

## Mild Traumatic Brain Injury Striking Postconcussion Symptoms Due to Inadequate Management

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**Abstract:** Pediatric mild traumatic brain injury is a frequent cause for emergency consultations. Very often, management decisions focus only on acute neurological problems, without considering possible long-term impairment. Our case describes a 14-year-old girl who developed a pronounced and prolonged postconcussive syndrome and subsequent posttraumatic stress symptoms after (mild) traumatic brain injury. Early discharge without adequate instructions about the appropriate time to return to school and daily life activities promoted these striking problems. Only the delayed interventions including reduction of school workload and initiation of physiotherapy led to an improvement of symptoms.

**Conclusions:** Traumatologists, pediatricians, and general practitioners should call families' and teachers' attention to the risk of potential postconcussive syndrome and advise them on appropriate coping strategies. Thorough clinical examination should rule out potentially treatable physical impairments. Prescription of physical and cognitive rest at an early stage is mandatory and should be part of concussion management already at emergency department. Pediatricians or general practitioners should follow up patients and support their gradually working back into full activity.

**Key Words:** management, postconcussion, traumatic brain injury

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Traumatic brain injury (TBI) is one of the leading causes for consultations in pediatric emergency departments (EDs) and constitutes with a prevalence of 200 to 500 per 100,000 children a significant public health concern. In 80% to 90% of all pediatric TBI cases, the TBI is mild, mostly defined by Glasgow Coma Scale score of 13 to 15.<sup>1</sup> Management after mild TBI (mTBI) in children focuses on acute problems guided by neurological examination and cerebral imaging findings.<sup>2</sup> Timely registration of treatable complications from injury, like secondary intracranial hemorrhage or cerebral edema, can be lifesaving.<sup>2</sup> On the other hand, most of the children after TBI (even after mTBI) present with acute non-life-threatening postconcussive symptoms (PCSs) (Table 1A).<sup>3</sup> Persistence of PCSs in the long term often impedes successful return to school as well as daily activities and social life.<sup>3</sup> Adequate coping strategies during the first few days and weeks after trauma influence the trajectory of these symptoms positively, but are frequently neglected in acute care. Discharge without concussion specific diagnosis or activity restriction is common.<sup>4</sup> The case report of a 14-year-old girl with striking PCSs is reported to sensitize to adequate management in mTBI in children. Recommendations are given concerning rest and recovery

council regarding physical and cognitive activities with the guide of literature.

### CASE

A 14-year-old girl presented with problems of unexpected worsening of school performance to our outpatient clinics. Four months before, she had been involved in a snowboard accident with 2 to 3 minutes of unconsciousness. Without a pause, she continued snowboarding, but 10 minutes later, she collapsed and showed disorientation for several hours. Initial evaluation by an emergency doctor revealed no additional neurological impairment, and the patient was discharged. Because of fluctuating disorientation, strong headaches, dizziness, and blurred vision during the following hours, she presented to the local ED 5 hours after the accident: Initial assessment showed a Glasgow Coma Scale score of 15 and normal neurological examination. Retrograde amnesia covering the last 3 days was present. The patient was admitted for observation; no cerebral imaging was performed. During the next 24 hours, her condition stabilized, and she showed no more signs of disorientation, but the amnesia persisted. Because of missing focal neurological signs, she was discharged home the next day without any further instruction regarding adjustment of school attendance and workload. Three days after the accident, the patient went back to school, attending all lessons, except for physical education. During the following months, persisting daily headache, concentration and memory problems, fatigue, dizziness, and blurred vision dominated the life of the patient. Several weeks after the accident, a complete ophthalmologic examination performed by an ophthalmologist (including visual performance, eye tracking, and evaluation of refracting media) was normal. The parents, asking for additional support in the patient's school activities, were not provided with any further recommendation or support. Because of progressive deterioration, a neuropsychological evaluation was initiated through the patient's family doctor 4 months after the accident. Despite the obvious clinical problems and despite previously diagnosed attention problems and dyscalculia, the patient's neuropsychological performance in several functions (attention, learning and memory performance, processing speed, executive functions) was normal. Nevertheless, the girl still reported a high number of ongoing PCSs such as daily headaches, attention problems, memory problems, blurred vision, dizziness, and fatigue. Therefore, another neurological clinical examination focusing on vestibulo-ocular system was performed in our rehabilitation department. Our clinical neurologic examination comprised gross extraocular movements, smooth pursuits, near-point convergence, horizontal and vertical saccades, vestibulo-ocular reflex, Hallpike maneuver, gait, tandem gait, hopping and standing on one foot each, postural stability, and screening hearing test (finger rubbing). No pathologies were found, and no symptoms were referred during the examination.

We prescribed physical therapy to cope with dizziness and to learn relaxation techniques, and we arranged a reduction of

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**TABLE 1A.** Postconcussive Syndrome: Symptoms and Potential Coping Strategies\*

Common PCSs	Coping Strategies
<b>Somatic symptoms</b>	
Headache <sup>†</sup>	<ul style="list-style-type: none"> <li>•Begin with a reduced school workload</li> <li>•Learn in a distraction-free environment (without smart-phone, radio, or TV)</li> <li>•If the headaches persist: please visit a medical doctor</li> </ul>
Dizziness <sup>†</sup>	<ul style="list-style-type: none"> <li>•Take things slow and easy after the injury</li> <li>•If the dizziness persists: please visit a medical doctor</li> </ul>
Fatigue <sup>†</sup>	<ul style="list-style-type: none"> <li>•Reduce school workload, visit only some lessons at school after the injury</li> <li>•Pay attention that you get enough sleep; have a regular sleep cycle</li> <li>•Make more breaks, take a nap if you are tired</li> </ul>
Noise or light sensitivity	<ul style="list-style-type: none"> <li>•Work in a shaded room</li> <li>•Wear sun glasses</li> </ul>
Blurred or double vision	
Clumsiness	
Poor balance	
Decreased endurance levels	
<b>Behavioral symptoms</b>	
Sleep problems <sup>†</sup>	<ul style="list-style-type: none"> <li>•Consider regular sleep time to get enough sleep</li> </ul>
Difficulties interacting with peers, making or keeping friends	
<b>Cognitive symptoms</b>	
Slower thinking	<ul style="list-style-type: none"> <li>•Reduce the amount of work</li> <li>•Do not follow time limitations</li> <li>•Ask for more time to finish tasks, avoid situations where there is pressure to do things quickly</li> </ul>
Concentration problems <sup>†</sup>	<ul style="list-style-type: none"> <li>•Avoid noisy or busy environments, stressful activities, and anything requiring concentration</li> <li>•Make regular breaks, relax between tasks which are challenging</li> <li>•Work in a calm environment, without any distractions (eg, tidy desk, without any distraction from the TV, smartphone, or radio)</li> <li>•Do difficult tasks only when you feel rested</li> </ul>
Memory problems <sup>†</sup>	<ul style="list-style-type: none"> <li>•Ask people to speak slowly and to explain things simply</li> <li>•Ask the teacher for clear instructions, complex instructions should be split into manageable components</li> <li>•Note (write or draw) down anything important: Use a daily planner, calendar, or notebook</li> </ul>
Some difficulties with speech and language (eg, expressing themselves)	
<b>Emotional symptoms</b>	
Irritability <sup>†</sup>	<ul style="list-style-type: none"> <li>•Learn relaxation techniques</li> </ul>
Symptoms of anxiety or depression	<ul style="list-style-type: none"> <li>•Speak about newly acquired anxieties and depressive symptoms</li> </ul>
Problems tolerating stress/emotion/alcohol <sup>†</sup>	

\*Data from Sady et al.<sup>21</sup>

<sup>†</sup>Symptoms that are considered for a diagnosis of postconcussion syndrome. According to the *International Classification of Disease, 10th Revision*, 3 of these 8 symptoms have to persist longer than 1 month after the injury to diagnose a postconcussion syndrome.

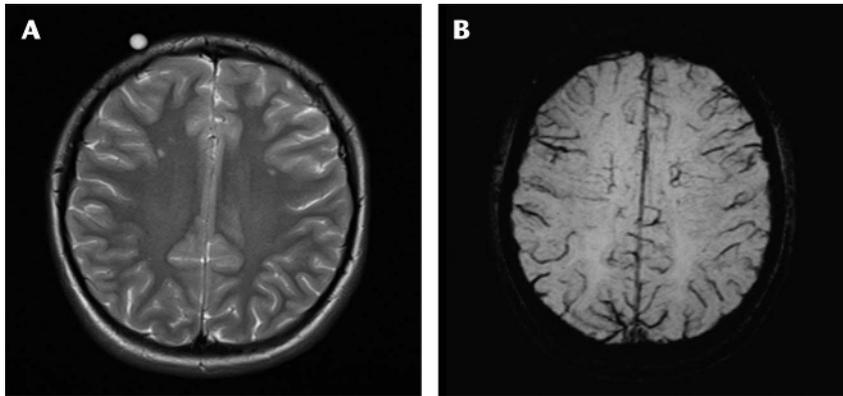
school workload (50%), including individualized educational objectives. After a temporary improvement, 7 months later, symptoms reoccurred as soon as school activities went back to normal. Because of the persistence and intensity of symptoms, a cerebral magnetic resonance imaging was performed 8 months after the injury. No pathologic susceptibility artifacts in susceptibility-weighted imaging could be seen as a sign of persisting hemorrhagic products (Fig. 1). But, multiple T2 hyperintense white matter lesions were found, which might represent posttraumatic gliosis as a consequence of shearing injuries after mTBI.

The dominating headaches continued. Sports activities and school visits were reduced again, and additional treatment with oral magnesium was initiated. Relaxation therapy as well as psychological support was continued. Occupational therapy was prescribed, but finally refused by the patient. Slow gradual improvement of all symptoms was observed over the next 6 months to an almost complete recovery. However, 14 months after the injury, after an excursion to the mountain ski area where the accident had

happened, a relapse of symptoms occurred. The patient complained again about episodes of blurred vision, stomach aches, and concentration and sleep problems, as well as disorientation. Additionally, several episodes of a cardiac presyncope were observable. Our repeated neurological and neuropsychological examinations did not show any abnormalities. There were no obvious symptoms of depression. As general physical examination was normal as well, no further additional investigations were initiated. The relapse of symptoms was interpreted as a sign of posttraumatic stress, triggered by the confrontation with the location where the accident occurred (mountain area). The patient refused psychiatric evaluation. To come to terms with the accident and the injuries, psychological coaching was continued.

## DISCUSSION

Our case report describes the follow-up of a 14-year-old teenager after mTBI with delayed admission to hospital and inadequate acute management. As loss of consciousness lasted only



**FIGURE 1.** A, Brain MRI axial T2-weighted sequence: 3 hyperintense lesions. B, Brain MRI susceptibility-weighted imaging sequence: no pathologic susceptibility artifact.

several minutes, initially, the brain injury was considered to be mild. The persistence of retrograde amnesia over the following months implies a moderate head injury, which was also supported by neuroimaging (Fig. 1). The girl was hospitalized and set to rest for 3 days, but thereafter there was no slow buildup, neither of physical nor cognitive activities.

Whether the persistence of amnesia could have been shortened by improved management including time of rest for different activities is in question. Thus, regardless whether the TBI was mild or moderate, this case report shows that missing adequate information on PCSs and potential coping strategies to patient, family, and caregivers such as neglected interventions according to different symptoms led to severe persisting problems. It has to be assumed that more careful initial management and follow-up according to current literature and guidelines<sup>4,5</sup> would have helped to recognize and manage these problems without delay.

In the following paragraph, we first analyze the failures of the management of this case. We also discuss the current recommendations from literature concerning concussion management according to physical and cognitive impairments separately. Finally, we draw our own conclusions suggesting a stepwise, active management in pediatric concussion.

### Initial Failures in Concussion Management

At the ED, no vestibulo-ocular reflex (VOR) and no Dix-Hallpike test were performed. Except for ophthalmologic evaluation, no supplementary vestibulo-oculomotor investigations were realized, despite persisting symptoms such as dizziness and blurred vision during the first days after concussion. This would have been essential to detect potential and treatable dysfunction.

Immediate participation in all school activities a few days after brain injury led to a vicious circle of symptoms: pronounced symptoms of PCSs resulted in failing all classes at school, which again led to psychological stress due to the feeling of falling behind. Missing support from school led to insecurity of the whole family and promoted deterioration of the patient's social activities and behavior. Such emotional problems are known to develop late in the recovery period of concussion.<sup>6</sup> Previous studies emphasized that preexisting psychological problems, such as depression, anxiety, and premorbid learning and attention deficits, can mimic or exacerbate PCSs.<sup>7</sup> Because our patient was premorbidly diagnosed with attention problems and dyscalculia, it is possible that these impairments posed risk factors for the prolonged persistence of PCSs.<sup>8</sup> Unfortunately, these previous cognitive and behavior

features have not been taken into consideration. Hence, parents and teachers were not informed about the high risk of developing PCS syndrome. The patient was turning back to daily activity and to full school workload far too early. Only the delayed arrangement of cognitive rest and the installation of interdisciplinary support coached by the neuropsychologist helped our patient to gradually improve school performance.

The reported symptoms of repetitive sudden relapses and recurrent episodes of confusion 14 months after the injury are not typical for PCSs and were interpreted as posttraumatic stress symptoms or anxiety disorder. They underline the degree of the patient's suffering and reflect how prolonged symptoms after mTBI can impair daily life even months after recovery. We hypothesize that all these long-term effects could have been minimized by consequent cognitive rest and early information about accurate coping strategies in PCSs.

### Aspects of Physical Impairment

As also described in a majority of patients with mTBI and concussion,<sup>5</sup> screening neurological examination at the ED was normal. Unfortunately, we do not have more detailed information about the initial neurological examination. But when the patient was sent to our department 4 months after the injury, the neurological evaluation including a complete assessment of oculomotor and vestibulo-ocular system (see Case) was normal. However, as we know from literature, commonly, PCSs after mTBI in children are the sign of a dysfunction of the vestibular and oculomotor system.<sup>9</sup> Many potentially treatable causes of dizziness in children can result from trauma to the inner ear following a head injury and may be overlooked in the setting of PCSs.<sup>10</sup> The vestibular and oculomotor systems share rich reciprocal connections and incorporate diffuse and complex brain circuitry, which are commonly affected by concussion. Furthermore, they increase the risk of prolonged PCSs.<sup>11,12</sup> Therefore, it is important to identify such vestibulo-ocular pathologies early in order to consult the families properly and apply for early specific therapy such as vision therapy or vestibular rehabilitation.<sup>13</sup> Ellis et al<sup>14</sup> presented a novel pathophysiological approach to postconcussion syndrome distinguishing between impairments in global brain metabolism (physiologic postconcussion disorder [PCD]) and neurological subsystem dysfunction (vestibulo-ocular and cervicogenic PCD) by adding a treadmill exercise test to thorough initial examination.

Early initiation of tailored therapeutic intervention such as vestibular rehabilitation, vision therapy, or subsymptom threshold aerobic exercise was suggested in vestibulo-ocular PCD.

Darling et al<sup>15</sup> proposed a standardized exercise treadmill test (Buffalo Concussion Treadmill Test [BCTT]) as additional tool to evaluate return to play in sports. In this study, none of the adolescents with normal BCTT reported a setback of symptoms during the 2 months after return to play. Studies in adults are supporting these data.<sup>16,17</sup> However, as in the study of Darling et al,<sup>15</sup> the follow-up was only validated by phone calls to the young athletes themselves; truthful report of symptoms is questionable. Further studies focusing on children and adolescents would be necessary to evaluate BCTT. Until today, the majority of guidelines<sup>5,18</sup> for children contain more general suggestions: no return to sport activities before the child/adolescent is completely symptom-free and/or has managed to return to school successfully.

Pathologies such as benign paroxysmal positional vertigo or labyrinthine concussion should not be missed, however. They are typical impairments after mTBI and have a relevant impact on daily activities and particularly on school performance.<sup>19</sup>

In most cases, they are diagnosed clinically by tests as pathologic VOR or Dix Hallpike test. Sometimes more specific tests as post-rotatory chair nystagmus test, subjective vertical bucket test, or dynamic visual acuity test are necessary to evaluate the problem and initiate early therapy.

Our patient reported no anamnestic hints for benign paroxysmal positional vertigo, but labyrinthine concussion or other peripheral vestibular dysfunction could have been the origin of the vertigo during the first days after concussion. Unfortunately, no specific testing was performed.

Four months after concussion, despite persistent dizziness and blurred vision, VOR and Dix-Hallpike test were normal. The long period of persisting symptoms is not typical for vestibulo-ocular deficits in mTBI. Deferred early interventions might have led to a progressive deconditioning in daily activities, and excessive demands further deteriorated the situation and ended in a posttraumatic stress disorder. Early intervention with better coaching and start of physical therapy could have prevented this course of the problems.

### Aspects of Cognitive and Psychological Impairment

From early return to school, our patient reported persisting concentration and memory problems, worsening her antecedent school performance. No neuropsychological assessment prior or shortly after the accident was reported. In view of the course of problems, early posttraumatic PCSs in the cognitive range must be assumed. Neuropsychological assessment 4 months after the accident showed no more signs of attention or memory problems. Therefore, these complaints together with the social retirement were interpreted in the frame of posttraumatic stress disorder. Also here, early interventions including coping strategies (Table 1A) most likely would have improved the long-term psychological and neuropsychological course.

### Physical and Cognitive Rest

In accordance with literature,<sup>20,21</sup> our case underlines the importance of initial “cognitive rest” during the first days to weeks following mTBI in children.

Recent research points out there is the possibility that sustained rest might adversely affect the posttraumatic recovery and lead to physical deconditioning and reactive depression.<sup>22</sup> The recent literature in adults suggests early rest first (only for days), followed by gradual working back into full activity, depending on ongoing symptoms.<sup>23</sup> In view of the longer recovery time because of different pathophysiology in children,<sup>24,25</sup> recommendations for children have been adapted. The consensus statement on concussion in sport (November 2012)<sup>5</sup> implies a more conservative approach concerning cognitive and physical rest in the subgroup of children and adolescents. Our case highlights this concept of “cognitive rest” and points out the importance of ongoing support by the health care provider to initiate early therapeutic and coaching interventions.

**TABLE 1B.** Postconcussive Syndrome: Recommended Clinical Management After TBI\*

Clinical Management	
Acute phase: first 48 h	<ul style="list-style-type: none"> <li>• Neurological evaluation, assess PCSs (eg, Acute concussion evaluation. Gioia et al, <i>J Head Trauma Rehabil</i> 2008;23:230–242)</li> <li>• Surveillance at hospital or at home—depending on clinical evaluation</li> <li>• Sensitize patient and family to necessary rests:                         <ul style="list-style-type: none"> <li>○ No sport activities (high-risk activities<sup>†</sup> for a minimum of 6 wk)</li> <li>○ Define time point to go back to school (including reduced workload, at the beginning not &gt;50%)</li> </ul> </li> <li>• Discuss expected trajectory for PCSs</li> <li>• Ensure that teachers are informed</li> <li>• Provide an information handout, containing given recommendations as well as contacts of the responsible caregivers and pediatrician</li> </ul>
Post-acute phase: discharge up to 3 mo after injury	<ul style="list-style-type: none"> <li>• If impairment in cognition and behavior or social integration problems persist:                         <ul style="list-style-type: none"> <li>○ Initiate abbreviated neuropsychological assessment (consider preexisting neuropsychological impairments)</li> </ul> </li> <li>• Reassure the patient and parents, including giving coping strategies (Table 1A)</li> <li>• Reevaluate sports activity and school workload</li> <li>• Individually define sport restriction according to persisting symptoms</li> <li>• Define further strategies within the school network</li> </ul>
Long term	<ul style="list-style-type: none"> <li>• If posttraumatic stress disorder symptoms persist:                         <ul style="list-style-type: none"> <li>○ Initiate appropriate coping strategies (Table 1A)</li> <li>○ Consider cognitive-behavioral psychotherapy</li> </ul> </li> <li>• Ongoing reevaluation of school workload and define long-term strategies within the school network</li> </ul>

\*Data from Kirkwood et al.<sup>26</sup>

<sup>†</sup>Such as horse riding, football, skiing, contact martial arts, jump on trampolines.

## Concussion Management Recommendations

Our case illustrates that accurate management after (mild) TBI, and subsequent rehabilitation process already begins at the ED. After exclusion of severe brain injury, a careful clinical examination including special tests for vestibulo-ocular functions and basic cognitive evaluation (eg, by performance of the SCAT3<sup>5</sup>) should be performed. Depending on these clinical findings, further investigations and especially therapeutic approaches should be discussed—concerning not only relief of symptoms but also managing going back to school.<sup>9,10</sup>

Information for parents and teachers on the importance of suspension of physical activities and cognitive rest is essential<sup>26</sup> (Table 1A). Written information by leaflets might be very helpful<sup>27</sup> (Table 1B). Children should be regularly followed by their family physician for recovery and return to school. If prolonged physical, cognitive, or psychological symptoms persist, further diagnostics and subsequent therapies have to be evaluated. If signs of posttraumatic stress disorder are occurring, psychiatric support is helpful.

## CONCLUSIONS

Regarding academic achievement as well as emotional and social well-being, the initial management after mTBI in childhood and adolescence is crucial for long-term outcome. Our case is representative for initial mismanagement. Management of mTBI includes providing families and teachers with adequate information and coaching for rest and reintegration to sports activities and school. Initial examination should rule out potentially treatable physical impairments. Careful follow-up by a pediatrician or family physician allows timely recognition of prolonged PCSs and helps to initiate necessary therapeutic support.

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