Specificities of Awake Craniotomy and Brain Mapping in Children for Resection of Supratentorial Tumors in the Language Area

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BACKGROUND: **In the pediatric population, awake craniotomy began to be used for the resection of brain tumor located close to eloquent areas. Some specificities must be taken into account to adapt this method to children.**

OBJECTIVE: **The aim of this clinical study is to not only confirm the feasibility of awake craniotomy and language brain mapping in the pediatric population but also identify the specificities and necessary adaptations of the procedure.**

METHODS: **Six children aged 11 to 16 were operated on while awake under local anesthesia with language brain mapping for supratentorial brain lesions (tumor and cavernoma). The preoperative planning comprised functional magnetic resonance imaging (MRI) and neuropsychologic and psychologic assessment. The specific preoperative preparation is clearly explained including hypnosis conditioning and psychiatric evaluation. The success of the procedure was based on the ability to perform the language brain mapping and the tumor removal without putting the patient to sleep. We investigated the pediatric specificities, psychological experience, and neuropsychologic follow-up.**

RESULTS: **The children experienced little anxiety, probably in large part due to the use of hypnosis. We succeeded in doing the cortical-subcortical mapping and removing the tumor without putting the patient to sleep in all cases. The psychological experience was good, and the neuropsychologic follow-up showed a favorable evolution.**

CONCLUSIONS: **Preoperative preparation and hypnosis in children seemed important for performing awake craniotomy and contributing language brain mapping with the best possible psychological experience. The pediatrics specificities are discussed.**

INTRODUCTION

Intraoperative direct stimulation during awake surgery is considered to be the gold standard for identifying eloquent cortical sites (19). It was first described by Penfield for sensory motor function and language functions. The most common technique is based on the work of Berger and Ojemann (3, 19). Duffau reintroduced the technique more recently in France in adults and clearly showed the importance of the method in term of the quality of resection respecting eloquent areas (8-10). We can say that today awake craniotomy with intraoperative direct stimulation is routinely used all over the world to operate in eloquent areas of the brain in adults.

To the best of our knowledge, only small series have been conducted regarding children. The few existing studies often involved young adults and mainly focused on describing the technical side of the surgery. However, this procedure in children raises certain questions concerning ethics, psychologic experience, brain plasticity, cortical language area organization, and intraoperative direct cortical stimulation in maturating brains.

The main purpose of this publication is less to demonstrate the feasibility of surgery while awake in children than to expose, through our clinical experience, the specificities of the adaptation of this method in children with particular attention on the psychologic conditioning and psychologic experience of these patients. We propose using hypnosis to improve the cooperation and experience for the children. We also insist on the neuropsychologic follow-up for each patient. In the discussion we

Key words
- Awake craniotomy
- Children
- Hypnosis
- Language brain mapping
- Neuropsychology
- Supratentorial brain tumor

Abbreviations and Acronyms
MRI: Magnetic resonance imaging

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Citation: World Neurosurg. (2015) 84, 6:1645-1652.
http://dx.doi.org/10.1016/j.wneu.2015.06.073

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

explain the specific points of brain mapping and awake craniotomy in the pediatric population.

MATERIAL AND METHODS

This publication lies on a morally acceptable clinical study, which only involves current normal clinical practice. Furthermore, there are no additional risks for the patient and the benefit in terms of functional outcome, quality of resection, and survival is demonstrated and admitted by all.

Population

Our experience is based on 7 procedures on 6 youth from 11 to 16 years old suffering from brain lesions in eloquent areas, operated on while awake between 2008 and 2015 (Table 1). Patients 2 and 3 were operated on twice while awake. Patient 2 just turned 18 years old for the second surgery, and patient 3 was 15 years old for the second surgery. In all cases the preoperative planning included functional MRI, neuropsychologic examination by a pediatric speech therapist, psychiatric evaluation (by a child psychiatrist), and psychological preparation. All but the fourth and the last of these patients were right-handed. Patient 4 and 6 were actually left-handed, but the neuropsychologic assessment and functional MRI concluded a bilateral representation of the cortical sites involved in language.

Magnetic Resonance Imaging Preoperative Planning

Morphologic and functional MRI were performed for each patient. The functional MRI in our experience contributes to help shorten the duration of the peroperative neuropsychologic evaluation by directly targeting the eloquent areas to be stimulated. However, care must be taken: The functional MRI does not replace the electrical cortical mapping and certainly not the subcortical mapping.

Psychologic Patient Preparation

A child psychiatrist examined each patient before and after surgery.

We used hypnosis conditioning in the last 5 procedures (including the second look of patient 3) for anesthetic induction, peroperative awakening, and during periods without stimulation. The hypnosis conditioning was done by the anesthetic team. The patient had been seen in hypnosis clinics 1–3 weeks before surgery by the same trained team to establish communication. The purpose of this meeting with the hypnotist is intended to collect some themes about pleasant places and pleasant sensations including visual, hearing, kinesthesia, smell, and taste. Above the analgesic effect, the aim of this management is to recreate during the induction and during the awakening a relaxing environment. In our experience this approach allows an induction and an awakening in calm conditions. Hypnosis is also of major interest for the peroperative periods without stimulation, such as periods of tumor resection during which cooperation of the child is not necessary, in creating a spatio-temporal distortion based on the predefined themes identified from the initial encounter. In focusing the attention of the child on pleasing situations, the psychological experience and course of the operation are facilitated. Concerning the analgesic effect, hypnosis is obviously insufficient, so we add intravenous analgesic drugs.

In the last 4 procedures we offered the patient the chance to meet another child who had been operated on by awake craniotomy to explain his psychological experience. Among our patients, there is a 12-year-old girl (patient 4) operated on while awake and cured of a left parietal cavernoma. This young teenager is happy to meet other children who need to undergo awake craniotomy to speak about her psychological experience.

We show the patient pictures and a video describing the atmosphere of the operating room.

Patient 5 visited the operating room and met the surgical and anesthetic team before surgery to get acquainted with the atmosphere.

Neuropsychologic Evaluation

A child language therapist examined the child in each case before, during and 3–6 months after the surgery. The preoperative and postoperative evaluation is based on the Boston Diagnosis Aphasia Examination (12).

The peroperative evaluation is based on the "object denomination task" described in Ojemann's work on adults and children, corresponding to a black line drawing of an object together with the carrier phrase "this is …" on a white slide (19, 20). We use a

Table 1. Pediatric Population Operated on by Awake Craniotomy

Patient	Age	Sex F/M	Handedness	Neurologic Presentation	Tumor Location	Hypnosis Preparation	Pathology
1	15	F	Right	Seizure	Left precentral sulcus	No	Grade 1 ganglioglioma
2	16	M	Right	Seizure, right facial palsy	Left parietal opercula	No	Grade 1 ganglioglioma
3	14	M	Right	Seizure	Left frontopolar area	Yes	Grade 3 ependymoma
4	12	F	Left	Seizure, motor palsy, dysarthria	Left parietal postcentral sulcus	Yes	Cavernoma
5	11	F	Right	Motor weakness, language disturbance	Left temporal, parietal, and occipital lobes	Yes	Grade 3 ependymoma
6	14	M	Left	Seizure	Left temporal lobe	Yes	Cavernoma

F, female; M, male.