CORTICAL STIMULATION OF LANGUAGE FIELDS UNDER LOCAL ANESTHESIA

Optimizing removal of brain lesions adjacent to speech areas

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Abstract – Objective: The main objective when resecting benign brain lesions is to minimize risk of postoperative neurological deficits. We have assessed the safety and effectiveness of craniotomy under local anesthesia and monitored conscious sedation for the resection of lesions involving eloquent language cortex. Method: A retrospective review was performed on a consecutive series of 12 patients who underwent craniotomy under local anesthesia between 2001 and 2004. All patients had lesions close to the speech cortex. All resection was verified by post-operative imaging. Six subjects were male and 6 female, and were aged between 14 and 52 years. Results: Lesions comprised 7 tumour lesions, 3 cavernomas and 1 dermoid cyst. Radiological gross total resection was achieved in 66% of patients while remaining cases had greater than 80% resection. Only one patient had a post-operative permanent deficit, whilst another had a transient post-operative deficit. All patients with uncontrollable epilepsy had good outcomes after surgery. None of our cases subsequently needed to be put under general anesthesia. Conclusion: Awake craniotomy with brain mapping is a safe technique and the “gold standard” for resection of lesions involving language areas.

KEY WORDS: cortical mapping, awake craniotomy, tumor, speech area.

Resumo – Objetivo: O presente estudo visa discutir as vantagens e as limitações do uso da técnica de mapeamento cortical da fala com o paciente acordado. Método: Esta é uma revisão retrospectiva dos casos em que foi realizado monitoramento cortical intraoperatorário em cirurgias para ressecção de lesões intracranianas localizadas próximas à área da fala. Todos os pacientes foram submetidos a avaliação neuropsicológica no pré e intra-operatório. O grau das ressecções foi verificado através de exames de imagem pós-operatórios. Foram avaliados um total de 12 pacientes. Destes, 6 eram do sexo masculino e 6 do feminino. Resultados: 7 lesões eram tumorais. A ressecção total foi atingida em 66% e ressecção subtotal nos remanescentes. Apenas 1 paciente apresentou déficit motor permanente no pós-operatório e todos os pacientes com quadro prévio de epilepsia refratária obtiveram bom controle das crises no pós-operatório. Em nenhum caso houve necessidade de conversão da anestesia para geral. Conclusão: O mapeamento funcional intraoperatorário na craniotomia com o paciente acordado otimiza a extensão da ressecção da lesão minimizando morbidade permanente. Esta é uma técnica eficaz no manejo de lesões em íntimo contato com o córtex eloqüente, que outrora, seriam designadas inoperáveis.

PALAVRAS-CHAVE: mapeamento cortical, craniotomia acordado, tumor, área da fala.

Cortical locations corresponding to neurological functions can vary significantly among individuals and some brain lesions are able to distort the anatomy, hindering the localization of certain key intra-operative points. Determining the exact functional area is essential for safe and effective resection12.

As the extent of tumor lesion resection is directly related to outcome, the surgeon should attempt to maximize the extent of removal without compromising the patient’s quality of life.

In this study, we aimed to evaluate the safety of intraoperative cortical stimulation in the awake patient, to...
analyze how the application of this technique allows total resections, and to determine to what extent cortical mapping can prevent postoperative deficits.

**METHOD**

Twelve patients, with brain lesions in close proximity to language-specific cortex, operated from 2001 to 2004, were studied. Of these, 6 were female and 6 male. Age varied from 14 to 52 years (mean 35.4 y). The patients were submitted to a protocol where age, clinical symptomatology, the Karnofsky scale (KPS) and radiological findings through computed tomography (CT) and magnetic resonance (MRI) were analyzed.

A neuropsychological evaluation composed by the Boston Diagnostic Aphasia Examination-III was conducted at bedside to identify patient characteristics in order to optimize subsequent language testing in the operating room.

All were submitted to a left craniotomy under sedation and local anesthesia without muscular relaxation. A three-pin head holder was placed after head block using 0.5% lidocaine, 0.25% bupivacaine with epinephrine (1:200,000) and saline (Fig 1). Surgical incision and skin flap base were anesthetized with the same solution. In half of the surgeries, sedation was achieved using midazolam, fentanyl and propofol. The main anesthetic for sedation in six procedures was dexmedetomidine at a loading dose of 3 mg/Kg/h over 20 minutes, maintained with 0.5 mg/Kg/h (Almeida et al.). The anesthesist and the principal surgeon were the same in all surgeries (S.I. and A.N.A., retrospectively).

Cortical stimulation was carried out to identify the eloquent areas. Intraoperative stimulation was carried out using a monopolar probe (Grass Stimulator) in 11 patients (Figs 2 and 3), while in one patient a bipolar probe was applied (Micromar). The current for stimulation varied from 3–13 mA, with single pulse of 1 millisecond and frequency of 60 Hz. The safety limit adopted in this study was the adjacent pia mater of the functional cortex with preservation of the intersulcal vessels. The resection type was graded into total, subtotal (>80%), partial (<80%) and biopsy, according to postoperative radiological findings (contrasted CT scan and MRI). The surgeries were accomplished in an oncologic view when applicable, in a bid to achieve both maximum lesion removal and treating the epileptic condition, present in the vast majority of patients.

After surgical procedures, all patients were submitted to a CT scan within 6 hours. An MRI was performed after 3 to 9 months to evaluate the resection extent compared to previous exams.

![Fig 1. Positioning. (A) The surgeon view. See the head fixed by three-pin head holder and the skin exposition. (B) The anesthesiologist view: free airway. Note that is important to expose the face to motor and neuropsychological assessment and the contralateral hand.](image)

![Fig 2. (A) Intraoperative cortical stimulation with electrode monopolar; (B) identification of 2 speech areas in posterior temporal lobe (black dotted narrow and black narrow) and (C) satisfactory exeresis of the lesion preserving the functional cortex.](image)
The postoperative complications were classified into neurological, regional or systemic and median follow up was 6 months.

**RESULTS**

All the patients presented with seizures. Half of these presented with refractory seizures non-responsive to clinical treatment. Just one patient presented speech disturbance in the preoperative neurologic exam (fluent aphasia). No patients had motor deficits in the preoperative clinical evaluation. Headache was the initial symptom in one patient, who presented a cavernous angioma with signs of bleeding. All patients harboring tumorous lesions had Karnofsky scale (KPS) 100.

Most lesions were located in the inferior left frontal lobe (8), followed by the left posterior temporal lobe (2) and inferior parietal lobe (2). We identified the language areas in 11 patients. Patient 1 exhibited 2 areas where stimulation provoked aphasia (Fig 3). We were unable to locate the speech area in patient 5.

Of the identified lesions, 7 were tumorous, 6 of which were low grade tumors. The five benign lesions were cavernous angiomas (3), dermoid cyst (1), and gliosis (1) in a...
patient who underwent craniotomy due to brain contu-
usion and was admitted with refractory epilepsy.

Concerning grade of resection, 8 patients (66%) had
total gross resection whereas 4 patients underwent sub-
total resection. In patient 2 the number of speech distur-
bances decreased postoperatively.

Two out of the six patients submitted to conscious se-
dation using dexmedetomidine presented focal seizures
during surgery. Patient 1 had two focal and one gener-
alized seizure. All of the episodes were transitory and
ceased upon application of cold crystaloids (NaCl 0.9%)
to the cerebral cortex. Patient 1 presented three seizures
during the procedure, one before dural opening and two
during cortical stimulation. The other patients had sei-
zeures during cortical stimulation.

Six patients (50%) underwent sedation with dexme-
tomidine (patients 1, 2, 6, 8, 9, 10) as this was deemed by the
anesthesiologist and patients to be the most comfortable
anesthetic. However, no fits occurred under the other an-
esthetic scheme.

One patient, harboring an oligodendroglioma, had a
postoperative transitory motor deficit that receded by
the second postoperative month, while only 1 patient
developed permanent deficit characterized by hemiple-
gia and expression aphasia. The same patient presented
with meningitis due to cerebrospinal fluid leakage and de-
ceased 4 months later. Control of epilepsy was achieved
in all patients with refractory episodes through the sur-
gical procedure. Subsequent reduction of anti-epileptic
drugs resulted and 1 patient had total withdrawal of drugs
after 6 months (Table).

**DIscussion**

In mapping studies performed by Ojemann et al. on
117 patientsa, 67% had more than one distinct essential
language area and 24% had three or more distinct areas
subserving the language function in the dominant hemi-
sphere peri-Sylvian region. Thus, in lesions that invade
the language centers the surgical procedure to achieve
total gross resection becomes progressively more diffi-
cult. The gold standard for identifying cortical function
remains the direct cortical stimulation at surgery time in
the awake patientb, despite the several techniques such as
functional MRI, magnetoencephalography which have
been described recentlyc. Given intraoperative cortical
stimulation can identify eloquent areas, many authors
routinely adopt this technique to guide brain lesion re-
sections and to maintain integrity of the functional path-
waysd. Vitaz et al. compared the use of local anesthesia
with general anesthesia in patients submitted to resection
of lesions adjacent to eloquent cortex and reported a
higher success rate of stimulation in awake patients (100%
versus 50%) who required a significantly lower stimulation
current (5 mA versus 13 mA, p<0.0001). A recent random-
ized prospective study compared general anesthesia with
awake surgery and found that better tumor cytoreduction
and neurological improvement was seen in the former,
demonstrating that this topic remains controversiald. In
our series, it proved impossible to identify the speech
area in patient 1, although this did not affect the postop-
erative outcome. This can be explained by the fact that
speech area can often be located in different regions and
may be as small as 2.5 cm2. The stimulation current ranged
from 3 mA to 13 mA. Gross total resection was achieved
in 66% of our series, similar to the rate to found by other
authors ranging from 37.5 to 62%e,13,14. Neurological wors-
ening in the immediate postoperative period followed by
recovery within several weeks coincides with other series
reported in the literature (27 to 83%)13,14. This worsening
could be related to edema caused by surgical manipula-
tion, to the effect of traction on eloquent areas or due to
transgression of certain safety margins in mapping. Danks
et al. found a rate of 4% for permanent deficit postop-
eratively, similar to the 8% found in our study.

Surgical procedures performed under local anesthesia
allow evaluation of certain intra-operative cerebral func-
tions, such as the language area, and to avoid the risks
attributed to general anesthesia, besides reducing length
of stay in intensive care unitsd. Danks et al. found some
anesthetic complication in 45% of the procedures, where
pain represented the main cause (10%), with epileptic ep-
isodes occurring in 7.6%. In their series of 122 patients
there was a need to resort to general anesthesia in one
patient. In the present study, the high frequency of sei-
zeures did not represent increased morbidity or length of
hospital stay. The seizures lasted some seconds and were
controlled quickly using cold isotonic solution on the cor-
tex. None of our cases called for general anesthesia.

For a satisfactory procedure we ideally require an
awake, cooperative patient capable of undergoing neu-
rocognitive testsf. Different anesthetic combinations,
including neurolept, propofol with or without opioid in-
fusions, and asleep-awake-asleep techniques, have been
reported for awake craniotomy. In all these techniques,
respiratory depression has been reported as a compli-
cation14,16. There was no respiratory complication in our
series when using propofol, midazolam and fentanyl.
Dexmetomedine provided the best neurological feedback
during lesion is resected and did not produce agitation.
Seizures occurred in two out of six patients who used a
dexmetomedine anesthetic agent. Experimental studies
have demonstrated the proconvulsant effect of dexmeto-
medine17,18, but this has yet to be confirmed in humans.
In the majority of series, surgical resection is recommended to within 0.5 to 2 cm of the functional cortex. However, the technique used by the authors was subpial resection, adjacent to the sulci that delimits the functional cortex. There was no significant increase in post-operative deficits employing this technique. We believe that using motor mapping in awake patients the neurosurgeons can feel safer nearing the functional cortex in this type of resection.

In conclusion, brain mapping by cortical stimulation allows the extent of resection to be optimized thereby minimizing postoperative deficits. Awake surgery is a safe technique that allows the direct physiologic feedback of patients in the operating room. Association with cortical mapping optimizes resections in close contact with eloquent areas, allowing similar results to those achieved for surgical procedures carried out in less critical areas.

REFERENCES