Head Trauma, Drunk, or Just Stupid?

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Objectives:

After completing this article, the reader will be able to:

1. Understand the pathophysiology of head injuries
2. Describe the treatment of patient's with closed head injuries
3. Explain the relationship between CO_2 and ICP

Early one morning a 22-year-old young woman was riding her bicycle for her routine exercise. While riding along side a country road she was struck from behind by a pickup truck. The driver was intoxicated and on his way home from Octoberfest. On arrival, EMS found Beth lying beside the road responsive only to painful stimuli. The paramedics, realizing the severity of her condition, rapidly loaded and transported her to the local trauma facility. Initial assessment found her respiratory rate to be eight and shallow. The paramedic attempted intubation and found that Beth was clinching her teeth. Not sure how else to control her airway, they continued transporting code three using a BVM to assist respirations. As they reached the emergency department she began projectile vomiting and seizing. They quickly wheeled her in to trauma room one. After evaluation by the emergency department physician, she determined that surgery was needed. The surgeon was called from home and arrived within one hour. Beth was then rapidly taken to surgery to evacuate an expanding hematoma. She was moved to the ICU were she spent the next ten weeks.

Six months later, Beth is alive but struggles to re-learn simple tasks such as eating. Her speech is disorganized and difficult to understand. With many months of rehabilitation, she may begin to return to a self-reliant life style. Her family, while thankful she is alive, remembers the young active woman that now must have constant help just to eat. The driver of the truck, with one prior conviction for driving while intoxicated, pleads no-contest and is out of jail one week after Beth is released from the hospital.

Head trauma is the leading cause of traumatic death in the United States. Every fifteen seconds head injury occurs in this country, and every twelve minutes someone dies from head injury. If these statistics do not seem dramatic enough, head injury not only carries with it a high mortality rate, but also may lead to physical and psychological impairment and a lifetime of continual medical care.

Head trauma is an area in which EMS providers can have a major impact. As with other injuries, prompt and accurate evaluation is essential for a favorable outcome. Early intervention may prevent cerebral hypoxia and swelling, which are associated with poor prognosis. In the past it has been taught that to treat head trauma properly you must be able to differentiate specific areas of damage such as epidural, subdural, and intracerebral hemorrhage. However, these specific diagnoses have little usefulness when treating head trauma patients in the prehospital setting. Therefore, it is important to concentrate on treatments to alleviate the most dangerous aspects of head trauma; hypoxia, and increased intracranial pressure (ICP), rather than differentiating specific injuries.

Although not essential for field treatment, it is helpful to have a basic knowledge of the head and brain anatomy and physiology to understand what is causing the signs and symptoms experienced by head trauma patients. The head is composed of a rigid skull surrounding soft brain tissue. (Figure 1) The skull is composed of flat sheets of bone that provides a strong but lightweight barrier of protection from injury. The skull protects the brain, but also serves as a major mechanism of brain injury. The skull acts as a closed box and increases in pressure and volume have little room to expand.

The brain is lined with several layers of protective tissues called meninges. As illustrated in figure 1, the outermost lining is the **dura mater** ("tough-mother"), a durable membrane that lays just above the **arachnoid membrane**. The arachnoid is a thick membrane that suspends arteries and veins. Beneath it lays the delicate **pia mater** ("tender mother"). Beneath these membranes, the brain floats in a bath of fluid called **cerebral spinal fluid** (CSF). This nutrient fluid is produced within the ventricles of the brain and flows around the brain to act as a shock absorber for the brain. The CSF is continually recycled and absorbed by the arachnoid membrane.

The brain occupies the entire cranial vault, and does not have much room for expansion. When the brain is traumatized, it swells like other tissues do when they are bruised. In cases of cerebral swelling or bleeding within the skull, brain tissue is compressed causing the major pathophysiology associated with closed head injury (CHI).

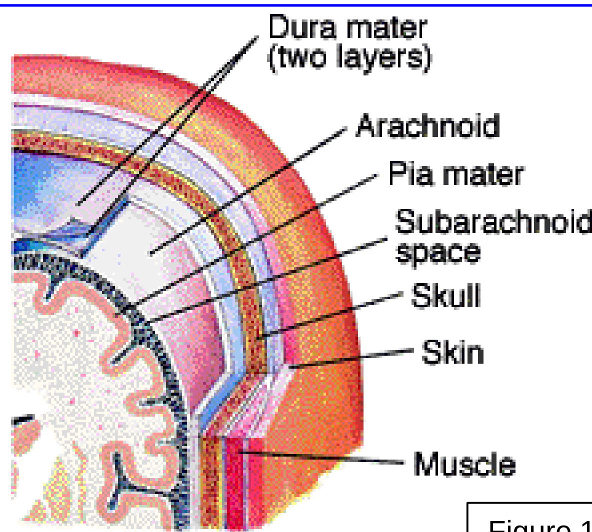

Figure 1

The factors that commonly cause closed head injury are from external forces acting on the skull, not against the brain itself. These forces usually cause bruising of the brain or cause the brain to shift within the cranial vault and tear arteries or veins resulting in intracranial bleeding. In cases of deceleration accidents, such as the head hitting the windshield in a MVC, the skull strikes the windshield and the brain has a delayed reaction as the force is distributed through the CSF. The brain strikes the inner skull at the point of impact then rebounds to cause damage to the opposite side of the brain. This reaction is called “coup-contrecoup." This damage to two opposite sides of the brain can result in twice the swelling greatly increase the pressure within the cranium.

The interior of the skull is rough with many ridges. As the brain is rapidly shifting within the cranium, bony protrusions can cause various degrees of injury to brain tissue and rupture of blood vessels. The inner surfaces of the temporal bones of the skull have many sharp ridges and protrusions. Rapid movement of the brain across this rough area can cause intracranial bleeding. With this in mind, a patient with an intact skull can still have significant brain injury and need intervention.

The initial response of the brain to a bruising injury is swelling. Bruising causes vasodilatation and increases blood flow to the damaged area. As blood accumulates in the damaged area it exerts pressure on the surrounding tissue. Since there is limited space within the cranium the excess pressure causes the uninjured areas to be compressed, decreasing blood flow to the healthy tissue. As the pressure within the cranium increases it takes a higher blood pressure to pump needed oxygen and nutrients to the brain. The brain, feeling the need for oxygen, sends signals to the heart and vessels to increases the flow of blood to the brain. The heart increases its force of contraction and the vessels constrict to increase peripheral vascular resistance; the combination of these increases blood pressure and cerebral perfusion. As more blood is pumped into the cranium, the ICP increases and the vicious cycle of head trauma spirals toward death if the ICP is not controlled.

The best way to control ICP is early recognition and treatment. One of the earliest and most reliable signs of head injury is altered level of consciousness. Mental status should be monitored continuously and any changes noted. In addition, pupillary dilation, bruising around the orbits or behind the ears, and any unusual drainage, may also indicate head injury. Later signs of head trauma may include abnormal posturing of the extremities, projectile vomiting, and seizures. Careful assessment for these signs may provide clues to the degree of head injury and the need for aggressive management.

Initial management of patients with possible closed head injury is similar to any other trauma patient. A general impression of the situation should be made as you approach the patient to determine level of consciousness and mechanism of injury. Cervical spine precautions should be initiated, and the airway should be controlled by whatever means necessary. Assessment of breathing and control of major bleeding should be your next concern. Following this initial assessment, a decision should be made as to the patients transport priority. The most common finding that will place your patient with closed head injury into a rapid transport decision, is altered mental status. Any patient with suspected CHI and altered mental status should be transported rapidly to a surgical facility.

An assessment tool that is widely recognized for the head-injured patient is the Glasgow Coma Scale (GCS). The GCS measures mental status, motor, and verbal response. (Table 1) It has been very closely linked to patient outcome and helps trend change in patient status. The GCS should be noted when you evaluate the patient and after each intervention. Repeated GCS values are very helpful in determining patient progress. A pneumonic associate with the GCS can help with the decision of how to control the airway; “GCS of less than eight, intubate.”

Glasgow Coma Scale		
Eye Opening	Spontaneous	4
	To Voice	3
	To Pain	2
	None	1
Verbal Response	Oriented	5
	Confused	4
	Inappropriate words	3
	Incomprehensible words	2
	None	1

Motor Response	Obeys Commands Localizes pain Withdraws (pain) Flexion (pain) Extension (pain) None	6 5 4 3 2 1
Glasgow Coma Score Total		

Table 1

Vital signs associated with isolated head injuries are unique. As ICP increases, blood pressure also increases to perfuse the swelling brain. Decreases in blood pressure are usually preterminal signs in head injury and should typically be associate with fluid loss elsewhere, not increased ICP. The respiratory patterns associated with increased ICP are variable. They can be accelerated or slow, but usually the pattern is erratic. The vagus nerve, which branches from the brain at the brain stem, is the parasympathetic nerve that innervates the heart. As increases in ICP occur, the vagus nerve releases more neurotransmitter (acetylcholine) onto the heart, causing bradycardia. These can be used to differentiate head injury from other forms of shock. (Table 2) This set of vital signs associated with rise in intracranial pressure is called Cushing's triad. These are late signs of head trauma, and their absence should not rule out head injury.

Vital signs	**Shock**	**Head Injury with increased ICP**
Blood Pressure	Decreased	Increased
Pulse	Increased	Decreased

Respirations	Increased	Erratic
Level of Consciousness	Decreased	Decreased

Table 2

The most important intervention for patients, especially those with closed head injury, is airway management. Patients with altered mental status, which must be supine on a backboard, are at increased risk for airway obstruction and aspiration. Therefore, good management is essential to prevent complications of aspiration and hypoxia. Proper maintenance of the airway is crucial in those patients with increased ICP. As carbon dioxide levels in the blood increase from hypoventilation or hypoperfusion, the vessels dilate in attempt to remove the excess CO_2. This dilation may worsen cerebral edema. Therefore, lowering carbon dioxide levels may cause vasoconstriction and reduce swelling. Insuring adequate ventilation may reduce CO_2 levels by eliminating it through the lungs. A respiratory rate of 20-24, with good tidal volume, is sufficient to maintain CO_2 at acceptable levels (30-35 torr). Hyperventilation in excess of 24 breaths per minute may cause excessive vasoconstriction and cause tissue hypoxia in the surrounding areas of the brain.

Basic airway measures can often maintain adequate airway control, however in the patient with altered mental status, endotracheal intubation is the definitive adjunct to control the airway. In those patients with adequate control of their airway, 100% oxygen can help decrease brain hypoxia.

Endotracheal intubation in head injured patients can be a complicated procedure. These patients are often combative which makes airway management difficult. Also, these patients need cervical immobilization, which further hampers proper intubation. The maintenance of cervical alignment is necessary when intubating any patient with suspected head trauma. The force exerted to cause head trauma can easily cause spinal trauma as well. One person should be dedicated to stabilize the cervical spine during all intubation attempts.

In conscious patients, who need airway control, there are typically two options, nasal intubation or oral intubation after chemical paralysis. Nasal intubation is a valuable tool that can often be accomplished in the conscious patient, and it does not compromise cervical spine alignment. Many patients with head trauma develop increased masseter tone, which is the contraction of the strong muscles of the jaw, making it difficult to insert the laryngoscope. Nasal intubation is an option for these patients as well, however, for nasal intubation to be successful the patient must have spontaneous respirations.

Nasal tracheal intubation is not advised for patients without spontaneous respiration or massive facial trauma. Oral intubation is an alternative, however most conscious patients will not tolerate it and those with clinched jaws will not allow it. In these cases chemical paralysis is a means of controlling the airway. Paralytic drugs can be administer intravenously which will stop all skeletal muscle activity. This will allow passing the laryngoscope and the oral endotracheal tube. Chemical paralysis is not without its concerns. Once the paralytic is administered the patient will not breathe without assistance. Therefore if you cannot successfully intubate the patient, you must have another method to control the airway until the drug wears off. The duration of action can be from 15- 90 minutes depending on the patient and the drug used. BVM ventilation is an option in this case, but it is often difficult to do properly with one rescuer. Also, patients with facial trauma the mask seal may not be adequate. Surgical airway is an option but it requires much training and can be difficult to perform in a crisis. With these consequences in mind, the decision to use chemical paralysis is a difficult one.

There is another consideration when attempting advanced airway control in the head injured patient. Any manipulation of the pharynx can cause a gag response, and this response can cause an increase in ICP. Placing a laryngoscope in the back of someone's throat will elicit the gag reflex and may increase their ICP. To minimize this 1-1.5 mg/kg of lidocaine can be administered prior to an intubation attempt. Lidocaine stabilizes membrane potentials and may prevent the ICP changes associated with gagging and intubation. For lidocaine to be most affective, it should be administered two to three minutes prior to intubation.

Children respond differently to intubation than adults. The stimulation of the pharynx may cause significant vagal stimulation and bradycardia. This may reduce cerebral blood flow and worsen tissue hypoxia. Pulse oxymetry or EKG monitors provide a good continuous heart rate monitoring in all patients during intubation. As a preparatory step, 0.02mg/kg of atropine can be administered. This may prevent bradycardias and help to dry up oral and gastric secretions.

With all of these drugs to consider, it is a challenging task to provide advanced airway management in the head injured patient. These techniques can be life saving, but they can also lead to deteriorating outcomes with prolonged hypoxia. With continual practice and good medical direction, these advanced airway skills can be safe and effective for most prehospital providers.

Once the airway has been secured and bleeding controlled, transport should be initiated. All patients with suspected head trauma should be transported to a trauma facility so that surgical repair, if necessary, can be done as soon as possible. Evacuation of the accumulating blood is the best definitive treatment and should be done by a neurosurgeon. Neurosurgical services are typically only readily available at a level one trauma center. Therefore, transport to a facility without surgical support may prolong life saving treatments. Aeromedical transport may be considered as a method for getting patients from rural communities to hospitals with surgical support.

During transport simple intervention such as raising the head of the backboard 30 degrees can help drain fluid from the head and slow down increases in ICP. Peripheral venipuncture should be initiated but should not delay transport. The fluid of choice for head trauma is normal saline. It can serve as a volume replacement fluid if needed, and it is compatible with blood and other drugs used in treating head trauma. Treatments to help lower ICP should be considered for patients with signs and symptoms of increased ICP. Mannitol is a drug that may help lower ICP. It is an osmotic diuretic, which causes fluid to be removed from the head by increasing tonicity of the blood and increasing the amount of fluid that is eliminated by the kidneys. As a hypertonic solution, it pulls fluid from the interstitial space into the vascular space to be removed by the kidneys. Mannitol is given intravenously and the dosage range is 0.25 - 2.0 grams/kg. Mannitol should be given as a fast infusion over 10-15 minutes or faster. Slow infusions of mannitol may not cause the osmotic shifts needed to pull fluids from the tissues.

Mannitol use is controversial in the pre-hospital setting. It does decrease ICP by pulling fluid from the swollen brain tissue, however this may create more room for further bleeding and worsen the condition. Mannitol also causes a condition known as rebound. After the Mannitol has removed all of the fluid it can, reverse osmotic shifts and can cause rebound increases in ICP. With these things in mind, Mannitol can be used to decrease ICP in those patients with evidence of increased ICP and herniation. However, surgical support should be readily available to definitively control ICP and prevent rebound.

Head injured patients may have high or low blood pressure depending on the degree and stage of injury. Hypertension is commonly seen and usually is the result of increases in ICP. Hypotension on the other hand, can be a preterminal sign or as a result of hemorrhage elsewhere in the body. Caution should be use when treating hypertension in head trauma victims, since, the brain may need a higher pressure to assure it receives the blood and nutrients it requires. Hypotension however, is a very harmful condition for patients with increased ICP and should be treated aggressively. Outcomes for patients with hypotension are far worse than patients with hyper or normotension. Fluid or should be administered to maintain adequate blood pressure. Some recommend maintaining a mean arterial pressure of at least 90 mmHg to assure cerebral perfusion.

Seizures are a common side effect of head trauma, and can lead to deadly hypoxia and increase ICP. The control of seizures in head injured patients is similar to other types of seizure management. Protection of the airway and prevention of aspiration are important to ward off hypoxia. To control the convulsions, one of the benzodiazepines, such as Valium® or Ativan®, can be used. Once the initial seizure has been stopped, a long acting agent such as Dilantin is usually recommended to inhibit subsequent seizures.

The management of patients with closed head trauma can be challenging. These patients rarely have an isolated head injury, and we are forced to deal with multiple injuries. The most effective method to assure good treatment is first to recognize the signs and symptoms of head injury and to start treatment early. To prevent the two most harmful side effects of head injury, assure your patient is well ventilated to prevent tissue hypoxia and to decrease ICP. We must also realize that in the prehospital setting we cannot cure head injury. The definitive treatment must be at the hospital and the sooner our patients can be evaluated and treated by the neurosurgeon the better the outcome.

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http://www.callamer.com/~cns/tbi/injury.html

Questions:

1. Which of the following is the most reliable indicator of closed head injury?

   a. Low blood pressure

   b. Tachycardia

   c. Altered mental status

   d. Blown pupils

2. The Glasgow Coma Scale evaluates?

   a. motor response, gag reflex, verbal response

   b eye opening, motor response, verbal response

   c. eye opening, pupillary response, motor response

   d. verbal response, pupillary response, motor response

2. Select the correct statement regarding the Glasgow Coma Scale.

   a. A score of 3 is normal

   b. A score of 7 represents coma

   c. A score of 12 represents brain death

   d. A score of 15 is indicative of poor prognosis

3. Cushing's triad is an early indicator of head injury.

   a. True b. False

4. **Early** signs of increased intracranial pressure include:

   a) nausea, vomiting, decrease in pulse and respiratory rate.

   b) headache, nausea, vomiting, and altered level of consciousness.

c) widened pulse pressure, decreased pulse, altered level of consciousness.

d) increased systolic pressure, widened pulse pressure, decrease in pulse and respiratory rate.

5. Descriptive terms such as "drowsy," “lethargic” and "obtunded" should be used to describe a patient's level of consciousness.

a) True

b) False

6 You are called for a 24-year-old victim of a motorcycle crash. The patient was not wearing a helmet. Examination reveals blood and teeth in the mouth, an open fracture of the right femur with significant bleeding, and abrasions over the upper and lower extremities, chest, and face. Your highest priority in the management of this patient will be to:

a) manage the patient's airway.

b) immobilize the femur fracture.

c) control bleeding from the right femur.

d) evaluate the patient for associated injuries.

7 The membranes surrounding the brain are called?

a) the peritoneum

b) meninges

c) cranial sheaths

d) cerebral mater

8 Which of the following is **correct** when managing the circulatory status of the patient with head trauma?

a) hypotension is normal and may protect the brain in cases of increased ICP

b) hypertension should be treated aggressively and medication should always be administered to lower blood pressure.

b) Hypotension, in patients with increased ICP, may decrease cerebral perfusion and increase hypoxia.

c) Hypertension is an early indicator of increased ICP and should be treated with beta blockers to lower blood pressure.

9 The mechanism of injury associated with striking the head against the windshield of an automobile, and the brain is bounced between the anterior and posterior skull is called?

a) distraction.

b) lateral bending.

c) coup/contra coup

d) hyper-rotation.

10 Head injury patients need detailed assessment and time should taken on scene to start IV's and evaluate vital signs to assure proper diagnosis?

a) True.

b) False

11 Hypotension in the head trauma patient:

a) may be cause by intercerebral bleeding.

b) is a common sign in patients with increased ICP

c) is not usually associated with isolated head injury and should raise suspicion of hemorrhage elsewhere in the body.

d) should be considered part of Cushing's triad and treated with hyperventilation.

12 The MOST important sign in the evaluation of a head-injured patient is:

a) tachycardia.

b) blood pressure.

c) level of consciousness.

d) tachypnea.

13 As intracranial pressure increases, breathing patterns change as the brain stem is compressed.

a) True b) False

14 A 23-year-old patient has suffered severe maxillofacial trauma with gross deformity of the structures of the midface. Management of this patient's airway should include:

a) cricothyrotomy

b) EOA

c) nasotrachael intubation.

d) bag-valve-mask ventilation.

15 Why is hyperventilation important in the head-injured patient with signs and symptoms of increased ICP?

a) hyperventilation increases the level of CO2 resulting in cerebral vasodilation.

b) hyperventilation decreases the level of CO2 resulting in cerebral vasodilation.

c) hyperventilation decreases the level of CO2 resulting in cerebral vasoconstriction.

d) hyperventilation increases the level of CO2 resulting in cerebral vasoconstriction.

16. A patient who opens his eyes in response to pain, makes no verbal response, but withdraws from pain has a Glasgow Coma Score of:

a) 3

b) 5

c) 7

e) 11

17. What are the concerns when intubating a conscious child with traumatic brain injury?

a) Controlling hypertension associated with laryngoscopy.

b) Controlling bradycardia associated with laryngoscopy.

c) Avoiding hypotension induces by tachycardia.

d) Assuring adequate CO_2 retention during intubation.

18. Which of the following is **TRUE** concerning Mannitol.

a) It is used to pull blood from the body to perfuse the brain.

b) It causes osmotic diuresis and decreases urine production.

c) It decreases cerebral edema, but may cause a rebound effect.

d) Dose ranges from 4 to 10 mg/kg given in an I.V. bolus.

19. The bradycardia seen in patients with closed head injury should:

a) will be accompanying hypotension and should be reversed with atropine.

b) be treated by attempting to lower ICP.

c) be considered an early indicator of increased ICP.

d) be considered normal in trauma patients and should be of no concern.

20. All adult head trauma patients should be hyperventilated at a rate between 20-30 breaths per minute.

a) True

b) False