NEUROPSYCHOLOGICAL REHABILITATION OF AN ADOLESCENT PATIENT AFTER INTRACRANIAL EMBOLIZATION OF AVM – A CASE STUDY

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SUMMARY

Background: This paper discussed a case study of a 15-year-old girl who had had a hemorrhagic stroke, caused by arteriovenous malformation. A brain arteriovenous malformation is a defect in the vascular system, a tangle of abnormal blood vessels connecting arteries and veins in the brain. The patient attended regularly neuropsychological rehabilitation and several various therapeutic methods were applied.

Material/ Methods: A neuropsychological diagnosis was performed before and after therapy. The first assessment showed some cognitive disturbances: difficulties in the organization of memorized material, difficulties in maintaining attention and deficits in abstract thinking. Furthermore there were observed emotional problems: depression and high perfectionism. The patient participated in individual therapy lasting one year. The program was directed toward cognitive and emotional difficulties.

Results: As a result, there was observed an improvement in consequent cognitive functions: organization of memorized material, working memory, abstract thinking and verbal fluency. The emotional state was stable.

Conclusions: It is important that the therapy should be holistic and includes all aspects of the patient's functioning, which may have an influence on the final result of rehabilitation. One of the most important aims of the therapy psychologist was an acceptance of the disease. The cognitive tasks can also include psychological and therapeutic exercises.

Key words: attention, working memory, abstract thinking, depression, neurofeedback

INTRODUCTION

A stroke is a serious life-threatening medical condition in both adults and children. One of the first symptoms of a stroke are: limb paresis, hemiplegia or sometimes epileptic attacks (Agrawal, Joharapurkar & Harde, 2007; Shellaas et al. 2006). Symptoms in children and adolescents are usually acute and sudden. Focal neurological signs are different depending on the stroke location, but in the general clinical picture there can be also observed: reduced level of consciousness, vomiting, cranial nerves palsy or speech disorder.

Headache is a symptom accompanying more often hemorrhagic than ischemic strokes (Pilarska, Lemka, Pienczk-Ręcławowicz, 2009). In most cases the first commissioned study is Computed Tomography (CT), mainly due to the higher availability of the equipment, the relatively short duration of the assessment and the differentiation accuracy of hemorrhagic and ischemic changes (Kilpatrick et al., 2001). Nevertheless, the most accurate examination is magnetic resonance imaging (fMRI), especially the magnetic resonance angiography (MRA). There can be observed multiple abnormalities in 80% of children with a brain stroke, such as – brain artery stenosis or occlusion, Moyamoya disease or cerebrovascular disease (Trystuła 2018). It is advised that one assess the regularity and structure of the blood vessels in the brain by means of angiography AEG (Ganesan et al., 1999).

The consequences of a brain stroke depend on multiple factors like: the location and extent of damage, child age, previous functioning level and a general cause. Main difficulties are usually: a lowered level of cognitive functioning – and worse educational results achieved in school, movement disorders, epilepsy attacks, behavioral disorders and insomnia (Mathews et al., 2003; Max et al., 2002; Lansing et al., 2004). Indisputably, the most often reported difficulties are emotional dysregulation disorders. It is assumed that 13-25% of affected children will fully recover after the brain stroke (Steinlin, Roellin, Schroth & 2004), but the risk of the next stroke is higher than in the general population (Sträter et al., 2002) depending on various risk factors. The causes of stroke risk are less known for adolescents than for adults (Kopyta, Marszał, 2004). Vascular malformations are some of the most common causes of a brain stroke in children and adolescents (Pilarska, 2009).

A brain arteriovenous malformation is a defect in the vascular system, which occurs in fetal life or just after birth. The root cause is still unknown. The malformation is a tangle of abnormal blood vessels connecting arteries and veins in the brain. It affects 0.14-0.18% of the population and is considered as a root cause of 17% of hemorrhagic strokes in children (Jordan & Hillis, 2007). The direct connection between blood vessels and veins are responsible for a higher pressure gradient, which supported by vein-walls thinning, increases the risk of a hemorrhagic stroke (Mast et al., 1992). The risk of bleeding from the malformation is about 2-4% yearly. A diagnostic procedure of non-symptomatic arteriovenous malformations (angiomas) includes medical assessments like CT

angiography or MRA. The treatment of angiomas may involve different techniques: neuro-microsurgical resection, radiosurgery and endovascular embolization and usually it is divided into multiple stages. The choice of method depends on multiple factors, including AVM location. To achieve better results in treatment, in most cases neurosurgical methods are applied together with embolization or embolization with irradiation.

Rehabilitation after a brain stroke is always a holistic process, in which many aspects must be considered because of their influence on the final effect: location, the size and nature of the damage, the current level of cognitive functioning, insight into one's own problems, motivation level, style of coping with stress, emotional functioning, social status before the brain damage and the cognitive reserve (Pąchalska, 2014).

The main consequences of a brain stroke are difficulties in cognitive functioning. A deficit profile may be different depending on the damage location. The most common disorders concern: attention, memory, orientation in space and abstract thinking. Compared to people from the control group, they have more often problems with visuospatial functions, executive functions, attention and language, and more rarely with memory (Tatemich et al., 1994). Disorders of abstract thinking, execution and the rate of information processing are considered to be one of the most important aspects of cognitive functioning impairment (Srikanth et al., 2003; Sachdev, 2004). After a brain stroke in children, a drop in the intelligence quotient is noticed (Hogan et. al., 2000).

The results of research on the effectiveness of cognitive training sessions performed by people after brain strokes are inconsistent. Lincoln and others confirmed the effectiveness of training sessions in terms of maintaining attention and vigilance (Lincoln et al., 2000). Even though the meta-analysis of some research proved the short-term improvement of selected attention functions, the achieved results are not generalized and patients do not notice any improvement in their daily functioning. It is possible to achieve better results in the functioning of a trained skill after 1 year from the brain stroke, but there has not been observed any influence on other capabilities (Westerberg et al., 2009). One of the aims of neuropsychological rehabilitation is the reduction of the negative effects of a stroke in terms of cognitive functioning. Improvement in intellectual capabilities is related to quality of life, the competence of caregivers and the mortality rate amongst patients.

CASE STUDY

Characteristics of a patient's functioning

Patient H. A. was 15 years old at the time of the first neuropsychological examination (June 2017). She was in the first year of high school. Since the beginning of education she had undertaken an individual education program, which

allowed for the parallel implementation of the education program and her to attend sport training sessions. Sport played an important role in her life – she had achievements at the national level. For many school years she has received good marks. Psychological and pedagogical tests performed in clinics proved a higher level of IQ. The patient defined herself as an ambitious person. She claims that she functions at a relatively high level of perfectionism – she sets high standards for herself and the people she cooperates with. The conclusions noted during the first psychological observation confirmed the self-description: motivation to education above average, great cognitive curiosity, inquisitiveness while solving complex cognitive problems and persistence in striving for a goal. H. A. has always had outstanding language skills, especially at English (C1 level). She did not have any plans for any specific field of studies - rather she focused merely on the prestige of the university.

In December 2016, the patient had a hemorrhagic stroke. She was diagnosed with arteriovenous malformations of the cerebral vessels in the right temporal area. The intracranial embolization AVM was applied in the right temporal lobe. The result of embolization of the arteriovenous malformation was a totally closed flow through the malformation. The results of magnetic resonance imaging showed a pathological, hyperintense change in the hippocampus and in the white matter of right hemisphere of the cerebellum.

In the medical history performed in June 2018, the patient complained of headaches, auditory hypersensitivity and memory impairment (elongated memorizing time) and concentration. Moreover, H. A. complained of a significant decrease in mood which, according to her, was caused by a decrease in her functioning level and difficulties in relationships with peers, who did not provide an adequate support. Her parents also observed a change in the behavior of their daughter, which became unpredictable – they described it as "increased teenage rebellion". H. A. became a touchy person, often cried and initiated quarrels with her parents. At the same time that H. A. was tking the first neuropsychological assessment, she was provided with psychiatric care – they diagnosed depression and implemented treatment with selective serotonin reuptake inhibitors.

To assess the cognitive functioning after half of a year following the brain stroke, a neuropsychological assessment was performed. The examination showed difficulties in the organization of acquired material – no fast learning strategies were observed. The learning curve was flattened, but the coding process of new material proceeded properly. Difficulties in maintaining attention were observed. The patient made mistakes due to a lack of focus, mainly noticeable during mathematics classes. She would mistake digits, also their order in the written form of numbers. Moreover, clinical trials presented deficits in her abstract thinking.

Tasks engaging visuospatial and executive functions revealed other difficulties. The verbal fluency test showed differences between phonemic and semantic

Table 1. Results of the neuropsychological assessment

Test	Assessment I (June 14, 2017)	Assessment II (Apr 04, 2018)
CVLT/AVLT	Learning curve: 8, 10, 13, 14, 13; Recognition: 15/16	Learning curve: *10, 14, 14, 14, 15;* Recognition: *15/15*
Digit Span	Straight: 7 Backwards: 6	Straight: 9 Backwards: 9
Information	WP: 10	-
Vocabulary	-	WP: 18
DUM	5 trials range Spontaneously reproduce: 8/9	5 trials range Spontaneously reproduce: 9/9
WAIS-R Block Design	-	WP: 12
TUS test	-	6 standard ten
Colourful Connections Test (CTT)	-	CTT1 – percentile 88 CTT2 – percentile 79
Rey's Figure	Copy: 35/36	Copy: 36/36 Play from memory: 30/36
Benton's Test (Method A)	10/10	10/10
Fluency Test	22 (semantic category) 11 (phonemic category) 8 (narrow semantic category)	33 (semantic category) 27 (phonemic category) 14 (narrow semantic category)
Raven's Matrix Test (version for advanced)	-	8 standard ten

trials, what may indicate problems in creating memory lookup strategies. H.A. had language competences at a high level – she didn't face any problems with creating statements. She was coping well with Polish and foreign languages. She had criticism for her stakes. Achieved scores during the diagnosis allowed to describe the profile of cognitive disorders and implement an individual therapeutic plan. Although the results gained were not below the norm, it should be noted that H. A. had been functioning earlier at a relatively high intellectual level. It means that all average results should be considered as a significant impairment comparing to the patient's cognitive functioning level before the brain stroke.

Therapeutic framework plan

Based on the data collected during the interview and in the assessment, a therapeutic plan was prepared, which underwent slight adjustment during its execution. The therapeutic program was oriented on the particular person, and considered

Table 2. Main resources and deficit spheres of the patient H.A.

Resources	Deficit spheres
High motivation to work	Concentration difficulties
High intelligence level before the brain stroke	Worse memorizing skills
Language capabilities	Problems with abstract thinking
Perseverance in pursuing goals	Difficulties in dealing with failures

the deficit resources and areas mentioned in Table 2. The therapy lasted 1 year, meetings were organized regularly 2 times per week.

After the stroke, the patient started to spend more time on education. She often finished doing her homework at night. Emotional problems were strongly bound with cognitive difficulties. On the one hand, a high motivation to undergo the therapy was the patient's strong point, on the other one, the failure to gain the expected results at school despite big efforts caused a decrease in mood. After the stroke, the patient did not attend school in favor of an individual educational program. Taking into consideration the doctor's advice, she resigned from regular sporting training sessions. H. A. is still afraid of a deterioration in her health. She claimed that she had lost control of her life, because the stroke has significantly changed her future plans.

After this event, a level of perfectionism and environmental control arose. Every change or unexpected event (e.g. getting stuck in a traffic jam) was an reason for an instant drop in mood and a lack of willingness to engage in any interaction with the environment.

Neuropsychological therapy oriented on training the impaired cognitive functions was proposed.

Memorizing skills were being developed, especially ones related to the organization of material, these being intended to increase the learning speed. To achieve the goal, a few therapeutic sessions were conducted, during which the patient

Table 3. Methods used during therapy

Cognitive skills	Emotional abilities
Mnemotechniques	Music therapy
Biofeedback sessions	Art-therapy (drawing, painting)
Paper-pen cognitive tasks	Biofeedback sessions
Computer cognitive tasks	Elements of cognitive-behavioral therapy
Creativity training	Relaxation

came into contact with different types of mnemotechniques. Later some exercises were performed to allow the patient to automate the material organization process using the described mnemotechniques. Finally, H. A. selected methods which seemed to her the most effective, mainly the memory hooks method. Moreover, there were proposed exercises supporting working memory and procedural memory. Exercises oriented on procedural memory engage also executive functions, mainly the monitoring and planning skills.

These were usually exercises based on executing complex tasks involving memory resources. The progress level was continuously observed. Another trained skill was that of attention. In that case the compound attention model proposed by Posner (2001) was used. The therapeutic process began with simple exercises engaging vigilance and followed by orientation processes. These exercises included materials, presented on the computer display, which required the patient's quick reaction. The goal of the task is to quickly and precisely identify objects. The exercises engaging attention monitoring functions were performed in parallel with ones targeted at executive functions. They required one to maintain and switch attention. In the next stages of the therapy, while performing tasks favoring concentration, audio distractors were applied. The goal of these exercises was an improvement of concentration skills on a particular activity and a faster habituation to the noise sound – a part of the adaptation process facilitating a return to school.

The patient was also ordered to perform tasks engaging abstract thinking, mainly by focusing on analogies between different elements and a categorization capability. Elements of creativity training were also implemented and selected aspects, initially intended to develop creativity, constituted a starting point for exercises related to the reduction of control of one's environment and autocriticism. The patient tended to present her strengths and weaknesses of functioning in a metaphorical way. In a short time, there was observed progress in divergent nature problem solving, a more flexible thinking process and a quick generation of new ideas. Based on the patient's preferences, the creativity training involved elements of the art therapy, mainly by presenting solutions with pictures. In many cases the visual presentation form was a more adequate way to prove the accuracy of ideas and was also a decent way to overcome the patient's resistance to working with her emotions.

Despite the still occurring fluctuations observed was a mood improvement during the therapy. It can be assumed with a high probability that the improvement was a resultant of the pharmacological treatment and the therapeutic meetings. Cognitive exercises were supported by methods focused on an effective coping with emotions. To achieve the goal, elements of cognitive-behavioral therapy were used: identification of automatic thoughts, and ones accompanying them and replacing automatic thoughts with safe, alternative ones. Most of the therapeutic interventions were targeted at a reduction in learned helplessness, which was a result of losing control of life, as compensated by a higher level of

perfectionism. Moreover, there were proposed relaxation sessions, including the popular training sessions of Szultz and Jacobson, which aim at stress reduction in challenges at school. The key element during the therapy was patient perseverance and motivation, who was asked to do some exercises at home (especially at the early stages of the therapy). Despite significant mood fluctuations, she always cooperated willingly, presented an inquisitive attitude, persevering and often asked questions. Most likely this was the main factor which contributed to the improvement in many aspects of cognitive functioning.

There were additional training sessions performed using Neurofeedback running with the following protocols: Theta/SMR in the central lead Cz and Theta/Beta in the frontal lead Fz. During the first diagnosis there were observed a lower level of Beta (in the frontal lead) and SMR (in the central lead) waves. With the Theta/SMR training, relaxation training sessions were performed in parallel.

Beta (above 15- 18Hz) – is related to the state of wakefulness, external orientation, logical thinking, problem solving and attention focus. However high Beta is observed in stressful situations. SMR (12-15 Hz) – is the sensorimotor rhythm, related to the state of calmness (Thompson, Thompson, 2012; Bidzan-Bluma, Pielak & Budnik-Przybylska, 2017; Pachalska, Kaczmarek, Kropotov 2014).

During the neurofeedback sessions, reactions to different stimuli were verified, e.g.: a selected music genre may reduce the stress level significantly, something that can be noticed in the indicator results (Poćwierz-Marciniak, Bidzan, 2017). Each session lasted about 40 minutes. During the Theta/Beta training sessions, there were noticed two fluctuations of concentration and difficulties in maintaining attention. The intentionality of targeting attention processes was measured during every session (decreased values of the Theta/Beta indicators), but results achieved were still far behind the proposed norms (Theta/Beta < 2.0, Theta/SMR < 2.0, see Figures 1-2).
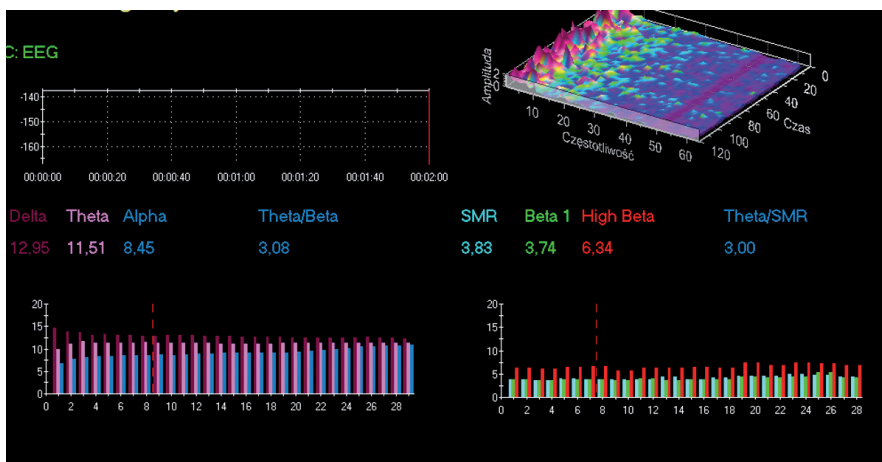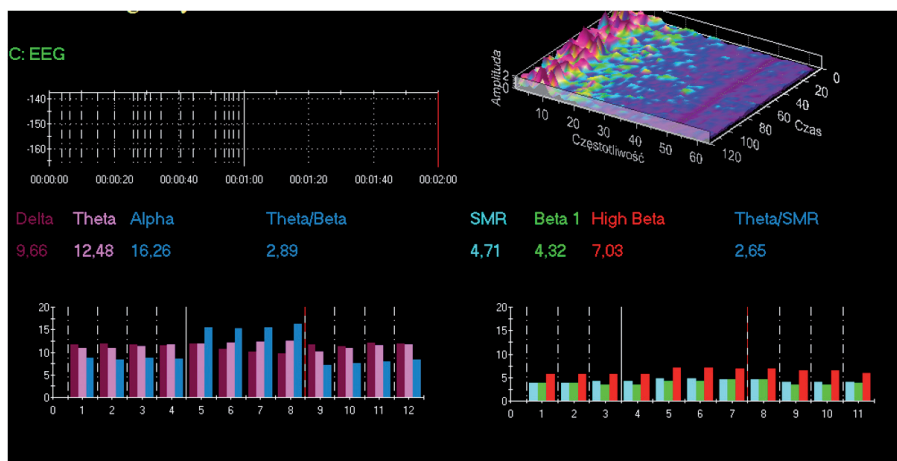

Fig. 1. First diagnosis – diagnosis screen

Fig. 2. Second diagnosis – after 25 Biofeedback sessions – diagnosis screen

DISCUSSION

The therapy lasted 1 year and was holistic. The plan was based on the reduction of deficits in skills, considering the resources and potential of the patient. As a result, there was an improvement of the cognitive functioning level in the following spheres: learning capabilities, working memory, abstract thinking, verbal fluency understood as the ability to spontaneously call up words belonging to a given category. All the mentioned functions are psychological resources. There are still difficulties in the concentration areas, mainly at the attention maintaining level while working with not terrible diverse material (e.g. numbers). Mistakes made may have a strong relation to emotional tension during class tests or quizzes, which can worsen the deficit of concentration.

An improvement in a few cognitive spheres is a resultant of the amount of exercises, features of character and learning at school, but also at the biological level – neuroplasticity. The severity of depressive symptoms diminished and the mood in general has improved. However, there are still significant fluctuations of mood. The results achieved in the Questionnaire for Depression Measurement suggest that the patient declares a low or average level of cognitive deficits, pessimism and alienation, a feeling of guilt, anxiety and psychosomatic symptoms and self-regulation. People who have had strokes are often diagnosed with a lower life satisfaction level and a higher risk of developing psychiatric disorders, mainly depression, especially in the first 3 months after the stroke. It is assumed that the quality of life increases with time, but the social support is an important factor protecting them from a depressive state (Astrom, Asplund & Astrom, 1992).

The main factor was the therapy engagement level, which was one of the most important variables considering those deemed to have an influence on any significant improvement (Tatemich et al., 1994; Tharawadeepimuk & Wongsawatg 2018). It was crucial to establish a relationship with the patient to not only work on the

cognitive difficulties, but also on distorted cognitive schemes and accompanying emotions. These results might be interpreted according to the microgenetic theory of symptom formation (Pachalska, MacQueen, Cielebąk 2018).

CONCLUSIONS

It is important that the therapy has a holistic dimension and includes all aspects of the patient's functioning, which may have an influence on the final result of rehabilitation. One of the aims of meetings with a psychologist is an acceptance of the disease (Golińska, Bidzan, 2017a,b). It is also worth considering the interaction between cognitive and emotional factors. Cognitive exercises can be also a way to establish a proper relationship between the patient and the therapist. With appropriate tasks, the patient can exercise their cognitive and emotional functions, and often reduces resistance to working on distorted cognitive schemes.

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