

LETTER TO THE EDITOR**TO THE EDITOR****Community Health Consequences of a Second-Impact Syndrome Death Following Concussion**

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Second-impact syndrome (SIS), identified in 1984,¹ is a rare condition said to occur when a person sustains a second head injury before symptoms from the first have resolved, and develops cerebral swelling.² We describe a victim of possible SIS and the subsequent medical examiner inquest in the province of Manitoba, Canada.

A 16-year-old male judo athlete struck his head while sparring. He complained of dizziness but received no medical evaluation. The next day he was thrown and hit the back of his head. Approximately two minutes later, he complained of headache and lost consciousness. He was stabilized within 40 minutes and flown to a tertiary care centre: his initial Glasgow Coma Score was 5/15, computed tomographic (CT) scan showed right-side brain swelling and intracranial pressure (ICP) was 16 mmHg. On day 4, his ICP reached 48 mmHg despite hyperventilation and sedation, and CT scan showed right cerebral infarction. He died five days after admission. His medical history included leukemia at 3 years of age treated with chemotherapy (until age 7) and whole-brain radiotherapy (24 Gy), and later treatment for meningitis. He was in remission without neurological sequelae.

Autopsy revealed a swollen brain (weight 1360 g), thin (1-mm) subdural haematoma over the right hemisphere and herniation of the right uncus. There were no contusions. Sectioning showed a 7-mm haematoma in the right middle temporal gyrus (Figure 1) and haemorrhage in the midbrain and pons secondary to herniation. The magnitude of brain swelling was greater than would be expected for the focal haemorrhagic lesions identified. Microscopic examination showed neuron and axon damage due to hypoxic-ischemic injury. There was no vascular anomaly, radiation change or hyperphosphorylated tau protein immunoreactivity.

The boy's death occurred in August of 1997, and a judicial inquest report was issued in January of 2000.³ The five (paraphrased) recommendations were: (1) return to participation based on the 1986 Cantu guidelines;⁴ (2) an advisory to be sent to the guardian concerning head injury; (3) health records used in sport should have a head injury section; (4) amateur sport organizations of Manitoba should allow referees to issue medical suspensions if there is suspicion of concussion; and (5) coaches should encourage young athletes to verbalize injuries they may have sustained. The inquest judge wrote, "What has come out loud and clear from this Inquest is that the most important factor in preventing a serious outcome from a sports related head injury is to ensure an adequate amount of recovery time before allowing an athlete to return to the sport."

ThinkFirst Canada had been established in 1992 to prevent head injury (amalgamated into Parachute in 2012; <http://www.parachutecanada.org>). However, education about "mild" head injury was not widespread at the time. The Sport Medicine Council of Manitoba disseminated the judicial

recommendations and hosted "concussion in sport" seminars in 1999 and 2000, around the same time that other provinces were promoting concussion awareness. However, the recommendations were not immediately implemented. In 2001, Judo Canada still advocated that in "cases of mild concussions, fighters should not be allowed to resume activity for 20 minutes." Findings of the first International Conference on Concussion in Sport were published in 2002.⁵ By 2003, the Coaching Association of Canada had revised concussion guidelines and officiating rules—for example, in judo "the Referee shall call the Doctor to attend to a contestant who has received a severe impact to the head." The Manitoba Brain Injury Association began a "Heads Up" awareness program in 2003. Despite escalating media attention about head injury in professional athletes, further official advances were sluggish for a decade. In Winnipeg, a concussion center (Heads Up Concussion Institute) was opened in 2012, and a paediatric-concussion program opened in 2013 at the Pan Am Clinic. Since then, citywide concussion protocols for football and hockey require medical evaluation, a standardized emergency room discharge information sheet and clearance prior to return to play. However, concussion education of students and athletes remains the responsibility of local school boards and provincial sports organizations and is difficult to assess. A search of Manitoba school division websites showed that fewer than half even contain the word "concussion," and its earliest appearance was in 2013. A survey of Canadian coaches in 2012 revealed that ~90% of the 6,937 respondents were aware of the physical and cognitive consequences of concussion, but only half were aware of such mental health changes as irritability, depression or anxiety.⁶

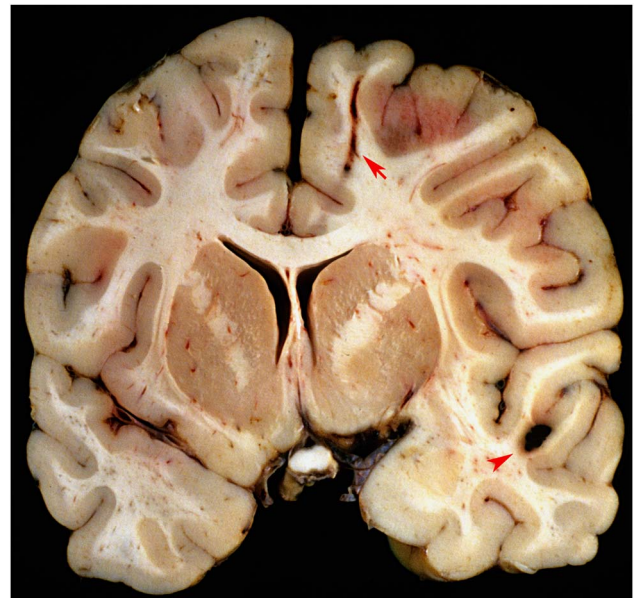


Figure 1: Coronal slice through the cerebrum at the level of the nucleus accumbens showing small lateral ventricles, slight right-to-left shift of the midline structures, a haemorrhagic track (red arrow) in the right frontal lobe associated with the intraventricular catheter and a small (7-mm) haematoma in the right temporal lobe (red arrowhead).

Whether SIS actually exists or is simply a chance coincidence remains unclear. It is rare and has not been modelled in animals.² Rapid-onset cerebral swelling after head trauma may be due to loss of cerebral blood flow autoregulation. A recent study using blood oxygen level-dependent (BOLD) magnetic resonance imaging showed abnormal regional brain responses to carbon dioxide challenge in symptomatic adolescents months after concussion.⁷ This supports the postulate that a post-traumatic period of vascular susceptibility might play a role in SIS. The role of prior brain irradiation in the presented case is unknown.

Although firm evidence for SIS is lacking, this must be weighed against the tragic nature of these cases, where any possibility for prevention should be considered. The recommendations of the Manitoba judicial inquest in 2000 were appropriate, and were initially disseminated rapidly at the local level. However, it is not clear that they were actually implemented. Furthermore, the report is not readily accessible to the public, precluding any broad value. Indeed, a similar death occurred in 2013 when a 17-year-old girl sustained three concussions during high school rugby matches over the period of a week. The 2015 Ontario inquest resulted in a set of 49 recommendations,⁸ which are essentially an update of the 2000 Manitoba inquest conclusions, with many additions focused on the school system.

It remains to be determined if preceding head injuries actually lower the threshold for loss of cerebral autoregulation in children. Autopsy examination remains important in these deaths; however, autopsy does not shed any understanding on the presumed functional changes in brain vasculature. Continued research into the pathogenesis of concussion and relentless public awareness campaigns are necessary.

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DISCLOSURES

Carly Scramstad, Michael Ellis and Marc Del Bigio hereby state that they have nothing to disclose.

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