Animated Mild Traumatic Brain Injury

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Video Link: http://www.brainline.org/content/multimedia.php?id=850

Narrator: Traumatic brain injuries, also referred to as TBIs occur across the United States at an estimated rate of 1 every 16 seconds. Symptoms of these so called mild traumatic brain injuries (TBIs) typically involve problems with memory, mood changes and personality changes. Most of these injuries go undiagnosed because the symptoms are only detectable by those who knew the person well before the injury occurred. Frequently diagnosis of a mild TBI is dependent upon history and clinical presentation because physical evidence of injury often does not exist.

There may be no evidence of a direct blow to the head or any type of direct head trauma immediately following incidence of a mild TBI. Such evidence may be absent because injury can occur with little or no impact to the head. The TBI itself results from the soft friable brain impacting on the hard sharp ridges on the inside of the skull during a sudden acceleration or deceleration event.

There maybe absolutely no head impact involved, or the head impact may be against a cushioned surface such as an airbag or head rest leaving little or no evidence of impact on the face or head.

Traditional imaging studies like CT and MRI most often show no evidence of mild TBIs because they are not sensitive enough to detect the widespread microscopic axonal injuries that can collectively result in devastating neuropsychological and cognitive deficits.
TBIs can occur as the result of impacts at varying speeds from multiple directions. The severity of the TBI does not necessarily correlate with the speed of a vehicle during a collision, but with the unique combination of deceleration and rotational forces that affect the brain during the collision.

The car crash animation sequences show how a sudden deceleration injury typically occurs. For purposes of demonstration, an impact at a speed of 15-35 miles per hour into a sturdy barrier was used. A frontal impact was selected because frontal impacts are one of the most commonly occurring causes of TBIs. The crash depicted in the animation was based on video studies of crashes studies performed by a number of crash test engineers.

The first animation sequence shows the impact and sudden deceleration at a speed that is slightly slower than real time to help demonstrate the violence of the motion. The collision is then repeated in slow motion to highlight the detailed movements of the upper body and head. Prior to the impact of the vehicle, the body and head are traveling at the same rate of speed. At the moment of impact the vehicle suddenly stops but the body and head continue to travel forward.

Next, the bodies forward motion is halted by the seatbelt, but the head continues to travel forward. The left shoulders forward motion is halted by the shoulder harness before the rest of the body. So rotation is added to the upper body and head in addition to the continuing forward motion. The head then comes to a sudden halt as it impacts with the air bag. At the moment of impact, the head violently rotates and begins an immediate reversal of movement. This back and forth motion is sometimes referred to as contra-coup effect.

The head then rebounds into the headrest experiencing yet another immediate and violent impact and change of direction.

In order to understand how TBI s occur one must have a detailed understanding of some areas of the brain as well as a basic understanding of the relationships of various significant structures of the brain to the head and skull. In this animation sequence the head and brain are sectioned through the left eye. The brain is surrounded in the skull by cerebrospinal fluid. This fluid helps protect the soft, friable brain from impacts with the hard jagged edges of the inner skull.

The brain is composed of gray matter and white matter. Gray matter consists of cell bodies. White matter consists of myelinated extensions of the cell bodies that communicate with other cell bodies. These extensions are called axons. The arteries that supply the brain penetrate the external surfaces of the brain and divide into smaller and smaller branches. Upon microscopic examination of the brain one can appreciate the relationship between the fragile axons as compared to the much larger and more resilient blood vessels.

Axons typically measure from one fourth of one micron to 10 microns in diameter. While the blood vessels in this area typically measure from 30 to 240 microns in diameter.

During a sudden deceleration as shown in the beginning of the animation sequences, the brain violently impacts against the inner surface of the skull at two times. First, when the head impacts with the air bag or otherwise stops its forward motion and begins it's immediate rapid, violent reversal of motion. And second, when the head impacts against the headrest and repeats the immediate, rapid and violent reversal of motion.

By observing the collision from a view that follows the motion of the head, one can appreciate the deformation of the brain as it violently impacts against the front and back of the skull. When the impacts of the brain against the skull are viewed in slow motion, the shockwaves that travel through the brain during the impacts can be observed.

Close inspection of an area of the outer surface of the brain and inner surface of the skull during the initial impact shows the soft fragile brain scraping against the hard, jagged inner surfaces of the skull to create shearing forces.
As the gray matter, comprised of cell bodies, and the white matter comprised of axons are of two different densities. The shearing forces create a plane of cleavage where many axonal injuries occur. The axons may be completely torn, partially torn, or separated from their connections with other cells.

Thousands or even millions of scattered axons may be torn but unless some of the larger and more resilient arteries are also torn no bleeding occurs.

Traditional imaging studies such as CT or MRI are not nearly sensitive enough to detect individual axonal injuries or even relatively large groups of axonal injuries. CT and MRI are designed to detect areas of bleeding. Unless a blood vessel or multiple blood vessels are torn creating a relatively large bleed, these studies fail to demonstrate any findings that would indicate the presence of multiple, widespread and microscopic axonal injuries that can result in devastating neuropsychological deficits.

In situations where the forces involved are severe enough to result in an injury to the blood vessels, the injuries to the axons are even more severe. An injury to one or more blood vessels results in the release of one or more blood cells into the surrounding brain tissue.

CT and MRI are designed to detect blood, or after a period of time the remnants of blood called Hemosiderin. Large quantities of red blood cells must hemorrhage from a blood vessel or blood vessels to be detectable on CT or MRI. If even one small hemorrhage occurs that is detectable, it is an indicator that there are likely vast numbers of associated axonal injuries that are not depicted in the scans.

In addition to the deceleration forces rotational forces are typically involved in most collisions. The combination of rotational and decoration forces results in traumatic forces on the brain that may be far greater than the force of the collision may imply. This combination of forces is very similarly to combining cold temperatures with high winds. Either alone may be tolerable, but when temperatures of 30 degrees are combined with winds of 30 miles per hour the net effect can be quite chilling.

When the skull and brain are viewed in section from above, it can be seen that the brain consists of two halves that are connected by only a few central structures. One of these structures is called the corpus Collosum. The Corpus Collosum consists of axons, that allow for communication between opposite sides of the brain. The front of the Corpus Collosum is called the Genu. The two halves of the brain are separated by a tough, ligamented structure called the Falx. The Falx is rigidly fixed to the skull in the front back top and bottom of the skull.

During the violence in the impact involving the combined sudden deceleration and rotational forces, similar to the one shown in earlier animation sequences, the corpus Collosum can often become injured. The injuries occur because the soft, friable brain reacts in a fluid like way as a result of the violent forces.

The left side of the brain impacts against the Falx, and the right side of the brain pulls away from the Falx. Because the Falx is rigid, the axons that comprise the Corpus Collosum are torn and broken, again thousands of axons may be torn without being evident on imaging studies.

Unfortunately the majority of mild traumatic brain injuries go undiagnosed. The difficulty in diagnosing these injuries is most likely due to the combination of two factors. One, the absence of injuries on traditional imaging studies. And two, the causal clinicians perception that of a normal appearing and behaving individual.

Careful interviews of friends, family and coworkers regarding the changes in an individual before and after a traumatic event may be the most reliable way to recognize those who have suffered these injuries. Those close to a brain injured individual will often describe a completely different person before and after the incident.

Only after the presence of a traumatic brain injury is diagnosed, can one then proceed with measures to improve, or at least help cope with the resulting problems.