Mechanical Ventilation and Intracranial Pressure

Ouch.

Image taken from http://www.trauma.org

Objectives

- Be able to define ICP and related terminology
- Identify problems associated with elevated ICP
- List causes of elevated ICP
- Describe monitoring devices

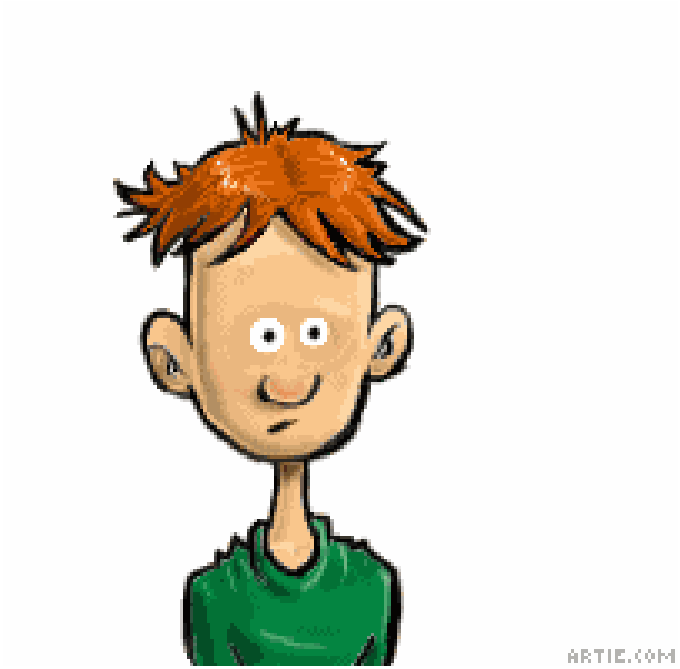
Objectives

- Implications for Respiratory Therapist
  - Intubation techniques
  - Ventilator strategies

ICP – What is it?

- ICP stands for IntraCranial Pressure
  - This is the pressure of the brain, Cerebrospinal fluid (CSF), and the brain's blood supply within the intracranial space.[1]
  - Since The Skull is basically a closed system, an increase in volume will produce an increase in pressure.

Elevated ICP = Danger



Animated GIF taken from http://www.artie.com

Other Problems

- Elevated ICP can also affect the perfusion of the brain
- Cerebral Perfusion Pressure (CPP) is measured by taking the Mean Arterial Pressure (MAP) and subtracting Intracranial Pressure (ICP)

What does this mean?

- This shows that if the ICP goes up… and MAP stays constant… then the CPP decreases.
- This means the patient is not getting as much blood flow to the brain.

Poor Outcomes

- Having an elevated ICP is one of the most damaging aspects of neurological trauma, and is directly related to poor prognosis.[2]

Normal Values

- A normal ICP in an adult ranges from 0-15 mmHg[2]
- An ICP cannot surpass 40 without causing harm.[3]
- Even values between 25-30 are considered fatal if they are prolonged.[2]
- Adam Williams TBI Initiative → tx ICP > 20 mmHg

Causes?

- An elevated ICP can be caused by many different etiologies.
  - Traumatic Brain Injuries
  - Lyme Disease
  - Hydrocephalus
  - Brain Tumor
  - Severe Hypertension
  - Venous Sinus Thrombosis
  - Restricting Jugular Venous flow (i.e. C-collars)
  - Etc.

Monitoring

- There are 4 main types of devices for monitoring ICP[4]
  - Intraventricular Catheters
  - Fiber optic Monitors
  - Subarachnoid Bolts
  - Epidural Monitors

Intraventricular Catheters[4]

- Most widely used devices – Most Accurate
- A catheter is actually placed inside one of the ventricles (a fluid filled cavity in the brain where CSF is produced)
- Allows treatment and monitoring simultaneously
  - Can be used to take out excess CSF, thereby decreasing ICP

Fiber optic Monitors[4]

- Relatively new technology
- A fiber-optic probe is inserted
  - Into the Brain
  - Ventricles
  - Subdural space
- The probe contains a transducer on the tip that measures pressure

Subarachnoid Bolts[4]

- These consist of an actual metal "bolt" that is inserted into the skull so that the tip is resting in the subarachnoid space
- Easy to install (hey… it's what they said!)
- Limited accuracy

Image taken from http://library.ucf.edu/Frankenstein/

Epidural Monitors[4]

- Recording devices that are placed into the epidural space
- This is a potential space that is located between the inner surface of the skull and the dura matter

Problems

- Main problem is Ischemia due to a decreased CPP – self perpetuating cycle
  - The body's response to a decreased CPP is to raise blood pressure and dilate blood vessels in the brain
  - This increases cerebral blood volume
  - This increases ICP
  - This decreases CPP
  - This causes normal body response
  - This increases cerebral blood volume
  - This increases ICP
  - This decreases CPP
  - ETC!

Animated GIF taken from http://www.artie.com

Why does this affect RT?

- There are several aspects that Respiratory Therapists need to be aware of when caring for a patient that either has, or probably has, an elevated ICP

Intubation

- During normal laryngeal intubation, the normal body's reaction is to get agitated
  - This causes hypertension
  - This causes an elevated ICP
- Therefore adequate pre-medication for intubation is essential[5]

Intubation

- Preferred method:
  - Pre-oxygenation
  - Rapid Sequence Intubation (RSI)
- Lidocaine?
  - Not supported in random clinical trials
  - But is recommended to suppress the autonomic response from laryngeal stimulation[5]

RSI

- Rapid Sequence Intubation involves administration of a sedative and a paralytic before intubation
- Sedatives used:[6]
  - Sodium thiopental
  - Propofol
  - Etomidate

RSI

- Paralytics used:[6]
  - Rocuronium
  - Succinylcholine
- A recent study looked at using midazolam during RSI
  - Found an increase in RSI-associated hypotension[7]

Sedation

- Agitation increases ICP, therefore it is important to keep the patient well sedated.

Sedation

- Why is it important to RT if the patient is fully sedated?
  - Low ventilatory drive
  - Must be sure to provide safeguards to ensure adequate minute ventilation

Ventilatory Strategies

- One of the most important treatments for high ICP is to control the ABGs
  - This is because hypoxemia and hypercapnia can cause the cerebral blood vessels to dilate and raise ICP even more[8]
  - Hypoxemia can also lead to a lactic acidosis, lowering pH and causing even more vasodilatory effects[2]

Ventilatory Strategies

- Hyperventilating a patient down to a state of hypocapnia will do the opposite of hypercapnia – it will vasoconstrict the vessels in the brain.
- BUT……

Image taken from http://www.trentu.ca/careers/students/selfassess.html

Ventilatory Strategies

- This limits blood flow to an already-compromised-brain.
- Also, the brain adjusts to the new level of CO_2 after 48-72 hrs
  - Meaning vessels could rapidly dilate if CO_2 were to return to normal too quickly[9]

Ventilatory Strategies

- This strategy is used now if there are signs of brain herniation, because the herniation might make it worthwhile to constrict blood vessels.
- If this strategy is used, be sure to go back to normocarbia GRADUALLY

Adam Williams TBI Initiative[10]

- Ventilation goals for first 24 hours
  - pH 7.36 – 7.48
  - $PaCO_2$/End Tidal 35-45 mmHg
  - $P_{\text{brain tissue}}O_2$ > 20 mmHg or
  - SpO_2 100%
  - ICP < 20 mmHg

Ventilatory Strategies

- What about PEEP?
- Not unless explicitly needed for oxygenation (Adam Williams Initiative calls for 5 cm H_2O PEEP initially)[10]
- PEEP can also increase ICP
- Be especially sure to have HOB up if using PEEP

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