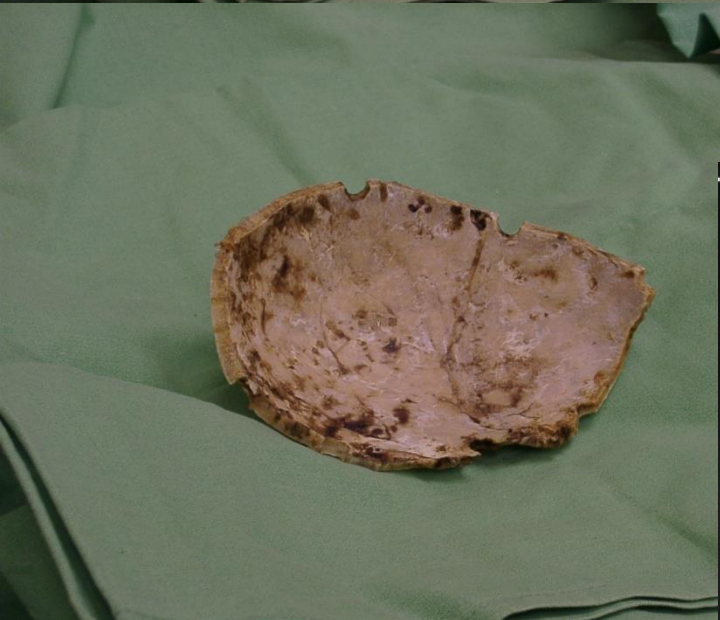
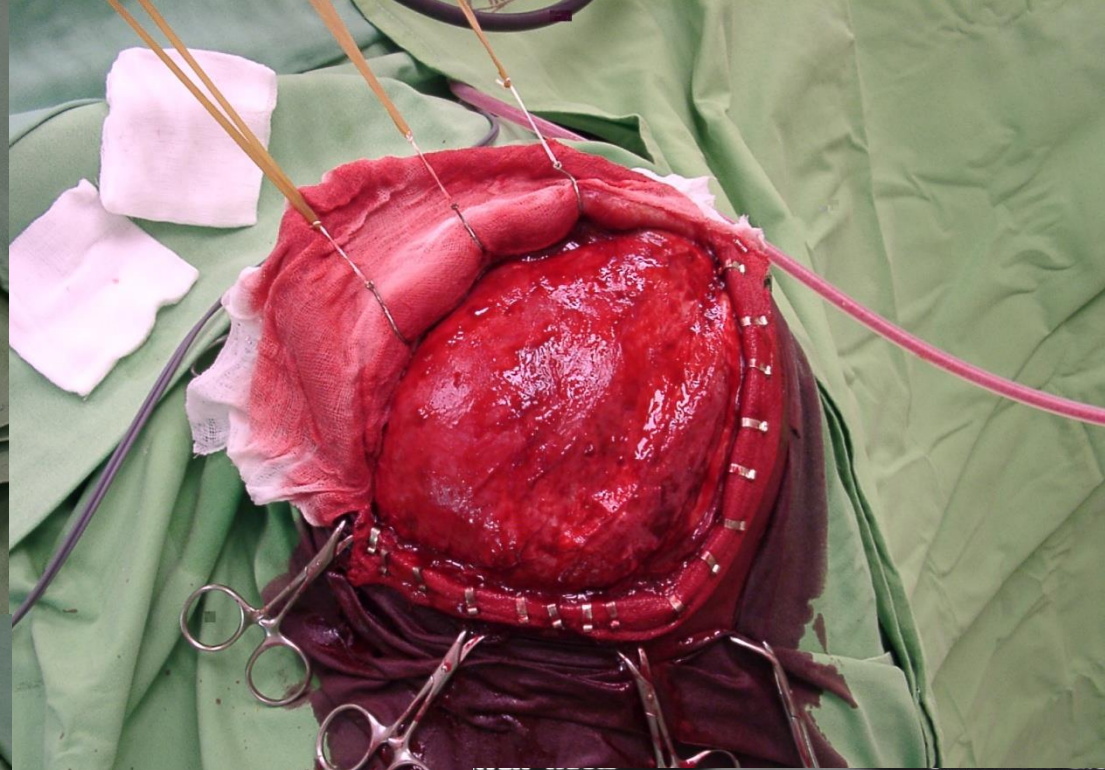
- Decrease edema
 - Mannitol (0.5-1G/kg), hypertonic saline
 - Monitor electrolytes, osmolality (aim <320)
 - Aware of “rebound”
 - Dexamethasone (tumors, abscess, NOT stroke)
 - Furosemide (Lasix)
- Surgical decompression/evacuation
- Decompresssive craniectomy
- CSF drainage procedure

Decompressive craniectomy

- **Cushing H:** The establishment of cerebral hernia as a decompressive measure for inaccessible brain tumors: with the description of intermuscular methods of making the bone defect in temporal and occipital regions.

**Surg Gynecol Obstet 1:297314,
1905**



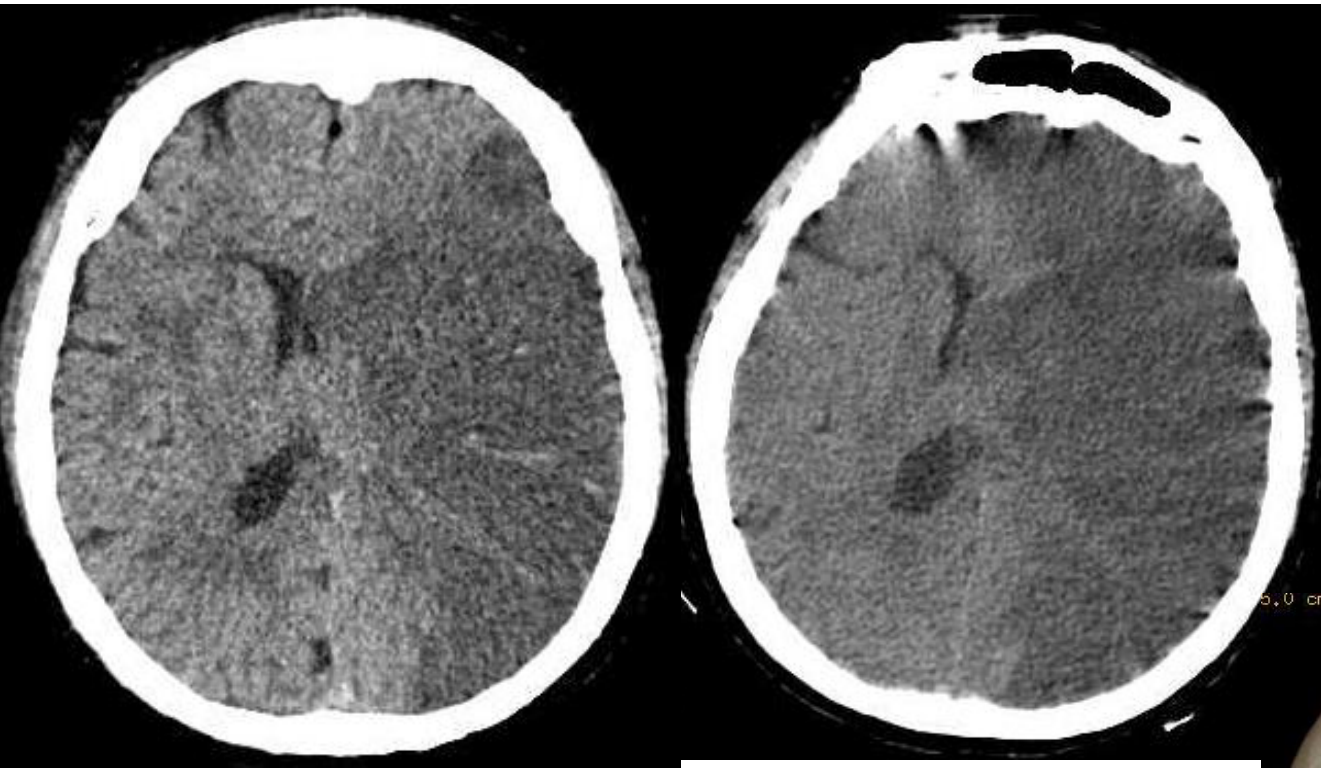


Decompressive craniectomy

Protection after bilateral decompressive craniectomy

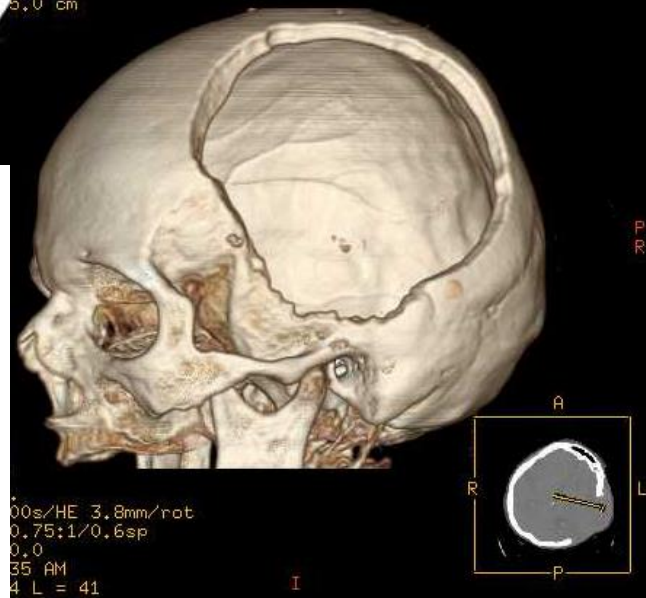


66y F acute stroke (total occlusion of left MCA)



Jan 27, 2015

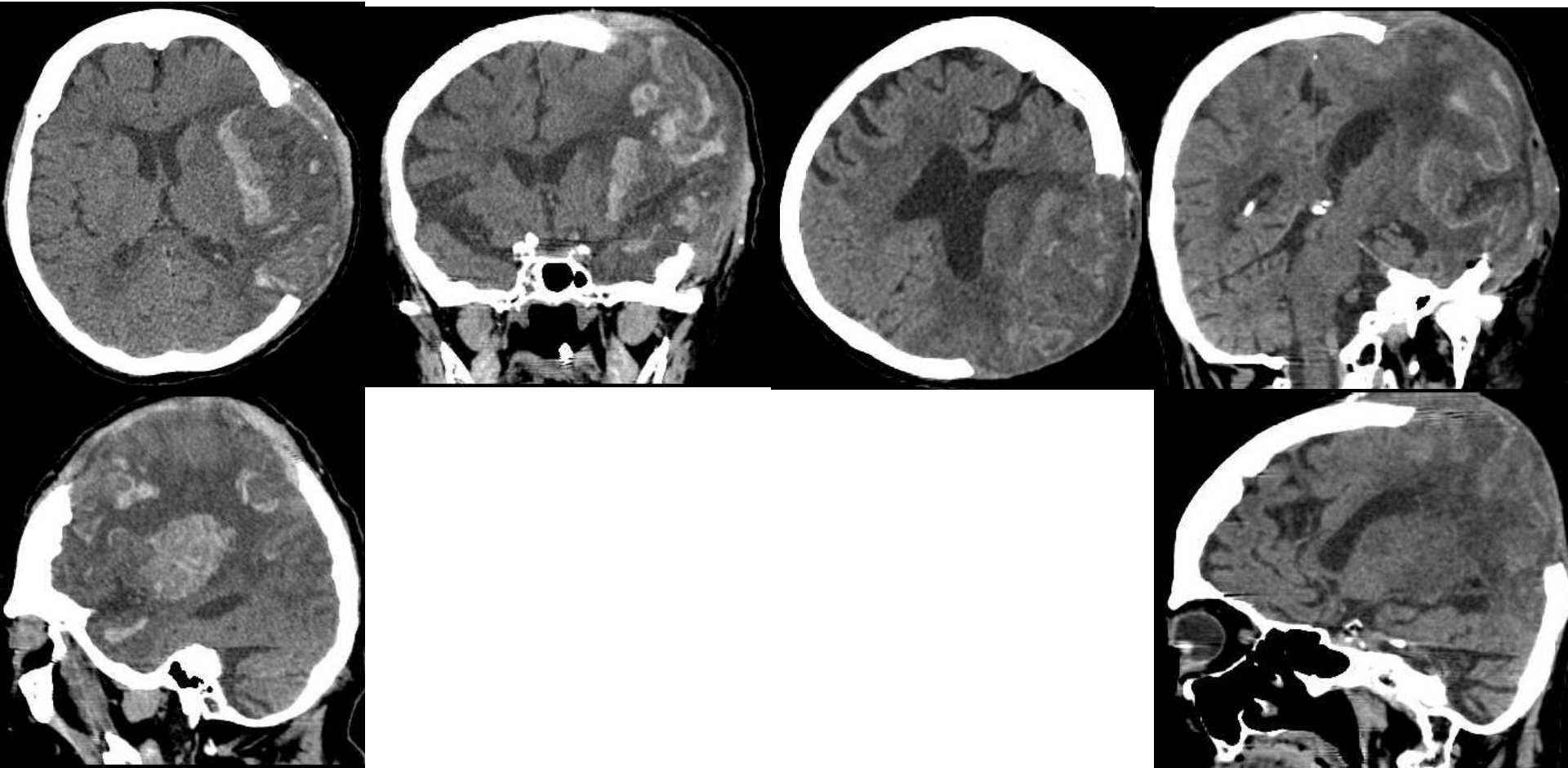
Jan 29, 2015



66y F acute stroke (total occlusion of left MCA) cont.

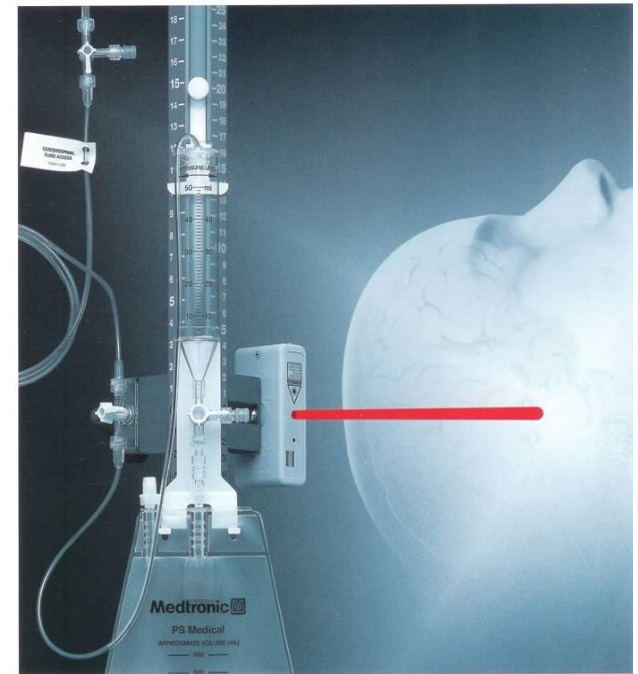
Feb 5, 2015

Feb 11, 2015 at discharge



Management of \uparrow ICP (CSF)

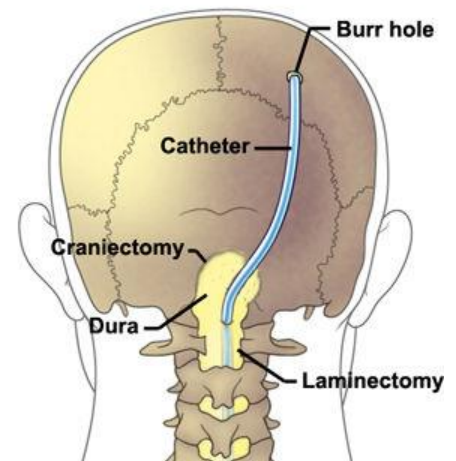
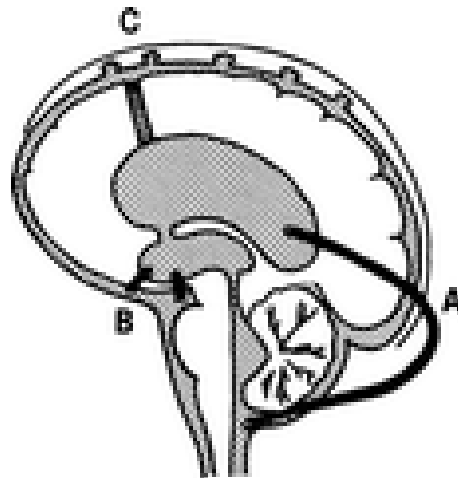
- ◆ Divert CSF to lumbar spine...HOB elevated
- ◆ *Divert CSF* out of body with ventricular drain
- ◆ Acetazolamide to decrease production



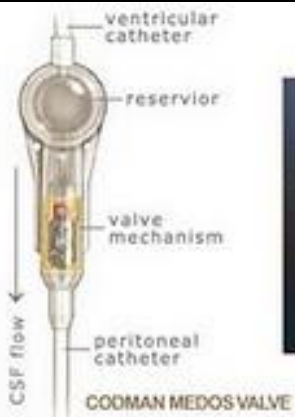
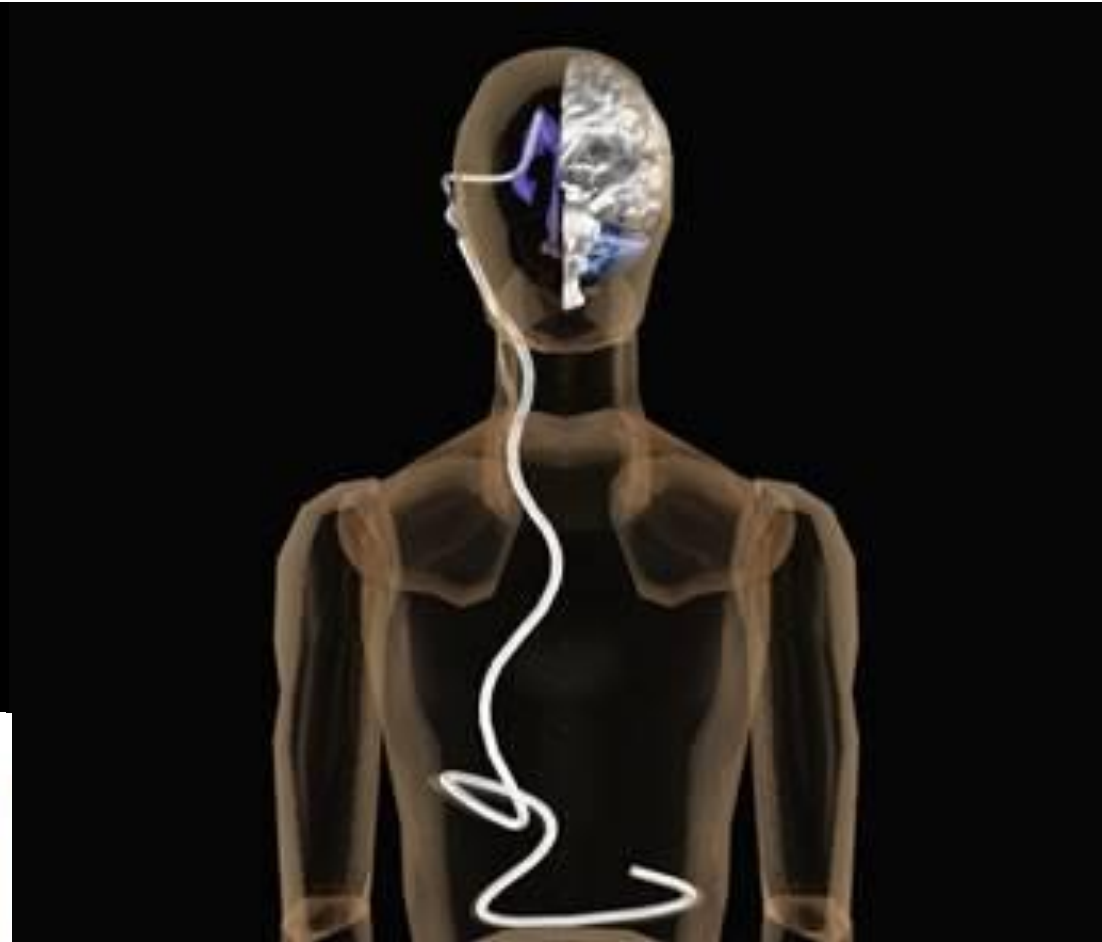
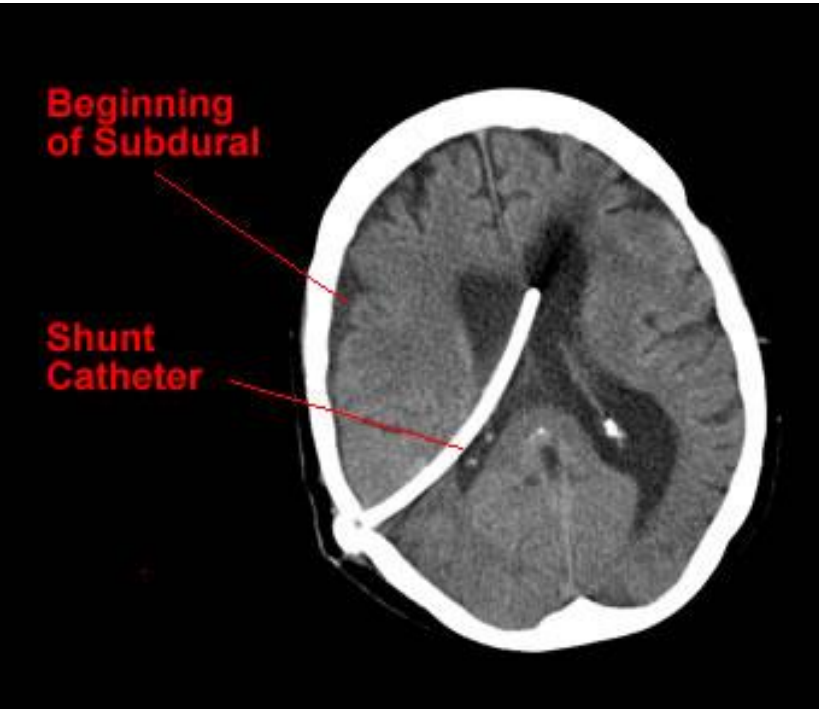
EFFICIENCY, SIMPLICITY, AND ACCURATE CONTROL

CSF diverting methods

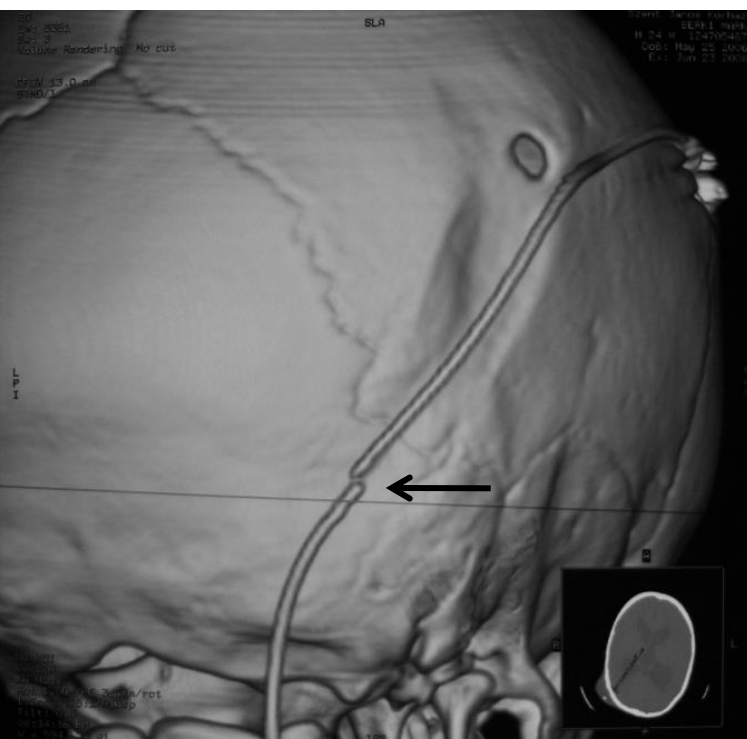
- Arne Torkildsen 1899-1968
 - Norwegian neurosurgeon (Oslo)
 - Ventriculo-cisternostomy
 - 1937- first 4 operations
 - 1939- published
- 1949- first in Hungary (Zoltán László OH)



Intracranial shunts



3D CT imaging of shunts



Thank you for your attention !

