Head Trauma Inservice
(October)

Head trauma is the leading cause of death in trauma patients. Having a basic understanding of the anatomy and physiology of the brain along with signs and symptoms of various head injuries can provide pertinent clinical information for the health care provider. This in turn will lead the health care giver toward making appropriate decisions on early assessment, treatment, and transport to appropriate facilities.

Knowledge of head and brain anatomy is essential for understanding the causes and results of head injuries. The anatomy of the head and brain is well beyond the scope of this inservice; however, having a basic understanding will give us a good refresher on the location and function of the major parts. "Staying awake through some of this material can be a challenge and is the responsibility of which part of your brain?"

The scalp is the outermost, thickest layer of body covering. It provides a spongy protection for the skull. Because the scalp is highly vascular, uncontrolled bleeding from an injury can lead to significant blood loss. Rarely are scalp injuries life threatening, and can usually be controlled with direct pressure.

The skull consists of cranial bones and facial bones. It is composed of 22 bones. This includes eight cranial bones, and fourteen facial bones. The skull (or cranium), also known as the cranial vault, sits on the superior end of the vertebral column. The cranium provides protection to the brain tissue and underlying structures. The interior walls of the skull at the base are rough and irregular. Due to these sharp outcroppings, brain injuries with acceleration and deceleration injuries are often severe. These injuries are often known and coup (near the site of the injury); countercoup (opposite hemisphere) injuries. Frontal and temporal lobes are common sites of contrecoup-type contusions (PHTL, 2003).

The brain tissue is covered by three different membranes called the meninges. The outermost layer is the dura mater, the middle layer is the arachnoid membrane, and the inner layer is the pia mater.

The brain is composed of four principle parts: The brain stem, cerebellum, diencephalon, and cerebrum. The brain stem is continuous
with the spinal cord and consists of the medulla oblongata, pons, and midbrain. Posterior to the brain stem is the cerebellum. Superior to the brain stem is the diencephalon, consisting of the thalamus and hypothalamus. The cerebrum spreads over the diencephalon like a mushroom cap and occupies most of the cranium. The brain tissue occupies approximately 80% of the intracranial space.

- **Cerebrum:** Divided into two hemispheres, left and right halves. Each hemisphere is further separated into several lobes, each of which is responsible for the control of specific intellectual, sensory, and/or motor functions. (Controls voluntary movement).
  - **Thalamus:** Makes up 80% of the diencephalon, is the principal relay station for sensory impulses that reach the cerebral cortex from the spinal cord, brain stem, cerebellum, and other parts of the cerebrum. It controls wakefulness by linking and relaying impulses between the reticular activation system and the cerebrum.
  - **Hypothalamus:** Controls autonomic and neuroendocrine functions such as the synthesis and release of hormones (i.e., ADH secretion).
  - **Midbrain:** Connects the pons and diencephalon and surrounds the cerebral aqueduct. It conveys motor impulses from the cerebrum to the cerebellum and spinal cord, sends sensory impulses from the spinal cord to the thalamus, and regulates auditory and visual reflexes.
  - **Pons:** Located superior to the medulla. It connects the spinal cord with the brain and links parts of the brain with one another by way of tracts. It relays nerve impulses related to voluntary skeletal movements from the cerebral cortex to the cerebellum. The pons contains the pneumotaxic and apneustic centers, which help control breathing.
  - **Medulla oblongata:** Continuous with the superior part of the spinal cord and contains both motor and sensory tracts. It contains nuclei that are reflex centers for regulation of heart rate, respiratory rate, vasoconstriction, swallowing, coughing, vomiting, and sneezing.
  - **Reticular activating system:** Matrix of fibers in the brainstem and thalamus; responsible for integration of ascending and descending impulses; has an excitatory center and inhibitory center that increases and decreases cerebral activity. The RAS is responsible for maintaining consciousness and for awakening from sleep.
  - **Cerebellum:** Occupies the inferior and posterior aspects of the cranial cavity. It functions to coordinate skeletal muscles and to maintain normal
Cerebral spinal fluid: Cerebral spinal fluid is a clear colorless fluid produced in the choroids plexus. In the adult, approximately 450 cc of CSF is produced in a 24 hour period. There is a total of 150 cc circulating at any given time, thus it is “turned over” three times a day. It functions to give nutrients to nerve cells, and take waste away. It acts as a buffer or shock absorber. It transports releasing factors from the hypothalamus to the pituitary gland. It also maintains a stable chemical environment contributing to the blood brain barrier.

The brain requires a constant supply of oxygen and glucose. The brain uses approximately 20% of the body’s total oxygen supply. Cerebral blood flow (CBF) is supplied by 2 pairs of major arteries: The left and right carotid and the left and right vertebral arteries. CBF is regulated by autoregulatory mechanisms located in the cerebral arterioles. CBF is affected by carbon dioxide and oxygen concentrations. When CO2 increases due to a traumatic injury to the brain, it will cause cerebral vessels to dilate, which in turn are attempting to increase CBF. If CO2 levels decrease (as with hyperventilation), this will cause the cerebral vessels to constrict, which can decrease intracranial pressure, and subsequently cause a secondary ischemia. The ability of the brain to maintain adequate CBF over wide ranges of pressures is known as cerebral autoregulation. Cerebral autoregulation is intact if mean arterial pressure (MAP) is between approximately 50-150 mmHg. Pressures above and below can result in ischemia and cell death.

Cerebral perfusion pressure (CPP) is the pressure gradient across the vascular bed of the brain or the pressure at which the brain is perfused and is an estimate of CBF. CPP is the stimulus for pressure autoregulation. CPP is the difference between the mean arterial pressure (MAP) and the intracranial pressure (ICP). CPP = MAP-ICP. Normal CPP is approximately 70mmHg. Maintaining a systolic blood pressure of at least 90 mmHg will help keep CPP at normal levels. Untreated hypotension will result in decreased cerebral perfusion!

The etiology of head trauma can be classified into primary brain injury and secondary brain injury. Primary brain injury occurs at the time of the insulting event. Secondary brain injury can occur seconds to days after initial injury. Secondary injury can result from cerebral ischemia related to hypercarbia, cerebral edema, increased intracranial pressure (ICP), hypotension, or hypoxia. Of all the secondary brain injuries, hypotension and hypoxia may be the most deleterious.
Assessment and treatment of patients with head trauma and traumatic brain injury should always be done within the scope of our standing flight protocols. Please refer to section 3.12.1 for a review. Included below is a list of common specific head trauma conditions. Remember that preventing secondary brain injury is the most important aspect of trauma to the brain!

**Cerebral concussion:** Is a temporary loss of consciousness (LOC) with associated memory deficit and without underlying brain injury. Depending on which literature you read, LOC can last minutes up to several hours, but usually resolves within 6 hours without permanent brain injury. Signs and symptoms include: Headache, dizziness, nausea and vomiting.

**Cerebral contusion:** A contusion is a common focal brain injury in which brain tissue is bruised and damaged in a local area. This type of injury is common with acceleration or deceleration forces applied to the head. Signs and symptoms include: Altered LOC, unusual behavior, abnormal posturing, persistent nausea and vomiting. These signs are usually caused by impact to the reticular activating system (RAS).

**Epidural hematoma:** Is a focal brain injury resulting in a collection of blood between the skull and the duramater. Usually results from a tear and bleeding from the middle meningeal artery. Signs and symptoms include: Initial LOC, followed by a return of consciousness (Lucid interval), then after minutes to hours later lapse back into unconsciousness, persistent decrease in LOC, developing hemiparesis on the opposite side of injury, which can lead to abnormal motor posturing, dilated and fixed pupil common on the side of impact.

**Subdural hematoma:** Is a focal brain injury located between the dura and the cortex. Subdural hematomas results from tearing of the bridging veins across the dura or laceration of the cortical arteries during acceleration-deceleration forces. They are classified as acute (zero to 72 hours), subacute (3-21 days), or chronic (weeks to months) after injury. Signs and symptoms include: Confusion and disorientation, persistent headaches, nausea and vomiting, steady decline in LOC, hemiparesis or hemiplegia on the opposite side of the hematoma, slurred speech.
Skull fractures: Three types; a *linear skull fracture* is a nondisplaced fracture of the cranium. It is of minor consequence unless the fracture site crosses an area where underlying vessels may be lacerated. Signs and symptoms include: headache, possible decreased LOC. A *depressed skull fracture* extends below the surface of the skull and can cause brain tissue compression and dural laceration. Signs and symptoms include: headache, possible decreased LOC, possible open fracture, palpable depression of skull over the fracture site. Finally, a *basilar skull fracture* is a fracture of one or more of the five bones of the base of the skull. These fractures may accompany injury to other intracranial structures, such as the brain, dura mater, or cranial nerves. Signs and symptoms include: headache, ALOC, periorbital ecchymosis (raccoon’s eyes), mastoid ecchymosis (battle’s signs), or blood behind the tympanic membrane (hemotympanum).

Recognizing that correct identification of head trauma, brain injury, and prompt resuscitation and treatment can significantly improve the chances of a good outcome even in severe traumatic brain injury.

**Resources:**

*Guidelines for Prehospital Management of Traumatic Brain Injury (1998).*

*Principles of Anatomy and Physiology, Ninth Edition (2000).*

*Prehospital Trauma Life Support, Fifth Edition (2002).*

*Trauma Nursing Core Course, Fifth Edition (2000).*

**QUESTIONS:**

1. What area of your brain is responsible for maintaining consciousness, causes awakening from sleep, and contributes to regulating muscle tone?

2. The ability of the brain to maintain adequate cerebral blood flow over a wide range of pressures is known as?

3. An epidural hematoma usually results from a tear and bleeding from the?