Case report

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# Language assessment in awake craniotomy: case report

## Avaliação da linguagem em cirurgia de craniotomia com paciente acordado: relato de caso

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## ABSTRACT

The purpose of this report is to describe the case of a patient who underwent awake craniotomy for neurosurgical resection of a glioma and pre, intra and postoperative linguistic assessment. Male patient, 27 years old, incomplete higher education presenting vomiting, mental confusion and tonic-clonic seizures. After the evaluation of the patient by the team and due preoperative guidance, the proposal of excision of the lesion while awake was clarified and accepted. At the start of the procedure, the fields were adjusted to keep the airway and eyes accessible for mapping with electrical stimulation and intraoperative language assessment. Due to the location of the tumor close to the speech motor area, tasks were proposed for the assessment of language in four moments: preoperative, intraoperative, immediate postoperative and mediate postoperative. The language skills tested in the four assessments were: comprehension and expression of oral language, linguistic transposition, associative language, naming, visual discrimination, fluency and syntax organization. In order to control and eliminate the learning effect of testing, the same tasks were requested, but with different contents for testing skills in the four phases. Surgery with the patient awake allowed the complete and safe resection of the tumor, without motor or linguistic damage to the patient. Team engagement, interdisciplinary interaction and detailed surgical planning constitute the pillar for the good result of such a complex and delicate procedure

**Keywords:** Neurosurgery; Anesthesiology; Speech, Language and Hearing Sciences; Speech Therapy; Electrical stimulation

## RESUMO

O objetivo deste relato foi descrever o caso de um paciente submetido à craniotomia, acordado, para a ressecção neurocirúrgica de um glioma e a avaliação linguística pré-operatória, intraoperatória e pós-operatória. Paciente do gênero masculino, 27 anos, escolaridade nível superior incompleto, apresentando vômitos, confusão mental e crise convulsiva tônico-clônica. Após a avaliação do paciente pela equipe e devidas orientações pré-operatórias, a proposta de excisão da lesão em estado de vigília foi esclarecida e aceita. Ao iniciar o procedimento, os campos foram ajustados para manter as vias aéreas e os olhos acessíveis para mapeamento com estimulação elétrica e avaliação da linguagem no período intraoperatório. Devido à localização do tumor próximo à área motora da fala, foram propostas tarefas para a avaliação da linguagem em quatro momentos: pré-operatório, intraoperatório, pós-operatório imediato e pós-operatório mediato. As habilidades linguísticas testadas nas quatro avaliações foram: compreensão e expressão da linguagem oral, transposição linguística, linguagem associativa, nomeação, discriminação visual, fluência e organização da sintaxe. Com o objetivo de controlar e eliminar o efeito de aprendizagem da testagem, foram solicitadas as mesmas tarefas, porém, com diferentes conteúdos para a testagem das habilidades nas quatro fases. A cirurgia com o paciente acordado permitiu a ressecção completa e segura do tumor, sem prejuízo motor ou linguístico. O engajamento da equipe, a interação interdisciplinar e o planejamento cirúrgico detalhado constituem um pilar para o bom resultado de um procedimento tão complexo e delicado.

**Palavras-chave:** Neurocirurgia; Anestesiologia; Fonoaudiologia; Fonoterapia; Estimulação elétrica

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## INTRODUCTION

Gliomas and metastatic tumors may be located within or close to eloquent areas of the central nervous system, areas that are involved in important motor or speech processes, potentially compromised by conventional surgical techniques[1,2].

Brain surgery in an awake patient (awake craniotomy), with intraoperative mapping, the gold standard in the approach to these cases[1,2], allows maximum tumor resection with minimal consequences on neurological functions[1,2]. It is an important tool for performing a safe tumor resection, helping the neurosurgeon to maintain the delicate balance between maximum resection and the preservation of neurological functions[1-3].

Intraoperative direct electrical stimulation and the interaction of an interdisciplinary team with the patient during surgery[3] allow the identification of critical cortical and subcortical language areas and pathways, which can hardly be resected conventionally without postoperative language deficits[1,2].

The main eligibility criteria for performing the surgery with the patient awake include adult, cooperative patients with preserved neurological and cognitive function, or only slightly affected[4].

Absolute and surgery-related contraindications are described in the literature according to the team's experience, and for some authors, the main absolute contraindication is the presence of severe neurological deficit, to the point of making it impossible to perform neurological tests during mapping[4-6].

Other studies describe patient refusal as an absolute contraindication and as relative contraindications confusion, severe aphasia, cognitive disorders (dementia, Down syndrome), inability to remain still for long periods, claustrophobia, mood instability, uncontrolled persistent cough, morbid obesity, obstructive sleep apnea and psychiatric history[4-7].

During this type of surgery, patient cooperation is essential, and preoperative selection and preparation are critical steps for the success of the surgery[6]. Therefore, the assessment of the functional benefit and the neurological risks associated with craniotomy in an awake patient is an individual decision for each one of them and is the responsibility of a multidisciplinary team, involving the patient and his family[3-6].

In order to perform the aforementioned procedure, it is extremely important to carefully conduct the anesthetic technique, to ensure analgesia, sedation, hemodynamic stability, and control of possible intercurrences, such as convulsive crises with cortical manipulation, however, so as not to have any damage to the intraoperative neurological and linguistic assessment of the patient[2,7].

Anesthesia is based on blocking the sensitive nerves of the scalp, preventing the conduction of painful afferents, associated with conscious sedation techniques (patient awake or lightly sedated throughout the procedure), or general anesthesia, of the "asleep, awake, asleep" type (patient undergoes anesthetic induction, is awake during intraoperative tests and then returns to the initial anesthetic plane)[2,7].

Therefore, the expected actions of the drugs used during surgery are analgesia in situations where pain control is not completely obtained with the scalp block alone(7), control of periods of greater discomfort or intraoperative complications: seizures or psychomotor agitation[2,8], conscious sedation and maintenance of airway patency and protection and respiratory drive[2,7].

Language tests are aimed at detecting preoperative deficits, promptly identifying the occurrence of intraoperative impairments, and establishing the course of postoperative language status. The preoperative, intraoperative, and postoperative assessment of language allows for systematic analysis and recording of the status of language function[4,9]. The intraoperative assessment of language, which aims to preserve the linguistic functions necessary for adequate communication, should consider the phonological, semantic, syntactic, and articulatory aspects of language and, if indicated, writing tasks[8-12].

During brain surgery with the patient awake, linguistic functions are monitored through tests, which must meet specific criteria: the performance must be performed during electrical stimulation and, consequently, the time for the presentation of stimuli must be short[4].

Several tasks, from very simple, such as counting, to more complex or specific ones, such as semantic associations or translation skills, are used to monitor language functions in awake patient surgery, however, there is no single standardized assessment protocol that evaluates the linguistic function during functional neurosurgery[5,13].

Oral comprehension tasks, repetition, naming, reading aloud, fluency, verb generation, automatic speech, comprehension of sentences, words, and situations, naming actions with verbs in the infinitive, repetition of phrases and words, semantic associations, spontaneous speech, word-image correspondence and sentence-image correspondence, tasks that can be considered of great interest for the evaluation of language in surgery with awake patient[5,13,14]. In addition to more experimental paradigms, there are some standardized neuropsychological tests, such as the *Test de Dénomination Orale D'Images* and the *Boston Naming Test*[5].

The assessment of language in surgery with the patient awake must be performed by a specialized professional, such as the speech-language pathologist, to direct the surgical plan quickly and in real-time[10].

The role of the language specialist includes: performing a preoperative language test to identify preoperative symptoms and changes; performing a careful selection of intraoperative tasks to monitor and detect if language is being affected by direct electrical stimulation; perform intraoperative stress management (e.g., discomfort or pain), while providing feedback to the surgeon, and assess language functions in the postoperative period[10].

Not many studies were found in the literature on the participation of the speech-language pathologist, however, there are descriptions of the relevance and importance of the presence of this professional in the multidisciplinary team in the process of surgery with the patient awake, reinforcing the achievement of better results in real-time intraoperative cognitive and linguistic assessment, with rapid detection of the presence of alterations and immediate communication to surgeons[10,13].

Given the above, the objective of this report was to describe the case of a patient who underwent craniotomy, awake, for neurosurgical resection of low-grade glioma, and preoperative, intraoperative, and postoperative linguistic assessment.

## CLINICAL CASE PRESENTATION

The present case report complied with the criteria of ethics in research with human beings, Resolution 466/2021 of the

Brazilian National Health Council, and was approved by the Research Ethics Committee of the "Hospital Governador Israel Pinheiro", under number 4,611,786. The participant signed the Free and Informed Consent Term, thus consenting to the carrying out and dissemination of the research and its results.

A 27-year-old male patient, incomplete higher education student in the 8th period of the Medicine course. Due to an episode of tonic-clonic seizures, he was taken to the hospital in the city of Belo Horizonte, where he underwent computed tomography of the skull and, later, magnetic resonance imaging of the brain (Figure 1), which identified a lesion in the topography of the upper and middle frontal gyrus of the frontal lobe on the left, with edema and effacement of the perilesional grooves, without midline deviation.

He reported that, about five months ago, he was found by family members with vomiting and mental confusion, in an episode suggestive of postictal, with unseen seizures. He did not perform a diagnostic workup at the time. Previously healthy patient, he denied continuous use of medications, smoking, alcoholism, or drug use.

In the initial neurological evaluation, the patient was alert, oriented, without changes in expression or understanding of language, without meningism, isophotoreactive pupils, visual field without alterations, cranial nerve function intact, muscle strength globally preserved, normoactive reflexes, without pathological reflexes, preserved sensitivity and coordination, and atypical gait.

The language assessment took place in four moments: preoperatively (24 hours before surgery), intraoperatively (during surgery), immediate postoperatively (12 hours after surgery), and mediate postoperatively (8 days after surgery).

The language skills tested in the four assessments were: comprehension and expression of oral language: cognitive level and ability to sustain linguistic exchanges/turns in conversation, retention, memory and automatic recall; linguistic transposition: audio phonic transposition, involving auditory perception, comprehension and retention of the stimulus; associative language: creativity and selection within a restricted internal stock, mental elaboration for evocation; oral propositions: understanding, retaining and memorizing linguistic material, chaining reasoning for choices of propositions, retention for memorization and verbalization; naming/categorization/conceptualization: visual recognition, perception of form, symbolization, choice of a signifier linked to a meaning and evocation of classes and categories; evocation of language/abstraction - semi-automatic and associative language; fluency: creating and organizing language, morphosyntactic rules, retention and logical and contextualized combination of data elements; visual discrimination/naming: visual recognition, shape perception, conceptualization and response linked to previous learning; syntax organization: knowledge of grammatical rules and auditory stimulus/context association.

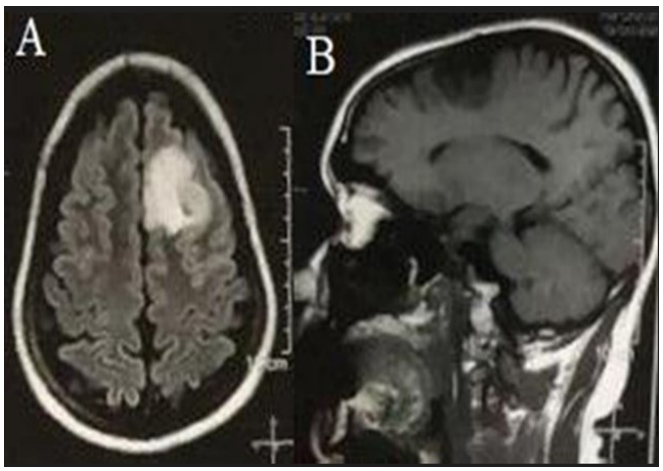


**Figure 1.** Magnetic resonance in axial section FLAIR (A) and sagittal T1-weighted (B) showing hyperintense image (A) and hypointense image (B) in the upper frontal gyrus of the left frontal lobe with characteristics of primary glial tumor

No standardized tests were found for the assessment of language in the surgery process with the patient awake, but descriptions of the experience of specialized services and professionals in the area, as described throughout the literature review[4,9,10,13].

The choice of linguistic tasks for the evaluation of the case described in this report was based on the Aphasia Rehabilitation Test - Rio de Janeiro[15], as it is a test with simpler, shorter, and more objective tasks, as it contemplates the linguistic functions described as necessary to the pre, intra and postoperative evaluations[5,13,14] and for being a test developed for the Brazilian specificities and standardized for application in adult patients, tested in the age group between 19 and 80, for educational level from primary school to higher education[15], thus considering the age group and education level of the patient in this case study.

In the case described, it was not possible to use the aforementioned test in its entirety, following all the tasks as stated in the protocol, as it was performed in a hospital and surgical context, which requires the use of more agile and objective tasks, with reduced application time.

To classify the results, the count was performed according to the patient's correct answers[15]. The answers were considered adequate when they correctly described the requested item and/or when there was a self-correction of a wrong answer at the same moment of the evaluation. They were considered altered in the presence of error without self-correction, absence of response, or need for facilitation. The content of the assessment tasks was adapted by the evaluating speech-language pathologist in the case described in this report, through data from informal conversations with the patient regarding their daily reality, social environments they attended, and routine activities of study, work, and leisure intending to make the assessment objective, contextualized and appropriate to the patient's cognitive level and interests.

The intraoperative linguistic assessment had its items reduced due to the need to speed up the procedure for biosafety reasons and to reduce the exposure time of brain structures, to avoid edema and other unwanted clinical effects during and after the surgical procedure (Figure 2). To carry out this adaptation of the test for the intraoperative phase, simpler tasks were selected, with colloquial content that contemplates the essential linguistic functions for communication, also present in the evaluations of the other phases (comprehension, evocation, association, and expression of language, repetition, naming and fluency), but with fewer tasks tested due to the need to reduce time.

To control and eliminate the learning effect of testing, the same tasks were requested, however, with different content for testing skills in the four phases, as described in Figure 2.

During the speech-language assessment of language in the immediate preoperative period, preserved comprehensive and


**Figure 2.** Language assessment script used in the case described in this study
**Subtitle:** Elaboration/adaptation: Margaret Côrte

expressive language was observed, with only one episode of disfluency (the patient reported episodes of disfluency before the diagnosis of the lesion). The automatic recall of language (colloquial, automatic, and associative) and the skills of naming, conceptualization, contextualization, language organization, generalization, and abstraction were considered adequate (Table 1).

The anesthetic procedure begins with the puncture of accesses for infusion of continuous intravenous sedation and cardiovascular and clinical monitoring. Conscious sedation is started (dexmedetomidine and remifentanil) and ultrasound-guided scalp block is performed (major and minor occipital, major auricular, supraorbital, supratrochlear, zygomatic-temporal

**Table 1.** Results of language assessments

| Skill tested | Evaluation results | | | |
|---|---|---|---|---|
| | Pre-surgical | Intraoperative | 1st post-surgical | 2nd post-surgical |
| Understanding/Expression of Oral Language | Adequate | | Adequate | Adequate |
| Repetition | Adequate | Signs of motor aphasia | Adequate | Adequate |
| Associative language | Adequate | to electrostimulation | Adequate | Adequate |
| Oral propositions | Adequate | of the speech area or | Adequate | Adequate |
| Evocation of language/ abstraction | Adequate | surroundings | Altered (mild degree) | Adequate |
| Fluency | Prior mild disfluency (rare) | | Altered (mild degree) | Adequate |
| Visual discrimination/ naming | Adequate | | Adequate | Adequate |
| Naming /Categorization/ Conceptualization | Adequate | | Altered (mild degree) | Adequate |

and auriculotemporal nerves). Once the effectiveness of the blockade with complete analgesia is confirmed, the head is fixed with a Mayfield type support and triple prophylaxis for nausea and vomiting, followed by the infusion of Propofol during the craniectomy, to minimize the discomfort resulting from the perforation of the skull, being turned off during the period of evaluation of cortical functions and maintaining only dexmedetomidine infusion, so as not to compromise the clinical examination due to excessive sedation.

After the eloquent testing phase, the infusion of medication was restarted to keep the patient sedated until the end of the procedure (Figure 3).

After surgical access (skin incision, craniotomy, and opening of the dura mater), cortical electrical stimulation was performed with the patient awake and conscious, to allow interaction with the interdisciplinary team. The parameters of electrical stimulation are already well defined in the medical literature and the standard recommended for mapping the speech area was used[3,6,11].

Corticectomy, performed after identifying the main motor area (precentral gyrus), the language motor area (opercular and triangular portions of the inferior frontal gyrus), and the tumor location in the superior and middle frontal gyri, occurred bordering the superior frontal sulcus, being in-depth, a tumor with a subcortical glial aspect was identified.

During tumor resection, periodic functional tests were performed with continuous monitoring of motor and language functions. Thus, the tumor was resected in its entirety and safely, without motor or linguistic damage to the patient.

In the intraoperative linguistic assessment, areas close to the motor regions of speech were electrically stimulated and a positive result site was identified when the patient began to develop difficulties in any of the language tests during stimulation, or motor reactions associated or not with speech. Language tasks were requested (Figure 2) with adequate responses and without linguistic alterations, up to the point at which the stimulation reached the speech motor area, when, then, the patient presented signs of motor aphasia (Table 2), with the area being delimited of safety for tumor resection, without language prejudice. All the requested tasks had as input the auditory and visual stimuli and, as an output, the verbal response.

The patient was evaluated in the immediate postoperative period with fluent speech and preserved linguistic skills, however, with a slight change in automatic language recall, concerning the representation and connection between a signifier and a meaning, characteristic alteration in the immediate postoperative period due to cortical manipulation and post-surgical edema[4,6].

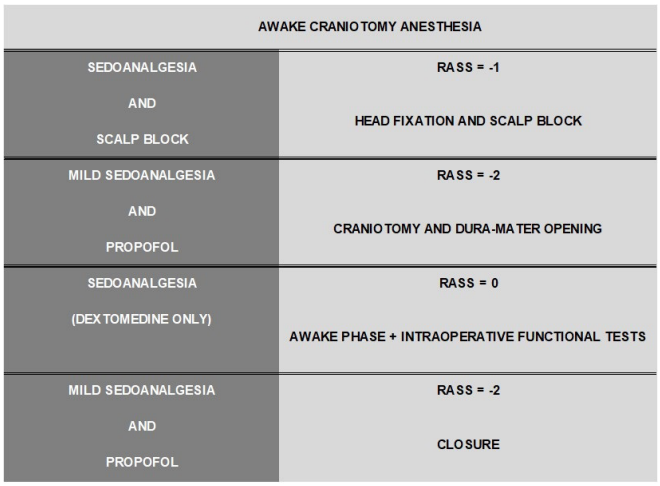


**Figure 3.** Schematic representation of anesthesia administered to the patient during surgery
**Subtitle:** RASS = Richmond Agitation Sedation Scale

In the immediate postoperative period, fluent speech and phonological, semantic, and syntactic aspects of the language were preserved, without changes, omissions, or wrong answers, with only a brief latency period in the responses related to the word-image correspondence (naming of objects).

The results observed in the four linguistic assessments are described in Table 1. After hospital discharge, the patient was referred for reassessment and outpatient speech-language therapy.

## DISCUSSION

The speech-language pathologist acts as a mediator for the mapping of language function during the neurosurgical procedure. Its performance occurs from the preoperative period, with the assessment of language to verify possible impairments already installed by the presence of the tumor. During the intraoperative period, before resection, the language areas close to the tumor are mapped, to avoid further damage to this function, and in the

**Table 2.** Examples of altered responses to electrical stimulation of the speech motor area

| Linguistic skill/motor response | Question/Instruction | A* A** A |
|---|---|---|
| Colloquial language | In what city were you born? | Pa * aaaaa ** racatu |
| Automatic language (reverse count) | Say the numbers from 10 to 1 | Ten, nine, eight, se.. * ... ** six, five, four, three, two, one |
| Evocation of language | Say 3 colors | Blue, *eh...eh... ** Yellow, Green |
| Motor Reaction | * | Spasms: fingers of right hand ** Cessation of spasm |

*Application of electrical stimulation; **Suppression of electrical stimulus
**Subtitle:** R = Answer

postoperative period, with the final evaluation of the patient. The mapping is built from stimulation of brain areas close to the tumor, performed by the neurosurgeon, concomitantly with language stimulation, with tasks of naming pictures, oral comprehension, repetition, semantic and phonemic fluency, and reading words, phrases, and numbers, performed by the speech-language pathologist. With this proposal, it is possible to prevent possible deficits in language and verbal fluency in patients undergoing surgery for resection of primary tumors[4,6,10].

In the intraoperative phase, practice standards suggest continuous live assessment and several informal assessments to quickly detect clinical deterioration in the patient, considering their preoperative baseline and with the potential to direct the surgical plan in real-time[9,10].

The intraoperative linguistic evaluation reveals the importance of monitoring the patient's language in the craniotomy with the patient awake, in the sense of contributing to the complete resection of the tumor, allied to the safety in the preservation of linguistic functions and verbal communication[9-12].

The patient followed up in this case report had a tumor close to the speech motor area (Broca's Area) and, for this reason, we chose to select assessment tasks involving the skills of understanding and expressing oral language, designation of words by associative fields, interpretation of syntactic/spatial concepts, organization of syntax and naming, conceptualization and repetition of words and phrases. Mild changes were observed in the immediate postoperative period, attributable, according to the neurosurgery team, to post-surgical edema, with remission of difficulties.

In the preoperative period, an adequate doctor/patient relationship and a thorough explanation of all phases of the anesthetic-surgical procedure are of major importance for the success of anesthetic and surgical management in the intraoperative period, during which the patient's cooperation and interaction with the anesthesiologist and the speech-language pathologist are widely needed. For that, fine control techniques of sedation and analgesia are necessary, to allow the maintenance of consciousness at opportune moments[6,9].

The preoperative evaluation made it possible to verify the linguistic behavior of the patient, noting the absence of linguistic alterations in this phase. This parameter served as a guide for further evaluations, and we expected, then, the absence of further linguistic alterations in the mediate and late postoperative period, that is, after the immediate postoperative edema phase, which was confirmed.

Thus, tumors located in eloquent regions of the central nervous system can be completely and safely resected, improving the postoperative oncological prognosis, without causing motor or linguistic deficits to the patient[11].

The monitoring and consequent preservation of linguistic functions contributed to keeping the linguistic function of communication intact, promoting functionality and quality of life, which is an important factor in interaction and human functionality.

Surgical resection is the mainstay of treatment for patients diagnosed with glioma, even when it involves areas of the brain of presumed functional significance. Thus, care must be taken to preserve neurological function while seeking maximum lesion resection, since permanent postoperative neurological impairments, particularly involving language and motor function, are associated with worse overall survival and lower quality of life[8].

The interdisciplinary follow-up aligned between the medical, anesthesiological, and speech-language pathology teams, direct electrical stimulation, and intraoperative language tests during surgery allowed the complete resection of a glial tumor located close to Broca's Area, minimizing the risks of significant language deficits.

## FINAL REMARKS

The engagement of the entire team, adequate interdisciplinary interaction, and detailed surgical planning make up a pillar for the good result of such a complex and delicate procedure.

The assessment of linguistic skills for understanding and expressing oral language, linguistic transposition, associative language, oral propositions, naming, language evocation, fluency, and syntax organization made it possible to draw a profile of the language pattern of the patient in question, helping to preserve the linguistic function and, consequently, in his daily functionality, since he depends a lot on these skills preserved for his routine.

The intraoperative linguistic assessment made clear the need for this procedure to preserve linguistic functions, as observed in the altered, aphasic linguistic responses during electrostimulation of language-related brain areas.

According to evidence from the literature and the reflection on the case in question, it is necessary to create a language assessment protocol for the intraoperative phase, to provide greater safety and effectiveness in the preservation of language skills in the postoperative period.

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