HARBORVIEW
INJURY PREVENTION
& RESEARCH CENTER

Traumatic Brain Injury Module for DSHS

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ALS provider course

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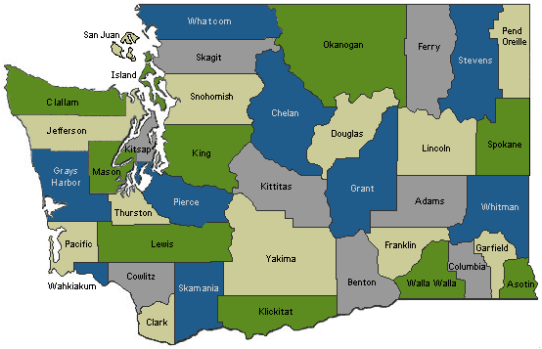
DEPARTMENT OF
SOCIAL & HEALTH
SERVICES

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**

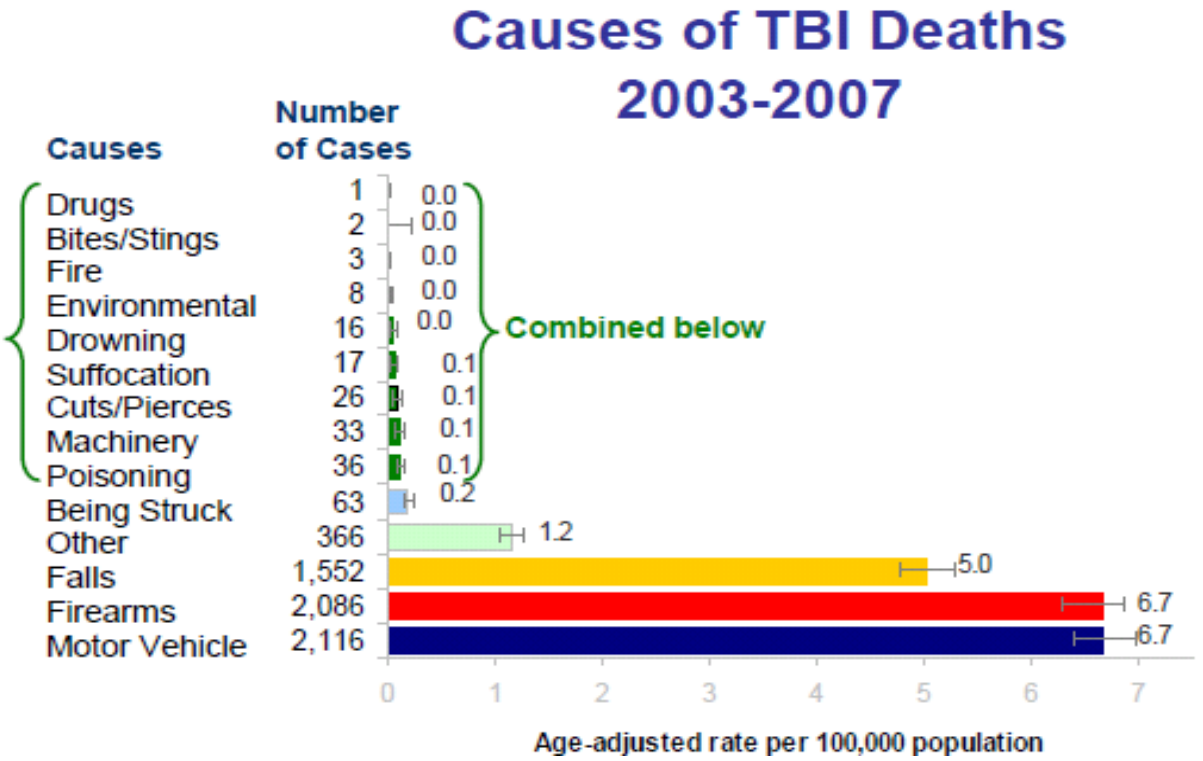
TBI Epidemiology: WA State

Population; 6,664,195 - Jul 2009
Source: U.S. Census Bureau



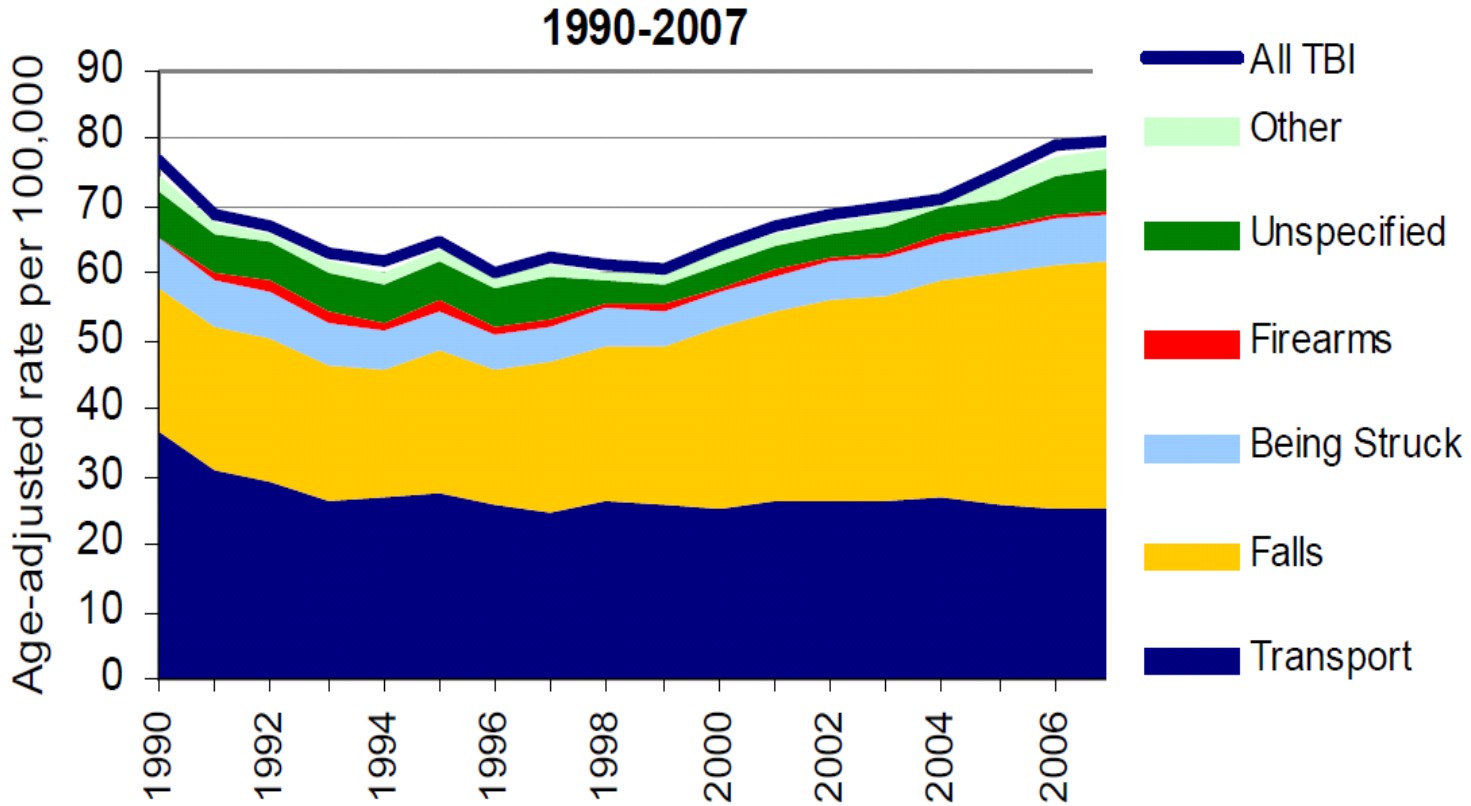
- **TBI ~ 10% of all injury related hospitalizations**
- **TBI deaths are about 29% of all injury related fatalities**
- Nearly 123,750 residents with TBI related disabilities
- ~ 26,000 residents had TBI (2005–2009)
- ~ 5,500 hospitalizations and 1,300 deaths/year (2002–2006)
  - **You will see TBI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

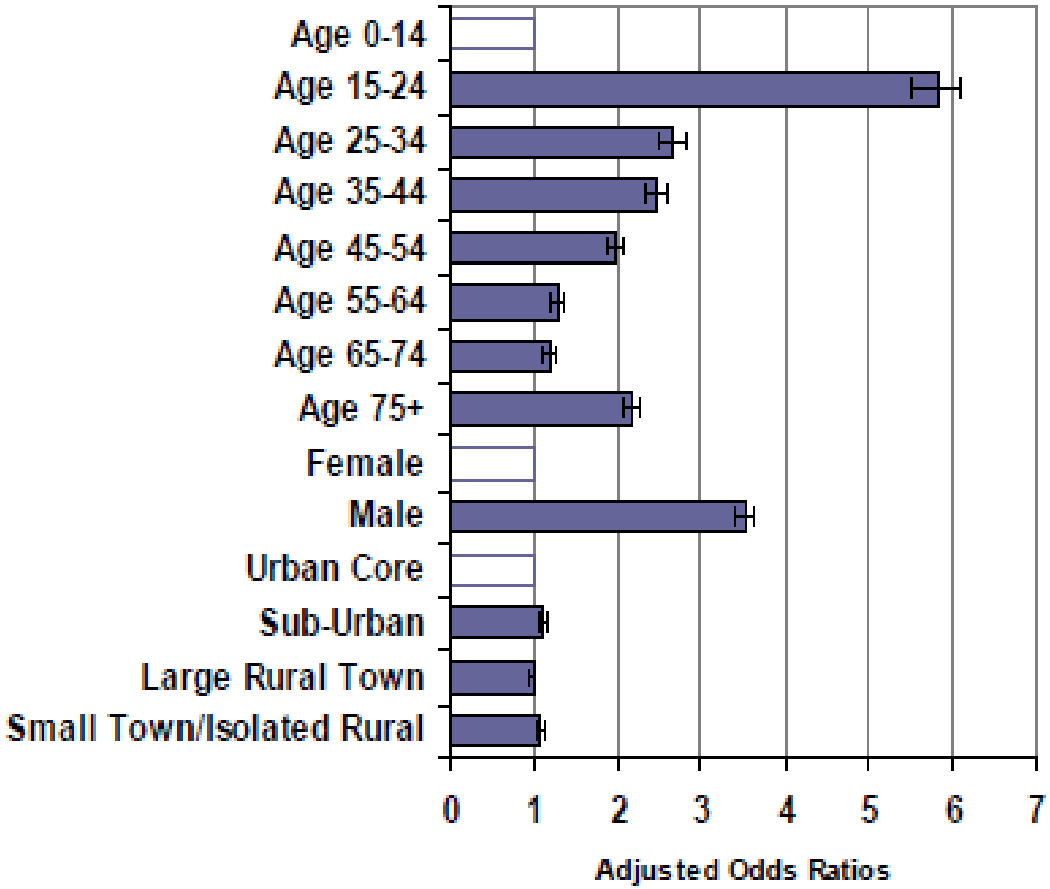
- **1** out of **5** falls causes a serious injury such as a head trauma (TBI) or fracture

- 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 ventillatory/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
- 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_2 monitoring
  - Avoid inadvertent hyperventilation

- If no SpO_2 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 (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 minuet
  - 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 a 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

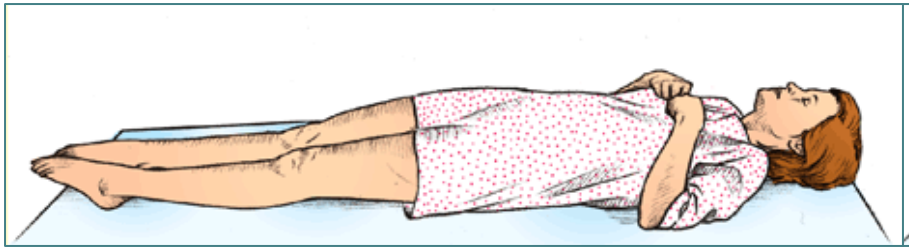
5- Localizes-(purposeful movements towards painful stimuli)

4-Withdraws from pain

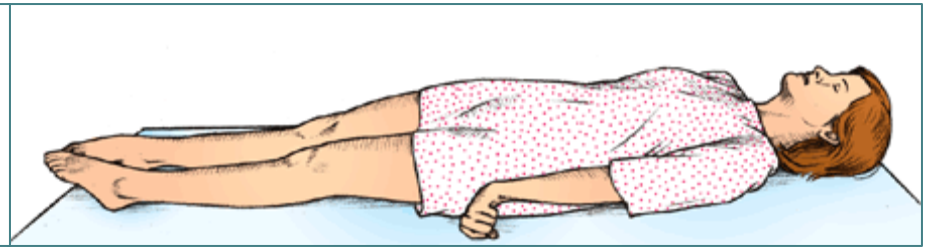
3 Abnormal flexion - **Image A**

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 ≥ 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 and impending cerebral herniation**

- Pupillary size should be measured after the patient has been stabilized

Pupils: Pathophysiology

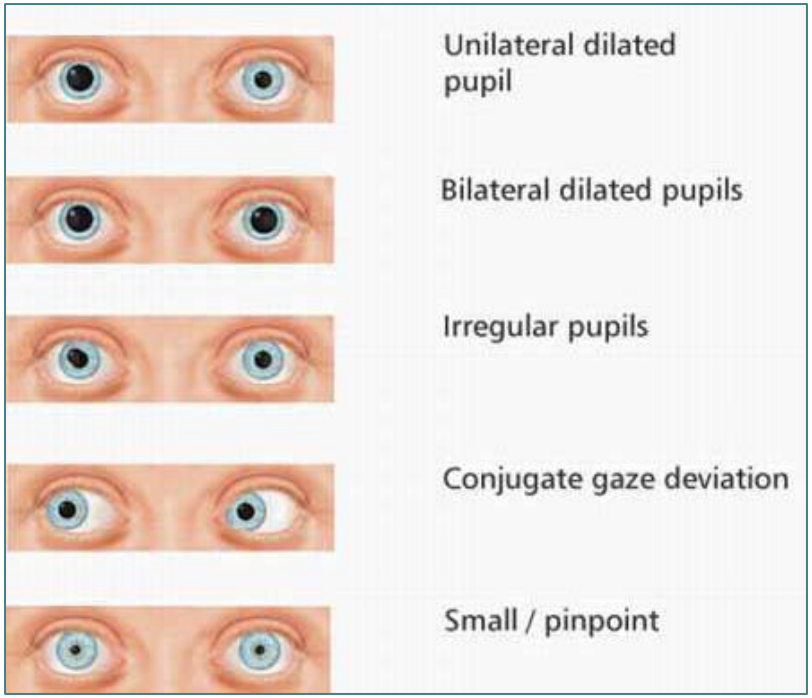
- Why do pupils dilate?
  - The presence of intracranial hematoma can cause downward displacement of the brain, until it puts pressure on the cranial nerve responsible for pupil dilation

- Other causes of abnormal pupils:

Hypoxia
Drug use (opiates)
Toxic Exposure
Orbital trauma
Pharmacological treatment, (e.g. Atropine)
Hypotension
Hypothermia
Artificial eye
Congenital abnormality
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
- When to intubate
- Capnography

Ventilation:

- Goals
- End-tidal CO_2
- Hyperventilation

Fluid Resuscitation:

- Goals
- Vascular Access
- Intraosseous Access

Cerebral Herniation:

- Signs and Symptoms
- Hyperventilation
- Additional Considerations
- Pharmacological concerns

Airway: Priorities

- Protect cervical-spine alignment with manual in-line stabilization, beware facial trauma
- Provide combitube or supraglottic airway if not certified to provide advanced airway adjuncts
- When airway cannot be secured by Endotracheal tube; consider alternate airway devices
- Rapid Sequence Intubation
  - Useful to facilitate intubation for TBI patients with GCS < 9
- Intubation medications and doses per discretion of MPD

Airway: When to Intubate

- Secure airway (e.g. endotracheal tube, cricothyroidotomy) if:
  - GCS < 9 in an unconscious and unresponsive patient
  - Unable to maintain adequate airway
  - Hypoxemia (SpO_2 < 90%) not corrected by supplemental oxygen
  - Respiratory failure or apnea
- Intubate and normoventilate: (~12 breaths per min)
  - If pupils are symmetric and reactive accompanied by localization, withdraw, or flexion responses
- Intubate and hyperventilate: (~20 breaths per min)
  - If pupils are asymmetrical (differ more than 1 mm)
  - If dilated (greater or equal to 4 mm) and fixed
  - If accompanied by extensor posturing or flaccid motor response
    - Considered signs of herniation
    - The motor component of the GCS exam is used to determine signs of cerebral herniation.

Airway: Capnography

- EMS systems implementing endotracheal intubation protocols including RSI should monitor blood pressure, oxygenation, and when feasible end tidal CO_2 ($ETCO_2$) monitoring (monitoring modality for ventilation)

- After intubation confirm placement of tube with lung auscultation and $ETCO_2$ determination

  - – indicated by $ETCO_2$ 35-40 mm Hg

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_2
- Adult – normal ventilation rates: 10-12 breaths per minute
- **Ventilate to maintain SpO_2 > 90%**
  - Patients with TBI normoventilate
  - Patients with TBI who are unconscious and unresponsive: intubate and normoventilate
  - Patients with TBI and suspected brain herniation: Hyperventilate

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

Ventilation: End-tidal CO_2

- Use $ETCO_2$ to:
  - Confirm endotracheal tube placement
  - Measure the adequacy of ventilation.
    - Target range: 35 – 40 mm Hg
  - Guide hyperventilation therapy
    - Severe hyperventilation: < 30 mm Hg
    - $ETCO_2$ < 25 mm Hg is not recommended

- If patient is in shock, $ETCO_2$ values may be low due to poor perfusion

- **$ETCO_2$ < 35 mm Hg should be avoided unless signs of cerebral herniation**

Fluid Resuscitation: Priorities

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

- Administer isotonic crystalloid solutions to maintain SBP in normal range
  - Use dextrose free isotonic fluid
    - (0.9% NaCl or Lactated Ringers)
  - Administer isotonic fluids to maintain ≥SBP 90 mm Hg

- Treat for shock as opposed to restricting fluids

Fluid Resuscitation: Vascular Access

- Preferred percutaneous access site is forearm
  - Alternative sites are antecubital fossa, hand, and upper arm (cephalic vein)

- For patients in shock or with serious injuries, two large-bore (14- or 16-gauge), short (1-inch) IV catheters should be inserted

- Central venous lines or venous cutdowns are generally not appropriate access techniques in the pre-hospital setting

- **Transport should never be delayed to initiate IV lines**

Fluid Resuscitation: Intraosseous Access

- Intraosseous can be alternative route for vascular access
  - for failed peripheral IV access
  - For delayed or prolonged transport

- Appropriate device inserted via the sternal technique (adults only), or used to establish access in the distal tibia above the ankle

- **Focus should remain on rapid transport rather than IV fluid administration**

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

- Hyperventilation goal – $ETCO_2$ of 30-35 mm Hg
  - Monitor with capnography

- **Prophylactic hyperventilation ($PaCO_2$ < 35 mm Hg) should be avoided**

- 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

- Agitation and combativeness can increase intracranial pressure. Optimize patient transport by using short acting sedation, analgesia, and neuromuscular blocks, that are concurrent with local protocol and medical direction

- Some of these treatments cause hypotension, consider patients hemodynamic state and avoid hypotension

- 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

Cerebral Herniation: Pharmacological concerns

Controversial brain targeted therapy

- Mannitol
  - The pre-hospital use of Mannitol currently cannot be recommended
- Hypertonic Saline
  - This investigational therapy, while showing promise in hospital, is not yet recommended for prehospital use
- Lidocaine
  - No literature to support use of lidocaine as a single agent prior to intubation

Transport: Overview

Transport decisions:

Priorities

Priorities

Receiving facilities

Transport Decisions: Priorities

- Minimize prehospital time by selecting appropriate mode of transportation
- 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 expedious 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

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