Neurosurgery Education and Outreach Network NEON

Intracranial Pressure (ICP)

Causes, Considerations and Management

NEON Statement

The Neurosurgery Education and Outreach Network (NEON) is comprised of Neurosurgery Nurse Educators, Advanced Practice Practitioners, Clinical Nurse Specialists and Directors from each of the 13 neurosurgery centres.

The mandate of the NEON is to plan and implement neurosurgery system-wide improvements, through education and outreach, to address gaps in skills and knowledge, and improve access and patient flow between neurosurgery and non-neurosurgery centres.

Disclosure Statement

The Neurosurgery Education and Outreach Network (NEON) and Critical Care Services Ontario (CCSO) have no financial interest or affiliation concerning material discussed in this presentation.

This presentation provides direction for how to provide nursing care to adult and paediatric patients who have intracranial pressure (ICP) concerns, to ensure consistency within and across organizations. It was developed by a sub-group of clinical neurosurgical nurses and neurosurgical educators for health care professionals (HCPs) across Ontario. This presentation is not meant to be exhaustive, and its contents are recommended but not mandated for use. HCPs should use their clinical judgment and utilize other assessment parameters if determined necessary. Please note this document is not intended to supersede your hospital's policies and physicians' orders.

Objectives

- Identify the components of the Cranial Vault
- Identify the components of Intracranial Pressure (ICP)
- Identify the causes of rising ICP
- Identify the treatments of rising ICP
- Recognize patients with increased ICP and facilitate safe transfer to a neurosurgical centre

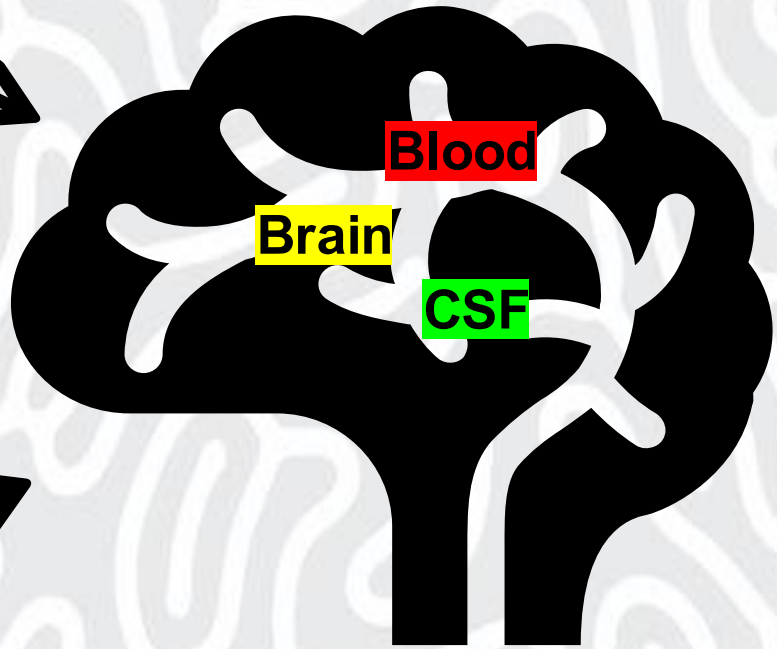
Anatomy and Physiology

Skull contains 3 major components

10% Blood (Arterial supply and Venous return)

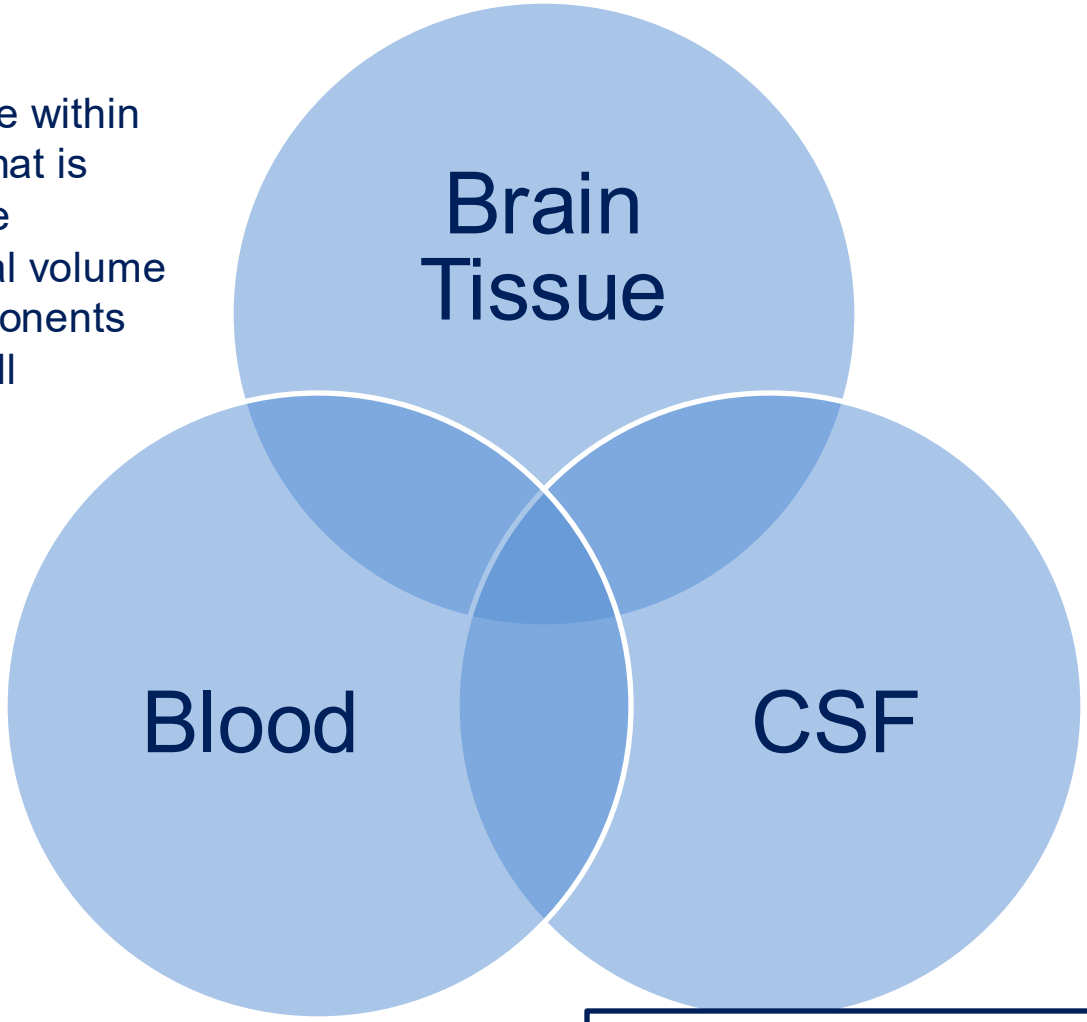
80% Brain

10 % Cerebral Spinal Fluid (CSF)



What is ICP?

…the pressure within the cranium that is exerted by the combined total volume of the 3 components within the skull



MONROE-KELLIE DOCTRINE

Monroe-Kellie Doctrine

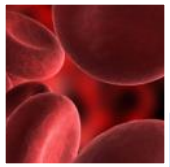
- Brain tissue, blood volume, and CSF volumes are in a state of dynamic equilibrium
- If one of the components increases (e.g., brain tissue), one or both components (e.g., blood and CSF) must decrease or an elevation of ICP will result

TAKE AWAY: Changes in one will inevitably cause changes in the other two!

Factors that can Increase/Affect ICP

Brain tissue

- Tumours
- Cerebral Edema



Blood

- Jugular vein compression
- Severe Hemorrhage

O_2

CO_2

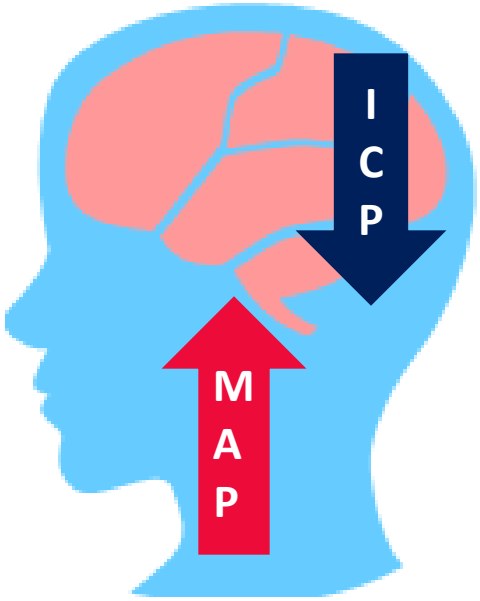
CSF

- Blockage of CSF drainage due to…..
- Blocked shunts
- Tumours
- Cerebral Edema
- Blood in Ventricles

Cerebral Perfusion

CPP = MAP - ICP

Cerebral perfusion pressure is the amount of pressure required to carry oxygen to the brain



Maintain CPP by keeping SBP > 100 mmHg

- When a patient is suspected of having an increased ICP, to ensure proper oxygenation of the brain, maintain a MAP > 65 mmHg or a SBP > 100 mm Hg

Elevated ICP

- ICP can become elevated for various reasons in response to disease, environment, emotion, and normal bodily functions
- Factors can be non-pathologic or pathologic in nature
- These can cause slow elevations or rapid increases in ICP

Elevated ICP

Non-pathological causes include:

- Coughing
- Sneezing
- Lifting
- Bending
- Valsalva (bearing down)
- Stress
- Blood pressure changes
- Emotional responses
- Body positioning

Elevated ICP

Pathological causes include:

- Concussion
- Contusion

Traumatic Brain Injury

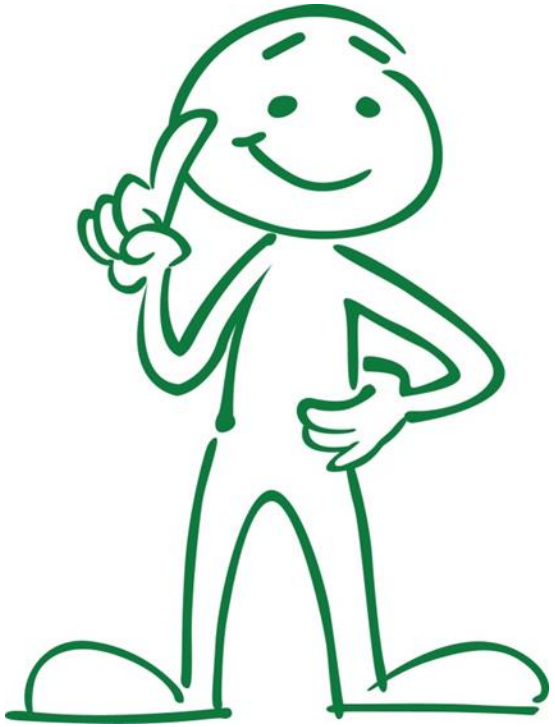
- Subdural Hematoma
- Epidural Hematoma
- Subarachnoid Hemorrhage
- Hydrocephalus
- Tumour
- Edema
- Abscess or Infection

Space Occupying Lesions

Elevated ICP

Primary factors that influence elevated ICP include:

- Blood pressure
- Heart function
- Intra-abdominal/Intrathoracic pressure
- Temperature
- Pain
- Carbon Dioxide/Acidosis
- Hypoxia



Signs & Symptoms of Increasing ICP

Early Signs

- Headache
- Increasing confusion
- Decreased mental abilities
- Carphologia (non-purposeful movement/psychomotor agitation)
- Nausea & Vomiting
- Double vision
- Generalized weakness or fatigue
- Intractable yawning, hiccupping, and air hunger
- Amaurosis (temporary vision loss), blurred vision, nystagmus, eye deviation, facial twitching

Late Signs

- Seizures
- Unequal and or unreactive pupils
- Loss of consciousness
- Impairment of brain stem reflexes
- Extensor posturing
- Cushing's triad
  - Hypertension
  - Bradycardia
  - Irregular respirations or apnea

Signs & Symptoms of Increasing ICP in Paediatrics

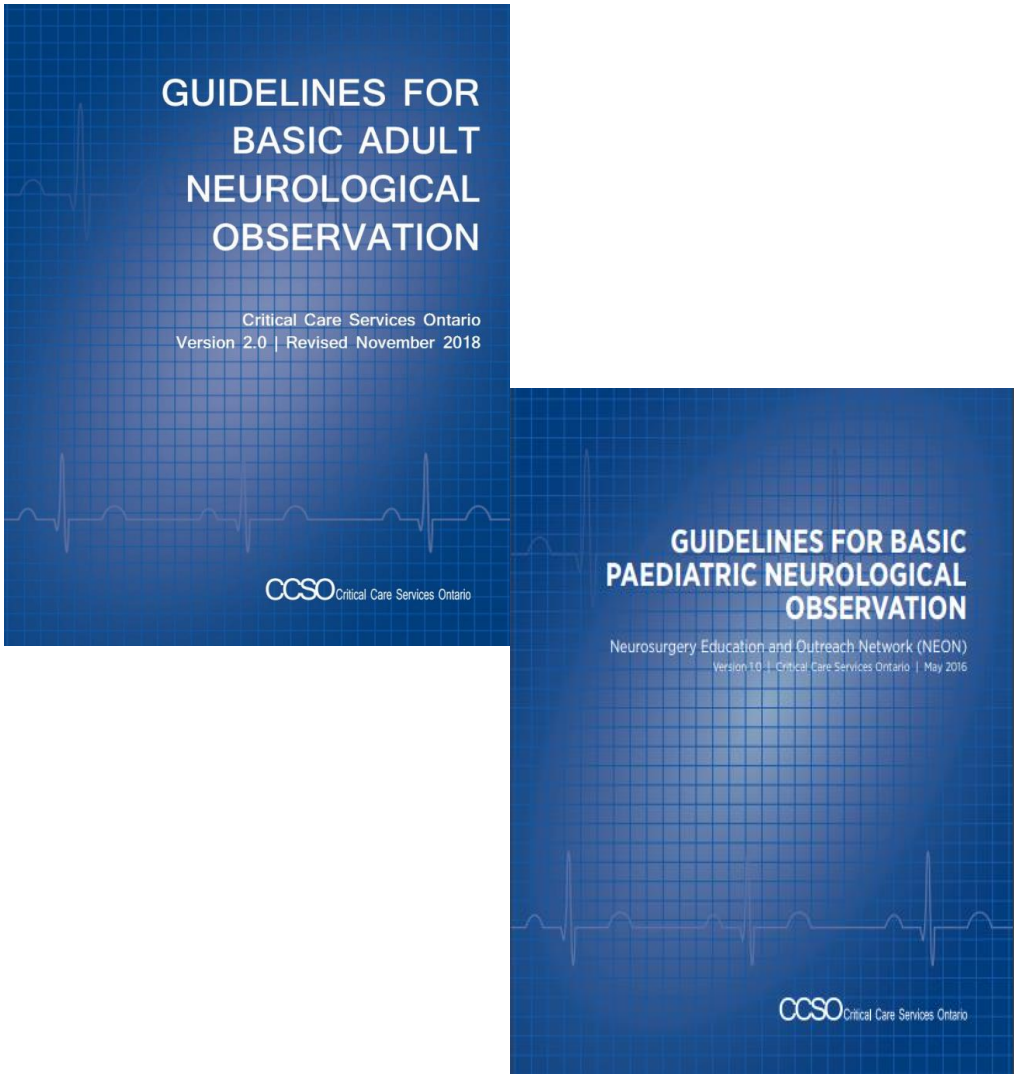
Infants & Toddlers

- Sunsetting eyes
- Bulging/full fontanelle
- Frontal bossing
- Distended scalp veins
- Increased sleepiness
- Vomiting
- Irritability
- Not meeting milestones
- Increasing head circumference

Older Children

- Headache
- Drowsiness
- Irritability
- Nausea and/or vomiting
- Ataxia
- Change in thinking or unable to concentrate
- Poor performance at school
- Not meeting milestones or a regression in milestones

Neurological Assessment

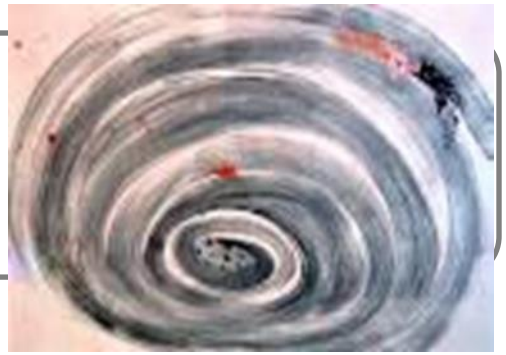


- Consistent approach
- Facilitates the indication of neurological change

Basic Components:
LOC (GCS)
Pupils
Motor strength & symmetry
Vital Signs

Cushing's Triad

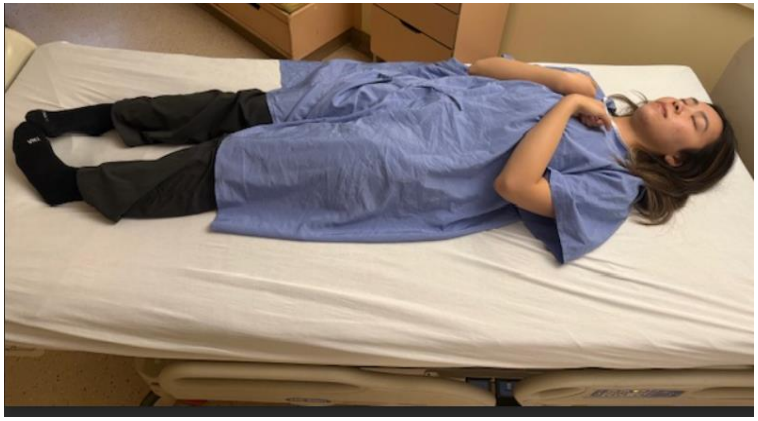
1. HYPERTENSION
   - Pulse Pressure Widens
2. BRADYCARDIA



3. IRREGULAR RESPIRATIONS

…..Late Signs

Consequences of Prolonged Elevated ICP



Abnormal flexion (decorticate rigidity)

Extension posturing (decerebrate rigidity)

- Cerebral ischemia and stroke
- Irreversible brain damage and cerebral hypoxia
- Permanent physical disability
- Brain herniation and brain death

What Can Be Done to Lower ICP?

Nursing Management for the Patient with Increased ICP

- **Baseline Neurological assessment with frequent monitoring** (LOC {GCS}, pupils, motor strength & symmetry, vital signs)
- **Reduce stimulation**
  - Space out nursing care
  - Fewer tasks, spread out
  - Explain to family importance of a quiet visit (limiting stimulation)
- **Reduce severe hypertension**
  - BE AWARE: Blood pressure is not always reduced as permissive hypertension may be neuroprotective
  - Monitor Mean Arterial Pressure (MAP) as ordered by MRP to provide adequate cerebral perfusion
- Monitor CBC/Hemoglobin/Hematocrit**: treat anemia**
- **Prevent & treat seizures**

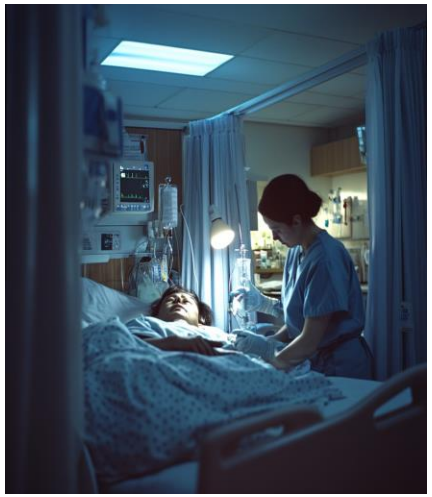


Image retrieved from https://stockcake.com/i/hospital-bedside-care_1352873_950608

Photo property of the NEON stock image library (2024)

Nursing Management for the Patient with Increased ICP

- **Control intra-thoracic pressures**
  - Minimizing airway stimulation (e.g., coughing, suction only when needed)
  - Pharmacological agents (e.g., Propofol)
  - Minimizing positive end-expiratory pressure [PEEP]
  - Gastric decompression (Nasogastric/Orogastric tube)

- **Fever management**
  - Normothermia (e.g., acetaminophen (NSAIDS typically avoided), cooling blankets, room temperature)

Nursing Management for the Patient with Increased ICP

- **Obstruction of venous return**
  - Maintain head and neck in neutral alignment with head of bed elevated (normally 30°, follow MRP order)
  - If patient has cervical collar, ensure fit is not obstructive (not too tight)
  - Reduce agitation as it can increase cerebral blood flow (CBF)

- **Respiratory factors**
  - Airway protection - monitor patient's ability to protect airway
  - Monitor arterial/venous blood gases to assess for hypoxia and hypercapnia
  - Prepare for intubation and mechanical ventilation if needed

Nursing Management for the Patient with Increased ICP

- Narcotics and sedatives:
  - May alter LOC
  - Be cautious in their use

- Avoid large fluctuations in blood pressure:
  - Hypotension decreases the Mean Arterial Pressure (MAP) and cerebral perfusion
  - Maintain Systolic BP > 100 mmHg

- Keep oxygen saturation ≥ 94% or as per MRP order:
  - Hypoxia alters LOC and decreases the amount of oxygen available

Considerations for the Patient with Increased ICP

- Carbon Dioxide (CO_2) is the enemy:
  - Hypercarbia causes neurological decline
  - Avoid CO_2 Narcosis!

- Think nutrition:
  - A hypermetabolic brain requires more protein to heal
  - Enteral feeding may be necessary in the short-term. *This is a consideration if there is a delay in transfer

- Blood sugar fluctuations:
  - Avoid hypoglycemia

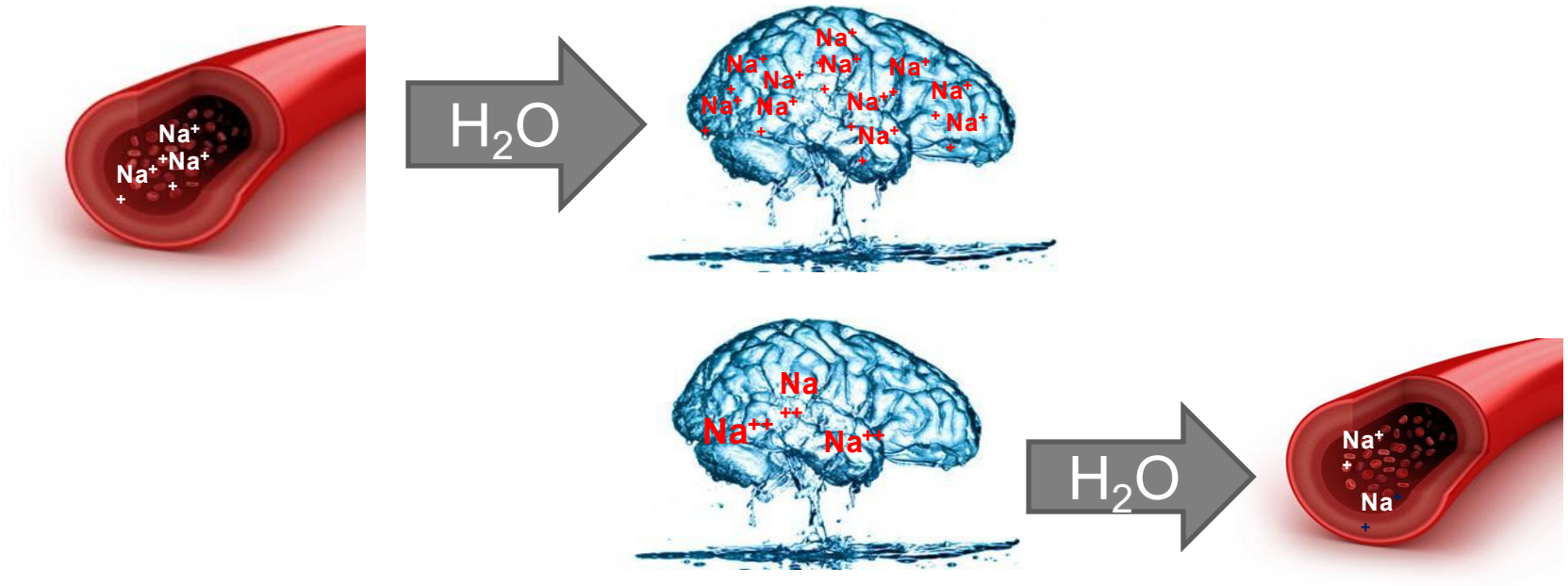
Considerations for the Patient with Increased ICP

- Fever can influence neurological exam:
  - Normal temperature is the goal
  - Treat fevers

- Admission date/time:
  - Peak swelling of cerebral edema can be 3-5 days before it decreases
  - By performing frequent neurological assessments, the nurse will be able to identify subtle changes in the neurological status

Controlling Cerebral Edema Prior to Transfer Is Imperative

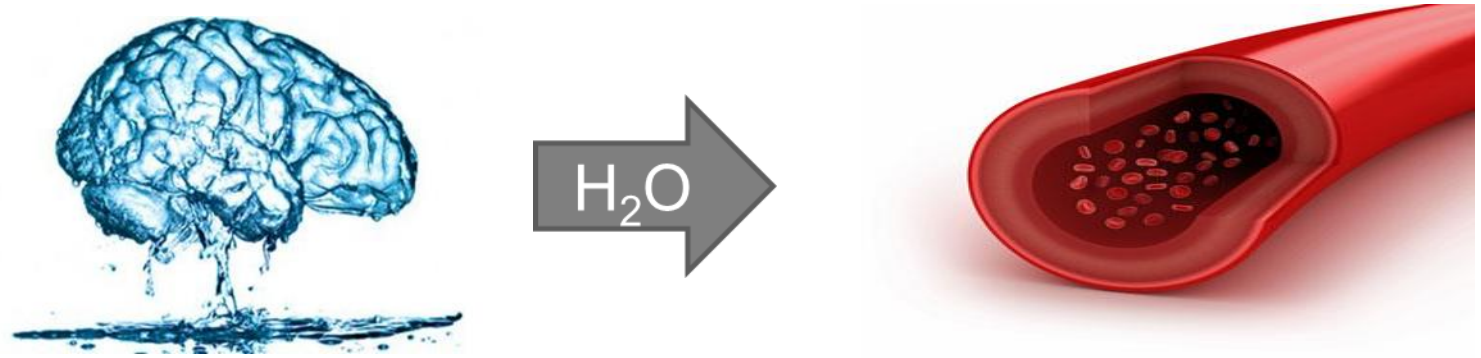
- In the brain, water movement is mainly determined by sodium movement



- Water moves by osmosis to the area of greatest sodium (Na) concentration

20% Mannitol

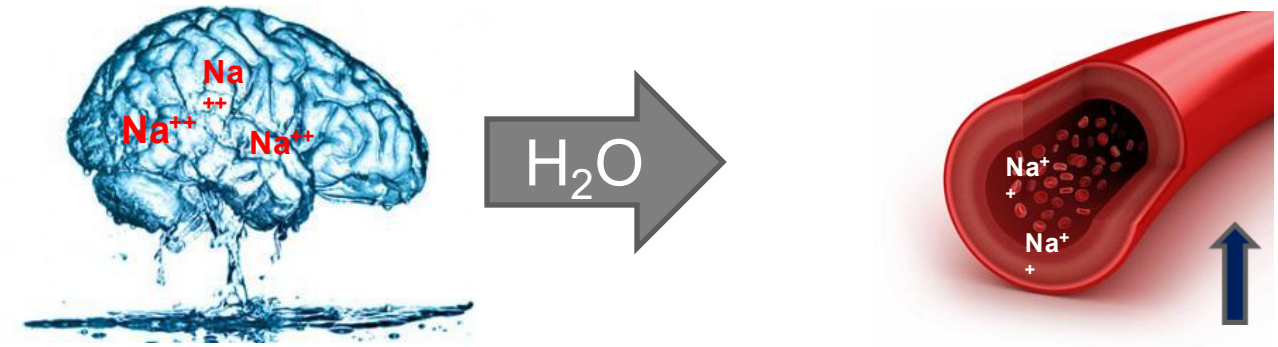
- Mannitol decreases cerebral edema by removing water rapidly though diuresis



- The hypertonic concentration draws water from the brain and opens the kidneys. This draws water out of the brain, decreasing brain edema and lowering ICP

Hypertonic 3% Sodium Chloride

- Water moves by osmosis to the area of greatest Na concentration



- Hypertonic 3% NaCl administration increases sodium in the blood. This draws water out of the brain, decreasing brain edema and lowering ICP

- Slower process with greater consistent decrease in brain edema

Care Considerations for Administering 20% Mannitol/3% Sodium Chloride can include (but are not limited to)

- Rapid fluctuations in serum electrolytes and hydration:
  - Frequent electrolyte monitoring
- Monitor vital signs frequently
- Large amounts of urine output:
  - Foley catheter with urometer for accurate ins/outs
- Ideally given over 30-60 minutes **Remember always follow your hospital's guidelines/MRP orders**
- Extravasation:
  - Frequent IV site assessment
- Filter required for **Mannitol** administration
- Not appropriate for patients with renal impairment
- Use **Manntiol** with caution in patients with hypotension

Higher Level of Care is required when… Patient is Urgent/Emergent or considered Life or Limb

- Injuries with pathological causes previously mentioned
- Patients with head injuries- severe traumatic brain injury (TBI) or deteriorating mild to moderate
- Posterior fossa tumours
- Third ventricle tumours (colloid cysts)
- Pineal tumours (compression of cerebral aqueduct)
- Subarachnoid hemorrhage (SAH) with associated communicating hydrocephalus (arachnoid villi become plugged)
- Non communicating hydrocephalus

Preparing Patient for Transport to Neurosurgical Centre

Consider the following:

- Establish a definitive airway if GCS is trending downward or if patient deterioration is anticipated
- Sedation (Propofol)
- Analgesics (Fentanyl)
- Neuromuscular blocking agents if needed (Nimbex, Rocuronium)
- Anti – epileptics (AED's) (Dilantin, Keppra, Benzodiazepines for active seizure)
- Vasopressors
- Antihypertensives
- Anti- emetics

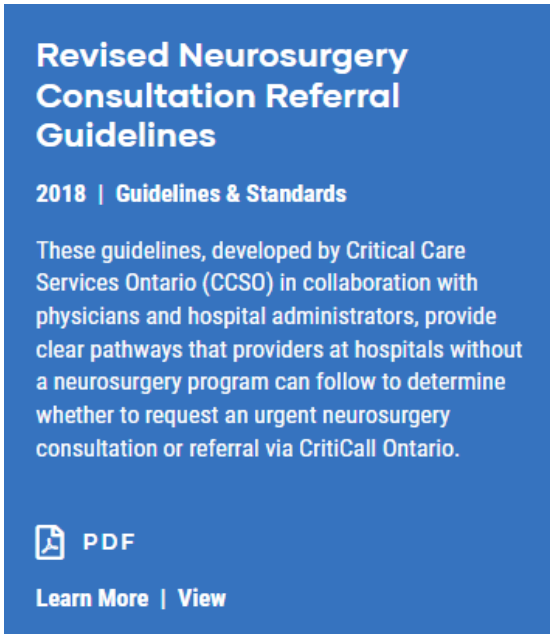
ANTICIPATE THE WORST!

Neurosurgical Consultation

Most Responsible Physician (MRP) or Emergency Department (ED) physician review updated Neurosurgical Consultation Referral Guidelines and connect with a Neurosurgeon via CritiCall if deteriorating status has been detected by:

- Deteriorating neurological assessments (LOC + Pupils+ Movement + Vital signs)
- Repeat imaging
- Deteriorating clinical picture

https://www.criticall.org/wp-content/uploads/2024/04/Revised-Neurosurgery-Consultation-Referral-Guidelines_English2023.pdf



Summary

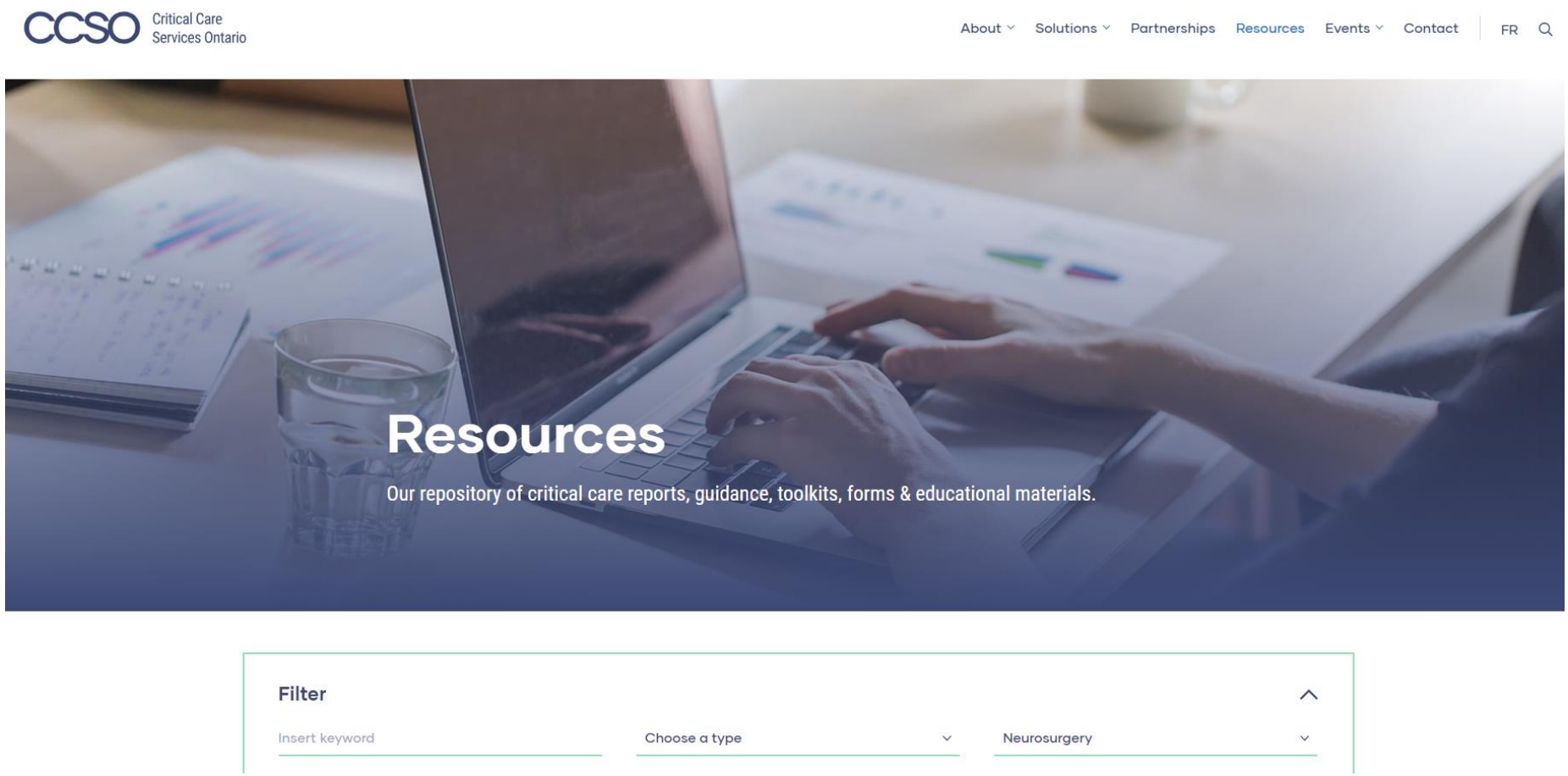
- Rises in ICP can occur after any brain injury, mild to severe
- Maintaining adequate cerebral perfusion is the goal
- Serial neurological assessments with documentation of the neurological trending can detect the rising ICP
- Transfer may be necessary for higher level of care and neurosurgical interventions

Your Role

- ✓ Do what is within your scope!
- ✓ Conduct neurological assessments more often to detect, document, and identify the trend in status
- ✓ Enact nursing interventions to decrease ICP
- ✓ Communicate
- ✓ Be persistent
- ✓ Work with MRP to treat underlying causes
- ✓ Support family
- ✓ Document

Web Links

https://criticalcareontario.ca/resources/



References

- American Association of Neuroscience Nurses. (2020). *Evidence-Based Review:Nursing Care of Adults with Severe Traumatic Brain Injury*. Chicago, Illinois.
- Criticall Ontario (2023). Neurosurgery Consultation Referral Guidelines. www.criticall.org Critical Care Services Ontario. (2016). Guidelines for Basic Paediatric Neurological Observation (pp. 12, 20-21). *CCSO Neurosurgery Education and Outreach Network document.* Retrieved October 25, 2024, from http://www.criticalcareontario.ca.
- Hickey, J. (2003). *The clinical practice of neurological and neurosurgical nursing* (5th ed.). Philadelphia: Lippincott.
- McDonald, M. (2020). Airway and Ventilation. (P. 54) Emergency Nurses Association. Trauma Nursing Core Course (TNCC). 8th Ed.
- Marcoux, K. (2005). Management of increased intracranial pressure in the critically ill child with an acute neurological injury. *AACN Clinical Issues, 16*(2), 212–231.
- Tymianski, D., Sarro, A., & Green, T. (2012). *Navigating Neuroscience Nursing: A Canadian Perspective.* Pappin Communications. Pembroke. Ontario
- UpToDate. (2023). Evaluation and management of elevated intracranial pressure in adults. www.uptodate.com
- Woodward, S., & Mestecky, A. (2011*). Neuroscience nursing: Evidence-base practice.* Malaysia: Wiley-Blackwell