Omega-3 long-chain fatty acids and their use in traumatic brain injury and concussions

Michael Lewis

- Traumatic brain injury (TBI) is a major cause of death and disability worldwide.
- Long-term treatment primarily involves rest, and recovery times vary significantly.
- The following article considers whether supplementation with omega-3 long-chain fatty acids, which play a major role in brain development and health, could make it easier for the brain to heal itself.

Traumatic brain injury (TBI) is a major cause of death and disability worldwide, especially in children and young adults. Of the 44 million youths in the United States who play organized sports, at least a half million are estimated to suffer a sports-related head injury each year, while the Centers for Disease Control and Prevention (CDC) estimates that, on an annual basis, sports, car accidents, and falls (the young and old are particularly at risk) combined cause between 1.7 and 3.4 million Americans to suffer a head injury. Survivors of TBI and concussions are often left with significant cognitive, behavioral, and communicative disabilities, and some patients develop long-term medical complications. According to the US National Institutes of Health (NIH), TBI has left more than 5 million Americans with a permanent need for help in performing daily activities, costing more than $76 billion annually.

According to two of the most up-to-date clinical websites (NIH and CDC), in addition to seeking appropriate medical care, the two most important things to do after a concussion are (i) to eliminate the possibility of additional blows to the head and (ii) to rest to allow the brain to heal as quickly as possible. When the brain is injured, its consumption of glucose and other

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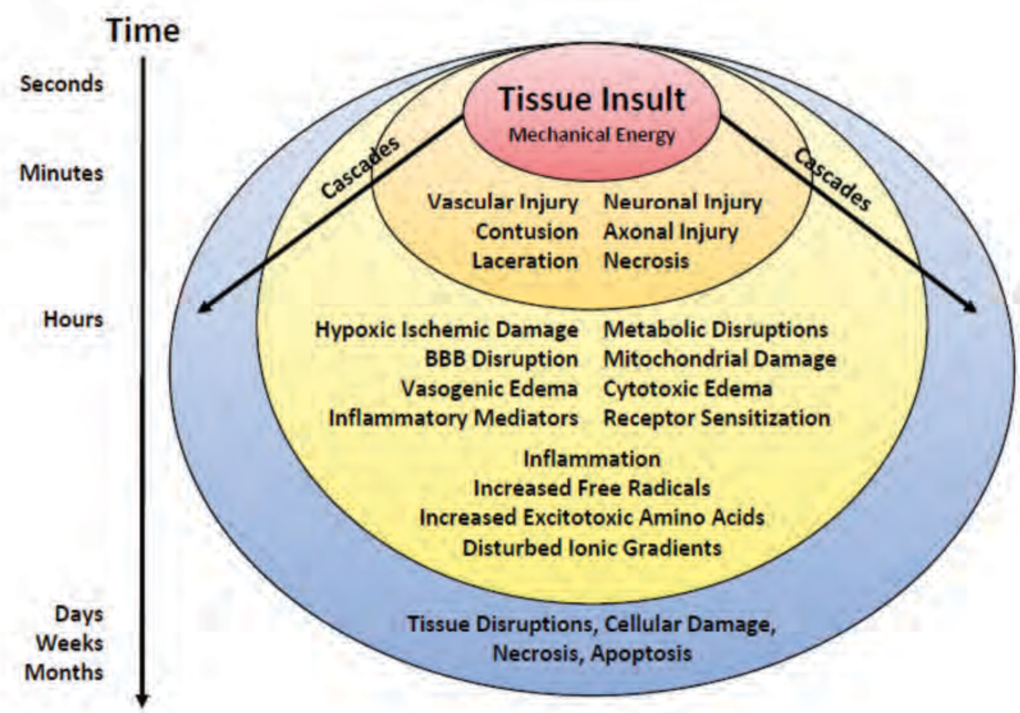

FIG. 1. *Secondary phase of brain injury after the primary insult. BBB, blood brain barrier.*

substrates is greatly increased. Physical rest, as well as rest from thinking and other cognitive activities such as reading, studying, using a computer, and playing video games, is critical for the brain to heal and return to its baseline metabolism. The length of time it takes for this to occur can vary widely, from hours to days to weeks to months.

BASICS OF TRAUMATIC BRAIN INJURY

The brain may sustain a primary injury when mechanical energy is transferred to the brain, whether through a motor vehicle accident, falling and hitting the floor, a head-to-head collision in football, a gunshot to the head, or exposure to a blast wave from an explosion. While the devastating effects of a severe TBI are immediately apparent, the effects of a concussion, sometimes called a mild TBI, may not be detectable right away—even with an MRI scan. In either situation, cascades of biochemical events cause secondary injuries over minutes, hours, days—even weeks after the initial injury. This secondary response leads to increased damage (see Fig. 1).

Major advances in the acute care of severe TBI have occurred over the past decade, particularly neurosurgical interventions born out of necessity on the battlefields of Iraq and Afghanistan by US military surgeons. However, despite considerable research efforts, current treatment of brain injury beyond acute surgical intervention is largely confined to supportive measures. These advances are not trivial. They have resulted in countless patients living through a severe TBI, when otherwise they would not have survived. But in both severe TBI and in concussions, the secondary injury phase of brain injury can be a prolonged pathogenic process characterized by neuroinflammation, excitatory amino acids, free radicals, and ion imbalance. There are no approved therapies to address these underlying cascades and limit the damage that continues to occur following the primary injury.

So what does medicine have to offer a patient after a severe TBI or a concussion that remains symptomatic? As the mother of one victim said, "He [her son] lived, he survived, and now what?" Herein lies the problem: *There is nothing.* Modern medicine has nothing to offer. Patients and their families are told only time will heal the brain and are offered little else except pharmaceutical intervention for each individual symptom. If the patient is having pain, they are prescribed a pain medicine (or two, or three, or worse, narcotic pain medications). Trouble sleeping? Prescription sleep medications. Anxiety? Benzodiazepines. Depression? SSRI [selective serotonin reuptake inhibitor] antidepressant medications. None of these interventions addresses the underlying damage to the brain.

As a physician in the US Army, I spent more than three years developing programs for the military on the use of omega-3 long-chain fatty acids (omega-3s) to treat TBI. My idea was to make it easier for the brain to repair itself by providing it with more of the raw materials it needs. Since omega-3s—particularly docosahexaenoic acid (DHA)—are the "bricks" of the brain's cell walls, my strategy was to speed the brain's recovery by delivering optimal amounts of omega-3s to saturate the brain, giving it the best opportunity to heal itself. In my clinical experience advising hundreds of patients over the past few years, not only do omega-3s help the brain heal, but patients often experience a rapid improvement of post-concussive

Omega-3s and brain injury

We know omega-3 long-chain fatty acids (omega-3s) are important throughout life. They are essential for the development of the fetal human brain, as well as through infancy and childhood. (The January 2013 issue of *Inform* featured a cover story about the omega-3 fatty acid docosahexaenoic acid—DHA—in the brain.) In fact, the male brain continues to grow until around age 25.

But while omega-3s are known to support cardiovascular and heart health as well as neurological health, the typical diet in most Western countries is woefully deficient in omega-3 intakes, particularly when compared to intakes of their competitive cousin, omega-6 long-chain fatty acids (omega-6s).

Omega-6s are commonly found in seeds, nuts, and the oils extracted from them. A common source, soybean oil, is widely used in snack foods, cookies, crackers, sweets, and fast food consumed in the United States. The consumption of soybean oil has increased by 1200% since around 1970 (Blasbalg *et al.*, 2011). It is so ubiquitous in processed foods and fast foods that an astounding 20% of the calories in the American diet is estimated to come from this single source.

Omega-6s increase inflammation, blood clotting, and cell proliferation, whereas omega-3s modulate those functions. Both families of omega fatty acids must be in balance with each other to maintain optimal health. However, due to significant changes in the US food chain and dietary habits, that balance has been skewed in American society from one or two omega-6s for every omega-3 to a ratio of 25:1 or higher (Blasbalg *et al.*, 2011; Lewis *et al.*, 2011). Consequently, we generally have too many omega-6s and a deficit of omega-3s, which limits the brain's ability to repair itself with the anti-inflammatory building blocks it needs. This omega-3 deficiency puts us at increased risk of a difficult recovery from a concussion, particularly soldiers in theaters of war and youths who participate in collision sports such as American football, soccer, hockey, rugby, and others.

symptoms such as headaches, lethargy, insomnia, and cognitive difficulties.

According to Hee-Yong Kim of the NIH, omega-3s have three important functions during a brain injury. They are neuroprotective (keep brain cells alive); they are anti-inflammatory; and they promote neurite development and synaptogenesis (increase the length and number of branches from a brain cell, creating more connections between brain cells). A few animal studies clearly demonstrate the ability of omega-3s to preserve neurologic tissue in stroke (Belayev *et al.*, 2009) and spinal cord injury models (King *et al.*, 2006). Only one series of studies, conducted by researchers has shown their usefulness directly in TBI (Bailes and Mills, 2010). Unfortunately, there is not much to be found in the scientific literature beyond animal studies. Only two case reports have been published about the use of omega-3s in severe brain injury in people.

In January 2006, the Sago Coal Mine Disaster occurred in West Virginia. When faced with the lone survivor, Randy McCloy, physicians at West Virginia University's hospital had to employ extreme methods to save his life. McCloy had suffered severe carbon monoxide and methane gas poisoning resulting in kidney and liver failure, a heart attack, and significant brain damage from a lack of oxygen. Kidney dialysis and hyperbaric oxygen therapy were used aggressively. However, with nothing available to help the brain recover, the attending neurosurgeon began administering large doses of fish oil through McCloy's feeding tube. His thought was to use the same substance that is known to build the human brain *in utero* to see whether it could perhaps help the brain recover. It did and, and the results were published as a case report in 2008 (Roberts *et al.*, 2008).

In March 2010, a Virginia teenager sustained a severe TBI in a motor vehicle accident. The attending neurosurgeon's impression was that the injury was likely lethal. Citing the Sago Mine Disaster case, Michael Lewis, at that time a physician in the US Army, recommended to the neurosurgeon and the patient's family that the use of high doses of fish oil containing omega-3s might be useful in promoting recovery. The son survived and even attended his high school graduation three months later (Lewis, Ghassemi, and Hibbeln, 2013).

While these two case reports are the only published experiences using omega-3s with severe brain injury (carbon monoxide poisoning in one; a severe TBI in the other), they have been well documented and featured on multiple news programs, such as CNN's *Sanjay Gupta, MD* show. As a result of this media exposure, hundreds of people have reached out to groups such as Brain Health Education and Research Institute asking for advice. In some instances, parents and doctors have taken action, such as in the case of an 8-year old girl who made a surprising recovery following a near drowning. She was administered omega-3 fish oil after being in a coma for over two months and within two weeks came out of her comatose state. This case was documented on a local ABC television affiliate in upstate New York. Physicians managing other cases of severe TBI and sports concussions continue to access protocols made available online by the Brain Health Education and Research Institute (www.brainhealtheducation.org).

WHAT CAN BE DONE FOR TBI NOW?

Conventional medicine can take survivors of severe TBI and symptomatic concussions only so far. Concussion patients may continue to experience symptoms for months, even years, without any effective therapies. The situation is even worse for severe TBI patients who often end up heavily medicated at home

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or in a nursing home, overwhelming family resources. According to Goldstein (2012), the father of a TBI survivor, unconventional therapies are not merely a reasonable option, they are a necessity. Several very safe therapies (nutrition such as omega-3s, hyperbaric oxygen, craniosacral manipulation, and others) can have enormous impact. These do not cure brain injury, but they optimize the brain's opportunity to heal itself and give a patient the best chance to regain as much function as possible.

The potential role for omega-3s seems obvious but has yet to be systematically studied outside the research laboratory (Lewis & Bailes, 2011). Unfortunately, sometimes even the best-trained, most-skilled, and well-intentioned professionals within the medical establishment suffer tunnel vision, sticking to their familiar, well-trodden paths rather than be pioneers blazing new trails to help patients and families. We don't yet have a randomized, placebo-controlled, clinical trial of omega-3s for either severe TBI or concussions. But we do know that omega-3s are the nutritional foundation of the brain and the neuronal cell wall. We know from scientific research that omega-3s are neuroprotective, modulate inflammation in the brain, and even promote synaptogenesis. And we know from growing amounts of clinical experience, that omega-3s can be immensely useful to decrease or eliminate many of the symptoms that plague patients following brain injury. With this knowledge, why not use the best available knowledge today to help brain injury patients?

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Dozens of 380-million-year-old intact biolipids have been found in the fossil of a crustacean from the Devonian Reef in the Kimberley region of northwestern Australia. The lipids, which are 250 million years older than any found previously, include original sterols from algae in the oxygenated part of the ocean, cholesterol from the crustacean itself, at least 70 different steroids, and a range of compounds formed by sulfate-reducing bacteriathat degraded the organic matter contained in the crustacean. Other compounds found in the fossil included aromatic steroidal hydrocarbons often found in petroleum. More information is available at http://phys.org/news/2013-11-reef-fossil-age-limit.html or in the original paper (Melendez, I., K. Grice, and L. Schwark, *Sci. Rep.*, doi:10.1038/srep02768, 2013).