

Overlapping Concussion Syndrome: Defined in a Pediatric Population

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ABSTRACT – The purpose of this study is to introduce and define Overlapping Concussion Syndrome (OCS) as a new term in concussion assessment. A retrospective chart review was conducted at a tertiary referral sports medicine pediatric clinic to describe the clinical presentation and course of OCS. The results indicate that individuals with postconcussion syndrome (PCS) had significantly greater symptom scores than both the standard concussion (SC) and OCS groups after the initial concussion, but after the second injury, the OCS group had similar symptom scores to the PCS group. Patients who experienced a second head injury prior to the resolution of their initial concussion experienced an increased number of symptoms and a protracted recovery. However, these patients cannot be classified as having PCS; therefore, the term Overlapping Concussion Syndrome should be used to describe this subset of the concussion population.

Introduction

Over the last half century, the diagnosis and management of concussions has rapidly evolved. The elimination of terms that trivialized concussions such as “bell ringers”¹ demonstrates how concussions are no longer considered minor, inconsequential injuries. Today, concussions represent a major public health issue that is commonly discussed in the health care setting as well as in the main stream media. As the concern about concussions has expanded, the body of literature describing the diagnosis and management has also grown and evolved.^{1,3-7} However, this has led to competing and sometimes conflicting information within the literature. While this information is not incorrect, it represents differences in the understanding of concussions over time. For instance, there are two widely accepted definitions for the term “concussion.” One definition refers to a concussion as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces associated with the rapid onset of short-lived impairment or neurological functions that can resolve spontaneously.⁷ The second definition defines a concussion as a traumatically-induced alteration in mental status that may or may not involve the loss of consciousness; confusion and amnesia are often hallmarks of a concussion and may occur immediately or within several minutes of injury.⁸ At first glance, these definitions seem similar, but upon closer examination, each definition stresses a different facet of the concussion and represents the understanding of that era. The first definition was created in the 1960s and stresses the biomechanical causes of a concussion, but still trivializes it slightly by indicating that it can resolve spontaneously, whereas the second definition was created in

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the 2000s and stresses the neurological hallmarks of a concussion, but also raises the concern for the effects a concussion may have.

The rapid development of knowledge in a relatively short amount of time has left the medical community with a paucity of terminology to define the different clinical courses seen in concussion. Single-event concussions are the most typical and result from single or multiple blows during a single event, such as a hockey player getting checked into the boards and then striking their head a second time on the ice, or a football player getting tackled and striking their head a single time. Typically, these concussions are thought to follow a predictable recovery pattern that takes approximately one month⁹ for symptoms to resolve.⁹⁻¹² Unfortunately, concussion recovery does not always follow a predictable pattern and 10% – 30% of patients will demonstrate persistent symptoms.¹³⁻¹⁵ This clinical course is often referred to as Post-Concussion Syndrome. PCS is defined by the World Health Organization's ICD-10 diagnostic criteria¹⁶ as a history of head trauma, usually with some loss of consciousness, and at least three of the eight symptoms listed in Table 1, which persist for an extended period of time. It has never been clear if PCS is caused by the failure to fully recover from the initial concussive event or if PCS is the evolution of a single-event concussion into a different clinical entity. It has been suggested that patients diagnosed with PCS become anxious about their concussion symptoms and this preoccupation actually exacerbates and prolongs their symptoms, making the condition far more difficult to treat.^{17,18} Another term that has been explored as an additional means of describing the clinical course of a concussion is Second Impact Syndrome (SIS). SIS is a controversial subject in concussion literature since SIS

by definition is not a concussion due to the associated structural damage to the brain.^{19,20} SIS occurs when an athlete who is acutely symptomatic from a previous head injury sustains a second head injury before the symptoms of the first injury subside.^{8,18,19} The cumulative effect of the two concussive blows creates a far more substantial effect than each of the respective blows.²¹ Rather than SIS being a complication of recurrent concussion, it is far more likely that the clinical condition represents "diffused cerebral swelling," a well-recognized complication of traumatic brain injury.²² SIS is extremely rare; only 39 possible cases have been reported to the United States National Center for Catastrophic Sports Injury Research.¹⁹ However, SIS is usually catastrophic, due to the loss of cerebral vasoregulation that leads to brain herniation.^{8,23}

Current terminology is inadequate for primary care physicians and specialists to accurately describe the differences in recovery time when counseling patients with a concussion. Pathophysiologic studies suggest that there is an increased window of brain vulnerability after a concussion due to the impairment of cellular energy metabolism.²⁴ A recent animal study suggests that a second injury before the brain has recovered results in cellular metabolic changes as well as significant increases in cognitive deficits.^{24,25} When a blow is delivered within the period of vulnerability, the cognitive effects of multiple concussions are cumulative and persistent.²⁵ In humans, this may translate to increased susceptibility to repeat concussions, increased morbidity from relatively lower force blows, or prolonged symptom duration and neurocognitive recovery.²⁶ Therefore, this study proposes a new descriptor to aid in the classification of the clinical recovery course for a concussion. This new classification, termed Overlapping Concussion Syndrome, has a superficial similarity to SIS only in that it also occurs when a patient receives a second blow while still symptomatic from a previous concussion. It is hypothesized that patients with OCS will experience a protracted recovery course similar to those diagnosed with PCS, but the protracted recovery is caused directly from the accumulation of multiple concussive blows, rather than a single inciting incident. Herein, we define OCS and describe the differences between OCS, PCS, and single event concussions in a pediatric sports medicine practice.

Methods

This retrospective study was approved by the Connecticut Children's Medical Center's Institutional Review Board. The charts of all new patients presenting to the pediatric sports medicine concussion clinic

Table 1. ICD-10 Definition of Post-Concussion Syndrome Symptoms

<i>ICD-10 Post-Concussion Syndrome Symptoms</i>
Headache
Dizziness
Fatigue
Irritability
Difficulty concentrating and performing mental tasks
Impairment in memory
Insomnia
Reduced tolerance to stress, emotion, excitement, or alcohol
Symptoms may be accompanied by feelings of depression and patients may adopt a permanent sick role

between September 2010 and August 2012 were reviewed for this study. Patients were included if they were between the ages of 11 and 19 when they were concussed, they received their concussion in an athletic-related activity, and they completed their care at our facility. Patients who were still actively receiving treatment after the open period for the study, were lost to follow-up, or chose to transfer their care to another facility or department were excluded from this study.

The included patients were categorized into one of three groups. The first group, termed SC, was comprised of those patients who received a concussion from a single event, and showed symptom resolution and were discharged from care within 43 days from the initial injury, consistent with standard recovery times for young adolescents.²⁷ The second group, termed PCS, was comprised of those patients who received a concussion from a singular event, and symptom resolution and discharge from care occurred after 180 days from the initial injury. The final group, termed OCS, was comprised of patients who could be classified as having Overlapping Concussion Syndrome. These patients received a concussion and within 43 days of the initial concussive event and prior to the cessation of symptoms, they received a second head injury. Since the OCS group was much smaller than the first two groups, patients from the SC and PCS groups were randomly selected to be age and gender matched to the OCS group. To perform the randomization, the standard concussion group was reviewed to identify patients in the same age range as the OCS group. The group was then further divided into two subgroups based on gender. A random number generator in Excel was used to assign each patient a number. Patient lists were then sorted by the randomly generated number. The first set of patients from the male and female lists were selected for the study group. This process was repeated for the PCS group.

Descriptive statistics were calculated for all variables of interest and included time to discharge and

patient's Immediate Post-Concussion Assessment and Cognitive Test (ImPACT), which included the composite scores for verbal memory, visual memory, visual motor speed, reaction time, and total symptom, and are presented throughout the remainder of this work as means and standard deviations for ease of understanding. A single-factor ANOVA was used to determine if there were statistically significant differences between the three groups. A *P* value of less than .05 was considered a statistically significant finding. In cases where statistical significance was noted, a Tukey post-hoc analysis was performed to determine which of the three groups drove the statistically-significant finding.

Results

Between September 2010 and August 2012, a total of 615 patients were evaluated for concussions. Of these, 419 patients met the inclusion criteria for the study. Eleven patients were noted to have OCS as defined for this study, 36 patients were classified as PCS, and the remaining 372 patients were classified as SC. The demographics for the three groups are listed in Table 2. The SC group required 27 ± 5 days to recover from their concussion, the OCS group required 86 ± 51 days, and the PCS group required 351 ± 79 days ($P < .001$).

The results showed that when looking at the initial postinjury ImPACT test scores, none of the domains indicated a statistically significant difference between the three groups, but there was a significant difference in symptoms scores (Table 3). The results showed that the PCS group had a statistically greater symptoms score than either the OCS or SC group, but there was no difference in symptoms scores between the OCS and SC groups ($P = .035$) (Figure 1). There were also no statistically significant differences noted in the ImPACT domain scores at the time of discharge (Table 3). Despite a limited sample, ImPACT test results for OCS patients completed within a week of

Table 2. Comparison of Demographic Information and Recovery Data Among the Three Study Groups

	<i>Standard Concussion</i>	<i>PCS</i>	<i>OCS</i>	<i>P value</i>
Age (years)	15 ± 1.3	15 ± 2.1	15 ± 1.6	.872
Sex (M/F)	6/5	7/4	7/4	.881
Days to initial evaluation	5 ± 2	8 ± 4	26 ± 16 ^a	< .001
Days between concussions	–	–	12 ± 8	–
Days until recovery	27 ± 5	351 ± 79 ^b	86 ± 51 ^c	< .001

- a Differences between SC and PCS compared to OCS group
- b Differences between SC and OCS compared to PCS group
- c Differences between SC and OCS group

their second injury showed an increase in symptoms score from an average of 5 ± 5 to 19 ± 11 . It is also important to note that when comparing the ImPACT symptom scores from the SC and PCS groups' initial test to the OCS group's second injury, a statistically significant difference was noted between scores ($P = .047$). Results of the Tukey indicated that the SC group had statistically lower symptoms scores compared to the other two groups.

Discussion

The purpose of this study was to introduce a new term to describe the clinical recovery course of patients who receive a secondary injury while still recovering from an initial concussion, but do not experience the catastrophic results associated with SIS. In our cohort of 419 concussions, 11 patients (2.6%) presented with OCS. While the numbers are low, these patients reflect a clinical recovery course that is unique, different, and deserving of further classification.

Several authors have identified that youth and adolescent patients take longer to recover from a concussion than adults.²⁸⁻³⁰ Recovery time for a younger patient could vary from a few days to several months.^{25,31,32} Meehan et al identified that 97.1% of high school athletes had resolution of their symptoms within one month of their initial injury.²⁵ The data in this study indicate that the time to resolution for those with OCS is substantially longer than SC. In addition, these patients clearly had not developed SIS, lending credence to the need for this new term for concussion management. Yet, interestingly, patients in the OCS group still recovered faster than those with PCS. This could potentially indicate that while the second injury exacerbated the concussion symptoms, causing a protracted recovery, it was not associated with the psychological worry about why the symptoms were still present as commonly seen in pa-

tients with PCS, as these patients understood there was a direct relationship between the second blow and the prolonged symptoms. Further work is warranted to understand the psychological differences between these two groups and how these differences may play a role in recovery.

Also of importance is that the initial presentation of symptom reporting, as determined by the ImPACT tests, showed that the OCS and SC groups were nearly identical. It was not until the second injury that the symptoms score rose to the levels associated with the PCS group. This indicates that most, if not all of those classified as having OCS, in this study, may have followed a typical recovery were it not for the subsequent injury. Interestingly, the symptoms after the second injury were similar to those of the initial symptoms scores of the PCS group, yet the OCS group still recovered more rapidly than the PCS group. These data suggest that the second injury can exacerbate symptoms and cause lingering residual effects that take longer to resolve, but not to the extent as observed with PCS. This provides further evidence for the potential for differences postinjury between the OCS and PCS groups that need to be further analyzed.

This study is not without limitations. This is a retrospective look at patients who were seen between September 2010 and August 2012. As such, there were a number of patients who had missing or incomplete data, which reduced the numbers available for study. However, while the study sample size is small, the purpose of this study is to justify new concussion terminology, while providing information for future studies.

Another limitation is that our clinic is a tertiary referral center; therefore some of the milder concussions may not be referred to us by primary care physicians. This reduces the chance of seeing potential OCS pa-

Table 3. Comparison of the ImPACT Domain Scores Among the Three Study Groups

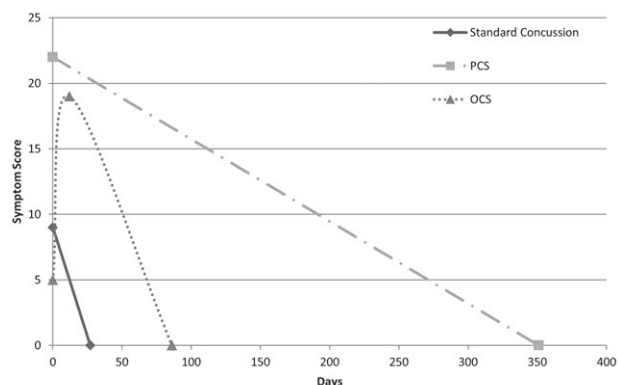
	<i>Standard Concussion</i>	<i>PCS</i>	<i>OCS</i>	<i>P value</i>
Verbal memory	80 ± 14	72 ± 20	78 ± 8	.582
Visual memory	69 ± 14	63 ± 25	78 ± 8	.389
Motor speed	34.7 ± 8.3	29.7 ± 12.7	36.2 ± 1.9	.447
Reaction time	0.58 ± 0.10	0.82 ± 0.44	0.57 ± 0.30	.199
Impulse control	7 ± 4	13 ± 10	7 ± 3	.242
Symptoms score	9 ± 8	22 ± 16 ^a	5 ± 4	.035
Symptoms score after second blow	–	–	19 ± 10 ^b	.047 ^c

a Differences between SC and OCS compared to PCS group

b Differences between SC and OCS group

c Compares second blow scores to initial blow scores for SC and PCS groups

Figure 1. Differences in Symptoms Score and Time to Recovery. Shows results of three study groups: solid line is standard concussion, dotted line is OCS, and dash-dot is PCS.



tients until after their second injury, which then reduces available data. It is also important to note that of the 11 patients classified as having OCS, only four of these patients received their second concussion after their initial presentation at our clinic. The remaining seven patients received their second head injury prior to presenting at our clinic, indicating that after the second blow, their symptoms increased, spurring a referral to a “concussion specialist.” Therefore, this problem may be far more common but underrepresented in our study.

As demonstrated in this paper, there are significant differences in recovery time between the OCS group and those with PCS or SC, in a pediatric setting. This significant difference in recovery outcomes necessitates a unique term to describe the clinical course of patients who have received a second head injury prior to the resolution of the initial concussion. The term overlapping concussion syndrome fits this scenario well, and describes a far more common occurrence than SIS. The introduction of this new concussion terminology allows physicians a framework to better counsel patients as to their clinical course and estimated recovery. In addition, the identification of OCS gives practitioners another reason to emphasize the importance of not returning to play until concussion symptoms have completely resolved.

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