Raised Intracranial Pressure

Objectives:

Not Given.

Resources:

- Davidson's (Chapter 24 pg 462).
- 436 doctors slides.
- 435's teamwork.
- Surgical Recall.

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Color index:

Notes , Important , Extra , Davidson's

Editing file

Feedback

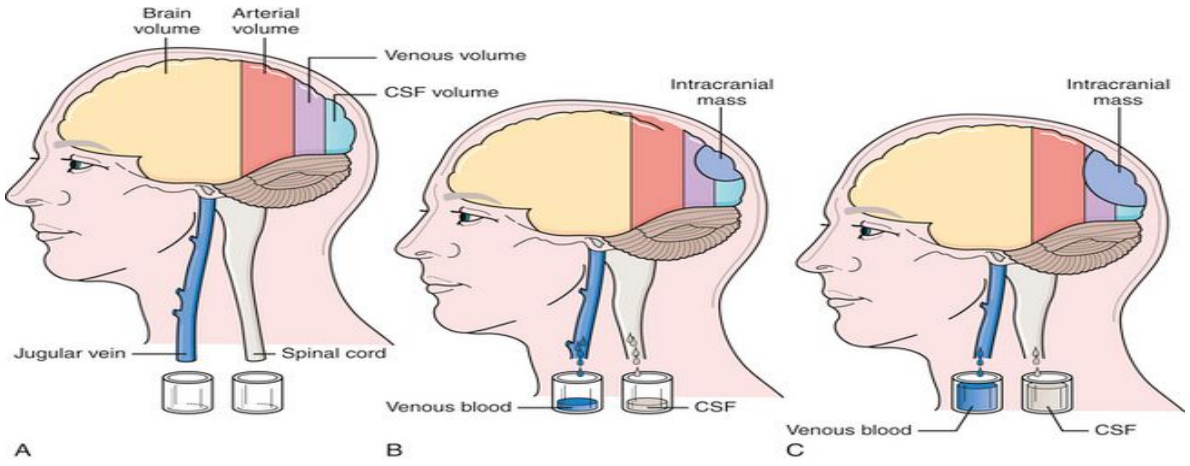
IntraCranial Pressure (ICP)

Basics

- The brain is enclosed within a rigid bony container (the skull which is a closed cavity; like a box). Intracranial pressure (ICP), therefore, depends on the relative volumes of **components of cranium:**
  1. Brain parenchyma = **1400** ml
  2. CSF = **75-100** ml
  3. Blood = **75** ml
- These contents are in constant **balance**. If one constituent increases, then another must decrease; this is the essence of the **Monro-Kellie doctrine**.
- ICP fluctuates in response to normal variations in intrathoracic pressure (e.g. increased by coughing, sneezing and defecation) and cardiac pulsation.These transient increases do no harm.

Monro-Kellie Doctrine:

- It states that the volume of blood, brain, and cerebrospinal fluid within the cranium must remain constant for ICP to remain constant. If an additional substance, such as an expanding hematoma, is added, the ICP will increase unless a compensatory amount is removed.
- These contents are incompressible[1]. Most of the contents of the brain (CSF, blood, and the brain cells) are basically water & water isn't compressible, so pressure on the brain itself won't compress it or the other structures, they will just move from one area to another.
- Therefore, change in the volume of the brain (eg: mass, or abscess) is associated with change in CSF or blood volume as compensation → such as ↓ CSF production or ↑ venous drainage.
- The blood pressure (normally 120/80) pumps the blood into the cranial cavity, and any increase in blood pressure needs to be accomodated.



Pressure-Volume

- **Increase in volume** in one compartment leads to **change in volume** in the other ones, for example brain tumor (which is an increase in tissue volume) leads to **decrease** in CSF volume → **decrease** in blood volume. By increasing venous drainage to compensate.
- For how long could this go on? It depends on how fast it develops (if slow it has time to compensate but if very fast the system might struggle)

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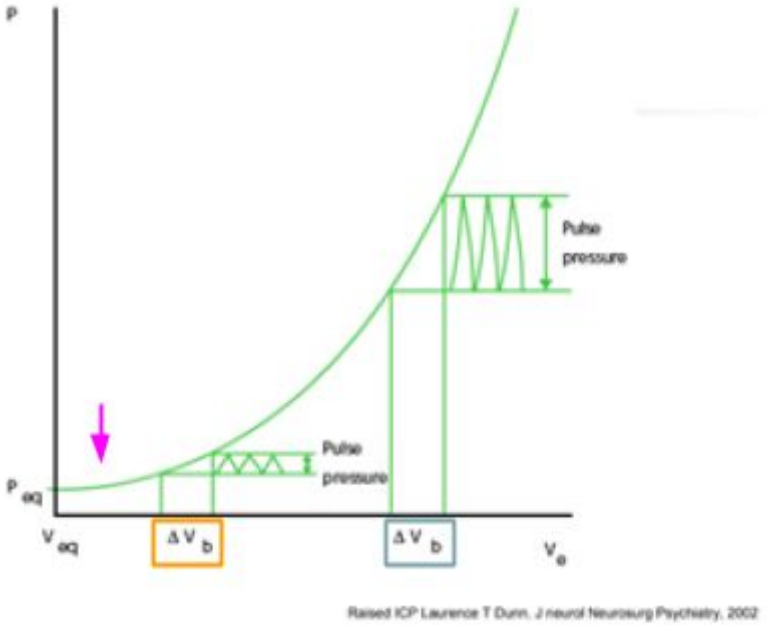
[1]What is a compressible substance?لو في كرتون فاضي وشاغل مساحه من المكان، لو ضغطت عليه وأصبح مصطح ال (فوليوم) حقه في المكان اختفى
Air is compressible, but water is not. So if I have an empty container that is occupying a space and I put pressure on it I will be able to shrink it. But if it was filled with water, it can't do that. I can't compress the water it has to go somewhere else. The same concept applies to the brain because it is made up of water; when there is pressure it can't compress so it will simply try to move to another place.

Pressure-Volume Curve

It is important to understand the pressure volume curve: (x-axis is **volume** and y-axis is **pressure)**. Keep in mind that they do not have a linear relationship (the graph is a **curve** NOT a straight line).
Basically when the volume increases the pressure also increases:

- ★ At first when the volume changes for example in patients with intracranial **mass lesions** (Tumour, haemorrhage), **oedema** or **CSF obstruction** there is only a mild change in pressure because there is compensation by a reduction in cerebral blood volume and CSF volume. (so the patient may only have **headache** or **nausea**).
- ★ However, a critical point is reached where no further compensation is possible, and any additional volume insult or any small change in volume will lead to exponential/rapid rise in intracranial pressure.
- ★ Example: a brain tumor that is slowly growing, the tumor might bleed. This small change in volume may cause **loss of consciousness**.
- ★ Another example is abscess formation followed by abscess encapsulation[2] within the head then gradually edema starts to build up. Little increase in the amount of edema is associated with a sudden massive increase in the pressure & the patient collapses.



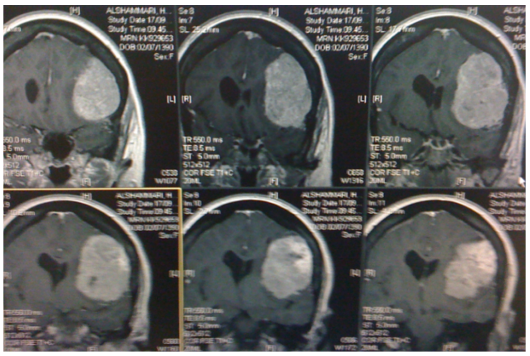
Raised ICP Laurence T Dunn. J neurol Neurosurg Psychiatry, 2002

So **1 unit of volume** increase can cause no change in pressure in the beginning (left) of the curve, small change in the middle of the curve and a large change in the pressure at the right of the curve.

Why is it important? Because patients may present in the early stages (with only headache for example), but the CT or MRI shows a large mass effect. (you don't know where the patient is on the curve)

Can somebody walk around with a raised Intracranial Pressure (ICP)? YES

- If the raised ICP is chronic then there may be few clinical signs or symptoms. A rapid increase in ICP may precipitate acute reduction in conscious level. Therefore, the **rate of increase** in the volume of intracranial mass is crucial.
- With more chronic slow-growing lesions such as brain tumours, abscesses or congenital abnormalities, extraordinary degrees of compensation can occur.
- In some situations, even massive lesions can lead to minimal symptoms and signs, despite brain herniation.



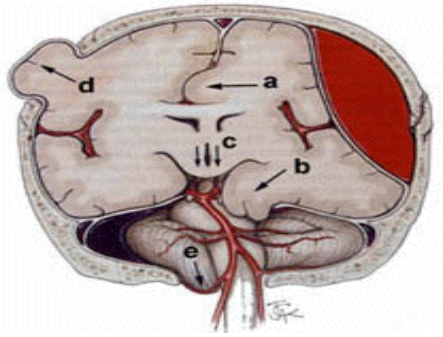
These images are from my patient, a 35 y/o female complaining of numbness and slight weakness in the right side of the body: upper & lower limbs
The scan shows a large tumor (meningioma). The tumor slowly grows which provides the chance for the brain to compensate.
We can also see midline shifting (the falx should be in the middle & septum pellucidum is supposed to come in the midline) due to the mass effect.

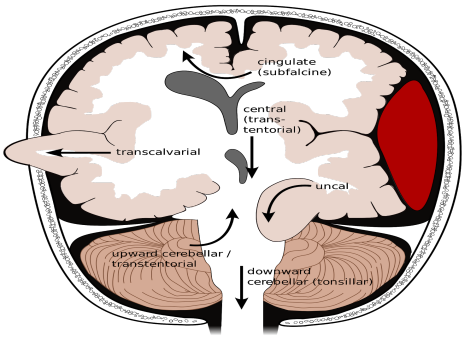
[2] تغليف

Brain Herniation Syndromes Video(14:48)

Raised Intracranial Pressure (ICP) and brain shift "herniation":

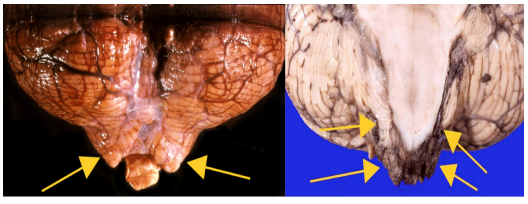
- Generalised or localised increase in ICP can lead to marked displacement (herniation) of intracranial structures causing blood vessel compression, further compromising brain perfusion.
- We agreed that if we apply pressure to the brain, the brain will find another place to go to. It will herniate.
- Herniation is defined as content of one compartment moving (exiting) from its original compartment to another compartment.
- Types of herniation (*they are labeled according to the first image*):
  For better understanding of the types of herniation click here to review some neuroanatomy.





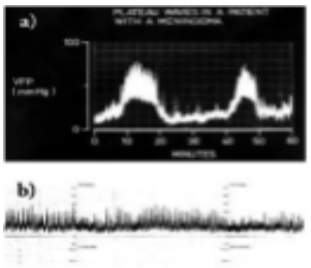
a	**Cingulate herniation** aka **(Subfalcine)**	With a parasagittal mass, the ipsilateral cingulate gyrus may herniate beneath the free edge of the falx cerebri.
b	**Uncal herniation** aka **(Transtentorial)**	With large ipsilateral brain lesions, the medial part of the temporal lobe (the uncus) is pushed down through the tentorial notch to become wedged between the tentorial edge and the midbrain. The uncus is close to the brainstem so it may push it as well. It is **common** with a common problem called (epidural hematoma) which usually occurs when a middle-aged person falls and breaks their skull. This injures the middle meningeal artery which bleeds and starts accumulating blood within the space & it pushes the dura & brain until the pressure inside equalizes the pressure within the artery & then it stops. **Simply:** epidural hematoma is arterial bleeding from skull fracture.Why it is important with uncal herniation? Because of the site of the bleed. The middle meningeal usually affected by fracture of temporal bone & then the bleeding pushes the temporal lobe which pushes everything towards midline. If we catch it early and evacuate the hematoma we can prevent this & pt can go home.
c	**Central herniation**	A pressure comes from above and pushes the center of the brain down into the tentorial hiatus.
d	**Outside herniation** aka **(Transcalvarial)**	After trauma there will be a skull fracture and the brain content can herniate outside of the skull.
e	**Tonsillar herniation** aka **(Foraminal)**	Very **common**. Can happen with mass lesions of the posterior cranial fossa,or when lumbar puncture is performed on someone with high intracranial pressure.

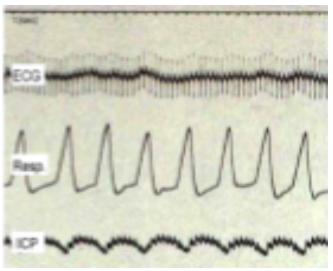
Tonsillar herniation: (you can see that the tonsils are not round but are flat peak/pointed tip) pt most likely had extensive bleeding and edema. The tonsils go down into the foramen magnum and compress the upper part of the cervical cord and result in **weakness** and **decreased/compromised breathing**.



Can we measure the ICP?

Yes ICP can be measured using a probe (catheter) inserted through an opening in the skull which will record **Intracranial Pressure (ICP)** as **waveform ----------->** (they appear as waves because it is a reflection of the blood pressure coming from the heart).





Normal Intracranial Pressure (ICP):

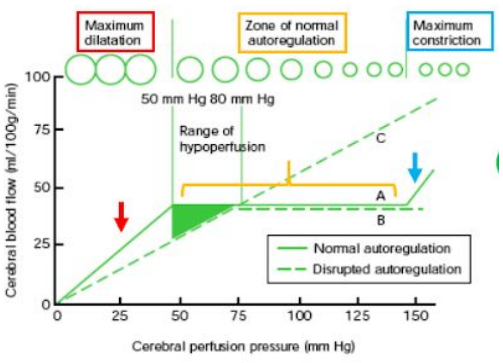
- Adults **<10 -15** mm Hg
- Children **3 - 7** mm Hg (because they have a softer brain)
- Term infants **1.5 - 6** mm Hg (much less than adults because the skull sutures are not fused, so with raised ICP Infants may have large head because the head expands to accommodate the pressure, but they are still conscious)

Cerebral Autoregulation

- The brain is the jewel of the body so it needs to be protected. If the BP is is too high (ex: when you're angry) or too low (ex: if you are dehydrated or blood loss) this will affect the blood reaching the brain (cerebral perfusion). Therefore it needs to be controlled.
- Ability of cerebral vessels to maintain cerebral perfusion within strictly determined limits:
  - **Rise** in SBP[3] will lead to → **Constriction** of cerebral arteries[4].
  - **Low** SBP will lead to → **Dilatation** of cerebral vessels to accommodate.
- Loss of autoregulation: Change in cerebral blood flow with the change in blood pressure (BP).
- Loss of regulation occurs due to trauma or tumors.

Blood Pressure (BP) and Cerebral Blood Flow (CBF):

- If Intracranial pressure (ICP) goes up, how does the brain get perfusion?
  Process of autoregulation:
  - Cerebral perfusion pressure **(CPP) =** Mean Arterial Pressure **(MAP) -** Intracranial pressure **(ICP)**[5]
  - If MAP=85 mmHg and ICP=15 mmHg then CPP will be = **70** (normal range= **50-140** mmHg, we want to keep the perfusion between **60 and 70**)
  - We can measure the blood pressure and ICP to make sure the brain is receiving enough flow, and if needed we can adjust it → For example, you can increase the mean arterial pressure by giving epinephrine or dopamine. And you can control the ICP by draining CSF. If MAP increases, the ICP should increase to accommodate.



- The green line represents the **cerebral blood flow** & it is constant; always you have the same constant amount of flow of blood no matter the pressure outside.
- **Cerebral blood pressure** is variable, let's say from 50 to 150. But any pressure value within this range will result in same amount of blood flow.
- Pressure below this range would result in maximum **dilation** of blood vessels to allow more blood flow
- If above the limit you would get maximum **constriction**.

[3] Systolic Blood Pressure
[4] Because if the pressure is too high the brain might bleed & result in loss of the consciousness.
[5] You should know how to use this formula to calculate ICP or optimal cerebral perfusion pressure.

Example:
20 year old man, had car accident (MVC) as unrestrained driver. He presented with Blood Pressure (BP) of 75/30 (low) and Heart Rate (HR) (high) of 125 bpm. Unconscious, with right hemiplegia.
What is going on?
This pt has raised ICP due to unconsciousness & hemiplegia -> indicates mass compressing the brain (most likely hematoma) - Brain can not survive without enough blood
So, correcting the blood pressure is your **first priority** even before surgery to maintain cerebral blood flow.
What to do? → ABC
1) **A**irway & cervical spine protection with collar: will need intubation[6] since pt is unconscious
2) **B**reathing: check for chest movement, air reaching both lungs, saturation.
Chest tube is inserted in cases of pneumothorax
3) **C**irculation: 2 large bore IV lines & start IV fluid (we have to elevate the BP!) & blood if needed
4) **D**isability: CT to ensure no hematoma after stabilization.

Raised IntraCranial Pressure

I. Possible Causes:

★ **VITAMEN D** (a mnemonic, no actual relation with vitamin D).

- **V**: Vascular
- **I**: Infection
- **T**: Trauma
- **A**: Autoimmune
- **M**: Metabolic
- **E**: Endocrine
- **N**: Neoplastic
- **D**: Drugs

Other Causes: ----------->

Table 2 Examples of causes of raised intracranial pressure

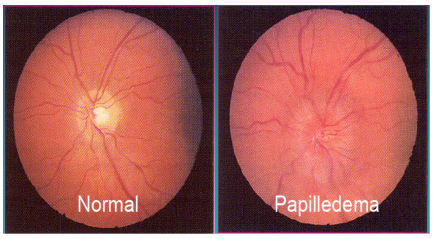
Pathological process	Examples
Localised mass lesions	Traumatic haematomas (extradural, subdural, intracerebral) Neoplasms (glioma, meningioma, metastasis) Abscess Focal oedema secondary to trauma, infarction, tumour
Disturbance of CSF circulation	Obstructive hydrocephalus Communicating hydrocephalus
Obstruction to major venous sinuses	Depressed fractures overlying major venous sinuses 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

(arranged according to the structure within the cranium "anatomical features")

II. Clinical Presentation of raised intracranial pressure (ICP)

Classic Triad: Headache, vomiting, papilloedema

- Headache[7]
  - Early morning[8] (symptoms are worse in the morning!)
  - Throbbing / Bursting
  - ↑ by sneezing, coughing: due to increase in intrathoracic pressure, decreased venous return from head, temporary increase in ICP
- Papilloedema (swelling or congestion of the optic disc)
  - Occurs due to interruption of venous drainage from the eyes.
  - Reliable but may **take several days**.
  - Associated fundal haemorrhage indicates acute and severe rise in ICP.
  - Obliteration to the margins, Dilation of the veins which become tortious & distended.



[6] Any pt that is unconscious or with GCS score of 8 or less needs intubation because they cannot maintain their airway.
[7] New onset headache after age of 40 is suspicious and needs further imaging.
[8] Because patient is supine when sleeping so the venous drainage decreases and ICP increases.

Neurological

If a 30 year old was ejected after a motor vehicle accident and after stabilizing and assessing him you found him to have a GCS of 8 → you need to check these:

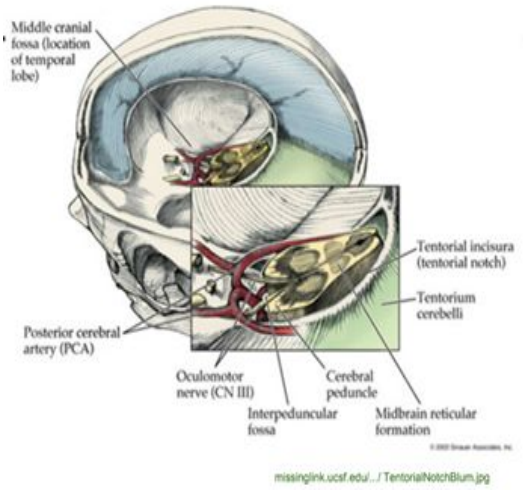
1) **Pupillary dilation** (Pupillary response)
2) **Hemiplegia**
3) Cranial nerve deficit

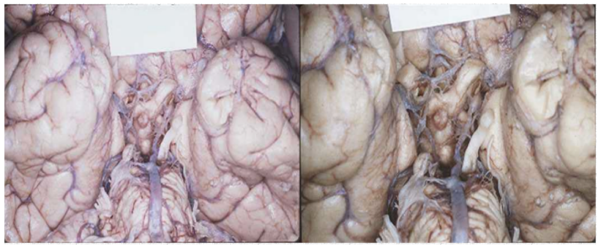
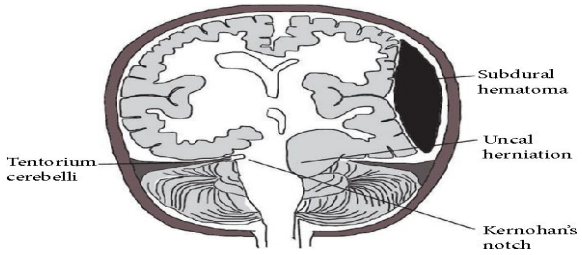
Why do pts w/ uncal herniation get dilated pupils or hemiplegia?

The temporal lobe is closely related to the edge of the tentorium & the midbrain. When the temporal lobe is pushed, it becomes close to the midbrain. So if the lesion is in the left side it will compress:

- the left side[9] of midbrain (which will cause **contralateral** (right side) hemiplegia or weakness because it is above the level of decussation) &
- 3rd nerve (resulting in 3rd nerve palsy → **ipsilateral** "left" dilated pupil)

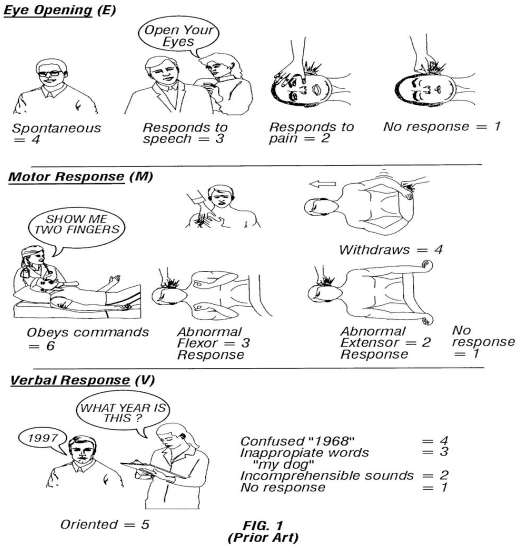
This is what we see **classically** but SOMETIMES there is a false localisation (Kernohan's notch) so instead of compressing the same side, all the structures will be pushed, then the opposite side will be compressed against the tentorium resulting in the **opposite manifestations** (contralateral pupil and ipsilateral hemiplegia). So we always need a **CT** to confirm the location of the lesion.



Trans-tentorial herniation	False localisation (**Kernohan's notch**)
- Ipsilateral dilated pupil - Contralateral weakness	- Contralateral dilated pupil - Ipsilateral weakness
	

Glascow coma scale (GCS)

- The GCS is a measure of conscious level that has greatly facilitated the classification and objective management of head-injured patients.
- Way of assessing coma state of patient (especially trauma pts) and relies on 3 components: eye opening, motor response, and verbal response.
- The lowest score is 3 (close to death) and the highest is 15:
  - From 3-8 → severe head injury (poor prognostic indicator)
  - 9-12 → moderate head injury
  - 13 & 14 → mild head injury
- When given a **scenario** you should know how to calculate the GSC.



[9] In the brainstem the ipsilateral side is compressed **BUT** the manifestation will be in the opposite contralateral side because of the crossing of the motor tracts.

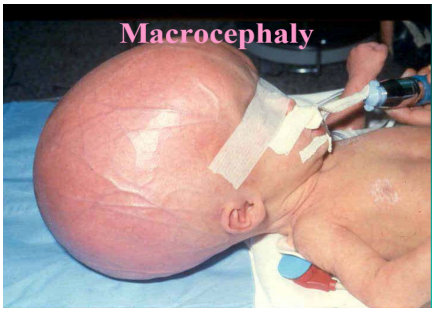
Glasgow Coma Scale Video(06:10)		
Eyes open	**Motor response**	**Verbal response**
• Spontaneously **4** • To verbal command **3** • To pain **2** • No response **1**	• Obeys verbal command **6** • Localises pain **5** • Flexion withdrawal **4** • Abnormal flexion (decorticate rigidity) **3** • Extension (decerebrate rigidity) **2** • No response **1**	• Oriented and converses **5** • Disoriented and converses **4** • Inappropriate words **3** • Incomprehensible sounds **2** • No response **1**

Systemic

- Reactive Raised BP → as compensation to increase blood flow to the brain (recall: CPP=MAP-ICP)
  Example: pt comes in with early intracerebral hematoma, they will have a very high BP (this is expected)
- Respiratory change (not common b/c pts are usually intubated) → Cheyne-Stokes breathing:
  - Oscillating[10] periods of apnea-tachypnea (alternating)
  - Respiratory in the brainstem centers are compromised
- **Cushing's triad**: increase BP (to overcome ICP), bradycardia, lower respiratory rate.

III. Raised Intracranial Pressure in Infants

- Widened sutures.
- Increased Head circumference (if you decrease the pressure the size will go back to normal).
- Dilated head veins.
- "Sunset" eyes (the eyes are looking down)



IV. Investigations

- Ideal imaging for the brain is **MRI** but in trauma we need something quick, so URGENT **CT** for the head is the investigation of choice (it can also detect skull fractures).
- **NO** Lumbar Puncture! (Even if they present with signs & symptoms of meningitis) because when we take out the CSF for a sample the pressure in the spinal column drops and the brain will herniate to the area with less pressure. Patients may **die on the spot!**

V. What is the treatment of high Intracranial Pressure ? Basically treat the **cause.**

General measures to reduce the ICP (we do all of these to patients with ICP if there is no contraindication)**:**

- Head **elevation** (30 degrees) → to improve the venous drainage.
- **No** neck compression (make sure collar is supporting but not tight or squeezing the neck).
- **Mannitol** (osmotic diuretics) for patients who have decreased level of consciousness LOC (or Furosemide).
- Steroids (**Dexamethasone**) for **tumors** only! If it's **trauma** steroids are **contraindicated**.
- **Hyperventilation**[11]: controlled to PCO2 35-40 mmHg.
- Sedation, muscle relaxants, hypothermia → lowers metabolic rate and demands
- Barbiturates: **terminal** option if everything fails (rarely done, if nothing works you can induce coma).

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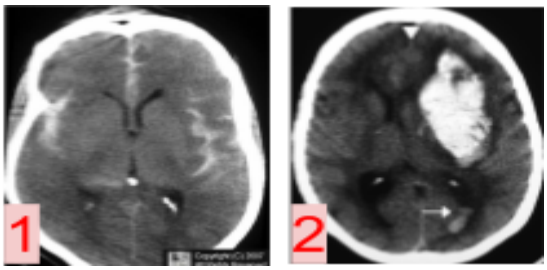
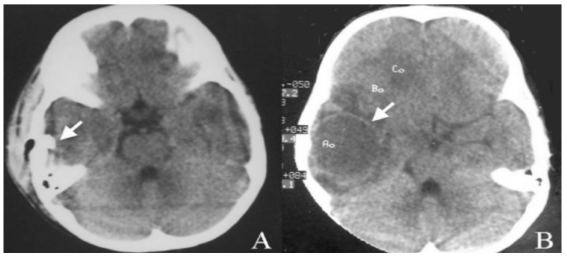
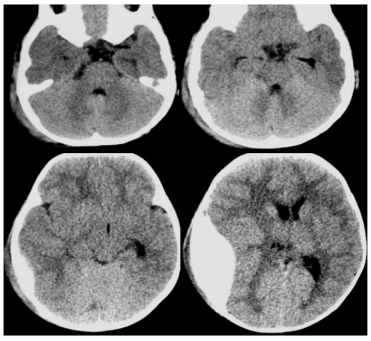
[10] فترات مختلفة

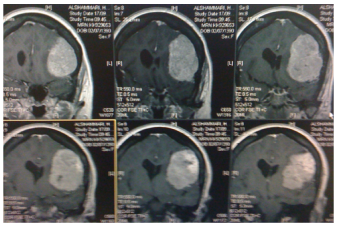
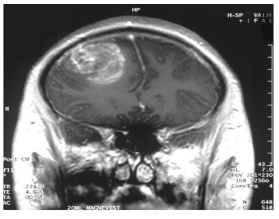
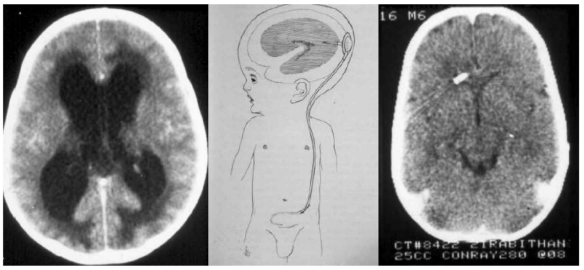
[11] When you hyperventilate you wash out CO2 which is a potent vasodilator. So when it goes out we get vasoconstriction, but you want to wash it out to a certain degree because you don't want too much vasoconstriction which will cut off the blood supply. So you have to maintain the CO2 concentration within the normal range.

Specific treatment:

★ Depends on the cause; **VITAMEN D.**

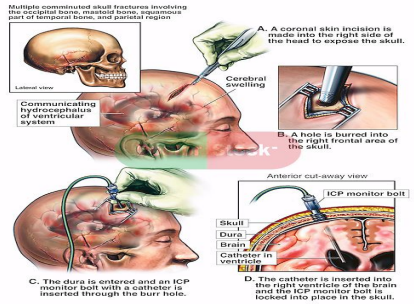
1- Vascular - SAH / ICH	2- Infection / Abscess
 **1.** Subarachnoid hemorrhage (the white is blood) **2.** Large intracerebral hematoma with midline shift Vascular causes need **evacuation**.	 The arrow shows an abscess (dead necrotic tissue) and the wall enhances with contrast "ring enhancement". Abscess should be **taken out / drained**.

3- Trauma: localised & diffuse		
a- Localized		b- Diffuse
Epidural Hematoma	Subdural Hematoma	
 Appears as lense shaped[12] and it has good outcome because the brain is normal.	 It is associated with brain injury so it has less favorable prognosis.	 Here there is diffuse axonal injury. The nerves in the white matter are subjected to trauma when there is acceleration-deceleration (brain shaking). When the fibers are injured we see them as petechial hemorrhages "**salt and pepper hemorrhage**" No midline shift Good ventricles ICP monitoring is useful

4- Tumors (need resection)		5- Hydrocephalus
Meningioma	Glioblastoma Multiforme	
The most common extra-axial tumor 	The most common intra-axial tumor 	 Increase in the amount of fluid within the ventricles leading to pressure effect on the surrounding brain & edema around the cortices. Treatment is **shunt**.

[12] Lens- shaped (biconvex) because the epidural space is a space that does not exist, the bleeding creates the space by pushing the dura until it hits the sutures where the dura is firmly attached, so it compresses the brain significantly.

Monitoring Intracranial Pressure:



- Can we monitor ICP? Yes.
- Should we monitor all patients? No it depends on the case:

We monitor a patient with petechial hemorrhage (diffuse injury). BUT a patient with epidural hematoma, for example, doesn't need monitoring; by the time you put a catheter in he will be dead. He needs head elevation, mannitol, hyperventilation and surgery (to evacuate the hematoma).

Recall: (EXTRA)

What is the Glasgow Coma Scale (GCS)?
GCS is an objective assessment of the level of consciousness after trauma.
What indicates coma by GCS score?
<8 (Think: "less than eight—it may be too late").
What does unilateral, dilated, nonreactive pupil suggest 'blown pupil'?
Focal mass lesion with ipsilateral herniation and compression of CN III
What do bilateral fixed and dilated pupils suggest?
Diffusely increased ICP.
What is the initial radiographic neuroimaging in trauma?
1. Head CT scan (if LOC or GCS < 15) 2. C-spine CT scan 3. T/L spine AP and lateral
Should the trauma head CT scan be with or without IV contrast? Without!
What is normal ICP? 5 to 15 mm H_2O
What is the worrisome ICP? > 20 mm H_2O
What determines ICP (Monroe-Kelly hypothesis)?
1. Volume of brain 2. Volume of blood 3. Volume of CSF
What is the CPP?
Cerebral **P**erfusion **P**ressure = mean arterial pressure—ICP (normal CPP is > 70)
What is Cushing's reflex?
Physiologic response to increased ICP: 1. Hypertension 2. Bradycardia 3. Decreased RR (abnormal breathing)
What are the three general indications to monitor ICP after trauma?
1. GCS <9
2. Altered level of consciousness or unconsciousness with multiple system trauma.
3. Decreased consciousness with focal neurologic examination abnormality.
What non operative techniques are used to decrease ICP?
1. **Elevate** head of bed (HOB) 30◦ (if spine cleared).
2. Diuresis-mannitol (osmotic diuretic), Lasix®, limit fluids.
3. Intubation (PCO_2 control).
4. Sedation.
5. Pharmacologic paralysis.
6. Ventriculostomy (CSF drainage).
What is the acronym for the treatment of elevated ICP? "**ICP HEAD**":
INTUBATE
CALM (sedate)
PLACE DRAIN (ventriculostomy)/ **P**ARALYSIS
HYPERVENTILATE TO PCO_2 approximately ≈35
ELEVATE head
ADEQUATE BLOOD PRESSURE (CPP> 70)
DIURETIC (e.g., mannitol)
Can a tight c-collar increase the ICP? Yes (it blocks venous drainage from brain!)
Why is prolonged hyperventilation dangerous?
It may result in severe vasoconstriction and ischemic brain necrosis!. Use only for very brief periods.

Summary

- The pressure in the skull is called the Intra-cranial pressure (ICP). The rigid bony framework enclosing the central nervous system means that any increase in mass content increases intracranial pressure (ICP).
- The ICP must stay balanced in order for the brain to survive.
- Cerebral autoregulation is the ability of cerebral vessels to maintain cerebral perfusion within strictly determined limits.
- Cerebral perfusion pressure **(CPP) =** Mean Arterial Pressure **(MAP) -** Intracranial pressure **(ICP)**
- Acute increases in ICP lower perfusion pressure and, if unrelieved, lead progressively to decreased coma score, herniation syndromes, hypertension, respiratory abnormalities (e.g. apnoea), and etc..
- Types of brain herniations :
  - ➔ Cingulate herniation
  - ➔ Uncal herniation (common due to epidural hematoma)
  - ➔ Central herniation
  - ➔ Outside herniation
  - ➔ Tonsillar herniation (very common complication of LP in pt with high ICP)
- The **principal symptoms** of raised ICP are **headache** (early morning and throbbing)**, vomiting and papilloedema.**
- They may also have neurological deficits such as: hemiplegia, pupillary dilation, and cranial nerve deficit.
- Signs: hypertension, bradycardia, lower respiratory rate (**cushing's triad**).
- INVESTIGATION OF CHOICE IS **URGENT HEAD CT!**
- **Treatment of high Intracranial Pressure**
  - ➔ **Head elevation** 30 degrees
  - ➔ **No neck compression** for patients who have decreased level of consciousness.
  - ➔ **Steroids** for **tumors** only! If it's trauma steroids are **contraindicated**.
  - ➔ Hyperventilation : controlled to PCO2 35-40 mmHg.
  - ➔ Sedation, muscle relaxants, hypothermia.
  - ➔ Barbiturates: terminal option if everything fails.
  - ➔ Then we do specific treatment depends on the cause; VITAMEN D.

Glascow Coma Scale		
Eyes open	**Motor response**	**Verbal response**
• Spontaneously **4** • To verbal command **3** • To pain **2** • No response **1**	• Obeys verbal command **6** • Localises pain **5** • Flexion withdrawal **4** • Abnormal flexion (decorticate rigidity) **3** • Extension (decerebrate rigidity) **2** • No response **1**	• Oriented and converses **5** • Disoriented and converses **4** • Inappropriate words **3** • Incomprehensible sounds **2** • No response **1**
Score: (3 lowest , 15 highest) **3**-**8** → severe head injury (poor prognostic indicator) / **9**-**12** → moderate head injury / **13** & **14** → mild head injury		

Questions

1- A 55 y/o lady presented to the hospital with neurological symptoms, CT was done and she was found to have a large meningioma which compressed the surrounding structures. Which one of the following compensatory mechanisms is expected in her case?
A. Increased CSF production
B. Increased arterial flow
C. Increased venous return
D. Decreased brain tissue

2- Which one of the following is a classical manifestation of a left uncal herniation?
A. Contralateral pupillary dilation
B. Ipsilateral Weakness
C. Ipsilateral pupillary dilation
D. Hemorrhage

3- Increased Intracranial pressure headache is worse at which time of the day?
A. Afternoon
B. Early morning
C. Night
D. Evening

4- A 27 y/o gentleman presented to the ER with RTA, the ER physician checked his ABCs and evaluated his GCS which was found to be 8, CT brain was done and showed areas of petechial hemorrhages (salt and pepper appearance) which one of the following drugs is contraindicated in his case?
A. Dexamethasone
B. Acetaminophen
C. Furosemide
D. Propofol

5- In an ICU patient the following was measured, CPP= 70 MAP= 85. What is her ICP?
A. 13
B. 12
C. 18
D. 15

Answers: 1:C 2:C 3:B 4:A 5:D