

## Military veterans: Your Brain has been disconnected

Carol L Henricks, MD

An **Army Ranger** jumps out of a plane and his parachute deploys and jerks his head and neck. He lands, strikes the ground and strikes the back of his head and is momentarily stunned. Then he walks a distance carrying his full ruck with weapons and explosives into the village to “clear it” and breeches door after door, setting off explosive after explosive. He may need to use his own weapons during the mission. An **infantryman** on the battlefield firing a rocket launcher from his shoulder. He fires round after round passing the recommended limit. But this is war and nobody is counting. With each insult the intracranial injuries compound, and toxic burden is increased, from super-toxic sites, heavy metals, and environmental toxins) being inhaled, and absorbed through the skin and GI tract. A **Navy corpsman with her marine unit** who stays with her team and is on the battlefield for every combat mission: in harms way every time and experiencing blasts and exposed to toxicity. The **helicopter pilot** on rescue missions who is exposed to the constant down beating of propellers and the **fighter pilot** who pulls a lot of G’s. Military members in theater have many potential sources of injury, particularly brain injury. NorthStar Neurology and NorthStar Hyperbaric Clinic has treated hundreds of military veterans for their brain injury conditions over the past 20 years. 80% of the patients I treat are military veterans and first responders with brain injury conditions that have been caused by a combination of concussion, blast, and toxic exposure as a result of their service. When veterans do not suffer other physical trauma, their brain trauma often goes unrecognized. Being able to walk, talk, and eat does not signify a lack of injury. Concussion is not just a brain bruise, it is a serious injury with profound consequences if healing does not occur. It is time for concussion injury to be correctly diagnosed and treated.

### Recognizing concussion

The role of **concussion** including blast injury, other traumatic brain injury, (TBI), toxicity, the link to suicide, Post Traumatic Stress Disorder (PTSD) symptoms and neurodegenerative disease is receiving increasing attention in the medical literature. Unfortunately, the seriousness of the injury and the underlying neuropathology is not commonly elaborated in the medical literature. There is a misconception that a concussion is like a “**brain**

**bruise**” that is relatively inconsequential and will heal unaided within a short period of time. (1) When veterans continue to experience post – concussion symptoms (PCS) they are sent to a psychiatrist to manage “psychiatric” symptoms instead of being treated with a protocol to heal their brain wound.

The complexity of functional areas of the brain, such as biochemical microenvironments, fiber tracts, and intricacy of the brain is **unlike any other tissue in our body**. Traumatic injury to the brain is the likely stepping stone to many neurodegenerative disease processes. A history of concussion injury correlates highly with future diagnoses of ALS, Alzheimer’s and Parkinson’s disease and is likely a **precursor** for those conditions. (2) Diagnoses of those neurodegenerative conditions are at epidemic proportions: Military Veterans are proven to be at increased risk. While the connection between severe TBI with skull fracture, penetrating wounds, intracranial bleed, or complicated by a stroke may seem like a more obvious precursor to neurodegenerative disease than a series of milder concussions, severe concussion, and particularly multiple concussions may be just as ominous.

Being aware of historical diagnoses of concussion is additionally a critical consideration when evaluating **mental health**; you can’t have **mental health** if you do not have **brain health**. The brain is the organ that is the seat of all emotions, thoughts, and behaviors. An injured brain does not function optimally. There has commonly been a **misattribution** of a cluster of symptoms known as “PTSD” or post – traumatic stress disorder in patients that actually have a **post – concussion syndrome**. (3) Every symptom designated as a “PTSD” symptom is also a post- concussion symptom. Depression and suicidality are common to PCS and are associated with damage to the left subfrontal and temporal lobe cortex.

Concussion diagnosis has been overlooked because of misconceptions about **how the injury is caused**. A blast injury may have caused injury even if it did not knock you down. You don’t have to “black – out” or strike your head to have sustained a concussion; shaking your brain around inside your head is all that is necessary to cause injury. Damaging specific areas of the brain causes specific symptoms. The points of impact within the skull and the associated movement of the brain determine the deficits caused by the injury. If the impact causes the left hemisphere of the brain to experience a “**coup**” impact, typically language function will be affected; so the injury

causes both a focal injury and a diffuse injury. If the brain is shaken anteriorly to posteriorly, the left **subfrontal cortex**, for example, will be injured. The left subfrontal cortex and the left temporal lobe (amygdala) called the arcuate fasciculus and uncinate fasciculus of the brain is associated with mood stability and emotional regulation. When the left hemisphere is injured, this effects brain waves resulting in an alpha – theta rhythm. The right hemisphere then will become over- aroused and will have a high beta brain wave activity resulting in feelings of depression and anxiety. This type of diffuse axonal injury in the left prefrontal cortex and temporal cortex presents as suicidal ideation. Hyperbaric Oxygen Therapy (HBOT) and neurofeedback (NFB) restore these pathways and brain waves. (4) When it is damaged, there is associated depression, mood instability and **suicide risk**. Transcranial Magnetic Stimulation (TMS) is directed over the left frontal lobe of the brain to treat depression. The physical trauma causes a biological sadness evidenced by lethargy and accompanying emotional sadness.

Concussion, as a diagnosis, has often been overlooked because appropriate **imaging** has not been used to visualize the injury. For mild to moderate concussion injuries (or series of injuries), a head CT scan without and with contrast, and / or Brain MRI scans without and with contrast are often unremarkable. This is a **limitation of the study** and does not mean that no injury has occurred; those studies are more the equivalent of taking a gross anatomical look at the brain. (5) More sophisticated imaging to assess the consequences of the diffuse microscopic injuries are necessary. A Brain MRI – DTI – NQ without contrast uses a metric known as fractional anisotropy (FA) which reflects the diffusivity of water. The scanning protocol uses calculations to create an image of fiber tracts within the brain. When there is increased diffusivity of water along a fiber tract, that reflects a point of injury and the created image will demonstrate a truncated fiber tract at that point. Observing the fiber tract disconnections correlates the physical injury to the neurobehavioral pathology and / or mental illness symptoms. A brain quality SPECT scan is specifically designed to assess metabolic activity in different areas of the brain using radioactive dye that is attached to sugar molecules. Injured brain tissue is dysregulated and may have increased or decreased metabolic activity.

Clinically a concussion presents as dysfunction in multiple areas of life. Clinical presentation of concussion is based on observations, clinical history, self – reporting, and supported by some specific testing. Concussion

presentation can be assessed by considering 5 critical areas (or pillars) of function: visual function, memory, attention and information processing, sleep, balance and emotions. (6) These are all areas that reflect fiber tract network function in the brain, and their function is disrupted by concussion. Compromised brain health is not just a function of a recent injury, but can be a product of the accumulation of injuries (trauma, toxins, infections, inflammation, ischemia, etc) and healing that have taken place throughout life. (7) A concussion is not one simple injury but actual physical damage to a complex sophisticated network of fiber tracts, metabolic environments, and blood vessels and the lymphatic system, and neurons and astrocytes. The hypothalamic pituitary axis at the base of the brain is also impacted by multiple concussions, severe trauma and toxins. Local brain trauma may damage a control center while the more diffuse axonal injury to the network damages the functional communication system.

### Neuropathological changes

Brain function is carried out by finely tuned networks that are both chemical and electrical. When chemical and electrical processes are disrupted, functional network performance is compromised. Even a mild concussion injury can cause physical injury to the brain that may be disruptive. Brain injury and healing from brain injury is complex, but our brains and our bodies are designed to heal themselves under the right conditions. The brain can always learn by rewiring, re-networking and recruitment but when **overwhelming injury** has occurred, healing therapies are necessary to support the healing process. Healing processes include HBOT, NFB, diet, supplements, and other adjunctive therapies.

At the base of the brain is the **hypothalamic – pituitary axis (HPA)**. Damage to the HPA by concussion, blast force, and toxicity causes profound pathology. The hypothalamus is the seat of the autonomic nervous system (ANS) which controls the automatic functions of the body like breathing, blood pressure, heart rate, GI motility etc. Damage to the hypothalamus may disturb control of those automatic functions. Damage to the pituitary gland disrupts hormone function in the whole body. Many military members become hypothyroid and have low Testosterone levels and female hormone cycles may also be disrupted.

The **metabolic environment** around the neuron is critical: electrolytes around the neuron have positive electrical charges that mobilize when an

action potential is initiated. There are large proteins in the cell which carry a negative charge. Everything is balanced. An electrical signal is propagated when positive charges go inside the axon and negative charges leave creating an electrical impulse. As the electrical impulse travels down the axon, it signals the release of chemical neurotransmitters into the synaptic space to communicate with the next cell. If the metabolic environment is disrupted, then effective electrical signaling cannot occur. The metabolic environment must recover after each impulse. When there is physical trauma (concussion), blast injury, toxicity in the metabolic environment it must be corrected. Clinically when the metabolic environment is disrupted, someone with a concussion may experience a confusional state. The confusion is often described as “**brain fog**”. This is only one component of the brain injury associated with concussion, but documentation of disruption of electrical signaling can be demonstrated with quantitative EEG recording of slowing and possibly disorganization. (8) The disrupted metabolic environment along with the cascade of injury and inflammation, as well, as the circulating toxins influxing due to breaching of the blood brain barrier all create a toxic storm that the brain is not prepared to process. There are many unknowns, but the physiology is different after multiple injuries and brain function is additionally altered by immersion in a multi-toxic metabolic environment.

The physical trauma of a concussion **pulls synapses apart**. When the signaling cell releases the neurotransmitter into the synaptic space after a concussion, the neurotransmitter may never reach the receiving cell. A greater separation between the signaling brain cell and the receiving brain cell can result in a failure of communication between those two cells. Multiple failures caused by the diffuse injury of concussion throughout the brain cause network or system failures which result in loss of functional abilities such as balance, complex decision making and complex information processing.

**Brain shear injury** is the classic anatomical injury associated with concussion. As the brain forcefully moves to and fro inside the skull, as a result of trauma, it causes tears or shears in the axons. (9) Axonal shears may damage only the myelin or may completely tear through the axon. This interferes with transmission of the electrical signal through the axon and therefore damages the network. When the brain is injured by concussion, there are multiple injuries throughout the brain disrupting network function.

It is like having a computer with a lot of wires cut, there is a lot of slowing and functional glitches.

The physical trauma of concussion, blast injury and toxicity damages small (and sometimes larger) blood vessels which destroys the protective mechanism of the **blood brain barrier (BBB)**. Even a mild concussion may injure the BBB. (10) When the BBB is breached, toxins circulating in the blood have direct access to brain cells and may poison them. Military veterans and first responders experience toxins that are released into the air from burning debris of burn pits, exposure to HAZMAT and super – toxic sites **AFTER** exposure to blasts and physical trauma when their BBB is breached. PFAS and “forever chemicals” are common in the toxic mix. Toxins are absorbed through the skin, oral and nasal mucosal membranes, into the lungs and GI tract. Toxins from burn pits and fires are caustic corrosive neurotoxins that may directly damage brain cells and cause tremendous disruption of function. The more injury to the BBB, the more toxins are able to flood in. An additional concern is that breaching the BBB opens the door to Central Nervous system (CNS) autoimmune diseases.

**Blast injuries** are most like the bends: a veteran is engulfed by a pressure wave followed by a vacuum. This is most like being deep underwater and being brought to the surface quickly: it gives you bubble trouble. There is CNS injury associated with the bends as well as with blast injury. Military members may suffer from “**Breacher syndrome**” as a result of their cumulative blast injuries. (11) An accumulation of milder injuries can be quite damaging and cause persistent functional deficits. **Blast injury** contributes to other traumatic injury by creating small infarcts from gas bubbles throughout the body. A blast injury is most like the bends; the body is exposed to tremendous whole body pressure from the blast peak overpressure wave (like being under pressure deep underwater) and then suddenly the pressure is reversed (like coming to the surface of the water too quickly) as the negative pressure wave spreads out from the point of explosion. The rapid change in pressure causes Nitrogen gas (which is inert in our bodies) to coalesce into bubbles or gas emboli that block blood flow to different areas of the brain causing small infarcts or strokes and infracting other tissue. Military service members on the battlefield suffer multiple blast injuries in rapid succession creating a much worse pathology than a simple concussion.

Veterans and first responders have become so **chemicalized** from multiple sources of toxic exposure that the individual effects of toxins cannot be sorted out. Heavy metals from weapons fired, burn pits, super toxic sites, vaccine injury, mefloquine reactions, and hormone disruption all potentially disturb brain function, but also affect other organs and put veterans at high risk of cancer, poisoning and organ failure. You cannot have healthy brain function if there is metabolic disturbance in the body. HBOT promotes detoxification.

Physical trauma breaks the **microtubular infrastructure** of the cell, particularly the axon, which has been considered as a major cause of the axon degeneration and eventual cell death. (12) The microtubular infrastructure facilitates transport of neurotransmitters and other necessary nutrients that are made in the main cell body to be transported down the axon to supply the axon and the synapse. If the microtubular infrastructure is broken and disorganized, this function cannot take place: the injured cell is then not part of the functioning network. A drug, Epothilone D, is being studied as a possible agent to stabilize microtubules after injury and manipulate injury – induced synaptic plasticity. (13) What happens to any structure when you continue to physically assault it: the more trauma, the more injury. You eventually destroy the cell. An injured cell that does not heal begins a dying back process known as Wallerian degeneration; eventually after enough brain cells die there is resulting brain atrophy.

Concussion damages the **astrocytes** interfering with their ability to carry out homeostatic functions. Damaged astrocytes may trigger a reactive gliosis that may be a first step in causing a **glioblastoma**. (14)

Concussion injury damages **lymphatic drainage channels**. The meningeal lymphatic system helps to **clear metabolic waste** from the brain and CSF. If this metabolic waste is not cleared, there is dysfunction of the neuro-immune clean-up process and a worsened clinical outcome. (15)

### Treatment planning

Military members who suffer these injuries need to be properly assessed and treated. The brain heals slowly and **if you are injured again before you heal it is disastrous**. It is likely that brain atrophy (the endpoint of neurodegeneration) is not a normal part of aging, but a pathological process caused by the accumulation of brain insults throughout life.

There is a **clear pathophysiological pathway from concussion to neurodegenerative conditions** and toxic exposure only makes things worse. The clinical presentation of Alzheimer's, Parkinson's and ALS (neurodegenerative conditions) can be seen in veterans with a combination of concussion and toxic exposure. Different clinical presentations of neurodegenerative conditions have different patterns of brain atrophy; microscopically post-mortem they all have biological markers of the final common products of brain cell death. When diagnosing neurodegenerative syndromes, it is critically important to consider the history of physical trauma as part of the causal etiology of the disease presentation. Healing the brain after physical trauma and toxic exposure is key to stemming the epidemic. **Medication may transiently mitigate** some symptoms, but healing the brain and detoxifying the brain and the body is critical to stopping disease progression.

There are **no medications** that perform this complex healing process and detoxification. We need to support our brain's ability to heal. Our bodies, our brains are designed to heal. When tissue is wounded, **extra oxygen** is necessary for the tissue to survive and heal. HBOT is a powerful tool that enhances the oxygen delivery in the blood and has been proven to help the brain to heal and detoxify. There is extensive documentation of the use of HBOT to heal brain injury conditions.(16) Specific studies have been done on healing the individual components of that brain injury, including healing the BBB (17), angiogenesis, regeneration of nerve fiber tracts (18), improving ANS function (19), and improving cellular (mitochondrial) function (20). HBOT is proven to be significant in healing the brain and the body.

**Healing the brain pathophysiologically is critical for functional recovery to take place.** Initial brain health assessment should include a brain MRI – DTI – NQ without contrast, a RightEyeQ screening of visual function and a cognitive screening test. We recommend:

1. Nutritional consult and supplement recommendation.
2. Toxicity screen and detoxification protocol.
3. Endocrine function screening and HRT protocol.
4. HBOT with an initial 40 sessions @ 1.5 ata with 100% oxygen.
5. Begin neurofeedback sessions after 20 – 40 HBOT sessions.
6. Reassess and consider additional therapies.

Many military veterans become first -responders after they leave the service. As first responders they continue to experience the same kind of injuries that they suffered during active duty. There is an epidemic of brain injury in military veterans and first responders. The health and well – being of our military veterans is dependent on **brain health. Their brain wounds need to be healed.** When a veteran returns from deployment, they should be screened and treated for their injuries both traumatic and toxic. That is how we will **curb the suicide crisis** in our military veterans.

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Dr. Carol Henricks is a neurologist in Tucson, Arizona who has been in private practice since 1999. She does consultation in her neurology office, NorthStar Neurology, PC and since 2004 she has had NorthStar Hyperbaric, a clinic that specializes in the use of hyperbaric oxygen therapy and other healing therapies to treat neurological conditions. Primarily her patients are military veterans and first responders. She began “Healing Arizona Veterans” to support treatment for post 9-11 veterans, but separated from it when it became a non-profit. She has treated hundreds of veterans over the past 20 years and is an advocate for brain health.