Clinical Applications of Direct cortical Stimulation During Awake Craniotomies. Commentary on Passive Functional Mapping Using Infrared Thermography in Epilepsy Awake Surgery

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Abstract

As clinicians, we rely on a variety of imaging methods to identify abnormal brain lesions. The myriad of neurological disorders that we can encounter can be distinguished by using imaging alone, imaging along with electrophysiological monitoring, or imaging with electrophysiological monitoring and direct cortical stimulation. This last alternative is the most frequently used approach to diagnose brain lesions that require awake craniotomies for adequate management. Awake craniotomies have become the standard of care for focal lesions including vascular malformations, such as cavernous angiomas, intrinsic brain tumors, such as gliomas, vasculitic brain lesions, postinfectious brain lesions, brain metastasis and epilepsy surgery. Surgery for epileptic patients requires the interaction of a multidisciplinary team along with the use of a variety of surgical adjuncts. Clinical decision-making proceeds along a specific protocol following a rigorously defined technique for awake craniotomies. The utilization of a systematic approach to avoid postoperative complications makes awake craniotomy a reliable, reproducible and precise methodology for the treatment of epilepsy. While direct cortical stimulation remains the mainstay of evaluating for potential postoperative neurological deficits, there is certainly a need for new technologies that can help increase the sensitivity and specificity of abnormal findings, and thus inform management decisions.

Keywords: Awake craniotomy, frameless approaches, stereotactic neurosurgery

1. Introduction

The clinical method to identify an abnormal neurological sign or a pathognomonic symptomatology is of paramount importance during the initial evaluation of all neurological conditions. Brain imaging is required in order to distinguish brain lesions and identify the intracranial location of the lesions. In many regions, encountering multiple brain lesions is not uncommon. In developing countries, where neurocysticercosis is endemic, as high as 15–20% of the population may display abnormal stigmata that can be further elucidated on imaging. During the initial diagnostic approach, multiple brain lesions can be found that correlate with symptomatic presentation.

Vascular lesions include giant brain aneurysm, cavernous angioma, venous angioma and a variety of other vascular lesions. Tumors include intrinsic tumors, such as meningioma, wherein symptoms generally correlate reasonably well with tumor location, or gliomas that can be present in different regions in the brain showing no symptoms or present acutely, sometimes necessitating urgent decompressive craniotomy. The presentation and imaging characteristics of extrinsic tumors, such as brain metastasis, vary depending upon the site of origin and the location of metastatic brain lesions. Metabolic disorders represent several derangements with characteristic imaging signaling on specific MRI sequences that can be difficult to diagnose clinically. Infectious disorders encompass bacterial, viral and

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fungal brain lesions that sometimes require diagnostic imaging series to identify the causative pathogen. The standard of care for abnormal focal lesions should generally consist of an initial imaging procedure followed by stereotactic brain biopsy to define and diagnose the underlying etiology [1,2]. Once the final diagnosis is made, the specific methodology for lesion resection can be addressed [1–3].

Awake craniotomy has become the standard of care when treating brain lesions proximal to or within eloquent areas or for patients suffering from epilepsy [3]. Awake craniotomy requires a thorough planning procedure that must be addressed preoperatively utilizing MRI and metabolic studies such as SPECT, PET and/or Functional MRI (fMRI) to adequately target the underlying lesion [4–6]. Once the planning process has been completed, the surgical plan can be followed. Immediately prior to the surgery, a specific protocol ought to be followed, including an initial electrocorticography to record the baseline characteristics of the treatment site. In some centers evoked potentials can be utilized to identify the motor strip, direct cortical and subcortical stimulation can be done using commercially available stimulators to identify afterdischarges that may herald postoperative complications [1,2,7]. The surgical technique is meticulous due to the necessity of identifying the abnormal areas correlated with the presenting pathology and removing the lesion without causing postoperative deficits. The identification of inactive lesions has been explored utilizing a variety of techniques. In this paper, the authors describe a simple methodology utilizing thermography to identify abnormal regions using surface temperature and the creation of an imaging protocol of the aberrant margins. This case represents an excellent opportunity to make use of the advantages inherent in the awake craniotomy due to the proximity of the speech areas and the motor areas for the face and the right hand. The protocol that has been described in this paper can be considered a surgical adjunct that may improve our level of understanding of the operative region and can be leveraged in the decision making for such complex cases. This approach can also be improved and continuously analyzed to improve surgical utility in the future. In this paper, the authors describe a hyperemic response at the center of the lesion. From the surgical standpoint, increased temperature is not simply a tissue specific response; the surgical arena is dynamic, with the use of surgical lights, normal saline irrigation to adequately clean the surgical field, and iced water to halt epileptic responses. A normal physiological response to direct cortical stimulation may also lead to increased temperature of the stimulated region and within the lesion itself. As such, the methodology described in this report is able to distinguish between these various responses due to the relative temporality of the thermographic procedure.

1.1. Avoidance of postoperative deficits

Instrumentation during awake craniotomies for lesion removal is critical in avoiding postoperative complications. Multiple classifications exist in trying to define the possibility of an increased neurological deficit that may present after complete lesion removal [8]. Multiple studies over have addressed the importance of critical structures in the surrounding region that may show minimal signs but can lead to neurological deficits after resection. In some lesions, multiple regions may be involved with concomitant involvement of subcortical structures. Some centers have been able to use subcortical stimulation to define the extent and proximity of multiple tracts. In the last decade, neurosurgeons have had tremendous opportunity to import functional MRI into the complex schema of awake cranial surgery [4–6]. There are a myriad of publication on the utilization of this technology to better define the proximity of tracts relative to lesions. During the direct cortical stimulation, multiple methods are already in use trying to better define sensory, motor and speech areas. Potentially the most complex decision making arises when handling the speech process. While functional MRI (fMRI) may replace some of the techniques already described, direct cortical stimulation remains the standard of care when managing lesions in these regions. It is possible that the continued investigation and implementation of imaging in awake craniotomies will develop into a simple methodology that can track changes in real time and hasten monitoring without requiring the patient to sit fixed for long periods of time. Intraoperative ultrasonography, intraoperative magnetic resonance imaging, and intraoperative brain tomography can be conducted within the span of minutes along to directly monitoring specific areas. New technologies can be simultaneously be applied to monitor abnormal regions, potentially increasing the sensitivity and specificity of any abnormal findings.

1.2. New methodologies

We strongly believe that, at this juncture, the most reliable surgical methodology to define abnormal regions is direct cortical stimulation along with direct subcortical stimulation to rule out postoperative neurological deficits. We congratulate the authors for their courage to include new technologies in the surgical management of complex lesions.

2. Conclusions

The surgical management of abnormal brain lesions is a complex interaction of available resources and surgical adjuncts to better define the margins and the physiological correlation during the process of resection. New technologies are welcome to improve our complex understanding in this critical process.

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Conflict of interest

None.

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