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Case Report

Awake Brain Surgery in Children: Case Report and Review of Literature

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Abstract

Awake craniotomy is today a common and effective practice worldwide and in Algeria, however it remains a rare surgical procedure in children due to age and psychological aspects that hinder with its feasibility and limits its application. Despite extensive literature in the adult population awake brain surgery remains poorly reported in the pediatric population. The aim of this article is to report a case of a 15 years old child who was treated in our department with excellent outcome.

Keywords: Awake brain surgery; Child, Pediatric; Awake craniotomy

Introduction

The purpose of awake brain surgery (ABS) with cortical stimulation is to help identify and preserve eloquent areas during cortical and subcortical' s tumor resections, during surgery for arteriovenous malformations, and for respective epilepsy surgery [1]. The overall outcome in adult population has been extensively studied and reported in several patients' cohorts [2,3]. While ABS became a standard of care in adults, ABS in pediatric patients finds obstacles in an assumed increased psychological fragility in children and age-related cooperation capacity interfering with feasibility and psychological outcome [4,5].

Case Report

A 15-year-old male left-handed patient with a long-standing history of drug-resistant epilepsy was referred to our unit for surgical resection of what was presumed to be a low-grade glioma in the right Rolandic operculum. For the previous 8 months, he had been experiencing 6 -7 seizures per month despite appropriate dosages of valproic acid and carbamazepine. Physical examination did not reveal any neurological disorder; however, he did have a moderate headache. Neuropsychological tests showed good administration of the cognitive functions essential to the control and achievement of motivated behaviors, as well as good planning, judgment and decision-making capacities, self-monitoring, and mental flexibility. There was no deficit of linguistic activities (no aphasia). The episodic system and short-term memory were preserved. MRI imaging revealed an 18 x18.7x18 mm intra-axial cortico-subcortical right parietal nodular formation, oval, with clear limits, T2 hyperintense, T1 iso-intense, with intra-lesional annular enhancement. Spectroscopy showed a choline peak with an increase in the choline/creatine ratio (2.02) and the choline / Naa ratio (2.60) which points to a low-grade glial tumor (Figures 1,2,3).

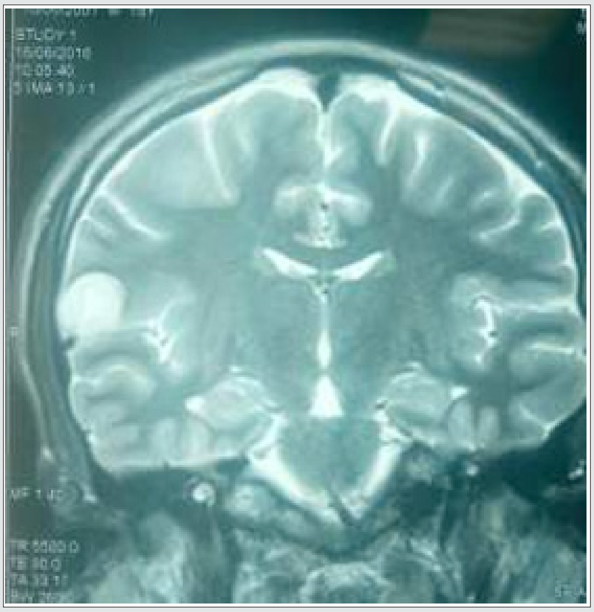

Figure 1: coronal T2 MRI demonstrating right parietal tumor.

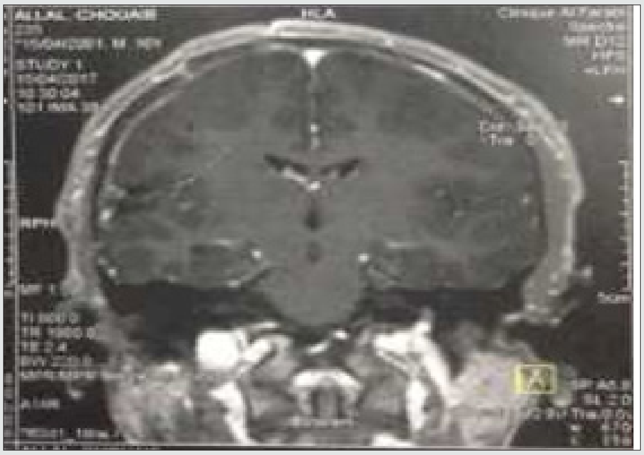

Figure 2: coronal T1 MRI demonstrating right parietal tumor.

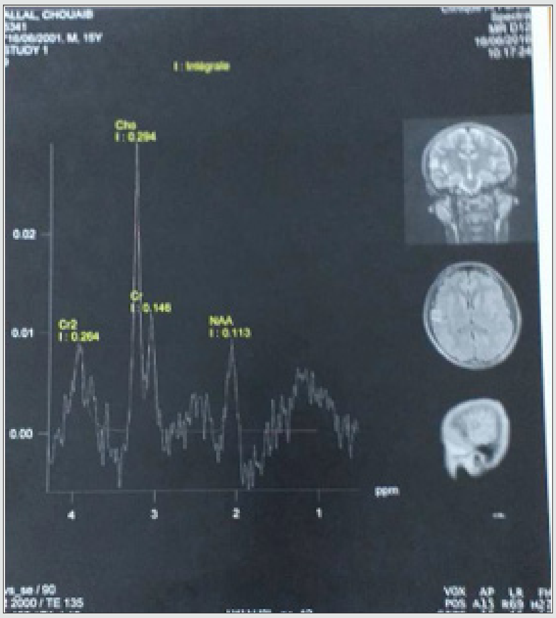

Figure 3: MRI spectroscopic profile of a low grade glial tumor.

A preoperative multi-session conditioning with the neuropsychologist had been followed for 3 months. The patient was dressed in theatre attire and brought into the theatre on a theatre trolley. He was then transferred onto the theatre bed and positioned in the same manner as he would be for the actual surgery. His head was placed on a horseshoe headrest, but not pinned. A blood pressure cuff, pulse oximeter, nasal cannula with oxygen flow, and calf pumps were applied. He was then draped precisely as he would have been for the procedure. Theatre lighting was set as it would be for the surgical case. The speech therapist spoke with him through the procedure, enquiring repeatedly on what would make him feel more comfortable and less stressed. The surgical team explained to him the steps that he would be put through on the day of surgery.

Anesthetic Technique

An asleep-awake-asleep technique was planned and employed. Anesthesia was induced and maintained with total intravenous anesthesia (TIVA) using a propofol target control anesthesia model (Paedfusor). A laryngeal mask airway (LMA) was placed, and the patient breathed spontaneously with pressure support provided from the ventilator. The choice of an LMA over an endo-tracheal tube was in order to avoid any injury occurring to the patient due to coughing on extubation while he was in head pins, and an LMA was easy to put back at the end of the awake phase. Standard monitoring was used. With close communication from the surgeon, the propofol infusions were discontinued for the awake part of the craniotomy. At the time of discontinuation of the infusions, in preparation for the wake up, propofol dose was at an estimated plasma site concentration of 4.2mcg/ml (dose titrated to clinical effect, entropy, and the neurophysiological monitoring). The patient opened his eyes, and the LMA was removed 14 minutes after stopping propofol.

After an initial period of some disorientation, he was able to respond properly to questions. At the end of the awake period, which lasted a total of 83 minutes, the propofol infusions have been started again, the patient was anesthetized, and the LMA was reinserted to maintain airway patency.

Surgical Technique

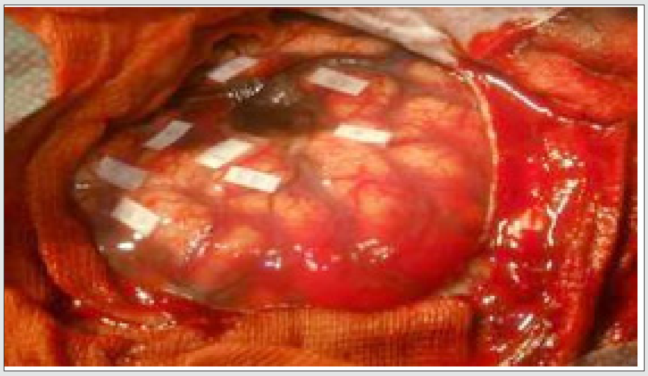

Figure 4: positive and negative motor and speech mapping.

An asleep-awake-asleep technique was employed. The patient was positioned in a left lateral position. The head was placed in a left lateral position on a Mayfield head holder. A right fronto-temporal arciform incision of the scalp was done. the bone flap was turned, and the dura was infiltrated with local anesthetic (2% xylocaine). At this point, the patient was woken up and the LMA was removed. When the child was able to communicate with the linguist and was calm and cooperative, the dura was opened. Intraoperative ultrasound neuronavigational was used to identify tumor boundaries. It was located under the Sylvian fissure. A bipolar electrode, delivering a biphasic current, was applied, and positive and negative motor and speech mapping was performed (Figure 4). The tumor was in the functional areas of language and facial motricity. For sites involved in language function, spontaneous speech was assessed by the speech therapist. After gross total tumor resection, the child was anesthetized, and the LMA was reinserted. The post-operative evolution was favorable both clinically and radiologically. The child was seen four weeks postoperatively. A follow-up MRI scans revealed gross total removal. Histology confirmed allow grade glioma. The patient had no further seizures, and no postoperative deficits. He reported having no pain or anxiety during the procedure. He had no significant negative emotions related to the surgery.

Discussion

The principle of awake brain surgery (ABS) evolved since the first maps of the sensory and motor cortices of the brain have been developed by Wilder Penfield [6]. It became a surgical approach that helps to identify and preserve eloquent areas during cortical and subcortical tumor resections, during surgery for arteriovenous malformations, and for respective epilepsy surgery. Awake surgery with direct cortical stimulation is the gold standard for identifying eloquent cortical sites in the adult population [7,8]. Only a few small series, however, have been published regarding this treatment modality in children [9,10]. The purpose of ABS with electro cortical mapping is to minimize neurological morbidity while performing the best possible cyto-reduction within eloquent areas [11-13]. The use of awake protocols in pediatric brain surgery remains limited due to assumed increased psychological fragility and vulnerability. Moreover, the pediatric population presents specific challenges related to cooperation, full understanding, and managing concomitant anxiety [14]. With decreasing age, the child's ability to cooperate, understand, and manage the stressful surgical environment of an awake craniotomy becomes more and more relevant [15,16]. Some authors [17] consider 11 to12 years of age being the absolute minimum, whereas other authors have successfully applied this technique in children as young as 8years of age [18,19].

In 1954, Pasquet noted that "uncooperative adults and children under 10 years" will not tolerate the application of local anesthesia, scalp incision, and craniotomy [20]. Contrarily, Klimek et al. demonstrated in their case report that an awake craniotomy is feasible and can be performed safely even in very young patients, and it seems unacceptable to maintain an age restriction [21]. Several studies confirmed that the extent and the quality of preoperative psychological preparation and intra-operative support have a relevant impact on the psychological experience. Furthermore, they correlate with neuropsychological outcome [22,6,23]. Thus, attempts should be made to establish eligibility criteria for the pediatric age group and to increase the overall psychological support by qualified psychologists. According to Girvin [24], "the psychological preparedness of the patient is the most important consideration" for a successful awake craniotomy. Despite this degree of preparation, at least 10–15% of adult patients still report severe anxiety during the procedure [25]. The preparation of a child for awake surgery is more difficult, firstly to ensure that the child will be cooperative and safe during the awake part of the surgery and also to minimize the anxiety and posttraumatic stress-like symptoms following an awake craniotomy [26]. Riquin et al. [18] describe a very simple preparation phase including having the child examined by a child psychiatrist, hypnotic conditioning of the child, offering the child an opportunity to meet another child who has been operated on while awake, showing the patient pictures and a video describing the atmosphere of the operating room, a visit to the operating room, and a chance to meet the surgical and anesthetic team. Using mental diversion techniques (virtual reality glasses) can be very helpful before and during the surgery.

Laura-Nanna Lohkamp an Al. [2] have established some preoperative recommendations for a successful ABS in child, but precise protocols on psychological/neuropsychological eligibility criteria that represent an important tool in the complex multidisciplinary preparation of children for ABS remain unsettled. The accuracy of intraoperative ultrasound (IoUS) was initially tested in laboratory setting and lately confirmed in surgical theatres. Lindseth et al. described an accuracy of 1.40±0.45 mm (arithmetic mean) for ultrasound-based neuron avigation system, and highlighted that improper probe calibration was the major contributor to these accuracy errors. Of note, by simultaneously recording Doppler and B-mode images, this accuracy can be further improved; Morin et al. quantified this increase in over 10%, with a 67% correction of brain-shift. Similarly, by adopting Doppler IoUS images acquired on the surface of the dura to correct brain-shift and other sources of registration in accuracies, Chen et al. found that target registration errors (TRE) were less than 2.5 mm in more than 90%of cases. These figures were confirmed in clinical scenarios were the TREs was on average inferior to the 3 mm of standard neuronavigational based on preoperative MRI scans alone [27].

Conclusion

Awake brain surgery is beneficial to an efficient tumor resection with simultaneous preservation of neurological functions. It requires, however, a serious psychological preparation of the child. Neuropsychological testing before and after surgery is essential to determine cognitive outcome, which can be altered in a minority of patients.

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