TBI

INFORMATION FOR TBI SURVIVORS, MENTORS & CAREGIVERS

This pamphlet furnishes general information on Traumatic Brain Injury to assist in understanding the nature of these types of injuries. It will not make you a health care expert but is just to offer you background information on TBI. It is not designed for health care professionals conducting medical treatment and is not a medical treatment reference document. It is also not a Department of Defense official document medical or otherwise. Any difference between the information in this document and any health care professional should be resolved in favor of the medical and health care professionals. Any references to medical information are not necessarily DoD's health care policies. Should you have a question on medical/health care treatment, ask a member of your medical care team or Nurse Case Manager.

TBI SECTION OUTLINE:

- **THE BRAIN**
- **WHAT IS A TRAUMATIC BRAIN INJURY?**
- **SYMPTOMS**
- **EFFECTS & IMPACTS OF TBI**
- **CLASSIFICATIONS:**

✓ **PENETRATING TBI (the "dura" is pierced -- the foreign object enters the brain itself)**
✓ **NON-PENETRATING-- BLUNT/ CLOSED TBI**

- **Mild**
  - **Moderate**
    - **Severe**
      - **Severe Penetrating**

- **OTHER ASPECTS OF A TBI:**

✓ Bruising of brain tissue
✓ Shearing / tearing of brain tissue & internal bleeding in the brain
✓ Headaches
✓ Anoxic Brain Injury
✓ Seizures

- **DIAGNOSIS**
- **TREATMENT**
- **REHABILIATION**
- **RECOVERY**
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- **VISION & BRAIN INJURY--*article***

TRAUMATIC BRAIN INJURY

Traumatic Brain Injury is a "signature" wound of the Global War on Terrorism. Returning combat veterans may not even know they have suffered such a wound. This is why Department of Defense and the Department of Veterans Affairs doctors want these "new warriors" and their families to know about TBI.

I. THE BRAIN[1]:

Inside the skull, the brain is covered by three thin protective layers called the meninges. The space between the meninges and the brain is filled with a clear liquid called cerebral spinal fluid. This fluid works to keep the central nervous system healthy.

The brain is constantly sending and receiving signals from all over the body. The body then uses these signals to do things like think, move, talk, see, and understand. These signals also control our personalities and the way we behave. Each part of the brain has a specific job and links with other parts of the brain to do more difficult tasks.

- **CEREBRUM: The outermost and largest part of the brain is called the cerebrum** and it controls things like thoughts and actions. It has a wrinkled surface and is divided it into two halves, known as the left and right hemispheres. Each hemisphere of the cerebrum is divided into four sections, called lobes. These lobes are known as the frontal lobe, the parietal lobe, the occipital lobe, and the temporal lobe.

Lobe Functions

1. **Frontal lobes** are the largest of the four lobes and deal with reasoning, planning, self-control, some speech and emotion functions, and problem solving. The

[1] See APPENDIX "A" and APPENDIX "B" for more information

frontal lobes also play an important part in memory, intelligence, concentration, and are responsible for executive functions. There are many executive functions of the brain such as the ability to plan, set goals, and organize. These functions include being able to determine right from wrong and being able to monitor and change behavior as needed. Executive functions also allow people to adapt to new situations and to override or control reactions when appropriate. The abilities to form concepts, socialize, and think abstractly are often considered part of executive function.

2. **Parietal lobes** are involved with movement, and also help people to understand signals received from other areas of the brain such as vision, hearing, sensory and memory. A person's memory and the sensory information received give meaning to objects and "pull it all together."

3. **Occipital lobes** are found at the back of the brain. These lobes receive signals from the eyes, process those signals, allow people to understand what they are seeing, and influence how people process colors and shapes.

4. **Temporal lobes** are located at about ear level, and are the main memory center of the brain, contributing to both long-term and short-term memories. The temporal lobe is also involved with understanding what is heard, and with the ability to speak. An area on the right side is involved in visual memory and helps people recognize objects and faces. An area on the left side is involved in verbal memory and helps people remember and understand language. The back area of the temporal lobes helps people interpret the emotions and reactions of others.

➔ **LIMBIC SYSTEM:** Beneath the cerebrum is the **limbic system**, sometimes referred to as the "emotional brain." This part of the brain is involved with human emotions and memories. The limbic system (or Paleomammalian brain) is a set of brain structures including the hippocampus, amygdala, anterior thalamic nuclei, septum, limbic cortex and fornix, which seemingly support a variety of functions including emotion, behavior, long term memory, and olfaction (sense of smell).

➔ **CEREBELLUM** -- divided into two halves, called hemispheres. Controls, regulates and coordinates movement, posture, and balance.

➔ **BRAIN STEM** -- the most basic functions of the brain, such as breathing, are controlled at the deepest level--the **brain stem**.

For more detailed information about the brain, go to this interactive brain Injury (TBI) Web Site: **http://www.traumaticbraininjuryatoz.org/**

II. What is Traumatic Brain Injury?

Traumatic brain injury, often referred to as TBI, is most often an acute event similar to other injuries. That is where the similarity between traumatic brain injury and other injuries ends. One moment the person is normal and the next moment life has abruptly changed. [2]
TBI, also called acquired brain injury or simply head injury, occurs when a sudden trauma causes damage to the brain. The damage can be focal - confined to one area of the brain - or diffuse - involving more than one area of the brain. TBI can result from a closed head injury or a penetrating head injury. A closed injury occurs when the head suddenly and violently hits an object but the object does not break through the skull. A penetrating injury occurs when an object pierces the skull and enters brain tissue.

In most other aspects, a traumatic brain injury is very different. Since our brain defines who we are, the consequences of a brain injury can affect all aspects of our lives, including our personality. A brain injury is different from a broken limb or punctured lung. An injury in these areas limit the use of a specific part of your body, but your personality and mental abilities remain unchanged. Most often, these body structures heal and regain their previous function.

Brain injuries do not heal like other injuries. Recovery is a functional recovery, based on mechanisms that remain uncertain. No two brain injuries are alike and the consequence of two similar injuries may be very different. Symptoms may appear right away or may

Department of Veterans Affairs/Department of Defense Joint Definition of Traumatic Brain Injury

A traumatically induced structural injury and/or physiological disruption of brain function as a result of an external force that is indicated by new onset or worsening of at least one of the following clinical signs, immediately following the event:

- Any period of loss of or a decreased level of consciousness;
- Any loss of memory for events immediately before or after the injury (post-traumatic amnesia – PTA);
- Any alteration in mental state at the time of the injury (e.g., confusion, disorientation, slowed thinking);
- Neurological deficits (e.g., weakness, balance disturbance, praxis, paresis/pelgia, change in vision, other sensory alterations, aphasia) that may or may not be transient;
- intracranial lesion;

[2] Department of Veterans Affairs C&P Evaluation for Traumatic Brain Injury; VA Research & Development Division; 2009

not be present for days or weeks after the injury.

One of the consequences of any brain injury is that the person often does not realize that a brain injury has occurred.

What is the prognosis?

Approximately half of severely head-injured patients will need surgery to remove or repair hematomas (ruptured blood vessels) or contusions (bruised brain tissue). Disabilities resulting from a TBI depend upon the severity of the injury, the location of the injury, and the age and general health of the individual. Some common disabilities include problems with cognition (thinking, memory, and reasoning), sensory processing (sight, hearing, touch, taste, and smell), communication (expression and understanding), and behavior or mental health (depression, anxiety, personality changes, aggression, acting out, and social inappropriateness). More serious head injuries may result in **stupor--**an unresponsive state, but one in which an individual can be aroused briefly by a strong stimulus, such as sharp pain; **coma--** a state in which an individual is totally unconscious, unresponsive, unaware, and unarousable; **vegetative state--** in which an individual is unconscious and unaware of his or her surroundings, but continues to have a sleep-wake cycle and periods of alertness; and a **persistent vegetative state (PVS)--**in which an individual stays in a vegetative state for more than a month.

III. SYMPTOMS

Signs and Symptoms of TBI

Symptoms of a TBI can be mild, moderate, or severe, depending on the extent of the damage to the brain. Some symptoms are evident immediately, while others do not surface until several days or weeks after the injury. A person with a moderate or severe TBI may show these same symptoms, but may also have a headache that gets worse or does not go away, repeated vomiting or nausea, convulsions or seizures, inability to awaken from sleep, dilation of one or both pupils of the eyes, slurred speech, weakness or numbness in the extremities, loss of coordination, and/or increased confusion, restlessness, or agitation. The signs and symptoms of a traumatic brain injury (TBI) can be subtle. Symptoms of a TBI may even be missed as people may look fine even though they may act or feel differently. Here are some common signs and symptoms of a TBI:

- Headaches or neck pain that do not go away;– *see HEADACHE section*
- Irritability for no reason…even for “small” things
- Feelings of depression or anxiety
- Emotional disturbances/ Mood changes (feeling sad or angry for no reason);
- Poor attention span; inability to concentrate/focus

- Memory loss--difficulty remembering, concentrating, or making decisions; primarily short term memory loss
- Slowness in thinking, speaking, acting, or reading;
- Getting lost or easily confused;
- Chronic Fatigue: Feeling tired all of the time, having no energy or motivation;
- Sleep disturbances: Changes in sleep patterns (sleeping a lot more or having a hard time sleeping);
- Light-headedness, dizziness, or loss of balance—vertigo;
- Urge to vomit (nausea); felling like you may vomit but not actually vomiting
- Visual disturbances--blurred vision or eyes that tire easily;
- Increased sensitivity to lights, sounds, or distractions;
- Loss of sense of smell or taste
- Ringing in the ears
- Seizures
- Loss of taste
- Loss of smell

Injury to specific areas of the brain will cause some or all of these specific symptoms. TBI's are usually unique to the damage and the person. For example, injury to the frontal lobes will cause loss of higher cognitive functions, such as loss of inhibitions leading to inappropriate social behavior. Injury to the cerebellum will cause loss of coordination and balance. The brainstem controls things like breathing and heart rate, as well as arousal. An injury to this area could inhibit any of these processes.

Symptoms may not be present or noticed at the time of injury. They may be delayed days or weeks before they appear. The symptoms are often subtle and are often missed by the injured person, family and doctors.

The person looks normal and often moves normal in spite of not feeling or thinking normal. This makes the diagnosis easy to miss. Family and friends often notice changes in behavior before the injured person realizes there is a problem. Frustration and/or stress at work or in the patient's living environment or when performing household tasks may "activate" some of these symptoms and may very well bring the patient to seek medical care.

Effects and Impacts of TBI

Most people are unaware of the scope of TBI or its overwhelming nature. TBI is a common injury and may be missed initially when the medical team is focused on saving the individual's life. Before medical knowledge and technology advanced to control breathing with respirators and decrease intracranial pressure, which is the pressure in the fluid surrounding the brain, the death rate from traumatic brain injuries was very

high. Although the medical technology has advanced significantly, the effects of TBI are significant.

The impact/effects of a TBI can include:

- **Cognitive deficits including difficulties with:**
  - Attention
  - Concentration
  - Distractibility
  - Memory
  - Speed of Processing
  - Confusion
  - Perseveration
  - Impulsiveness
  - Language Processing to include problems with understanding an otherwise common word (reactive aphasia)
  - "Executive functions"
- **Speech and Language**
  - -not understanding the spoken word (receptive aphasia)
  - difficulty speaking and being understood (expressive aphasia)
  - slurred speech
  - speaking very fast or very slow
  - problems reading
  - problems writing
  - problems getting the right word: word aphasia

- **Sensory** -- difficulties with interpretation of touch, temperature, movement, limb position and fine discrimination
- **Perceptual** -- the integration or patterning of sensory impressions into psychologically meaningful data
- **Vision** *(see vision section later on in this paper)*
  - partial or total loss of vision
  - weakness of eye muscles and double vision (diplopia)
  - blurred vision problems judging distance
  - involuntary eye movements (nystagmus)
  - intolerance of light (photophobia)

- **Hearing**

  - decrease or loss of hearing
  - ringing in the ears (tinnitus)
  - increased sensitivity to sounds

- **Smell** -- loss or diminished sense of smell (anosmia)
- **Taste** -- loss or diminished sense of taste
- **Seizures** -- the convulsions associated with epilepsy that can be several types and can involve disruption in consciousness, sensory perception, or motor movements
- **Physical Changes:**

  - Physical paralysis/spasticity
  - Chronic pain
  - Control of bowel and bladder
  - Sleep disorders – generally difficulty with getting to sleep and/or staying asleep
  - Loss of stamina
  - Appetite changes
  - Regulation of body temperature
  - Menstrual difficulties

- **Social-Emotional Issues and Mood Disorders:** TBI's are almost always accompanied by what the neurologists and Neuro-Psychologists call "mood disorder." It is a much more common and serious aspect of TBI's than we would think. So look for these symptoms:

  - Dependent behaviors
  - Lack of motivation
  - Irritability
  - Aggression
  - Disinhibition -- making poor or impulsive decisions; saying things "without thinking" that may hurt others feelings; increase in impulse buying; getting violently angry over little things—flying “off the handle” without sufficient cause to do so
  - Denial/lack of awareness
  - **Emotional ability –** loss of emotional control
  - **Depression or feelings of depression**

The last two, ***Emotional ability & Depression or feelings of depression***, are the ones that are important to focus on. It is common for TBI patients to also have: 1) Survivor's Guilt; 2) PTSD—in addition to and aggravated by the TBI; and 3) severe depression with suicidal ideations (thoughts of suicide) with suicide a possibility**.**

So ensure that any TBI patient is also being seen/treated by Neuro-Psychologists, Psychiatrists (for meds); and understands that these "feelings" are NOT because they are mentally ill but instead are a direct result of the TBI.

TBI and PSYCHOLOGICAL MOOD DISORDERS:

TBI and PTSD: PSYCHOLOGICAL MOOD DISORDERS

- **Be aware that persistent effects of TBIs often include secondary psychological disorders sometimes summarized as simply "mood disorders"**
- **In addition, symptoms and signs of TBI (especially mild TBI cases) and PTSD may commingle and be very difficult to separate. *These are the comorbid (co-occurring) effects of the primary medical condition of TBI***

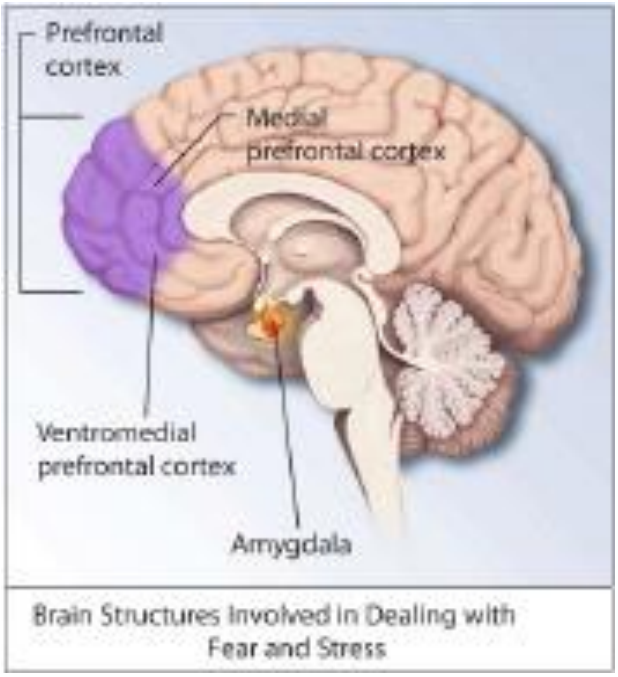
Other Co-occurring (Comorbid) effects:

Differential diagnosis of TBI and other common comorbidities are:

- **Anxiety disorders**
- **Chronic fatigue syndrome**
- **Chronic pain**
- **Depression or other mood disorders**
- **Insomnia**
- **Metabolic disorders (chemical imbalances in the body/brain)**
- **Sleep apnea**
- **Stress disorders**
- **Substance use**

NOTE: ***Comorbid***: a medical condition in a patient that causes, is caused by, or is otherwise related to another medical condition in the same patient

Physiologic factors of PTSD:



Brain Structures Involved in Dealing with Fear and Stress

The amygdala is a key brain structure implicated in PTSD. Research has shown that its exposure to traumatic stimuli can lead to fear conditioning, with resultant activation of the amygdala and associated structures, such as the hypothalamus, locus ceruleus, periaqueductal gray, and parabrachial nucleus. This activation and the accompanying autonomic neurotransmitter and endocrine activity produce many of the symptoms of PTSD.

The orbitoprefrontal cortex exerts an inhibiting effect on this activation. The hippocampus also may have a modulating effect on the amygdala. However, in people who develop PTSD, the orbitoprefrontal cortex appears to be less capable of inhibiting this activation, possibly due to stress-induced atrophy of specific nuclei in this region.

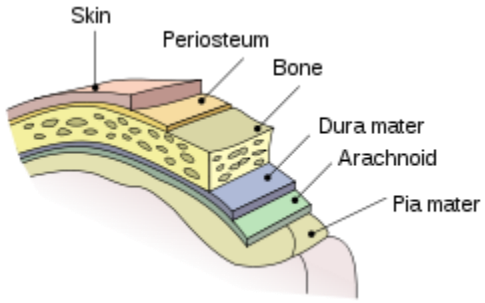
So please note the areas of the brain that influence PTSD. If one has their TBI in those areas, then it would not be unreasonable nor surprising to have co-occurring (comorbid) effects.

Medications: Your WII WW TBI patient may be taking **Selective Serotonin Reuptake Inhibitors** or **SSRI's** or other types of anti-depressants**.** For TBI victims, these are often administered in reduced doses than the doses for a traditional depressed individual. Types of anti-depressants are: Selective serotonin reuptake inhibitors (SSRIs), tricyclics (TCAs), and monoamine oxidase inhibitors (MAOIs). SSRI's are the newest class of antidepressants. They help to relieve the symptoms of depression by increasing the available supply of serotonin, a substance in the brain believed to influence mood.

On other MEDICATIONS: Make sure your TBI survivor understands that they must take all medications, as prescribed by their medical treatment team. This is very important. Some of the TBI medications take up to six (6) weeks to take effect AND for the side-effects to "wear out." This is an issue of TRUST!

IV. CLASSIFICATIONS[3]

TBI is classified into two major classifications: (1) PENETRATING *(the dura[4] next under the skull is pierced--see diagram*) **and (2) NON-PENETRATING.**



➔ **PENETRATING TBI is almost always a "severe" TBI but is simply called/categorized as a "Penetrating TBI" abbreviated "S/P TBI"**

➔ **NON-PENETRATING categories: Mild, Moderate; and Severe. This classification can also be called "BLUNT" and/or "CLOSED" TBI**

- **You may encounter some technical medical terminology:**

The Department of Defense coding is determined with the **DoD ICD-10[5] coding guidance** for TBI. It codes level of severity with a "V" code and contains: a) common symptoms associated with TBI; b) Emotional/Behavioral Symptoms codes; c) Late effect codes; d) The "Dizziness Handicap Inventory (DHI); the Epworth Sleepiness Scale (ESS); "Glasgow Coma Scale (3-15);" the "Multidimensional Assessment of (MAF) of Fatigue Scale; Neurobehavioral Symptom Inventory (NSI); Patient Health Questionnaire

[3] In rating disability for a TBI, the terms "mild," "moderate," and "severe" TBI, which may appear in medical records, refer to a classification of TBI made at, or close to, the time of injury rather than to the current level of functioning. This classification does not affect the rating assigned under diagnostic code 8045.

[4] The dura mater or dura, is the outermost of the three layers of the meninges surrounding the brain and spinal cord. It is derived from mesoderm. The other two meningeal layers are the ***pia*** mater and the ***arachnoid*** mater. The dura surrounds the brain and the spinal cord and is responsible for keeping in the cerebrospinal fluid. The dura has been described as "tough and inflexible" and "leather-like"--

[5] The International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) is a coding of diseases, signs and symptoms, abnormal findings, complaints, social circumstances and external causes of injury or diseases, as classified by the World Health Organization (WHO). The code set allows more than 14,400 different codes and permits the tracking of many new diagnoses.

(PHQ-9); PTSC checklist (PCL-M); are also common diagnostic procedures used to determine severity of effects.

So one may see many different "codes" for their TBI Wounded Warrior—don't be alarmed. Talk with your Wounded Warrior's Neurologist for explanation of the codes you see.

But generally, you find TBIs classified as: Mild, Moderate; Severe and Severe Penetrating.

● MILD Traumatic Brain Injury (mTBI):

A brain injury can be classified as mild if loss of consciousness and/or confusion and disorientation is shorter than 30 minutes. A person with a mild TBI may even remain conscious or may experience a loss of consciousness for a few seconds or minutes. The person may also feel dazed or not like himself for several days or weeks after the initial injury. Other symptoms of mild TBI include headache, confusion, lightheadedness, dizziness, blurred vision or tired eyes, ringing in the ears, bad taste in the mouth, fatigue or lethargy, a change in sleep patterns, behavioral or mood changes, and trouble with memory, concentration, attention, or thinking. This (mTBI) is sometimes called a "post-concussion syndrome."

For Mild TBI's while MRI and CAT scans are often normal, the individual has cognitive problems such as headache, difficulty thinking, memory problems, attention deficits, mood swings and frustration. These injuries are commonly overlooked. While a traumatic brain injury (TBI) can be classified as mild if loss of consciousness and/or confusion and disorientation is shorter than 30 minutes. While MRI and CAT scans are often normal, the individual has cognitive problems such as headache, difficulty thinking, memory problems, attention deficits, mood swings and frustration. These injuries are commonly overlooked. However, the effects of a "mild" TBI can be severe. So even though this type of TBI is called "mild", the effects on the family and the injured person can be devastating.

Just because one is diagnosed with a "MILD TBI" does not mean they have a mild injury—any traumatic brain injury is serious and can be life threatening—including a "Mild TBI"

Other Names for Mild TBI

- Concussion
- Minor head trauma
- Minor TBI
- Minor brain injury
- Minor head injury

Mild Traumatic Brain Injury is:

- Most prevalent TBI
- Often missed at time of initial injury
- 15% of people with mild TBI have symptoms that last one year or more.
- Defined as the result of the forceful motion of the head or impact causing a brief change in mental status (confusion, disorientation or loss of memory) or loss of consciousness for less than 30 minutes.
- Post injury symptoms are often referred to as post concussive syndrome.
- But, most important is that people with Mild TBI often recover within 3 months.

● MODERATE Traumatic Brain Injury (MTBI):

Any major damage to the brain. Also, this category is associated with loss of consciousness for more than 30 minutes and memory loss after the injury or penetrating skull injury longer than 24 hours. The deficits range from impairment of higher level cognitive functions to comatose states. Survivors may have limited function of arms or legs, abnormal speech or language, loss of thinking ability or emotional problems. The range of injuries and degree of recovery is very variable and varies on an individual basis. Moderate brain injuries typically refer to injuries that have these characteristics:

- Moderate brain injury is defined as a brain injury resulting in a loss of consciousness from 30 minutes to 6 hours and a Glasgow Coma Scale of 9 to 12

● SEVERE Traumatic Brain Injury (STBI):

Depends on the severity of initial injury; rate/completeness of physiological recovery; functions affected; and meaning of dysfunction to the individual. Severe TBI's have the same general symptoms and impacts as Moderate and Moderate-to-Severe except the degree of damage is greater in a Severe TBI. Hence, almost all "Penetrating" brain injuries are also "Severe."

- Severe brain injury is defined as a brain injury resulting in a loss of consciousness of greater than 6 hours and a Glasgow Coma Scale of 3 to 8 The impact of a moderate to severe brain injury depends on these factors:

  → Severity of initial damage to the brain
  → Rate/completeness of physiological recovery
  → Functions affected
  → Meaning of dysfunction to the individual
  → Resources available to aid recovery
  → Areas of function not affected by TBI

● SEVERE/PENETRATING Traumatic Brain Injury (S/P TBI):

Severe/Penetrating Traumatic Brain Injuries are when the ***dura*** next under the skull is penetrated and foreign objects enter into the brain. S/P TBI usually require a craniotomy (neurosurgery) to remove fragments.

Comment: Traumatic brain injuries (TBI) result in permanent neurobiological damage that can produce lifelong deficits to varying degrees. The effects of any TBI can be profound. Individuals with penetrating and/or severe injuries can be left in long-term unresponsive states. For many people with severe TBI, long-term rehabilitation is often necessary to maximize function and independence. Even with mild TBI, the consequences to a person's life can be dramatic. Change in brain function can have a dramatic impact on family, job, social and community interaction.

V. OTHER ASPECTS OF A TBI:

Some of the common features that are common for most TBI's are:

➔ BRUISING OF BRAIN TISSUE

Skull fractures can cause bruising of brain tissue called a contusion. A contusion is a distinct area of swollen brain tissue mixed with blood released from broken blood vessels. A contusion can also occur in response to shaking of the brain back and forth within the confines of the skull, an injury called contrecoup. This injury often occurs in car accidents after high-speed stops and in shaken baby syndrome, a severe form of head injury that occurs when a baby is shaken forcibly enough to cause the brain to bounce against the skull. In addition, contrecoup can cause diffuse axonal injury, also called shearing, which involves damage to individual nerve cells (neurons) and loss of connections among neurons. This can lead to a breakdown of overall communication among neurons in the brain.

➔ SHEARING / TEARING OF BRAIN TISSUE & INTERNAL BLEEDING IN THE BRAIN

Brain Tearing is best explained as similar phenomena if one plays with the food "Jell-O". For example, if you put a thin cut in a square of Jell-O with a knife and let it go, the Jell-O will come back to shape if you jiggle it. The Jell-O will look perfectly good up until the time you go to lift it up, and then there will be the slice in the jello. The brain has a consistency slightly firmer than Jell-O, but the same effect applies. In the case of the traumatic concussion usually from both the blast and being hurled into something hard (closed brain injury), the brain is thrown forward, then bounced backward. In this forward/backward motion, the brain is usually torn. The brain can also be torn by the effects of "energy" called blast effects. If you take a block of ice and hit it with a hammer (assuming you don't completely shatter the ice), you will see little cracks in the ice. Energy from the hammer has been transferred to the ice, producing the web-like cracks. However shearing in the brain is very serious. Shearing / Tearing in the brain can also

"cut" the wires that make the brain work.[6] These wires are called an **axon** (or nerve fiber). An axon is a long, slender projection of a nerve cell, or neuron that conducts electrical impulses away from the neuron's cell body or soma. They are the primary transmission lines of the nervous system and as bundles they help make up nerves. Individual axons are microscopic in diameter - typically about one micrometer across (1μm) - but may extend to macroscopic (>1mm) lengths. If this condition is present, your TBI Wounded Warrior may have the annotation of **"Diffuse axonal injury" (DAI).** One of the problems with tearing is that it happens on a microscopic level (the brain has about 100 billion of these "wires"). This tearing may not show up on typical medical tests. Devices that take pictures of the brain may not see these small tears. Two common ways of viewing the brain are with a CT scan (using X-rays) and an MRI (using magnetic fields) to create pictures of the brain. Both of these techniques are very good at seeing blood and tumors in the brain, but they are not as good with tears (which are very small). In a number of medical studies with people who have head injuries, only 10 to 15 percent had "positive" CT Scans or MRI findings. By the way, a "positive" in the medical business is NOT a good thing. It means that they found something that is abnormal in the brain.

Also, because of this "energy" effect, damage to a major blood vessel in the head can cause a hematoma, or heavy bleeding into or around the brain. Three types of hematomas can cause brain damage. 1) An epidural hematoma involves bleeding into the area between the skull and the dura, 2) A subdural hematoma, bleeding is confined to the area between the dura and the arachnoid membrane, and 3) Bleeding within the brain itself is called intracerebral hematoma.

➔ HEADACHES

Probably the most frequent and enduring impact of a TBI are headaches. Headaches can be a serious problem with a head injury. If there is pain every day (headaches can also wake you in the middle of the night), headaches will wear you down mentally and emotionally. How common are headaches in head injury? In one study of head-injured people, 50% reported having a headache when they were discharged from the hospital. After one year, 33% of this same group of people said "*my head still hurts.*" That's a long time to have a headache.

[6] However the brain has the ability to form new neural connections throughout life—See Section X, RECOVERY on **Neuralplasticity.**

HEADACHES: Worse Than Giving Birth

Peter Goadsby, M.D., professor of Clinical Neurology at University College, London, and head of the Headache Group at London's Institute of Neurology, is a cluster headache expert. His patients have provided him with graphic descriptions of the pain they experience during cluster attacks.
"Women with cluster headache will tell you that an attack is worse than giving birth," Goadsby says. "So you can imagine that these people give birth without anesthetic once or twice a day, for six, eight or 10 weeks at a time, and then they have a break. It's awful."

Here are four (4) common types of headaches that are associated with many TBI's. There are many other variations on the types of headaches that can develop, but most head-injured people will have one (or more) of the following:

1. **Pain In The Back Of the Head/Neck/Shoulder**

This type of head pain is described as a pain that starts at the base of the head/neck area. The pain commonly gets worse as the day goes on and it may spread over the top of the head to the front part of the head. What is causing this? You have to remember that when you were in a car accident, your head was traveling at a high rate of speed. For example, a car is traveling 50 mph and it suddenly stops. Everything in the car goes from 50 mph to zero in an instant, and your head is thrown forward. The only thing holding your head on the top of your body is a bunch of muscles, some bones, and some cartilage. Your neck consists of bones, rubbery disks (bones don't bend--the disks help the neck to bend), and muscles so you can move your neck and head. When your head is thrown forward in the accident, the disks that are between the bones can get squished. These squished disks may press on nerves in the neck. Pressing on the nerve can make parts of the body numb or decrease strength in parts of the body. Another problem that can happen at the same time is stretched muscles. If you take a rubber band and stretched it almost to the breaking point, then let it come back, you may have noticed a change in the rubber band. A similar thing happens with muscles. If you really yank on them, they come back in knots. Sometimes, you can actually feel the knots. This stretched muscle problem is called myofacial pain disorder by doctors. The pain at the back of the head can go on for a long period of time (possibly for years, especially if you keep re-injuring or stressing the sore muscles). So, the first type of head pain is due to muscle tension and/or nerve problems. Unfortunately, this type of headache can trigger a migraine-type of headache following a head injury.

2. **Migraine-Like Headaches**

The second type of headache is much tougher. Following a head injury, you can develop a headache that resembles a migraine headache. Pain tends to be in the front of the head. Many complain that their forehead or temples throb. It is commonly described as a "pounding" pain. Emotional stress or intense concentration tends to

bring on or make these headaches worse. One possible explanation of this problem is a change in the vascular system of the brain. The brain has veins and arteries that supply blood to it. The brain weighs only about three pounds but uses 30% of the oxygen and energy in your body. So there's a lot of blood flowing to the brain. Think of this blood flowing through a hollow tube, like the water flowing through pipes in your home. These pipes, however, can change their diameter. If the veins and arteries couldn't change shape, all the blood would run down to our feet. The heart is pumping the blood around the body and veins constrict to keep a constant pressure. If I make the diameter smaller and put more pressure on the system, I develop high blood pressure. If my blood pressure is too low, I'll faint because there's not enough pressure to make things work. With head injury, these very finely tuned little pipes get stretched or injured. Remember, the brain is yanked forward and backward in an accident. Things get stretched and don't work the way they normally do. In a classic migraine headache, blood is flowing at a normal rate and the tubes (veins/arteries) suddenly get much smaller. During this constriction phase, some people get a warning sign. They may become very sensitive to light, or they may lose their peripheral vision (the outside of their vision goes black and they just see the middle part). That's just the start. The veins go from being very small to "giving up", in which they suddenly open wide. When this happens, the pounding or throbbing headache begins.

3. The "Stabbing" Headache

The third type of headache is described as a sudden, sharp pain. One person described this as "*I'm walking along and all of a sudden I feel like someone is jamming a hot metal rod through my skull.*" It is a severe pain that will nearly bring some people to their knees by its intensity. The pain may last from a few seconds to a minute or two. Most doctors don't treat it because it lasts for a very short period of time. There are some drugs (typically of the anti-seizure variety) that can help with this problem. Some of my patients have reported improvement when a physical therapist or massage therapist works on the neck area. If you are thinking about this option, ALWAYS talk with your physician first!

4. Cluster Headache:

The cluster headache can be devastating on day-to-day life. Cluster Headaches strike in a group or "cluster" for up to a few hours and recur daily for days, weeks, months, or years on end. There are some periods of freedom between attacks. These headaches occur in clusters of relatively short attacks of severe, often excruciating pain. Cluster headaches typically affect one side of the head and are centered around the eye. During cluster headaches there are several attacks (typically one to four) a day, followed by an attack-free remission period. The cluster period usually lasts from a few weeks to a couple of months. A remission period may last for months or even years though some TBI people experience no significant remission. There are cases of severe penetrating traumatic brain injury patients having cluster headaches their entire life. There is an example of one S/P TBI veteran who still has cluster headaches 40 years after his combat TBI (multiple craniotomies to remove fragments (MFW) of an

82mm mortar round from his brain). The exact cause of cluster headaches is not known, although there is some evidence that abnormal nerve cell activity in the hypothalamus may be involved like in our 40 year TBI survivor whose hypothalamus was damaged by shrapnel some of which is still embedded in that area of his brain[7].

Some researchers consider cluster headaches a variant of migraines, largely because the excruciating pain is centered on one side of the head, as in a migraine. **But unlike the throbbing of a migraine, this pain is steady and piercing.** Cluster headaches are not biochemical events caused in some way by blood vessels in the brain but, instead, are related to abnormalities in the structure of the brain and how it works. A traumatic injury to the brain can alter the structure and pathways (how it works) of brain functions. However, the brain will attempt to "compensate" to the internal injuries (but only to a certain degree) by building new paths and systems within the functioning of the brain.

There are two subtypes of cluster headache -- **episodic** and **chronic**. **EPISODIC**: The episodic type is more common, experienced by about 80 percent of patients who suffer this type of headache. These are characterized by pain episodes or headaches that occur together in periods known as "a cluster." Clusters may last from seven days to a year, but those of the episodic variety are normally separated by periods of 14 days or longer when no headaches occur. **CHRONIC:** In the chronic form, the cluster of headaches occur for more than a year, without any remission lasting for as long as 14 days. Generally, cluster headaches that are chronic occur more often and are less responsive to treatment than are those that are episodic in character.

Symptoms: **Cluster headaches are uncommonly painful. The intense pain is usually only on one side of the head and often described as a pain that's sharp, burning or boring into the head. It's frequently focused in the region around or within the eye socket. One cluster headache sufferer described the sensation as "having a pencil pushed into your eyeball that just keeps being pushed further and further in." The headaches come on rapidly and can last for as long as three hours of sustained, high degree of intensity and debilitating effects.**

Coping With Head Pain

If you have one or more of these headaches, what should you do about them? Let's start with the neck/back of head pain. After an accident, your doctor may send you to a physical therapist. It is important to find a physical therapist who is familiar with this problem. The first time a physical therapist works on your neck, the pain may get much worse. I've even had one or two people say the pain was so bad that they passed out. And this was just from simple moving or stretching. Many people say "*I went to this physical therapist and it made me worse so I'm not going back.*" Tell your physical therapist that you hurt. But remember, it gets worse before it gets better. Physical therapy alone may not be enough. You may have to continue loosening these muscles

[7] For more insight and information on this particular case, contact the WWMP.

up by exercising. Of all the exercise approaches, most of my patients feel that swimming is a big benefit. A warm water pool is probably one of the very best ways of preventing these headaches. Its also very helpful for a lot of people who have back pain.

Migraine-like headaches are a lot tougher to deal with. These headaches will generally require some form of medication. Medications that doctors use to treat headaches tend to generate a lot of questions. There are two medication approaches: controlling pain that already exists and preventing headaches from getting started. To control pain, many people use drugs like Motrin, Darvocet, and Tylenol. One problem with pain medications is that you have to take them every 4 to 6 hours. They can interfere with your thinking and memory as well. In using pain killers, be aware of the following:

- If you use pain medications more than three days per week, you need to be aware of something called "analgesic rebound headache". Chronic use of pain killers can cause you to have MORE headaches (an increase in the number of headaches).

- Don’t assume that all over-the-counter medications are safe! For example, long term or intensive use of Tylenol can produce liver damage. People also seem to feel free to take extra amounts of over-the-counter pain killers (if two pills work, six must be better). If you have chronic head pain, ALWAYS talk with your doctor about over-the-counter medications.

There are some very effective preventative types of medications. These tend to be "unusual" types of drugs. For example, some anti-depressant medications can help with headaches. Why? Did you ever notice that when you're depressed you feel more achy? Burn victims, people who have intense pain, often use anti-depressant medications. These medications help decrease both depression and pain. Some of these anti-depressant medications may also help normalize sleep. Without a good night's sleep, you're going to be more prone to headaches. Another medication approach to headaches is to stop them just as they are starting. In this approach, a medication (i.e., Imitrex, Zomig) is used in the very early phase of a headache. Timing of taking the drug is critical with this approach. One of the best ways to deal with headaches is to prevent them. In a new use for a drug that’s been around awhile, the anti-seizure drug Depakote has been approved by the FDA to treat migraine headaches. This drug works very well in about 70 percent of head-injured patients. However, many people have problems with the side effects of this drug. It’s hard on the stomach; so many people have to take this drug with food.

A warning about vascular headaches--they tend not to have a "quick fix" with medications and there is a lot of trial and error in finding the medication that works. For many, medication may reduce, but not eliminate, head pain. You need to be very patient in working with your doctor. **TAKE MEDICATIONS EXACTLY AS YOUR DOCTOR DIRECTS!** Doctors who feel that you are taking medications improperly will hesitate to use more powerful medications that might benefit you. Read the section of

this book on Dealing with Doctors. This chapter will help you to establish a positive relationship with your doctor. If you have frequent headaches, a solid relationship with your doctor is essential.

What can you do for vascular headaches on your own? The most common way people deal with a headache is to go to sleep or lie down. Try to lie down early before the headache gets bad. When you lie down, find a dark and/or quiet place. Most headache patients also avoid eating--largely because they report that their headaches make them sick to their stomachs. This next approach may help to prevent this type of headache: Wear dark sunglasses! Some people who go from a dark building out into the bright sunlight and have instant headaches. You can get these headaches especially in the early fall or in the summer when the sun is very low, and when you're looking at or driving into the sun. In general, the cheaper and darker the sun glasses, the better. Some people have used photo gray glasses; they tend to be not dark enough.

Some of the things that you eat and drink may affect the vascular type of headache. For example, some people who drink red wine will get an instant headache. There is an amino acid in red wine that can trigger a headache. In general, it's a good idea to avoid drinking alcohol following a head injury (a hangover is the brain's way of reminding you that you are hurting it). The same amino acid in red wine is also found in some foods (such as hard cheeses). An allergic reaction may also cause a headache. If you have these nasty pounding headaches, pay close attention to your diet to see if food is triggering a headache.

Another important strategy for vascular headaches and muscular headaches is to manage your stress level. Involvement in something very stressful or something that makes you very nervous will often trigger a headache. If you have to do something stressful, it's better to deal with it early in the day when your thinking is better. If you deal with something late in the day when you are really tired, you're more likely to get a headache.

Sleep has an indirect role with headaches. When it's too warm in the house or you have too many covers on the bed, the body heats up and you'll have less restful sleep, which in turn increases headaches. A lot of people do something called "turtling," in which they pull the covers over their face if it's too cold in the house (like a turtle hiding in a shell). If you do this, you're breathing the same air over and over. The problem is that you're breathing carbon dioxide. There is less oxygen going into your brain, which may trigger a headache. The temperature of food can also trigger a headache. Remember taking large bites of really cold ice cream and remember those ice cream headaches? If you get headaches easily, you might have to take smaller bites of ice cream or make sure you warm up your mouth before you take another bite.

Keep a headache journal. Get a monthly calendar and each day rate your headaches on a 1 to 10 scale with "1" being no headache and "10" being the worst headache you've ever had. You can also note what events in your life tend to trigger a headache. A lot of people start to realize how important stress is when they look through the entire

month and see the relationship between their bad headaches and the activities of the same time period. They may notice a pattern developing. Some people get more headaches toward the end of the week because stress tends to build up over time. You can get more headaches on the weekends due to family and friends visiting.

It is very helpful to bring this journal to your doctor. If the two of you are struggling with the best drug or a combination of drugs to use, the doctor is going to need some method of rating how they're doing. If your doctor asks "how's your headaches?" after trying a medication and you say "the same," the doctor may stop the medication. Because of the way you reported it, this may have been a mistake. For example, you bring in your headache journal sheet and you had 7's before the medication and now after the medication you have 5's. Your doctor may have been onto something, but you asked to stop it too early. So make a headache journal if you get headaches.

It is important to take medications for headaches (and other medical conditions) at the same time every day (no more than plus or minus 15 minutes). This is a big problem for many people with head injuries because they tend to be forgetful and may be missing important medications. For under $40, Casio makes a watch that can be programmed for five events during the day. The beeping of the watch will remind you when to take medications. A lot of people don't want to carry all the jars of medications with them at once. You can buy little plastic holders for medications that you fill once a day (cost under $10). Another nice thing about these pill holders is that you can double check to see whether or not you took your medication.

➔ Hypoxic-Anoxic Brain Injury (HAI):[8]

The brain requires a constant flow of oxygen to function normally. A hypoxic-anoxic injury, also known as HAI, occurs when that flow is disrupted, essentially starving the brain and preventing it from performing vital biochemical processes. Hypoxic refers to a partial lack of oxygen; anoxic means a total lack. In general, the more complete the deprivation, the more severe the harm to the brain and the greater the consequences. The diminished oxygen supply can cause serious impairments in cognitive skills, as well as in physical, psychological and other functions. Recovery can occur in many cases, but it depends largely on the parts of the brain affected, and its pace and extent are unpredictable.

> *(Four minutes without oxygen will kill brain cells. This can bring on anoxic brain injury. Such a very short time deprived of oxygen, yet it can have an enormous effect on the rest of the victim's life.)*

As a result, HAI can have a catastrophic impact on the lives not only of those injured but their families, friends and caregivers as well. Treatment can be costly and complicated, especially because HAI patients frequently need substantial medical and rehabilitative help and may suffer from significant long-term disabilities. A shortage of easy-to-

[8] FAMILY CAREGIVER ALLIANCE National Center on Caregiving ©Family Caregiver Alliance

understand, accessible information about HAI can make the situation even more stressful for affected individuals and their families. This Fact Sheet will help answer your questions about this condition.

Symptoms

HAI is generally marked by an initial loss of consciousness or coma, a condition which looks like sleep but from which a person cannot be awakened. The period of unconsciousness, whether short or long, might be followed by a persistent vegetative state, in which a person is neither comatose nor responsive to external stimuli. This state is frequently referred to as “wakeful unresponsiveness.”
Even when a person has fully recovered consciousness, he or she might suffer from a long list of symptoms. In many ways, these symptoms are similar to those commonly seen after a blow to the head. The effects can vary widely depending upon the part of the brain that has been injured and the extent of the damage. Some of the major cognitive (thought) problems are:

- ***Short-term memory loss***. This is the most common cognitive symptom, especially among those who have HAI. The reason is that the part of the brain that is believed to be responsible for learning new information, called the hippocampus, has neurons that are highly sensitive to oxygen deprivation.

- ***Decline in executive (cognitive/thinking) functions.*** Disruption of such critical tasks as reasoning, making judgments, and synthesizing information. This can lead to impulsive behavior, poor decision-making, inability to direct, divide, or switch attention.

- ***Difficulty with words***, also known as ***anomia***. These linguistic problems include not being able to remember the right word, selecting the wrong word, confusing similar words, not understanding commonly used words, and so on.

- ***Visual disturbances***. Difficulty processing visual information can occur in some cases. One rare disorder is called ***cortical blindness***, in which the area of the brain responsible for vision becomes disconnected from the rest of the brain. Because the brain cannot tell that this part is damaged, people may appear to act as though they can see even though they display no ability to identify or recognize objects, shapes or colors.

Some common physical deficits are:

- ***Ataxia,*** or a lack of coordination. This often expresses itself as a sort of bobbing or weaving, similar to what is seen in people who are drunk.

- ***Apraxia,*** or an inability to execute a familiar sequence of physical movements such as brushing teeth, combing hair, using eating utensils, etc.

- ***Spasticity, rigidity*** and ***myoclonus***, disorders which can include a tendency toward jerky motions, trembling of the extremities, or other abnormal movements.
- ***Quadriparesis***, a weakness of the arms and legs.

- ***Other symptoms*** can include: ***hallucinations*** and ***delusions***; ***increased agitation*** and ***confusion***; ***depression*** and other ***mood disorders***; ***personality changes***, such as irritability and a ***reduced threshold for frustration***; and an ***inability to focus or concentrate***.

Advice for Caregivers for HAI:

As recovery may take months and even years, it is important for both the patient and family members involved in rehabilitation efforts to establish a good working relationship with the various specialists. It's important to understand that rehab often proceeds in an unpredictable way, with progress measured in small steps rather than giant leaps. Patients and family caregivers, therefore, often experience intense bouts of frustration at what they perceive to be the slow pace of recovery. Expectations and hope may at times outstrip the person's actual level of progress, and the potential for disappointment and misunderstanding—between patient and family, or caregivers and rehabilitation professionals—can be significant.

While the process will never be easy, the following tips may help to minimize possible tension and conflict:

- Find out as early as possible who will be part of the rehab team. Get to know the professionals as soon as they begin working with the patient. Ask them for a realistic assessment of the situation. What can you and the patient expect? What is the bare minimum they hope to achieve? What is the likely outcome? What is the most optimistic forecast? This way, you will understand the range of possibilities and can gauge your expectations accordingly.

- Learn as much as possible about the role of each of the rehabilitation specialists. Ask them how you can make their jobs easier. Are there steps you need to take to prepare the patient for them each day? Are there exercises you can help with? Are there times you would be better off staying out of the way?

- Stay informed and involved. Family members and friends can play a critical role in monitoring care, charting progress, providing support to both the patient and the professionals, and answering any questions that may arise. Working as a team is one way to help maximize the recovery potential.

- Plan regular meetings for family members and friends involved in the caregiving process. This will give everyone a chance to exchange information, voice concerns and stay on top of the changing situation. If possible, invite one or more

of the rehabilitation professionals so they can fill in the group as a whole rather than having to repeat information to every individual.

- Recovery can be completely unpredictable, and the love of those around a patient can play a key role in stimulating progress. Motivation is an important factor, and someone who feels supported in his or her efforts may well find greater reserves of internal strength to press forward with the rehabilitation process.

- Celebrate every success, not just the big ones. The first time the patient takes a step unaided, handles a fork properly or remembers someone's name should be considered a major victory. Hopefully, more will follow, but it is important to take joy in every advance, small or large.

➔ SEIZURES: Seizure Disorder

***GENERAL**:* Simply said, in seizure disorders, the brain's electrical activity is periodically disturbed, resulting in some degree of temporary brain dysfunction. Normal brain function requires an orderly, organized, coordinated discharge of electrical impulses. Electrical impulses enable the brain to communicate with the spinal cord, nerves, and muscles as well as within itself. Seizures may result when the brain's electrical activity is disrupted. Many people have unusual sensations just before a seizure starts. Some seizures cause uncontrollable shaking and loss of consciousness, but more often, people simply stop moving or become unaware of what is happening. If needed, drugs can usually prevent seizures. In Seizure Disorders, TBI seizures have no apparent cause (or trigger) and occur repeatedly.

SEIZURES--SOME INFORMATION NOTES:

It may be hard to tell if someone is having a seizure. Some seizures only cause a person to have staring spells. These may go unnoticed. Specific symptoms depend on what part of the brain is involved. They occur suddenly and may include:

- **Brief blackout followed by period of confusion (the person cannot remember a period of time)**

- **Changes in behavior such as picking at one's clothing**
- **Drooling or frothing at the mouth**
- **Eye movements**
- **Grunting and snorting**
- **Loss of bladder or bowel control**
- **Mood changes such as sudden anger, unexplainable fear, panic, joy, or laughter**
- **Shaking of the entire body**
- **Sudden falling**
- **Tasting a bitter or metallic flavor**
- **Teeth clenching**
- **Temporary halt in breathing**
- **Uncontrollable muscle spasms with twitching and jerking limbs**

Symptoms may stop after a few seconds minutes, or continue for 15 minutes. They rarely continue longer.

The person may have warning symptoms before the attack, such as:

- **Fear or anxiety**
- **Nausea**
- **Vertigo**
- **Visual symptoms (such as flashing bright lights, spots, or wavy lines before the eyes)**

Categories: There are generally two major categories of seizures: 1) small, subtle, indistinct seizures (petite mal); and 2) easily recognizable major seizures (grand mal).

The **Petit Mal Seizure** is a mild, very brief generalized seizure

The **Grand Mal Seizure** is also called a generalized Tonic-Clonic Seizure and is the seizure of grand mal epilepsy, consisting of a loss of consciousness and generalized tonic convulsions followed by clonic[9] convulsions.

Symptoms vary depending on which area of the brain is affected by the abnormal electrical discharge

Almost all seizures are relatively brief, lasting from a few seconds to a few minutes. Most seizures last 1 to 2 minutes. When a seizure stops, people may have a headache, sore muscles, unusual sensations, confusion, and profound fatigue. These after-effects are called the postictal state. In some people, one side of the body is weak, and the weakness lasts longer than the seizure (a disorder called Todd's paralysis). Most people who have a seizure disorder look and behave normally between seizures.

Symptoms

In about 20% of people who have a seizure disorder, seizures are preceded by unusual sensations (called aura), such as the following:

- Abnormal smells or tastes
- Butterflies in the stomach
- A feeling of déjà vu
- An intense feeling that a seizure is about to begin

Symptoms by location of the brain and brain Dysfunction as in the following:

- An intensely pleasant or unpleasant taste if the part of the cerebrum called the ***insula*** is affected
- Visual hallucinations (seeing unformed images) if the ***occipital lobe*** is affected
- Inability to speak if the area that controls speech (located in the ***frontal lobe***) is affected
- A convulsion (jerking and spasms of muscles throughout the body) if ***large areas on both sides of the brain are affected***

Other possible symptoms include numbness or tingling in a specific body part, brief episodes of unresponsiveness, loss of consciousness, confusion, and loss of muscle or bladder control.

[9] **Clonic Seizure** one in which there are generalized clonic (*person's muscles will start to contract and relax rapidly, causing convulsions*) contractions without a preceding tonic phase.

Symptoms also vary depending on whether the seizure is partial or generalized. About 70% of people have only one type of seizure. The rest have two or more types.

PETIT (small) MAL SEIZURES: We will focus on the Petit Mal Seizures: Most **petit mal seizures** last only a few seconds.

The person may stop walking or talking in mid-sentence, and start again a few seconds later. The person usually does not fall. The person is usually wide awake and thinking clearly immediately after the seizure.

Symptoms of typical Petit Mal Seizures may include:

- **Muscle activity changes**
  - No movement
  - Hand fumbling (especially with longer spells)
  - Fluttering eyelids
  - Lip smacking (especially with longer spells)
  - Chewing (especially with longer spells)

- **Consciousness changes**
  - Staring episodes (unintentional)
  - Lack of awareness of surroundings
  - Sudden halt in conscious activity (movement, talking, etc.)
  - May be provoked by hyperventilation or flashing lights, in some cases
  - Abrupt beginning of seizure
  - Each seizure lasts no more than a few seconds
  - Full recovery of consciousness, no confusion

- **No memory of seizure**

Symptoms of *atypical* Petit Mal Seizures: *Atypical* petit mal seizures begin slower, last longer, and ***may have more noticeable muscle activity*** than typical petit mal seizures. There is usually no memory of the seizure. Symptoms may include:

- Unintentional staring
- Lack of awareness of surroundings
- Sudden stop of conscious activity (movement, talking, etc.)
- Hand fumbling
- Fluttering eyelids
- May be provoked by hyperventilation, in some cases
- May have slower, gradual beginning of seizure
- Each lasts only seconds to minutes
- Recovery may be slower
- May have short period of confusion or bizarre behavior
- No memory of seizure

- May change into a different type of seizure (such as a grand mal or atonic seizure)

Seizure types are organized according to whether the source of the seizure within the brain is **localized** (partial or focal onset seizures) or **distributed** (generalized seizures). Partial seizures are further divided on the extent to which consciousness is affected (simple partial seizures and complex partial seizures). **If consciousness is unaffected, then it is a simple partial seizure**; otherwise it is a complex partial seizure.

In **simple partial seizures**, abnormal electrical discharges begin in a small area of the brain and remain confined to that area. Because only a small area of the brain is affected, symptoms are related to the function controlled by that area. For example, if the small area of the brain that controls the right arm's movements (in the left frontal lobe) is affected, the right arm may begin to shake and jerk. People are completely conscious and aware of the surroundings. A simple partial seizure may progress to a complex partial seizure.

In **complex partial seizures**, abnormal electrical discharges begin in a small area of the temporal lobe or frontal lobe and quickly spread to other nearby areas. The seizures usually begin with an aura that lasts 1 to 2 minutes. During the aura, people start to lose touch with the surroundings.

TYPES: A partial seizure may spread within the brain—a process known as **secondary generalization**. Generalized seizures are divided according to the effect on the body. These include:

1) **Absence seizure** involves a brief, sudden lapse of conscious activity. An absence seizure may look like the person is merely staring into space--with or without jerking or twitching movements of the eye muscles. The person may stop walking or talking in mid-sentence, and start again a few seconds later. The person usually does not fall. The person is usually wide awake and thinking clearly immediately after the seizure. These periods last for seconds, or even tens of seconds. Those experiencing absence seizures sometimes move from one location to another without any purpose. Compared with other types of epileptic seizures, absence seizures appear mild. But that doesn't mean they can't be dangerous. Absence seizures can usually be controlled with anti-seizure medications.

2) **Atonic Seizure** is characterized by sudden loss of muscle tone and/or muscle strength

3) **Adversive Seizure** a type of focal motor seizure in which there is forceful, sustained turning to one side by the eyes, head, or body

4) **Automatic Seizure** a type of complex partial seizure characterized by automatisms, often ambulatory and involving quasipurposeful acts

5) **Tonic Seizure** one in which the person will quickly lose consciousness, and the skeletal muscles will suddenly tense, often causing the extremities to be pulled towards the body or rigidly pushed away from it, which will cause the person to fall if standing. The tonic phase is usually the shortest part of the seizure, usually lasting only a few seconds. The person may also express vocalizations like a loud moan during the tonic stage, due to air forcefully expelled from the lungs

6) **Complex Partial Seizure** a type of partial seizure associated with disease of the temporal lobe and characterized by varying degrees of impairment of consciousness and automatisms, for which the patient is later amnestic[10]

7) **Myoclonic Seizure** is characterized by a brief jerking movement that arises from the central nervous system, usually involving both sides of the body. The movement may be very subtle or very dramatic

8) **Sensory Seizure** is a simple partial seizure manifested by paresthesias[11] and/or hallucinations, including several types of aura and/or a reflex seizure in response to a sensory stimulus

9) **Frontal Lobe Seizures** symptoms can vary, depending on where the seizures originate in the brain. Seizures that begin in the front of the brain (frontal lobe seizures) may produce unusual symptoms *that can appear* to be related to a psychiatric problem or a sleep disorder. They often occur during sleep and may feature bicycle pedaling motions and pelvic thrusting. Some people scream profanities or laugh during frontal lobe seizures. Signs and symptoms of frontal lobe seizures may include: Head and eye deviation to one side Complete or partial unresponsiveness, or difficulty speaking Explosive screams or laughter Abnormal body posturing, such as one arm extending while the other flexes, as if the person is posing like a fencer Repetitive movements, such as rocking or bicycle pedaling

10) **Temporal Lobe Seizure** starts in the part of the brain that processes emotions, fight or flight reactions, and short-term memory. Many who have temporal lobe seizures may experience odd feelings — ranging from euphoria to fear, deja vu, and hallucinations of taste or smell — at the onset of their seizures. Temporal lobe seizures are often resistant to anti-seizure medications. Surgery may be an option for some people if their seizures consistently begin in only one of their two temporal lobes. Many become free of temporal lobe seizures when the affected portion of the lobe is removed.

[10] Amnestic: partial or total loss of memory, usually resulting from shock, psychological disturbance, brain injury, or illness

[11] Paresthesias is a sensation of tingling, pricking, or numbness of a person's skin with no apparent long-term physical effect. It is more generally known as the feeling of "pins and needles" or of a limb "falling asleep" (although this is not directly related to the phenomenon of sleep).

Symptoms: An unusual sensation or emotion, known as an **aura** *(sometimes described as "sparkling lights" OR simply "sparkles" in the peripheral vision field*), may precede a temporal lobe seizure, acting as a warning. Not everyone who has temporal lobe seizures experiences auras, and those who do have auras may not remember them. The aura is actually a small seizure itself — one that has not spread into an observable seizure that impairs consciousness and ability to respond. **Examples of auras include:**

- A sudden sense of unprovoked fear
- A deja vu experience
- The sudden occurrence of a strange odor or taste
- A rising sensation in the abdomen
- People who have temporal lobe seizures usually remain partially conscious during a seizure, but they lose awareness of their surroundings and usually don't remember what happened.
- A temporal lobe seizure usually lasts 30 seconds to two minutes. Characteristic signs and symptoms of temporal lobe seizures include:
- Loss of awareness of surroundings
- Staring
- Lip smacking
- Repeated swallowing or chewing
- Unusual finger movements, such as picking motions

After a temporal lobe seizure, the patient may have:

- A brief period of confusion and difficulty speaking
- Inability to recall the events that occurred during the seizure
- Unawareness of having had a seizure until someone else tells you

➔ BULBAR PALSY:

Bulbar Palsy refers to a range of different signs and symptoms linked to impairment of function of the cranial nerves 9, 10, 11, 12, which occurs due to a lower motor neuron lesion in the medulla oblongata or from lesions of the lower cranial nerves outside the brainstem.

Symptoms

- dysphagia (difficulty in swallowing)
- difficulty in chewing
- nasal regurgitation
- slurring of speech
- difficulty in handling secretions

- aspiration of liquids
- dysphonia (defective use of the voice, inability to produce sound due to laryngeal weakness)
- dysarthria (difficulty in articulating words due to a CNS problem)

Signs

- nasal speech lacking in modulation and difficulty with all consonants
- tongue is atrophic and shows fasciculations.
- dribbling of saliva.
- weakness of the soft palate, examined by asking the patient to say aah.
- normal or absent jaw jerk
- absent gag reflex

In addition, there may be lower motor neuron lesions of the limbs.

The ocular muscles are spared and this differentiates it from myasthenia gravis.

Causes

- Genetic: Kennedy's disease, acute intermittent porphyria
- Vascular causes: medullary infarction, such as lateral or medial medulary infarction.
- Degenerative diseases: amyotrophic lateral sclerosis, syringobulbia, Wolfram syndrome
- Inflammatory/infective: Guillain–Barré syndrome, poliomyelitis, Lyme disease
- Malignancy: brain-stem glioma, malignant meningitis
- Toxic: botulism, venom of bark scorpion (species Centruroides), some neurotoxic snake venoms]
- Autoimmune: myasthenia gravis

Diagnosis: Differential diagnosis[edit]

In contrast, pseudobulbar palsy is a clinical syndrome similar to bulbar palsy but in which the damage is located in upper motor neurons of the corticobulbar tracts in the mid-pons (i.e., in the cranial nerves IX-XII), that is the nerve cells coming down from the cerebral cortex innervating the motor nuclei in the medulla. This is usually caused by stroke.

VI. DIAGNOSIS OF TBI

With moderate to severe traumatic brain injury (TBI), the diagnosis is often self-evident especially in an “open head” injury—penetrating head injury. In the presence of other life threatening injuries, which are often the case with motor vehicle accidents like those we see in our soldiers from being “thrown around” in their vehicle by an IED, closed head injury can be missed. The primary focus is first on lifesaving measures. In open head injuries (the skull is penetrated or broken) it is obvious that the WW patient has a TBI.

The patient may be on a ventilator (breathing machine) and sedated and the evaluation for brain injury will be limited until the patient is allowed to emerge from medications and mechanical ventilation. However, Mild traumatic brain injury may not be diagnosed until the individual begins to have problems in what were once easy tasks or social situations (see symptoms).

Methods of Diagnosis

- A detailed neurological examination is important and will bring out evidence of brain injury.
- Brain imaging with computed tomography (CT) scan, Magnetic resonance imaging (MRI), SPECT and PET scan may be useful. Most of our WW’s are screened with CAT/MRI at Landstuhl Regional Medical Center as well as an incoming MedEvac patient arriving at WRAMC by neurological medical personnel.
- Cognitive evaluation by a Neuropsychologist with formal neuropsychological testing.
- Evaluations by physical, occupational and speech therapists help clarify the specific deficits of an individual.

DIAGNOSTIC TESTS

The medical staff may conduct a number of diagnostic tests to determine what is occurring internally after the accident or illness.

X-rays, CT scans and MRI's of brain are pictures of the inside of the head. The picture will show if there is bleeding and/or swelling, skull fractures and where the damage has been done.

Often, **Cervical Spine and other spinal films** may be completed. When someone is involved in trauma, the neck and back may also be injured.

EEG: this test shows the presence of brain waves, their intensity and frequency. It is also used to determine if the patient is having seizures.

VII. TREATMENT

Most of us ask: "Is there any treatment?" THERE IS!

Anyone with signs of moderate or severe TBI should receive medical attention as soon as possible. Because little can be done to reverse the initial brain damage caused by trauma, medical personnel try to stabilize an individual with TBI and focus on preventing further injury. Primary concerns include insuring proper oxygen supply to the brain and the rest of the body, maintaining adequate blood flow, and controlling blood pressure. Imaging tests help in determining the diagnosis and prognosis of a TBI patient. Patients with mild to moderate injuries may receive skull and neck X-rays to check for bone fractures or spinal instability. For moderate to severe cases, the imaging test is a computed tomography (CT) scan. Moderately to severely injured patients receive rehabilitation that involves individually tailored treatment programs in the areas of physical therapy, occupational therapy, speech/language therapy, physiatry (physical medicine), psychology/psychiatry, and social support.

Initial treatment of a Traumatic Brain Injury (TBI) begins upon arrival to a hospital. At the hospital, a team of medical professionals, generally led by the trauma surgeon, will meet the patient. The trauma surgeon, acting as the leader, will direct the team. The trauma staff will initiate resuscitation procedures, monitor the body's vital functions, respond to potential life-threatening changes and coordinate care with other hospital personnel.

The patient may need surgery for injuries. Severe Penetrating brain injuries, especially those with shrapnel in the brain, usually demand "brain surgery" or a craniotomy. [12] In addition to the trauma surgeon, the surgical staff could include the neurosurgeon, a physician who performs brain and spinal cord surgery; an orthopedic surgeon, a physician who works with broken bones such as fractures of the arms and legs or the spinal column; or a general surgeon.

While the physicians are assessing the patient and the response to treatment, the trauma nurse is caring for the patient: providing resuscitation, stabilization and supportive care. The nurses have the responsibility to coordinate and provide communication within the hospital and with the family.

[12] Craniotomy is a cut that opens the cranium. During this surgical procedure, a section of the skull, called a bone flap, is removed to access the brain underneath. The bone flap is usually replaced after the procedure with tiny plates and screws. A craniotomy may be small or large depending on the problem. It may be performed during surgery for foreign objects (bullets), swelling of the brain, or infection. Depending on the reason for the craniotomy, this surgery requires a hospital stay that ranges from a few days to a few weeks.

Once stabilized, the patient will be transferred to a specialized trauma care unit. Care will be provided by the critical care nursing staff. The nursing staff's responsibility is to assess, monitor and interpret vital physiologic or body functions, notify the physician of changes, repeat assessments at regular intervals and provide information for the family. The patient will be monitored for signs of infection and pain.

Other key staff also will play a role on the specialized trauma care unit. The respiratory therapist will help with the initial resuscitation efforts, will provide oxygen therapy, will configure the ventilator settings and will assure proper equipment functioning. In addition, the respiratory therapist will monitor the patient's breathing: looking at blood gas results and listening to the lungs.

In most trauma centers, a psychologist familiar with acute trauma will be part of the team. Using crisis intervention techniques, the psychologist will assist the patient and family in decision-making during a crisis. The psychologist will provide counseling and education about the injury, as well as assess the cognition of the patient.

A trauma social worker may also work with the family after the injury. Like the psychologist, the social worker will prepare the family emotionally and physically to face the ill or disabled patient. The trauma social worker will assist the family in making plans for the duration of recovery, especially if the recovery progresses slowly. The trauma social worker will encourage the family to consider role and responsibility changes while the patient is ill, including changes in finances and family support. The trauma social worker will also assist the family in discharge planning.

Acute Treatment

Acute treatment of a Traumatic Brain Injury (TBI) is aimed at minimizing secondary injury and life support.

Mechanical ventilation supports breathing and helps keep the pressure down in the head. A device may be placed surgically in the brain cavity to monitor and help control intracranial pressure and/or to drain excess cerebrospinal fluid (CSF). A discussion later in this handbook will discuss hydrocephalus. Medications to sedate and put the individual in a drug-induced coma may be used to minimize agitation and secondary injury. Seizure prevention medications may be given early in the course and later if the individual has seizures.

Medications to control spasticity may be used as the patient recovers function Behavioral issues also can be treated with medications. Medications for attention problems and aggressive behavior are often tried.

Surgical Treatment

Surgical treatment is often used for patients of Traumatic Brain Injury (TBI).

In closed head injury, surgery does not correct the problem. . If there was bleeding in the skull cavity, this may be surgically removed or drained. Bleeding vessels or tissue may need to be repaired. In severe cases, if there is extensive swelling and damaged brain tissue, a portion may be surgically removed to make room for the living brain tissue.

An open head injury confronts doctors with the same issues as a closed head injury; however, in addition, skull fractures may need to be repaired and damaged tissue removed.

Intracranial Pressure: Hydrocephalus and a "Shunt"

Intracranial pressure (the pressure within the brain) is detected through the use of monitoring devices. Doctors place a small bolt in the patient's skull to measure intracranial pressure (ICP). A catheter is attached to the bolt in the brain which connects to a gauge that registers the amount of pressure in the skull. This procedure is most commonly performed on patients with moderate or severe brain injury. It also can be determined by any physician by looking at the optic nerve inside the eye--it will be bulged-out if there is increased hydrocephalus. Most severe headaches for a TBI victim are caused by increased hydrocephalus, however **hydrocephalus is a very serious, potentially fatal, condition**.

Why this is because the **cerebrospinal fluid (CSF) is produced at a rate of 500 ml/day. Since the brain can only contain 150 ml** if the CSF is not drained, serious things can happen. Normally, large amounts of CSF are drained primarily into the blood...but if this flow is interrupted (stenosis) increased pressure ensues--this pressure has the potential of pressing the brain against the skull and thus destroying the brain tissue causing more damage.

Shunts:

So, in cases of severe hydrocephalus, sometimes a cerebral **"SHUNT"** is called for. This is one-way "drain" valve used to drain excess cerebrospinal fluid (CSF) from the brain and carry it to other parts of the body. This shunt valve usually sits outside the skull, but beneath the skin, somewhere behind the ear or down the back of the skull and around to drain into the chest cavity. The peritoneal cavity is now the most common distal site for shunt placement (ventriculoperitoneal shunt). It is a large cavity, more than capable of handling any amount of CSF delivered by the shunt in all but the most unusual cases. Most neurologists and neurosurgeons discuss the advantages and disadvantages of a shunt with the patient. Shunts have to be replaced often (more brain surgery). If, as in my case (I don't have a shunt), there is a blockage instead of just a stenosis, the patient has about 5 hours to live without Neurosurgery to relieve the pressure. **Needless to say, this (hydrocephalus) is a serious condition** that the patient and you as a mentor must be aware of.

In cases where a shunt is not immediately called for, the trauma care staff may also try to keep the pressure down by:

- Controlling body temperature (keeping the temperature low to normal)
- Elevating the head of the bed
- Using controlled narcotic sedation to cause paralysis, keeping the person still and comfortable
- Ensuring proper breathing
- Administering medication including Mannitol
- Hypertensive therapies

The overall goal of all surgical treatment is to prevent secondary injury by helping to maintain blood flow and oxygen to the brain and minimize swelling and pressure.

VIII. REHABILIATION

Most Moderate to Severe TBI patients go to a rehabilitation facility.

Rehabilitation Facility

The families of traumatic brain injury (TBI) victims often have many questions when their loved one is transferred to a rehabilitative care center. The *Defense Center of Excellence for Psychological Health & Traumatic Brain Injury* (DCoE) and the *Defense and Veterans Brain Injury Center* (DVBIC) is an invaluable asset in arranging this transfer. *(See the list of references at the end of this section)*

What happens in rehabilitation?

Similar to the acute care facility, the TBI patient will be cared for by a team of professionals who specialize in the care of trauma victims.

Their goals are to:

1. Stabilize the medical and rehabilitation issues related to brain injury and the other injuries.
2. Prevent secondary complications. Complications could include pressure sores, pneumonia and contractures.
3. Restore lost functional abilities. Functional changes could include limited ability to move, use the bathroom, talk, eat and think.
4. The staff will also provide adaptive devices or strategies to enhance functional independence.
5. The staff will begin to analyze with the family and the patient what changes might be required when the person goes home.

Each day, the patient will participate in therapy. Initially, the patient may require staff assistance for even the simplest activities: brushing teeth, getting out of bed and eating. The patient also may require staff for safety because there is a risk of falling, eloping (trying to get out of the hospital to go home) or getting hurt. The patient may be confused and forgetful.

The Rehabilitation Team

A **Neurophysiatrist** is the team leader in the rehabilitation program. The physiatrist is a physician specializing in physical medicine and rehabilitation. Physiatrists treat a wide range of problems, including the changes after brain injury. The physiatrist will assess and prescribe the treatment and direct the team.

The **Clinical Neuropsychologist** is a key member of the rehabilitation team. The neuropsychologist will assess the patient's changes in thinking and behavior. Changes could include:

- Poor memory
- Poor attention and concentration
- Poor decision-making
- Impulsivity
- Disorientation
- Language and communication abilities
- Inability to speak
- Inability to understand when spoken to

Many patients are unaware of the changes in the brain and how those changes affect their daily lives. A patient may not understand what has happened and may be distraught by being away from home. Through education and counseling, the neuropsychologist can help assure the patient and the patient's family.

The **Rehabilitation Nurse** assists patients with brain injury and chronic illness in attaining maximum optimal health, and adapting to an altered lifestyle. The Rehabilitation Nurse provides care for the patient on the nursing unit. The focus of nursing care is on:

- Health maintenance
- Nutrition
- Potential for aspiration
- Impaired skin integrity
- Bowel and bladder incontinence
- Impaired physical mobility
- Impaired or limited ability to take care of self
- Ineffective airway
- Sleep pattern disturbance
- Chronic pain

- Impaired cognition
- Impaired verbal communication and comprehension
- Sexual dysfunction

The **Physical Therapist** works with people with orthopedic problems, such as low back pain, knee injuries or pain reduction. With traumatic brain injury, the PT's job is to minimize or overcome paralyzing effects related to the brain injury. Physical therapists are experts in the examination and treatment of musculoskeletal and neuromuscular problems that affect the abilities to move and function in daily life.

Physical therapists help with transfers to and from the bed when a patient cannot walk alone. They train a person to begin to walk and move more normally. PTs will assess:

- Balance
- Posture
- Strength
- Need for a wheelchair, brace or cane
- Quality of movement
- Spontaneous movement
- Coordination of movement
- Increased sensation of sensory-motor activities
- Pain management

The **Occupational Therapist** assesses functions and potential complications related to the movement of upper extremities, daily living skills, cognition, vision and perception. OT's help determine, with the patient, the best ways to perform daily living skills including showering, dressing and personal hygiene. The OT will identify equipment for eating, dressing and bathing.

The OT also will look at skills to prepare the patient for a return to the home—to become self-reliant. **These skills include:**

1. **Cooking**
2. **Grocery shopping**
3. **Banking**
4. **Budgeting**
5. **Readiness for returning to work by assessing prevocational and vocational skills**

AND THE ACTIVITIES OF DAILY LIVING (see section 16 on ADL):

1. **Bathing**
2. **Continence**
3. **Dressing**

4. **Eating**
5. **Toileting**
6. **Transferring**

SUPPORTIVE CARE

The medical staff providing supportive care for the unconscious individual is highly trained and understands how to care for traumatic brain injury (TBI) patients.

TBI patients are monitored with equipment for breathing, heart rhythm, blood pressure, pulse and intracranial pressure.

Sometimes the unconscious individual cannot breathe without assistance. The airway is maintained and breathing occurs though special tubes that help maintain oxygen in the blood. It may be necessary to suction, as to remove thick secretions and keep the air tube clean.

The tube may be located in the mouth or in the neck. If it is in the neck, it is called a tracheotomy tube. Either tube will need to be cleaned daily. A pulse oximeter measures the amount of oxygen the patient is receiving through a device that resembles a finger splint.

After head trauma, seizures can occur. Dilantin is the usual medication administered through the IV to prevent seizures. A tetanus shot also may be given.

Fluid is administered through the IV for nutrition and liquid. The unconscious person cannot eat or drink safely. The need for nutritional support using parenteral (IV) or enteral solutions (a tube placed in the stomach) is determined by a registered dietician and the doctor.

A urinary catheter may be placed in the bladder for urine collection. If so, the individual is not aware of the need to use the bathroom. The catheter attaches to a bag hanging from the side of the bed.

It is important to maintain the unconscious patient's blood pressure through IV fluid and medication. Ideally, the blood pressure range should be close to 90/70.

The patient is turned and positioned in bed to prevent bedsores because most unconscious people cannot move independently.

The unconscious person may have a compression device wrapped around the legs that resembles a plastic tub mat. This device prevents blood clots. Daily injections are also given to prevent blood clots..

IX. RECOVERY

Recovery from a Traumatic Brain Injury (TBI) varies based on the individual and the brain injury. Attempts at predicting the degree of TBI recovery remain crude. Recovery can be seen months, and even years, after the initial injury. Devastating and fatal injuries can be easier to ascertain than other injuries.

Prognosis for Recovery: These are the indicators the medical team uses for prognosis:

- Duration of Coma. The shorter the coma, the better the prognosis.
- Post-traumatic amnesia. The shorter the amnesia, the better the prognosis.
- Age: Younger adult patients have a much better prognosis for recovery than older TBI patients. .

Recovery of brain function is thought to occur by several mechanisms. Some common theories:

- **Diaschisis.** Depressed areas of the brain that are not injured but linked to injured areas begin functioning again. The function is taken over by a part of the brain that does not usually perform that task.

- **Neuroplasticity/Neuralplasticity:** this is the brain's ability to reorganize itself by forming new neural connections throughout life. Neuroplasticity allows the neurons (nerve cells) in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment. Brain reorganization takes place by mechanisms such as "axonal sprouting" in which undamaged axons grow new nerve endings to reconnect neurons whose links were injured or severed. Undamaged axons can also sprout nerve endings and connect with other undamaged nerve cells, forming new neural pathways to accomplish a needed function. For example, if one hemisphere of the brain is damaged, the intact hemisphere may take over some of its functions. The brain compensates for damage in effect by reorganizing and forming new connections between intact neurons. In order to reconnect, the neurons need to be stimulated through activity.

- **Redundancy:** There is often a redundancy in the function performed so another area of the brain takes over.

- **Behavioral substitution**: The individual learns new strategies to compensate for deficits.

X. LONG-TERM OUTCOMES OF TBI

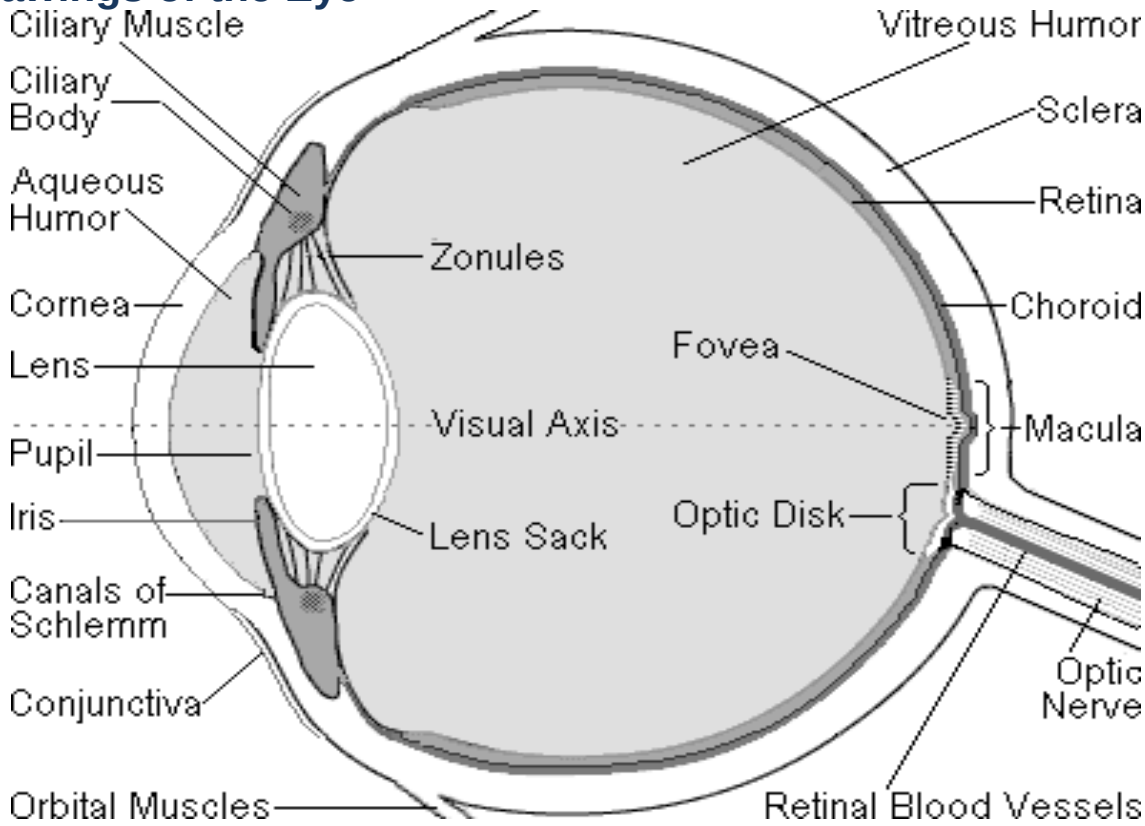
TBI can cause a wide range of functional changes affecting thinking, sensation, language, and/or emotions. It can also cause epilepsy and increase the risk for conditions such as Alzheimer's disease, Parkinson's disease, and other brain disorders that become more prevalent with age. That is to say that the outcomes of a TBI will probably get worse over the years.

- Thinking (i.e., memory and reasoning);
- Sensation (i.e., touch, taste, and smell);
- Language (i.e., communication, expression, and understanding); and
- Emotion (i.e., depression, anxiety, personality changes, aggression, acting out, and social inappropriateness).
- Headaches

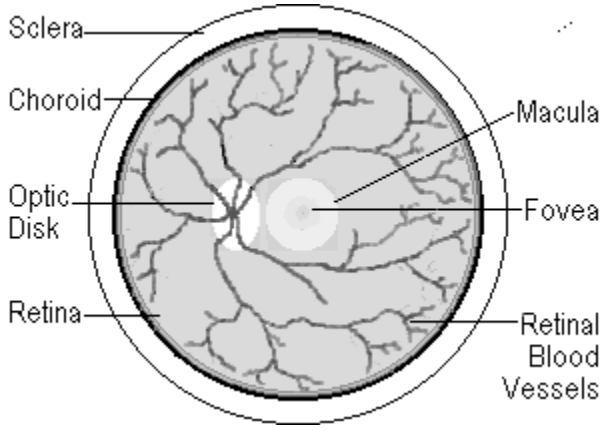
XI. VISION & BRAIN INJURY

The Eye: Information About Vision Loss And Blindness

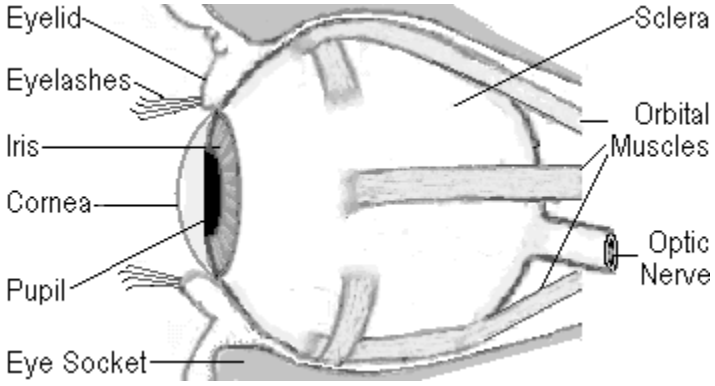
Drawings of the Eye



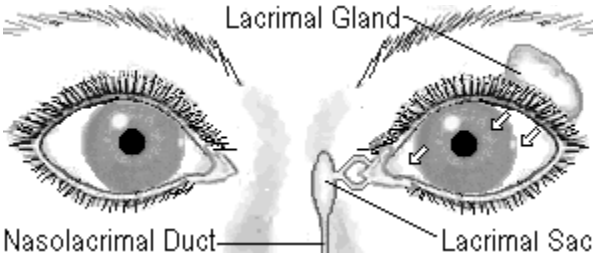
Cross section drawing of the eye - (side view) with major parts labeled.



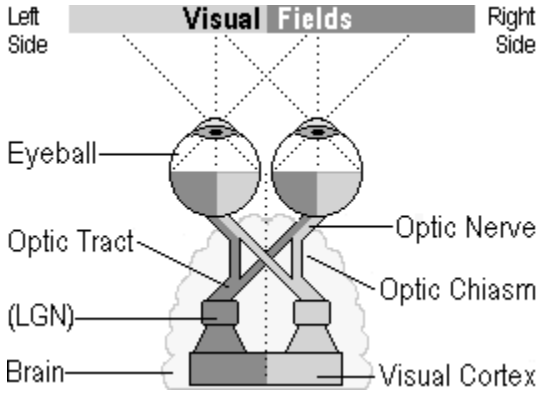
Cross section drawing of the eye - (rear view).



Cut-away view of the eye in its socket showing the: bony socket, orbital muscles, eyelids and eyelashes.



The lacrimal system - (tear ducts) produce tears to clean, moisten and lubricate the eyes and then drains the excess fluid into the nose.



Our Eyes and brain divide what we see into a right and left half. In the drawing above, light gray represents the left half; dark gray represents the right half. The eyes invert the image and the left side of what we see ends up in the right side of our brain and visa versa. This all works out because the right side of our brain controls the left side of our bodies and visa versa.

- **Anterior Chamber**

The space between the cornea and iris filled with Aqueous Humor.

- **Aqueous Humor**

A water like fluid, produced by the ciliary body, it fills the front of the eye between the lens and cornea and provides the cornea and lens with oxygen and nutrients. It drains back into the blood stream through the canals of schlemm.

• Brain Injury & Vision—a short discussion:

The brain is where the electrical signals sent from our eyes are processed into vision. Damage to the brain can lead to vision loss if the visual cortex or optic pathways are damaged. The majority of nerve fibers in the optic tract connect to the LGN. Several nerve fibers leave the optic tract before the LGN to connect to sub cortical structures throughout the brain. These parts of the brain regulate things like: eye and head movements, pupillary light reflex - (pupil size), and circadian rhythms - (light/dark cycle). Damage to these parts of the brain often leads to vision disorders too.

Visual disturbances. **Difficulty processing visual information can occur in some cases. One rare disorder is called cortical blindness, in which the area of the brain responsible for vision becomes disconnected from the rest of the brain. Because the brain cannot**

tell that this part is damaged, people may appear to act as though they can see even though they display no ability to identify or recognize objects, shapes or colors.

Hemianopic Field Loss--**A two fold approach is used to treat visual field loss. Visual rehabilitation activities are prescribed by the doctor and administered by the therapist to teach scanning of the hemianopic field loss. This is a difficult task. It is the act of seeing something that brings our visual attention and scanning to bear. However, these patients do not see to the field they are being trained to scan and attend. Therapy is aimed at teaching that and several approaches have been developed to assist in this, but remediation still requires a lot of effort and patience.**

Special visual field awareness prism lenses are used in treating visual field loss. As the patient scans into the prism the optics are shifted so as to perceptually gain about 15 to 20 degrees of visual field recognition. Since diplopia is perceived when scanning into the prism, fixation in the prism must be brief. These are used as spotting devices only to determine if there is an object in the periphery that deserves further visual attention. When such an object is spotted, the patient turns their head to view it in detail with their intact central vision.

VISION IS OUR DOMINANT SENSE

More than just sight is measured in terms of visual acuity; vision is the process of deriving meaning from what is seen. It is a complex, learned and developed set of functions that involve a multitude of skills. Research estimates that eighty to eighty five percent of our perception, learning, cognition and activities are mediated through vision.

The ultimate purpose of the visual process is to arrive at an appropriate motor, and/or cognitive response.

There is an extremely high incidence (greater than 50%) of visual and visual-cognitive disorders in neurologically impaired patients (traumatic brain injury, cerebral vascular accidents, multiple sclerosis etc.) Rosalind Gianutsos, Ph.D.

"Visual-perceptual dysfunction is one of the most common devastating

residual impairments of head injury". Barbara Zoltan, M.A., O.T.R. "The majority of individuals that recover from a traumatic brain injury will have binocular function difficulties in the form of strabismus, phoria, oculomotor dysfunction, convergence and accommodative abnormalities". William Padula, O.D.

The process of vision can be broken down into three general categories; 1) visual acuity and visual field, 2) visual motor abilities and 3) visual perception.

VISUAL ACUITY and VISUAL FIELD

Visual Acuity - This refers to clarity of sight. It is commonly measured using the Snellen chart and noted, for example, as 20/20, 20/50, 20/200 etc. Visual acuity becomes blurred in various refractive conditions, for example, **myopia** (nearsighted), **hyperopia** (far-sighted), **astigmatism** (mixed), and **presbyopia** (age related loss of focusing).

Visual Field - This is the complete central and peripheral range, or paNORAma of vision. Various neurologic conditions, such as stroke, cause characteristic losses of the visual field, for example hemianopsia. The person may, or may not, concurrently demonstrate a visual neglect which is a perceptual loss of vision and visual motor integration to the side of the visual field loss.

THREE OF THE MOST DEVASTATING AND INTOLERABLE VISUAL PROBLEMS RESULTING FROM BRAIN INJURY

Although there are many visual problems that arise from brain injury and stroke, three are more devastating and impairing than the rest. These are visual field loss, intractable double vision, and visual / balance disorders.

1. Visual Field Loss

With a visual field loss the patient is literally blind to half of their field of vision. This places the person at increased risk of further injury and harm

from bumping into objects, being struck by approaching objects, and falls.

Hemianopic Field Loss
A two fold approach is used to treat visual field loss. Visual rehabilitation activities are prescribed by the doctor and administered by the therapist to teach scanning of the **hemianopic field loss**. This is a difficult task. It is the act of seeing something that brings our visual attention and scanning to bear. However, these patients do not see to the field they are being trained to scan and attend. Therapy is aimed at teaching that and several approaches have been developed to assist in this, but remediation still requires a lot of effort and patience.

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2. Double Vision (Diplopia)

Double vision (diplopia) is a serious and intolerable condition that can be caused by strabismus, ophthalmoplegia, gaze palsy, and decompensated binocular skills in patients with brain injury, stroke and other neurologically compromising conditions. Prisms, lenses and / or vision therapy can oftentimes help the patient achieve fusion (alignment of the eyes) and alleviate the diplopia. If and when these means are not employed, the patient may adapt by suppressing the vision of one eye to eliminate the diplopia. If lenses, prisms, and / or therapy are not successful and the patient does not suppress, intractable diplopia ensues.

In this population of patients, patching has frequently been used to eliminate the diplopia. Although patching is effective in eliminating diplopia it causes the patient to become monocular. Monocular as opposed to binocular vision will affect the individual primarily in two ways; absence of stereopsis and reduction of the peripheral field of vision. These limitations

will directly cause problems in eye hand coordination, depth judgments, orientation, balance, mobility, and activities of daily living such as playing sports, driving, climbing stairs, crossing the street, threading a needle etc.

A new method of treating diplopia that does not have these limitations has been successfully evaluated. It is called the "spot patch" (invented and named by this author) and is a method to eliminate intractable diplopia without compromising peripheral vision. It is a small, usually round or oval, patch made of dermacil tape, 3-M blurring film (or another such translucent tape). It is placed on the inside of the lenses of glasses and directly in the line of sight contributing to the diplopia. The diameter is generally about one centimeter, but will vary on the individual angular subtense required for the particular strabismus, or gaze palsy.

3. Visual Balance Disorders

Visual balance disorders can be caused by a Visual Midline Shift Syndrome (VMSS), oculo-motor dysfunction in fixations, nystagmus, and disruptions of central and peripheral visual processing. A full description of these disorders is beyond the scope of this paper. The treatment will depend on the visual diagnosis and etiology. Lenses, prisms and visual rehabilitation activities are used in the remediation of these disorders

- **Canals of Schlemm**

These canals are located around the perimeter of the iris. They allow aqueous fluid to drain back into the blood stream. The Trabecular Meshwork along with the Canals of Schlemm regulate the eyes internal pressure. In the eye disease called glaucoma, these canals become blocked leading to increased pressure. The increased pressure, from this condition, destroys the optic nerve.

- **Choroid**

The choroid is a layer of blood vessels between the retina and sclera; it supplies blood to the retina. In the disease called Macular Degeneration, abnormal blood vessels grow into the space between the retina and choroid damaging the macula.

- **Ciliary Body**

This is where the Aqueous Humor is produced.

- **Ciliary Muscle**

The eye can bring the fine print in a phone book into focus, or focus in on the moon over ¼ million miles away. The ciliary muscle changes the shape of the lens - (this is called accommodation). It relaxes to flatten the lens for distance vision; for close work it contracts rounding out the lens. Everyone will develop an eye condition called presbyopia. As we age, the ciliary muscle and crystalline lens lose their elasticity. This is why most people need reading glasses by their 40's.

- **Conjunctiva**

The conjunctiva is a thin, clear membrane covering the front of the eye and inner eyelids. Cells in this lining produce mucous that helps to lubricate the eye. This is the eyes first layer of protection against infection. Inflammation of this membrane is called conjunctivitis, or pink eye.

- **Cornea**

The cornea is a clear, dome-shaped surface that covers the front of the eye. It is the first and most powerful lens in the eye's optical system. To keep it transparent the cornea contains no blood vessels. Tears that flow over it and aqueous humor in the chamber behind it keep it nourished. When you hear of eye banks and eye transplants, it is the cornea that is being replaced. The cornea can be damaged from: accidents, infections, and genetic defects.

- **Crystalline Lens**

The eye's crystalline lens works like the adjustable lens in a camera. Positioned just behind the cornea; it is responsible for keeping images in focus on the retina. It is adjustable for distance and close work. A cataract is the lens clouding up. This happens to most people as they age. A few people are even born with cataracts. Modern surgery has all but eliminated cataracts as a cause of blindness in the developed world.

- **Eyeball**

The eye is like a little video camera measuring about 1 inch or 2.5 cm. in diameter. If someone's eyeball is larger then this, they will be nearsighted (myopic); if it is smaller then this, they will be farsighted (hyperopic). Having two eyes gives us binocular vision - (depth perception). This is due to the fusing of both images in the visual cortex.
Eyelashes and Eyebrows

These specialized hairs protect the eyes from particles that may injure them. They form a screen to keep dust and insects out. Anything touching them triggers the eyelids to blink.

- **Eyelids**

Our eyelids protect and lubricate our eyes. Small oil-producing glands line the inner edge of our eyelids. These oils mix with tears when we blink, keeping the eye moist and clean.

- **Eye Socket**

The orbit or eye socket is a cone-shaped bony cavity that protects the eye. The socket is padded with fatty tissue that allows the eye to move easily.

- **Fovea - (small pit)**

The fovea is an indentation in the center of the macula. Its diameter is only 1.5 mm or about 1/16 inch. This small part of our retina is responsible for our highest visual acuity. It is the center of our central vision.

- **Lacrimal Gland - (Tear Duct)**

This gland continually releases tears and other protective fluids onto the surface of the eye. It lubricates and keeps the cornea from becoming dehydrated.

- **Lacrimal Sac**

The lacrimal sac is a tiny pump that drains tears and other debris from the eye. The fluids flow down the nasolacrimal duct into the nose where they help keep the nasal linings moist. This is why your nose runs when you cry.

- **Lateral Geniculate Nucleus - (LGN)**

This part of the brain acts as a relay station; it decodes visual information from the optic tract before sending it to the visual cortex for final processing.

- **Lens Sack or Capsule**

During modern cataract surgery the outer membrane of the lens is left in place. The artificial intraocular lens is placed in this sack.

- **Iris**

This is the colored part of the eye: brown, green, blue, etc. It is a ring of muscle fibers located behind the cornea and in front of the lens. It contracts and expands, opening and closing the pupil, in response to the brightness of surrounding light. Just as the

aperture in a camera protects the film from over exposure, the iris of the eye helps protect the sensitive retina.

- **Macula - (yellow spot)**

This part of the retina is the most sensitive. Its diameter is only 7 mm or about 1/4 inch. It is responsible for our central, or reading vision. This part of the retina gives us 20/20 vision. Without the macula, you would be blind - Legally Blind that is. People with eye diseases like Macular Degeneration have vision from 20/200 to 20/800.

- **Optic Chiasm**

This is the first part of the brain to receive visual input. Each eye takes a slightly different picture of the world. At the optic chiasm each picture is divided in half. The outer left and right halves continue back toward the visual cortex. The inner left and right halves cross over to the other side of the brain then continue back toward the visual cortex. See Drawing of optic pathways.

- **Optic Disk**

The optic disk is the spot on the retina where the optic nerve leaves the eye. There are no sensory cells here, creating a blind spot. Each eye covers for the blind spot of the other eye and the brain fills in the missing information.

- **Optic Nerve**

Each optic nerve has about 1.2 million nerve fibers. This is the cable connecting the eye to the brain.

- **Optic Tract**

The nerves that connect the optic chiasm to the LGN are called the optic tract. If one of these tracts is damaged, vision will be lost in one side of each eye.

- **Orbital Muscles**

Six muscles are in charge of eye movement. Four of these move the eye up, down, left and right. The other two control the twisting motion of the eye when we tilt our head. Defects in these muscles and the nerves that control them lead to conditions like Nystagmus and Amblyopia (Lazy Eye).

- **Photoreceptor Cells**

The retina is composed of two types of photoreceptor cells. When light falls on one of these cells, it causes a chemical reaction that sends an electrical signal to the brain.

Cone cells give us our detailed color daytime vision. There are 6 million of them in each human eye. Most of them are located in the central retina - macula fovea area. There are three types of cone cells: one sensitive to red light, another to green light, and the third sensitive to blue light.

Rod cells are about 500 times more sensitive to light then cone cells; they give us our dim light or night vision. They are also more sensitive to motion then cone cells. There are 120 million rod cells in the human eye. Most rod cells are located in our peripheral or side vision.

- **Posterior Chamber**

The space between the iris and the front of the lens filled with Aqueous Humor.

- **Pupil**

The pupil is the hole in the center of the iris that light passes through. The iris muscles control its size. **Mydriasis** is the dilation of the pupil, usually having a non-physiological cause, or sometimes a physiological pupillary response. Non-physiological causes of mydriasis include disease, trauma, or the use of drugs.

> **Dilation of the pupil is abnormal and may signal a brain injury or other condition that raises the pressure within the cranial cavity (increased intracranial pressure)**

Normally, as part of the pupillary light reflex, the pupil dilates in the dark and constricts in the light to respectively improve vividity (clearness) at night and to protect the retina from sunlight damage during the day. A mydriatic pupil will remain excessively large even in a bright environment. **The excitation of the radial fibres of the iris which increases the pupillary aperture is referred to as a mydriasis**. More generally, mydriasis also refers to the natural dilation of pupils, for instance in low light conditions or under sympathetic stimulation. Fixed, **unilateral mydriasis could be a symptom of raised intracranial pressure**. The opposite, constriction of the pupil, is referred to as ***miosis***. Both mydriasis and miosis can be physiological. ***Anisocoria*** is the condition of one pupil being more dilated than the other. Dilation of the pupil on one side only is also abnormal and may signal a brain injury or other condition that raises the pressure within the cranial cavity (increased intracranial pressure). Some causes of dilated pupils (mydriasis): Cerebral Edema *(Edema is swelling caused by excess fluid trapped in your body's tissues: Signs of edema include);* Drug Overdoses; **Elevated Intracranial**

Pressure; Elevated Intraocular Pressure; **Intracranial Hemorrhage;** Low Ambient Light; Medications; Poisonings; Sexual Arousal; Skull Fracture; **Trauma.**

- **Retina**

The retina is the film of the eye. It converts light rays into electrical signals and sends them to the brain through the optic nerve. The sides of the retina are responsible for our peripheral vision. The center area, called the macula, is used for our fine central vision and color vision. The retina is where most the problems leading to vision loss Occur. Three of the leading causes of blindness, from retina damage, are Retinitis Pigmentosa, Macular Degeneration and Diabetic Retinopathy.

- **Retinal Blood Vessels**

A doctor can see the blood vessels that supply the retina when he looks into your eyes. These vessels are in the choroid just beneath the retina. Abnormal blood vessel growth and leaking blood vessels are the cause of vision loss in eye conditions like, Diabetic Retinopathy, ROP, and Macular Degeneration.

- **Retinal Pigment Epithelium - (RPE)**

The RPE is a layer of cells between the retina and choroid. The inside of a camera is panted black to absorb scattered and reflected light. The black pigment known as melanin in the RPE dose the same job for the eye. The RPE gets rid of waste products produced by the photoreceptor cells. As we age, the RPE can sometimes lose its ability to process this waste. Deposits of this waste, called drusen, can distort and damage the retina leading to an eye condition called dry macular degeneration.

- **Sclera**

The sclera is the white, tough wall of the eye. It along with internal fluid pressure keeps the eyes shape and protects its delicate internal parts.

- **Uvea**

The uvea is the middle Vascular layer of the eye. It is made up of three parts: the iris, ciliary body and chorid. Uveitis is the inflammation (or swelling) of these parts of the eye.

- **Visual Axis**

The Visual Axis is an imaginary line drawn through the center of the pupil to the center of the Fovea. The orbital muscles keep the visual axis of both eyes aligned on the center of what you are looking at (fixation point). An eye condition called Strabismus - (misaligned eyes) results when the orbital muscles fail to keep the eyes in alignment. Any damage to eye structures along this axis leads to severe vision loss.

- **Visual Cortex**

The part of the brain that processes and combines visual information from both eyes and converts it into sight. Damage to the visual cortex results in a condition called cortical blindness.

- **Visual Fields**

The retina of each eye has two sections the nasal retina - (nose side) and temporal retina - (ear side). For example: with your right eye, you see the right half of the world with your nasal retina; you see the left half of the world with your temporal retina. The picture your eye takes is flipped left for right and upside down; it's up to the brain to sort things out.

- **Vitreous Cavity**

The space between the lens and retina filled with the gel like Vitreous Humor.

- **Vitreous Humor**

The vitreous humor is a jelly like liquid that fills most of the eye (from the lens back). As we age it changes from a gel to a liquid and gradually shrinks separating from the retina. This is when people start seeing floaters, dark specs in their vision. This is a normal sign of aging, but in a few cases the retina can become detached as the vitreous separates.

- **Zonules**

Zonules are hundreds of string like fibers that hold the lens suspended in position and enable it to change shape for near or distant vision.

XII. COPING WITH TBI: Information available for the TBI patient/survivor and their families:

REFERENCE SITES/MATERIALS/WEB SITES:

1. Defense Centers of Excellence: For Psychological Health & Traumatic Brain Injury (DCoE)

http://www.dcoe.health.mil/

The ***DCoE*** provides the Military Health System with current and emerging psychological health and traumatic brain injury clinical and educational information. DCoE identifies gaps and prioritize needs in psychological health and TBI research, and then translate that research into clinical practice to improve patient outcomes. DCoE is a division of the **Defense Health Agency** (link is external) (DHA) Operations directorate. DHA is a joint, integrated combat support agency that supports the Military Health System (link is external).

DCoE is located at/in Building 51 on NSA Bethesda Base (WRNMMC) grounds in Bethesda, Maryland. The center serves members, leaders, veterans and healthcare providers of all the uniformed services as well as their families. DCoE promotes resilience, recovery and reintegration of service members facing psychological health and traumatic brain injury issues, and works to advance research, education, diagnosis and treatment of these conditions. The DCoE conducts comprehensive psychological health (PH) and traumatic brain injury (TBI) assessments.

The DCoE is designed to accept on referral those military members whom the services struggle to help, those whose injuries are so elusive to not be detected, or that are unresponsive to treatment developed at base hospitals, which are lacking in proper equipment, staffing and expertise. It will focus exclusively on traumatic brain injury (TBI), post-traumatic stress disorder (PTSD) and other psychological health issues. It is designed for the treatment for service members and veterans diagnosed with traumatic brain injury (TBI) and psychological health problems.

DCoE has three subsets: **1)** ***Psychological Health Center of Excellence***: PHCoE works to improve psychological health and deployment-related health care for our nation's warriors and their families; **2)** ***National Center for Telehealth and Technology***: T2 develops telehealth and technology solutions for psychological health and traumatic brain injury to improve the lives of our nation's warriors and their families; **3)** ***Defense and Veterans Brain Injury Center***: DVBIC serves military and family members with traumatic brain injuries through state-of-the-art clinical care, research, and education

The mission of the Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury (DCoE) is to improve the lives of our nation's service members, veterans and their families by advancing excellence in psychological health and traumatic brain injury prevention and care.

More information is available at **http://www.dcoe.health.mil**.

1.a *Defense and Veterans Brain Injury Center* (DVBIC):

http://dvbic.dcoe.mil/

The ***Defense and Veterans Brain Injury Center (DVBIC)*** is a part of the U.S. Military Health System(link is external). Specifically, DVBIC is the traumatic brain injury (TBI) operational component of the **Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury (DCoE)**(*link is external*) and, as such, is also a subset of the **DEFENSE HEALTH AGENCY**. Founded in 1992 by Congress, DVBIC's responsibilities have grown as its network of care and treatment sites has grown

DVBIC's mission is to serve active-duty military, their beneficiaries, and veterans with traumatic brain injury through state-of-the-science clinical care, innovative clinical research initiatives and educational programs, and support for force health protection services. DVBIC fulfills this mission through ongoing collaboration with the Department of Defense (DoD), military services, Department of Veterans Affairs (VA), civilian health partners, local communities, families and individuals with TBI.

DVBIC works at the macro-level, screening and briefing troops heading into theater, performing pre-deployment provider training at military treatment facilities, gathering data mandated by Congress and DoD, and overseeing research programs. At the micro-level, DVBIC treats service members and veterans with mild, moderate or severe TBI, and helps them from the moment of injury to their return to duty or reintegration into the community. DVBIC develops, provides and distributes educational materials for both military and civilian providers, families, service members and veterans.

2. National Intrepid Center of Excellence (NICoE) for Traumatic Brain Injury and Psychological Health at *Walter Reed National Military Medical Center* Bethesda

http://www.wrnmmc.capmed.mil/NICoE/SitePages/index.aspx

NICoE Healthcare Services

The NICoE's interdisciplinary care model pulls from the best of western and alternative medicine to offer patients a variety of treatment options for traumatic brain injury (TBI) and psychological health (PH) conditions. NICoE provides Unique Care Plans for Each Patient. The care plans developed at the NICoE are made up of a combination of treatments to suit the clinical needs and preferences of each patient. Care plans consider all aspects of a patient's diagnosis and are unique to every patient.
Each patient's team of providers stays in regular contact with each other to discuss and evaluate treatment options and make sure patients have the opportunity to try different types of treatment as needed.

NICoE Outpatient Services

NICoE Outpatient Services provide diagnostic evaluations, treatments, diagnoses, and follow-up care for traumatic brain injury (TBI) of all severities. Patients work with providers and case managers to get personalized outpatient rehabilitation services, symptom management, and treatment plans. Rehabilitation team providers meet regularly to discuss and monitor patients' progress and to make sure patients receive the care that meets their unique needs and goals. Treatment continues on a case-by-case basis to help patients return to their highest level of functioning for as long as providers recommend to support healing and recovery.

NICoE Evaluation Track

Since its inception, the NICoE has reviewed a number of patient cases where the full four-week Intensive Outpatient Program (IOP) wasn't necessary but where a plan of care beyond a traditional, same-day outpatient service was needed. The need for an evaluation-only type program, and not an evaluation and treatment program, was the driving force for development and piloting the NICoE Evaluation Track (NET).

Designed as a one-week program, the NET is being evaluated as an alternative to the IOP for its potential to clarify TBI diagnosis and identify treatment recommendations to patients and home station referring providers. The NET pilot program was launched with a small cohort of patients in December 2014 to gather initial data. Information from this cohort was used to refine the program, and the next phase of the NET was launched in late 2015. Continuing evaluation of the NET may allow the NICoE to address a critical need for patients who require a thorough TBI evaluation, or perhaps a re-evaluation, of their TBI condition.

NICoE Treatment Programs and Services

- **Intensive Outpatient Program (IOP):** The Intensive Outpatient Program is a four-week program for patients coping with both TBI and PH conditions. During the program, providers will work together with patients and their families to create a tailored treatment plan that focuses on the mind, body and spirit. Patients play an active role in creating a plan of action to increase resilience and well-being, learning the skills they need to self-manage their symptoms in the long-term. Weeks One and Two: Clinical Evaluation. Weeks Three and Four: Treatment Planning and Family Support, Now and Beyond. This program is open to active-duty service members with

TBI (mild to moderate) and PH conditions who have not responded to traditional treatment.

- **NICoE Evaluation Track:** This one-week evaluation program began in October 2015 as an additional diagnostic option for patients. Patients in this program will leave with a clear diagnosis of their condition along with treatment recommendations from a team of providers.

- **TBI Service:** The TBI Service is an outpatient clinic which provides individualized assessment and treatment services in an interdisciplinary team approach. Patients receive personalized treatment as needed to help them heal and recover from TBI of any severity.

- **Brain Fitness Center:** The Brain Fitness Center gives NICoE patients the opportunity to use computer-based training tools to enhance the rehabilitation process. Brain fitness programs can train multiple cognitive domains or specific areas such as attention, memory and decision making.

3. The Caregiver's Journey from DVBIC: Traumatic Brain Injury: *A Guide for Caregivers of Service Members and Veterans*:

The Caregiver's Journey is designed to help those who provide care for patients with TBI. Family members, friends, and other caregivers will find information about how to care and advocate for their injured loved one, along with tips on how to take care of themselves in the process. Information about benefits and other resources is also provided. Take your time and explore the menus in each section, or use the search function to look for something specific. **An electronic version of this Guide can be found and downloaded at www.traumaticbraininjuryatoz.org *NOTE: This guide is currently being rewritten/updated.***

Caregiver Guides

This guide, on which this web program is based, contains the complete four module curriculum developed by the TBI Family Caregiver Advisory Panel. A Caregiver's Companion, with frequently used tools, is also included. These guides can be printed or downloaded to help caregivers of TBI patients navigate their journey. Caregiver's Guides – Modules 2, 3, and 4 contain live links to web resources related specifically to care giving. View the Caregiver Guides now.

Resource Center

The Resource Center is a location where you can find helpful information and links such as Journal Templates, Frequently Asked Questions and Glossary.

Caregiver Journeys

In this inspiring section, TBI patients and their caregivers discuss their experiences and challenges as they share their Caregiver Journeys.

4. TBI treatment and recovery: Interactive Brain Program:
http://www.traumaticbraininjuryatoz.org/Home.aspx

5. The Journey Home - the CEMM Traumatic Brain Injury (TBI) Web Site. **This site provides an informative and sensitive exploration of Traumatic Brain Injury (TBI), including information for patients, family members, and caregivers**. Topics include types and symptoms of brain injury, TBI treatment and recovery, and helpful insights about the potential long-term effects of brain injury. Animation is used to help patients clearly understand the brain, and the results of injuries to different parts of the brain. Survivors and their caregivers share courageous stories about their own experiences, providing down-to-earth facts along with inspiration and hope. Animation is used to help patients clearly understand the brain, and the results of injuries to different parts of the brain. Survivors and their caregivers share courageous stories about their own experiences, providing down-to-earth facts along with inspiration and hope. Watch the Traumatic Brain Injury introduction video. **http://www.traumaticbraininjuryatoz.org/**

6. Brain Injury Association of America (BIAA) **http://www.biausa.org/**
BIAA is proud to announce that the 2009 National Directory of Brain Injury Services is available as an on-line searchable database at www.biausa.org. Consumers looking for rehabilitation programs, professional services or local resources are able to find services 24 hours a day, 365 days a year, from the comfort of their home, office or even from the hospital while they are visiting their loved one with brain injury. This comprehensive database offers fast searches to locate the right programs and professionals across the country - from injury and acute care, to rehabilitation and community services. Users can search for information by organization name, contact name, professional service provided, age group served, program types, accreditations and service specialties in the following areas:

- **State affiliates**: BIAA has chartered state affiliates that provide a wealth of information on brain injury, support for persons with brain injury and their families, education and training opportunities and much more.

- **Support groups**: Support groups that are affiliated with BIAA state affiliates and can be contacted for details about meeting locations, times and dates.

- **State** resources: This section includes a wide range of state agencies that offer information and services to persons with brain injury and their families. In most cases, the agencies serve persons with many different types of disabling conditions.

- **Professional services:** Search for professionals by their area of expertise, such as case managers, neuropsychologists, cognitive therapists, attorneys and many more.

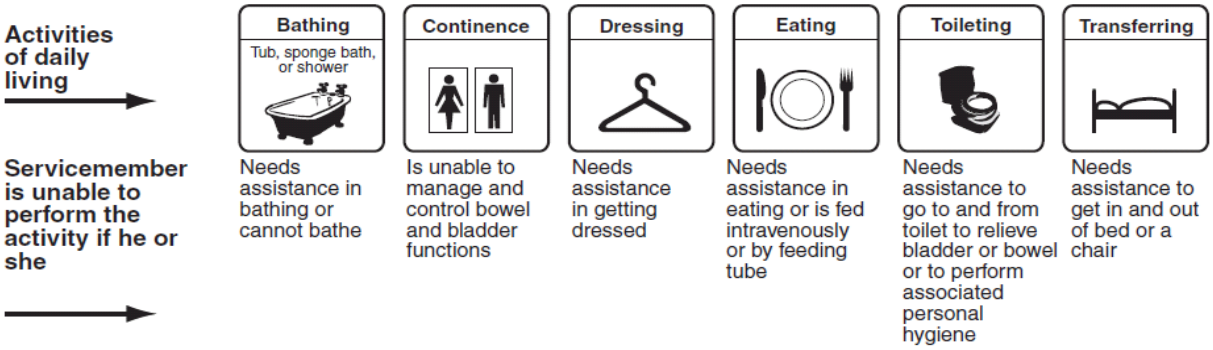
- **Facility and program providers**: This section includes information about medical, rehabilitation and community-based services for persons with brain injury. Many listings are enhanced with logos and hyperlinks to program/facility Websites for even more functionality

7. **Brain Injury Resource Foundation (BIRF):** Mission of the Brain Injury Resource Foundation is to provide education, advocacy and support for persons affected by brain injury

8. **Brainline.org**: is a national multimedia project offering information and resources about preventing, treating, and living with TBI. BrainLine.org is a service of WETA, the public TV and radio station in Washington, DC and is funded by the Defense and Veterans Brain Injury Center through a contract with the Henry M. Jackson Foundation and Veterans Brain Injury Center through a contract with the Henry M. Jackson Foundation

9. ACTIVITIES OF DAILY LIVING

- **Bathing**
- **Continence**
- **Dressing**
- **Eating**
- **Toileting**
- **Transferring**



For ADL Loss, you must be unable to independently perform two or more of the six ADLs--this is the loss that is most difficult to adjudicate due to the supporting documentation and time constraints

Claim must demonstrate:

- Type of ADL loss (must show at least 2)
- Duration ("WHEN")of each ADL loss
- How the Soldier requires assistance
    1. Physical assistance: *Hands-on*
    2. Stand-by assistance: *Within arm's reach*
    3. Verbal assistance: *Must be instructed because of cognitive impairment*

***If a service member is able to use adaptive behavior or equipment to perform ADLs, the service member is considered capable of independently performing their ADLs (this <u>does not include</u> bedpans, colostomy bags and catheters unless the Soldier is able to care for them himself)"**

10. TBI SCREENING TOOL[13]:

3 Question DVBIC TBI Screening Tool Instruction Sheet

Purpose and Use of the DVBIC 3 Question TBI Screen

The purpose of this screen is to identify service members who may need further evaluation for mild traumatic brain injury (MTBI).

Tool Development

The 3 Question DVBIC TBI Screening Tool, also called The Brief Traumatic Brain Injury Screen (BTBIS), was validated in a small, initial study conducted with active duty service members who served in Iraq/Afghanistan between January 2004 and January 2005.

Schwab, K. A., Baker, G., Ivins, B., Sluss-Tiller, M., Lux, W., & Warden, D. (2006). The Brief Traumatic Brain Injury Screen (BTBIS): Investigating the validity of a self-report instrument for detecting

[13] Defense and Veterans Brain Injury Center (http://www.dvbic.org/); Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury (http://www.dcoe.health.mil/)

traumatic brain injury (TBI) in troops returning from deployment in Afghanistan and Iraq. Neurology, 66(5)(Supp. 2), A235.

Who to Screen

Screen should be used with service members who were injured during combat operations, training missions or other activities.

Screening Instructions

Question 1: A checked **[√]** response to any item A through F verifies injury.
Question 2: A checked **[√]** response to A-E meets criteria for a positive (+) screen. Further interview is indicated. A positive response to F or G does not indicate a positive screen, but should be further evaluated in a clinical interview.
Question 3: Endorsement of any item A-H verifies current symptoms which may be related to an MTBI if the screening and interview process determines a MTBI occurred.

Significance of Positive Screen

A service member who endorses an injury [Question 1], as well as an alteration of consciousness [Question 2 A-E], should be further evaluated via clinical interview because he/she is more highly suspect for having sustained an MTBI or concussion. The MTBI screen alone does not provide diagnosis of MTBI. A clinical interview is required.
For more information contact: Telephone: 1-800-870-9244 Email: info@DVBIC.org Web: www.DVBIC.org

➔ 3 Question DVBIC TBI Screening Tool

1. Did you have any injury(ies) during your deployment from any of the following? (check all that apply):

A. □ Fragment
B. □ Bullet
C. □ Vehicular (any type of vehicle, including airplane)
D. □ Fall
E. □ Blast (Improvised Explosive Device, RPG, Land mine, Grenade, etc.)
F. □ Other specify: _____

2. Did any injury received while you were deployed result in any of the following? (check all that apply):

. □ Being dazed, confused or “seeing stars”
B. □ Not remembering the injury
C. □ Losing consciousness (knocked out) for less than a minute
D. □ Losing consciousness for 1-20 minutes
E. □ Losing consciousness for longer than 20 minutes
F. □ Having any symptoms of concussion afterward (such as headache, dizziness, irritability, etc.)
G. □ Head Injury
H. □ None of the above

3. Are you currently experiencing any of the following problems that you think might be related to a possible head injury or concussion? (check all that apply):

A. □ Headaches
B. □ Dizziness

C. □Memory problems
D. □ Balance problems
E. □ Ringing in the ears
F. □ Irritability
G. □ Sleep problems
H. □ Other specify:_____

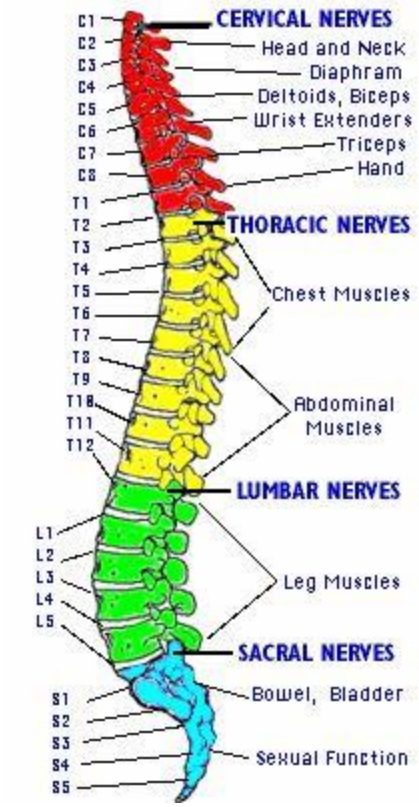
Schwab, K. A., Baker, G., Ivins, B., Sluss-Tiller, M., Lux, W., & Warden, D. (2006). The Brief Traumatic Brain Injury Screen (BTBIS): Investigating the validity of a self-report instrument for detecting traumatic brain injury (TBI) in troops returning from deployment in Afghanistan and Iraq. *Neurology, 66*(5)(Supp. 2), A235.

NOTE: Confirm F and G through clinical interview
NOTE: Endorsement of A-E meets criteria for positive TBI Screen
For more information contact: Telephone: 1-800-870-9244 Email: info@DVBIC.org Web: www.DVBIC.org

11. SPINAL CORD INJURIES: AN OVERVIEW

FOR INFORMATION: Spinal Cord Injuries: Injuries / Prognosis

The types of disability associated with SCI vary greatly depending on the severity of the injury, the segment of the spinal cord at which the injury occurs, and which nerve fibers are damaged. Most people with SCI regain some functions between a week and 6 months after injury, but the likelihood of spontaneous recovery diminishes after 6 months. Rehabilitation strategies can minimize long-term disability



The level of injury is very helpful in predicting what parts of the body might be affected by paralysis and loss of function. Remember that in incomplete injuries there will be some variation in these prognoses.

Neck: Cervical (neck) injuries usually result in quadriplegia.

C-1 to C-4: These very high injuries (C-1, C-2) can result in a loss of many involuntary functions including ability to breathe, necessitating breathing aids such as mechanical ventilators or diaphragmatic pacemakers.

C-5: C-5 injuries often result in shoulder and biceps control, but no control at the wrist or hand. C-6: C-6 injuries generally yield wrist control, but no hand function.

C-7 and T-1: Individuals with C-7 and T-1 injuries can straighten their arms but still may have dexterity problems with the hand and fingers. Injuries at the thoracic level and below result in paraplegia, with the hands not affected.

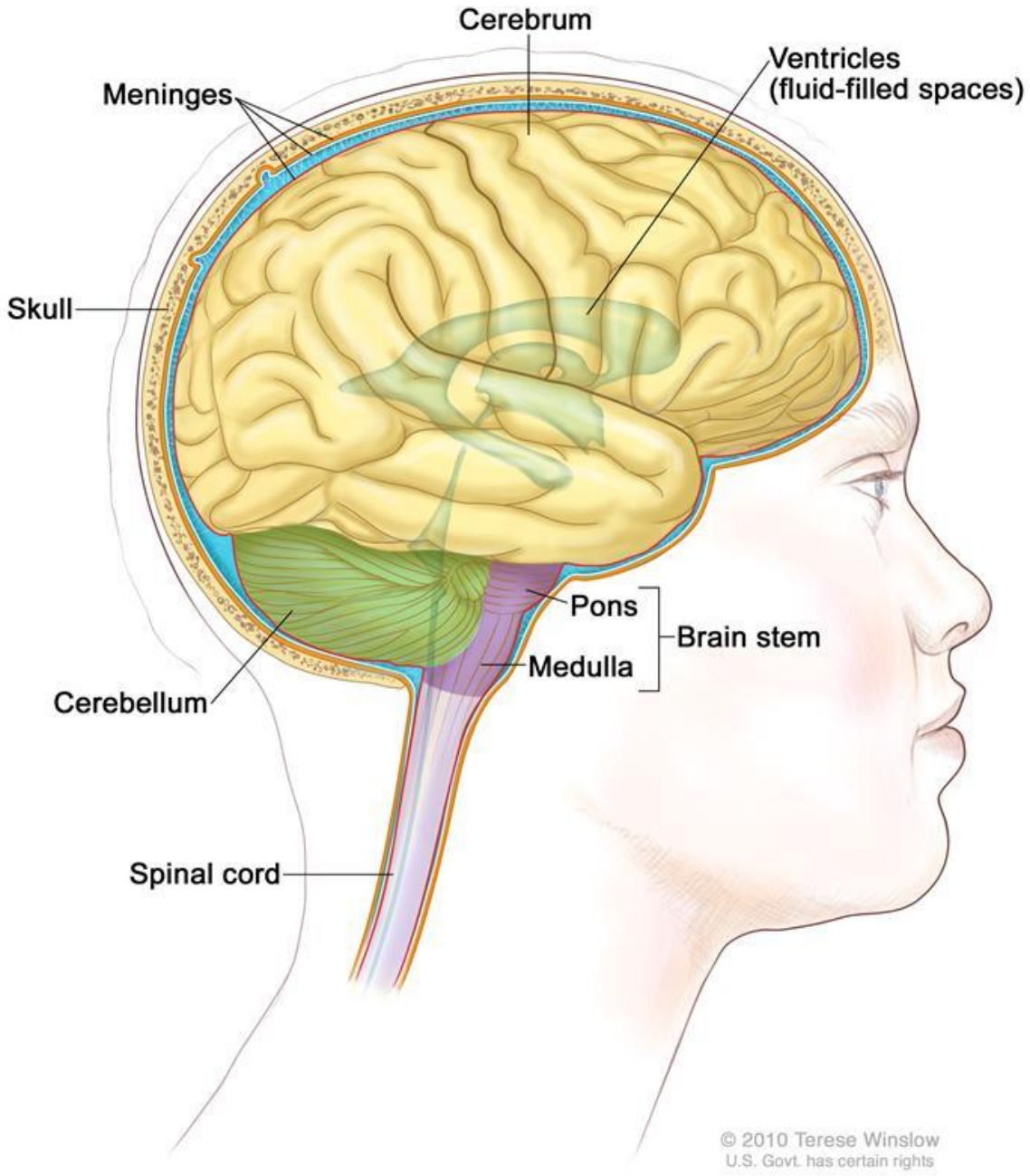
T-1 to T-8: At T-1 to T-8 there is most often control of the hands, but poor trunk control as the result of lack of abdominal muscle control.

T-9-T12: Lower T-injuries (T-9 to T-12) allow good truck control and good abdominal muscle control. Sitting balance is very good. Lumbar and Sacral injuries yield decreasing control of the hip flexors and legs.

Besides a loss of sensation or motor functioning, individuals with SCI also experience other changes. For example, they may experience dysfunction of the bowel and bladder. Men with SCI may have their fertility affected, while women's fertility is generally not affected.

Other effects of SCI may include low blood pressure, inability to regulate blood pressure effectively, reduced control of body temperature, inability to sweat below the level of injury, and chronic pain.

► APPENDIX "A"


Cerebrum
Ventricles
(fluid-filled spaces)
Meninges
Skull
Pons
Brain stem
Medulla
Cerebellum
Spinal cord
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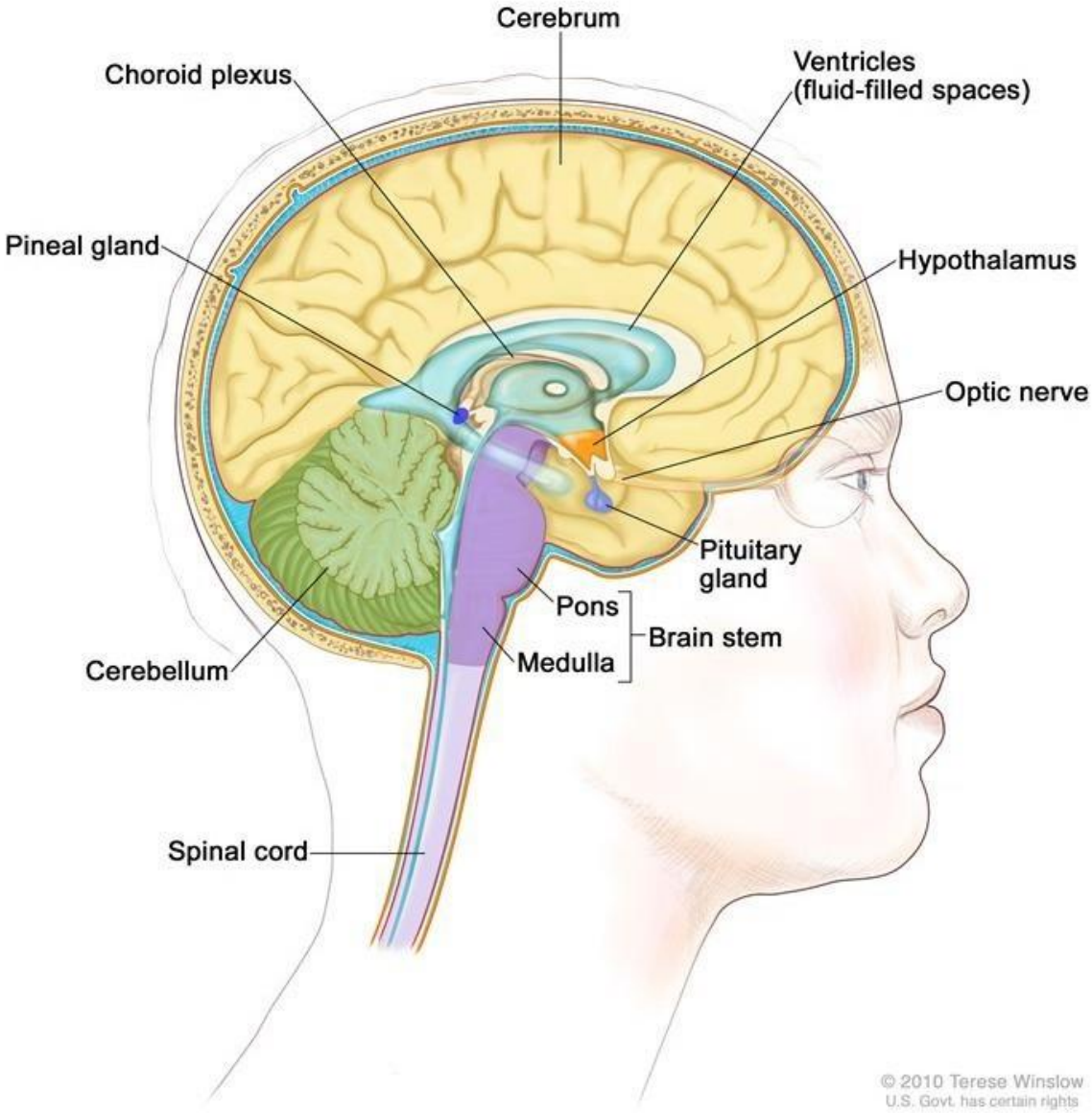
Cerebrum
Choroid plexus
Ventricles
(fluid-filled spaces)
Pineal gland
Hypothalamus
Optic nerve
Pituitary
gland
Pons
Brain stem
Medulla
Cerebellum
Spinal cord
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► APPENDIX "B"

(2) Basic Anatomy and Physiology of the Human Brain

This chapter contains some basic background on the anatomy and physiology of the human brain relevant to this project. The final section focuses on the neonatal brain and some common pathologies.

2.1 Anatomy of the head

The human *nervous system* consists of the *central nervous system* (CNS) and *peripheral nervous system* (PNS). The former consists of the brain and spinal cord, while the latter composes the nerves extending to and from the brain and spinal cord. The primary functions of the nervous system are to monitor, integrate process) and respond to information inside and outside the body. The brain consists of soft, delicate, non-replaceable neural tissue. It is supported and protected by the surrounding skin, skull, meninges and cerebrospinal fluid.

Skin

The skin constitutes a protective barrier against physical damage of underlying tissues, invasion of hazardous chemical and bacterial substances and, through the activity of its sweat glands and blood vessels, it helps to maintain the body at a constant temperature. Together with the sweat and oil glands, hairs and nails it forms a set of organs called the *integumentary system*. Figure 2–1 shows a cross-section of the skin and underlying subcutaneous tissue. The skin consists of an outer, protective layer, the *epidermis* and an inner layer, the *dermis*. While the top layer of the epidermis, the *stratum corneum*, consists of dead cells, the dermis is composed of vascularised fibrous connective tissue. The *subcutaneous tissue*, located underneath the skin, is primarily composed of *adipose tissue* (fat).

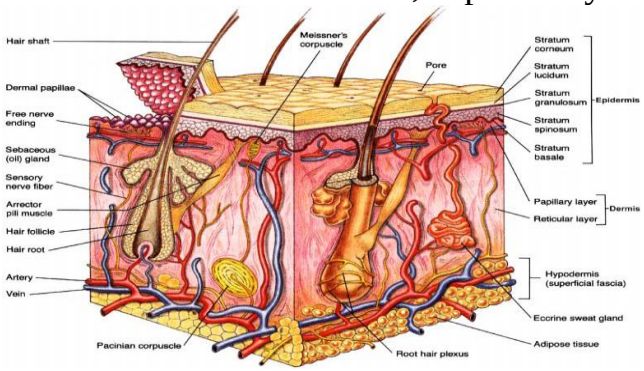

Figure 2–1 Skin and underlying subcutaneous tissue. (Reproduced from [Marieb 1991]).

Skull

Depending on their shape, bones are classified as long, short, flat or irregular. Bones of different types contain different proportions of the two types of osseous tissue: compact and spongy bone. While the former has a smooth structure, the latter is composed of small needle-like or flat pieces of bone called *trabeculae*, which form a network filled with red or yellow bone marrow. Most skull bones are flat and consist of two parallel compact bone surfaces, with a layer of spongy bone sandwiched between. The spongy bone layer of flat bones (the diploë) predominantly contains red bone marrow and hence has a high concentration of blood.

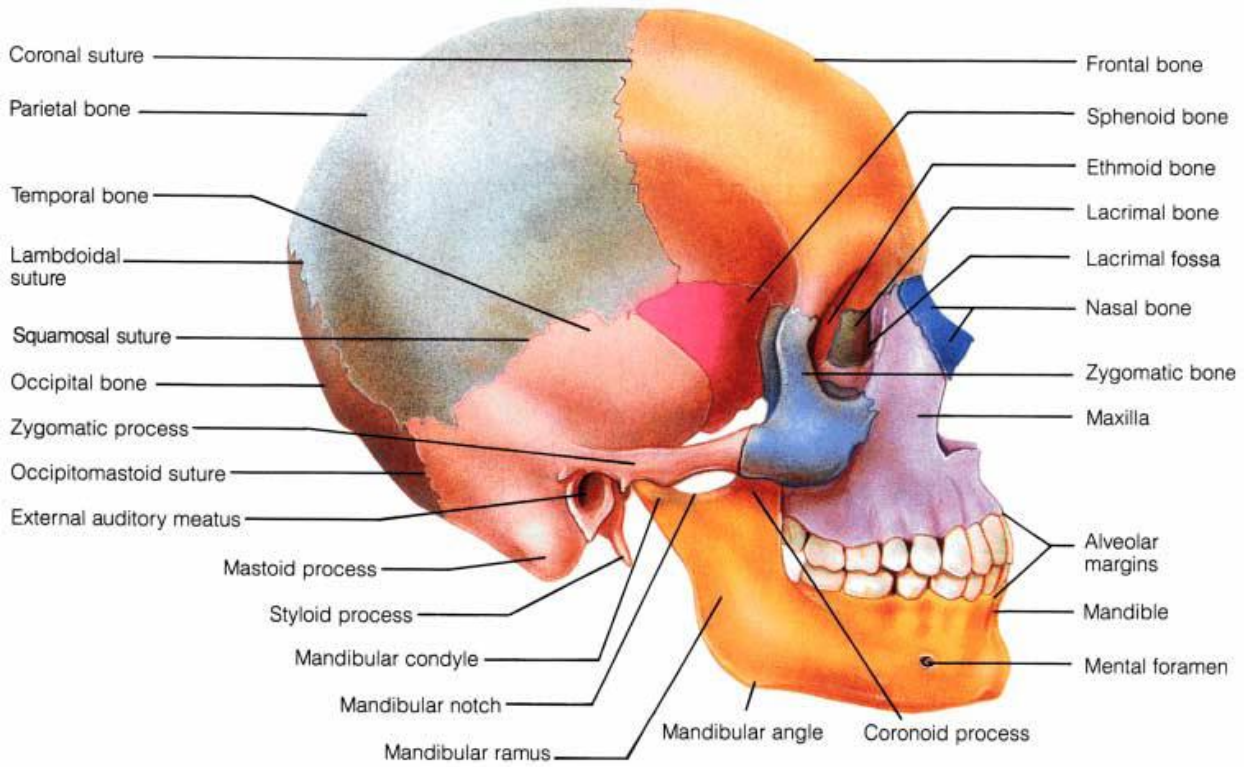

Figure 2–2 Skull. (Reproduced from [Marieb 1991]).

The skull is a highly complex structure consisting of 22 bones altogether. These can be divided into two sets, the *cranial bones* (or *cranium*) and the *facial bones*. While the latter form the framework of the face, the cranial bones form the *cranial cavity* that encloses and protects the brain. All bones of the adult skull are firmly connected by *sutures*. Figure 2–2 shows the most important bones of the skull. The *frontal bone* forms the forehead and contains the *frontal sinuses*, which are air filled cells within the bone. Most superior and lateral aspects of the skull are

formed by the *parietal bones* while the *occipital bone* forms the posterior aspects. The base of the occipital bone contains the *foramen magnum*, which is a large hole allowing the inferior part of the brain to connect to the spinal cord. The remaining bones of the cranium are the *temporal*, *sphenoid* and *ethmoid bones*.

Meninges

The *meninges* (Figure 2–3) are three connective tissue membranes enclosing the brain and the spinal cord. Their functions are to protect the CNS and blood vessels, enclose the *venous sinuses*, retain the *cerebrospinal fluid*, and form partitions within the skull. The outermost meninx is the dura mater, which encloses the *arachnoid mater* and the innermost *pia mater*.

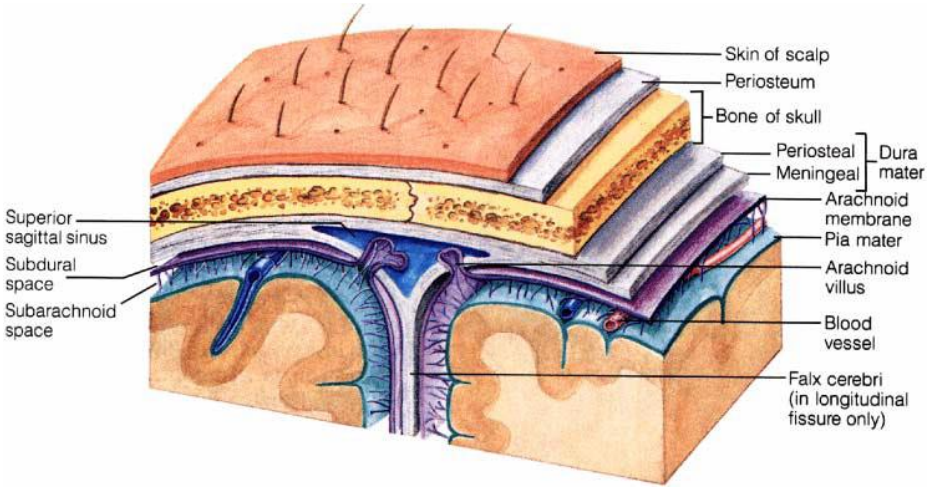

Figure 2–3 Meninges. (Reproduced from [Marieb 1991]).

Cerebrospinal fluid

Cerebrospinal fluid (CSF) is a watery liquid similar in composition to blood plasma. It is formed in the *choroid plexuses* and circulates through the ventricles into the *subarachnoid space*, where it is returned to the dural venous sinuses by the *arachnoid villi*. The prime purpose of the CSF is to support and cushion the brain and help nourish it. Figure 2–4 illustrates the flow of CSF through the central nervous system.

The CSF occupies the subarachnoid space (between the arachnoid mater and the pia mater) and the ventricular system **around and inside the brain and spinal cord**. It fills the ventricles of the brain, cisterns, and sulci, as well as the central canal of the spinal cord. There is also a connection from the subarachnoid space to

the bony labyrinth of the inner ear via the perilymphatic duct where the perilymph is continuous with the cerebros.

The body produces about 500mL of cerebrospinal fluid every day. The body's capacity for cerebrospinal fluid is about 125mL of CSF at any one time. So if there is any stenosis in the cerebrospinal fluid flow, one can develop increased intracranial pressure.

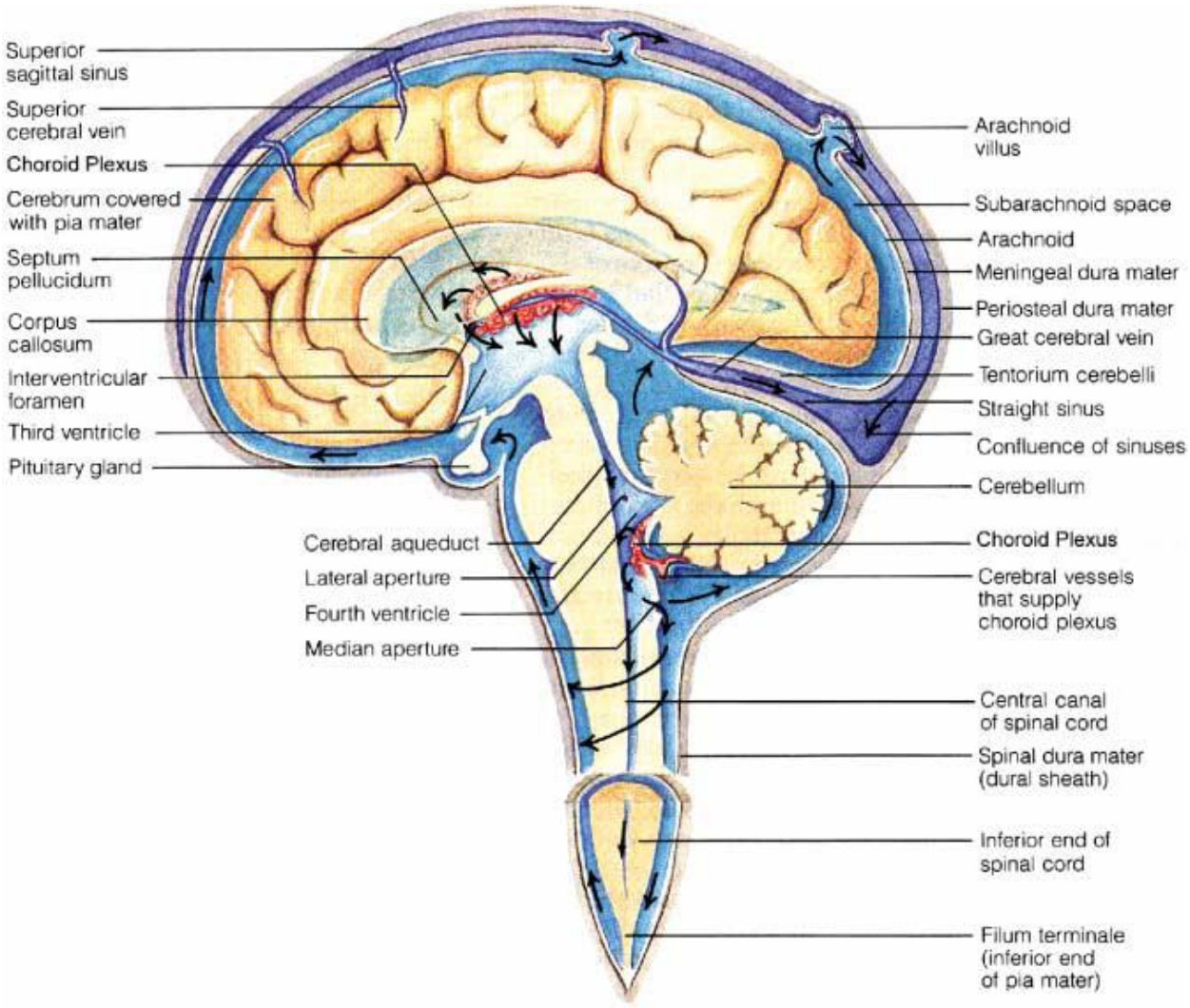

Figure 2–4 Cerebrospinal Fluid. (Reproduced from [Marieb 1991]).

2.2 Major regions of the brain and their functions

The major regions of the brain (Figure 2–5) are the *cerebral hemispheres*, *diencephalon*, *brain stem* and *cerebellum.*

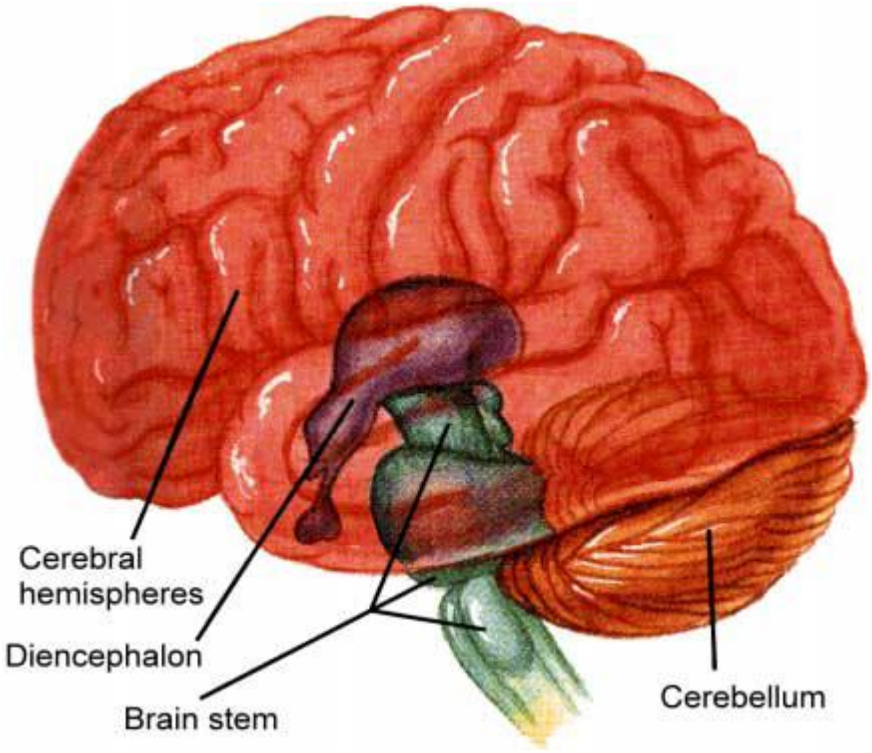

Figure 2–5 Major Regions of the Brain. (Reproduced from [Marieb 1991]).

Cerebral hemispheres

The *cerebral* hemispheres (Figure 2–6), located on the most superior part of the brain, are separated by the *longitudinal fissure*. They make up approximately 83% of total brain mass, and are collectively referred to as the *cerebrum*. The *cerebral cortex* constitutes a 2-4 mm thick *grey matter* surface layer and, because of its many convolutions, accounts for about 40% of total brain mass. It is responsible for conscious behaviour and contains three different functional areas: the *motor areas*, *sensory areas* and *association areas*. Located internally are the *white matter*, responsible for communication between cerebral areas and between the cerebral cortex and lower regions of the CNS, as well as the *basal nuclei* (or *basal ganglia*), involved in controlling muscular movement.

Diencephalon

The *diencephalon* is located centrally within the forebrain. It consists of the *thalamus*, *hypothalamus* and *epithalamus*, which together enclose the third ventricle. The thalamus acts as a grouping and relay station for sensory inputs ascending to the sensory cortex and association areas. It also mediates motor activities, cortical arousal and memories. The hypothalamus, by controlling the autonomic (involuntary) nervous system, is responsible for maintaining the body's homeostatic balance. Moreover it forms a part of the *limbic system*, the 'emotional' brain. The epithalamus consists of the *pineal gland* and the CSFproducing *choroid plexus*.

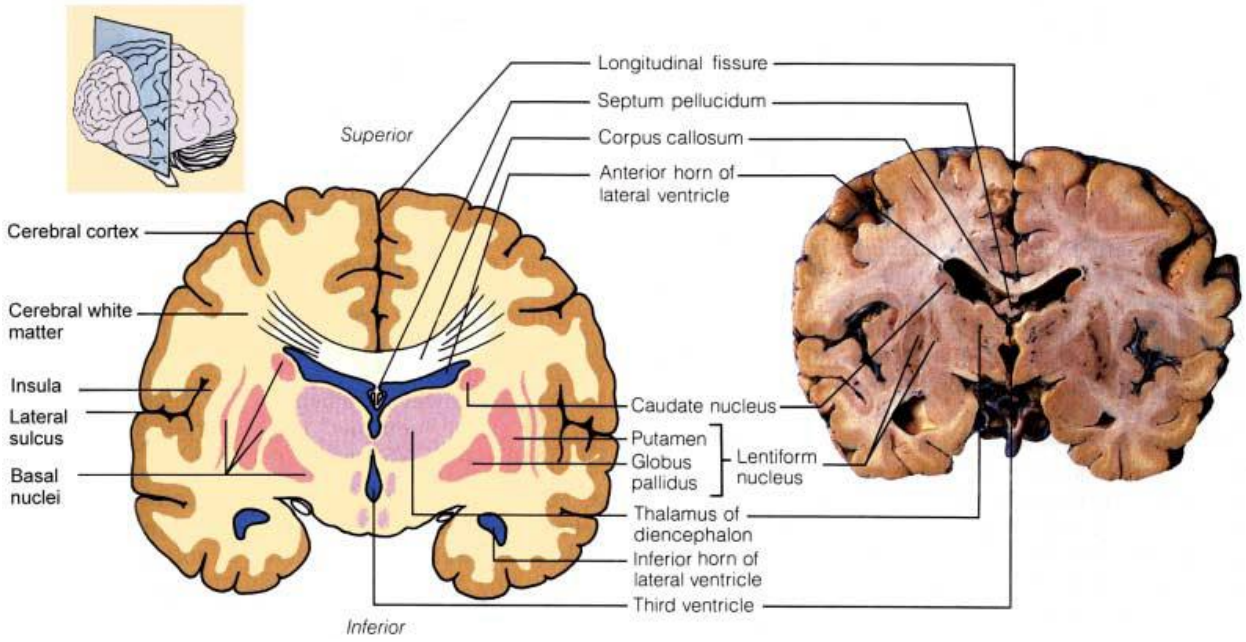

Figure 2–6 Major Regions of the cerebral hemispheres. (Reproduced from [Marieb 1991]).

Brain stem

The brain stem is similarly structured as the spinal cord: it consists of grey matter surrounded by white matter fibre tracts. Its major regions are the midbrain, pons and medulla oblongata. The midbrain, which surrounds the cerebral aqueduct, provides fibre pathways between higher and lower brain centres, contains visual and auditory reflex and subcortical motor centres. The pons is mainly a conduction region, but its nuclei also contribute to the regulation of respiration and cranial nerves. The medulla oblongata takes an important role as an autonomic reflex centre involved in maintaining body homeostasis. In particular, nuclei in the medulla regulate respiratory rhythm, heart rate, blood pressure and several

cranial nerves. Moreover, it provides conduction pathways between the inferior spinal cord and higher brain centres.

Cerebellum

The cerebellum, which is located dorsal to the pons and medulla, accounts for about 11% of total brain mass. Like the cerebrum, it has a thin outer cortex of grey matter, internal white matter, and small, deeply situated, paired masses (nuclei) of grey matter. The cerebellum processes impulses received from the cerebral motor cortex, various brain stem nuclei and sensory receptors in order to appropriately control skeletal muscle contraction, thus giving smooth, coordinated movements.

2.3 THE CEREBRAL CIRCULATORY SYSTEM

Blood is transported through the body via a continuous system of *blood vessels*. *Arteries* carry oxygenated blood away from the heart into *capillaries* supplying tissue cells. *Veins* collect the blood from the capillary bed and carry it back to the heart. The main purpose of blood flow through body tissues is to deliver oxygen and nutrients to and waste from the cells, exchange gas in the lungs, absorb nutrients from the digestive tract, and help forming urine in the kidneys. All the circulation besides the heart and the pulmonary circulation is called the *systemic circulation*. Since it is the ultimate aim of this research project to image cerebral oxygenation and haemodynamics some aspects of the cerebral circulatory system are described below.

Blood supply to the brain

Figure 2–7 shows an overview of the arterial system supplying the brain. The ***Major Arteries*** are the ***vertebral*** and internal ***carotid arteries***.

The ***two posterior*** and ***single anterior communicating arteries*** form the ***circle of Willis***, which equalizes blood pressures in the brain's anterior and posterior regions, and protects the brain from damage should one of the arteries become occluded. However, there is little communication between smaller arteries on the brain's surface. Hence occlusion of these arteries usually results in localized tissue damage.

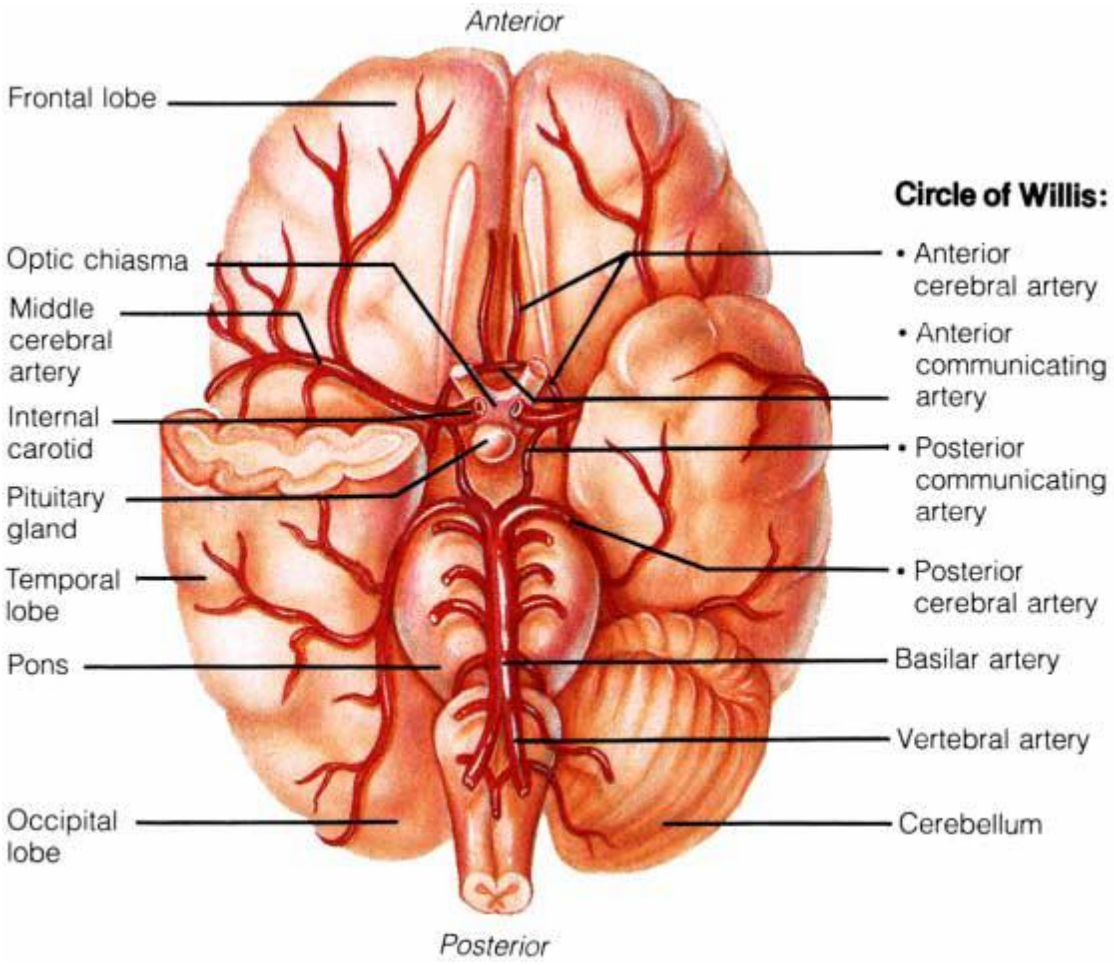

Figure 2–7 Major cerebral arteries and the circle of Willis. (Reproduced from [Marieb 1991]).

Cerebral haemodynamics

The cardiac output is about 5 l/min of blood for a resting adult. Blood flow to the brain is about 14% of this, or 700 ml/min. For any part of the body, the blood flow can be calculated using the simple formula Resistance Pressure Blood flow = (2.1) Pressure in the arteries is generated by the heart which pumps blood from its left ventricle into the aorta. (Since pressure was historically measured with a mercury manometer, the units are commonly expressed in terms of [mm Hg], although the official SI unit is the Pascal [Pa].) Resistance arises from friction, and is proportional to the following expression (Vessel Diameter)4 Vessel Length Resistance ∝ Viscosity× (2.2) Hence blood flow is slowest in the small vessels of the capillary bed, thus allowing time for the exchange of nutrients and oxygen to surrounding tissue by diffusion through the capillary walls.

Approximately 75% of total blood volume is ‘stored’ in the veins which, because of their high capacity, act as reservoirs. Their walls distend and contract in response to the amount of blood available in the circulation. However, the function of cerebral veins, formed from sinuses in the dura mater, is somewhat different from other veins of the body, as they are non-collapsible.

Autoregulation

[Panerai 1998] describes *autoregulation* of blood flow in the cerebral vascular bed as the mechanism by which cerebral blood flow (CBF) tends to remain relatively constant despite changes in cerebral perfusion pressure (CPP). With a constant metabolic demand, changes in CPP or arterial blood pressure that would increase or reduce CBF, are compensated by adjusting the vascular resistance. This maintains a constant O2 supply and constant CBF. Therefore cerebral autoregulation allows the blood supply to the brain to match its metabolic demand and also to protect cerebral vessels against excessive flow due to arterial hypertension. Cerebral blood flow is autoregulated much better than in almost any other organ. Even for arterial pressure variations between 50 and 150 mm Hg, CBF only changes by a few percent. This can be accomplished because the arterial vessels are typically able to change their diameter about 4-fold, corresponding to a 256-fold change in blood flow. Only when the brain is very active is there an exception to the close matching of blood flow to metabolism, which can rise by up to 30-50% in the affected areas. It is an aim of PET, functional MRI, near infrared spectroscopy (NIRS), and, possibly, near infrared imaging, to detect or image such localised changes in cortical activity and associated blood flow.