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Defining Concussion and Mild Traumatic Brain Injury: a History of Confusion and Debate.

Brenda Seymour

As the understanding of the brain has evolved throughout history, so too has the understanding of brain injury and concussion. To this day, there is still debate over the definition of concussion, and what it entails. Some definitions, including that of the Merriam-Webster Dictionary, define a concussion as “(a) ...a jarring injury of the brain, or (b) a hard blow or collision” [1], whereas the Center for Disease Control defines a concussion as a “complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces secondary to direct or indirect forces to the head” [2]. In the first definition, the concussion is the act of the physical blow; in the second definition the concussion is the state of having abnormal brain function after a blow to the head. These distinctions have evolved from various hypotheses about head injuries throughout history, and today they are often used interchangeably. In this essay I will outline the history of knowledge of head injury and concussion, in parallel with increased knowledge of neuroscience and the brain, followed by an analysis of current day texts and terms used in an attempt to better understand the history of the term and the modern day use of the word.

Descriptions of head injuries date back to ancient times, as documented by the Egyptians, Greek, and Romans. Egyptian records have been found describing head injuries that were associated with disturbances in speech [3], which today we consider a symptom of concussion. Although there are many Roman recordings of head injury, they all appear to be lumped together [3], and there is no evident distinction of concussion from other types of head injuries. A translation of the Hippocratic corpus from ancient Greece says, “...In cerebral *concussion*, whatever the cause, the patient becomes speechless...falls down immediately, loses their speech, cannot see and hear...” [3]. However, it is unclear what exactly Hippocrates is describing as the concussion, whether it is the initial blow and the loss of consciousness that ensues, or the lingering symptoms of what we now call a concussion in the days following the injury. Perhaps he is combining both under one term. However, even though this clinical description of concussion existed, the term concussion had not yet been coined, and was inserted into this translation by modern day translators [3]. Hippocrates, the father of Western medicine, was the first scholar to state that intelligence and sensation came from the brain [4] (as opposed to the heart or other organs), which explains why he would associate head injury with difficulties of speech, sight, and hearing. In another of Hippocrates' books, *Epidemics*, he describes trephination of the skull in order to release pressure (another modern day symptom of concussion [5]), indicating attempts to treat what we now call concussions [3].

In the 9th Century A.D., Arabic physician Rhazes was the first to define concussion as an abnormal physiological state [3], thus making the initial distinction between concussion and severe brain injury. Lanfrancus, a European physician, added to this definition in the 13th century by noting that this abnormal physiological state (consisting of temporary paralysis of cerebral function) is caused by the shaking of the brain [3]. This proposed mechanism for the concussion of the brain is the first pathophysiologic description of this injury. Throughout medieval times the definition of

concussion was refined, including distinguishing between concussion as a non-fatal injury and skull fracture as a fatal injury [3].

It wasn't until the 16th century that much progress was made in the understanding of concussion. By this time the basic composition of the brain was better understood and it had been determined that the brain consisted of two types of tissue: grey matter and white matter, with the white matter responsible for transporting information to the grey matter [4]. Berengario da Carpi specified the mechanism for concussion by stating that it was the thrust of the "soft structure of the brain against the solid part of the skull" [3]. Various physicians added to the description of symptoms of concussion throughout the 16th Century, adding to the list "a faltering in the speech, impairing of the memory, dullness of understanding", lethargy, and vertigo. On top of the new list of symptoms, "Doctor Read" listed the clinical stages of concussion as "1. A ringing of the ears after the wound is received. 2. Falling after the blow. 3. Swooning for a time. 4. Slumbering after the wound is received. 5. Dazzling of the eyes. 6. A giddiness which passes rapidly." [3]. As we can see, by this time much was known (or at least postulated) about the clinical symptoms of concussion. However, with the exception of the hypotheses of Lanfrancus and Da Carpi (called *commotio cerebri*), the pathophysiological mechanism was still a mystery.

During the 17th and 18th centuries, Enlightenment thought spread throughout Europe and the approach to studying concussions changed from clinical observations towards a pathophysiological understanding. The Enlightenment offered a new way of thinking, encouraging people to challenge the traditional beliefs of the church, and to instead think and reason for themselves. This created the path towards the scientific method, which demanded that scientific knowledge be obtained through measureable and quantifiable observations. Thus, physicians turned towards physiologic understanding of the brain and nervous system, and towards a pathophysiologic understanding of concussion, focusing on neuropathologic changes of the brain after concussion [3]. According to this new approach, a concussion was simply the loss of consciousness after a blow to the head; thus, concussion was a symptom rather than a physiologic state [3], and the point of interest turned towards the physiological condition of the brain after a concussion. In 1792 it was shown that there was no structural brain injury upon concussion [3], which set the stage for a series of hypotheses as to why the brain acts as it does after receiving a concussion. With the discovery of the cell in the 17th century, many of these hypotheses since then have been based on injury at the cellular level.

One hypothesis, that of the collision of the brain against the skull, has been studied using biomechanics and is still in use today. Others, such as that concussion is a result of cerebral congestion due to circulatory failure, have been disproved, as well as another hypothesis that stated that the jostle and jolting of railway travel could cause trauma to the nervous system, thus causing concussion [3].

Two main hypotheses regarding the mechanism of concussion remain today, between which there is still dispute: the mechanism of concussion as a structural damage to the brain, or the mechanism of concussion as a temporary disruption of function of the brain. Advocates of concussion as structural damage to the brain claim the presence of hemorrhagic lesions leading to a hematoma [6], axonal injury, or neuronal death [3]. Conversely, advocates of concussion as functional inhibition claim

that it causes the suspension of brain functions, a physical stress to neurons, or a deformation of the lipid bilayer of cell membranes, which leads to a change in ion concentration within neurons [3]. Advocates of this view also claim that these changes are temporary and can be restored to normal function. The main debate between these hypotheses is whether or not concussions cause permanent pathophysiological damage.

To this day, there are still questions regarding terminology of concussion. It remains unclear as to whether the concussion is the moment of injury (a blow to the head), making it a symptom, or whether it is the abnormal state of brain function in the days after a blow to the head. Often times, it is interchangeable. For example, an excerpt from the American Journal of Sports Medicine reads, “Iverson *et al.* reported that 37% of concussed high school athletes were still clinically impaired on 2 or more neurocognitive measure at 10 days after concussion” [7]. In this sentence, the first use of the word concussion refers to the pathophysiological state after receiving a blow to the head, whereas with the second use of the word, concussion refers to the act of receiving the blow.

Another point of confusion stems from the accuracy of the use of ‘brain injury’, ‘head injury’, and ‘mild traumatic brain injury’ as synonyms for concussion. This has caused confusion among the academic/medical world as well as the general public. A study by McKinlay *et al.* surveyed the general public for knowledge about concussion and synonymous terms and found that it has been misinformed about certain symptoms and treatments for concussion. In the survey the different terms were received with various degrees of negativity, showing that the general public perceives ‘brain injury’ to be more negative than ‘head injury’, for example [8]. McKinlay *et al.* also pointed out that this confusion exists on medical websites, where some websites state that a brain injury is less severe than a concussion, whereas other websites say they are congruous [8]. This confusion also exists in peer-reviewed literature and textbooks, because MTBI lacks a single definition. According to the American Medical Society for Sports Medicine, a concussion is always an MTBI, whereas an MTBI isn’t always a concussion [9]. Thus, when reading about an MTBI it is impossible to know whether or not it’s a concussion. This confusion is evident in a “Facts for Physicians” pamphlet from the CDC, where concussion and MTBI are used interchangeably [2].

Despite the multiple points of confusion regarding the definition of concussion, it is possible to come to some general conclusions regarding the term. A concussion, in the general sense of the word, pertains to a blow to the head as well as to the abnormal pathophysiological state of the brain in the following days, weeks, and/or months. Although brain injury and head injury can both be used to describe a concussion, it is most accurate to refer to a concussion as a concussion. As the term ‘Mild Traumatic Brain Injury’ comes into more widespread use, and as more is learned about the pathophysiological processes of concussion, it will be necessary to come to a general consensus on the definition of the term so that researchers, doctors, and patients alike can all be in accord as to what they are discussing.

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