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Case Report

Balance disorders in children after cranial-cerebral trauma with total damage to the vestibular apparatus

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ABSTRACT

Introduction: Posttraumatic brain injury is one of the most common causes of disability and death among children. Every 2nd child in Poland requires medical intervention after suffering from cranial-cerebral trauma, and every 10th is being admitted to hospital for the same reason. In children, only a very small fraction of this type of traumas leads to temporal bone fracture with complete vestibular apparatus damage, followed by disturbances in balance and dizziness.

Aim: The aim of this paper is to provide with easily accessible and unsophisticated therapy methods applied in children with total damage to vestibular system.

Case study: This paper presents a case of a 6-year-old boy who has suffered from cranial-cerebral trauma with a total damage to the vestibular system, with accompanying symptoms of dizziness, impaired balance, and unilateral hearing loss. Patient was implemented in rehabilitation based on vestibular physiotherapy, visual- and mobility-coordination exercises, balance exercises and adequate psychotherapy. Improvement relied on simple and child-friendly methods.

Results and discussion: Diminution of dizziness and balance deficit in vestibular apparatus damage depends upon alignment of bioelectrical activity between two vestibuli. Onset of such process begins few hours after the vestibular damage has occurred and is based on inhibition of excessive reactions from unaffected vestibulum, as well as stimulation of the one with defect. It is being regulated in CNS on the basis of positive and negative feedbacks.

Conclusions: Easily accessible and friendly methods of rehabilitation significantly shorten the time of almost full recovery in children with vestibular system damage; moreover continuous stimulation of CNS through repetition of mobility exercises shortens recovery time and has a significant value in development of correct image of spatial information.

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1. Introduction

This paper presents a case of a 6-year-old boy after cranial-cerebral trauma with complete injury to the vestibular system, with accompanying symptoms of dizziness, impaired balance and unilateral hearing loss. Every year an increase in the number of children who experience a posttraumatic brain injury is noticed. Although it has become a leading cause of disability and death among both children and adolescents, survival and recovery is being achieved through introduction of advanced medical therapy, as well as complex rehabilitation. Epidemiological reports on traumas among children and adolescents, including cranial-cerebral injuries appear very seldom in Poland and are insufficient in comparison to foreign literature. In 1995, in Poland, hospitalization coefficient due to cranio-cerebral traumas was estimated. It was 753 per 100 000 cases in infants, 883 per 100 000 cases in children aged 1 to 4 years old, 995 per 100 000 in children aged 5 to 14 years old, and 1230 per 100 000 cases in children aged 14–19 years old.[1] Frequency of traumas in children aged 11–15 is characterized by increasing tendency. It has risen from 18% to 24%. Other reports state that during the last year in Poland there were approx. 30 000 children hospitalized due to cranial-cerebral traumas and its complications. A small percentage of those traumas leads to a complex fracture of temporal bone with complete injury to vestibular apparatus, followed by dizziness and impaired balance.

Clinical symptoms characteristic for vestibular apparatus damage are dizziness (subjective sign) as well as objective signs arising from changes within respective muscle groups i. e. nystagmus (involuntary eye movement) and balance disturbances. Clinical presentation varies and significantly depends on localization of the damage. Sudden unilateral deficit of vestibular function leads to development of so-called vestibular shock syndrome described by a number of unpleasant vegetative symptoms (nausea, vomiting, cardiac arrhythmia, sudden changes in arterial blood pressure, sialorrhea, hyperhidrosis, feeling of warmth and cold in staggered manner, etc.), as well as dizziness. While vegetative symptoms usually last for 3 days, high-intensity vertigo continues for 10 days. They are accompanied by severe fast phase eye velocity with a direction towards unaffected vestibulum, which can be observed for about 10–14 days. However electronystagmography (ENG) with eyes closed, can reveal nystagmus for another few months. There is a relationship between rapidity, suddenness of vestibular damage, and extent of its damage and the course of compensatory mechanisms. Usually, sudden and complete deficit of vestibular function is associated with a longer period of compensation. Conservation of remaining activity of altered vestibulum can significantly delay and downright preclude the process of compensation, so that in many cases labyrinthectomy is necessary. Such disorder leads to development of signs characteristic for damage within vestibulo-ocular (nystagmus) and vestibulo-medullary (balance disorder) pathways. Conservation of those pathways is crucial in maintenance of correct posture and stability vision field. The essence of ''equalization'' mechanism of damage to the peripheral receptor is a bioelectrical activity process at the level of vestibular nuclei and above, that occurs in a central part of vestibular apparatus. Such extraordinary, pathological situation results in a quick response of central nervous system (CNS) and stimulation of inhibitory activity of cerebellum, described as ''cerebellar clamp.'' It is a process that relies on a quick feedback from cerebellum to brainstem vestibular nuclei, resulting in inhibition of reception of damage in bioelectrical balance of both vestibular systems, especially until the time when cerebral cortex can adapt. Higher cortical centres are characterized by a great neuroplasticity[2] and a potential to adapt to a new situation, where other senses (sight, proprioception) are used to overcome difficulties associated with the lack of full information or delivery of false information from vestibular system. Good condition of CNS is essential for optimal function of this process, especially structures like reticular formation, lower olivary bodies, and cerebellum. During this process, most likely new synaptic connections are being formed, which link the two complexes of vestibular nuclei (Fig. 1). During the time of compensatory progress, the role of efficient vision and proprioception is of great value.[3] Both, pharmacotherapy and surgical approach have not solved the problem of treating dizziness yet. Failure of these methods determines a significant role of rehabilitation in children, which shortens the process of central compensation and meliorates coordination mechanisms between sight and proprioception.

2. Aim

The aim of this paper is to provide with easily accessible and unsophisticated therapy methods applied in children with total damage to vestibular system.

3. Case study

A 6-year-old boy after cranial-cerebral trauma, caused by a fall from a bunk bed on to a wooden floor, followed by a transient loss of consciousness, with accompanying quick phase left-beating nystagmus, massive emesis and dizziness was admitted on May 17, 2010, to neurosurgery department in Voivodship Hospital Complex in Elbląg, where it was diagnosed as: cranial-cerebral trauma, fracture of squama occipitalis and lateral side of temporal bone, concussion, and bony labyrinth syndrome. Computed tomography of the head revealed mixed, right temporal bone fracture without signs of intracranial haemorrhage. On May 18, 2010, patient was transferred to Paediatric Surgery Department in Municipal Hospital in Elbląg conscious, in recumbent position, in general serious medical condition with vomiting, dizziness, quick phase left-beating nystagmus, and right unilateral hearing loss. In pharmacotherapy, intravenous antybiotycotherapy was implemented with betaserc.

Rehabilitation was introduced after vegetative symptoms had disappeared and dizziness diminished with following exercises: habituation exercises towards diminution of pathological reactions to head and body movement – head movements in right to left manner, visual following of objects, changing of body position, playing movement games in sitting position, visual-mobility coordination exercises consisting of

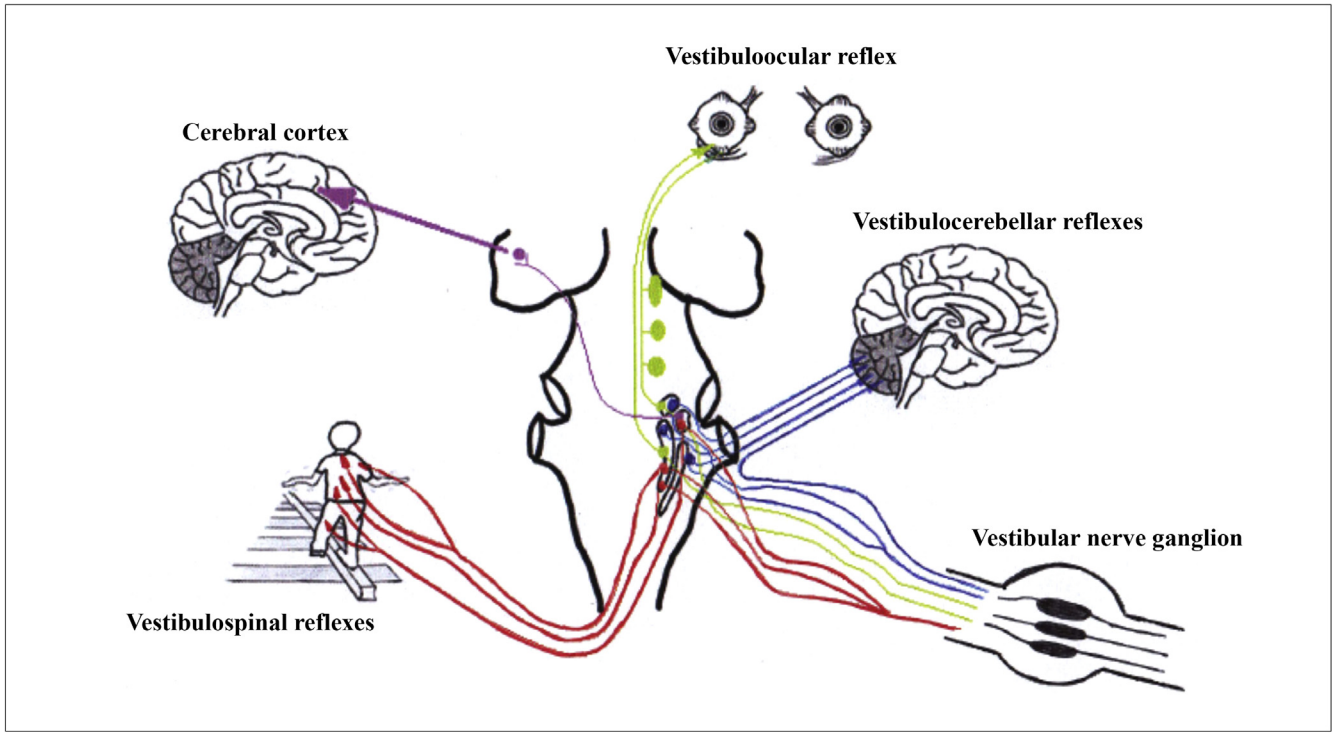

Fig. 1 – Scheme of vestibular system pathways.

drawing, cutting paper, reading, and exercises enhancing spatial orientation. After a week of hospitalization, patient was verticalized, and after 14 days he was discharged. In home setting physiotherapy of vestibular system was implemented, as well as general rehabilitation based on simple, child-friendly methods occurring in the form of play. Following exercises were applied: coordination exercises, exercises enhancing spatial orientation skills, control of posture, habituation exercises achieved with the use of sandy beach and sea water, health paths with terrain obstacles, inoperative railway tracks, playground with carousel, seesaws, etc., ropes course, and bicycle (patient has learnt cycling without the support of training wheels). On the fourth month after trauma, patient was challenged to test his coordination skills in the Upside Down House in Szymbork, where part of healthy tourists fall because of disturbed coordination (Fig. 2).

In 2011 a kinect device was used – motility sensor for Xbox 360 games. This device enables user to interact with the console with no need of operating the controller through interface that uses moves of the whole body, notably controls posture, trains spatial orientation, visual-mobility coordination, and balance. Since September 2011 patient attends judo classes and gets by just fine.

Fig. 2 – The Upside Down House in Szymbork. Source: www.szarlota.pl.

4. Results and discussion

Chronic dizziness can lead to disablement with a significant limitation to lifestyle, inability to practice one's profession, deterioration of general functionality and can have a significant consequence in further life. Beneficial effect of physical activity in patients suffering from dizziness is known since 1940s, however only in the last few years interest in this method is being observed. It is possible to distinguish two major trends in modern labyrinthology. One based on adaptation and compensatory mechanisms that occur in CNS, and second based on a concept of mechanical disturbances in vestibulo-cochlear complex of inner ear.[2] During the initial stage, rehabilitation was based on general enhancement of patient's health status.[4] As the electrophysiological investigation developed, attention has been paid to contribution of vision and muscle proprioceptors to the course of compensatory mechanisms of damaged vestibular apparatus. New techniques were invented that use audiovisual devices, correct basal reflexes, and enhance sensitivity of proprioceptors.[5,6] In following years, value of individual training programme approach has been appreciated,[7–12] meaning its

adjustment towards specific patient's needs and illness. Diminution of dizziness and balance deficit in vestibular apparatus damage depends upon alignment of bioelectrical activity between two vestibuli. Onset of such process begins few hours after the vestibular damage has occurred and is based on inhibition of excessive reactions from unaffected vestibulum, as well as stimulation of the one with defect. It is being regulated in CNS on the basis of positive and negative feedbacks. In some cases, recovery proceeds independently and harmoniously between two organs. However in most cases, recovery period lengthens and dizziness consolidates, impeding social function of the patient. In such cases, pathological image of spatial information transducted between proprioception, ocular, and vestibular organs is being embedded, a result which is incompatible with expected one i. e. the one that exists in healthy individuals. For correct development of image, mobility exercises are of great importance as they provide patient with continuous stimulation. Repetition of stimuli, in this case movements, is being controlled with the habituation process.[13–16] The more active patient is, the quicker time of recovery from dizziness. In sudden damage to the vestibular apparatus, where dizziness is severe and associated with vegetative symptoms, implementation of exercises is not recommended. Instead pharmacological agents are used that diminish symptoms' intensity. Rehabilitation should begin as soon as possible, starting from the time of disappearance of vegetative symptoms and diminishment of dizziness. Implemented rehabilitation programme should be based on habituation exercises, aiming to lessen pathological reactions to movement of body and head, exercise posture control, train spatial orientation,[15] and visual-mobility coordination. Recovery, especially in young patients, should be accomplished through implementation of simple methods, preferably in the form of games and play that have a significant impact on the rate of return to nearly full capacity in children with vestibular apparatus damage.

5. Conclusions

1. Easily accessible and user-friendly methods of rehabilitation have a significant impact on the rate of return to nearly full capacity in children with vestibular apparatus damage.
2. Continuous stimulation of CNS through repetition of mobility exercises shortens recovery time and has a significant value in development of correct image of spatial information.

Conflict of interest

None declared.

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