

Traumatic Brain Injury for VR Counselors

Margaret A. Struchen, Ph.D. and Laura M. Ritter, Ph.D., M.P.H.

Training Session 1a: Basic Definition of TBI, Mechanism of Injury, and Epidemiology

- [What is a traumatic brain injury \(TBI\)?](#)
- [What is the difference between a head injury and a TBI?](#)
- [How do we know that brain functioning has been disrupted as a result of injury?](#)
- [How does the brain become injured?](#)
- [What is the difference between traumatic brain injury \(TBI\) and acquired brain injury \(ABI\)?](#)
- [What does it mean to say a client has sustained a mild, moderate, or severe TBI?](#)
- [To what extent is traumatic brain injury \(TBI\) a common health problem?](#)
- [References](#)



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What is a traumatic brain injury (TBI)?

A traumatic brain injury is also referred to as a TBI. A TBI occurs when an outside physical force is applied to the head and affects brain functioning. The physical force can consist of a blow to the head (such as from an assault, a fall, or when an individual strikes his/her head during a motor vehicle accident) or from a rapid acceleration-deceleration event (like a motor vehicle accident). It is possible for the brain to become injured even if the head has not directly struck or been struck by another object. The brain can become injured whether or not the skull is fractured. The most common causes of TBI include the following:

- Falls (28%)
- Motor vehicle-traffic crashes (20%)
- Struck by/against (19%)
- Assaults (11%).¹
- Blasts are a leading cause of TBI for active duty military personnel in war zones.²

[Return to top](#) or [Continue](#)



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What is the difference between a head injury and a TBI?

A head injury happens when a mechanical force is exerted towards an individual's head. Many things can cause a head injury. For example, a car accident, a fight, a fall, or other events can all cause a head injury.

- Most of the time, a head injury does not cause lasting problems. This is because the brain is well protected. The brain is surrounded by fluid, called cerebral spinal fluid (CSF). This fluid acts as a shock absorber. There are also several coverings around the brain. These coverings include the hair, the scalp, and the skull. There are also layers of tissue that cover the brain called *meninges*. These protective layers will often keep the brain from getting hurt. Often, a bruise, swelling of the scalp, or a cut to the scalp may be the only injury
- Sometimes the force of the blow to the head is greater. The skull can fracture or break. The skull is like a “helmet” that protects the brain. When the skull breaks, it lessens the force of the blow. This may help keep the brain from getting hurt. However, sometimes the force exceeds the skull's ability to protect the brain, and the brain itself can be injured. Given sufficient force, the brain can become injured whether or not the skull is fractured.
- When the force that resulted in the head injury affects brain functioning, such as reducing level of consciousness or by causing a period of confusion, the injury is called a **traumatic brain injury**. Only a subset of head injuries will result in traumatic brain injury.
 - For example, if you bump your head on the roof of your car, you probably will not injure your brain. If the only consequence of this injury is a sore head, no brain injury has occurred. This is a head injury, but not a traumatic brain injury.
 - However, if your car is struck by another vehicle and you have trouble recalling what happened during the first 24 hours after the injury, you may have experienced a TBI.

[Return to top](#) or [Continue](#)



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How do we know that brain functioning has been disrupted as a result of injury?

- We know that brain functioning has been disrupted if an individual has a change in their level of consciousness after injury or in their ability to be alert and/or fully oriented after injury. In general, the greater and/or longer the period of alteration in consciousness, the more severe the injury has been.
- After a TBI, some people are “knocked out” or lose consciousness. This can be for a short time (seconds to minutes) or for a much longer time (days to weeks). This longer period of time is often referred to as a *coma*.
- On the other hand, some people who experience a mild TBI may not lose consciousness at all. Instead, they may feel dazed, confused, or “out of it” for a period of time.
- For many people who experience a TBI, there may be loss of memory for the events that occurred just before and immediately after the injury. This is called *post-traumatic amnesia*.
 - The loss of memory for events before the injury is called *retrograde amnesia*.
 - The period of time when memory for events occurring after a TBI is forgotten is called *anterograde amnesia*.

[Return to top](#) or [Continue](#)



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How does the brain become injured?

Injury to the brain can happen in many different ways. There are two main types of TBI: Closed TBI and Open TBI.

- **Closed TBI** happens when the brain is hurt without anything (like a knife, a bullet, or other object) going through the skull. Other terms you may encounter for a closed TBI include brain injury due to *blunt-force trauma* or *non-penetrating TBI*. There are many ways that the brain can be injured in a closed TBI.
 - When force is applied to the head, the brain can shake around inside the skull. Think of the brain being like jello in a bowl. If you shake the bowl quickly and then stop it, the jello bounces around against the inside of the bowl. Just like jello, the brain can bounce against the inside of the skull. If the head stops quickly after it has been moving, the brain can hit the inside of the skull. When this happens, the brain can get a bruise. Sometimes the brain can be bruised both at the point of impact (*a coup injury*) and at a point directly opposite to that impact (*a contre-coup injury*). This is because the brain can “bounce” within the skull such that it will bruise both on the side where it has been struck and on the opposite side where the brain has “bounced” back after the impact.
 - When the brain is shaken inside the skull, other injuries can happen. The brain is made of millions of nerve cells called *neurons*. Each nerve cell has long and thin fibers called *axons*. These axons are important for the transmission of messages from one neuron to another. These fibers are very small and cannot be seen by the human eye. Some of these nerve fibers can be stretched or broken when the brain is shaken. This stretching and breaking of axons may be seen throughout the brain and is called *diffuse axonal injury*. Sometimes a person can have an injury to the brain, even when the head is not hit by anything. The force of the brain moving inside of the skull can cause these stretching or tearing injuries to the nerve fibers. If many of these fibers are damaged, the injury can sometimes be seen with neuroimaging tests, like a CT scan or MRI scan.
 - The brain has lots of blood vessels in it. These are called arteries and veins. If there is sufficient force applied to the head, these blood vessels can tear and bleed. Bleeding will show up on tests, like a CT scan or MRI scan. A collection of blood in the spaces between the *meninges* (layers of tissue surrounding the brain) and the skull is called an *epidural hematoma*. One that occurs between the outer layer of the meninges and the second layer of meninges is called a



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subdural hematoma. Blood collection below the second layer of meninges is called a *subarachnoid hemorrhage*. Finally blood that collects within the brain tissue itself is called *intracerebral hemorrhage*. If there is only a little bleeding, it will usually stop on its own. The blood vessels will heal, just like any cut on the body heals. If the bleeding is severe, doctors may recommend treatment, like surgery, to remove the blood.

- Sometimes extra fluid will build up near the hurt brain. This causes swelling or *edema*. Think of what happens when you hit your arm on something. You may see swelling in the injured area. This is because the body sends extra fluid to the injured body part to protect it and help with healing. This same thing can happen to the injured part of the brain.
- If too much pressure builds within the skull due to edema or to accumulation of blood, the individual is said to experience *intracranial hypertension*. This condition can cause additional damage to brain tissue if it is unable to be controlled and may even be life-threatening.
- **Open TBI** happens when something penetrates through the skull and hurts the brain. Other terms you may encounter for this type of injury include *penetrating TBI*. Things like a gunshot wound to the head, a stab wound, or a severe skull fracture can cause an open TBI.
 - In an open TBI, most of the damage happens to the part of the brain that was cut or bruised by the object penetrating the skull.
 - Just like in closed TBI, additional injury can occur due to bruising, bleeding, or swelling.

[Return to top](#) or [Continue](#)



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Training Session 1a: Basic Definition of TBI, Mechanism of Injury and Epidemiology

What is the difference between traumatic brain injury (TBI) and acquired brain injury (ABI)?

Increasingly, as one reads news articles, consumer-focused periodicals, and scientific publications about brain injury, the term “Acquired Brain Injury” or ABI has gained prominence. So, what distinguishes a TBI from an ABI?

- **Traumatic brain injury (TBI)** refers specifically to injuries to the brain that are the result of mechanical force. As described above, falls, motor vehicle accidents, assaults, and falling objects may cause a traumatic brain injury.
- **Acquired brain injury (ABI)** is a more general term that refers to any acquired (i.e., not developmental) injury to brain tissue. Traumatic brain injury is just one type of acquired brain injury. All traumatic brain injuries would be considered acquired brain injuries. However, not all acquired brain injuries should be considered traumatic brain injuries. Although not an exhaustive list, other causes of brain injury that would be classified as acquired brain injuries include:
 - **Stroke** (or “brain attack”) is when brain cells are damaged or die due to interruption of blood flow to the brain. There are two main types of strokes: 1) blockage of a blood vessel in the brain due to either a clot or a buildup of fatty deposits and cholesterol in the walls of blood vessels; and 2) breakage of a blood vessel in the brain with bleeding from the blood vessel.
 - **Cerebral aneurysm** is a weak or thin spot on a cerebral blood vessel wall that can break under pressure and result in a bleed or hemorrhagic stroke.
 - **Arteriovenous malformation** (also known as AVMs) are defects of the circulatory system that typically involve a collection of blood vessels with abnormal connections. Such malformations are usually present from birth and can occur in various areas of the body, including the brain. Typically, AVMs are non-symptomatic. However, a certain percentage of these cerebral malformations can cause problems such as headache, seizure, and other neurological symptoms. These occur either through bleeding from the AVM, through blockage of blood flow, or due to pressure effects on surrounding brain tissue.
 - **Brain Tumor** is a mass or growth of abnormal cells within the brain. These can be benign (noncancerous) or malignant (cancerous), slow-growing or fast-



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growing, and can be primary (the first site of cancer) or metastatic (a second site of cancer that has spread from somewhere else in the body).

- **Brain abscess** is an uncommon, but serious or life-threatening infection. An abscess is a mass of immune cells, pus, and other material due to bacterial or fungal infection.
- **Cerebral hypoxia** occurs when there is a decrease of oxygen supply to the brain even though there is adequate blood flow. Drowning, strangling, choking, suffocation, cardiac arrest, head trauma, carbon monoxide poisoning, and complications of general anesthesia can create conditions that can lead to cerebral hypoxia. Brain cells are extremely sensitive to oxygen deprivation and can begin to die within five minutes after oxygen supply has been cut off.
- **Radiation necrosis** is a focal structural lesion that usually occurs at the original tumor site and is a potential long-term central nervous system (CNS) complication of radiotherapy or radiosurgery. Radiation necrosis can occur when radiotherapy is used to treat primary CNS tumors, metastatic disease, or head and neck malignancies. It can occur secondary to any form of radiotherapy modality or regimen.

[Return to top](#) or [Continue](#)



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Training Session 1a: Basic Definition of TBI, Mechanism of Injury and Epidemiology

What does it mean to say a client has sustained a mild, moderate, or severe TBI?

Every brain injury is different. The level of severity of the initial injury can be related to many different variables. Such variables include how much force was involved, how hard the head was struck, how heavy the object was that struck the head, and how fast the head or object was moving at the time of injury. When an injury is referred to as mild, complicated mild, moderate, or severe, we are referring to the initial injury itself – not the eventual outcome that an individual with TBI may experience. It is possible that a person with an initial rating of mild TBI may experience a poor outcome that includes areas of moderate to severe difficulty. Likewise, an individual who presents initially with a severe injury may experience a very good outcome. However, in general, initial injuries with greater severity will be associated with poorer outcomes.

As soon as healthcare professionals encounter an individual with TBI, an attempt is made to grade the severity of the injury. The level of severity is determined to assist with initial triaging and to help with treatment planning. There are several factors that are considered when assessing injury severity, including loss of consciousness, duration of post-traumatic amnesia, and scores on the Glasgow Coma Scale, which is described below.

- **Loss of Consciousness (LOC):** One thing that the medical team looks at is called loss of consciousness. After a head injury, an individual may be “knocked out” or lose consciousness. Typically, the longer the period of unconsciousness, the more severe the injury that has occurred. In an acute hospital setting, the medical team will be tracking consciousness on an hourly and daily basis. Frequently, such tracking is done using a scale called the Glasgow Coma Scale (GCS).
- **Post-Traumatic Amnesia (PTA):** People may be confused or disoriented for a period of time after a TBI. They may not know where they are for minutes, hours, or even days. They may not be able to accurately state the day, date, time, month, or year. This period of time is called post-traumatic amnesia or post-traumatic confusion. It is a common experience for persons with TBI. During this time, people may be unable to make new memories. They may not remember this period of time later. In general, the longer the period of PTA, the more severe the injury has been. In acute hospital settings and in rehabilitation settings, a record of orientation is typically conducted on at least a daily basis. You may find this in a description from the treating physician or nursing staff, and you may find it in a report by the neuropsychologist or therapy staff.
- **Glasgow Coma Scale (GCS):** The GCS is a scale to assess responsiveness after TBI and is widely utilized in many hospital settings throughout the United States and the



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Training Session 1a: Basic Definition of TBI, Mechanism of Injury and Epidemiology

world.³ The GCS evaluates three aspects of responsiveness: eye opening (can the individual open his/her eyes spontaneously?), motor responses (can the person move when asked or when responding to painful stimuli?), and verbal responses (can the person speak and is the person oriented?). The GCS score can range from 3 to 15, with scores of 13-15 considered mild, 9-12 moderate, and 3-8 severe levels of injury. The scale values are shown in the table below. The medical team completes this scale at the scene of the injury if the individual is transported by EMS. The GCS is also completed upon arrival at the emergency room. If the individual requires hospitalization due to the injury, the GCS may be conducted hourly and/or several times daily until the individual is consistently responding as alert and oriented.

Mild TBI

A person with a mild TBI will have a loss of consciousness for 30 minutes or fewer. GCS scores at the time of injury range from 13 to 15. This means that the person can talk, can follow commands, and can open their eyes when asked. Persons with mild TBI may also have a period of time (from minutes to hours to days) when they are confused or disoriented. Another name for a mild traumatic brain injury is a “concussion.”

For some clients, their GCS score can be lower at first; however, this low score may be due to things other than the head injury. Medication effects or having had alcohol or drugs before the injury can lower a GCS score. After the effects of the medications have worn off, the injured person’s GCS score quickly begins to be within the “mild” range.

- **Uncomplicated Mild TBI:** An injury is called “uncomplicated” if the person has a mild TBI and there are NO problems seen on CT scan or MRI of the brain.
- **Complicated Mild TBI:** An injury is called “complicated” if the person has a mild TBI and there are abnormalities seen on a CT scan or MRI of the brain. Abnormalities on neuroimaging may reflect bruising of the brain or a collection of blood in the brain. Some research has shown that persons with complicated mild TBI may have longer-term outcomes that are more similar to those with moderate TBI.

Moderate to Severe TBI

For individuals who have sustained a moderate to severe TBI, GCS scores at the time of injury are lower. Traditionally, GCS scores ranging from 9-12 would be classified as “moderate” injuries, while GCS scores ranging from 3-8 would be classified as “severe” injuries.

Someone with a moderate to severe TBI may not be able to open their eyes, move on their own, talk, or respond to things or people around them. People with this severe of an injury



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may have had a loss of consciousness for just over 30 minutes or for as long as several days or weeks. They may have post-traumatic amnesia for many days or weeks both before and after they had their TBI. For most individuals with moderate to severe TBI who survive their initial injuries, a progression from coma through vegetative and minimally conscious states to a fully conscious state takes place. These individuals will usually take longer to recover than patients with a mild TBI. In some cases, some symptoms may be permanent. For a small subset of individuals with severe TBI, responsiveness may be affected for a much longer period of time. For nearly all those who experience moderate to severe TBI, treatment at a rehabilitation hospital is usually recommended and can help recovery.

[Return to top](#) or [Continue](#)



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Training Session 1a: Basic Definition of TBI, Mechanism of Injury and Epidemiology

To what extent is traumatic brain injury (TBI) a common health problem?

TBI is a pervasive health problem in our society, with an estimated incidence of 1.4 million new injuries per year.¹ The incidence rate of TBI substantially exceeds that of other neurological conditions, including epilepsy, stroke, and multiple sclerosis.⁴

Most cases of traumatic brain injury (approximately 80-85%) would be considered mild in severity, with the remaining 15-20% comprising individuals with more severe injuries. The majority of individuals with mild TBI experience symptoms in the initial weeks and months after injury, but tend to improve to near pre-injury levels after approximately three months. However, a subset of individuals with mild TBI continues to experience persisting symptoms following their injuries. At this time, it is not well understood why some individuals continue to have difficulties over time after mild TBI. The likely contributions to outcome after brain injury are multifactorial in nature, and include variables related to the force and type of injury, personal characteristics of the injured person (and brain), severity of injury, the symptom presentation, reactions to such symptoms, and available resources to address issues after TBI.

For those with moderate to severe TBI, it is more likely that initial injury-related symptoms may continue to be a factor long-term after injury. With increasing severity of injury and with greater degrees of initial impairments related to such injuries, the probability that symptoms will be longstanding increases.

Epidemiological studies have shown that TBI results in severe disability for 30 to 40 per 100,000 individuals.⁵⁻⁶ which translates to approximately 75,000 to 80,000 new cases of disability each year.⁷ Recently, estimates suggest that there are 5.3 million people living with disability as a result of TBI.⁸ These statistics underscore the large number of individuals, families, and communities that are affected by TBI.

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- [Return to the top](#)
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Training Session 1a: Basic Definition of TBI, Mechanism of Injury and Epidemiology

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Training Session 1a: Basic Definition of TBI, Mechanism of Injury and Epidemiology

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- [Return to Top](#) or [Continue to Training Session 1b](#)



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