Traumatic Brain Injury

Hope Through Research

National Institute of Neurological Disorders
and Stroke
National Institutes of Health

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What is a TBI?

A traumatic brain injury (TBI) can be caused by a forceful bump, blow, or jolt to the head or body, or from an object that pierces the skull and enters the brain. Not all blows or jolts to the head result in a TBI.

Some types of TBI can cause temporary or short-term problems with normal brain function, including problems with how the person thinks, understands, moves, communicates, and acts. More serious TBI can lead to severe and permanent disability, and even death.

Some injuries are considered ***primary***, meaning the damage is immediate. Other outcomes of TBI can be ***secondary***, meaning they can occur gradually over the course of hours, days, or appear weeks later. These secondary brain injuries are the result of reactive processes that occur after the initial head trauma.

There are two broad types of head injuries: penetrating and non-penetrating.

- *Penetrating TBI* (also known as *open TBI*) happens when an object pierces the skull (for example, a bullet, shrapnel, bone fragment, or by a weapon such as hammer or knife) and enters the brain tissue. Penetrating TBI typically damages only part of the brain.

- *Non-penetrating TBI* (also known as *closed head injury* or *blunt TBI*) is caused by an external force strong enough to move the brain within the skull. Causes include falls, motor vehicle crashes, sports injuries, blast injury, or being struck by an object.

Some accidents such as explosions, natural disasters, or other extreme events can cause both penetrating and non- penetrating TBI in the same person.

What are the signs and symptoms?

Seek immediate medical attention if you experience any of the following physical, cognitive/behavioral, or sensory symptoms, especially within the first 24 hours after a TBI:

Physical

- headache
- convulsions or seizures
- blurred or double vision
- unequal eye pupil size or dilation
- clear fluids draining from the nose or ears
- nausea and vomiting
- new neurologic deficit, i.e., slurred speech; weakness of arms, legs, or face; loss of balance

Cognitive/behavioral

- loss of or change in consciousness anywhere from a few seconds to a few hours
- decreased level of consciousness, i.e., hard to awaken
- mild to profound confusion or disorientation
- problems remembering, concentrating, or making decisions
- changes in sleep patterns (e.g., sleeping more, difficulty falling or staying asleep); inability to waken from sleep
- frustration, irritability

Perception/sensation

- light-headedness, dizziness, vertigo, or loss of balance or coordination

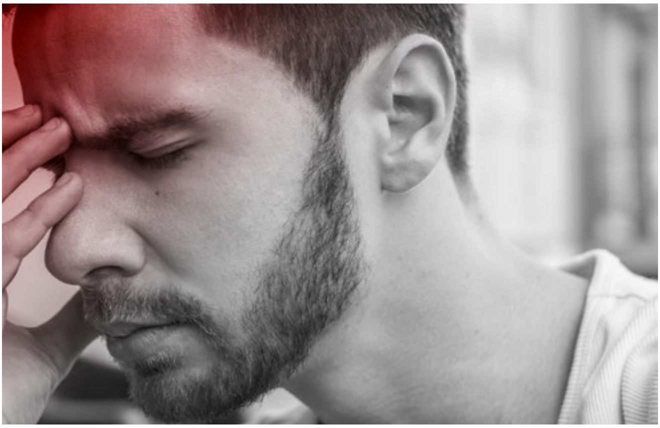
- blurred vision
- hearing problems, such as ringing in the ears
- bad taste in the mouth
- sensitivity to light or sound
- mood changes or swings, agitation, combativeness, or other unusual behavior
- feeling anxious or depressed
- fatigue or drowsiness; a lack of energy or motivation

Headache, dizziness, confusion, and fatigue tend to start immediately after an injury, but resolve over time. Emotional symptoms such as frustration and irritability tend to develop during recovery.

TBI in children

Children might be unable to let others know that they feel different following a blow to the head. A child with a TBI may display the following signs or symptoms:

- changes in eating or nursing habits
- persistent crying, irritability, or crankiness; inability to be consoled
- changes in ability to pay attention
- lack of interest in a favorite toy or activity
- changes in sleep patterns
- seizures
- sadness or depression
- loss of a skill, such as toilet training
- loss of balance or unsteady walking
- vomiting



TBI symptoms including headache, dizziness, confusion, and fatigue tend to start immediately after an injury, but resolve over time.

Effects on consciousness

A TBI can cause problems with consciousness, awareness, alertness, and responsiveness. Generally, there are four abnormal states that can result from a severe TBI:

- ***Minimally conscious state*** — People with severely altered consciousness who still display some evidence of self-awareness or awareness of one's environment (such as following simple commands, yes/no responses).
- ***Vegetative state*** — A result of widespread damage to the brain, people in a vegetative state are unconscious and unaware of their surroundings. However, they can have periods of unresponsive alertness and may groan, move, or show reflex responses. If this state lasts longer than a few weeks, it is referred to as a *persistent vegetative state*.
- ***Coma*** — A person in a coma is unconscious, unaware, and unable to respond to external stimuli

such as pain or light. Coma generally lasts a few days or weeks after which the person may regain consciousness, die, or move into a vegetative state.

- ***Brain death*** — The lack of measurable brain function and activity after an extended period of time is called brain death and may be confirmed by studies that show no blood flow to the brain.

How does TBI affect the brain?

TBI-related damage can be confined to one area of the brain, known as a *focal injury*, or it can occur over a more widespread area, known as a *diffuse injury*. The type of injury also affects how the brain is damaged.

Primary effects on the brain include various types of bleeding and tearing forces that injure nerve fibers and cause inflammation, metabolic changes, and brain swelling.

- ***Diffuse axonal injury (DAI)*** — one of the most common types of brain injuries — refers to widespread damage to the brain's white matter. White matter is composed of bundles of axons (the projections of nerve cells that carry electrical impulses and connect various areas of the brain to one another). DAI usually results from rotational forces (twisting) or sudden forceful stopping that stretches or tears these axon bundles. This damage commonly occurs in auto accidents, falls, or sports injuries. DAI can disrupt and break down communication among nerve cells (neurons) in the brain. It also leads to the release of brain chemicals that can cause further damage. Brain damage may be temporary or permanent and recovery can be prolonged.

- ***Concussion*** — a type of mild TBI that may be considered a temporary injury to the brain but could take minutes to several months to heal. Concussion can be caused by a number of things including a bump, blow, or jolt to the head, sports injury or fall, motor vehicle accident, weapons blast, or a rapid acceleration or deceleration of the brain within the skull (such as the person having been violently shaken). The individual either suddenly loses consciousness or has sudden altered state of consciousness or awareness. A second concussion closely following the first one causes further damage to the brain — the so-called "second hit" phenomenon — and can lead to permanent damage or even death in some instances. Post-concussion syndrome involves symptoms that last for weeks or longer following concussion.

- ***Hematomas*** — bleeding in and around the brain caused by a rupture to a blood vessel. Different types of hematomas form depending on where the blood collects relative to the meninges, the protective membranes surrounding the brain, which consist of three layers: dura mater (outermost), arachnoid mater (middle), and pia mater (innermost).
  - *Epidural hematomas* involve bleeding into the area between the skull and the dura mater. These can occur within minutes to hours after damage to a brain vessel under the skull and are particularly dangerous.
  - *Subdural hematomas* involve bleeding between the dura and the arachnoid mater, and, like epidural hematomas, exert pressure on the outside of the brain. They are very common in the elderly after a fall.

- *Subarachnoid hemorrhage* is bleeding between the arachnoid mater and the pia mater.
- Bleeding into the brain itself is called an *intracerebral hematoma* and damages the surrounding tissue.

- ***Contusions*** — a bruising or swelling of the brain that occurs when very small blood vessels bleed into brain tissue. Contusions can occur directly under the impact site (i.e., a *coup injury*) or, more often, on the complete opposite side of the brain from the impact (i.e., a *contrecoup injury*). They can appear after a delay of hours to a day. Coup and contrecoup lesions generally occur when the head abruptly decelerates, which causes the brain to bounce back and forth within the skull (such as in a high-speed car crash or in *shaken baby syndrome*).
- ***Skull fractures*** — breaks or cracks in one or more of the bones that form the skull. They are a result of blunt force trauma and can cause damage to the membranes, blood vessels, and brain under the fracture. One main benefit of helmets is to prevent skull fracture.
- ***Chronic traumatic encephalopathy (CTE)*** is a progressive neurological disorder associated with symptoms that may include problems with thinking, understanding, and communicating; motor disorders (affecting movement); problems with impulse control and depression; confusion; and irritability. CTE occurs in those with extraordinary exposure to multiple

Skull fractures result from blunt force trauma and can cause damage to underlying areas of the skull.

blows to the head and as a delayed consequence after many years. Studies of retired boxers have shown that repeated blows to the head can cause issues including memory problems, tremors, and lack of coordination and dementia. Recent studies have demonstrated rare cases of CTE in other sports with repetitive mild head impacts (e.g., soccer, wrestling, football, and rugby). A single, severe TBI also may lead to a disorder called *post-traumatic dementia (PTD)*, which may be progressive and share some features with CTE. Studies assessing patterns among large populations of people with TBI indicate that moderate or severe TBI in early or mid-life may be associated with increased risk of dementia later in life.

Secondary damage can include:

- ***Hemorrhagic progression of a contusion*** *(HPC)* injuries occur when an initial contusion from the primary injury continues to bleed in and around the brain and expand over time. This creates a new or larger lesion — an area of tissue that has been damaged through injury or disease. This increased exposure to blood, which is toxic to brain cells, leads to swelling and further brain cell loss.

- ***A breakdown in the blood-brain barrier*** — a network of cells that controls the movement of cells and molecules between the blood and fluid that surrounds the brain's nerve cells. Once the blood-brain barrier is disrupted, blood, plasma proteins, and other foreign substances leak into the space between neurons in the brain and trigger a chain reaction that causes brain swelling. It also causes multiple biological systems to go into overdrive, including inflammatory responses which can be harmful to the body if they continue for an extended period of time. It also permits the release of neurotransmitters — chemicals used by brain cells to communicate — which can damage or kill nerve cells when depleted or over-expressed.

- ***Increased intracranial pressure***, usually caused by brain swelling inside the confined area of the skull as a result of the injury. This pressure can damage brain tissue and can prevent blood flow to the brain and deprive it of the oxygen it needs to function.

Other secondary damage can be caused by infections to the brain, low blood pressure or oxygen flow as a result of the injury, hydrocephalus (a buildup of fluid in the brain that can increase pressure on brain tissue), and seizures.

What are the leading causes of TBI?

Falls. According to data from the Centers for Disease Control and Prevention (CDC), falls are the most common cause of TBIs and occur most frequently among the youngest and oldest age groups. From 2006 to 2010 alone, falls caused more than half (55 percent) of TBIs among children aged 14 and younger. Among Americans age 65 and older, falls accounted for more than two-thirds (81 percent) of all reported TBIs.

Blunt trauma accidents. Accidents that involve being struck by or against an object, particularly sports-related injuries, are a major cause of TBI. Anywhere from 1.6 million to 3.8 million sports- and recreation-related TBIs are estimated to occur in the United States annually.

Vehicle-related injuries. Pedestrian-involved accidents, as well as accidents involving motor vehicles and bicycles, are the third most common cause of TBI. In young adults aged 15 to 24 years, motor vehicle accidents are the most likely cause of TBI.

Assaults/violence. Assaults include abuse related TBIs, such as head injuries that result from domestic violence or shaken baby syndrome, and gunshot wounds to the head. TBI-related deaths in children age 4 and younger are most likely the result of assault.

Explosions/blasts. TBIs caused by blast trauma from roadside bombs became a common injury to service members in recent military conflicts. The majority of these TBIs were classified as mild head injuries.

Adults age 65 and older are at greatest risk for being hospitalized and dying from a TBI, most likely from a fall. In every age group, serious TBI rates are higher for men than for women. Men are more likely to be hospitalized and are nearly three times more likely to die from a TBI than women.

Additional information about TBI and its causes can be found on the U.S. Centers for Disease Control and Prevention TBI website: http://www.cdc.gov/TraumaticBrainInjury/.

Vehicle-related injuries are the third most common cause of TBI.

How is TBI diagnosed?

All TBIs require immediate assessment by a professional who has experience evaluating head injuries. A neurological exam will judge motor and sensory skills and test hearing and speech, coordination and balance, mental status, and changes in mood or behavior, among other abilities. Screening tools for coaches and athletic trainers can identify the most concerning concussions for medical evaluation.

Initial assessments may rely on standardized instruments such as the *Acute Concussion Evaluation (ACE)* form from the Centers for Disease Control and Prevention or the *Sport Concussion Assessment Tool 2*, which provide a systematic way to assess a person who has suffered a mild TBI. Reviewers collect information about the characteristics of the injury, the presence of amnesia (loss of memory) and/or seizures, as well as the presence of physical, cognitive, emotional, and sleep-related symptoms. The ACE is also used to track symptom recovery over time. It also takes into account risk factors (including concussion, headache, and psychiatric history) that can impact how long it takes to recover from a TBI.

Diagnostic imaging. When necessary, medical providers will use brain scans to evaluate the extent of the primary brain injuries and determine if surgery will be needed to help repair any damage to the brain. The need for imaging is based on a physical examination by a doctor and a person's symptoms.

- **Computed tomography** (CT) is the most commonly used imaging technology to assess people with suspected moderate to severe TBI. CT uses a series of X-rays (concentrated bursts of ionizing radiation) to create a two-dimensional image of organs, bones, and tissues and can show a skull fracture or any brain bruising, bleeding, or swelling.

- **Magnetic resonance imaging** (MRI) uses computer generated radio waves and a powerful magnetic field to produce detailed images of body tissue. It may be used after the initial assessment and treatment as it is a more sensitive test and picks up subtle changes in the brain that the CT scan might have missed.

  Much of what is believed to occur to the brain following mild TBI happens at the cellular level. Significant advances have been made in the last decade to image milder TBI damage. For example, **diffusion tensor imaging** can image white matter tracts, more sensitive tests like **fluid-attenuated inversion recovery** can detect small areas of damage, and susceptibility-weighted imaging very sensitively identifies bleeding. Despite these improvements, currently available imaging technologies, blood tests, and other measures remain inadequate for detecting these changes in a way that can help diagnose mild concussive injuries.

The most common imaging technology used to evaluate people with suspected TBI is computed tomography or CT.

Neuropsychological tests to gauge brain functioning are often used in conjunction with imaging in people who have suffered mild TBI. Such tests involve performing specific cognitive tasks that help assess memory, concentration, information processing, executive functioning, reaction time, and problem solving. The ***Glasgow Coma Scale*** is the most widely used tool for assessing the level of consciousness after TBI. The standardized 15-point test measures a person's ability to open his or her eyes and respond to spoken questions or physical prompts for movement. A total score of 3-8 indicates a severe head injury; 9-12 indicates moderate injury; and 13-15 is classified as mild injury. (For more information about the scale, see http://glasgowcomascale.org/).

Many athletic organizations recommend establishing a baseline picture of an athlete's brain function at the beginning of each season, ideally before any head injuries have occurred. Baseline testing should begin as soon as a child begins a competitive sport. Brain function tests yield information about an individual's memory, attention, and ability to concentrate and solve problems. Brain function tests can be repeated at regular intervals (every 1 to 2 years) and also after a suspected concussion. The results may help health care providers identify any effects from an injury and allow them to make more informed decisions about whether a person is ready to return to their normal activities.

How is TBI treated?

Many factors, including the size, severity, and location of the brain injury, influence how a TBI is treated and how quickly a person might recover. People who receive immediate medical attention at a certified trauma center tend to have the best health outcomes.

Treating mild to moderate TBI

Some people with mild TBI such as concussion may not require treatment other than rest and over-the-counter pain relievers. Treatment should focus on symptom relief and "brain rest." Monitoring by a healthcare practitioner is important to note any worsening of symptoms or new ones.

Children and teens who have a sports-related concussion should stop playing immediately and return to play only after being approved by a concussion injury specialist.

Preventing future concussions is critical. While most people recover fully from a first concussion within a few weeks, the rate of recovery from a second or third concussion is generally slower.

Even after symptoms resolve entirely, people should return to their daily activities gradually once they are given permission by a doctor. There is no clear timeline for a safe return to normal activities although there are guidelines such as those from the American Academy of Neurology and the American Medical Society for Sports Medicine to help determine when athletes can return to practice or competition. Further research is needed to better understand the effects of mild TBI on the brain and to determine when it is safe to resume normal activities.

People with a mild TBI should:

- Make an appointment for a follow-up visit with their healthcare provider to confirm the progress of their recovery.
- Inquire about new or persistent symptoms and how to treat them.
- Pay attention to any new signs or symptoms even if they seem unrelated to the injury (for example, mood swings, unusual feelings of irritability).

These symptoms may be related even if they occurred several weeks after the injury.

Medications to treat some of the symptoms of TBI may include:

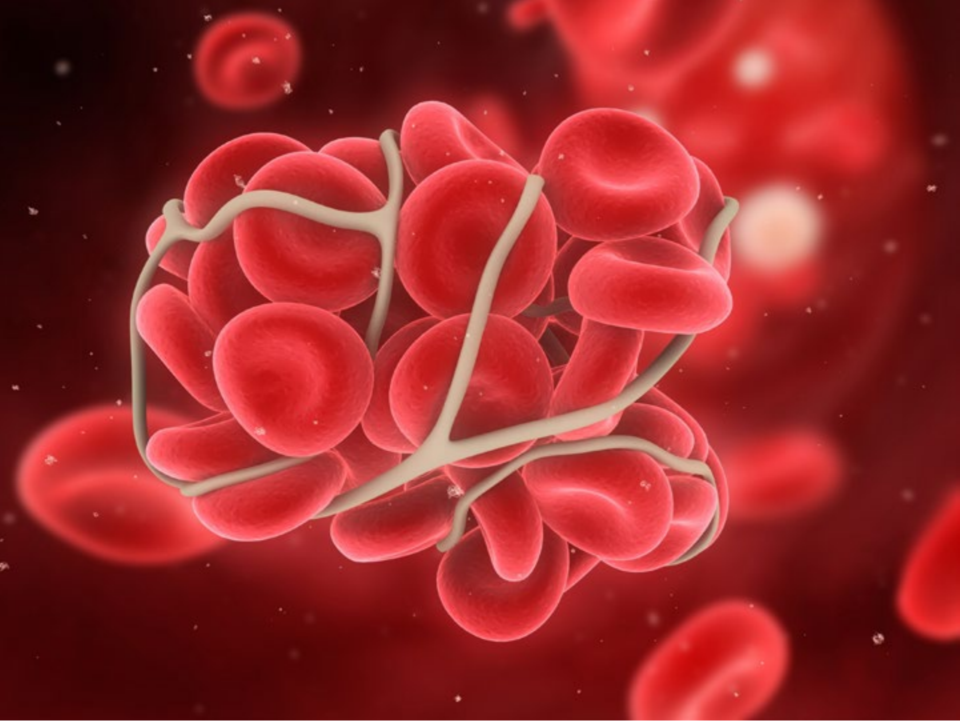
- Over-the-counter or prescribed pain medicines
- Anticonvulsant drugs to treat seizures
- Anticoagulants to prevent blood clots
- Diuretics to help reduce fluid buildup and reduce pressure in the brain
- Stimulants to increase alertness
- Antidepressants and anti-anxiety medications to treat depression and feelings of fear and nervousness.

Treating severe TBI

Immediate treatment for someone who has suffered a severe TBI focuses on preventing death; stabilizing the person's spinal cord, heart, lung, and other vital organ functions; ensuring proper oxygen delivery and breathing; controlling blood pressure; and preventing further brain damage. Emergency care staff also will monitor the flow of blood to the brain, brain temperature, pressure inside the skull, and the brain's oxygen supply.

Surgery may be needed to for emergency medical care and to treat secondary damage, including:

- relieving pressure inside the skull (inserting a special catheter through a hole drilled into the skull to drain fluids and relieve pressure)
- removing debris or dead brain tissue (especially for penetrating TBI)
- removing hematomas
- repairing skull fractures.



In-hospital strategies for managing people with severe TBI focus on preventing infection and blood clots (like the one shown above).

In-hospital strategies for managing people with severe TBI aim to prevent conditions including:

- Infection, particularly pneumonia
- deep vein thrombosis (blood clots that occur deep within a vein; risk increases during long periods of inactivity)

People with TBIs may need nutritional supplements to minimize the effects that vitamin, mineral, and other dietary deficiencies may cause over time. Some individuals may even require tube feeding to maintain the proper balance of nutrients.

Rehabilitation

After the acute care period of in-hospital treatment, people with severe TBI are often transferred to a rehabilitation center where a multidisciplinary team of health care providers help with recovery.

The rehabilitation team includes neurologists, nurses, psychologists, nutritionists, as well as physical, occupational, vocational, speech, and respiratory therapists.

Therapy is aimed at improving the person's ability to handle activities of daily living and to address cognitive, physical, occupational, and emotional difficulties. Treatment may be needed only short-term or throughout a person's life. Some therapy is provided through outpatient services.

Cognitive rehabilitation therapy (CRT) is a strategy aimed at helping individuals regain their normal brain function through an individualized training program. Using this strategy, people may also learn compensatory strategies for coping with persistent deficiencies involving memory, problem solving, and the thinking skills to get things done. CRT programs tend to be highly individualized and their success varies. A 2011 Institute of Medicine report concluded that cognitive rehabilitation interventions need to be developed and assessed more thoroughly.

Other factors that influence recovery

Genes

Genetics may play a role in how quickly and completely a person recovers from a TBI. For example, researchers have found that apolipoprotein E ε4 (ApoE4) — a genetic variant associated with higher risks for Alzheimer's disease — is associated with worse health outcomes following a TBI. Much work remains to be done to understand how genetic factors, as well as how specific types of head injuries, affect recovery. This research may lead to new treatment strategies and improved outcomes for people with TBI.

Age

Studies suggest that age and the number of head injuries a person has suffered over his or her lifetime are two critical factors that impact recovery. For example, TBI-related brain swelling in children can be very different from the same condition in adults, even when the primary injuries are similar. Brain swelling in newborns, young infants, and teenagers often occurs much more quickly than it does in older individuals. Evidence from very limited CTE studies suggest that younger people (ages 20 to 40) tend to have behavioral and mood changes associated with CTE, while those who are older (ages 50+) have more cognitive difficulties.

Compared with younger adults with the same TBI severity, older adults are likely to have less complete recovery. Older people also have more medical issues and are often taking multiple medications that may complicate treatment (e.g., blood-thinning agents when there is a risk of bleeding into the head). Further research is needed to determine if and how treatment strategies may need to be adjusted based on a person's age.

Researchers are continuing to look for additional factors that may help predict a person's course of recovery.

Can a TBI be prevented?

The best treatment for TBI is prevention. Unlike most neurological disorders, head injuries can be prevented. According to the CDC, doing the following can help prevent TBIs:

- Wear a seatbelt when you drive or ride in a motor vehicle.

Wearing a seatbelt when you drive or ride in a motor vehicle can help prevent TBI.

- Wear the correct helmet and make sure it fits properly when riding a bicycle, skateboarding, and playing sports like hockey and football.
- Install window guards and stair safety gates at home for young children.
- Never drive under the influence of drugs or alcohol.
- Improve lighting and remove rugs, clutter, and other trip hazards in the hallway.
- Use nonslip mats and install grab bars next to the toilet and in the tub or shower for older adults.
- Install handrails on stairways.
- Improve balance and strength with a regular physical activity program.
- Ensure children’s playgrounds are made of shock-absorbing material, such as hardwood mulch or sand.

What research is NINDS funding?

The mission of the National Institute on Neurological Disorders and Stroke (NINDS) is to seek fundamental knowledge about the brain and nervous system and use that knowledge to reduce the burden of neurological disease. The NINDS is a component of the National Institutes of Health (NIH), the leading supporter of biomedical research in the world.

NINDS supports research across the full range of TBI severity, in animal models and people, from children to adults. Projects focus on the mechanisms that result in immediate and delayed damage to the brain, on the processes that underlie recovery, and developing better diagnostic tools and more effective treatments.

Among NINDS research efforts:

- Transforming Research and Clinical Knowledge in TBI, or TRACK TBI, is an observational study of adults and children with TBI across the spectrum of injury severity. It is creating a TBI database and provides tools and resources to establish more precise methods to diagnose TBI, improve outcome assessment, and compare the effectiveness and costs of tests, treatments, and services. The data from this study will be available in the Federal Interagency TBI Research database (which enables comparisons across clinical trials and clinical studies.

- Scientists can now look in real time at how head injury affects thousands of individual cells and genes simultaneously in mice. Using a novel sequencing technique that can quickly analyze the gene activity of a cell, scientists were able to look individual brain cells in the hippocampus, a region of the brain involved in learning and memory, after TBI or in uninjured control animals. Scientists can now pinpoint which genes to treat with new therapies.

- Researchers are conducting studies to better understand the lasting effects of a single head injury vs. repetitive injuries to the brain, how repetitive TBI might lead to chronic traumatic encephalopathy, and how commonly these changes occur among adults. NINDS researchers are currently working to identify biomarkers (signs that may indicate risk of a disease and aid in diagnosis) for chronic traumatic encephalopathy in order to detect this and similar disorders in living people rather than through brain studies after death.
- Researchers are exploring ways to promote the brain's innate ability to adapt and repair itself, known as *neuroplasticity*.
- A developed mouse model of TBI is enabling researchers to look at potential treatments for concussion. Using the model, they found that applying glutathione (an antioxidant that is normally found in our cells) directly on the skull surface after brain injury reduced the amount of brain cell death.

NINDS funds a wide range of TBI research in an effort to find better ways to safely detect, treat, and ultimately prevent TBI.

- The NINDS-funded Translational Outcomes Project in Neurotrauma (TOP-NT) consortium supports development and creation of better assessment tools for preclinical studies in TBI and spinal cord injury and to support data sharing to improve preclinical studies and clinical trial design.
- In February 2018 the U.S. Food and Drug Administration authorized marketing the first blood test to help diagnose concussion. NINDS funded the early work on the project and the Department of Defense supported its later development.

In addition to NINDS, other NIH Institutes fund research on TBI. Research projects on TBI and other disorders can be found using NIH RePORTER (http://projectreporter.nih.gov), a searchable database of current and past research projects supported by NIH and other federal agencies. RePORTER also includes links to publications from these projects and other resources.

Clinical trials

Despite recent progress in understanding what happens in the brain following TBI, more than 30 large clinical trials have failed to identify specific treatments that make a dependable and measurable difference in people with TBI. A key challenge facing doctors and scientists is the fact that each person with a TBI has a unique set of circumstances based on such multiple variables as the location and severity of the injury, the person's age and overall heath, and the time between the injury and the initiation of treatment. These factors, along with differences in care across treatment centers, highlight the importance of coordinating research efforts so that the results of potential new treatments can be confidently measured.

The NINDS Common Data Elements Project brings the research community together to develop data collection standards.

NINDS co-leads the Strategies to Innovate EmeRgENcy Care Clinical Trials (SIREN) network, with projects that include TBI trials — one of which is looking at brain tissue oxygen monitoring to improve neurologic outcome in the most severely injured people with TBI.

Harnessing the efforts of the many physicians and scientists working on developing better treatments for TBI requires everyone to collect the same types of information from people, including details about injuries and treatment results. To lay the groundwork for these studies, NINDS started the Common Data Elements project. This effort brings the research community together to develop data collection standards.

Interagency and International Research Collaboration

NINDS — in coordination with the European Commission (that also supports brain health) — brings together studies through the International Initiative for TBI research (InTBIR) to collect data and encourage new collaborations to improve diagnosis and evaluate which types of care are associated with the best outcomes in children and adults.

NIH and the Department of Defense together lead the Federal Interagency TBI Research (FITBIR) database, which includes both new observational studies and other studies, such as the Child Health After Injury Study.

NIH investigators along with the Food and Drug Administration, are active collaborators in the Department of Defense-led TBI Endpoints Initiative to advance diagnosis and treatment of TBI.

NINDS also works with Department of Defense and the Departments of Health and Human Services, Veterans Affairs, and Education to coordinate TBI research for military members. This National Research Action Plan (NRAP) aims to improve prevention, diagnosis, and treatment of TBI and other mental health conditions such as PTSD that affect veterans and their families. The findings resulting from NRAP will be rapidly translated into new effective prevention strategies and clinical innovations, as well as identify biomarkers to detect these disorders early and accurately.

How can I support TBI research?

If you or someone you know has been diagnosed with a TBI, enrolling in a clinical trial or brain bank are the best ways to support research toward new and better treatment options.

Clinical trials are research studies that involve people. Studies involving individuals with TBI and healthy individuals offer researchers the opportunity to greatly increase our knowledge of TBI and find better ways to safely detect, treat, and ultimately prevent TBI. By participating in a clinical study, healthy individuals and those with TBI can greatly benefit the lives of those living with this disorder. Talk with your doctor about clinical studies and help to make the difference in the quality of life for all people with TBI. Trials take place at medical centers across the United States and elsewhere. For information about NINDS-funded studies on TBI, see www.clinicaltrials.gov and search for "TBI AND NINDS." For additional studies on TBI and information about participating in clinical studies, visit the "NIH Clinical Trials and You" website at (www.nih.gov/health/clinicaltrials). Always talk with your health care provider before enrolling in a clinical trial.

People with a TBI also can support TBI research by designating the donation of brain tissue before they die. The study of human brain tissue is essential to increasing the understanding of how the nervous system functions.

The NIH NeuroBioBank (https://neurobiobank.nih.gov) is an effort by the National Institutes of Health to coordinate the network of brain banks it supports in the United States to advance research through the collection and distribution of post-mortem brain tissue. Stakeholder groups include brain and tissue repositories, researchers, NIH program staff, information technology experts, disease advocacy groups, and most importantly individuals seeking information about opportunities to donate. It ensures protection of the privacy and wishes of donors. Creating a network of these centers makes it more likely that precious tissue can be made available to the greatest number of scientists.

Where can I get more information?

For more information on neurological disorders or research programs funded by the National Institute of Neurological Disorders and Stroke, contact the

Institute's Brain Resources and Information Network (BRAIN) at:

BRAIN
P.O. Box 5801
Bethesda, MD 20824
301-496-5751
800-352-9424
www.ninds.nih.gov

Additional information about TBI is available from the following organizations:

Brain Injury Association of America
1608 Spring Hill Road, Suite 110
Vienna, VA 22182
703-761-0750
800-444-6443
www.biausa.org

Brain Injury Resource Center
P.O. Box 84151
Seattle, WA 98124
206-621-8558
www.headinjury.com

Brain Trauma Foundation
1 Broadway, 6th Floor
New York, NY 10004-1007
212-772-0608
www.braintrauma.org

Uniformed Services University of the Health Sciences (USUHS)
Center for Neuroscience and Regenerative Medicine (CNRM)
NIH-USUHS TBI Center
4301 Jones Bridge Road
Bethesda, MD 20814-4799
www.usuhs.mil/cnrm

Defense and Veterans Brain Injury Center
7700 Arlington Blvd. Suite 5101
Box #22
Falls Church, VA 22041
800-870-9244
https://dvbic.dcoe.mil/

U.S. Centers for Disease Control and Prevention Heads Up to Concussion
National Center for Injury Prevention and Control (NCIPC)
Division of Unintentional Injury Prevention
1600 Clifton Road
Atlanta, GA 30329-4027
800-232-4636
TTY: 888-232-6348
www.cdc.gov/headsup/index.html

National Rehabilitation Information Center
8400 Corporate Drive, Suite 500
Landover, MD 20785
800-346-2742
www.naric.com

ThinkFirst
National Injury Prevention Foundation
1801 N. Mill Street, Suite F
Naperville, IL 60563
630-961-1400
800-844-6556
www.thinkfirst.org

National Library of Medicine
National Institutes of Health
8600 Rockville Pike
Bethesda, MD 20894
301-594-5983
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