SURGERY FOR CEREBRAL LESIONS IN LANGUAGE AREAS UNDER LOCAL ANAESTHESIA

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REZUMAT
Chirurgia tumorilor în zone funcționale cerebrale s-a ameliorat în ultimii ani grație dezvoltării imagisticii funcționale și a stimulării directe corticale sau a centrelor de asociatii. Țe-ul acestei tehnici este realizarea ablației tumorilor situate în zone elovente (senzitive, motorii sau limbaj), în mod cât mai complet posibil, cu un risc scăzut și acceptabil de deficit neurologic postoperator. În această lucrare prezentăm o serie de 16 paienti operați sub anestezie locală și stimulare electrică directă. O rezeție totală sau subtotală a fost realizată la 12 pacienți (75%). În perioada postoperatorie imediată 8 pacienți (50%) au prezentat o agravare tranzitorie a limbajului. Chirurgia cerebrală cu pacient vigil, cu stimulare electrică directă corticală și subcorticală este sigură și eficace, cu o rată de complicații definitive scăzută.

Cuvinte cheie: chirurgie cu pacient vigil, stimulare electrică directă, gliom, ariile limbajului

ABSTRACT
Surgery of tumours in functional areas of the brain has improved over last years, thanks to the development of preoperative functional imaging and direct electrical stimulation of cortical areas or association pathways. The goal of these techniques is to achieve a removal of tumors located in eloquent areas (sensitive, motor and language), as complete as possible and with a low and acceptable risk of long lasting postoperative neurological deficit.¹⁻⁷ We present a series of 16 patients operated under local anaesthesia and direct electrical stimulation. Total and subtotal resection was realised in 12 patients (75%). In the immediate postoperative period 8 patients (50%) presented transitory neurological aggravation with language disorders. Awake surgery with direct electrical cortical and subcortical stimulation is safe and effective with a low definitive complication rate.

Key Words: awake surgery, direct electrical stimulation, glioma, language areas

MATERIAL AND METHODS

We reviewed a series of 16 patients operated for lesions in language areas, under local anaesthesia, in our department between 2000 and 2007. All patients were submitted to a preoperative cerebral computed tomography (CT) and nuclear magnetic resonance imaging (MRI).

Functional MRI was realised in 13 patients. Positron emission tomography (PET) was realised in three patients.

Preoperative and postoperative orthophonic examination was performed in all patients.

The goal of the paper is to describe our technique and to evaluate the immediate postoperative results in terms of quality of surgical resection and functional results.

There were nine men and seven women. Mean age was 42 years (24 - 60). Symptoms were: partial epileptic seizures in eight patients (with post critic language disorders in five patients), generalised epileptic seizures in seven patients, complex temporal seizures in one patient, language disorders in two patients and numbness in one patient. Thirteen patients were right-handed, two patients left-handed and one ambidextrous.

Technique of awake surgery
Surgical operations performed under local anaesthesia are delicate and need a good surgical and
anaesthesiology team. Our technique is practically the same as used by Duffau or Guyotat after the pioneer works by Ojemann and Berger.\textsuperscript{1,4}

The position of the patient is extremely important. It must be comfortable for the patient, who is partly free of moving limbs (the head is usually fixed), and must give an easy access to the examination team. We usually use lateral decubitus, but supine position with turned head and elevated shoulder can also be used.\textsuperscript{12} (Fig. 1a,b)

\textbf{Figure 1.} Position of the patient (lateral decubitus) without holder (a), with Mayfield holder (b).

The general anaesthesia is induced by a Propofol/Remifentanyl mixture (Propofol 1-2 mg/kg; Remifentanyl 0.02 – 0.05 gamma/min). The anaesthesia is maintained by Diprivan (0.2 – 0.4 mg/kg/min) in a patient without endotracheal tube and without assisted ventilation.

The patient receives oxygen 10 l/min by mask. (Fig. 2 a,b)

Local anaesthesia is performed in the subcutaneous tissue under the incision line, in the mastoidian and supraorbitar region, and in the area of pins fixation of the head holder. We used a head holder (Mayfield) in the last 11 cases. (Fig. 1 a,b)

Infiltration is performed with maximum 70 ml of mixed liquid. The mixture contains: Adrenaline-Xylocaine (Lidocaine) 1% (20ml) + Naropeine (Ropivacaine) 7.5% (40ml) + Distilated water 20ml + Adrenaline 0.25 mg (1 ampoule) – maximum dose 70ml.

\textbf{Figure 2 a, b.} Image of the patient viewed by the electrophysiological team and ortophonist.

This technique was used in our last 10 patients, the first 6 patients received Xylocaine and Marcaine (Bupivacaine).

Dura mater is infiltrated with Xylocaine 1% without Adrenaline - 20ml. The dura was usually opened in the middle, then in cross, and after reflected.

The general sedation is administered during opening and closure times, and is interrupted about 20 minutes before cartography.

For our team the identification of functional areas, prior to the resection is mandatory. Therefore the craniotomy should be large and expose the entire temporal lobe and the central cortex.

Cortical electroencephalographic monitoring was used in all patients, with 2 cortical subdural electrodes which were also used for identifying motor and sensitive areas. (Fig 3 a,b)

The stimulation is performed with a bipolar probe (Ojemann), which is more precise than a monopolar one. A biphasic current is used, the frequency of electrical impulses is 60 Hz, during 0.3 -1 ms.
Electrical stimulations are generally started at 1 mA under local anaesthesia covering every 5 millimetres of exposed area. The intensity is progressively elevated by 1 mA till a response is obtained, not exceeding 8 mA under local anaesthesia. Usually the stimulation lasts one second to obtain motor or sensitive response and 3-4 seconds to obtain response during the investigation of cognitive functions.

The primary motor and sensitive area are usually identified first, looking for movements of the face, superior limb, or seldom inferior limb.

Language evaluation is performed with paradigms that the patient has been trained to practice one or two days before the operation. These tests must be easy, and realised at an interval of 4 seconds each. The base test is the denomination test (D0 80) consisting in denoming the objects projected on the screen of a PC, at a rate of 1 every 5 seconds. The test consists of 80 black and white pictures selected according to variable such as frequency, familiarity, age of acquisition and level of education.4,6,11-13

For some locations, other tests can be used: generation of verbs, lexical evocation, computation, verbal memory, reading, understanding (posterior parieto-occipital regions). The examiner looks for any hesitation, disartria, anomia, paraphasia.

The patient was asked to perform counting and picture naming, the two tasks often reported during intraoperative functional mapping, to identify the essential cortical language sites known to be inhibited by stimulation.1,3,6,11,13-18

Every cortical area is assessed three times before starting incision and resection, in order to avoid false negative responses. It is not recommended to stimulate two times successively the same cortical site, or two neighbour sites, in order to limit the risk of epileptic seizures.

When an intra operative electrocorticography is performed, the surgeon must wait for the disappearance of any post electrical discharge before stimulating again.

Every identified functional area is labelled with a piece of paper (with a letter or a digit) and will be preserved during the full surgical procedure. (Fig. 3 a,b) Some authors recommend preserving an area of 5-10 mm around each such risky functional area or only around language areas.12,17,19-23 For other authors, this margin would not be necessary, since it would not decrease the risk of a permanent post operative deficit.4 We usually preserved minimum 5 mm around a functional area.

During a second stage the lesion is removed alternating resection and subcortical stimulation, using microsurgical technique under operative microscope.

Cortical stimulation helps to delineate the superficial boundaries of the cortical incision, but must be pursued by a deep stimulation during the tumour resection, in order to avoid any interruption of the sub cortical functional pathways.

For the removal of tumours located in the insular area of the dominant hemisphere, the deep boundary was constituted by the external capsule, in which the arcuate fasciculus runs (eliciting paraphasia on stimulation).11,24

Sometimes, this deep simulation is the only method to obtain a functional cartography, where the cortical areas could not be identified. The intensity of stimulation for the subcortical stimulation should stay constant, being equal or 2 mA greater than the intensity used for cortical stimulation.

Under local anaesthesia the patient executes language tests or movement tests, being observed by the electrophysiologist and orthophonist. (Fig. 2 a, b) If the patient feels paresthesia or if a diminution of movements in contralateral limbs or language disorders (dysphasia) is observed, resection of the lesion is stopped and a new subcortical stimulation is performed.

The stimulation is performed to check for any involuntary motor response or speech disturbance.
### Table 1. Localisation and lesion details.

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age</th>
<th>Sex</th>
<th>Localisation</th>
<th>Preoperative symptoms and signs</th>
<th>Resection, Functional zones founded peroperatively</th>
<th>Language disorders postoperatively</th>
<th>AP</th>
<th>fMRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37</td>
<td>m</td>
<td>left temporal T2</td>
<td>epilepsy</td>
<td>STR, 4 cort</td>
<td>for 1 week transitory aggravation</td>
<td>Low grade oligodendroglioma gr II</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>2</td>
<td>54</td>
<td>m</td>
<td>left frontal F2</td>
<td>motor aphasia</td>
<td>TR, 3 cort</td>
<td>transitory aggravation</td>
<td>Glioblastoma</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>m</td>
<td>left supramarginal gyrus</td>
<td>partial seizures</td>
<td>STR, 4 cort</td>
<td>2 days transitory aggravation</td>
<td>Low grade oligodendroglioma gr II</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>m</td>
<td>left posterior frontal</td>
<td>epilepsy, motor aphasia</td>
<td>STR, 4 cort, 1 deep</td>
<td>no aggravation</td>
<td>High grade oligodendroglioma gr II</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>f</td>
<td>left temporal</td>
<td>complex temporal epileptic seizures</td>
<td>PR, 1 cort, 1 prof</td>
<td>transitory aggravation</td>
<td>Low grade oligodendroglioma gr II</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>f</td>
<td>left insular</td>
<td>partial epileptic seizures</td>
<td>PR, 10 cort, 1 deep</td>
<td>no aggravation</td>
<td>Low grade oligodendroglioma gr II</td>
<td>left lateralisation intralesional activation</td>
</tr>
<tr>
<td>7</td>
<td>52</td>
<td>f</td>
<td>left fronto – opercular</td>
<td>partial epileptic seizures</td>
<td>STR, 4 cort</td>
<td>transitory aggravation D1</td>
<td>High grade oligodendroglioma gr III</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>m</td>
<td>left fronto-insular</td>
<td>partial epileptic seizures</td>
<td>PR, 4 cort</td>
<td>no aggravation</td>
<td>Low grade oligodendroglioma gr II</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>9</td>
<td>42</td>
<td>m</td>
<td>left temporal</td>
<td>generalised temporal seizures</td>
<td>STR, 3 cort</td>
<td>transit aggravation for 14 days</td>
<td>High grade oligodendroglioma gr III</td>
<td>asymmetrical activation with left dominance</td>
</tr>
<tr>
<td>10</td>
<td>46</td>
<td>f</td>
<td>left temporono-insular</td>
<td>partial epileptic seizures</td>
<td>STR, 4 cort</td>
<td>no aggravation</td>
<td>High grade oligodendroglioma gr III</td>
<td>Broca area on right side, left dominance</td>
</tr>
<tr>
<td>11</td>
<td>57</td>
<td>m</td>
<td>left temporal</td>
<td>partial epileptic seizures</td>
<td>TR, 4 cort</td>
<td>no aggravation</td>
<td>Glioblastoma</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>12</td>
<td>60</td>
<td>m</td>
<td>left temporono-insular;</td>
<td>general epileptic seizure</td>
<td>PR, 2 cort, 1 deep</td>
<td>transit aggravation with afemia and hemiplegia</td>
<td>Low grade oligodendroglioma gr II</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>47</td>
<td>f</td>
<td>left temporal</td>
<td>numbness, language disorders</td>
<td>TR, 3 cort</td>
<td>no aggravation</td>
<td>Haematoma</td>
<td>left activation for Broca area, right activation for Wernicke area</td>
</tr>
<tr>
<td>14</td>
<td>34</td>
<td>f</td>
<td>Anterior temporal</td>
<td>temporal crisis</td>
<td>TR, 4 cort</td>
<td>transit aggravation</td>
<td>Low grade oligodendroglioma gr II</td>
<td>left Broca right activation for Wernicke area</td>
</tr>
<tr>
<td>15</td>
<td>24</td>
<td>m</td>
<td>Posterior temporal left</td>
<td>general epileptic seizure</td>
<td>STR, 3 cort</td>
<td>no aggravation</td>
<td>High grade oligodendroglioma gr III</td>
<td>left lateralisation</td>
</tr>
<tr>
<td>16</td>
<td>37</td>
<td>f</td>
<td>Temporo – insular</td>
<td>general epileptic, seizure</td>
<td>STR, 1 cort</td>
<td>no aggravation</td>
<td>High grade oligodendroglioma gr III</td>
<td>right lateralisation</td>
</tr>
</tbody>
</table>

TR= total resection, STR=subtotal resection, PR = partial resection, cort = cortical
If disturbances occur, the resection must be stopped and the same procedure is then performed in the neighbouring structures. If neither occurred, the patient is asked to rest, and a few minutes later resection is resumed under the same conditions.

Brain mapping in the posterior perisylvian region should include assessment of verbal repetition to avoid potential deficits resembling conduction aphasia.\(^{25}\)

At the end of the full procedure, functional areas are again stimulated. In case responses are fully obtained, one may consider that the integrity of the fibers has been preserved, so that a full recovery of any post operative deficit can be reasonably expected.\(^{4,24}\)

Closure is realised in standard fashion – all anatomical planes (water tight suture of dura mater – running fashion, suspension of dura mater, reposition of the bone flap and fixation, subgaleal drainage, suture of galea and of the skin

**EXAMPLES**

**Patient No. 1**

This 37-years-old right-handed man presented an initial generalised epileptic seizure. Preoperative language examination was normal.

The MRI showed a lesion in hyposignal on the T1-weighted sequences, without enhancement after Gadolinium injection, situated in the left temporal lobe. (Fig. 4 a,b) The lesion presented hyper signal on Fluid Attenuation Inversion Recovery (FLAIR) - weighted sequences. (Fig. 5)

![Figure 4. Preoperative coronal (a) and sagittal (b) enhanced T1-weighted sequence showing a left hyposignal temporal lesion (glioma) without enhancement.](image)

![Figure 5. Preoperative FLAIR MRI image showing a left hypersignal temporal lobe lesion.](image)

Functional MRI (fMRI) showed a left lateralisation of language zones, situated in the postero-superior part of the tumoral lesion. Visual tracking also showed a contact between the visual pathways and the deep tumoral zone.

A surgical therapy was decided for the patient.

The patient was operated under local anaesthesia, with cortical and subcortical mapping. Neuronavigation was used during the procedure.

Peroperatively, during stimulation four eloquent sites were found: three in the middle part of T2 gyrus and one in the fronto-opercular area. A partial crisis
started during stimulation and stopped after irrigation with cold saline solution. A subtotal tumour resection was performed using microsurgical technique and neuronavigation (more then 90%). Postoperative control MRI showed no contrast enhancement and a small residue at the deep posterior part of the lesion on the T1 and FLAIR images. (Fig 6 a,b)

A transitory aggravation occurred for one week, with language disorders. Three months later, the patient completely recovered and did well.

Anatomopathological result showed anaplastic oligodendroglioma, grade III (WHO). She was addressed to another department for chemotherapy.

**RESULTS**

11 patients were operated using neuronavigation (using preoperative 3-dimensional MRI) for localisation of tumoral limits and five patients with perioperative echography for localisation of the tumoral lesion.

**Patient No. 16**

This 37-years-old left-handed woman presented 6 months before a generalised epileptic seizure. The preoperative MRI showed a large temporo-insular right lesion. (Fig. 7, 8 a, b) The functional MRI showed right language activation even in the tumoral lesion. (Fig. 9) Medical treatment with antiepileptic drugs was started. She continued to present complex temporal seizures. 5 months after the initial MRI a small deep lesion contrast enhancement was detected on control MRI, without increase in tumoral size. (Fig. 10)

Surgical therapy was decided. Preoperatively, language examination showed no particular problems. She was operated under local anaesthesia, echography and direct electrical stimulation. One eloquent site was found during 3 time cortical electrical stimulation in the fronto- opercular zone. Subtotal resection of the lesion was realised under microscope. Postoperatively MRI showed a small deep right temporal residue on T2 and FLAIR images. (Fig 11 a, b) No postoperative aggravation was detected.

Anatomopathological result showed anaplastic oligodendroglioma grade III (WHO). She was addressed to another department for chemotherapy.
There were nine right-handed, two left-handed (patients No. 9 and 16) and one ambidextrous patient (No. 14) in this series.

Functional MRI (fMRI) was realised for 13 patients showing a left lateralisation of language areas in eight cases. In four cases the fMRI showed a bilateral hemispheric activation and in 1 case right activation.

For three patients, aPET scan examination was performed preoperatively for tumoral metabolism and also language activation.

Events during surgery

Perioperative seizures were observed in 3 cases – 19 % (5-20% of cases in the literature).
One case developed important headaches and became tired and restless, so the operation was stopped earlier.

50 functional cortical sites were identified during surgery (mean 3 per patient) and 4 deep functional sites.

**Quality of resection**

**Functional results**

A transitory aggravation was observed in 8 patients (50%) usually language disorders (dysphasia). Among those, 1 patient with a high grade glioma exhibited a moderate motor deficit when he was discharged.

8 patients (50%) didn't present any postoperative aggravation. Clinical evaluation was realised in the postoperative hospitalisation period.

**Onco logical results**

Total resection was realised in four patients (25%), subtotal in eight patients (50%) and partial resection in four cases (25%).

Total resection was considered if no residual lesion was observed on the postoperative MRI. Subtotal resection was considered in cases with a residual lesion less than 10 cm$^3$ (usually more then 90% resection). Partial resection is considered if more of 10 cm$^3$ of initial lesion was left in place. For low and high grade gliomas evaluation of residual lesion is done preferable on MRI T2 and FLAIR weighted images.

**Anatomopathological results**

Oligodendroglioma low grade (grade II WHO) was present in eight cases, oligodendroglioma high grade (gr III WHO) in five cases, high grade glioma (glioblastoma gr IV WHO) in two cases, while haemorrhagic infarction was present in one case.

Among the low grade gliomas, five presented a transitory aggravation.

One patient (No. 1) developed a postoperative wound infection, treated with craniectomy drainage and antibiotics. A cranioplasty was realised 6 months later.

**DISCUSSION**

The goal of this study was to describe the technique used for awake surgery and to evaluate the immediate functional results after performing a maximal resection according to the functional boundaries, determined with the support of neuro-navigation, echography, and intra operative cortical and sub cortical mapping.

It was the team of Berger and colleagues who honed the regular use of intraoperative cortical and subcortical electrical mapping in glioma surgery.

**Preoperative considerations**

The technical developments in functional mapping methods have allowed improving surgical strategies and postoperative outcome. The use of preoperative noninvasive methods of functional neuroimaging (PET - positron emission tomography scanning, functional MRI, and magnetoencephalography) allows one to estimate the location of cortical eloquent areas in relation to the glioma and permits to determine the best surgical approach and avoiding the damage of normal functional zones. The image-guided surgery allows the neurosurgeon to benefit from individual anatomical data as well as the incorporation of preoperative functional neuroimaging in the neuronavigational system.

Mayer showed that combining frameless computer-guided stereotaxis with cortical stimulation
and repetitive neurologic and language assessments improves the quality of tumour resection near eloquent brain areas.\textsuperscript{28}

The sensitivity of preoperative cortical neurofunctional mapping methods vary from 82-100\% for the identification of sensori-motor sites and 77-100\% for the identification of language areas. However, fMRI does not identify subcortical pathways, and thus cannot substitute the need for an intra operative mapping.\textsuperscript{4,12,29}

A recent fMRI imaging/electrostimulation correlation study demonstrated that in the temporal lobe, an electrostimulation radius of 10 mm must be assumed to achieve a nearly 100\% sensitivity in fMRI imaging, whereas in the frontal lobe, a smaller stimulation radius of 5 mm can be used to achieve 100\% sensitivity. These findings are consistent with reports that essential language sites are more concentrated in the frontal rather than in the temporal lobe.\textsuperscript{3,4}

Functional MRI was realised in 13 patients of our series, allowing us a better preoperative planning. Four patients presented bilateral cortical language activation (one of them was left-handed, and one ambidextrous). The images were not systematically integrated in the neuronavigation system but helped in the strategy of decision of an awake or general anaesthesia surgery. For three patients a preoperatively PET scan was performed.

At the beginning of our experience we didn’t fix the head of the patient in a Mayfield holder (four patients) so we couldn’t integrate the preoperative images during the surgery. Echography in such cases is necessary to identify the lesional limits. The advantage was a little more comfort for the patient but less for the surgeon. 12 procedures were performed with a holder permitting integration of neuronavigation images (in 11 cases) and so a better cortical localisation of tumoral limits.

Some authors suggested incorporating in the intra operative image-guided system data provided by the preoperative diffusion-weighted MRI imaging (DW MR), a recent method capable of tracking the white fibres. The combination of mapping functional cortical neurons by intraoperative cortical stimulation and axonal architecture by diffusion tensor MRI fiber tracking can be used to delineate the pathways between functional regions.

The combined techniques may provide improved preservation of eloquent regions during neurological surgery, and may provide access to direct connectivity information between functional regions of the brain.\textsuperscript{4,7,2,30}

**Perioperative considerations**

As shown by Duffau, identification and preservation of eloquent pathways within the white matter remains problematic. This is more difficult in low-grade glioma, because these tumours are infiltrative along the white mater fibbers. He thus emphasized the importance of doing an intraoperative real-time electrical cortical and subcortical stimulation, before each step of resection, in order to identify and preserve eloquent brain areas.\textsuperscript{1-7}

Perioperative seizures were observed in three cases – 19 \% (5-20\% of cases in the literature). Usually they are stopped by irrigating the cortex with cold physiologic serum.\textsuperscript{2,27,31}

One case developed important headaches and become tired and restless, so the operation was stopped earlier.

50 functional cortical sites were identified during surgery (mean: three per patient) and four deep functional sites.

In our series of patients the craniotomy was large and exposed the entire temporal lobe and the central cortex. Other authors consider it is enough to expose only the cortex above the tumour area (visible on T2 sequence – eventually integrated in the neuronavigation system) and 3 cm around. This technique saves time, but a negative cartography doesn’t exclude permanent postoperative deficits (2,5 \% in Taylor series).\textsuperscript{2,32}

**Results analysis**

Many studies showed the benefit for the survival and quality of life of patients in case of surgical resection of more than 90 \% of the lesion in cases of low grade glioma.\textsuperscript{1-9,12,22,23,33}

However, surgery has a risk of post operative neurological deficit in tumours located in functional areas, and most of the series are retrospective and non randomised.

**Functional results**

Patients operated under direct cortical stimulation for lesions in eloquent areas present a risk of a postoperative aggravation in 13-80\% of cases. The majority recover within the first 3-6 months. In our series, 8 patients presented a postoperative aggravation (50\%), usually with language disorders – paraphasia. These results are according to the literature.

Permanent deficits vary from 0 to 20\% (mean 4\%) in different series, usually secondary to a vascular lesion.\textsuperscript{4,8,9,12,24,32} All of the 7 patients with postoperative aggravation in our series presented a recovery in the 3 months after the surgery.

The improvement of a deficit in comparison with the preoperative status can be observed in 6-10\%. Seizures are controlled in 80\% of cases, during the
post operative period.4,12,17,28 We didn’t find a really improvement of neurological status in the immediate postoperative period.

For Duffau, subcortical stimulation presents two types of limitation: functional and oncological. The functional limitation is that despite systematically verifying the integrity of functional networks at the end of glioma removal, neurological function can worsen in the immediate postoperative period, even in the hands of experienced teams. This could be explained by the fact that secondary eloquent cortico-subcortical areas—those participating in, but not essential to function, were removed during surgery.

Sakurada operated five lesions under awake surgery, in the sub cortex of the perisylvian language zone, via the non-functioning intrasylvian cortex by a transopercular approach, without postoperative language dysfunction.54

Oncological results

Total or subtotal resection is usually realised in 52-80% in the literature.4,5,17 In our series we have 25% of total resections and 50% subtotal results, conform to the literature.

Benzagmout et al showed that, resulting from cerebral plasticity mechanism, it is possible to use the dynamic potential of the brain to remove tumours in Broca’s area while ensuring the preservation of subcortical language connectivity. They present a series of 8 patients with low grade gliomas in Broca area 44 and 45, and no or slight language disturbances.23

Language cortical and subcortical mapping is usually used for surgery of low grade glioma in functional zones. The argument is that a maximal tumour resection ameliorates the natural evolution of such tumours which usually consists of increase in size and undergo anaplastic transformation.4,34 Improving in quality of resection was showed by Reithemer and Duffau, comparing lesions in functional areas operated with or without direct electrical stimulation.4,36

For Brell, in a series of 25 patients total or subtotal resection was achieved in 16 patients (64%); in five cases (20%) resection was partial, and in the remaining (16%) only a biopsy was obtained. Tumors located in the supplementary motor area (SMA) or in the operculum were those which could be more often totally resected. Thirteen patients (52%) experienced immediate neurological worsening.19

The oncological limitation of direct electrical stimulation is the fact that there is no consensus regarding the long-term efficacy of such therapeutic strategy in low grade glioma, and its impact over the long-term survival has still to be clearly demonstrated.4,18,20 The role of surgery in prolonging survival of patients with low grade glioma however, remains controversial.33

Anatomopathological results in our series are heterogeneous. There were two glioblastoma (patient No. 2 and 11) localised in eloquent zones: one fronto-opercular ant the other anterior temporal who was also biopsied in another department before but, the anatomopathological result could precise only the high grade of the lesion. Both lesions were completely resected, one patient presenting a transitory aggravation. One patient (No. 13) presented no cellular tumours at anatomopathological examination. Possibly it was a cerebral cortical venous thrombosis with haemorrhagic transformation mimicking a haemorrhagic tumour. No clinical aggravation was found in the immediate postoperative period.

Although the awake surgery is recommended specially for low grade lesions, series in the literature present also patients with high grade lesions operated with this technique.22,13,37 In the series of Picht there were 20 low grade gliomas and 5 metastasis.38

Bello described a series of 88 patients with 44 low grade tumours and 44 high grade tumours. 62.5% of the patients with a low grade glioma and 71.4% of patients with high grade glioma presented a new language deficit or aggravation of a pre-existing language disorder. In this series all patients with low grade gliomas recovered their deficits at one and three months, but two patients with high grade presented neurological disorders at one month. This study supports the routine use of subcortical stimulation for language tract identification for lesions near language areas or pathways.22

The benefit of the technique was proven in large series of patients.

Taylor et al, in his series of 200 patients, showed that awake craniotomy is a practical and effective standard surgical approach to supratentorial tumours. This technique presents a low complication rate, and provides an excellent alternative to craniotomy performed with the patient in the state of general anaesthesia because it allows the opportunity for brain mapping.32 Also Serletis et al, in another large series of 600 patients, showed that awake craniotomy is safe, practical, and effective during resection of supratentorial lesions of diverse pathological range and location. It allows for intraoperative brain mapping that helps identify and protect functional cortex. It also avoids the complications inherent in the induction of general anaesthesia. Awake craniotomy provides an excellent alternative to surgery of supratentorial brain lesions in patients in whom general anaesthesia presents an important risk.39
In addition to preoperative functional neuro-imaging, intraoperative electrostimulation can be used on awake patients for language, cognitive and motor mapping. The electrostimulation enables us: to study the individual cortical functional organization before any resection; to understand the pathophysiology of areas involved by gliomas; to map the subcortical structures along the resection, allowing a study of the anatomofunctional connectivity; to analyse the mechanisms of on-line short-term plasticity, using repeated IES; to tailor the resection according to individual cortico-subcortical functional boundaries, enabling to optimize the benefit: risk ratio of surgery.2

CONCLUSION

Awake surgery for lesions in functional zones allows an improvement in quality of surgical resection avoiding installation of permanent postoperative deficits. It needs an experimented team – electro physiologist, anaesthesiist, orthophonist and neurosurgeon. This technique is a solution for operating lesions in functional zones which represent a challenge for the neurosurgeons. Surgery under local anaesthesia with direct electrical cortical and subcortical stimulation, remains safe and effective with low complications, however no clear long term benefit can be demonstrated, a randomised study being probably necessary.

REFERENCES