Traumatic Brain Injury

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Definitions

Traumatic brain injury (TBI) is a serious public health problem in the United States. Each year, traumatic brain injuries contribute to a substantial number of deaths and cases of permanent disability. In 2010 2.5 million TBIs occurred either as an isolated injury or along with other injuries.

Traumatic brain injury occurs when an external mechanical force causes brain dysfunction.

A TBI is caused by a bump, blow or jolt to the head or a penetrating head injury that disrupts the normal function of the brain. Not all blows or jolts to the head result in a TBI. The severity of a TBI may range from "mild," i.e., a brief change in mental status or consciousness to "severe," i.e., an extended period of unconsciousness or amnesia after the injury.

There are several ways to describe brain injuries. The brain is enclosed in the bony vault of the skull. The cerebrospinal fluid surrounds the brain and, most of the time, protects it from impact with the skull. If there is a rapid force applied to the skull or rapid deceleration of the head, the brain may strike the inside of the bony vault.

Brain tissue may stretch or tear because of the rapid movement. This can injure the nervous tissue of the brain directly. If a projectile such as a bullet enters the skull, it can directly injure the brain.

Below is a list of terms and definitions that refer to the different injuries of TBI.

Definitions Related to TBI

Closed Head Injury- the skull is intact and there is no penetration of the skull. Direct or indirect force to the head can cause this type of injury. This may be caused by rotational and/or deceleration in the case of both direct and indirect force.

Open Head Injury- penetration of the skull with direct injury to the head.

Diffuse Axonal Injury- diffuse cellular injury to the brain from rapid rotational movement. This is often seen in motor vehicle accidents or shaking injuries. The axons are the projections of the brains nerve cells that attach to other nerve cells. They are damaged or torn by the rapid deceleration. The injury is from the shearing force disrupting the axons, which compose the white matter of the brain.

Contusion- a bruise to a part of the brain. Like a bruise on the body, this is bleeding into the tissue.

Penetrating Trauma- any object that enters the brain. Causes direct injury by impact and pushing skull fragments into the brain.

Secondary Injury- swelling and release of chemicals that promote inflammation and cell injury or death. This causes swelling in the brain which may increase the intracranial pressure and prevent the cerebrospinal fluid from draining out of the skull. This causes further increase in pressure and brain damage. If this is not controlled or prevented the brain can herniate (push through) the base of the skull and cause respiratory failure and death. The only way to prevent the primary injury is to prevent the trauma. The prevention of this secondary injury is the focus of the acute medical care after injury.

Secondary Injury Includes:

- Intracranial hemorrhage (bleeding inside the skull)
- Brain swelling
- Increased intracranial pressure (pressure inside the skull)
- Brain damage associated with lack of oxygen
- Infection inside the skull, common with penetrating trauma
- Chemical changes leading to cell death
- Increased fluid inside the skull (hydrocephalus)

Acquired Brain Injury- injuries other than congenital, birth trauma, hereditary or degenerative. This includes traumatic brain injury. In the non-traumatic types of acquired brain injury, the brain is usually diffusely injured. These injuries are usually not included in traumatic brain injury but the symptoms span the same spectrum.

Common causes are *anoxia* and *hypoxia*. These are lack of oxygen to the brain and insufficient oxygen to the brain. They can occur because of mechanical problems with breathing, with cardiac arrest or bleeding. Drugs and poisoning can also cause acquired traumatic brain injury. Carbon monoxide poisoning is an example of poisoning that may cause brain injury.

Effects and Symptoms

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.

Traumatic brain injury can have wide-ranging physical and psychological effects. Some signs or symptoms may appear immediately after the traumatic event, while others may appear days or weeks later.

Mild traumatic brain injury may cause temporary dysfunction of brain cells. More serious traumatic brain injury can result in bruising, torn tissues, bleeding and other physical damage to the brain that can result in long-term complications or death.

TBI is classified into two categories: mild and severe.

A brain injury 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. Even though this type of TBI is called "mild", the effect on the family and the injured person can be devastating.

Mild TBI

The signs and symptoms of mild traumatic brain injury may include:

Physical symptoms

- Loss of consciousness for a few seconds to a few minutes
- No loss of consciousness, but a state of being dazed, confused or disoriented
- Headache
- Nausea or vomiting
- Fatigue or drowsiness
- Difficulty sleeping
- Sleeping more than usual
- Dizziness or loss of balance

Sensory symptoms

- Sensory problems, such as blurred vision, ringing in the ears, a bad taste in the mouth or changes in the ability to smell
- Sensitivity to light or sound

Cognitive or mental symptoms

- Memory or concentration problems
- Mood changes or mood swings
- Feeling depressed or anxious

Moderate to Severe TBI

Severe brain injury 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 to severe traumatic brain injuries can include any of the signs and symptoms of mild injury, as well as the following symptoms that may appear within the first hours to days after a head injury:

Physical symptoms

- Loss of consciousness from several minutes to hours
- Persistent headache or headache that worsens
- Repeated vomiting or nausea
- Convulsions or seizures
- Dilation of one or both pupils of the eyes
- Clear fluids draining from the nose or ears
- Inability to awaken from sleep
- Weakness or numbness in fingers and toes
- Loss of coordination

Cognitive or mental symptoms

- Profound confusion
- Agitation, combativeness or other unusual behavior
- Slurred speech
- Coma and other disorders of consciousness

The effects of TBI can be profound. Individuals with 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.

Infants and Children with TBIs

Infants and young children with brain injuries may lack the communication skills to report headaches, sensory problems, confusion and similar symptoms. In a child with traumatic brain injury, you may observe:

- Change in eating or nursing habits
- Persistent crying and inability to be consoled
- Unusual or easy irritability
- Change in ability to pay attention

- Change in sleep habits
- Sad or depressed mood
- Loss of interest in favorite toys or activities

Complications

Several complications can occur immediately or soon after a traumatic brain injury. Severe injuries increase the risk of a greater number of complications and more-severe complications.

Altered consciousness

Moderate to severe traumatic brain injury can result in prolonged or permanent changes in a person's state of consciousness, awareness or responsiveness. Different states of consciousness include:

- **Coma.** A person in a coma is unconscious, unaware of anything and unable to respond to any stimulus. This results from widespread damage to all parts of the brain. After a few days to a few weeks, a person may emerge from a coma or enter a vegetative state.

- **Vegetative state.** Widespread damage to the brain can result in a vegetative state. Although the person is unaware of his or her surroundings, he or she may open his or her eyes, make sounds, respond to reflexes, or move.
    - It's possible that a vegetative state can become permanent, but often individuals progress to a minimally conscious state.

- **Minimally conscious state.** A minimally conscious state is a condition of severely altered consciousness but with some evidence of self-awareness or awareness of one's environment. It is often a transitional state from a coma or vegetative condition to greater recovery.

- **Locked-in syndrome.** A person in a locked-in state is aware of his or her surroundings and awake, but he or she isn't able to speak or move. The person may be able to communicate with eye movement or blinking.
    - This state results from damage limited to the lower brain and brainstem. This rarely occurs after trauma and is more commonly due to a stroke in that area of the brain.

- **Brain death.** When there is no measurable activity in the brain and the brainstem, this is called brain death. In a person who has been declared brain dead, removal of breathing devices will result in cessation of breathing and eventual heart failure. Brain death is considered irreversible.

Seizures

Some people with traumatic brain injury will have seizures within the first week. Some serious injuries may result in recurring seizures, called post-traumatic epilepsy.

Fluid buildup

Cerebrospinal fluid may build up in the spaces in the brain (cerebral ventricles) of some people who have had traumatic brain injuries, causing increased pressure and swelling in the brain.

Infections

Skull fractures or penetrating wounds can tear the layers of protective tissues (meninges) that surround the brain. This can enable bacteria to enter the brain and cause infections. An infection of the meninges (meningitis) could spread to the rest of the nervous system if not treated.

Blood vessel damage

Several small or large blood vessels in the brain may be damaged in a traumatic brain injury. This damage could lead to a stroke, blood clots or other problems.

Nerve damage

Injuries to the base of the skull can damage nerves that emerge directly from the brain (cranial nerves). Cranial nerve damage may result in:

- Paralysis of facial muscles
- Damage to the nerves responsible for eye movements, which can cause double vision
- Damage to the nerves that provide sense of smell
- Loss of vision
- Loss of facial sensation
- Swallowing problems

Social problems

- Trouble with turn taking or topic selection
- Problems with changes in tone, pitch or emphasis to express emotions, attitudes or subtle differences in meaning
- Difficulty deciphering nonverbal signals
- Trouble reading cues from listeners
- Trouble starting or stopping conversation**s**
- Inability to use the muscles needed to form words (dysarthria)

Behavioral changes

People who've experienced brain injury often experience changes in behaviors. These may include:

- Difficulty with self-control
- Lack of awareness of abilities
- Risky behavior
- Inaccurate self-image
- Difficulty in social situations
- Verbal or physical outbursts

Emotional changes

Emotional changes may include:

- Depression
- Anxiety
- Mood swings
- Irritability
- Lack of empathy for others
- Anger
- Insomnia
- Changes in self-esteem

Degenerative brain diseases

A traumatic brain injury may increase the risk of diseases that result in the gradual degeneration of brain cells and gradual loss of brain functions, though this risk cannot yet be determined with any certainty for an individual. These include:

- Alzheimer's disease, which primarily causes the progressive loss of memory and other thinking skills
- Parkinson's disease, a progressive condition that causes movement problems, such as tremors, rigidity and slow movements
- Dementia pugilistica — most often associated with repetitive blows to the head in career boxing — which causes symptoms of dementia and movement problems

Causes

The number of people with Traumatic Brain Injury (TBI) is difficult to assess accurately but is much larger than most people would expect. According to the CDC (United States Centers for Disease Control and Prevention), there are approximately 1.5 million people in the U.S. who suffer from a traumatic brain injury each year. 50,000 people die from TBI each year and 85,000 people suffer long-term disabilities. In the U.S., more than 5.3 million people live with disabilities caused by TBI. Patients admitted to a hospital for TBI are included in this count, while those treated in an emergency room or doctor's office are not counted.

A blow or other traumatic injury to the head or body causes traumatic brain injury. The degree of damage can depend on several factors, including the nature of the event and the force of impact.

Injury may include one or more of the following factors:

- Damage to brain cells may be limited to the area directly below the point of impact on the skull.
- A severe blow or jolt can cause multiple points of damage because the brain may move back and forth in the skull.
- A severe rotational or spinning jolt can cause the tearing of cellular structures.
- A blast, as from an explosive device, can cause widespread damage.
- An object penetrating the skull can cause severe, irreparable damage to brain cells, blood vessels and protective tissues around the brain.
- Bleeding in or around the brain, swelling, and blood clots can disrupt the oxygen supply to the brain and cause wider damage

The causes of TBI are diverse. The top three causes are: car accident, firearms and falls. Firearm injuries are often fatal: 9 out of 10 people die from their injuries. Young adults and the elderly are the age groups at highest risk for TBI. Along with a traumatic brain injury, persons are also susceptible to spinal cord injuries, which is another type of traumatic injury that can result out of vehicle crashes, firearms and falls. Prevention of TBI is the best approach since there is no cure.

Common events causing traumatic brain injury include the following:

- **Falls.** Falling out of bed, slipping in the bath, falling down steps, falling from ladders and related falls are the most common cause of traumatic brain injury overall, particularly in older adults and young children.

- **Vehicle-related collisions.** Collisions involving cars, motorcycles or bicycles — and pedestrians involved in such accidents — are a common cause of traumatic brain injury.

- **Violence.** About 20 percent of traumatic brain injuries are caused by violence, such as gunshot wounds, domestic violence or child abuse. Shaken baby syndrome is traumatic brain injury caused by the violent shaking of an infant that damages brain cells.

- **Sports injuries.** Traumatic brain injuries may be caused by injuries from a number of sports, including soccer, boxing, football, baseball, lacrosse, skateboarding, hockey, and other high-impact or extreme sports, particularly in youth.

- **Explosive blasts and other combat injuries.** Explosive blasts are a common cause of traumatic brain injury in active-duty military personnel. Although the mechanism of damage isn't yet well understood, many researchers believe that the pressure wave passing through the brain significantly disrupts brain function.

Traumatic brain injury also results from penetrating wounds, severe blows to the head with shrapnel or debris, and falls or bodily collisions with objects following a blast.

Mechanisms of Injury

These mechanisms are the highest causes of brain injury: Open head Injury, Closed Head Injury, Deceleration Injuries, Chemical/Toxic, Hypoxia, Tumors, Infections and Stroke.

1. **Open Head Injury**

    - Results from bullet wounds, etc.
    - Largely focal damage
    - Penetration of the skull
    - Effects can be just as serious as closed brain injury

2. **Closed Head Injury**

    - Resulting from a slip and fall, motor vehicle crashes, etc.
    - Focal damage and diffuse damage to axons
    - Effects tend to be broad (diffuse)
    - No penetration to the skull

3. **Deceleration Injuries (Diffuse Axonal Injury)**

The skull is hard and inflexible while the brain is soft with the consistency of gelatin. The brain is encased inside the skull. During the movement of the skull through space (acceleration) and the rapid discontinuation of this action when the skull meets a stationary object (deceleration) causes the brain to move inside the skull. The brain moves at a different rate than the skull because it is soft. Different parts of the brain move at different speeds because of their relative lightness or heaviness. The differential movement of the skull and the brain when the head is struck results in direct brain injury, due to diffuse axonal shearing, contusion and brain swelling.

Diffuse axonal shearing: when the brain is slammed back and forth inside the skull it is alternately compressed and stretched because of the gelatinous consistency. The long, fragile axons of the neurons (single nerve cells in the brain and spinal cord) are also compressed and stretched. If the impact is strong enough, axons can be stretched until they are torn. This is called axonal shearing. When this happens, the neuron dies. After a severe brain injury, there is massive axonal shearing and neuron death.

4. **Chemical / Toxic**

- Also known as metabolic disorders
- This occurs when harmful chemicals damage the neurons
- Chemicals and toxins can include insecticides, solvents, carbon monoxide poisoning, lead poisoning, etc.

5. **Hypoxia (Lack of Oxygen)**

- If the blood flow is depleted of oxygen, then irreversible brain injury can occur from anoxia (no oxygen) or hypoxia (reduced oxygen)
- It may take only a few minutes for this to occur
- This condition may be caused by heart attacks, respiratory failure, drops in blood pressure and a low oxygen environment
- This type of brain injury can result in severe cognitive and memory deficits

6. **Tumors**

- Tumors caused by cancer can grow on or over the brain
- Tumors can cause brain injury by invading the spaces of the brain and causing direct damage
- Damage can also result from pressure effects around an enlarged tumor

- Surgical procedures to remove the tumor may also contribute to brain injury

7. **Infections**

- The brain and surrounding membranes are very prone to infections if the special blood-brain protective system is breached
- Viruses and bacteria can cause serious and life-threatening diseases of the brain (encephalitis) and meninges (meningitis)

8. **Stroke**

- If blood flow is blocked through a cerebral vascular accident (stroke), cell death in the area deprived of blood will result
- If there is bleeding in or over the brain (hemorrhage or hematoma) because of a tear in an artery or vein, loss of blood flow and injury to the brain tissue by the blood will also result in brain damage.

Types

Mild TBI

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. Even though this type of TBI is called “mild”, the effect on the family and the injured person can be devastating.

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.

Common Symptoms of Mild TBI

- Fatigue
- Headaches
- Visual disturbances
- Memory loss
- Poor attention/concentration
- Sleep disturbances
- Dizziness/loss of balance
- Irritability-emotional disturbances
- Feelings of depression
- Seizures

Other Symptoms Associated with Mild TBI

- Nausea
- Loss of smell
- Sensitivity to light and sounds
- Mood changes
- Getting lost or confused
- Slowness in thinking

These 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 at work or when performing household tasks may bring the person to seek medical care.

Moderate to Severe TBI

Brain injuries can range in scope from mild to severe. Traumatic brain injuries (TBI) result in permanent neurobiological damage that can produce lifelong deficits to varying degrees. Moderate to severe brain injuries typically refer to injuries that have the following characteristics:

- Moderate brain injury is defined as a brain injury resulting in a loss of consciousness from 20 minutes to 6 hours and a Glasgow Coma Scale of 9 to 12

- 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 the following:

- Severity of initial injury
- 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

Impacts of a moderate to severe TBI

The impact of a moderate to severe brain injury can include:

Cognitive deficits including difficulties with:

- Attention
- Concentration
- Distractibility
- Memory
- Speed of Processing
- Confusion
- Perseveration
- Impulsiveness
- Language Processing
- “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

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

- 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
- Loss of stamina
- Appetite changes
- Regulation of body temperature
- Menstrual difficulties

Social-Emotional

- Dependent behaviors
- Emotional ability
- Lack of motivation
- Irritability
- Aggression
- Depression
- Disinhibition

- Denial/lack of awareness

Prevention

Because Traumatic Brain Injury (TBI) cannot be cured, steps must be taken to prevent an injury from occurring. Advice for the prevention of TBI is often common sense.

TBI Prevention Methods:

- Always wear a seat belt in a motor vehicle
- Use an appropriate child safety seat or a booster
- Never drive under the influence of alcohol or drugs
- Always wear a helmet when on a bicycle, motorcycle, scooter, snowmobile and other open unrestrained vehicles
- Wear a helmet when participating in contact sports
- Wear a helmet when horseback riding
- Wear a helmet while skiing, snowboarding, skating and skateboarding

Fall Prevention Methods

- Use the rails on stairways
- Provide adequate lighting, especially on stairs for people with poor vision or who have difficulty walking
- Place bars on windows to prevent children from falling
- Sit on safe stools
- Do not place obstacles in walking pathways

Gun Safety

- Keep guns locked in a cabinet
- Store guns unloaded
- Store ammunition apart from guns

Preventing Head Injuries in Children

- Install safety gates at the top of a stairway
- Keep stairs clear of clutter
- Install window guards to prevent falls
- Put a nonslip mat in the bathtub or shower
- Use playgrounds that have shock-absorbing materials on the ground
- Make sure area rugs are secure
- Don't let children play on fire escapes or balconies

Diagnosis

Because traumatic brain injuries are usually emergencies and because consequences can worsen swiftly without treatment, doctors usually need to assess the situation rapidly.

With moderate or severe traumatic brain injury (TBI), the diagnosis is often self-evident. In the presence of other life threatening injuries, which is often the case with motor vehicle accidents, closed head injury can be missed. The focus is on lifesaving measures.

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. Mild traumatic brain injury may not be diagnosed until the individual begins to have problems in what were once easy tasks or social situations.

Injury to specific areas of the brain will cause certain symptoms. 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.

A detailed neurological examination is important and will bring out evidence of brain injury.

- Brain imaging with CAT scan, MRI, SPECT and PET scan may be useful.
- Cognitive evaluation by a Neuropsychologist with formal neuropsychological testing.
- Evaluations by physical, occupational and speech therapists help clarify the specific deficits of an individual.

Specific Tests and Medications

There are a few different systems that medical practitioners use to diagnose the symptoms of Traumatic Brain Injury. This section will describe a few of the tests used to diagnose TBI's.

Glasgow Coma Scale

The Glasgow Coma Scale is based on a 15-point scale for estimating and categorizing the outcomes of brain injury on the basis of overall social capability or dependence on others.

This 15-point test helps a doctor or other emergency medical personnel assess the initial severity of a brain injury by checking a person's ability to follow directions and move their eyes and limbs. The coherence of speech also provides important clues.

Abilities are scored numerically in the Glasgow Coma Scale. Higher scores mean less severe injuries.

The test measures the motor response, verbal response and eye opening response with these values:

I. Motor Response
6 – Obeys commands fully
5 – Localizes to noxious stimuli
4 – Withdraws from noxious stimuli
3 – Abnormal flexion, i.e. decorticate posturing
2 – Extensor response, i.e. decerebrate posturing
1 – No response

II. Verbal Response
5 – Alert and Oriented
4 – Confused, yet coherent, speech
3 – Inappropriate words and jumbled phrases consisting of words
2 – Incomprehensible sounds
1 – No sounds

III. Eye Opening
4 – Spontaneous eye opening
3 – Eyes open to speech
2 – Eyes open to pain
1 – No eye opening

The final score is determined by adding the values of I+II+III. This number helps medical practioners categorize the four possible levels for survival, with a lower number indicating a more severe injury and a poorer prognosis:

Mild (13-15):
- More in-depth discussion on the Mild TBI Symptoms page.

Moderate Disability (9-12):
- Loss of consciousness greater than 30 minutes
- Physical or cognitive impairments which may or may resolve
- Benefit from Rehabilitation

Severe Disability (3-8):

- Coma: unconscious state. No meaningful response, no voluntary activities
  Vegetative State (Less Than 3):
- Sleep wake cycles
- Aruosal, but no interaction with environment
- No localized response to pain
  Persistent Vegetative State:
- Vegetative state lasting longer than one month
  Brain Death:
- No brain function
- Specific criteria needed for making this diagnosis

Ranchos Los Amigos Scale

The Ranchos Los Amigos Scale measures the levels of awareness, cognition, behavior and interaction with the environment.

Ranchos Los Amigos Scale
Level I: No Response
Level II: Generalized Response
Level III: Localized Response
Level IV: Confused-agitated
Level V: Confused-inappropriate
Level VI: Confused-appropriate
Level VII: Automatic-appropriate
Level VIII: Purposeful-appropriate

Computerized Tomography (CT) Scan

A CT scan uses a series of X-rays to create a detailed view of the brain. A CT scan can quickly visualize fractures and uncover evidence of bleeding in the brain (hemorrhage), blood clots (hematomas), bruised brain tissue (contusions) and brain tissue swelling.

Magnetic Resonance Imaging (MRI)

An MRI uses powerful radio waves and magnets to create a detailed view of the brain. This test may be used after the person's condition has been stabilized.

Intracranial Pressure Monitor

Tissue swelling from a traumatic brain injury can increase pressure inside the skull and cause additional damage to the brain. Doctors may insert a probe through the skull to monitor this pressure.

Medications

Medications to limit secondary damage to the brain immediately after an injury may include:

- **Diuretics.** These drugs reduce the amount of fluid in tissues and increase urine output. Diuretics, given intravenously to people with traumatic brain injury, help reduce pressure inside the brain.

- **Anti-seizure drugs.** People who've had a moderate to severe traumatic brain injury are at risk of having seizures during the first week after their injury.

    - An anti-seizure drug may be given during the first week to avoid any additional brain damage that might be caused by a seizure. Additional anti-seizure treatments are used only if seizures occur.

- **Coma-inducing drugs.** Doctors sometimes use drugs to put people into temporary comas because a comatose brain needs less oxygen to function. This is especially helpful if blood vessels, compressed by increased pressure in the brain, are unable to deliver the usual amount of nutrients and oxygen to brain cells

Treatment

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.

Mild traumatic brain injuries usually require no treatment other than rest and over-the-counter pain relievers to treat a headache. However, a person with a mild traumatic brain injury usually needs to be monitored closely at home for any persistent, worsening or new symptoms. He or she also may have follow-up doctor appointments.

The doctor will indicate when a return to work, school or recreational activities is appropriate. It's best to avoid physical or thinking (cognitive) activities that make things worse until symptoms have resolved. Most people return to normal routines gradually.

The patient may need surgery for injuries. 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.

Emergency surgery may be needed to minimize additional damage to brain tissues. Surgery may be used to address the following problems:

- **Removing clotted blood (hematomas).** Bleeding outside or within the brain can result in a collection of clotted blood (hematoma) that puts pressure on the brain and damages brain tissue.

- **Repairing skull fractures.** Surgery may be needed to repair severe skull fractures or to remove pieces of skull in the brain.

- **Opening a window in the skull.** Surgery may be used to relieve pressure inside the skull by draining accumulated cerebral spinal fluid or creating a window in the skull that provides more room for swollen tissues.

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.

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 crises. The psychologist will provide counseling and education about the injury, as well as assess the cognition of the patient.

A trauma social worker will 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.

Rehabilitation Center Treatment

Most people who have had a significant brain injury will require rehabilitation. They may need to relearn basic skills, such as walking or talking. The goal is to improve their abilities to perform daily activities.

Therapy usually begins in the hospital and continues at an inpatient rehabilitation unit, a residential treatment facility or through outpatient services. The type and duration of rehabilitation varies by individual, depending on the severity of the brain injury and what part of the brain was injured.

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

The Physiatrist 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 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. OTS 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. These skills include:

- Cooking
- Grocery shopping
- Banking
- Budgeting
- Readiness for returning to work by assessing prevocational and vocational skills

Rehabilitation Center 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.

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.

Medications may be used for:

- Attention and concentration-amantadine and methylphenidate, bromocriptine and antidepressants.
- Aggressive behavior-carbamamazapine and amitriptyline

Surgical Treatment

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

In closed head injury, surgery does not correct the problem. A bolt or ICP (intracranial pressure) monitoring device may be placed in the skull to monitor pressure in the brain cavity. 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.

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.

Supportive Care Concerns and Specific Needs

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 tracheostomy 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 is put in the bladder for urine collection. 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.

Intracranial Pressure

Intracranial pressure (the pressure in the brain) is controlled 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.

The trauma care staff may 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

Coping and Support

A number of strategies can help a person with traumatic brain injury cope with complications that affect everyday activities, communication and interpersonal relationships. Depending on the severity of injury, a family caregiver or friend may need to help implement the following approaches:

- **Join a support group.** Talk to your doctor or rehabilitation therapist about a support group that can help you talk about issues related to your injury, learn new coping strategies and get emotional support.

- **Write things down.** Keep a record of important events, people's names, tasks or other things that are difficult to remember.

- **Follow a routine.** Keep a consistent schedule, keep things in designated places to avoid confusion, and take the same routes when going to frequently visited destinations.

- **Take breaks.** Make arrangements at work or school to take breaks as needed.

- **Alter work expectations or tasks.** Appropriate changes at work or school may include having instructions read to you, allowing more time to complete tasks or breaking down tasks into smaller steps.

- **Avoid distractions.** Minimize distractions such as loud background noise from a television or radio.

- **Stay focused.** Work on one task at a time.

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.

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. Patients over 60 or under age 2 have the worst prognosis, even if they suffer the same injury as someone not in those age groups.

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.
- Redundancy in the function performed so another area of the brain takes over.
- Behavioral substitution. The individual learns new strategies to compensate for deficits.

TR Implications

For a person that has suffered a TBI, therapeutic recreation can play a vital role in recovery. Because TBI can affect different people in different ways the treatment will vary depending on the patient. However TBI can be very stressful to patients and that is where therapeutic recreation comes into play. With many of the symptoms of TBI patients may have a loss memory, or muscle movements. Their life will dramatically change, so they need recreational therapy. For one reason they might be frustrated with life, because they are having to learn new skills all over again, and they need help relearning skills and they also need an outlet for stress. They also need a way to express themselves as they find their new selves.

Therapeutic Recreation is essential in the healing process for patients suffering from a TBI for three reasons: (taken from the Miami School of Medicine)

- A method of treatment to improve your physical, psychological, social, and emotional well-being, such as conducting a volleyball activity to improve balance
- A method of education to increase your knowledge of and successfully provide for your leisure activities, which are an integral part of your rehabilitation and social reintegration
- Recreational participation, which is necessary for a normalized, balanced lifestyle for all people, and essential as a means of self-expression, release, and socialization for the people with TBI.

Like all other rehabilitation therapies, therapeutic recreation helps you achieve your highest possible level of independence and quality of life.

Recreation Assessment

1. Strengths, interests and value
2. Previous recreational activities and experience
3. Resources in your home community
4. Social needs and relationships
5. Economic and other potential problems that may inhibit recreational activities
6. Life style adjustments needed for healthy leisure living

Aquatic Therapy

Aquatic therapy is an important part of the recreational therapy. From the Texas Women's University:

As a result of the myriad of deficits that can occur following a TBI, rehabilitation specialists are presented with a challenging opportunity to devise appropriate rehabilitation programs and adapted physical activity specialists to provide lifelong physical activity and recreation programs (Driver, 2002).

Specifically, aquatic recreation therapy allows an individual with a TBI to attempt patterns of movement in the water without fear of falling or weakness (Driver, O'Connor, Lox, & Rees, 2003). Further, completing movements in the water leads to strengthened postural muscles and increased stability. These benefits are particularly important to people with brain injuries whose balance may be compromised (Hrenko, Rees, Lox, & O'Connor, 2003).

Movement exploration in the water helps individuals understand their bodies, which is especially applicable to people with a brain injury who often lack feeling and knowledge of what their body is capable of doing (Lepore, Gayle, & Stevens, 1998). Some therapeutic psychomotor effects of water exercise include muscle relaxation, relief of pain and muscle spasms, maintenance or increased range of motion in joints, and improvement in muscular strength and endurance. This may lead to an increase in enjoyment of life, self-esteem, and self-awareness, as individuals are able to complete tasks on their own (Lepore, Gayle, & Stevens, 1998). Therefore, it is important to include recreation programs, such as adapted aquatics, that help to tackle the cognitive, physical, and social problems resulting from a brain injury (Zoerink & Lauener, 1991). Programs in rehabilitation are usually planned around the level of cognitive functioning a person exhibits (Lepore, 1987). The Adult Head Trauma service at Rancho Los Amigos Hospital (Downey, CA) has formulated a description of the levels of cognitive functioning at each stage of recovery.

Wheel Chair sports

Some people that suffer a TBI are left paralyzed in some way, which leaves them unable to walk. To help these patients stay active and healthy there are many wheel chair sports available to them. They can still participate in a variety of sports in their wheel chair these sports include: basketball, ping-pong, marathons, rugby, softball and many other sports as well. A wheel chair does not close the door to sports, it opens a door to many new forms of recreational activities.

Resources

National Resource Center for Traumatic Brain Injury
Virginia Commonwealth University
Physical Medicine and Rehabilitation
P.O. Box 980542
Richmond, VA 23298-0542
Phone:(804) 828-3704
Fax: (804) 828-2378
Email: jhmarwit@vcu.edu
Website: http://www.tbinrc.com/

Brain Injury Association of America
1608 Spring Hill Road, Suite 110
Vienna, VA 22182
PH 703-761-0750
Fax 703-761-0755
Website: http://www.biausa.org/index.htm

The Brain Injury Recovery Network
840 Central Street
Carlisle, OH 45005
PH 877-810-2100
Website http://tbirecovery.org/index.html

Family Caregiver Alliance

785 Market St., Suite 750
San Francisco, CA 94103
PH 800-445-8106
Website https://caregiver.org/

Brain Line
2775 S Quincy Street.
Arlington, VA 22206
Phone: 703.998.2020
E-mail: info@BrainLine.org
website: http://www.brainline.org/index.html

The Centre for Neuro Skills
email cns@neuroskills.com
phone **1.800.922.4994**
website: http://www.neuroskills.com/

Traumatic Brain Injury Resource Center
Website: http://www.braininjuryresources.org/

References

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http://www.twu.edu/inspire/traumatic-brain-injury-TBI.asp

http://calder.med.miami.edu/pointis/tbifam/rec1.html