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Not Just The Result Of Contact Sports And Combat

Traumatic Brain Injuries Are Pervasive In The US, And Often Go Undiagnosed

by [Brian Bossetta](#)

A pair of medical experts discuss traumatic brain injuries, their treatments, and some of the long-term complications they can cause, especially when not properly diagnosed and treated.

On any given Sunday, millions of Americans watch NFL players smash into one another. Millions more watch on Saturdays as college football players do the same. At the professional, college and even at the high school level, these collisions can lead to significant neurological damage – even if they appear harmless in the moment.

Mohammed Elamir, who specializes in treating neurological conditions such as traumatic brain injury (TBI) and concussion as a brain expert and lead physician for Aviv Clinics in The Villages, FL, has witnessed the hits high school players take on the field up close as the doctor on the sidelines for many games.

“Those impacts are going to affect these kids for sure,” Elamir told *Medtech Insight*. “And especially the cumulative hits, because every hit you take increases the risk.”

There have been efforts to improve helmets and other equipment to protect athletes in contact sports. For example, in February 2021 the Food and Drug Administration cleared the Q-Collar, a device designed to be worn around the neck by athletes as young as 13 to mitigate the effects of repetitive sub-concussive impacts to the head by increasing blood flow to reduce the movement of the brain inside the skull. (Also see "[FDA Authorizes Athletic Collar To Reduce Brain Injuries](#)" - Medtech Insight, 1 Mar, 2021.)

A potentially worst-case scenario unfolded recently when Miami Dolphins quarterback Tua Tagovailoa was clearly shaken and wobbly after a hit during a Sunday game, only to sustain a frightening hit less than a week later. After his head was slammed onto the turf, Tagovailoa splayed his fingers in an awkward gesture known as the fencing posture, an overt indicator of brain injury.

A recent article in [New York Magazine](#) highlights not only the severity of Tagovailoa's injury but the damage it might have done to the NFL's reputation, particularly when it comes to player safety.

***“There are a lot of mental health crises tied to traumatic brain injuries. And it's something that should be addressed.” –
Mohammed Elamir***

Elamir said contact sports are just one of many factors as to why there are so many brain injuries.

In the US alone, someone sustains a brain injury every nine seconds, Elamir said, and in 2020 there were more than 64,000 deaths associated with TBIs.

What is TBI

Brain injury, according to Elamir, is a general term to describe the destruction and death of brain cells, including the blood vessels that supply oxygen and nutrition to the brain.

Angela Sinner, a pediatrician and co-director of inpatient rehabilitation at Gillette Children's, a nonprofit hospital in St. Paul, MN, told *Medtech Insight* that TBIs result from significant forces being exerted upon the brain, be they direct blows to the head or indirect, as when the body is jolted with enough force for the brain to move around inside the skull.

“The brain is a gelatinous-like substance floating inside the skull in cerebral spinal fluid and is also attached on a stalk of the brain stem and spinal cord,” Sinner said. “When sustaining significant forces the brain can impact the skull, causing injury, trauma and possibly bleeding at the sites of impact. The brain can also sustain twisting forces causing shearing and injury to neurons or brain cells diffusely in the brain.”

The positioning of the brain as a free-floating organ inside the skull is why protecting football players is difficult, Elamir added.

“The helmets really can’t protect you too much because it’s the brain hitting against the skull inside your head from the concussion or the whiplash,” he said. “It’s not so much the head getting hit, but the brain hitting the inside of the head.”

Other Causes

The leading cause of brain injury, however, is not contact sports, but falls, especially among the elderly. As Elamir noted, diminishing muscle mass and loss of balance are often natural factors of aging that put this group at higher risk for brain trauma and injury.

On the other end of the spectrum, the very young just learning to walk are also susceptible to falls and potential brain trauma as well. Teenagers are also a high-risk group, Elamir said, particularly teenage boys who are more likely to engage in activities such as skateboarding, or reckless behavior, such as cliff diving.

But while contact sports, falls, and more dramatic events, such as car accidents and battlefield injuries are more obvious, brain injuries can result from just about any type of hit to the brain, even one that is not overly painful or hard.

“An acquired brain injury can also occur from other assaults to the brain including bleeding, infections, lack of oxygen or lack of blood flow,” Sinner said, adding that the onset of symptoms can be delayed or initial subtle.

Elamir refers to this delay of symptoms as the “march of injury,” where instead of immediate changes to the brain that are noticeable, the edema and inflammation that develop can progress days, weeks, or months after the initial trauma or attack.

PTSD

Post-concussion syndrome (PCS) is a more serious condition with repercussions that can manifest many years later, as in the numerous cases of former NFL players who suffer debilitating symptoms decades after leaving the game. The science on this has become clear, which is why there was so much controversy surrounding Tagovailoa’s injury and how he was cleared to play after he appeared to be concussed.

“A brain that has sustained a concussion or injury has a metabolic imbalance as it is working hard to recover and heal,” Sinner said. “Further stress on the brain at this stage could hinder recovery and healing.”

“A goal of early diagnosis and proper management is prevention of these chronic symptoms,” she said. “A delay in diagnosis can impact recovery.” – Angela Sinner

As with post-traumatic stress disorder (PTSD) that haunts many combat veterans, PCS symptoms can lead to extreme harm, including suicide. Elamir, who has treated both former NFL players and veterans, said these changes in the brain that drastically alter behavior can be linked directly to brain injury.

“I hear the same thing over and over again from retired players I work with – ‘I’m not the same person I was before my career.’ Their loved ones say it too,” Elamir said. “There are a lot of mental health crises tied to traumatic brain injuries. And it's something that should be addressed.”

As with concussions in football, Elamir said PTSD among veterans is clearly a result of trauma to the brain. “PTSD is not a psychological disease,” he said. “We have studies that show the changes in the brain that correlate with PTSD symptoms.”

COVID-19

But as Sinner pointed out, some brain injuries have nonphysical origins, such as infections. Elamir said symptoms of brain injury, notably “brain fog,” has gone up during the pandemic and is there evidence to suggest that aftereffects of COVID-19, or “long COVID,” can have a negative and perhaps lasting impact on the brain.

According to the Mayo Clinic, one in five people between 18 and 64 experience a medical condition – neurological symptoms among them – anywhere from one month to one year after having COVID-19.

Brain fog, Elamir said, is often associated with COVID-19 and is a symptom most people can relate to. And while a benign factor, such as a lack of sleep, can be the reason for brain fog, it can be a deeper cognitive issue related to the brain having been damaged.

Elamir said he separates symptoms of brain injury into four silos, the first being the physical ones that are easier to detect, such as headaches and changes in vision. Second are sleep disturbances, followed by stress, and lastly are the psychological ones that are often hard to pinpoint, such as anxiety, depression, agitation, and irritability.

“You could just be going through a difficult time, such as bad breakup or something at work,” Elamir said, “or it could be because of a brain injury you had months ago.”

Diagnosis and Treatment

Unlike most injuries from blunt force, such as broken bones, brain injuries are not as obvious, which makes them more difficult to diagnosis. But proper diagnosis – especially in sports where protecting players from further injury is vital – can then lead to proper treatment, which Sinner said begins with ruling out severe injury, then resting the recovering brain.

“A moderate or severe brain injury may require acute hospitalization and possibly hospital-based rehabilitation,” Sinner said.

A small subset of patients, she added, will sustain concussions that lead to chronic symptoms, including headaches, vision changes, balance impairments and cognitive challenges with memory and processing.

“A goal of early diagnosis and proper management is prevention of these chronic symptoms,” she said. “A delay in diagnosis can impact recovery.”

The FDA regulates numerous diagnostic tools aimed at detecting brain injuries early on, such as intracranial pressure monitors that are used in treating a range of neurological conditions from TBIs to stroke. In August, for instance, the FDA issued a class I recall of CereLink monitors because of inaccurate readings. (Also see "[Integra Issues Recall Of Intracranial Pressure Monitors](#)" - Medtech Insight, 25 Aug, 2022.)

And though a CAT scan in the emergency room can rule out brain bleeding, concussions often go undiagnosed – as many as 50%, according to a 2021 [study](#) published in *JAMA Network Open*. The study, “Validation of a Machine Learning Brain Electrical Activity-Based Index to Aid in Diagnosing Concussion Among Athletes,” included 580 male and female athletes from 10 colleges and high schools. The study also found the FDA-cleared BrainScope Concussion Index highly accurate in diagnosing concussive brain injury and evaluating whether an athlete should return to play.

Hyperbaric Oxygen Therapy

At his Florida clinic, Elamir specializes in a technology that’s been around for well over a century – hyperbaric medicine.

After assessing his patients through a series of scans to better understand the nature and degree of the brain injury or damage, Elamir begins hyperbaric oxygen therapy (HBOT), which involves breathing 100% pure oxygen in a special chamber known as a HBOT suite. The air in the suite is pressurized to above atmospheric levels, which increases oxygen levels in the body 10 to 15 times

higher than normal.

While breathing in a HBOT chamber, the lungs can take in much more oxygen than would be possible by breathing pure oxygen at normal air pressure. When this much extra oxygen is carried through the blood, it can help fight off bacteria and stimulate growth factors and stem cells, which promote healing.

“We're actually addressing the cause of those behavioral changes by fixing the brain.” – Mohammed Elamir

As a patient in the chamber breathes through a mask, Elamir will increase the oxygen levels. As the patient breathes in, oxygen is sent through the bloodstream to tissue in the body that has been oxygen deprived giving the brain the energy it needs to heal. Oxygen levels are then fluctuated, which triggers the body's regenerative mechanisms.

“Stem cells are blank cells that can be anything we want them to be,” Elamir explained. “So in this case, we want them to be new brain cells. So we trick the body to make it think it's in a low oxygen state triggering this factor to release new stem cells. And that factor also makes the body make new blood vessels. So all those little arteries and veins that got destroyed by the injury, we can actually build back new blood vessels and we can also subsequently help the metabolic function of every cell.”

In cases of TBI, be it from an impact to the head or from a stroke, Elamir can detect destruction of cells, loss of blood vessels, and decreased brain functions from scans prior to treatment. But after treatment when he repeats the scan, “I see new cells, new blood vessels, and improved brain function.”

The Future

While there's still a long way to go in treating brain injuries, Elamir believes he's on the right track with his clinic's hyperbaric treatment strategy, which was developed at Shamir Medical Center in Israel.

More than 200,000 hyperbaric sessions have been conducted at the hospital's Sagol Center for Hyperbaric Medicine and Research, with 10,000 patients treated with the Aviv protocol. According to the clinic, “the vast majority have seen marked improvement after treatment.”

“I’ve treated retired NFL players, people in car accidents, veterans, that have had all these changes in their lives,” he said. “In medicine we’re often putting on band aids and treating symptoms, but here we’re actually addressing the cause of those behavioral changes by fixing the brain.”

And research and development into TBIs and concussions holds even more promise, according to Sinner, such as improved sideline testing in sports, better helmet technologies, improved diagnostics, and enhanced brain imaging.

For example, in July Labcorp launched a new blood test that has the potential to treat brain diseases and injury more effectively through early detection and more accurate diagnosis. (Also see "[New Blood Test Detects Neurodegenerative Disease; Offers Hope For Earlier Treatment](#)" - Medtech Insight, 22 Jul, 2022.)

And in 2019, the FDA approved the first biomarker software as a medical device diagnostic tool to detect contusions on the brain. (Also see "[No Brainer: US FDA Greenlights First Biomarker Software As Medical Device Development Tool For Brain Injury](#)" - Medtech Insight, 20 Mar, 2019.)

“There’s also research ongoing to better understand who is at risk of chronic symptoms and how to best treat those patients,” Sinner said.

In the meantime, Elamir said there are five steps everyone can take to maximize and improve brain health: eating healthy, staying active, getting proper sleep, keeping the brain engaged, and managing stress.

And any activity where there’s a potential for injury – biking, horseback riding, skiing – Elamir advises wearing a helmet. “You should protect your head in every way possible.”