

REVIEW ARTICLE



# Systematic Review of the Clinical Course, Natural History, and Prognosis for Pediatric Mild Traumatic Brain Injury: Results of the International Collaboration on Mild Traumatic Brain Injury Prognosis

Ryan Hung, MD, MSc,<sup>a,b,i</sup> Linda J. Carroll, PhD,<sup>c</sup> Carol Cancelliere, DC, MPH,<sup>d,e</sup> Pierre Côté, DC, PhD,<sup>e,f,g,h</sup> Peter Rumney, MD,<sup>a,b</sup> Michelle Keightley, PhD,<sup>i,j</sup> James Donovan, DC,<sup>d</sup> Britt-Marie Stålnacke, MD, PhD,<sup>k</sup> J. David Cassidy, PhD, DrMedSc<sup>d,e,g,l</sup>

From the <sup>a</sup>Department of Rehabilitation and Complex Continuing Care, Holland Bloorview Kids Rehabilitation Hospital, Toronto, Ontario, Canada; <sup>b</sup>Department of Pediatrics, University of Toronto, Toronto, Ontario, Canada; <sup>c</sup>School of Public Health and Alberta Centre for Injury Control and Research, University of Alberta, Edmonton, Alberta, Canada; <sup>d</sup>Division of Health Care and Outcomes Research, Toronto Western Research Institute, University Health Network, University of Toronto, Toronto, Ontario, Canada; <sup>e</sup>Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada; <sup>f</sup>UOIT-CMCC Centre for the Study of Disability Prevention and Rehabilitation, Toronto, Ontario, Canada; <sup>g</sup>Division of Epidemiology, Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada; <sup>h</sup>Faculty of Health Sciences, University of Ontario Institute of Technology, Oshawa, Ontario, Canada; <sup>i</sup>Bloorview Research Institute, Holland Bloorview Kids Rehabilitation Hospital, Toronto, Ontario, Canada; <sup>j</sup>Departments of Occupational Science and Occupational Therapy, University of Toronto, Toronto, Ontario, Canada; <sup>k</sup>Department of Community Medicine and Rehabilitation, Rehabilitation Medicine, Umeå University, Umeå, Sweden; and <sup>l</sup>Institute of Sports Science and Clinical Biomechanics, Faculty of Health, University of Southern Denmark, Odense, Denmark.

## Abstract

**Objective:** To synthesize the best available evidence on prognosis after pediatric mild traumatic brain injury (MTBI).

**Data Sources:** We searched MEDLINE, Embase, PsycINFO, CINAHL, and SPORTDiscus (2001–2012), as well as reference lists of eligible articles, and relevant systematic reviews and meta-analyses.

**Study Selection:** Controlled trials and cohort and case-control studies were selected according to predefined criteria. Studies had to have a minimum of 30 MTBI pediatric cases. After 77,914 records were screened for the entire review, 299 studies were eligible and assessed for scientific rigor.

**Data Extraction:** Eligible studies were critically appraised using the Scottish Intercollegiate Guidelines Network (SIGN) criteria. Two reviewers independently reviewed each study and extracted data from accepted articles into evidence tables.

**Data Synthesis:** Evidence from 25 accepted articles was synthesized qualitatively according to SIGN criteria, and prognostic information was prioritized according to design as exploratory or confirmatory. Most studies show that postconcussion symptoms and cognitive deficits resolve over time. Limited evidence suggests that postconcussion symptoms may persist in those with lower cognitive ability and intracranial pathology

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on neuroimaging. Preliminary evidence suggests that the risk of epilepsy is increased for up to 10 years after MTBI; however, there is insufficient high-quality evidence at this time to support this link.

**Conclusions:** Common post-MTBI symptoms and deficits in children are not specific to MTBI and appear to resolve with time; however, limited evidence suggests that children with intracranial pathology on imaging may experience persisting symptoms or deficits. Well-designed, long-term studies are needed to confirm these findings.

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Mild traumatic brain injuries (MTBIs) are common in children and adolescents. It is estimated that as many as 500,000 children younger than 15 years sustain TBIs that require hospital-based care in the United States, and most of these injuries are mild in severity.<sup>1</sup> A national cross-sectional study in the United States estimated that 1 of every 220 pediatric patients seen in emergency departments receive a diagnosis of MTBI.<sup>2</sup> Physical, emotional, behavioral, and cognitive symptoms such as headache, sleep disturbance, disorders of balance, fatigue, irritability, and memory and concentration problems commonly occur after MTBI. Knowledge about the course of recovery is important because it allows clinicians to provide appropriate advice to patients and families, and to identify patients at risk for poor recovery. Persistent symptoms or deficits after MTBI may lead to substantial functional disability interfering with children's academic performance or quality of life.

In a large systematic review<sup>3</sup> of MTBI prognosis published in 2004, the World Health Organization (WHO) Collaborating Centre for Neurotrauma, Prevention, Management and Rehabilitation Task Force found consistent evidence that children's prognosis after MTBI is good, with quick resolution of symptoms and cognitive deficits (within 3mo), and little evidence of MTBI-specific residual cognitive, behavioral, or academic deficits. The Task Force also found similarities between children sustaining an MTBI and those sustaining other kinds of injuries (eg, orthopedic), suggesting that where deficits are observed, they were likely due to premorbid characteristics or the experience of sustaining an injury in general, or both.

Understanding the course of recovery and identifying potential prognostic factors affecting recovery after MTBI in children are important for effective management and rehabilitation. The objective of this review is to update the WHO Collaborating Centre Task Force findings by synthesizing the best available evidence on the clinical course, natural history, and prognosis after MTBI in children. This review does not include psychosocial outcomes such as behavioral, emotional, psychological, or psychiatric outcomes, or family functioning. These outcomes are reported in another article in this supplement.<sup>4</sup>

## Methods

### Protocol registration

Our review was conducted and reported in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.<sup>5</sup> In accordance with the statement, our systematic review protocol was registered in the International Prospective Register of Systematic Reviews<sup>6</sup> on July 11, 2011, and was last updated on November 2, 2012 (registration no. CRD42011001410). We also published the protocol for our review.<sup>7</sup>

### Search strategy

The literature search and critical review strategy are outlined in detail elsewhere<sup>7</sup> and in this special issue.<sup>8</sup> Briefly, the electronic databases MEDLINE, PsycINFO, Embase, CINAHL, and SPORTDiscus were systematically searched from January 1, 2001, to February 10, 2012. The search terms included *cranio-cerebral trauma*, *prognosis*, and *children* among others. The full search strategy can be found in the published protocol by Cancelliere et al.<sup>7</sup> The reference lists of all reviews and meta-analyses relating to MTBI, and articles meeting the eligibility criteria were screened for additional potentially relevant articles that may have been missed by our electronic searches. Additionally, members of the International Collaboration on MTBI Prognosis provided information about studies that they had knowledge of but were not found in the databases or reference lists.

### Selection of articles

Articles were screened for eligibility according to predefined criteria. Inclusion criteria included original, published peer-reviewed research reports in English, French, Swedish, Norwegian, Danish, and Spanish. Studies had to have a minimum of 30 pediatric MTBI cases and had to assess outcomes such as post-concussion symptoms and cognitive deficits. Psychosocial outcomes such as behavioral, emotional, psychological, or psychiatric outcomes, or family functioning are discussed in another article in this supplement.<sup>4</sup>

Eligible study designs were controlled trials, cohort studies, and case-control studies. Exclusion criteria included study designs such as cross-sectional studies, and case reports and series, as well as cadaveric, biomechanical, and laboratory studies.

### Case definition

Studies had to state a clear definition for MTBI, consistent with the definitions provided by the WHO Collaborating Centre Task Force and the Centers for Disease Control and Prevention (CDC). The WHO Task Force defines MTBI as "an acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include (1) one or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities such as focal signs, seizure, and intracranial lesion not requiring surgery; and (2) Glasgow Coma Scale score of 13–15 after 30 minutes postinjury or later upon presentation for healthcare. These manifestations of MTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries, (eg, systemic injuries, facial injuries, or intubation), caused by other problems (eg,

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