



Neuropsychological assessment of patients undergoing surgery due to low-grade glioma involving the supplementary motor area

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ABSTRACT

Objective: The aim of the study was to establish the usefulness of various neuropsychological tests in patients undergoing surgery due to low-grade glioma (LGG) involving supplementary motor area (SMA).

Patients and methods: 21 patients diagnosed with LGG involving the SMA underwent, before and after surgery, screening tests (Mini Mental State Examination – MMSE, Montreal Cognitive Assessment – MoCA and Frontal Assessment Battery – FAB), tests to assess language functions (Addenbrook's Cognitive Examination-III – ACE-III, phonetic fluency tests and semantic fluency tests), tests to assess memory functions (Rey's 15-word test – RAVLT and Diagnostic Test for Brain Damage by Hillers- DCS), tests to assess executive functions (Wisconsin Card Sorting Test - WCST, Ruff Figural Fluency Test – RFFT and Trail Making Test).

Results: Before surgery, in the screening tests the patients obtained below normal scores in the MoCA test only. After surgery, the scores of such tests were significantly worse than the scores before surgery, while the MMSE test scores continued to be within the normal range. In phonetic and semantic fluency tests, the patients obtained worse scores, both before and after surgery. The differences in the test scores between the two periods, i.e. before and after surgery, were statistically significant. Although the patients obtained worse scores both before and after surgery in the ACE III test, the differences in the test scores were not statistically significant. The scores obtained in all tests assessing the executive and memory functions before and after surgery were within the normal range. The scores in such tests (except the WCCT) dropped significantly after surgery.

Conclusions: Patients diagnosed with LGG involving the SMA reveal the impairment of cognitive functions, in particular language functions. After surgery, a significant impairment of all elementary cognitive functions, such as attention, memory, language and executive functions and complex cognitive functions, occurs. The most sensitive tests to detect cognitive disorders, executive dysfunctions and speech disturbances in patients undergoing surgery due to glioma include the MoCA, FAB and Phonetic and Semantic Fluency Tests.

1. Introduction

The cerebral cortex of the frontal lobes located to the front of the primary motor cortex (Brodmann area 6) is a complex anatomical and functional structure. It includes the complex of the supplementary motor area (SMA), comprising the proper SMA, pre-SMA and premotor cortex. The SMA plays an important role in the control and coordination of complex motor processes and takes part in programming sequential movement patterns. One function of the premotor cortex is the arrangement of complex motor processes requiring eye-hand coordination. Pathological processes located within the SMA usually

cause contralateral limb movement disorders in the form of apraxia or akinesia, accompanied by muscle weakness and problems with initiating the motor process [1–8]. If the disease process is located within the dominant hemisphere, speech disorders may appear. These symptoms are referred to as the SMA syndrome [9]. In addition, seizures with the tonic position of the limbs and clonic movements occurring in the final phase are also observed [10]. It has recently also been proposed that SMA plays a key role, as an important complex cognitive functions and language control network [11,12]. Due to the complex function of the secondary motor cortex, to fully evaluate disorders of the SMA and the premotor cortex, sensitive clinical and

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neuropsychological tests may be used in addition to neurological examination. The aim of the study was to establish the usefulness of various neuropsychological tests in patients undergoing surgery due to secondary motor cortex low-grade gliomas.

2. Patients and methods

The study included 21 patients admitted to the department of neurosurgery for surgical treatment of low-grade glioma located within the secondary motor cortex. The group included 12 women and 9 men. The mean age of the subjects was 37.1 ± 4.7 years (mean \pm SD). Five patients had primary education, seven subjects had secondary education and nine patients had higher education. Only two patients were left-handed. The inclusion in the study group was based on the confirmed location of the tumour within Brodmann area 6, based on the location of the primary motor cortex determined by fMRI. The mean tumour volume calculated by MRI with the FLAIR sequence was 60 ml (range of 32–119 ml). In ten patients, the brain tumour was located in the right hemisphere (47.6%) and in eleven patients in the left hemisphere (52.4%). On admission, all the patients were subjected to a basic neurological examination and complex neuropsychological assessment. The neuropsychological examination was performed by a qualified neuropsychologist. The study was voluntary and all patients gave consent. The study was carried out with complete confidentiality. Table 1 lists the tests used for the neuropsychological assessment. The duration of one examination did not exceed 2.5 h. A neuropsychological follow-up examination was conducted at discharge or following remission of neurological symptoms observed after surgical treatment. The mean time of follow-up examination was 14.1 days after surgery (9–27 days). If the surgery was followed by neurological deficits preventing a reliable neuropsychological assessment, the patient was not qualified for the follow-up study.

2.1. Methods of neuropsychological evaluation

The neuropsychological functional diagnosis was planned so as to determine the profile of deficits and the maintained competencies in that group of patients. Screening tests generally used in neuropsychological practice were applied as well as the methods of evaluating the efficiency of cognitive and executive functions, and 'higher' motor activity.

The applied methods and a description of the tested competencies, as well as scoring procedures are presented below [12–14].

Table 1

List of tests used in neuropsychological assessment.

Neuropsychological tests	
Assessment of praxis	Assessment of dynamic and pose praxis according to Luria's classification
Screening tests	Mini Mental State Examination (MMSE) Montreal Cognitive Assessment (MoCA) Frontal Assessment Battery (FAB)
Tests to evaluate language function	Attempts to name objects from Addenbrook's Cognitive Examination-III (ACE-III) Phonetic fluency tests Semantic fluency tests
Tests to assess mnemonic processes and auditory and visual memory	Rey's 15-word test (RAVLT) Diagnostic Test for Brain Damage by Hilliers (DCS)
Tests to assess executive functions	Wisconsin Card Sorting Test (WCST) Ruff Figural Fluency Test (RFFT) Trail Making Test
Test of unilateral attention	Bell test Test for visual search effectiveness

2.1.1. Screening tests

1. The Mini Mental State Examination (MMSE) – it is a clinical screening scale that enables scoring the various aspects of the patient's cognitive functions. It consists of 30 questions/tasks. The result is the total score obtained in the tests that evaluates: orientation to time and place (10 points), registration in the form of repeating three words (3 points), attention and calculation/backwards spelling (5 points), free recall of the previously remembered words after a short delay (3 points), naming two objects (2 points), repeating a short abstract phrase (1 point), following a verbal order (3 points), writing (1 point), reading comprehension (1 point) and copying two interlocking pentagons (1 point). The maximum score is 30 points. The cut-off point is a score lower or equal to 24 points.

2. The Montreal Cognitive Assessment (MoCA) – it is a screening tool used in evaluating mild cognitive impairment (MCI). Compared to the MMSE, it enables the evaluation of a larger spectrum of cognitive functions, but primarily allows for the initial diagnosis of executive functions. The sensitivity of scale in diagnosing deficits resulting from changes in the subcortical and prefrontal structures is emphasised. The result is the total score obtained in the tests assessing: visuospatial processes (which includes a working visual memory – forced fluency, copying, recall from memory of a representation of a clock and the meaning of the clock hands) (5 points), naming (3 points), concentration aspects (repeating digits forward and backward, attention and reacting to stimuli) (3 points), language functions (repeating sentences, phonemic fluency as a measure of the effectiveness of searching through lexical resources) (2 points), abstraction (ability of verbal generalisation) (2 points), delayed spontaneous recall of previously coded auditory-verbal material (5 points) and allopsychic orientation (6 points).

The maximum score is 30 points. The cut-off point is a score lower or equal to 26 points.

3. The Frontal Assessment Battery (FAB) – it is a set of clinical tests used in the neuropsychological diagnostics of neurological diseases of various aetiology, enabling the recognition of frontal, prefrontal, and frontal subcortical dysfunctions, by way of evaluating the aspects of a patient's cognitive and motor behaviour. The test consists of six subtests evaluating such cognitive functions as the ability of conceptualisation (abstract reasoning, creating superior ideas) (3 points); mental flexibility in non-routine situations, which require generating the strategy of recalling words from memory based on abstractive, non-specific criterion (letter fluency test) (3 points); programming and remembering a three-element motor sequence (by performing a Luria dynamic praxis test) (3 points); competencies in self-regulation of susceptibility to interference (as a reaction to conflicting or colliding instructions) (3 points); effectiveness of self-control and the ability to inhibit an improper reaction (go–no go test) (3 points); cognitive independence of the stimuli from the environment, environmental autonomy (as the ability to control a provoked prehension reaction (3 points). The maximum score is 18 points. The cut-off point is a score lower or equal to 14 points.

2.1.2. Language function evaluation tests

1. Addenbrooke's Cognitive Examination-R (ACE-R) – is a subtest within a battery of language function testing. The task of the patient is to name 12 visually presented objects. The proper score is assumed to be the absence of delay in updating the name and lack of circumlocutions or functional descriptions.

2. The tests of phonetic and letter fluency evaluating the capacity of controlled and fast recalling from the semantic memory and expressing words (within 60 s) in accordance with determined, non-specific criteria of the words updates (e.g. nouns starting with small case). The used letters were: f, a, and s. The cut-off point was a score lower or equal to 33 words, reduced for the number of faulty replies, understood as non-compliance with the task instructions (a word which is not a noun and/or is capitalised) as well as the number of repeated words.

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