Lesson 1

Things are not always as they appear...

Assessment

Assessment Objectives

- Describe the signs and symptoms of hypoxia in TBI
- Approximate the SaO₂ by pulse-oximetry and assessment of clinical signs
- Discuss the effects of hypotension on the TBI patient

Assessment Objectives

- Calculate an accurate GCS score
- Name a GCS score that indicates severe TBI
- Differentiate between flexor/decorticate and extensor/decerebrate posturing
- Perform an accurate pupil exam
- Identify prehospital signs of herniation

Definitions

- Oxygenation: delivery of oxygen to tissues from red blood cell hemoglobin
- Hypoxia: inadequate level of oxygen available to tissues
- Oxygen Saturation: percent of hemoglobin that is saturated with oxygen; measured by oximetry
- Ventilation: movement of air in and out of the lungs
Primary vs. Secondary Brain Injury

Primary Brain Injury
Definition – Damage to the brain from the biomechanical effects of the trauma, causing:
- Ischemia
- Anoxia/hypoxia or
- Shear injury

Secondary Brain Injury
Definition – The result of one or more of the following:
- Hypoxia
- Hypotension (decreased cerebral blood flow)
- Increased intracranial pressure (ICP)
- Hyper- or hypoglycemia
- Metabolic disturbances
- Seizures

Airway

- Maintain C-spine precautions
- Determine that airway is open
- Assess the need for artificial airway
- Assess every 5 minutes and as needed

Resuscitation

- Following ABCDE in order is essential.
- A - Airway
- B - Breathing
- C - Circulation
- D - Disability
- E - Exposure

Breathing

- Assess rate, depth, quality, and effectiveness of ventilation every 5 minutes and as needed.
- Hypoxia occurs in 40% of severe TBI.
- Assess for hypoxia.
- Important indicators of hypoxia:
  - SaO₂ < 90%
  - Central cyanosis

Assess Respiratory Rate

- Consider tachypnea at or above the following rates a sign of neurological deterioration:
  - Infant: 40 bpm
  - Children: 30 bpm
  - Adults: 20 bpm

Pulse Oximetry
Circulation for hypotension

- Look for visible signs of "shock"
- Assess SBP every 5 minutes & as needed
  - Adult critical threshold level 90 mm Hg
  - Child and infant levels are lower
  - Use age/size appropriate BP cuff
- Use appropriately sized BP cuff: should be about 2/3 as wide as length of upper arm.

Hypotension

- Signs that indicate the need for fluid resuscitation include:
  - Hypotension
  - Tachycardia
  - Loss of central pulses
  - Prolonged capillary refill time (> 3 seconds)
- Hypotension is a LATE sign of shock in children.

Hypotension

- Hypotension is defined as the following systolic blood pressure (SBP) levels:
  - For neonates 0 to 28 days - SBP < 60 mm Hg
  - For infants 1 to 12 months - SBP < 70 mm Hg
  - For children 1 to 10 years old - SBP < 70 mm Hg + (2 x age in years)
  - For children > 10 years old - SBP < 90 mm Hg
  - For adults - SBP ~ 90 mmHg

Mean Arterial Pressure

- MAP = \( \frac{SBP + 2DBP}{3} \)
- Mean Arterial Pressure is somewhere between systolic and diastolic pressures

Hypotension and TBI

- Any episode of hypotension can worsen outcome TBI.
- A decrease in mean arterial pressure (MAP) can decrease cerebral blood flow and cerebral perfusion pressure.
- Systolic BP is used as an indicator of MAP in prehospital care.
- Mean Arterial Pressure is somewhere between systolic and diastolic pressures.
- MAP = \( \frac{SBP + (2 \times DBP)}{3} \)

Hypotension and TBI

- The perfusion of the brain is driven by the Cerebral Perfusion Pressure (CPP).
- CPP = MAP – ICP
  - ICP = intracranial pressure
- The critical minimum threshold CPP for children (<8 years of age) is 40 mmHg.

AGE > 8
CPP of 60 = the critical minimum threshold
## CPP Calculations

- **Example #1:**
  - If MAP = 50 mm Hg and ICP = 30 mmHg, then CPP = 20 mmHg indicating decreased cerebral blood flow.
- **Example #2:**
  - If MAP is increased to normal value of 70 mmHg, then CPP = 40 mmHg, indicating normal cerebral blood flow.

**Take Home Message:**
Maintaining Blood Pressure is Critical

## D - Level of Consciousness

- Level of consciousness is an important predictor of TBI

## Disability: Level of Consciousness (LOC)

- The Glasgow Coma Scale (GCS) score is the best method to communicate LOC and severity of neurological injury in TBI.
- The GCS is the most widely employed method for reporting serial neurological evaluations.

## GCS Reliability

- The GCS indicates level of consciousness & severity of head injury.
- The GCS is reliably used by pre-hospital emergency medical care providers.¹
- A single field measurement of the GCS cannot predict outcome.


## Glasgow Coma Scale (GCS)

- The GCS is a reproducible measure of LOC, which can be properly assessed in a matter of seconds.
- Assess GCS every 5 minutes or as needed (i.e. if the patient’s status is rapidly changing).
- Deterioration by 2 or more points in the GCS is important and should be reported.

**The ONLY meaningful measure for TBI**

## Use the GCS Correctly!

- Measure GCS after initial assessment.
- Measure GCS after Airway, Breathing and Circulation.
- If possible, assess GCS prior to intubation but do not delay airway management to do so.
- Measure GCS prior to administration of sedatives, analgesics and muscle relaxant medications.
GCS: Children > 4 years old, Adolescents, and Adults

<table>
<thead>
<tr>
<th>Eye Opening</th>
<th>Verbal Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Spontaneous</td>
<td>5 Oriented</td>
</tr>
<tr>
<td>3 To speech/sound</td>
<td>4 Confused</td>
</tr>
<tr>
<td>2 To pain</td>
<td>3 Inappropriate</td>
</tr>
<tr>
<td>1 No response</td>
<td>2 Incomprehensible</td>
</tr>
<tr>
<td>1 No response</td>
<td>1 No response</td>
</tr>
</tbody>
</table>

**Motor Response**
- 6 Obeys commands
- 5 Localizes to pain
- 4 Withdraws from pain
- 3 Abnormal flexion
- 2 Abnormal extension
- 1 No response

**GCS** = Total score for Eye Opening + Verbal Response + Motor Response

Clinical features of Increased ICP

- Newborns and infants present a special case because increased pressure can be partially vented by the open fontanels

**Acute Signs of Increased ICP**

**In Infants**
- Bulging anterior fontanel
- Lethargy
- Shriek cry
- Setting sun sign (impaired upward gaze)

**In Children**
- Headache
- Mental status changes
- Nausea
- Vomiting

Modified GCS: Children < 4 years old

<table>
<thead>
<tr>
<th>Eye Opening</th>
<th>Verbal Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Spontaneous</td>
<td>5 Coos or babbles</td>
</tr>
<tr>
<td>3 To speech/sound</td>
<td>4 Irritable crying</td>
</tr>
<tr>
<td>2 To pain</td>
<td>3 Cries to pain</td>
</tr>
<tr>
<td>1 No response</td>
<td>2 Moans to pain</td>
</tr>
<tr>
<td>1 No response</td>
<td>1 No response</td>
</tr>
</tbody>
</table>

**Motor Response**
- 6 Spontaneous movement
- 5 Localizes pain
- 4 Withdraws to pain
- 3 Abnormal flexion
- 2 Abnormal extension
- 1 No response

**GCS** = Total score for Eye Opening + Verbal Response + Motor Response +

GCS Indicators of TBI Severity

- GCS 14-15 = MILD TBI
- GCS 9-13 = MODERATE TBI
- GCS 3-8 = SEVERE TBI

Admission GCS

- In a severe TBI patient, a decline in the GCS score over time can be indicative of the need for acute management and neurosurgical intervention
- In the prehospital setting- a drop of two or more points in GCS score- bad thing
  - Patient is getting into trouble
Pupillary Response

- Assess pupils every 5 minutes & as needed.
  - Pupil size
  - Symmetry (equal size)
  - Reactivity to light

Pupil Response

- Assess every 5 minutes & as needed
  - Pupil size
  - Symmetry
  - Reactivity to light

Measuring Pupil Response

Document these findings:

- Bilateral symmetry (asymmetric pupils differ more than 1 mm)
- Reactivity to light (a fixed pupil shows <1 mm change in response to bright light)
- Dilation (greater than or equal to 4 mm diameter in adults)

Research Findings

In-Hospital Studies

- Single fixed and dilated pupil
  - 45% poor outcome
- Bilateral fixed and dilated pupils
  - 82% poor outcome


Pupil Abnormalities

Conditions that can mimic pupil abnormalities:

- hypoxia
- hypothermia
- orbital trauma
- pharmacological treatment
- cataract surgery
- hypotension
- illegal drug use
- toxic exposure
- artificial eye
- congenital abnormality
- anisocoria

Blown Pupil

- Suggests herniation, which is compression of the brain stem
- Usually indicative of same-side mass
- Treat increased ICP, hypoxia & hypotension
**Indicators of Herniation**

An unresponsive patient (comatose) with:

- Bilateral dilated unresponsive pupils or Asymmetric pupils

**AND**

- Abnormal extension (decerebrate posturing) or No motor response to painful stimuli

**Take Home Messages**

- ABCs
- Level of Consciousness – GCS
- Herniation – Pupils and Motor Exam
- Thresholds:  90 / 90 / 9
  - These are the low end shoot for higher numbers!
- Use assessment to determine treatment

**Lesson 2**

**Treatment**

**Treatment Objectives**

- Demonstrate normal and hyperventilation rates for adults and children
- Describe proper fluid resuscitation in TBI
- List two field treatments for brain herniation

**Treat Airway**

- Protect C-spine alignment
- Airway support per scope of practice
- Intubate severe TBI patients
- Correct hypoxia
- Consider C-spine and facial trauma
**When should you intubate?**

- GCS < 9 (severe TBI)

**Treat Breathing**

- Rate, depth, quality, and effectiveness
- Administer oxygen
- Appropriate ventilation rate...
  - Age
  - Herniation

**SaO₂ at Scene of Accident**

<table>
<thead>
<tr>
<th>Oxygen Saturation</th>
<th>Mortality</th>
<th>Severe Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;90%</td>
<td>14.3%</td>
<td>4.8%</td>
</tr>
<tr>
<td>60-90%</td>
<td>27.3%</td>
<td>27.3%</td>
</tr>
<tr>
<td>&lt;60%</td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
</tbody>
</table>


**Normal Ventilation Rates**

Approximate normal ventilation rates:

- 10 bpm Adult
- 20 bpm Child
- 25 bpm Infant

**Hyper-Ventilation Rates**

Approximate hyper-ventilation rates:

- 20 bpm Adult
- 30 bpm Child
- 35 bpm Infant

**Take Home Messages**

- Early post-injury episodes of hypoxia greatly increase mortality and morbidity
- Evidence defines hypoxia as an oxygen saturation <90%
- Intubating unconscious and unresponsive TBI patients improves outcome
Ventilation Rates Practice

Match your bag squeeze rate to the audio tape rate

Treat Circulation - Hypotension

- Maintain SBP > 90mmHg in adults (lower for infants and children)
- Use isotonic IV fluids

Fluid Resuscitation

Infuse volume to achieve normal BP

Take Home Messages

- Evidence defines hypotension as a single observation of SBP < 90mm Hg (in adults)
- A single episode of hypotension
  - doubles mortality and increases morbidity
- Goal is to maintain SBP >90mmHg in adults

Brain-Targeted Therapy

- Glucose for hypoglycemia
- Sedatives for agitation
- Analgesics for pain
- Paralytics for ET intubation
- Controversial:
  - Mannitol
  - Lidocaine
  - Hypertonic Saline

Other Factors Affecting ICP

- Fear and anxiety
- Pain
- Vomiting
- Straining
- Environmental stimulation
- Endotracheal intubation
- Airway suctioning

Significance of these factors is largely unknown in terms of outcome
Brain-Targeted Therapy-Glucose

- Perform rapid blood glucose determination
- Rule out ↓ level of consciousness due to hypoglycemia
- Give IV glucose

Take Home Messages

- Manage ABCs
- Airway and intubation
- Oxygenation
- Blood pressure
- Hyperventilate (only when indicated)
- Glucose when appropriate
- Sedatives and analgesics per protocol

Lesson 3

Triage and Transport

Triage and Transport Objectives

- List 3 attributes of a trauma center with severe TBI capabilities
- Identify local and regional trauma centers with severe TBI capabilities

Destination Decisions

- GCS 14-15 --- Hospital Emergency Room
- GCS 9-13 --- Trauma Center
- GCS < 9 --- Trauma Center with severe TBI capabilities

Course Take Home Messages

- Do early and repeated neurological assessments
- **Identify patients with severe TBI (GCS < 9)**
- Avoid hypoxia, keep SaO2 > 90%
- Avoid hypotension, keep SBP > 90mmHg
- Hyperventilate only for clinical signs of herniation
- Triage and transport TBI to appropriate facilities based on severity
Case Scenarios

Case 1
- 21 year old male
- Unrestrained driver
- single vehicle MVC
- 20mph, sedan vs. concrete barrier
- No airbag
- Starred windshield
- No LOC

Initial Assessment
- Clear airway
- Bilateral breath sounds
- Strong radial pulse of 100
- Blood Pressure 120/80
- Speaking spontaneously

Physical & Neuro Evaluation
- Found out of vehicle walking near the accident scene
- 3x5 cm hematoma/contusion left forehead
- Opens eyes spontaneously
- Alert to person & place, but confused to month and year
- Follows motor commands
- GCS = ?

Treatment & Interventions
- Manual cervical spine stabilization
- Supplemental oxygen via non-rebreather mask
- Oxygenation with pulse oximetry (if available)
- Spinal immobilization with cervical collar and backboard
- Initiate transport
- Repeat vitals and neuro exam every 5 minutes and as needed
- IV access
- Rule out other causes of altered mental status

Causes of Altered Mental Status
- Hypovolemia
- Hypoxemia
- Drugs
- Alcohol
- Hypoglycemia
- Pain/Discomfort
- Traumatic Brain Injury (TBI)
Transport Decisions

- TBI severity?
- Destination?

GCS 14
- TBI Severity?
  - Mild TBI
- Destination?
  - Emergency Department

Case 2

- 9 year old female
- Fell off jungle gym at community park
- Fell approximately 10 feet
- Witnessed by father
- Child landed on head
- Apparent "broken arm"
- + LOC

Initial Assessment

- Clear airway
- Color pale, lips cyanotic
- RR 10 bpm
- BP 72 palpable
- Radial pulse 110
- Unresponsive

Physical & Neuro Evaluation

- Compound fracture left forearm
- 2 cm left temporal laceration
- Eyes open to painful stimuli
- Localizes to painful stimuli
- Speech incomprehensible words
- Pupils 4 mm, brisk reaction to light
- GCS = ?

Treatment & Interventions

- Manual stabilization of cervical spine
- Ventilate via BVM with supplemental oxygen
- Monitor oxygenation and ventilation with pulse oximetry
- Spinal immobilization with cervical collar and backboard
- Initiate transport
- Vitals & neuro status every five minutes and as needed
- 2 large bore IV’s with LR open, rapid infusion to >90mmHg SBP
- Immobilize left forearm
**Transport Decisions**

- TBI severity?
- Destination?

**GCS 9**
- TBI Severity?
  - Moderate TBI
- Destination?
  - Trauma Center

**Case 3**

- 30-year-old male
- Pedestrian struck by automobile while crossing busy intersection
- Thrown approximately 20 feet
- Multiple severe injuries
- + LOC

**Initial Assessment**

- Patient is unresponsive
- RR 6; cyanotic
- Radial pulse 132
- BP 80/44
- Right leg deformed
- Right foot traumatic amputation

**Physical & Neuro Evaluation**

- SaO₂ 84%
- Decreased breath sounds right chest
- Unresponsive
- Extensor posturing to painful stimuli
- Pupils unequal
  - Right 3mm brisk
  - Left 6 mm sluggish
- Right femur fracture
- GCS = ?

**Treatment & Interventions**

- Manual stabilization of cervical collar
- Secure airway, intubate if possible
- Hyperventilate via BVM with supplemental oxygen
- 20 breaths/minute
- Monitor oxygenation and ventilation with pulse oximetry
- Immobilize with cervical collar and backboard
- Initiate transport
- Repeat vitals and neuro status every five minutes and as needed
- 2 large bore IVs LR, rapid infusion to >90mmHg SBP
- Immobilize right lower extremity
Transport Decisions

- TBI severity?
- Destination?

GCS 4

- TBI Severity?
  - Severe TBI
- Destination?
  - Trauma Center with Severe TBI Capabilities