



Topical Review

The Controversial Second Impact Syndrome: A Review of the Literature



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ABSTRACT

BACKGROUND: Second impact syndrome is a devastating injury that primarily affects athletic children and young adults. It occurs when a second concussion occurs before symptoms from the first concussion have resolved. Diffuse and often catastrophic cerebral edema results. Reports of second impact syndrome are few, and some argue that second impact syndrome is simply diffuse cerebral swelling unrelated to the first concussion. **METHODS:** Ovid and PubMed were searched from years 1946 to 2015 using the terms “second impact syndrome,” “repeat concussion,” and “catastrophic brain injury.” In addition, review articles were found using a combination of the terms, “concussion,” “second impact syndrome,” and “repetitive head trauma.” **RESULTS:** Seventeen patients in seven publications met the criteria of having two witnessed hits and persistent symptoms from the first to the second concussion. Ten of the 17 (59%) included individuals were football players. All were male. Ages ranged from 13 to 23 years. All children with poor outcomes (death or permanent disability) were younger than 20 years, while four of the five players with good outcomes were older than 19 years. The lag time from first to second concussion ranged from one hour to four weeks, and in many cases, at least one of the two hits appeared minor. **CONCLUSIONS:** American football, male gender, and young age appear to be associated with second impact syndrome. Controversies surrounding this syndrome are discussed. There is a need for prospective studies to clarify risk factors and outcomes of second impact syndrome to guide return-to-play recommendations for young athletes.

Keywords: second impact syndrome, concussion, child, young adult, football, gender, traumatic brain injury, ischemic stroke
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Introduction

In recent years, sports-related concussions in children and young adults have gained increased attention.¹ The American Academy of Pediatrics defines concussion as a direct hit to the head or jarring blow to the body that gets transmitted to the head, resulting in brief disruption in neurological function. However, typical clinical neuroimaging studies reveal no

abnormalities.² Two back-to-back concussions may have particularly severe consequences. Allowing children to return to contact sports while still symptomatic from an initial concussion may increase their risk for second impact syndrome. Second impact syndrome occurs when an individual suffers a symptomatic head injury resulting in concussion symptoms, then before recovering sustains a second impact, developing altered mental status and sometimes loss of consciousness within seconds to minutes of the second hit.³⁻⁵ The second impact can be of smaller magnitude and not directly to the head.⁴⁻⁶ Second impact syndrome is evidently rare and can result in catastrophic neurological injury.⁷ This syndrome is not well understood, and its very existence is debated in the literature.⁸ We review previous literature on second impact syndrome, discuss possible mechanisms and risk factors, and propose directions for future research.

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TABLE.
Cases of Second Impact Syndrome That Fit Inclusion Criteria

Reference	Sport	Gender	Age, yr	First Concussion	Persistent Symptoms
Fekete ¹¹	Hockey	Male	16	Hit head on ice, brief, LOC+	Weakness, unsteadiness, headache
Kelly et al. ¹²	AF	Male	17	Concussion with LOC+ during game	Headache
Cantu and Voy ²³	Boxer	Male	17	Head injury during fight, car accident on day of final match, LOC–	Persistent headache, nausea
	Boxer	Male	19	Knocked down in boxing match, LOC–	Headache
	Boxer	Male	17	Head blows left boy dazed	Overly obsessive behavior to box again
Mori et al. ¹⁷	AF	Male	22	Strong tackle, LOC–, mild amnesia	Headache
	Karate	Male	20	Presumed block to head during first match, LOC+	Headache
	Boxing	Male	23	LOC–	Headache
Cantu and Gean ²²	Skiing	Male	22	LOC+	Headache
	AF	Male	13	Head-to-head collision, LOC–, headache and dizziness	Headache, dizziness, slowed behavior
	AF	Male	19	Head-to-head collision, LOC–	Headache
	AF	Male	16	Made defensive tackle, LOC–, headache	Headache
	AF	Male	15	Suffered concussion during practice, dazed, LOC–	Headache
	AF	Male	17	Several hard tackles, LOC–	Dazed
	AF	Male	16	Hit during practice, LOC–, headache	Headache, visual disturbances with activity
Potts et al. ¹⁸	AF	Male	13	Strong tackle, LOC–, fatigued	Headache
Weinstein et al. ³	AF	Male	17	Head-to-head collision, stunned, LOC–, developed headache and fatigue, saw doctor, CT-normal	Headache

Abbreviations:

AF = American football
 CT = Computed tomography
 LOC = Loss of consciousness
 PCA = Posterior cerebral artery
 SAH = Subarachnoid hemorrhage
 SDH = Subdural hematoma
 – = Absent
 + = Present

Materials and Methods

We reviewed the literature on second impact syndrome. Ovid and PubMed searches from 1946 to July 2015 were performed using the key terms “second impact syndrome,” “repeat concussion,” and “catastrophic brain injury,” yielding a total of 40 and 53 articles, respectively. We then used additional search parameters: “concussion,” “second impact syndrome,” “repetitive head trauma,” and “human subjects” to capture additional cases. Thirty-six examples of presumed second impact syndrome were identified and analyzed.^{3,4,9–21} We used inclusion criteria based on those suggested by McCrory and Berkovic,¹⁴ and Mori et al.¹⁷: (1) observed second head impact with immediate neurological deterioration (seconds to minutes) and (2) cerebral edema that could not fully be explained by structural pathology, together with (3) verification of continuous postconcussive symptoms after the first impact up to the time of the second impact or (4) evaluation by trained medical professional after observed first impact.

Results

A total of 36 cases were found in 15 publications. Seventeen cases in seven publications fit the criteria

previously outlined. Fifteen of the cases were previously reported in literature reviews that reported multiple cases.^{14,17} McCrory and Berkovic,¹⁴ Mori et al.,¹⁷ and Cantu and Gean²² published previous case series and reviews that each included five to eight of these 17 cases; there was some overlap among the reviews (Table).

Characteristics of the 17 identified cases

Patient population

Ten of 17 played American football. All were male. Ages ranged from 13 to 23 years. Ten of the 12 individuals with poor outcomes were younger than 18 years. Four of the five individuals with good outcomes were older than 19 years.

Presentation

Nine of the 17 suffered a direct blow to the head as the initial concussion. During the first concussion, 13 of the 17 did not lose consciousness. The lag time between the first concussion and the second concussion ranged from one

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