POST-CONCUSSION VESTIBULAR CHANGES

https://doi.org/10.56238/sevened2024.031-053

Henrique Cecchet[1] and Pricila Sleifer[2]

ABSTRACT

Concussion refers to a pathophysiological state resulting from mild traumatic brain injury. It is a functional, non-structural brain injury characterized by changes in brain function after a sudden blow to the cephalic, facial or cervical region. Rotational and acceleration forces, especially in the frontotemporal region and in children, increase the risk of diffuse brain injury. The main causes of concussion include domestic and automobile accidents, falls, sports, and violence. Since the year 2000, there has been a significant increase in the diagnosis of concussion in young people, especially during sports. Concussion is a global public health issue due to its prevalence and for affecting long-term quality of life. It is estimated that up to 1.9 million young athletes suffer concussion annually, of which 50% are concussions in the child population. However, about 10% face prolonged recovery, with possible complications such as post-traumatic migraine and neurocognitive deficits. Common symptoms include headache, disorientation, dizziness, vertigo, body imbalance and memory changes, and the affected brain region is closely related to clinical manifestations. Diagnosis in children is challenging, as many symptoms may be subtle or underestimated. Initial treatment involves adequate sleep, physical and cognitive rest for 24 to 48 hours, followed by a gradual, individualized return. Evaluation of the vestibular system is essential, as about 25% of pediatric dizziness cases are associated with post-concussion. Rehabilitation of vestibular function, with personalized exercises, is recommended for patients with persistent symptoms. Management should be multidisciplinary at all stages of clinical evolution, with attentive, qualified clinical guidance that considers post-concussion vestibular changes.

Keywords: Concussion. Cerebral Concussion. Vertigo. Vestibular System.

[1] Doctor. Degree in Medicine and Academic Laurel from FEEVALE University. Lieutenant of the Brazilian Army, working in the Health Section of the 8th Logistics Battalion in Porto Alegre - RS.
[2] Associate Professor, level IV, at the Federal University of Rio Grande do Sul (UFRGS). Master and Doctor in Medical Sciences: Pediatrics from UFRGS. Coordinator of the Center for Studies and Research in Electrophysiology of Hearing, Neuroaudiology and Otoneurology at UFRGS

INTRODUCTION

The term concussion is often used in the medical literature as a synonym for mild head injury, but more specifically describes a pathophysiological state that results in the characteristic symptoms and signs that individuals may present after a mild traumatic brain injury (TBI).

Concussion is a biomechanically induced clinical condition, related to changes in brain function, and is considered a functional brain injury, not a structural one. This is classified as a mild traumatic brain injury, i.e. it involves a disruption in normal brain function caused by a sudden blow to the cephalic, facial or cervical regions or by a blow to another site of the body with force transmitted to the head, which results in a period (of any duration) of decreased or loss of consciousness, neurological deficits or any change in mental status (Rose *et al.*, 2015; Rotter; Kamat, 2019; Sleifer; Borges, 2023; Sleifer *et al.*, 2024).

Rotational forces, acceleration and deceleration, especially in the frontotemporal region, and associated with the disproportion of the size of the head in relation to the trunk and incomplete myelination in the pediatric age group, have their effects enhanced, increasing the frequency of diffuse brain lesions (Zeitel; Flintz; Nogueras, 2017).

The main causes of concussion are related to domestic accidents, falls from one's own height, car accidents, sports and violence (shaken child syndrome). Beginning in the year 2000, there has been a considerable increase in concussion diagnoses in this population, with sports and recreational activities accounting for 25 to 50 percent of all concussions. Observational studies suggest that the incidence of sports-related concussion is higher in females, who attend high school and university, than in male athletes, when sports are governed by similar practices (Meehan; O'Brien, 2020).

It should be noted that concussion is considered a global public health issue, because it has a considerable prevalence, despite often being underdiagnosed, and because of the consequences it has for the quality of life of individuals in the long term (Mastrangelo; Midulla, 2017; Sleifer; Borges, 2023). It is estimated that up to 1.9 million young athletes suffer concussion annually, of which 50% are concussions in the child population. Most post-concussion patients have a rapid recovery (on average one month), due to compensation or adaptation of the central nervous system (Toledo; Rolnik, 2015). However, about 10% of patients have prolonged recovery, which may eventually progress to long-term complications, such as: post-traumatic migraine, neurocognitive deficits, poor school performance, and behavioral changes (Price *et al.*, 2022, Sleifer *et al.*, 2024).

The most common post-concussion symptoms include headache, confusion, inattention and disorientation, memory or speech changes, dizziness, nausea, vomiting, and

gait abnormalities. The affected brain region is closely related to certain symptoms. For example, a direct impact on the temporoparietal or parietooccipital regions can cause a vestibular concussion, producing nausea, vertigo, and nystagmus, in addition to the classic symptoms of a concussion. An impact that causes a fracture of the temporal bone can damage the labyrinth, cause hemotympanum and hearing deficit. In the past, lesions with a hyperflexion and extension mechanism ("whiplash") can injure the basilar artery, which partially irrigates the labyrinth, and also lead to vestibular symptoms. Blunt or penetrating trauma to the middle ear can rupture the oval window where the stapes articulates with the inner ear, causing a perilymph fistula (Walls; Teach, 2020).

One-minute loss of consciousness and seizures are uncommon among children and adolescents with sports-related concussions, occurring in less than 10 percent and approximately 1 percent of patients, respectively. Thus, the presence of these findings warrants immediate evaluation for a possible intracranial lesion (hemorrhages/hematomas).

Vestibular symptoms are common in pediatric post-concussion patients, accounting for about 25% of pediatric dizziness. Unresolved post-concussion vestibular and visual symptoms increase vulnerability to orthopedic injuries, highlighting the importance of diagnosing and treating such alterations (Rodriguez; Chiao; Spencer, 2021). It should be noted that studies show that children with a history of concussion have a four-fold increased risk of having a new injury, in addition to being more likely to develop vestibular disorders, such as benign paroxysmal positional vertigo (Van Lerssel *et al.*, 2021; Wang *et al.*, 2021).

The diagnosis of pediatric concussion is challenging, considering that in many cases the symptoms can be subtle or poorly reported, especially in younger age groups, as they are unaware of the symptoms and potential severity of concussions and can also disguise or hide some symptoms, so the physical examination plays an important role in the evaluation. The patient should undergo a detailed neurological evaluation, including mental status, gait, and body balance. Sensory, motor, and cranial nerve-related findings usually do not show changes in post-concussion children and adolescents.

Initial treatment of concussion focuses on avoiding further injury (second impact syndrome), restriction of physical activity, and relative neurocognitive rest. A study (Meehan; O'Brien, 2020) notes that no medication has been proven to speed up recovery from a post-concussion or prevent the long-term effects of injuries. Furthermore, the researchers described that, for children and adolescents with concussions, a period of physical rest lasting 24 to 48 hours followed by a gradual, individualized and supervised return to activities, avoiding symptomatic exacerbation and new traumas until complete recovery,

proved to be more efficient and with faster resolution of symptoms when compared to those children with a longer rest period and no prescribed activity (Meehan; O'Brien, 2020).

Cognitive rest is to avoid overloading a functionally injured brain and prevent metabolic overload. Studies have shown that patients benefit from one to two days of rest before returning to school. Once patients are able to concentrate, tolerating visual and auditory stimulation for 30 to 45 minutes, they should return to school with adjustments until full recovery. In cases where correct cognitive rest was not performed, there was a higher rate of prolonged and recurrent symptoms (Meehan; O'Brien, 2020).

Although symptomatic medications may be helpful, dependence and overuse should be avoided. For the treatment of headache, paracetamol and non-steroidal anti-inflammatory drugs should be used beyond the first few days after the injury, as they can cause headache as a rebound effect. Ondansetron is a reasonable therapy for nausea during the first two days after trauma, however, headaches, drowsiness, and dizziness are possible adverse effects that may aggravate other concussion symptoms (Meehan; O'Brien, 2024).

The emphasis on adequate sleep provides the best initial treatment for pediatric patients, given the high prevalence of post-concussion sleep disorders. If pharmacotherapy is required, a melatonin test of 3 mg in older children and 5 mg in adolescents is indicated. Benzodiazepines should be avoided due to daytime sleepiness and memory impairment, which makes it difficult to assess recovery.

Neuroimaging tests are usually avoided. However, if there is worsening and persistence (lasting more than three to four weeks) of symptoms, loss of consciousness, change in mental status, signs of fractures, or worrying factors, tomography or MRI should be performed, differential diagnoses investigated, and a multidisciplinary approach implemented.

In a randomized trial (McCarty *et al.* , 2016) with 49 children (11 to 17 years of age) with concussion and persistent symptoms ≥ 1 month after a sports-related concussion, collaborative treatment consisting of care management, cognitive behavioral therapy, and, when necessary, psychopharmacologic therapy was associated with significant reductions in post-concussive and depression symptoms at six months, when compared with usual care (87 vs. 58 percent of patients without elevated symptom levels and 78 vs. 46 percent of patients with ≥50 percent reduction in depression symptoms, respectively).

Regarding vestibular evaluations for post-concussion cases, studies refer to the importance and contribution to the diagnosis, in particular the analysis of ocular motility and the function of the semicircular canals. However, little is known about the damage caused to

the otolithic organs and their brainstem-mediated pathways. It is known, however, that otoliths are vulnerable in traumatic brain injury, as they are in a fluid-soaked space, whose sensitivity to excessive pressurization is remarkable. Such vulnerabilities, therefore, increase the risk of structural damage in the case of concussions and traumatic brain injuries (Rodriguez; Chiao; Spencer, 2021; Sleifer *et al*., 2024). In this context, vestibular myogenic evoked potentials (VEMPs) have been shown to be appropriate in the investigation of the functioning of the otolithic vestibular pathway and central pathways (aiding in diagnosis) unilaterally or bilaterally, and in monitoring the clinical evolution of patients (Santos Filha: Sleifer, 2024).

Zhou and Brodsky (2015) conducted a study with 42 post-concussion children and identified that 21% of the children tested had vestibular alterations, and 18% had abnormal cervical VEMP results. With this, researchers concluded that injuries involving linear acceleration as opposed to angular acceleration can affect otoliths.

Rodriguez, Chiao, and Spencer (2021) performed VEMPs on 76 individuals diagnosed with concussion, with a mean age of 15.64 years. The findings of the study demonstrate that children and adolescents with a history of concussion had a significantly higher prevalence of absent responses in the evaluation of VEMPs, when compared to the control group. In addition, they observed that children with a history of concussion and who played contact sports had a higher prevalence of absent responses when compared to those with concussion who did not practice contact sports. Thus, the study concluded that the otolytic organs, specifically the utricles and their pathways, are more prone to post-concussion injuries and reinforce that VEMP proved to be sensitive in identifying and quantifying these injuries (Rodriguez; Chiao; Spencer, 2021).

Based on the data presented above, it is possible to observe that some studies report a strong association of utricular alterations in post-concussion individuals. In addition, researchers report that VEMP is relevant for the screening, diagnosis, and treatment of post-concussion vestibular alterations in the child population.

Patients with visual and vestibular symptoms can benefit from rehabilitation of vestibular function, performed with personalized exercises and monitored by a speech therapist.

CONCLUSION

The care of children and adolescents after concussion must necessarily include multidisciplinary action at all stages of clinical evolution. Considering the advances in otoneurology regarding diagnostic and intervention methods, the need for attentive,

qualified clinical management that considers post-concussion vestibular alterations is reinforced.

REFERENCES

1. Cochrane, G. D., et al. (2021). Vestibular, oculomotor, and balance function in children with and without concussion. *The Journal of Head Trauma Rehabilitation, 36*(4), 264.

2. Gard, A., et al. (2022). Post-concussive vestibular dysfunction is related to injury to the inferior vestibular nerve. *Journal of Neurotrauma, 39*(11), 829-840.

3. Mastrangelo, M., & Midulla, F. (2017). Minor head trauma in the pediatric emergency department: Decision making nodes. *Current Pediatric Reviews, 13*, 92-99.

4. McCarthy, C. A., et al. (2016). Collaborative care for adolescents with persistent postconcussive symptoms: A randomized trial. *Pediatrics, 138*(4).

5. Meehan, A., et al. (2019). Prospective study of anxiety, post-traumatic stress and depression on postural control, gait, otolith, and visuospatial function in military service members with persistent post-concussive symptoms. *Undersea & Hyperbaric Medicine: Journal of the Undersea and Hyperbaric Medical Society, Inc, 46*(3), 271-287.

6. Meehan, W. P., & O'Brien, M. J. (2020). Concussion in children and adolescents: Clinical manifestations and diagnosis. In A. C. Hergenroeder & R. G. Bachur (Eds.), *Inc. Updated on September* (Vol. 14).

7. Price, A. M., et al. (2022). Exploring vestibular/ocular and cognitive dysfunction as prognostic factors for protracted recovery in sports-related concussion patients aged 8 to 12 years. *Clinical Journal of Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine, 32*(4), 408-414.

8. Rodriguez, A. I., Chiao, J., & Spencer, G. (2022). Vestibular-evoked myogenic potential outcomes associated with pediatric sports-related concussion. *The Laryngoscope, 132*(2), 436-442.

9. Rose, S. C., et al. (2015). The diagnosis and management of concussion in children and adolescents. *Pediatric Neurology, 53*(2), 108-118.

10. Rotter, J., & Kamat, D. (2019). Concussion in children. *Pediatric Annals, 48*(4), e182-e185.

11. Santos Filha, V. A. V., & Sleifer, P. (2024). Aplicações clínicas dos VEMPs. In A. Cabral, V. A. V. Santos Filha, & P. Sleifer (Eds.), *VEMPs tratado para atuação otoneurológica* (1ª ed., pp. 65-74). Rio de Janeiro: Thieme Revinter.

12. Sleifer, P., & Borges, V. M. S. (2023). Vestibulopatias centrais na infância. In A. Cabral (Ed.), *Tratado de otoneurologia infantil* (1ª ed., pp. 159-174). Ribeirão Preto: BookToy.

13. Sleifer, P., Oliveira, N. F., Borges, V. M. S., & Riesgo, R. S. (2024). Achados dos potenciais evocados miogênicos vestibulares nas alterações centrais. In A. Cabral, V. A. V. Santos Filha, & P. Sleifer (Eds.), *VEMPs tratado para atuação otoneurológica* (1ª ed., pp. 149-168). Rio de Janeiro: Thieme Revinter.

14. Toledo, R. N., & Rolnik, A. (2015). Trauma do osso temporal. In O. B. Piltcher et al. (Eds.), *Rotinas em otorrinolaringologia* (pp. 45-56). Porto Alegre: Artmed.

15. Van Ierssel, J., et al. (2021). What is the risk of recurrent concussion in children and adolescents aged 5-18 years? A systematic review and meta-analysis. *British Journal of Sports Medicine, 55*(12), 663-669.

16. Walls, T., & Teach, S. J. (2020). Causes of dizziness and vertigo in children and adolescents. In G. Nordli Jr., G. C. Isaacson, G. R. Fleisher, J. F. Wiley II, & J. L. Wilterdink (Eds.), *Uptodate*.

17. Wang, A., et al. (2021). Benign paroxysmal positional vertigo in children and adolescents with concussion. *Sports Health, 13*, 380-386.

18. Zeitel, R. S., Flintz, R. A., & Nogueras, C. C. (2017). Traumatismo craniano em pediatria. *Revista de Pediatria SOPERJ, 17*(Suppl. 1), 63-71.

19. Zhou, G., & Brodsky, J. R. (2015). Objective vestibular testing of children with dizziness and balance complaints following sports-related concussions. *Otolaryngology-Head and Neck Surgery: Official Journal of American Academy of Otolaryngology-Head and Neck Surgery, 152*(6), 1133-1139.