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Emotional disorders in patients with cerebellar damage - case studies

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Summary

Aim. Growing number of research shows the role of the cerebellum in the regulation of affect. Lesions of the cerebellum can lead to emotional dysregulation, a significant part of the Cerebellar Cognitive Affective Syndrome. The aim of this article is to analyze the most recent studies concerning the cerebellar participation in emotional reactions and to present three cases: two female and one male who suffered from cerebellar damage and presented post-traumatic affective and personality change.

Method. The patients' neuropsychological examination was performed with Raven's Progressive Matrices Test – standard version, Trial Making Test, Wisconsin Card Sorting Test, Auditory Verbal Learning Test by Luria, Benton Visual Retention Test, Verbal Fluency Test, Stroop Interference Test, Attention and Perceptivity Test (Test Uwagi i Spostrzegawczości TUS), Frontal Behavioral Inventory (FBI).

Results. The review of the literature suggest cerebellar participation, especially the vermis and paravermial regions, in the detection, integration and filtration of emotional information and in regulation of autonomic emotional responses. In the described patients we observed: oversensitivity, irritability, impulsivity and self-neglect. The man and the woman with right-sided lesions presented similar symptoms: rigidity of thought, stubbornness, lack of criticism, jocular and inappropriate behavior. The woman with left-sided cerebellar lesion was adynamic, apathic and passive, she presented emotional blunting, social isolation, lack of interests and motivation, general cognitive slowdown.

Conclusions. Both the analyzed research and the described cases indicate the connection between the cerebellum and emotion regulation. The symptoms presented by the described patients were most probably a consequence of damaged cerebellar projections to subcortical structures (the limbic system) and frontal areas. The diversification of symptoms depending

on the localization of lesions had not been described yet and seems to indicate an interesting direction for future research.

Key words: cerebellum, emotions, neuropsychology

Introduction

The cerebellum has been traditionally described as an organ involved in maintaining balance, control of muscle tone and movement coordination. However, the damage to the cerebellum does not necessarily result in motor impairments [1], it can lead to complex cognitive, behavioral and emotional symptoms, which Shmachmann and Sherman [2] have identified as the Cerebellar Cognitive - Affective Syndrome (CCAS). Besides the cognitive impairments (described in detail in Polish by Starowicz-Filip et al [3]) its symptoms include emotional disorders. According to the authors, emotional impairments are the most visible aspect of the CCAS in patients with cerebellar damage.

Shmachmann and colleagues [4] resumed the emotional disorders and neuropsychiatric dysfunctions accompanying cerebellar lesions. They divided them into five general categories: 1) attention control disorders, 2) emotional control disorders, 3) autism – spectrum disorders, 4) psychotic symptoms, 5) social skills' disorders. The disorders above can be characterized by an excessive or reduced emotional reaction to internal or external stimulation. The involvement of the cerebellum in regulation of emotions is likely due to its numerous connections to areas of the brain, that take part in the control of affect, i.e. nuclei of reticular formation, hypothalamus, cingulate gyrus, intralaminar nuclei [1], septum, insula, amygdala, basal ganglia and many areas of the neocortex [4]. Due to the multitude of connections cerebellum participates in components of emotional reaction such as autonomic response, inter- and exteroception, nociception [1].

The structures that seems to be particularly important in the affective component of the cerebellum are the vermis and paravermal zones of both hemispheres [1, 5-7]. Stoodley and Shmachmann [6] described the part containing the vermis and fastigial nuclei as "*the limbic cerebellum*", suggesting that this area is a node in the cortical-limbic network. This network consist of the dorsal anterior cingulate cortex and fronto-insular cortex and is probably involved in the detection, integration and filtering of emotional information [7]. The fMRI studies show that the vermis activates in healthy subjects in tasks requiring categorization of emotional stimuli and during passive observation of affective pictures [5, 8]. Research with Transcranial Magnetic Stimulation (TMS) revealed that stimulation of the vermis can result in changes in mood, motivation, and electrical activity of frontal areas [9-11]. Additionally, the vermial damage in humans and experimental animals results in impaired storage of the memory traces associated with fear, without compromising the primary motor and autonomic responses of the body in response to a stimulus causing fear. This fact most likely results from the connections of the cerebellar vermis to the hypothalamus [12].

A significant disproportion of the cerebellar activation appears depending on the type of emotion. The cerebellum activates strongly while observing unpleasant images [13], and experiencing negative emotions [14], what has probably an adaptive significance. Research by Turner et al. [15] concerning the emotional reactions in pa-

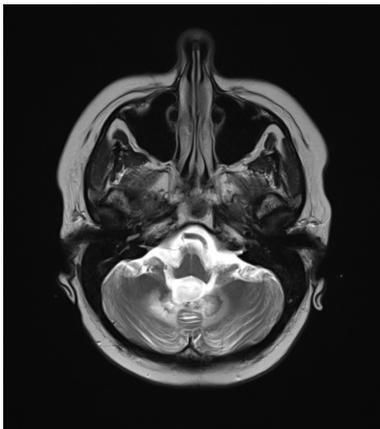
tients with cerebellar strokes has shown that that cerebellar lesions do not influence the ability to experience negative emotions, but are more likely connected to impairments in experiencing positive emotions. Those results indicate the adaptive plasticity of the brain and creation of compensatory mechanisms enabling negative emotional reaction despite the cerebellar damage.

To illustrate the emotional disturbances due to cerebellar impairments we described below three cases of patients with cerebellar damage, presenting post-traumatic changes in mood and affect. As the emotional and personality changes in consequence of cerebellar damage are frequently compared to the frontal lobe disorder symptoms [1, 2, 4], in the assessment we used the Frontal Behavioral Inventory (FBI) [16], translated into Polish by Paçalska and McQueen [17]. This questionnaire is filled – up by the patient’s family. It contains 24 questions concerning negative symptoms such as apathy, passivity, indifference, stubbornness, concreteness of thinking, neglect, disorganization, attention deficit, lack of insight, logopenia; and positive symptoms: perseveration, hypersensitivity, jocular attitude, lack of common sense, inappropriateness, impulsivity, anxiety, aggressiveness, oral hyperactivity, hypersexuality, user behavior. The severity of the difficulties mentioned above is rated on a four-level scale [18].

The examination of patients’ cognitive functions was performed with Raven’s Progressive Matrices Test – standard version, Trial Making Test, Wisconsin Card Sorting Test, Auditory Verbal Learning Test by Łuria, Benton Visual Retention Test, Verbal Fluency Test, Stroop Interference Test, Attention and Perceptivity Test (Test Uwagi i Spostrzegawczości TUS).

Case 1

Woman, age 38 with higher, economical education suffered from medulloblastoma of the IV ventricle, attached to the vermis and the right cerebellar hemisphere (tumor mass in the anterior cerebellar cavity and the hypodensity 20x10mm in the right cerebellar hemisphere- the ischemic changes). The tumor was operated in November, 2011. The patient went through radiotherapy until March, 2012 and three series of chemotherapy, the last one ended in April 2013. The most recent MRI examination in September 2013 did not show any signs of re-sumption of the tumor or other suspicious changes. Picture 1 shows the MRI scan of the patient 1.



Picture 1. The MRI scan of the patient 1.

The patient was submitted to the neuropsychological examination due to persistent cognitive and emotional disturbances. She reported difficulties in memory functions, especially with working memory and remembering new information. Additionally, the patient suffered from cognitive

slowdown, problems with concentration and attention divisibility. Moreover, she reported that she lacks words during conversations, what was influencing significantly her speech fluency.

The family reported a post-traumatic personality and emotionality change in the patient. In everyday life she had problems with emotional control, she presented a tendency to tantrums and irritability. In many situations her mood was inadequate, she was jocular and euphoric.

The patient had an average IQ, logical thinking and reasoning level. Examination of speech showed traces of dysarthria, discrete aphasia and weakening of both semantic and formal verbal fluency. Examination of memory functions showed decreased efficiency of short-term verbal and visual memory and learning new auditory material. Executive functions' examination revealed a decreased thought flexibility, attention divisibility and switching, a tendency to impulsive behavior and lack of error correction.

The FBI examination showed increased scores in scales: indifference and emotional blunting, rigidity of thought, neglect of appearance, lack of insight, logopenia, speech apraxia, hypersensitivity and irritability, jocular attitude, lack of common sense, oral hyperactivity. According to patient's husband, she underwent a significant change in affect and personality after the surgery. The ability to express emotion and their strength decreased, what could have been noticed in everyday situations. The patient was stubborn and unwilling to change her attitude. She neglected her appearance and became less talkative. Moreover, the patient became more irritable, she was reacting violently in stressful situations, even little things could disconcert her. Additionally, she was jocular and had a tendency to make inappropriate jokes, her behavior was often unreasonable and inadequate. She was prone to hasty decisions. Her appetite increased.

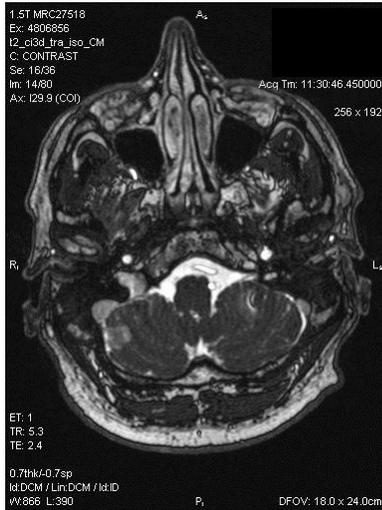
One could state that the cognitive and personality changes observed in the described patient were more likely to result from chemo- and radiotherapy rather than organic changes in the cerebellum. Disorders of cognitive functions such as executive functions, learning, working memory, attention, verbal fluency and speed of information processing can appear as a side effect of chemotherapy [19, 20]. However, in emotional functioning of patients after chemotherapy the dominating symptoms are depression, apathy, anxiety [21] rather than symptoms observed in the examined patient. The hypothesis of cerebellar origin of the patient's disorders can be confirmed by the second case, described below.

Case 2

A similar profile of personality and affective disorders was observed in the second patient, a 41 year old male who suffered from a right sided cerebellar stroke. The detailed description of patients cognitive functioning can be found in the article by Starowicz et al [22]. In this article we focused on patient's emotional profile. The examined patient had an ischemic stroke of a right cerebellar hemisphere two months before the neuropsychological examination. MRI scan of the patient revealed an area

of hypodensity within the right cerebellar hemisphere, corresponding to the focal area of fresh ischemia (see Picture 2).

Neurological examination of the patient revealed a cerebellar ataxia. Neuropsychological examination of cognitive and language functions showed the features of dysarthria, discrete anomic aphasia, difficulties in working memory, leaning new material and disorders of executive functions. His intellectual functioning, efficiency of logical thinking and reasoning remained at an average level of intelligence. The most visible symptoms were observed in patient's emotionality: he was hyperactive, sometimes dysphoric. He presented a noticeably reduced criticism, a tendency to shorten the distance – an inclination to bantering appeared (indecent jokes). The patient denied any difficulties associated with memory or attention. Patient's mood was elevated, slightly euphoric, with uncontrolled, forced laughter.



Picture 2. MRI scan of the patient 2.

Patient's relatives reported that his post-stroke behavior was infantile, devoid of criticism and inadequate in many situations. These traits are inconsistent with patient's personality type prior to the disease. According to relatives, he used to be a quiet, tactful and peaceful person.

The FBI examination was performed with the patient's sister. The results of the questionnaire indicated an organic personality change. The patient presented increased stubbornness, rigidity and concreteness of thoughts. The patient was unable to change his decision, even if it was wrong. Moreover, he interpreted others' statements too literally and had trouble with understanding abstract communicates. Since the stroke patient has been neglecting his appearance and hygiene. His behaviour was disorganized, he had difficulties in planning more complex actions and he was prone to resign from an already started action at the first obstacle encountered. Patient presented a lack of insight, he was not aware not only of the problems and changes in his environment, but also of his own difficulties. Patient was also more irritable and dysphoric; he was easily annoyed even by outwardly unimportant events. His relatives reported an increased jocular attitude and inadequate, unreasonable behaviour. Patient had a tendency to make indecent jokes; he was often infantile and inappropriate. He was prone to hasty decision making. Patient was also more impulsive and he acted regardless the probable consequences. The patient's hiperorality and increased appetite was also reported.

Case 3

A 63 year old women who went through a cerebellar left hemisphere stroke was submitted to neuropsychological examination in order to check her cognitive functions

and overall psychological state. The woman had vocational education. The stroke took place 2.5 months before the examination. Directly after the stroke the patient went through a MRI examination. Due to inaccessibility of the MRI pictures, below we cite its description: Acute ischemic lesions were visible in the left cerebellar hemisphere (the biggest's size: 8x5mm), in the middle cerebellar peduncle (size: 13x12mm), and in the left inferior cerebellar peduncle (size 7x4mm). Additionally, a few areas of increased signal sequences with long TR appeared in white matter of both hemispheres, mostly paraventricular - areas of nonspecific vascular demyelination.

The main reason for patient's submission to neuropsychological examination were disturbing changes in her behaviour. She became depressed and apathic. Her family reported that she lost the motivation and former interests. The neuropsychological examination revealed a decrease in cognitive functions efficacy, not reaching the stadium of dementia. The patient was fully oriented auto and allopsychically. Her language functions, verbal fluency, the ability to update the words and names, concentration of attention, the ability to abstract and calculia were intact. However, slight disturbances were noticed in short-term memory, the durability of memory traces, executive functions and visuo-spatial perception.

The FBI examination was performed with the patient's husband. In comparison to both previous cases, the patient presented a different profile of affective and personality changes. Even though she presented symptoms such as hypersensitivity, irritability and impulsivity, her profile was dominated by symptoms like apathy, passiveness, indifference and emotional blunting, neglect of appearance, disorganisation. Neither Jocular, lack of common sense, inadequate behaviour nor aggression were observed in the patient. The patient lost interest not only in her social life but also every-day activities. She was unable to take initiative and needed constant requests and persuasion to perform any activity. She was unable to feel and express emotions like happiness or sadness. Her behaviour was disorganized, she was unable to plan it. She was sluggish and isolated from social interactions.

Our patients' symptoms reassembled the Frontal Lobe Disorder, which in their case can be defined as pseudo-frontal personality disorder, appearing as a result of a cerebellar lesion. Common symptoms of all patients were: hypersensitivity, irritability, impulsivity and self-neglect. The man and the woman with right-sided lesions presented a similar profile of symptoms including: rigidity of thought, stubbornness, lack of criticism, jocular and inappropriate behavior, increased appetite and oral hyperactivity. In contrary, the woman with left-sided cerebellar lesion was adynamic, apathic and passive, she presented emotional blunting, social isolation, lack of interests and motivation and general cognitive and emotional slowdown. What is interesting, one can observe a relationship between the damaged hemisphere and presented symptoms. Patients with lesions in the right hemisphere were disinhibited, their behavior was often inadequate and jocular, with oral hyperactivity and increased appetite, whereas the patient with left sided damage was more isolated, suffeted from emotional blunting, lack of motivation and passiveness. A similar direction of this relationship can be found in the literature. Annoni et al. [23] described a man after an incident in left cerebellar hemisphere including left fastigial nucleus, affecting the fourth ventricle, who com-

plained about blunting of affect and a decrease in the sensation of hunger and pain. The patient was diagnosed with moderate depression. The examination of patient's skin conductance response revealed that autonomic nervous system did not differentiate the arousal in positive and negative situation, even though he presented a correct orienting reaction and had a normal Valsalva index. Authors suggest that the inability of autonomic differentiation of external stimuli valence may explain patient's affective blunting. Adamaszek et al. [24] reported a case study of a patient, who suffered from an acute right hemispheric cerebellar stroke. Patient had a decreased ability to control his impulses, his behaviour was inadequate and he was easily discouraged by any obstacles to his actions. Event related potentials study revealed that his symptoms may have been a consequence of impairments in attention switching and the deficits in unconscious, bottom-up processing of emotional stimuli. Shmachmann et al. [1] described a case of a 6 year old girl with right cerebellar hemisphere agenesis, who presented symptoms like aggression, emotional instability, stereotypical behaviours and hyperactivity. Though fMRI studies showed that distinct cerebellar areas activate in response to each of the five basic emotions - sadness, fear, disgust, anger and happiness [25], to our knowledge there is no research analysing the lateralisation of emotions' representation in the cerebellum and it's possible clinical consequences. This subject seems to indicate an interesting direction for future research.

The studies on humans and non-human primates indicate that the lateral posterior parts of cerebellum project to the frontal cortex [26, 27]. The frontal characteristics of symptoms observed in our patients seems to prove the existence of those connections. Moreover, all of our patients had lower results in the executive functions assessment indicating the relationship between the cerebellar damage and frontal lobe functioning. fMRI studies showed a functional relation between lateral posterior areas of cerebellum, especially the Crus I, and the Brain Default Network, which inter alia includes middle prefrontal cortex. This network activates in tasks comprising prospective thinking, introspection, future-planning and theory of mind [28]. It may be possible that in case of the man and woman presenting emotional disinhibition the stroke that damaged posterior areas of the right cerebellum, have also damaged the cerebellar connections with Brain Default Network, resulting in symptoms like social inappropriateness, lack of criticism and weaker introspection.

To sum up, numerous studies reports the connection between the cerebellum and emotional reactions. However the detailed characteristic of this connection is not yet known and requires further research. The recognition of the cerebellum's role in development of neuropsychiatric disorders has is important for the diagnostic process. Patients with cerebellar lesions should undergo an astute diagnostics in order to provide them with proper neuropsychological rehabilitation and pharmacotherapy. Further research is necessary in order to constitute the standards for neuropsychological tool, which will be sensitive from the deficits included in the CCAS.

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