Central nervous system

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FRCPATH

2017

LECTURE 2: disturbed fluid balance and increased intracranial pressure

Topics to be covered:

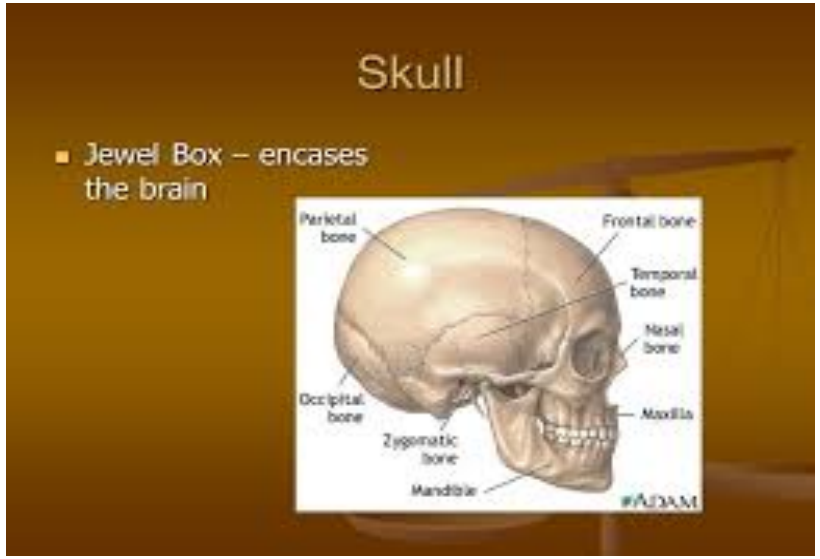
- Increased intracranial pressure.
- Brain edema
- Hydrocephalus
- Herniation
- Cerebral ischemia

ILOs

- Understand causes and symptoms of increased intracranial pressure.
- Define cerebral edema and know its types and causes.
- Define hydrocephalus and know its types and causes.
- Define herniation and know its types and complications
- Understand autoregulationo f blood flow in the brain
- List causes of hypoxia and ischemia
- Understand outcomes of global brain ischemia
- Apply the above knowledge in clinical cases.

The cranium..

- The brain is enclosed within the skull, which is a rigid box that protects it.
- In adults, skull bones cannot expand
- So if the material within the cranium increases.. Pressure will increase= increased intracranial pressure



What's inside the cranium?

- ROUGHLY: 80% brain tissue (including fluid; around 75%)
  : 10% blood
  : 10% CSF (cerebrospinal fluid)

IF any of these components increases, the intracranial pressure increases.

OK, so what is intracranial pressure (ICP)???

- It is the pressure inside the skull and is measured in millimeters of mercury
- at rest, it is normally 7–15 mmHg for a supine adult.
- The upper limit of ICP is 20–25 mm Hg

- **If pressure in the cranium is higher than this upper limit= increased intracranial pressure (= intracranial hypertension.**

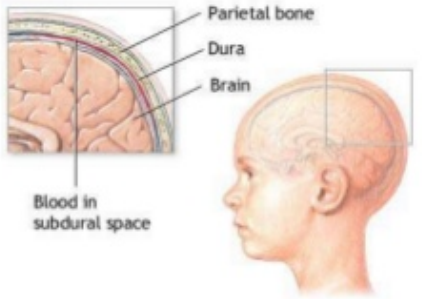
Causes of increased intracranial pressure

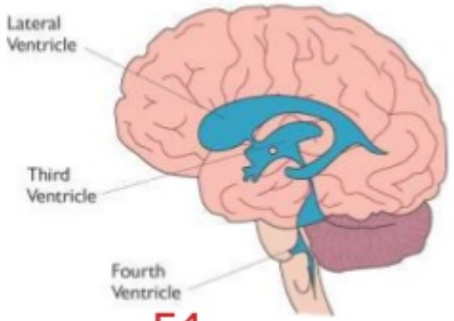
- mass effect : brain tumor, hematoma, or abscess.
- generalized brain swelling :ischemic-anoxia states, hypertension
- increase in venous pressure : heart failure
- obstruction to CSF flow and/or absorption or increased CSF production: hydrocephalus.
- Idiopathic or unknown

Increased Intracranial Pressure

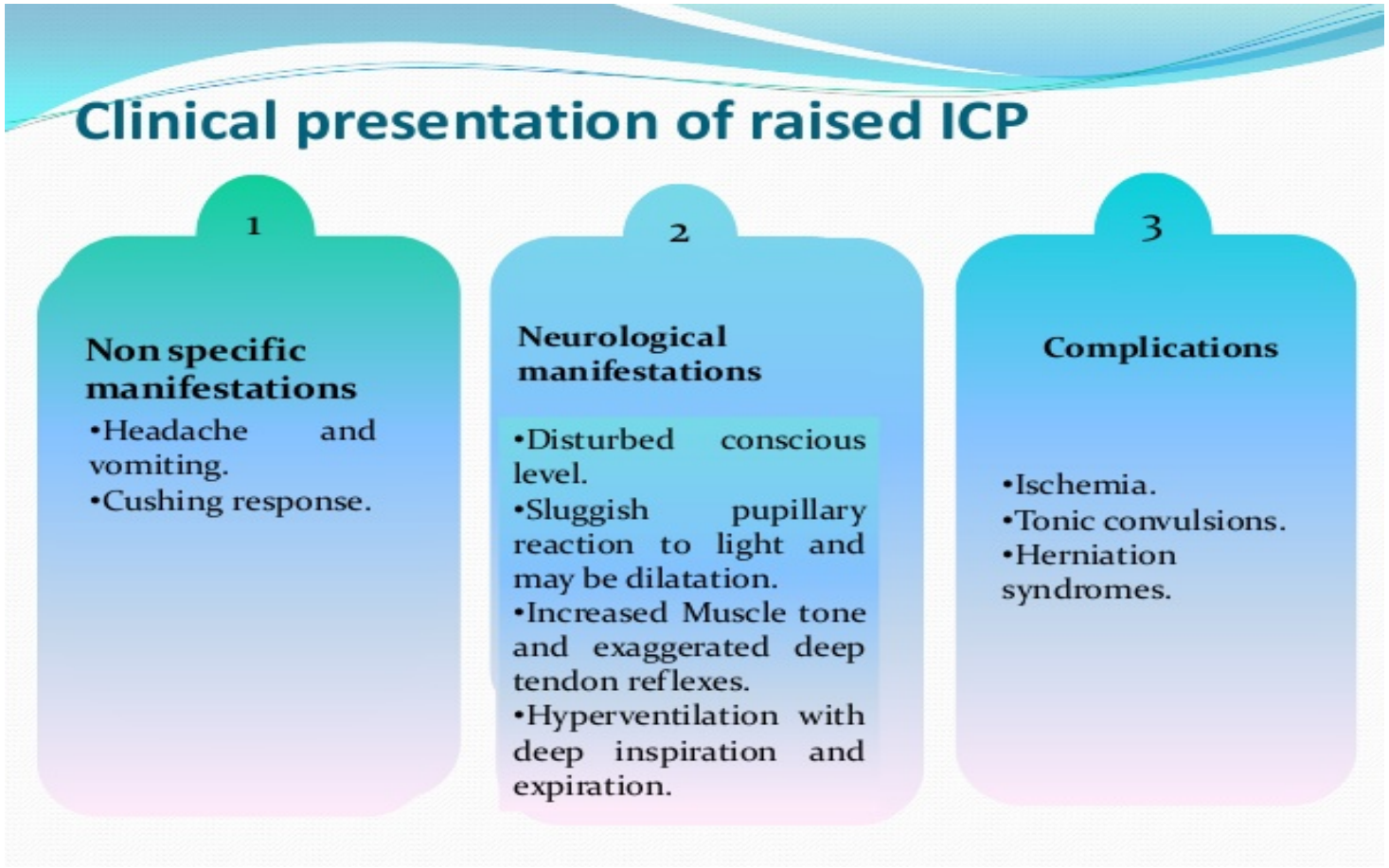
- ✓**Causes**
  - ✓Tumors
  - ✓Accumulation of fluid within the ventricular system
  - ✓Bleeding
  - ✓Edema in cerebral tissues

- ✓**Early signs and symptoms are often subtle and assume many patterns**





clinical presentation according to severity:



Brain edema= cerebral edema

- = accumulation of excess fluid within the brain parenchyma.
- Two types: vasogenic and cytotoxic edema.. Usually coexist

Vasogenic edema

- Due to disruption of blood brain barrier.
- So: shift of fluids from vessels to brain tissue.
- Lymphatic vessels are rare in the brain.. So there is little or no resorption of excess edema fluid.
- Can be generalised (due to hypoxia) or localised (due to inflammation or tumors)

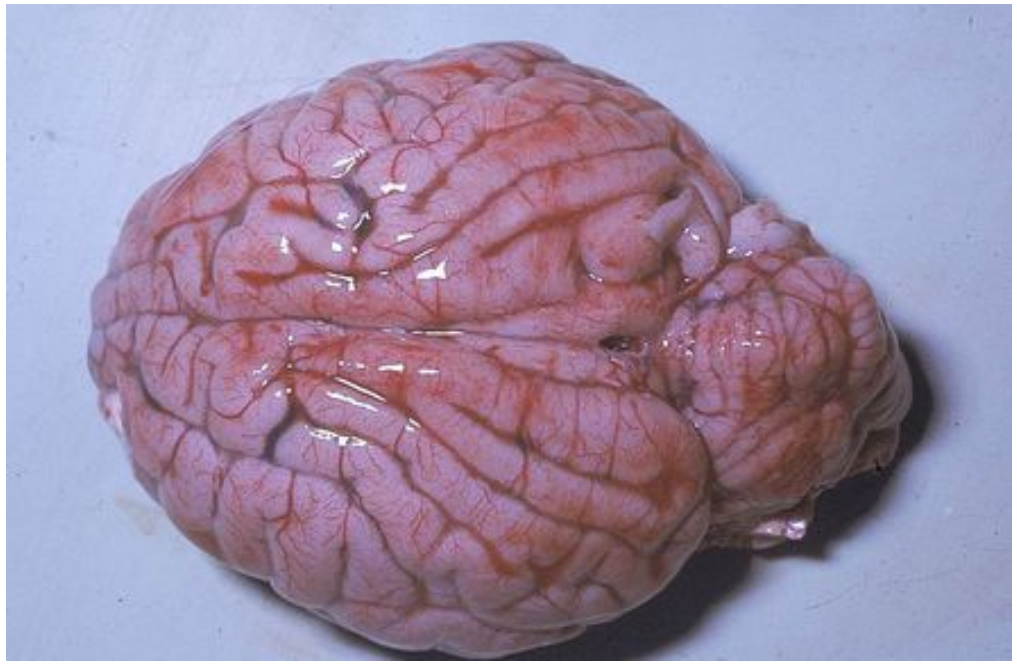
Cytotoxic edema

- Due to neuronal or glial cell membrane injury.
- Causes: toxins or hypoxia.
- Here fluid moves from cells to interstitial tissue.

morphology

- With edema, the brain becomes swollen.. And its weight increases.
- The normal adult human brain weighs on average about **1.2–1.4 kg** ,or about 2% of total body weight, although there is substantial individual variation.
- Edema causes flat gyri and narrow sulci

Brain edema



hydrocephalus

- Increased CSF within ventricles.
- Caused by overproduction or decreased resorption of CSF.
- Overproduction: rare, due to choroid plexus tumors.
- Decreased resorption.. Can be localised or generalised.

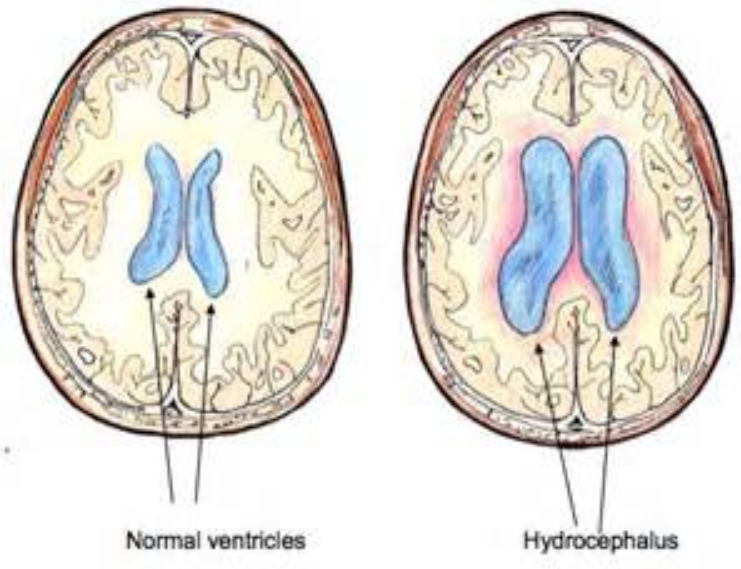
hydrocephalus

- Localised: noncommunicating hydrocephalus.
- Generalised: communicating hydrocephalus.

- In infancy, before closure of the cranial sutures , the head enlarges.
- After closure of the cranial sutures: increased intracranial pressure occurs. Of course there is no increase in head circumference

hydrocephalus

hydrocephalus



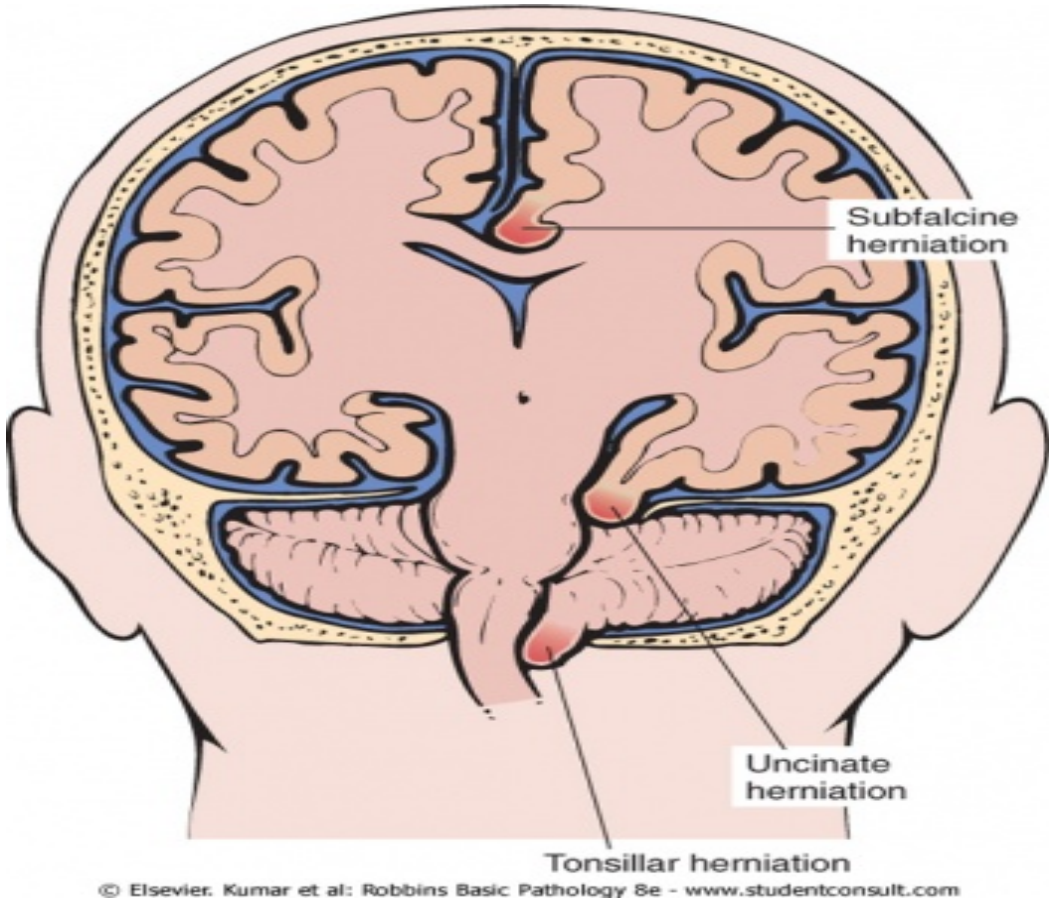
herniation

- Increased volume of tissue inside the skull.. Increased intracranial pressure which causes focal expansion of the brain tissue .
- Because the cranial vault is subdivided by rigid dural folds (falx and tentorium)…. The expanded brain tissue is displaced in relation to these folds.
- Expansion: herniation

herniation

- Subfalcine = cingulate
- Transtentorial = uncinate
- Tonsillar.

herniation



Cingulate herniation

-cingulate gyrus displaced under edge of falx

-Can cause compression of anterior cerebral artery

Transtentorial herniation

- Medial aspect of temporal lobe compressed against the free margin of the tentorium.
- Third cranial nerve compressed.. Dilated pupil, impaired ocular movement on the side of the lesion
- Posterior cerebral artery can be affected.. Ischemic injury to tissues supplied by it including visual cortex.

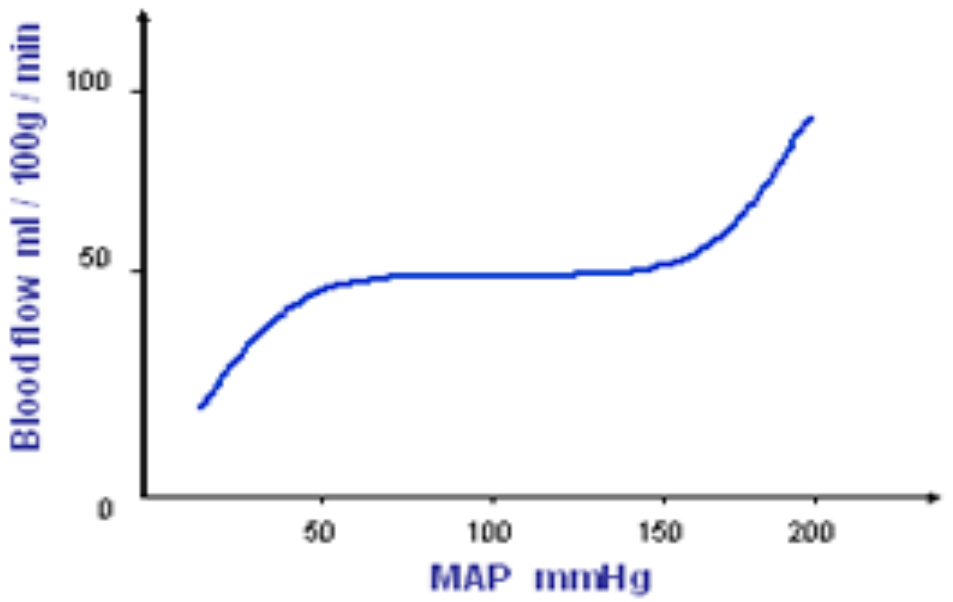
Tonsillar herniation

- Displaced cerebellar tonsils through foramen magnum
- Brain stem compression… respiratory and cardiac centres in medulla compromised.
- LIFE THREATENING

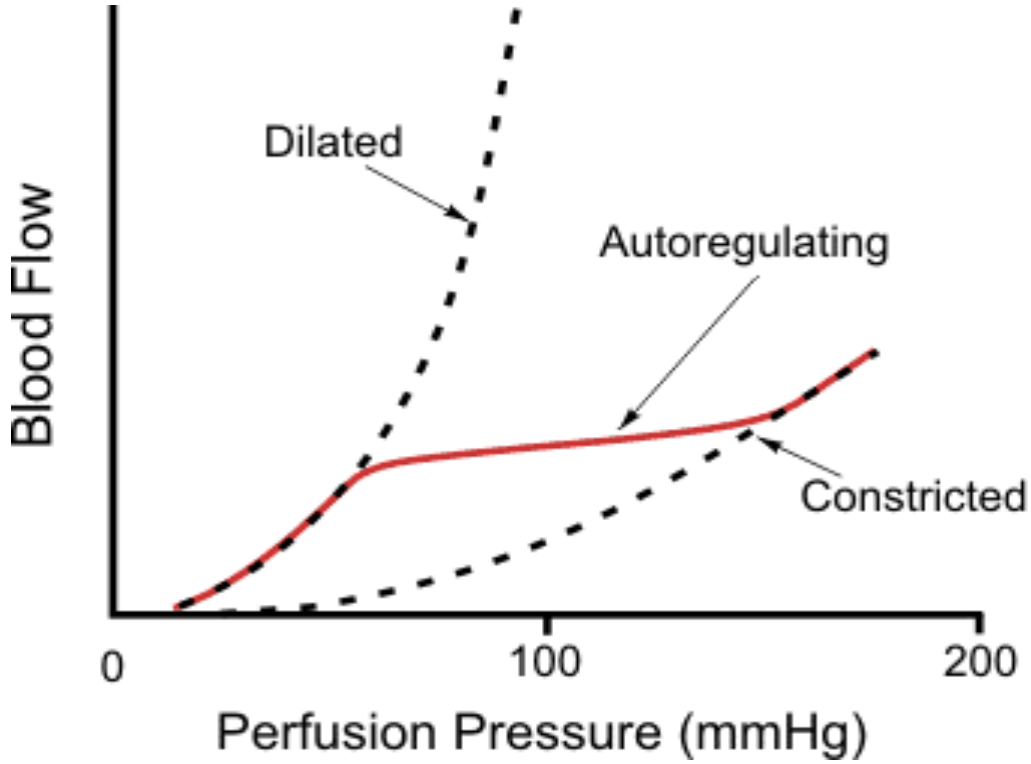
Hypoxia and ischemia

- Brain is highly oxygen dependent.
- Brain 2% of body weight but receives 15% of cardiac output
- 20% of total body oxygen consumption.
- Autoregulation of vascular resistance allows stability of cerebral blood flow over a wide range of blood pressures and intracranial pressure.
- If blood pressure very low (systolic less than 50)… hypoxia

Autoregulation of Cerebral Blood Flow



AnaesthesiaUK


Dilated
Autoregulating
Constricted
Blood Flow
0
100
200
Perfusion Pressure (mmHg)

Brain hypoxia

- Functional hypoxia.
- ischemic hypoxia

Functional hypoxia

- Low partial pressure of oxygen: high altitude
- Impaired oxygen carrying capacity: anaemia and CO poisoning
- Decreased oxygen use by tissues: cyanide poisoning

Functional hypoxia

Ischemic hypoxia

- Hypo-perfusion due to hypotension or vascular obstruction
- Ischemia can be global or focal
- Focal ischemia causes infarctions and this will be discussed in the next lecture.

Global cerebral ischemia

Occurs due to severe hypotension, systolic below 50mm Hg:

- Cardiac arrest
- Shock
- Severe hypotension

- Outcome depends on **severity** and **duration** of insult

Global ischemia

- Neurons more susceptible to hypoxic injury than glial cells.
- Most susceptible neurons: **pyramidal cells** of hippocampus and neocortex + **Purkinje cells** of the cerebellum

ischemia

- If mild: transient confessional state
- severe : neural death, if survive: severely impaired neurologically
- Severest forms result in brain death.

Morphology of reversible global ischemia

- Swelling
- Wide gyri
- Narrow sulci
- Poor grey white matter demarcation

Irreversible global ischemia can cause brain death

- Diffuse cortical injury with flat EEG (isoelectric EEG)
- Brain stem damage: No reflexes and no respiration
- If on mechanical support: autolysis of brain= respirator brain

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Suggested reading about brain death…for those who are interested

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2772257/
- Also a pdf is downloaded in my webpage…. This is an interesting read I encourage you to have a look!!


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