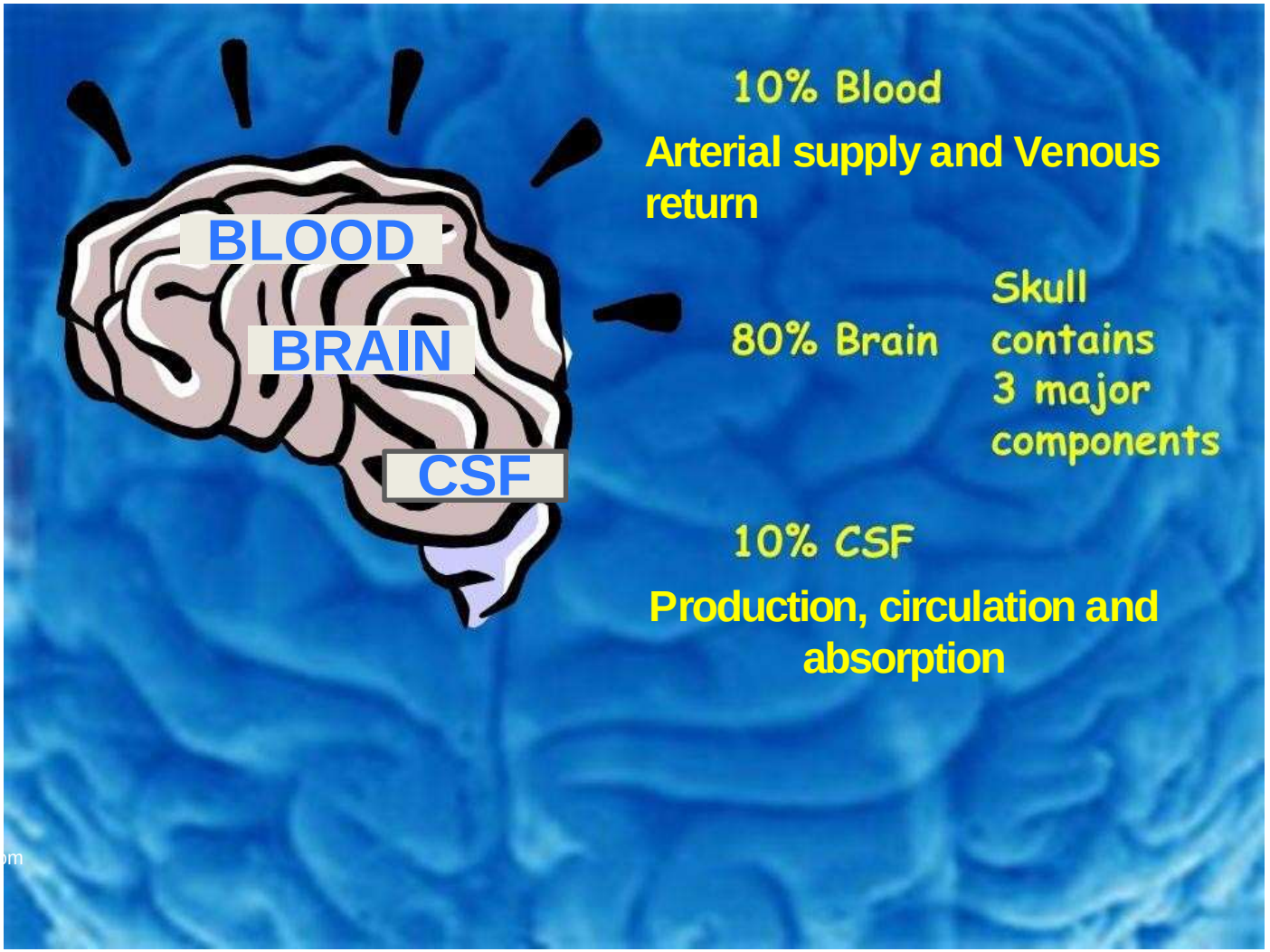
Intracranial Pressure (ICP)

Causes, Concerns and Management

Objectives

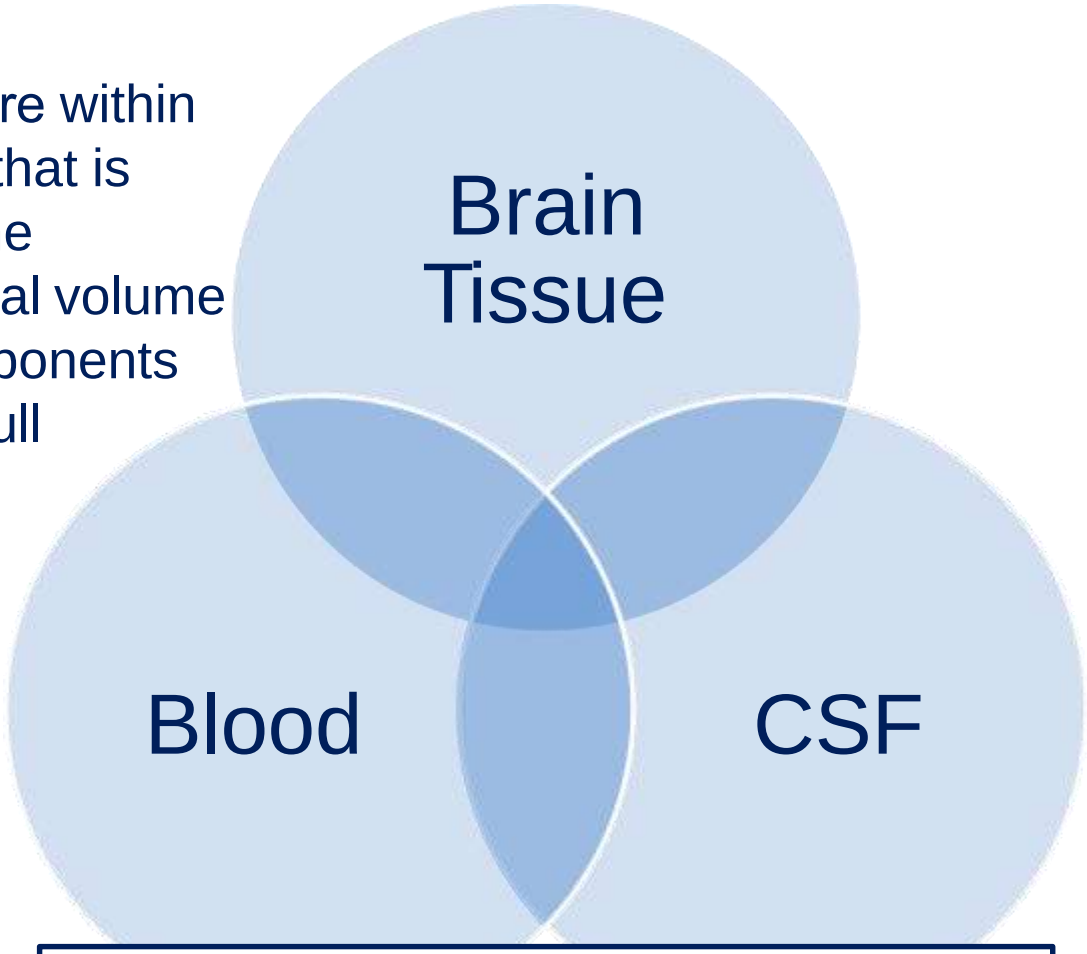
- Identify the components of the Cranial Vault
- Identify the components of Intracranial Pressure (ICP)
- Identify the causes of rising Intracranial Pressure
- Identify the treatments of rising Intracranial Pressure
- Identify transfer of patients because of rising Intracranial Pressure to a neurosurgical center

Anatomy and Physiology



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 an increase occurs in any of the above, the volume of one or more of the other components must decrease or an elevation of ICP will result

https://thebyproduct.com/2012/10/04/the-scale/

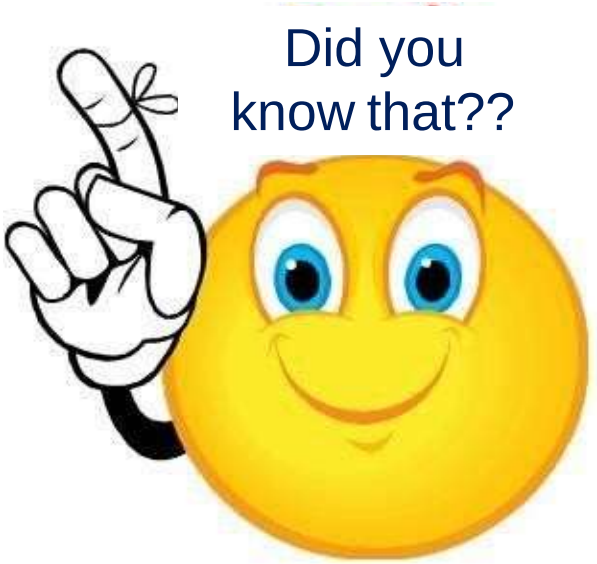
Elevated ICP

- 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
- Temperature
- Pain
- Carbon Dioxide/Acidosis
- Hypoxia

Why is it Important?

- Maintaining cerebral perfusion pressure is the main focus in management of cerebral injuries that impact the 3 components in the central system- brain/blood/CSF
- CPP is calculated using the Mean Arterial Pressure (MAP) and Intracranial Pressure (ICP)
- CPP = MAP – ICP
- What if you don’t know the ICP?

Why is it Important?

- Normal CPP 60 to 100 mmHg
- Goal is to maintain a minimum of 60mmHg for brain injuries
- Cerebral Perfusion Pressure (CPP) values of:
  - >150 disrupts the blood brain barrier and causes hyper-perfusion and potentially brain edema / swelling. This could potentially lead to herniation syndrome
  - <50 causes hypo perfusion and brain ischemia
  - <30 causes irreversible ischemia/ damage

Who Can Do This?

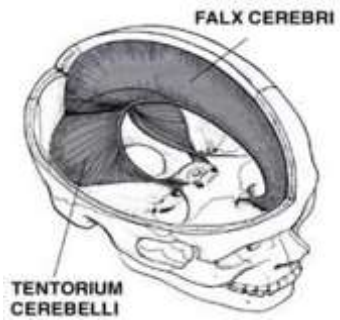
- Monitoring of the neuro assessments, including vital signs, can be done everyday by nurses
  - Ensuring systolic blood pressure is within a consistent range will improve perfusion

- Achievable in both neurosurgical center or non-neurosurgical center

Compensatory Mechanisms to Maintain Adequate Flow to the Brain

S & S of Increased ICP Depend On……

- Compartmental location of lesion (supratentorial or infratentorial)
- Specific location of mass (cerebral hemispheres, brain stem or cerebellum)
- Degree of intracranial compensation (compliance)



S+S of Increasing ICP

Patient Presentation:

- ❑ ↓ LOC (subtle)
- ❑ ↓ Motor function
- ❑ ↑ Restlessness
- ❑ Nausea & vomiting
- ❑ Sensory deficits
- ❑ Headache
- ❑ Visual changes
- ❑ Seizures
- ❑ Pupil changes

Vital Signs:

- ❑ Elevated BP with no obvious cause
- ❑ Rising systolic pressure
- ❑ Widening pulse pressure
- ❑ Bradycardia

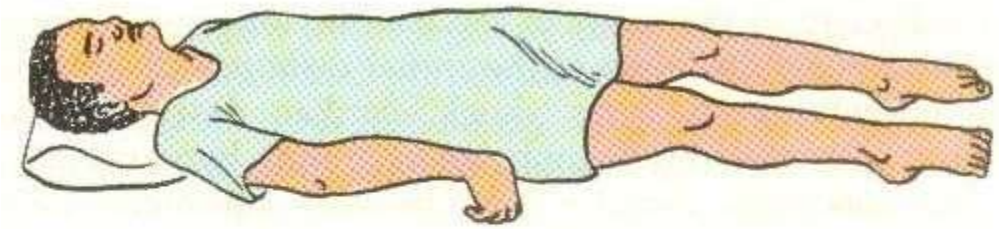
Cushing's Triad

1. HYPERTENSION
   - Pulse Pressure Widens
2. BRADYCARDIA

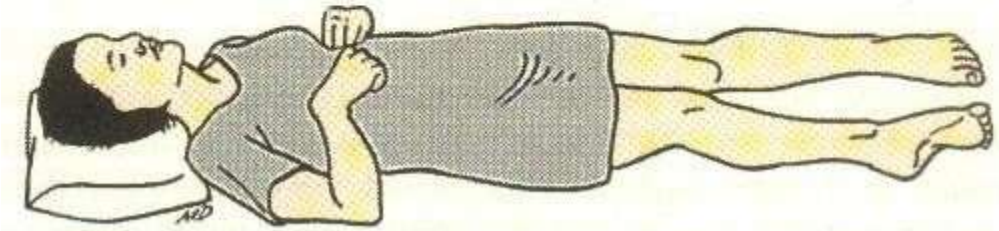
3. IRREGULAR RESPIRATIONS

…..Late Signs

Consequences of Prolonged Elevated ICP



A. Extension posturing (decerebrate rigidity)



B. Abnormal flexion (decorticate 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?

Eliminate Things That Elevate ICP

- Reducing stimulation
  - Space out nursing care
  - Fewer tasks, spread out
  - Explain to family importance of a quiet visit (limiting stimulation)

- Severe hypertension
  - Don’t routinely reduce this as permissive hypertension be neuroprotective

https://www.healthtap.com/

- Anemia
- Seizures

Eliminate Things That Elevate ICP

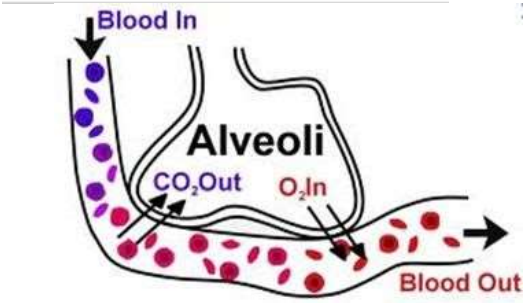
- Control intra-thoracic pressures
  - Minimizing airway stimulation (coughing)
  - Pharmacological agents (Propofol?)
  - Minimizing positive end-expiratory pressure [PEEP]
  - Gastric decompression

- Fever
  - Cool (Tylenol, cooling blankets)

Eliminate Things That Elevate ICP

- Obstruction of venous return
  - Head positioning – align, elevate
  - Agitation

- Respiratory problems
  - Airway obstruction
  - Hypoxia
  - Hypercapnia



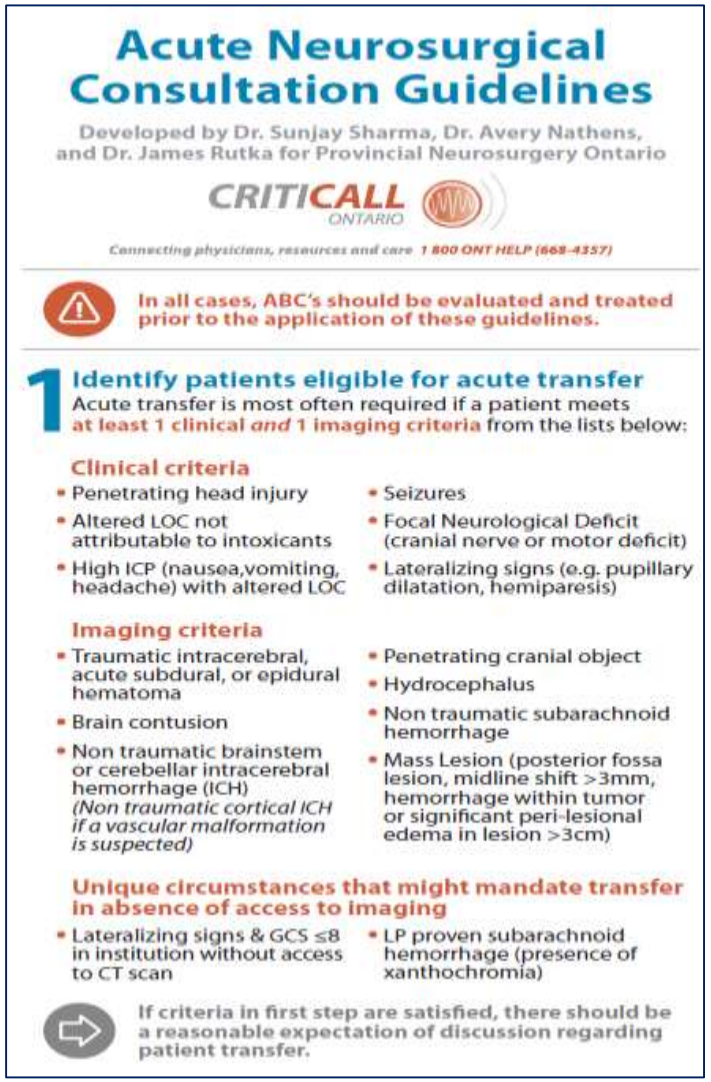
Neurological Assessment

- Consistent approach
- Facilitates the identification of neurological change
- **Basic components:**
  GCS
  Pupils
  Motor responses Motor strength Vital signs

Neurosurgical Consultation

MRP or ED and connect with a Neurosurgeon via CritiCall if deteriorating status has been detected by:

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



Acute Neurosurgical Consultation Guidelines

Developed by Dr. Sunjay Sharma, Dr. Avery Nathens, and Dr. James Rutka for Provincial Neurosurgery Ontario

CRITICALL ONTARIO

Connecting physicians, resources and care 1 800 ONT HELP (668-4357)

In all cases, ABC's should be evaluated and treated prior to the application of these guidelines.

1 Identify patients eligible for acute transfer

Acute transfer is most often required if a patient meets **at least 1 clinical *and* 1 imaging criteria** from the lists below:

Clinical criteria

- Penetrating head injury
- Altered LOC not attributable to intoxicants
- High ICP (nausea,vomiting, headache) with altered LOC
- Seizures
- Focal Neurological Deficit (cranial nerve or motor deficit)
- Lateralizing signs (e.g. pupillary dilatation, hemiparesis)

Imaging criteria

- Traumatic intracerebral, acute subdural, or epidural hematoma
- Brain contusion
- Non traumatic brainstem or cerebellar intracerebral hemorrhage (ICH) *(Non traumatic cortical ICH if a vascular malformation is suspected)*
- Penetrating cranial object
- Hydrocephalus
- Non traumatic subarachnoid hemorrhage
- Mass Lesion (posterior fossa lesion, midline shift >3mm, hemorrhage within tumor or significant peri-lesional edema in lesion >3cm)

Unique circumstances that might mandate transfer in absence of access to imaging

- Lateralizing signs & GCS ≤8 in institution without access to CT scan
- LP proven subarachnoid hemorrhage (presence of xanthochromia)

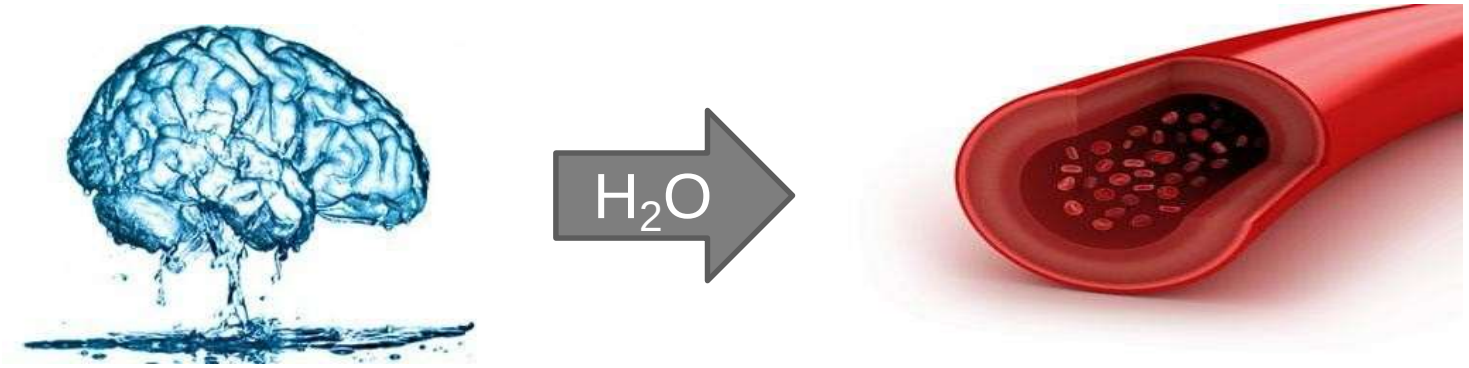
If criteria in first step are satisfied, there should be a reasonable expectation of discussion regarding patient transfer.

Higher Level of Care

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

20% Mannitol

- Mannitol decreases cerebral edema by removing water rapidly though diuresis

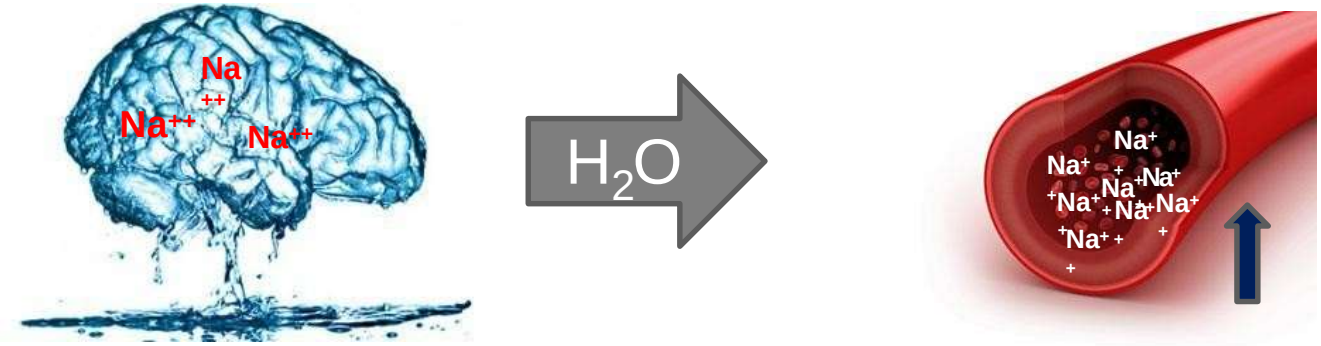


- The hypertonic concentration draws water from the brain and opens the kidneys. This draws water out of the brain, decreasing brain edema and lowering ICP

- Causes rapid fluctuations in serum electrolytes and hydration with large amounts of urine output

Hypertonic 3% NaCl

- 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 > consistent decrease in brain edema

Other Considerations

- Narcotics and sedatives:
  - Be judicial in their use
- Avoid large fluctuations in blood pressure:
  - Hypotension decreases the MAP and cerebral perfusion
- Keep oxygen up:
  - Hypoxia alters LOC and robs the brain of needed oxygen to function and heal

Other considerations

- Carbon Dioxide is the enemy:
  - Hypercarbia causes neurological decline
  - Avoid CO2 Narcosis!

- Think nutrition:
  - A hypermetabolic brain requires more protein to heal
  - Feeding may be necessary in short term

- Blood sugar fluctuations:
  - Avoid hypoglycemia

Other considerations

- 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
  - Frequent NVS assessments trend the status during this swelling time as it increases and begins to fade

Summary

- Rises in Intracranial Pressure (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 neuro-vital sign checks more often to detect, document and identify the trend in status
- ✓ Enact nursing interventions to decrease ICP
- ✓ Communicate
- ✓ Be persistent
- ✓ Work with MD to treat underlying causes
- ✓ Support family
- ✓ Document

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