

## Head Injuries

### What's Really Going On?

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In the last ten years, there has been more learned about concussion than any other area of sports medicine. People are more aware of concussion, partly because it has become a big story with NFL football players. It's been found that recurring concussions have significant consequences later in life and acute concussions have complications that can be even more devastating. This has heightened our awareness and allowed us a much better understanding of concussion management.

When I was in medical training 25 years ago, the idea of concussion was a complete loss of consciousness. Anything else was just considered a "bell ringer" and was not thought to have the same significance. However, the last ten plus years of research has shown us that even getting "dinged" represents a concussion. Concussion is now defined as a trauma-induced alteration of mental status with or without a loss of consciousness.

CAT scans, MRI's, EEG's and even the neurological exam cannot recognize the change in a patient with a concussion. These tests are very sensitive, so it's natural to think, "What is really going on inside the brain?" So let's go deep inside the brain and see what actually happens when someone experiences a concussion.

At the time of the injury, there is usually an impact that causes the brain and skull to move at different rates of speed. The brain is protected within the skull by several thin layers of tissue as well as a spinal fluid barrier. When the skull hits an obstacle and suddenly stops, the brain continues to move in a forward direction. If the force is strong enough, the brain is almost like a rubber ball and bounces back and forth within the skull until the energy of the accident has dissipated. Because the brain is anchored at the neck, the lower portion has less movement. The top of the brain, which is not anchored, is free to move through a wider angle backwards and forwards. This results in somewhat of a tearing or shearing effect on the neurons in the brain. This shearing does not literally tear the nerves in half, but can cause dents or tears in the wall of the nerve cell so it does not function normally.

Looking close up at one of these damaged nerves, there is a sudden over-excessive release of a messenger chemical (neuro transmitter) where it makes contact with another nerve. Normally these chemicals are released in small amounts by one nerve and cross over a very small gap to activate the following neuron in a series. This creates a number of controlled changes in the second nerve and results in the message being exchanged. At the time of a head injury, when the nerve is damaged, it may release an excessive amount of this

messenger chemical, thereby causing the next cell to be turned on and literally revved up to the max. This would be similar to starting your car, putting it in neutral and then flooring it. You would not be surprised if after awhile the engine exploded or locked up. This is similar to what can happen in the cells at the time of a concussion due to this increased activation. Fortunately, in most sports concussions this step does not result in a “locked or destroyed” engine. However, the “revving” has caused the cell to run out of gas (glucose and oxygen). This leaves the cell in a vulnerable state.

One would think that the brain would now try to get more glucose and oxygen to the area where it is most needed so that the cell could recover and be made well again. Unfortunately, the concussion causes a spasm or narrowing of the blood vessel to the damaged area of brain. This leads to a serious state of mismatch where the area of damage has used up all of the energy sources (glucose and oxygen), and the narrowed blood vessels are unable to meet these demands.

This mismatch is what is called the “vulnerable period” – a time when a further injury could cause the scales to be tipped beyond the point of return. In this state, the nerves that control the flow in the blood vessels suddenly become dysfunctional; allowing the once narrowed blood vessels to suddenly open up beyond what is safe. This results in a very large blood pressure reaching the area of damaged tissue. The blood vessels are swollen so much that there is actually leakage of fluid into the damaged area of brain, referred to as edema. Along with this edema, some of the very small blood vessels cannot withstand this increased blood pressure and can actually rupture, causing bleeding in the brain. These two changes of edema and bleeding lead to a swelling in the area where the damage occurred, resulting in a shift or pushing up against the normal tissues of the brain.

Since the brain is confined within the skull and there is no place to move, this leads to downward pressure on the brain to literally try and push it out at the base where your spinal cord enters. This can be a life-threatening event. This second head injury, during the time of mismatch and the subsequent changes of edema and hemorrhage, are what has been referred to as “second impact syndrome”. Second Impact Syndrome (SIS) is a very serious condition that leads to 100% morbidity or mortality. Our goal in concussion management is to be able to nurse someone through the mismatch period before sending them back to play, so that they do not sustain a second injury and put themselves at risk for second impact syndrome.

Concussion is a diagnosis to be respected, but not feared. Concussion management has been made much safer in the last ten years because of computerized neuro-psych testing that is now done.