

Closed Head Injury...



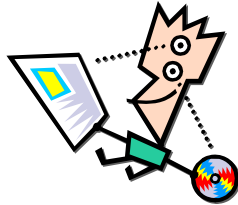
By Bob Page, NREMT-P, CCEMT-P, NCEE

Where We Are Now!

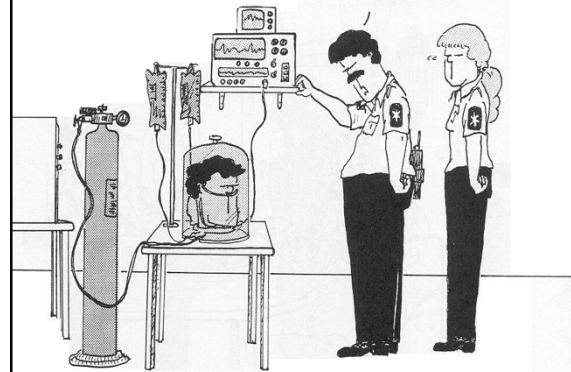


Objectives

- * Statistics
- * Anatomy
- * Mechanisms
- * Assessment
- * ICP Pathology
- * ICP Management
- * ICP Precautions



YA KNOW... YOU WOULDN'T BE ALIVE TODAY IF IT WASN'T FOR US.



BTF
BRAIN TRAUMA
FOUNDATION



Prehospital Emergency Care

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Guidelines for Prehospital Management of Traumatic Brain Injury 2nd Edition

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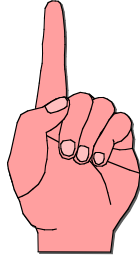
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EBM

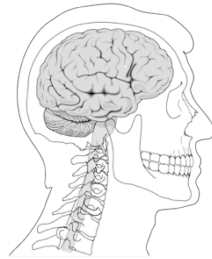


Head Injury

- * Number One Killer in Trauma
- * 25% of all trauma deaths
- * 50% of all deaths from MVC
- * 200,000 people in the US live with the disability caused by these injuries



Basic Anatomy



- * Scalp
- * Skull
- * Meninges
 - * Dura Mater
 - * Arachnoid
 - * Pia Mater
- * Brain Tissue
- * CSF and Blood

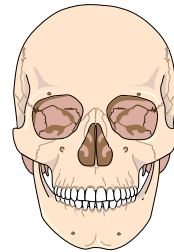
Basic Anatomy - Scalp



- * Very Vascular
- * Bleeds Freely
- * Vessels suspended in inelastic tissue
- * As a result, vasospasms are limited

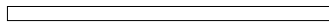
Basic Anatomy - Skull

- * Like a closed box
- * Only opening is the foramen magnum
- * Rigid structure protects and contributes to several injury mechanisms



Basic Anatomy - Meninges

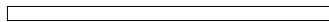
P IA MATER "SOFT MOTHER"



A RACHNOID MEMBRANE

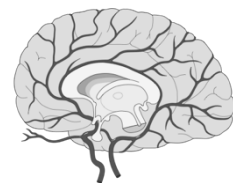


D URA MATER "TOUGH MOTHER"

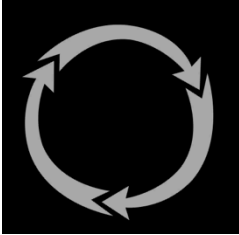


Intracranial Volume

- * 80% Brain Matter
- * 10% Blood
- * 10% CSF



Intracranial Volume



- * Volume is Fixed at 100%
- * If more of one thing is added, then something else must go.
- * This is called autoregulation
- * Monroe-Kellie Doctrine

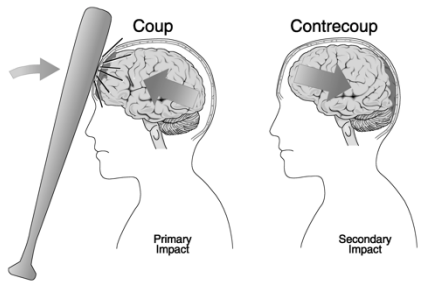
Mechanisms of Injury

***3 Collisions**

- * Car hits object
- * Head hits windshield
- * Brain hits inside of skull



Mechanisms of Injury



Mechanisms of Injury

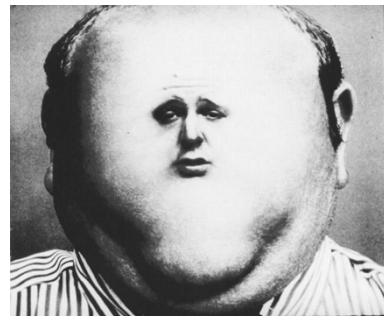
- * Brain movement inside the skull
- * Base of skull is very rough
- * Most brain movement is at the top
- * Brain suspended by vessels and brain tissue that can be torn by movement, especially at the base



Response to Injury

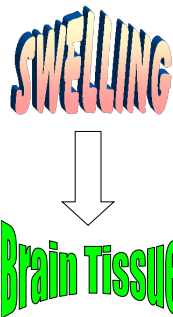
SWELLING

- * Due to increased blood volume (not edema)
- * Natural response to injury anywhere on your body
- * Body rushes nutrients to heal injured area





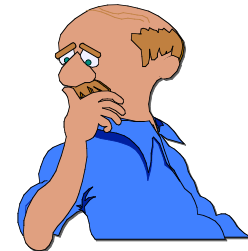
Penetrating Mechanism



- *Increase in blood volume exerts pressure on the brain tissue
- *This eventually decreases blood flow to the uninjured part of the brain

Response to Injury

- *Increase in cerebral edema (water) develops after 24-48 hours and peaks in 3-5 days
- *Not an acute concern, per say



Response to Injury

- *CO₂ levels in the blood have a critical effect on cerebral blood vessels
- *CO₂ is produced by hypoxic cells
- *CO₂ is a very potent vasodilator
- *What would happen if CO₂ levels were increased? Decreased?

CO₂ Levels

- *Normal CO₂ is in the range of 35-45 mm/hg (torr)
- *Mean CO₂ level is 40 torr.
- *How would you get rid of CO₂?
- *What would happen if you got rid of too much?

Review

*Two main factors that increase intracranial volume are:

***Vasodilation** (immediately)

***Cerebral edema** (24-48 hrs)

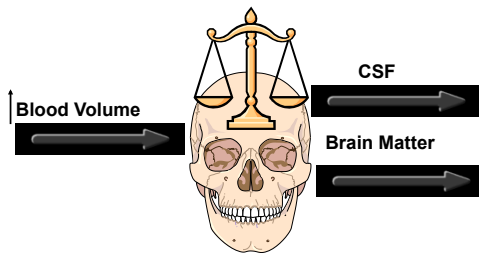
Autoregulation

*The brain had the ability to control its environment

*As long as there is adequate perfusion



Autoregulation



Autoregulation

*A rapid increase in intracranial volume cannot be compensated for by the small amount of area occupied by CSF

*This condition could be rapidly catastrophic



Intracranial Pressure

- *The pressure of the brain contents within the skull is intracranial pressure (ICP)
- *The pressure of the blood flowing through the brain is referred to as the cerebral perfusion pressure (CPP)
- *The pressure of the blood in the body is the mean arterial pressure (MAP)

Intracranial Pressure

*MAP (Mean Arterial Pressure) can be determined by a simple formula:

$$\text{MAP} = \text{systolic} + 2 \times \text{diastolic}$$

3

Intracranial Pressure

***Example of MAP**

***B/P is 120/80**

$$\text{MAP} = \frac{120 + 160}{3} = \frac{280}{3} = 93 \text{ mm/hg}$$

Intracranial Pressure

***Intracranial pressure (ICP) is measured by a device that is implanted through the skull by a surgeon**

***The normal value for ICP is 0 - 10 mm/hg**

Intracranial Pressure

***Cerebral Perfusion Pressure (CPP) can be determined by the following formula:**

$$\text{CPP} = \text{MAP} - \text{ICP}$$

***Normal CPP range is 60 - 150 for autoregulation to work well!**

Intracranial Pressure

***Example of CPP**

***Blood Pressure is 140/80**

***ICP is 30**

$$\text{CPP} = 100 - 30 = 70 \text{ mm/hg}$$

Is this enough for autoregulation?

What would happen if the ICP was 80?

Assessment Findings

***Increased ICP**

***Hypoxia is a common cause of increased ICP that can be overlooked**



Assessment Findings



***LOC Changes**

***Confusion**

***Lethargy**

***Disorientation**

***Restlessness**

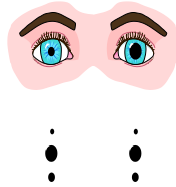
***Apathy**

***Agitation / combativeness**

***Motor response**

Assessment Findings

- * Pupillary Changes
- * Irregular shaped
- * Equality?
- * Constricted?
- * Dilated?
- * Vision Problems?

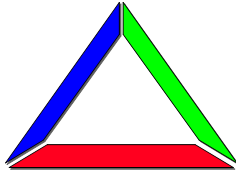


Assessment Findings

- * Vital Signs
 - * VS do not change much until late in the ICP process
 - * VS changes indicate uncompensated compression to the brain stem
 - * Rule out other factors that alter VS
 - * SHOCK!

Assessment Findings

- * Cushing's Triad
 - * hypertension
 - * bradycardia
 - * altered respirations
- * LATE SIGN!
- * Why do we get into Cushing's Triad?



Assessment Findings

- * Head injured patient is combative with a B/P of 110/70, P=90, RR=18
- * What is the MAP?
- * Is it in the normal range?



Assessment Findings

- * After 10 minutes:
- * B/P is 140/70
- * Pulse is 90
- * Pt is still combative.
- * Now what is the MAP?
- * Explain the change



Assessment Findings

- * As ICP rises, autoregulation increases the MAP (by raising the BP) to maintain an adequate cerebral perfusion pressure



Assessment Findings

*Understanding what the brain is trying to do, consider the "classic" increased ICP vital signs:

Widening pulse pressure: 250/130

Bradycardia: HR = 40

Abnormal Respirs: Cheyne Stokes

Assessment Findings

*BP of 250/130

*MAP would be 170!

*Why is the MAP so high?

*"The ICP is 100!"

*Is this a good thing?

*Should we lower the blood pressure?



Assessment Findings



*CPP=MAP-ICP

*170 - 100 = 70

Lower B/P to 190/100

*MAP would be 130

*New CPP is 30!

*Is this a good thing?

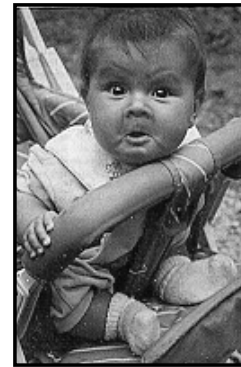


Table 8-2 GLASGOW COMA SCALE

Eye Opening	
Spontaneous	4
To verbal command	3
To pain	2
No response	1
Verbal Response	
Oriented and converses	5
Disoriented and converses	4
Inappropriate words	3
Incomprehensible sounds	2
No response	1
Motor Response	
Obeys verbal commands	6
Localizes pain	5
Withdraws from pain (flexion)	4

Lane, 2003¹⁹ Prospective study of prehospital providers (EMTs, RNs) to determine the effect of instructional video training on GCS scoring ability using 4 prepared case scenarios. II Training in GCS scoring using a video resulted in significantly improved scoring results.

Management of ICP

*Accomplished by maintaining PaO₂, PaCO₂, pH and specified levels

PaO₂
pH
PaCO₂

Management of ICP

- *Maintain a good pulmonary "toilet"
- *Limit suctioning to < 15 seconds
- *Hyperventilate before and after
- *Limit to one or two passes

Management of ICP

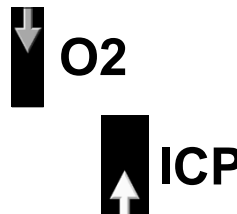
- *pH Changes
- *as pH decreases (acidosis) ICP increases
- *as pH increases (alkalosis) seizure threshold is lowered
- *seizures dramatically increase ICP!

Management of ICP

- *BVM Ventilation
- *100% Oxygen
- *Can correct acute increases in ICP in a little as 2-3 minutes



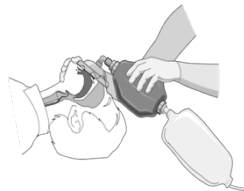
Management of ICP



- *Oxygenation
- *If PaO2 drops below 50 it will cause an increase in cerebral blood flow - increasing ICP

Management of ICP

- *Hyperventilation?
- *Removes CO2
- *CO2 Causes vasodilation
- *Vasodilation increase blood volume in brain
- *This increases ICP



Management of ICP



- *Hyperventilation?
- *How much?
- *How fast?
- *Can we do too much?
- *Can we do too little?

Management of ICP

- * Hyperventilation
- * To an ETCO₂ (capnometry) reading of about 30-35 mm/hg
- * That would be about **8-10 B/M** on an intubated patient

30 mm/hg

Table 8-2 GLASGOW COMA SCALE	
Eye Opening	
Spontaneous	3
To verbal command	2
To pain	1
No response	0
Verbal Response	
Oriented and converses	5
Disoriented and converses	4
Inappropriate words	3
Incomprehensible sounds	2
No response	1
Motor Response	
Obeys verbal commands	6
Localizes pain	5
Withdraws from pain (flexion)	4
Abnormal flexion in response to pain (decerebrate)	3
Extension in response to pain (decerebrate rigidity)	2
No response	1

Who gets it?

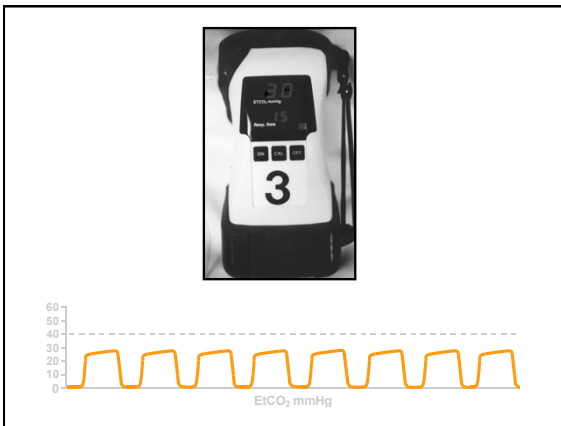
*GCS < 9 with...

*Unequal pupils

*Drops 2

*Posturing

*Other s/s herniation?



Management of ICP

- * Over doing the hyperventilation can reduce the CO₂ levels to where there is severely constricted vessels to the brain, causing ischemia and further edema.
- * Capnography should be the standard to guide ventilation

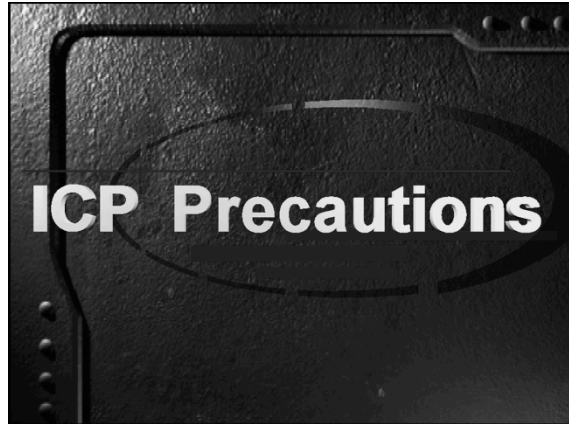


*This is the end of the "hard stuff"






*** Now for the surprising cool, unexpected and sometimes weird, controversial and yet respected, paramedic lookin', nurse laughing, stuff!**



ICP Precautions

- * Positional Changes**
- * Laying flat increases ICP**
 - * elevate backboard at head 15-30 degrees**




ICP Precautions

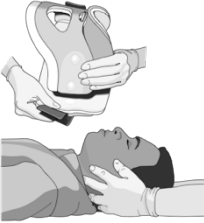
- * Hip flexion decreases venous return and increases ICP**
- * Coughing and valsalva increase ICP**
- * Body temperature**
 - * Too high causes increases metabolism = ICP**
 - * Too low causes shivering = ICP**

ICP Precautions

- * Head and neck in neutral position. Anything else will flatten jugular veins and inhibit venous return that leads to ICP**



ICP Precautions



- * Proper sizing of the C-Collar helps maintain neutral position**
- * Padding 2-4 cm behind the head on a LSB is needed on most adults to achieve neutral**

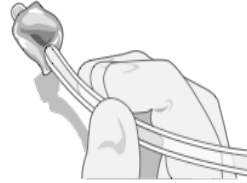
ICP Precautions

- * Intubation precautions
- * Pre-medicate with Lidocaine, 1mg/kg IV 2 minutes prior to attempt
- * Laryngoscopy produces an ICP Spike (CN IX)



ICP Precautions

- * Speaking of ET Tubes:
- * Avoid using any circumferential device to secure tube
- * Occludes jugular veins - increases ICP



Never Stop Learning

- * Intubation, and other skills in head injured persons are important.
- * They are also dangerous
- * Practice your sequences and procedures



ICP Precautions

- * Environment
- * External stimuli can increase ICP
- * If possible, avoid loud sounds and bright lights



ICP Precautions



- * "Better Living through Chemistry"
- * Sedation - Neurologists hate it, but great for reducing ICP
- * Fentanyl is a good choice as is Versed

ICP Precautions



- * Paralytics (RSI)
- * Decreases metabolic requirements
- * Use with sedation!
- * Can mask seizures - unseen increased ICP
- * Dilantin, Valium, others

Initial Resuscitation ... RSI

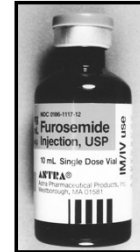
*Although a neuromuscular blockade would make our job easier in the field...



- * patients who receive these medications:
- * longer ICU stays
- * increased risk of sepsis
- * higher rate of pneumonia
- * no improvement in outcome

ICP Precautions

- * Diuretics
- * Decrease ICP by removing fluids
- * May decrease MAP and CPP
- * Mannitol – osmosis
 - * Intermittent bolus, not continuous infusion
- * Lasix - loop



ICP Precautions

- * Fluid selection
- * Isotonic Crystalloid
 - * Normal Saline or LR
- * Avoid sugar containing or hypotonic solutions like D5W
- * Maintain normal MAP with bolus therapy



ICP Precautions

- * Steroids
 - * Decadron, Solumedrol
- * “No proven benefit in traumatic head injury”
- * Some benefit in spinal trauma



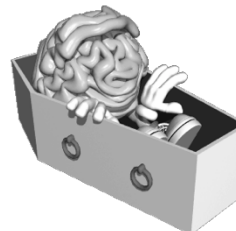
Summary - ICP Precautions

- | | |
|--|---|
| <ul style="list-style-type: none"> * BLS * Neutral Position * BVM with 100% O2 * Properly size C-collar / padding * Protect airway * Elevate head of backboard | <ul style="list-style-type: none"> * ALS * Secure airway * Pre-medicate with Lidocaine * Secure tube on one side only * Maintain MAP/ CPP * Consider sedation |
|--|---|

In the End...

Never let a head injured patient get

hypotensive
hypoxic



Thanks!



Questions?

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