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Cerebellar cognitive affective syndrome CCAS – a case report

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Summary

Aim. The aim of the study was to describe a case of the patient with cerebellar cognitive affective syndrome CCAS, characterize the role of cerebellum in the regulation of cognitive functions and present the procedure of neuropsychological diagnosis useful in indicating the specific cognitive and emotional problems in patients with cerebellar damage.

Case report. A 41- year old man with an ischemic cerebellar stroke of its right hemisphere manifested the neuropsychological symptoms typical for the frontal damage: euphoric mood, disorganized behavior, lack of criticism and mental plasticity, tendency to shorten the personal distance, problems with mistake correction. In neuropsychological diagnosis we used following methods: Raven Progressive Matrices Test, Mini Mental Stage Examination (MMSE), Trail Making Test, Wisconsin Card Sorting Test, Stroop Interference Test, Word Fluency Test, Auditory Verbal Learning Test by Łuria, Benton Visual Retention Test, Digit Span.

Results. Analyzing the obtained results we observed the significant decrease of all executive functions: planning, abstract thinking, cognitive flexibility, adaptation to new situations as well as memory impairments and changes in emotional and behavioral state similar to frontal syndrome. The whole of impairments including the typical cerebellar symptoms (ataxia, dysarthria, dysmetria,hypotonia) create the cerebellar cognitive affective syndrome CCAS with leading role of dysexecutive syndrome.

Conclusions. The cerebellum takes part in the regulation of cognitive functions. The cerebellar damages can imitate the emotional- cognitive problems of patients after frontal damages what additionally stress the functional link between these two brain structures. Patient's with cerebellar damages should have neuropsychological and neuropsychiatric diagnosis and care.

cerebellar cognitive affective syndrome

INTRODUCTION

The cerebellum, especially its phylogenetically older structures, the paleocerebellum and archicerebellum were typically associated with human motor functions such as maintaining balance, muscle tone and visual-motor coordination. However, the past few years have brought an increased number of reports indicating a markedly more extensive function of the cerebellum that also includes cognitive processes.

In 1997 Schmahmann and Sherman [1] observed a group of patients with cerebellar damage and concluded that these patients manifested complex cognitive-emotional symptoms, which extended beyond simple motor dysfunc-

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tions associated with visual-motor coordination or balance. The authors termed these emotional and cognitive difficulties "cerebellar cognitive affective syndrome" (CCAS) which includes:

- executive dysfunctions: problems with planning, mental flexibility, adaptation to new situation, inhibition of automatic reactions, abstract thinking, verbal fluency, attention and working memory,
- visual-spatial disturbances and visual memory dysfunctions,
- mood disturbances, ranging from blunted and flat affect to disinhibition and hyperexcitability,
- language dysfunctions-dysnomia, dysgrammatism, dysprosodia.

Since the publication of Schmahmann and Sherman, an increasing number of reports have been published on the relationship between the cerebellum and cognitive functions. They emphasize the role of the cerebellum in executive functions [2, 3], working memory [4, 5], language competence [6–10], dyslexia [11], visuospatial abilities [12, 13].

As it follows from studies carried out by Maryniak [14], Steinlin [15] Harasiewicz and Kwiatkowski [16] on children after cerebellar tumor surgery, the cerebellar cognitive affective syndrome does not affect solely adults, but it is also seen and clearly manifested in the pediatric population.

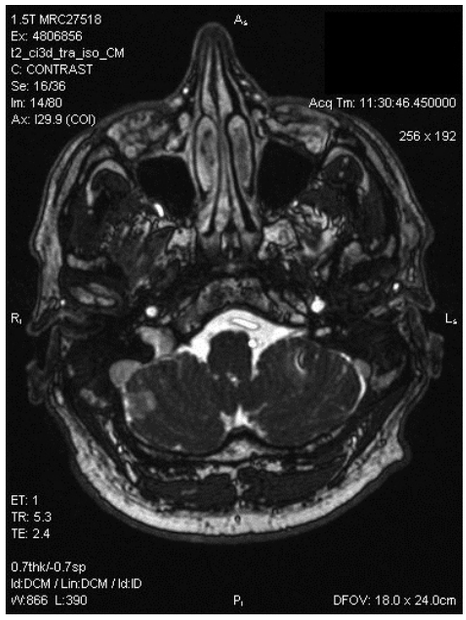
Haarmeier and Their [17] stressed that the results of the studies on the role of the cerebellum in regulation of cognitive processes are ambiguous and they are a source of numerous controversies. Thus, it seems that the subject needs further exploration. Moreover according to clinical practice we still observe the problem with describing the "strange" behavior of patients with cerebellar damage as well as with choosing the appropriate diagnostic tools, sensitive for these dysfunctions.

The main aim of this paper was to describe a person with a stroke of the right cerebellar hemisphere who demonstrated serious cognitive and emotional impairments, especially executive dysfunction and pseudofrontal changes of behavior – cerebellar cognitive affective syndrome CCAS. We also want to present the neuropsychological examination procedure and test selection useful in diagnosis of CCAS.

CASE REPORT

A 41-year old, right-handed man with an ischemic cerebellar stroke of the right hemisphere two months previously. A patient of rehabilitation clinic where he was directed to neuropsychological diagnosis because of the serious behavioral and cognitive problems. Demographic issues: not married, vocational school, own business (owner of the bookshop, working as a shop assistant and accountant).

Computed Tomography CT and Magnetic Resonance MRI showed a hypodense area within the right cerebellar hemisphere that corresponded to a fresh focal ischemia. Except the above lesions, CT and MRI did not show any other abnormalities. Tissue density of the white and gray matter was normal. The supratentorial ventricular system was symmetrical, not distended and of normal size. No areas of abnormal contrast uptake or intracranial bleeding were noted. No lesions involving the bone structures were seen.



After the cerebellar stroke neurologically, cerebellar ataxia was noted. Patient's speech manifested dysarthria (slightly staccato and blurred speech, dysprosody – intonation and accent disturbances, irregular breathing while speaking), but also signs of discrete aphatic anomia (decreased verbal readiness, discrete problems in word actualization in dialogue speech, lack of words characteristic of the "it is on the tip of my tongue" phenomenon, sporadic agrammatisms).

Premorbid functioning

Having the patient's permission we interviewed patient's sister and business partner about the premorbid functioning before the stroke (both sister and business partner visited him frequently during his stay in rehabilitation ward).

As for behavioral functioning, both the patient's sister and his business partner noticed the dramatic change of patients behavior right after the cerebellar stroke. As they described he become infantile, without criticism and his behavior was inadequate to situation. Concentrating on the patient's premorbid personality and emotional status it should be emphasized that - as it followed from the man's medical history taken from his sister, the patient was a peaceful, quiet and tactful person.

According to his cognitive functioning, he was well-read individual, characterized by diversified interests and extensive general knowledge. During his work as accountant he hadn't had any problems with arithmetic, making book orders and accountancy.

His social functioning was good. He has had a close relationship with his sister and her opinion about his premorbid functioning seemed to be reliable. He had a great contact with clients in his shop.

Neuropsychological examination

The following tools were employed in the neuropsychological diagnosis of CCAS:

- Intelligence and general cognitive measures: Raven Progressive Matrices Test, Mini Mental Stage Examination (MMSE),
- Executive functions: Trail Making Test (TMT) – a part of the Halstead-Reitan Test Battery, Wisconsin Card Sorting Test (WCST) , Color Reading Interference Test (Stroop test),
- Auditory memory: Auditory verbal learning test by Łuria,
- Visual memory: Benton Visual Retention Test,
- Language fluency: Verbal fluency tests,
- Attention and working memory: Digit Span Subtest form Wechsler Intelligence Test WAIS-P(PL),
- Clinical interview and observation.

The observation of the patient's behavior during the examination shows visible personality changes. Patient was hyperexcitable and dysphoric. He manifested decreased self-criticism and a tendency to shorten the distance between himself and the investigator - he exhibited a tendency to wisecracking (dirty jokes). The patient negated any problems with memory or attention. His mood should be characterized as slightly euphoric. During the examination, he manifested characteristic compulsory laughter, which he was unable to control.

Intellectual status

Our patient had a strong motivation to do the tests properly and he concentrated on the separated tasks. The patient demonstrated full auto and allopsychic orientation. He was capable of completely error-free providing information on the date, place, or facts from his autobiography. His MMSE (Mini Mental State Examination) score was 28 points, what placed him within the normal range for cognitive processes efficiency. The patient lost a point in the task that measured efficiency of short-term auditory memory (following a distraction, he was capable of reproducing two of three presented words) and in writing task. In the latter, he made an error consisting in perseverations of a given syllable while writing a word. The patient failed to note the error. Testing the level of conclusion drawing and logical thinking by the Raven Progressive Matrices test showed the patient's intellectual functioning to be average – in the upper values (Score III+, 66 centile).

Memory processes

Examination of the ability to learn new material (a list of 10 words read to patient in 5 trials) using the Auditory – Verbal Learning Test by Luria – demonstrated the difficulties in organizing the process of encoding auditory material. Patient repeated the presented word list in chaotic manner, without any mnemonic strategy, what resulted in numerous perseverations. He also added words that had not been included in the list. The patient did not correct these

mistakes with subsequent test trials. The course of the examination was fluctuating in character. Following a 20-minute distraction, independent reproduction of the previously learned material was significantly deteriorated.

Short-term visual memory was assessed by the Benton Visual Retention Test. The patient's score represented a borderline value for pathological decline of cognitive functions due to organic brain damage <-2; +2>. However, the qualitative analysis of errors showed preponderance of typical "organic" perseverative errors.

Attention and working memory

Attention and short-term auditory-verbal memory span (Digit Span form Wechsler Intelligence Scale) was found to be within normal range (6 elements). On the other hand, working verbal memory was clearly deteriorated – the patient was capable of repeating backwards only up to 3 digits.

Executive functions

The above presented results of tests and examinations suggested that the major problem of the patient was associated with dysfunctions in the sphere of metacontrol of intentional actions focused on purpose, or in other words the so-called executive functions. Disturbances of these functions result in a secondary decrease of efficiency of other cognitive processes that are in a way subordinate, such as memory. Thus, the subsequent part of the neuropsychological assessment was focused on a highly detailed analysis of the very executive functions.

While evaluating executive functions, the authors used the Trail Making Test - a part of the Halstead-Reitan Test Battery [18]. The test performed using this tool consists of two parts. In part A, the task of the patient is to connect as quickly as possible numbers from 1 to 23 that are scattered all over the page. In part B, patient needs to connect as quickly as possible alternately consecutive numbers and letters of the alphabet.

During the testing, the presented patient manifested significant problems in executive functions. Although he promptly (39 sec.) and without any errors completed part A of the test, what suggested his maintained ability of visual-spatial field searching and good performance rate, significant problems appeared in part B. Not only was the time needed to complete the task prolonged more than four times as compared to Part A (172 sec.), but also the patient manifested errors highly characteristic of executive dysfunctions. The very lack of time proportion between part A and part B is of a high diagnostic value. According to the literature, a threefold prolongation of time needed to complete part B as compared to part A is highly characteristic of patients with organic brain damage, especially frontal lobe lesions [19]s. To describe the manner of executing part B of the test and analyze the errors the patient had made, it should be noted that following several appropriate alternate connections of numbers and letters of the alphabet, he started impulsively connecting consecutive numbers, forgetting about switching to letters. Although the error was corrected by the investigator, the same type of mistake was repeated many times. This manner of performing the test suggests "frontal" problems in inhibiting the automatic reaction and a complete absence of self-correction of one's mistakes. While completing the test, on the occasion of committing the same error again, the patient many times repeated and verbalized the rule, according to which he should have properly performed the task, yet he was unable to implement the rule and use his knowledge in execution of the task. In patients with frontal damage, such a phenomenon is common and described as a „dissociation between what I know and what I do". As it turned out in the present study, it can be also observed in case of a patient with cerebellar damage.

To assess the executive dysfunction we also used The Wisconsin Card Sorting Test (WCST). The tool is employed in the following way: four stimulus cards are placed in front of the testee; the cards are marked with the following figures: one red triangle, two green stars, three yellow crosses, four blue circles. The remaining cards, different as to the number, shape and color of figures they represent are stacked in front of the tested individual. The task to be performed by the patient is to match cards picked up from the stack to the stimulus cards. The cards may be matched according to three rules: by color,

shape and number. Proper execution of the test requires the involvement of numerous executive functions: thinking flexibility, categorization, ability to correct one's mistakes, working memory as the ability to retain in short-term memory a given portion of information and to perform mental operations [20].

The above-defined precise tool for measuring the effectiveness of executive functions has proven to be of utmost importance in assessing these functions in the described patient. The type and manner of performing the tests by the subject and the types of committed errors bear a striking similarity to these characteristic of patients with frontal damage, what again confirms the significant role of the cerebellum in regulation of higher mental functions and above all executive functions.

While comparing the results achieved by the present patient with the table of normal scores for the appropriate age group, it should be stated that in the majority of the test categories, the patient scored very low. His performance was characterized by a very high total number of errors, perseverative responses, perseverative errors (a high percentage of the latter as compared to the total number of trials) and a low percentage of conceptual responses, what proves considerable rigidity of thinking, problems with abstraction and conceptual thinking. Throughout the entire test, the testee managed to complete three categories only. Two failures were also noted in attitude maintenance, what suggests high impulsiveness of his reactions, decreased vigilance and effectiveness of working memory. The Learning to Learn Index of the patient demonstrates his complete lack of this skill, problems with correcting his own errors and inability of drawing conclusions from his erroneous responses. Towards the end of performing the WCST test, the testee was highly irritated and impatient, unable to fully control his emotions and behavior. The entire score indicates massive executive dysfunctions. Tab. 1 and 2 – *next page*.

The last test which has been used in measuring executive dysfunction was Color Reading Interference Test (Stroop test). In the first part of the test, the testee is asked to read the names of colors as fast as possible. The chart consists of lines with names of particular colors. The real task, however, is associated with the second chart; the patient is asked to name the color of ink in which a given word is printed, with the name of the color being divergent with the color of ink. For the majority of people, paying attention solely to the color of print appears difficult due to automatic habit of reading, what results in slowed down reaction, what is termed "the interference effect" or "the Stroop effect". The most striking manifestation of the interference are the so-called intrusion errors, where the testee reads a word rather than supply the name of the color of ink, thus neglecting the primary purpose of the task.

The task is designed to assess the so-called inhibition control in a conflict situation, attention selectivity and resistance to interference. Assessment of neuroanatomical correlates of performing the Stroop test unambiguously points to a special role of the frontal region, and more precisely of the lateral prefrontal cortex and cingulate gyrus, in the mechanisms of inhibition and controlling reactions [21].

The interference effect was very clearly seen in the described patient. In performing the first part of the test was not associated with any major problems and he performed the task quickly (39 sec.) and faultlessly, the second – conflicting – part resulted in considerable trouble. The time needed for his reading the entire chart was 3 minutes and 28 seconds. The patients committed 18 intrusion-type errors. Initially, it was necessary to remind the patient of the principal rule governing this part of the tests. At a later stage, the number of errors did not diminish; although having made an error, the testee stopped and verbalized the rule on his own, yet later, he did not observe the very rule, what was for him a source of bewilderment and amusement.

DISCUSSION

The performed neuropsychological assessment of cognitive affective syndrome CCAS involving a single patient with isolated stroke of the right cerebellar hemisphere provides the argument for the significant role of the cerebellum in regulation of human cognitive and emotional functions. The described patient presents mainly the disturbances typical for executive dysfunctions, such as disorders of planning, elasticity of think-

Table 1. Summary of particular patient's results in WCST test and comparison with commonly accepted norms

WCST categories	Results in centiles	Standardized result	Generally accepted norms		
Total number of errors	84	14	Centiles	Standardized results	
Perseverative errors	10	81			
Percentage of perseverative errors	12	82	< 15	84	low
Non-perseverative errors	34	94	16-85	85-115	average
Percentage of non-perseverative errors	30	92	>86	> 116	high

Table 2. Summary of particular patient's results in WCST test

WCST categories	Rough result
Number of completed categories	3
Number of trials performed prior to completion of first category	2
Failure in attitude maintenance	2
Learning to learn	6%

ing, correcting his own mistakes and inhibition of an automatic erroneous reaction. These impairments disturb the effective adaptation to the new situation and changing environmental conditions. As it appears, executive dysfunctions, associated mainly with dysfunction of the frontal region of the brain, may be also manifested in patients with damages involving other brain structures, such as the cerebellum. Similar observations were made in single patients by other authors.

Marien and colleages [22, 23] observed posterior fossa syndrome PFS with neurobehavioral cognitive changes typical for CCAS in adult patient with right cerebellar haemorrhage. This syndrome is typically characterized by a short symptom-free postoperative period followed by mutism of variable duration and behavioural and affective changes. It is typical for paediatric patients after cerebellar tumour surgery and reports of adult patients are extremely rare.

Examining two patients with progressive atrophic, primarily degenerative processes involving the cerebellum, Krzysztof Jodzio and colleages [24] observed clearly intensified executive dysfunction that hindered attention focusing and selection of an optimal strategy of acting, what resulted in disorganization of the course of solving various test tasks, especially those involving drawings. In turn, Bellebaum and Daum [2] described a tendency towards perseverations, delayed reactions, chaotic performance and rigidity of thinking in patients with cerebellar tumors. Testing by the WAIS scale of patients with olivary-ponto-cerebellar degeneration suggests even more massive intellectual disturbances progressing into dementia. Particularly striking is concretization in thinking in such subscales as Similarities, Vocabulary and Comprehension [25].

It should be emphasized that the cerebellar cognitive affective syndrome CCAS combines not only the specific character of executive dysfunctions, but also emotional-personality disorders, which are a mix of such symptoms as passivity, emotional blunting or scarcely visible emotional expression with alternate disinhibition, improper nonchalant or childish behaviors [26]. The same characteristic properties were observed in the present patient, which clearly shortened distance between himself and the investigators, was euphoric, excited, demonstrated an evident decrease of criticism and behaviors inadequate with respect to social norms.

The associations between cognitive-emotional disturbances and damage to the cerebellar structure may be explained referring to the connection (associative) and neurodynamic model [26]. CCAS is a disconnection syndrome, caused by rupture of specific fibers that connect the cerebellum with other cerebral structures, especially the cortex. Another explanation is pathological interaction or mutual negative effect of the activity of the cerebellum and the brain due to diaschisis [27]. In this model, CCAS is caused by

a weakened or pathologically intensified interaction of cerebral and cerebellar function. The cerebellum has numerous connections not only with the medulla, reticular formation, hypothalamus and limbic system, but also with the motor and association cortical areas. Of particular importance for CCAS is the neuronal loop that connects the cerebellar cortex and the cerebral cortex. Probing into the genesis of neurobehavioral disorders, investigators take into consideration the afferent pontine tract. Its corticopontine segment is uncrossed, contrary to the crossed pontocerebellar neuron. Subsequently, the information from the cortex of the neocerebellum (which is also called the pontine cerebellum) reach the dentate nucleus, the origin of efferent fibers, which pass anteriorly and superiorly through the superior cerebellar peduncle. Having crossed in the mesencephalon, the fibers extend towards the thalamus, which in turn is rich in connections, including these with the motor and prefrontal areas. In this way, the corticocerebellar system is formed, which is responsible not only for motor, but also cognitive control.

The above-mentioned mechanism of diaschisis, resulting in cessation of processes of mutual stimulation and inhibition of the brain and cerebellum, is crossed and bilateral, and therefore, damage to one structure - in this case the cerebellum - results in a contralateral functional depression (e.g. hypoperfusion, hypometabolism) of the other structure - the brain [28]. Botez-Marquard and Botez [29] claimed that the development of the crossed diaschisis of the neocortex explained the versatility of behavioral abnormalities in more than 70 % of patients with primary cerebellar atrophy and in more than 30% of individuals with congenital spinocerebral ataxia. Marien et al. [7] determined that the signs of right cerebellar hemisphere destruction include - in addition to executive dysfunctions - also language disorders, which most likely reflect dysfunctions of the left cerebral hemisphere, particularly the frontal lobe. Such an observation is also confirmed in the case of the present patient, who - apart from typically disarthric speech abnormalities, also manifested left hemisphere-associated language impairments, such as decreased verbal fluency, agrammatisms and dysnomia.

Evidence from the f MRI indicates that there is a functional topography in the human cerebellum for overt control of movements vs. higher mental functions [30, 31]. Stoodley and colleques [32, 33] proved that cerebellum can be divided into zones depending on connectivity with sensimotor and multimodal association cortices. Using functional MRI they showed that region of cerebellum active overt movement are different from those involved in language, spatial processing and working memory. For example verb generation engaged right cerebellar lobules (VI-Crus I), mental rotation activation peaks were located to medial left verebellar lobule (VII-Crus II).

The question on the specific character of executive dysfunctions observed in patients with cerebellar damage remains open - we do not know whether such dysfunctions are characterized by any clinical distinct feature as compared to executive dysfunctions in frontal damage. We should also ponder on the issue whether, analogously to the functional specialization of the cerebral cortex, there is a similar, complex functional specialization within the cerebellar cortex. The subjects calls for further research on numerous and uniform groups of patients.

Finally, emphasizing the practical aspect of the CCAS syndrome and in view of its neuropsychological specificity, it should be postulated to extend neurological diagnostic management of patients with cerebellar damage of various origins by a functional neuropsychological examination. Cognitive-emotional disturbances, including executive dysfunctions, may oftentimes contribute to a higher degree to limitation of independent existence of the patient. Such a diagnosis is of a substantial importance not only in view of the patient's seeking various health benefits, but also for his future motor-cognitive rehabilitation.

CONCLUSIONS

1. The cerebellum participates in regulation of cognitive functions in man, especially in the executive functions.
2. Cerebellar damage may present as pseudofrontal disorders, what additionally confirms the functional association between these two central nervous system structures.
3. Neurological assessment of patients with cerebellar damage should additionally include a detailed neuropsychological and neuropsychiatric evaluation.

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