



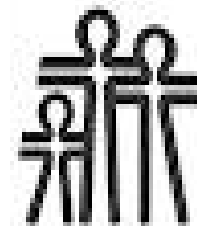
HARBORVIEW  
INJURY PREVENTION  
& RESEARCH CENTER

# Traumatic Brain Injury Module for DSHS



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**BLS provider course**



Washington State  
Department of Social  
& Health Services

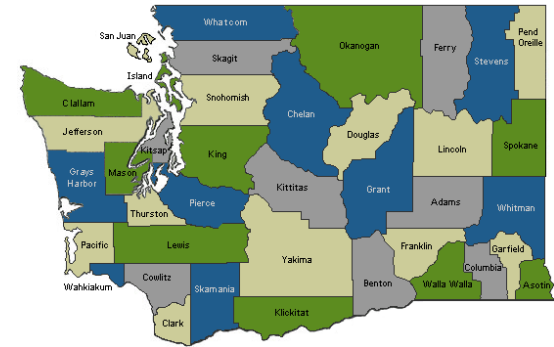
# TBI Epidemiology: Nationally

- Yearly 1.7 million people sustain Traumatic Brain Injury,(TBI)
  - ~1.36 million are treated in ED and discharged.
  - 275,000 are hospitalized
  - 80,000 to 90,000 are disabled
  - 52,000 die
- Today, 5.3 million Americans (~ 2%) are living with TBI-related disability and ~1% of people with severe TBI survive in a persistent vegetative state
- In 2000, the estimated lifetime direct medical costs and indirect costs (such as loss of life long productivity) from TBI amounted to **60 billion dollars**

# TBI Epidemiology: WA State

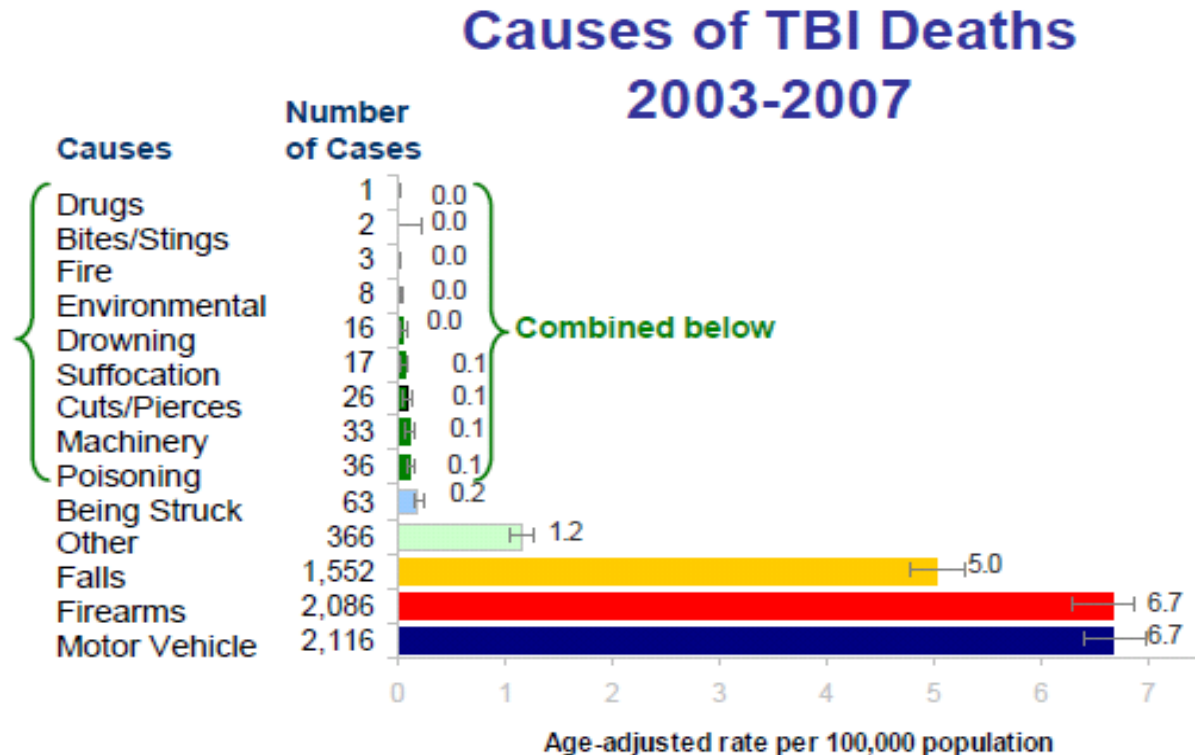
*Population; 6,664,195 - Jul 2009*

Source: U.S. Census Bureau



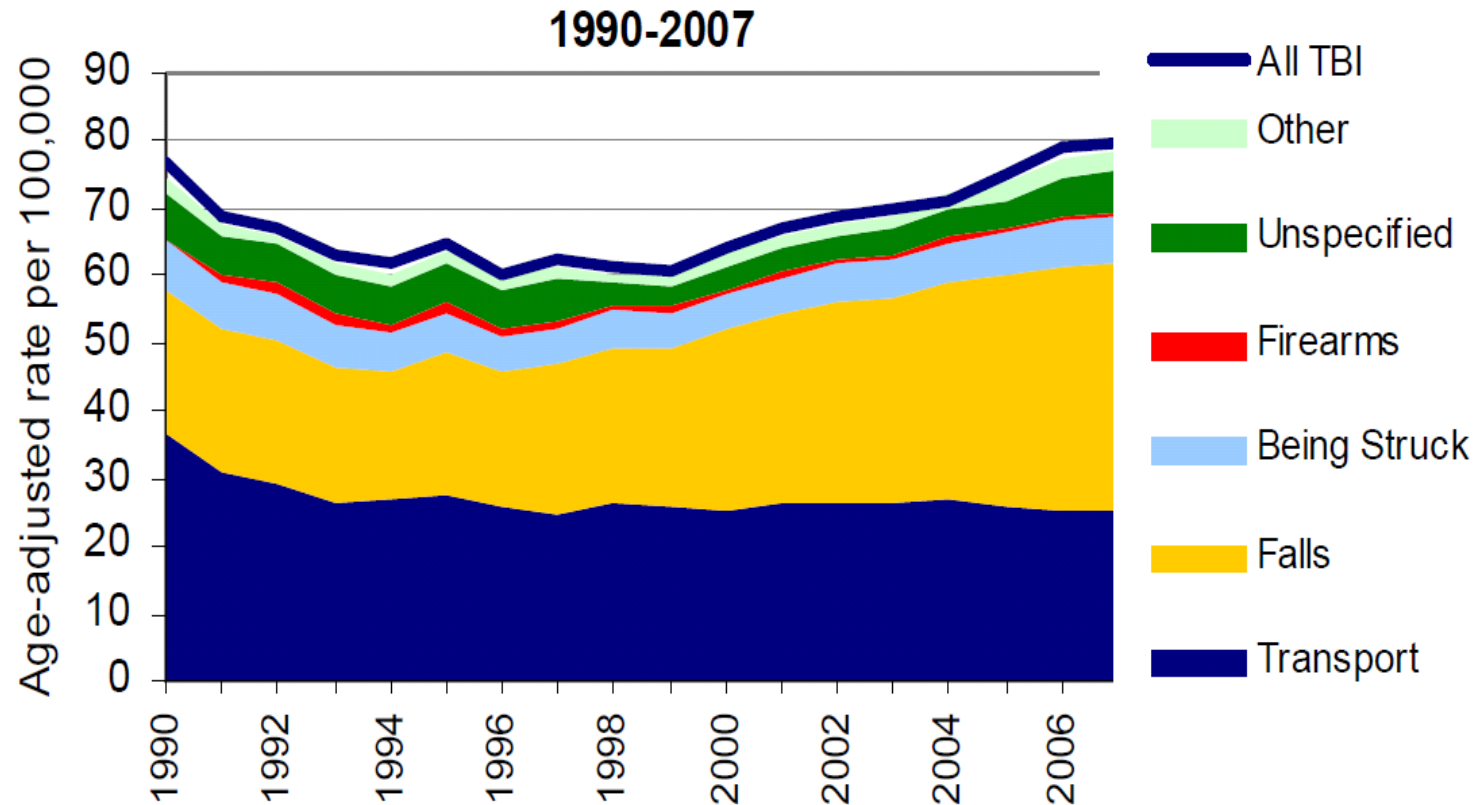
- **TBI ~ 10% of all injury related hospitalizations**
- **TBI deaths are about 29% of all injury related fatalities**
- Nearly 123,750 residents with TBI related disabilities
- ~ 26,000 residents had TBI (2005–2009)
- ~ 5,500 hospitalizations and 1,300 deaths/year (2002–2006)
  - **You will see TBI patients in your career**

# WA Epidemiology: TBI Causes



From 2003-2007, falls, being struck by an object, and motor vehicle related TBI injuries made about 90% of all TBI related hospitalizations and falls, firearms and motor vehicle related injuries made about 91% of TBI deaths.

# WA Epidemiology: TBI Hospitalizations by Cause



- TBI Hospitalizations due to transport injuries of various types fell in the early years, and then plateaued. Falls increased since the late 1990's, explaining the overall rise in TBI Hospitalizations. TBI hospitalizations by firearm injury remains low due to the low survival rate from the initial injury.

# WA Epidemiology: Elderly Fall Related TBI

- TBI related hospitalizations and deaths will steadily increase over the next few decades as the baby-boom generation (those born from 1946 to 1964) steadily ages
  - **1 in 3** adults age 65 + falls each year
  - **1 in 2** adults age 80+ falls each year
- **1 out of 5** falls causes a serious injury such as a head trauma (TBI) or fracture
- Only **1 in 5** people who are hospitalized for falls ever return home

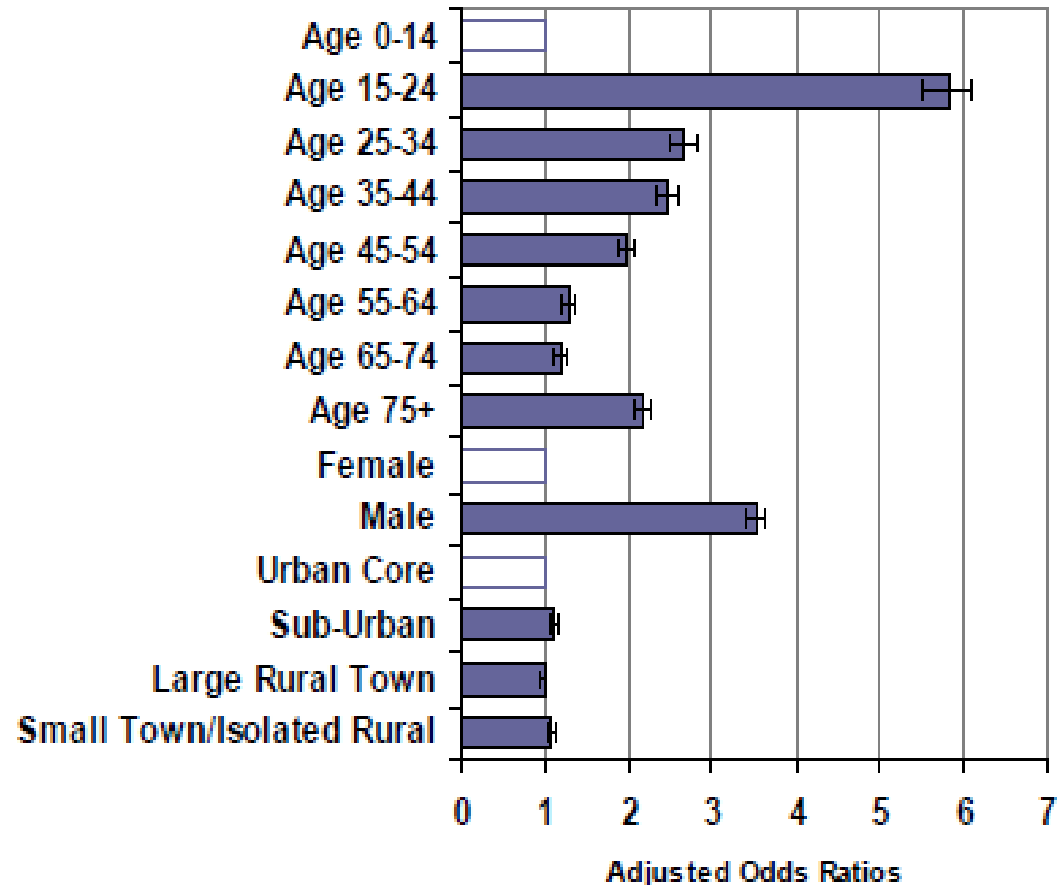
# WA Epidemiology: TBI Hospitalizations by Age

**Who is at Risk ?**

**Elderly**

**Age 15-24 years**

**Male gender**



# Traumatic Brain Injury (TBI)

- Injuries to the brain caused by physical trauma to the head.
  - Can be penetrating or blunt force injury
- Two forms of injury
  - *Primary*
    - Direct trauma to brain and vascular structures
    - Examples: contusions, hemorrhages, and other direct mechanical injury to brain contents (brain, CSF, blood).
  - *Secondary*
    - Ongoing pathophysiologic processes continue to injure brain for weeks after TBI
    - **Primary focus in TBI management is to identify and limit or stop secondary injury mechanisms**



# Secondary Injury

- After initial TBI, priorities are:
  - **Identification of secondary insults**
    - Intracranial hypertension – from expanding intracranial hematoma / brain swelling results in elevated intracranial pressure (ICP) and/or herniation
    - Hypoxia – from ventilatory/circulatory failure, airway obstruction, apnea, lung injury, aspiration
    - Hypotension – associated spinal cord injury, blood loss
      - Inadequate cerebral blood flow can cause inadequate oxygen and glucose delivery
    - Hypercarbia– from inadequate ventilation, apnea
  - **Rapid transport to a capable health care facility**

# Signs and Symptoms

## Signs

- diminished consciousness
- convulsions or seizures
- dilation of one or both pupils
- slurred speech
- repeated vomiting or nausea
- increasing confusion, restlessness, or agitation

## Symptoms

- headache
- blurred vision
- ringing in the ear
- bad taste in the mouth
- weakness or numbness in extremities
- loss of coordination
- dizziness/lightheadedness

# Scene Awareness

- Include the following in the patient care report:
- Kinematics leading up to the injury
  - MVC – speed, restraints, intrusion, helmet
  - Assault – head vs. object, repeat assault?
  - Sports related – body position, speed at impact
- **Witness account of Patient Behavior after Injury**
  - LOC, slurred speech, inappropriate behavior, duration

# Documentation

- Complete documentation could have a positive impact throughout a TBI patients life
  - **Diagnosis and Treatment after the injury may depend on thoroughness of PCR**
  - Include events occurring pre and post injury and before EMS arrival
- Ensure a successful hand off of the run sheet to the patient care providers in the ED.
  - After obtaining signature ensure a copy of the PCR is included in the patient chart

# Documentation

- Specific items to document include:
  - Mechanism of Injury/ LOC?
  - Primary symptoms/associated symptoms
  - Serial vital signs – HR, BP, RR
  - Component GCS and Pupils
  - Procedures preformed
  - Transportation decisions



# Assessment: Overview



## **Airway:**

Priorities

## **Breathing:**

Oxygenation

Hypoxemia

## **Circulation:**

Hypotension

Shock

## **Glasgow Coma Scale (GCS):**

Priorities

Patient Interaction

Components

Motor Component

Score

## **Pupils:**

Value

Pathophysiology

Abnormalities

## **Cerebral Herniation:**

Indicators

# Airway: Priorities

- Determine that airway is open and maintain patency
- Assess need for artificial airway
  - **For BLS providers, is a Medic evaluation needed?**
- Reassess every 5 minutes and as needed
- Maintain cervical spine precautions
  - Use cervical collar during transport

# Breathing: Oxygenation

- Assess rate, rhythm, depth, quality, and effectiveness of ventilation (movement of air in and out of the lungs) every 5 minutes and as needed
  - If possible use continuous SpO<sub>2</sub> monitoring
  - Avoid inadvertent hyperventilation
- If no SpO<sub>2</sub> monitoring look for apnea and slow/irregular breathing to indicate adequate tissue oxygenation and carbon dioxide removal levels



# Breathing: Hypoxemia

- Assess and monitor for hypoxemia ( $\text{SpO}_2 < 90\%$ ) –
  - **Occurs in 40% of TBI cases**
- If pulse oximetry not available, observe patient for indirect signs of hypoxia
- Potential Signs and Symptoms of Hypoxia:
  - Blue or dusky mucus membranes
  - Impaired judgment
  - Confusion, delirium, agitation
  - Decreased level of consciousness
  - Tachycardia-heart rate  $> 100$  beats per minute for adult
  - Cyanosis of fingernails and lips
  - Tachypnea - At or above 20 breaths per minute for adult

# Circulation: Hypotension

- Monitor for hypotension - inadequate cerebral blood flow can cause inadequate oxygen and glucose delivery
  - **Adult hypotension, systolic blood pressure (SBP) <90mm Hg**
- Monitor for hypertension - may indicate raised ICP when associated with bradycardia and irregular respiration
- Use correct cuff size to measure systolic and diastolic blood pressure
  - Cuff too small (false high or normal), too large (false low)
- Assess SBP every 5 minutes
  - Continuous monitoring if possible

# Circulation: Shock

- It is very important to recognize the signs and symptoms of shock and it is something that every EMS provider can do
- Signs and Symptoms of Shock:
  - Skin cyanosis, pallor
  - Restlessness, anxiety, change in level of consciousness
  - Tachycardia – rapid heart rate, greater than 100 beats per minute
  - Tachypnea – rapid, shallow respiratory rate
  - Narrowed pulse pressure – reduction in the range between the systolic and diastolic blood pressure
  - Cool extremities
  - Hypotension – SBP < 90 mm Hg
- If spinal shock is associated patient may be hypotensive with bradycardia

# Glasgow Coma Scale (GCS): Priorities

- GCS preferred method to determine level of consciousness
  - AVPU (Alert, Verbal, Pain, Unresponsive) is too simple to determine LOC & not quantifiable
- Follow ABC's before measuring GCS
- If possible, assess GCS prior to intubation
- Measure GCS before administering sedative or paralytic agents, or after these drugs have been metabolized
- Reassess and record GCS every 5 minutes

# GCS: Patient Interaction

- GCS obtained by direct patient interaction
- Pre-hospital provider must ask direct questions and perform specific actions for accurate GCS score
  - Do not simply say “squeeze my hands” (reflexive)
  - Instead say “show me two fingers”
  - **The EMT needs to illicit a response that demonstrates cognition, or the ability of the patient to think**
- If eye opening does not occur to voice, use axillary pinch or finger nail bed pressure

# GCS: Components

- GCS should be measured by pre-hospital providers who are appropriately trained

Eyes Open		Best Motor Response		Best Verbal Response	
Spontaneously	4	Obeys verbal orders	6	Oriented, conversant	5
To command	3	Localizes painful stimuli	5	Disoriented, conversant	4
To pain	2	Withdraws	4	Inappropriate words	3
No response	1	Painful stimulus, flexion	3	Inappropriate sounds	2
		Painful stimulus, extension	2	No response	1
		No response	1		

Maximum 15 points

GCS 14-15: Mild TBI

GCS 9-13: Moderate TBI

GCS 3-8: Severe TBI

# GCS: Motor Component

- Important part of GCS
- Motor response was designed to look at the best upper extremity response
- Spinal cord injury, chemical paralysis or excessive pain makes motor assessment impossible
- Abnormal posturing (decerebration & decortication) look similar in the lower extremities

## Motor Response

6- Obeys

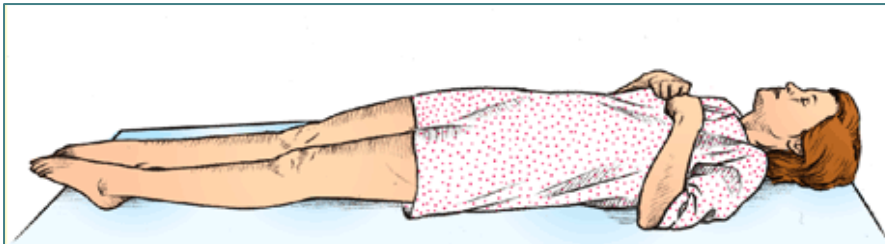
5- Localizes-(purposeful movements towards painful stimuli)

4-Withdraws from pain

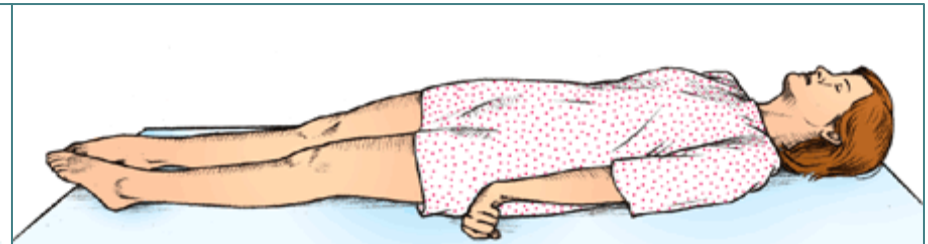
3 Abnormal flexion - **Image A**

2-Abnormal extension - **Image B**

1-No response



A: Abnormal flexion (decorticate rigidity)



B: Extension posturing (decerebrate rigidity)

# GCS: Value

- GCS provides basis for determining the method of transport and the preferred receiving facility
- Compare to previous scores to identify trend over time
  - A single field measurement cannot predict outcome
  - Repeated GCS scores can be valuable to ED staff
  - Deterioration of  $\geq 2$  points is a bad sign
- **GCS < 9 indicates a patient with a severe TBI and require tracheal intubation**



# Pupils: Value

- Pupillary size and their reaction to light should be used in the field as it can be helpful in diagnosis, treatment and prognosis
- **A fixed and dilated pupil is a warning sign and can indicate an impending cerebral herniation**
- Pupillary size should be measured after the patient has been stabilized

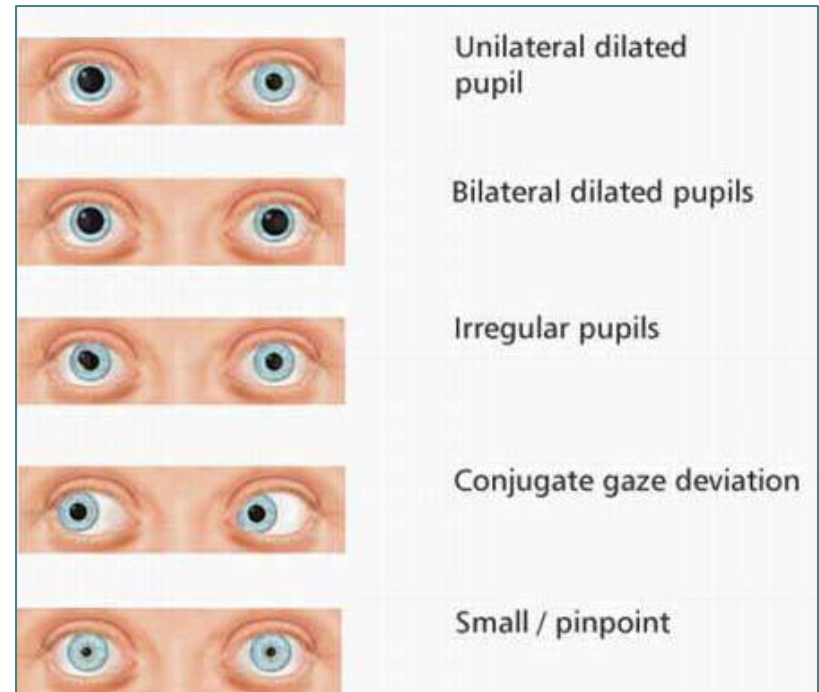
# Pupils: Pathophysiology

- Why do pupils dilate?
  - The presence of intracranial hematoma can cause downward displacement of the brain, until it puts pressure on the cranial nerve responsible for pupil dilation
- Other causes of abnormal pupils:

Hypoxia	Hypotension
Drug use (opiates)	Hypothermia
Toxic Exposure	Artificial eye
Orbital trauma	Congenital abnormality
Pharmacological treatment, (e.g. Atropine)	Cataract Surgery

# Pupils: Abnormalities

- Unequal or dilated and unreactive - suspect brain herniation
- Unilateral or bilateral pupils -
  - (asymmetric pupils differ  $> 1$  mm)
- Dilated pupils -
  - (dilation more than or equal to 4mm)
- Fixed pupils -
  - (fixed pupil less than 1 mm change in response to bright light)



- Evidence of orbital trauma should be recorded

# Cerebral Herniation: Indicators

- Unresponsive patient (no eye opening or verbal response)
  - Unilaterally or bilaterally dilated or asymmetric pupils
  - Abnormal extension (decerebrate posturing)
  - No motor response to painful stimuli
- Deteriorating neurologic examination, bradycardia (heart rate < 60 bpm), and hypertension should be viewed as a part of Cushing's response and implies impending herniation
- **Cushing's Triad (Reflex) is a LATE sign of herniation:**
  - **Elevated systolic BP**
  - **Bradycardia**
  - **Irregular respirations**

# Additional Considerations

- Patients with other illness/injury can have signs and symptoms similar to those of TBI
  - ETOH / drug abuse
  - Sports related injury / concussion
  - Violence / domestic violence
    - Has your partner hit or grabbed you are two questions EMT can ask to identify a possibly abusive situation
  - Decreased mental status in the elderly
- **These patients can also have a TBI!**

# Treatment: Overview

## **Airway:**

Priorities

## **Ventilation:**

Priorities

Hyperventilation

## **Fluid Resuscitation:**

Priorities

## **Cerebral Herniation:**

Signs and Symptoms

Hyperventilation

Additional Considerations



# Airway: Priorities

- **ALS/ Medic eval?**
- Protect cervical-spine alignment with manual in-line stabilization, beware facial trauma
- When airway cannot be secured by Endotracheal tube; consider alternate airway devices
  - According to county protocol
- Provide combitube or supraglottic airway if not certified to provide advanced airway adjuncts
  - According to county protocol

# Ventilation: Priorities

- Assess rate, rhythm, depth, and quality to determine the effectiveness of respirations
- Assist ventilations as necessary with Bag Valve Mask and supplemental O<sub>2</sub>
- **ALS/ Medic eval?**
- Adult – normal ventilation rates: 10-12 breaths per minute



# Ventilation: Hyperventilation

- Produces a rapid decrease in arterial partial pressure of carbon dioxide and causes
  - cerebral vasoconstriction
  - Decreased cerebral blood flow
  - decreased intracranial pressure (ICP)
- Hyperventilation is a **temporary** treatment used only in patients showing signs of herniation until definitive diagnostic or therapeutic interventions can be initiated
- Hyperventilation rates age >9 years: 20 BPM

# Fluid Resuscitation: Priorities

- **ALS/ Medic eval?**
- **Avoid hypotension** and inadequate volume resuscitation to maintain normotension and adequate tissue perfusion
  - **Hypotension (SBP < 90 mm Hg) doubles mortality**

# Cerebral Herniation: Hyperventilation

- In normoventilated, normotensive, and well oxygenated patients still showing signs of cerebral herniation, hyperventilation should be used as a temporizing measure and should be discontinued when clinical signs of herniation resolve
- Rate – 20 BPM for adults (Every 3 seconds)

# Cerebral Herniation: Signs & Symptoms

- Signs Symptoms
  - Dilated or unreactive pupils
  - Asymmetric pupils
  - A motor exam that identifies either extensor posturing or no response
  - Progressive neurologic deterioration, decrease in GCS score more than 2 points from patients prior best score - in patients with initial GCS < 9
- Other factors increasing ICP
  - Fear and anxiety
  - Pain
  - Vomiting
  - Straining
  - Environmental stimuli
  - Endotracheal intubation
  - Airway suctioning
- **Frequently re-evaluate patient neurologic status**

# Cerebral Herniation: Additional Considerations

- Rule out decreased level of consciousness due to hypoglycemia
  - Hypoglycemia - blood sugar below 70 mg/dL
  - Perform rapid blood glucose determination
    - If necessary, give IV glucose
    - Follow local protocol

# Transport: Overview

## Transport decisions:

Priorities

Priorities

Receiving facilities



# Transport Decisions: Priorities

- Minimize prehospital time by selecting appropriate mode of transportation, rendezvous with air medical service to decrease en route times
- Patient may require emergent surgery for hematoma evacuation, early transport must be the priority while resuscitation is ongoing
- If necessary, rendezvous with air medical service to decrease en route times

# Transport Decisions: Priorities

- All regions should have an organized trauma care system
- Protocols are recommended to direct EMS regarding destination decisions for patients with severe TBI
- Improved success attributed to integration of prehospital and hospital care and access to expeditious surgery



# Transport Decisions: Receiving facilities

- Transport to appropriate receiving facility based on GCS
  - GCS 14 – 15: Hospital Emergency Room
  - GCS 9 – 13: Trauma Center
  - **GCS < 9: Trauma Center with severe TBI capabilities**
- Patients with severe TBI should be transported to a facility with immediately available:
  - CT scanning
  - Prompt neurosurgical care
  - The ability to monitor ICP
  - The ability to treat intracranial hypertension

# References

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