

Awake craniotomy in Intraoperative magnetic resonance suite (IMRIS) setting: Our institutional experience

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ABSTRACT

Neurosurgery of the lesions within or near eloquent areas of the brain is challenging due to the risk of causing permanent neurological deficits during resection. Awake craniotomy allows intraoperative monitoring of the brain functions and guides the neurosurgeon continuously in maximum safe resection of lesions near the eloquent cortex with minimum neurological deficit. Intraoperative magnetic resonance imaging (iMRI) helps the neurosurgeon in improving the safety and efficacy during resection of the lesions. The combination of awake craniotomy and iMRI increases the overall challenges for both neurosurgeons and neuroanesthesiologists and requires close communication between all the teams involved. We present a series of ten cases of awake craniotomy done in the iMRI suite for the resection of gliomas located in close proximity to functionally eloquent areas of the brain.

Key words: Awake craniotomy, Eloquent cortex surgery, Intraoperative magnetic resonance imaging

The goal of neurosurgery in patients with lesions in/ near the eloquent cortex is to achieve maximal lesion resection while minimizing the risk to eloquent areas [1]. Intraoperative magnetic resonance imaging (iMRI) combined with awake craniotomy helps in maximizing the extent of resection as it provides near-real-time imaging guidance in the operating room that helps in further removal of the residual lesion. It has been shown to increase the survival of patients with gliomas and reducing the need for further surgeries [2-5].

CASE REPORT

The patient details are provided in Table 1. Thorough pre-operative assessment was done by neurosurgical, neuroanesthesia, and neuropsychological teams. The cognitive functions that were assessed preoperatively and intraoperatively are mentioned in Table 2. Pre-operative counseling helped to allay patients' fears, build up a rapport with caregivers, and increase patient cooperation intraoperatively.

Pre-operative investigations included a complete blood workup and electrocardiogram (ECG). Chest radiograph and 2D echocardiography were advised, if needed, based on patient history and physical examination. All patients were asked for implanted medical devices and their MRI safety. History was taken regarding contrast allergy, tattoos, previous surgery with placement of metallic implants, and aneurysm clips. Detailed airway assessment was done as airway assessment and management are an important domain of the anesthesiologist [6].

All patients denied a history of claustrophobia and obstructive sleep apnea (OSA).

Anesthetic Management

All patients were kept nil orally as per guidelines and received their prescribed medications on the morning of surgery. The patient monitoring included ECG, pulse oximetry (SpO₂), non-invasive blood pressure, and invasive arterial blood pressure. All monitoring devices were MRI-safe. Care was taken to avoid any direct skin-to-skin or skin-to-electrode contact by the wrapping of monitoring cables and patient fingers with cotton rolls as well as by placing cotton or foam pads between upper limb and body.

The anesthetic plan for awake craniotomy was scalp block supplemented by moderate sedation with the patients breathing spontaneously. Oxygen was provided through a face mask at 6–8 L/min and end-tidal carbon dioxide (E_TCO₂) was monitored through a side stream channel.

The patients were premedicated with intravenous dexmedetomidine and midazolam. Intravenous midazolam helped to alleviate patient anxiety in the operation room and provide moderate sedation while administering the scalp block. Intravenous fentanyl and paracetamol were used as analgesics to minimize pain during the scalp block. Scalp block was performed using a mixture of 2% lignocaine and 0.5% bupivacaine in a technique described by Pinosky *et al.* [7]. The total dose of local anesthetics was calculated to avoid local anesthetic toxicity. Care

was taken while blocking the auriculotemporal nerve to avoid inadvertent facial nerve palsy [8,9].

Airway protection devices were available to tackle any airway emergency. Three-pin head fixation using MRI-safe pins was done after local anesthetic infiltration at the pin site. Care was taken to avoid extreme flexion, extension, and lateral rotation during positioning. The patients were draped, keeping face exposed (Fig. 1). Intravenous infusions of dexmedetomidine and propofol were used if needed until dural opening. The level of sedation was assessed based on commonly used sedation scales. Intravenous mannitol was administered before craniotomy for intraoperative brain relaxation. Response to noxious stimulation of dural opening was blunted by placing cotton pledgets soaked in local anesthetic solution before dural opening.

The relation of the tumor with the eloquent cortex was established and the “safe” margins of the tumor were identified. Resection was then carried out under continuous neuromonitoring and functional testing in which the patients were asked to perform motor and language functions. All patients received intravenous antiepileptics and steroids intraoperatively. Ice-cold saline and an

intravenous bolus of midazolam were kept ready to treat focal or generalized intraoperative seizures.

Resection was stopped in three patients who developed intraoperative worsening of motor functions that did not improve after steroid administration. In all the other patients, the resection was stopped either when the limits of resection were reached (5 mm from eloquent cortex) [10] or complete microscopic resection of the tumor with surgical hemostasis was achieved.

Preparation for Intraoperative MRI Scan

MRI-unsafe equipments were moved out of the five Gauss (G) line. The infusion pumps were placed in an MRI-safe syringe pump holder and long extension tubings were used for intravenous infusions. Sedation was restarted with infusions of dexmedetomidine and propofol and oxygen was provided with a face mask. E_TCO₂ monitoring was continued using long extension tubings attached to a side stream monitor placed outside the 5G line. Delays in E_TCO₂ readings and anesthetic drug delivery were considered due to increased dead space of extension tubings.

Table 1: Patient, tumor location, and neuromonitoring details

Age/Sex	Operation	Preoperative neurological function	Location and neurological function monitored	Histology	Extent of resection	Postoperative neurological function	Operation duration
68/M	Primary	Impaired (4-4+/5)	Right parietal left upper limb, lower limb, face monitored	Glioblastoma multiforme (IV)	Subtotal resection	Worsening of motor function (3/5 proximal, 0/5 distal)	5 h 30 min
63/F	Primary	Normal	Left temporoparietal speech monitored	Oligodendroglioma (III)	Gross total resection	No change	5 h 30 min
41/M	Recurrent	Normal	Right frontal left upper and lower limbs monitored	Oligodendroglioma (III)	Gross total resection	No change	3 h 50 min
50/M	Recurrent	Normal	Right frontoparietal left upper and lower limbs monitored	Astrocytoma (II)	Gross total resection	No change	5 h 10 min
49/M	Primary	Normal	Left frontotemporal speech and right upper and lower limbs monitored	Oligodendroglioma (III)	Gross total resection	No change	5 h 20 min
43/M	Recurrent	Normal	Right frontal left upper and lower limbs monitored	Astrocytoma (II)	Gross total resection	Transient weakness of left upper and lower limbs	5 h 10 min
51/F	Primary	Normal	Right frontal left upper and lower limbs monitored	Oligodendroglioma (III)	Gross total resection	No change	5 h
28/M	Recurrent	Normal	Right frontal left upper and lower limbs monitored	Oligoastrocytoma (III)	Subtotal resection	Worsening (upper limb 0/5, lower limb 2/5)	4 h 20 min
41/M	Primary	Normal	Left frontoparietal right upper and lower limbs monitored	Oligodendroglioma (II)	Gross total resection	No change	3 h 55 min
41/M	Primary	Impaired	Left frontotemporal speech and right upper and lower limbs monitored	Oligodendroglioma (II)	Subtotal resection	Worsening (0–1/5)	4 h 10 min

Table 2: Cognitive functions assessed during awake craniotomy

Cognitive function to be assessed	Tests used or activities performed
Language	Counting (serial, forward, backward), spontaneous speech Object, picture naming Naming days of week and months of year Word and sentence comprehension Repetition (words, sentences)
Motor/sensory	Voluntary rhythmic movements (touching tip of thumb with other fingers) Simple repetitive movements of the contralateral upper limb Finger tapping Opening and closing of hand Regular movement of foot Grasping objects Strength of hand grip Eye movements
Memory	Worldspan Recognition of pictures with a distraction task Recalling object pictures, names, or words (with or without distraction items)

**Figure 1: Positioning of a patient for awake craniotomy**

Emergency intubation and medication trolleys were kept outside the 5G line. Earplugs were placed in the patients' ears for noise protection during scanning. MRI safety checklist was performed and patients were covered with plastic drapes keeping the face exposed by cutting the drape to prevent claustrophobia. The patients' vital parameters were continuously monitored during the scanning process. The total time taken for preparation and MRI scanning ranged from 1–1.5 h in addition to surgical time. The total operating time ranged from 4 to 6 h. All the patients remained comfortable and cooperated well throughout the surgery.

DISCUSSION

Intraoperative MRI has proved to be a useful adjunct in enhancing the safety and efficacy of tumor resections. It overcomes the

intraoperative “brain shift” to give an accurate, near real-time imaging of the lesion. This is an advantage over neuronavigation devices that are prone to some errors as a result of brain shift. The integration of iMRI with navigation systems could further enhance the safety profile during tumor resection.

Mapping and monitoring of eloquent areas of the brain responsible for speech would require the patient to be awake, cooperative and be able to perform specific tasks that would test the various aspects of speech, enabling early detection of worsening of function and limit resection. An awake craniotomy procedure in the iMRI suite poses challenges for the anesthesiologist with regards to anesthetic management and patient positioning. Sedation and analgesia during awake craniotomy need to be carefully titrated according to the intensity of the surgical stimulus to minimize complications of over-sedation and under-sedation.

Challenges and Complications of Intraoperative MRI

Accessibility to the patient is easier in low- and medium-field fixed iMRI scanners as compared to the mobile high-field scanners. MRI-unsafe patient monitoring devices need to be removed from the patients, thereby limiting patient monitoring. The electrical noise during MRI scanning distorts the ST segment and P wave on the ECG monitor resembling atrial fibrillation, ventricular fibrillation, or ECG artifacts. The long length of E_TCO_2 tubings can lead to inaccurate estimation of CO_2 levels resulting in delayed detection of respiratory depression. The iMRI system requires a long length of ventilatory and intravenous infusion tubings, making them prone to disconnection or kinking. Direct visualization of chest movements is difficult when the patients are in the scanner, making vigilant cardiorespiratory monitoring most essential during iMRI to prevent monitoring errors. Patients undergoing iMRI are prone to develop hypothermia as the optimization of the magnetic field requires low temperatures. Burns can occur as a result of MRI scanning if the patient's skin is in direct contact with monitor cables, MRI table, or if the electrodes are looped. Meticulous attention to patient padding, surgical positioning, and prevention of loop formation of electrodes can avoid this potentially disastrous complication [11].

The noise produced by the MRI scanner can have an adverse effect on the hearing of the patient and health-care personnel present in the operating room. They need to be protected using earplugs.

Challenges of Awake Craniotomy in iMRI Setting

Morbidly obese patients or those suffering from claustrophobia and OSA are contraindications for awake craniotomy in iMRI setting. The sterile drapes used for iMRI are non-breathable and care should be taken to prevent claustrophobia, hypoventilation, and hypoxia by providing supplementary oxygen in spontaneously breathing patients. Early termination of the scanning due to patient discomfort has been reported by Goebel *et al.* [12] and Kamata *et al.* [13], although without any long-term neuropsychological sequelae. Intraoperative seizures need to be controlled in awake

craniotomy patients to prevent physical damage to the patient such as tongue bite, aspiration, and scalp injuries when fixed on headpins. Uncontrolled seizures will necessitate emergency airway management in spontaneously breathing patients. Maldaun *et al.* [14] reported the incidence of seizures in three of 42 patients during scanning requiring emergency endotracheal intubation. Restlessness or agitation of patients may occur if surgery is prolonged, making their cooperation difficult. Kamata *et al.* [13] analyzed 365 cases undergoing awake craniotomy in iMRI setting, of which 356 patients had an unsecured airway. They observed critical adverse events in 21 patients with emergency discontinuation of MRI in four patients, of which two required invasive airway management.

We had no such reported complications in our cases except intraoperative discomfort and fatigue for which patient reassurance, supplemental analgesia, and sedation post-functional mapping was administered to prevent brain swelling intraoperatively.

CONCLUSION

An awake craniotomy can be safely and effectively performed in the iMRI environment. Proper patient selection, knowledge, and application of sedation protocols along with awareness of potential emergencies in this setup are the key to the successful management of these cases. Communication between all teams involved is essential for good outcomes.

REFERENCES

- White T, Zavarella S, Jarchin L, Nardi D, Schaffer S, Schulder M. Combined brain mapping and compact intraoperative MRI for brain tumor resection. *Stereotact Funct Neurosurg* 2018;96:172-81.
- Gandhe RU, Bhave CP. Intraoperative magnetic resonance imaging for neurosurgery-an anaesthesiologist's challenge. *Indian J Anaesth* 2018;62:411-7.
- Abraham P, Sarkar R, Brandel MG, Wali AR, Rennert RC, Lopez Ramos C, *et al.* Cost-effectiveness of intraoperative MRI for treatment of high-grade gliomas. *Radiology* 2019;291:689-97.
- Eljamel MS, Mahboob SO. The effectiveness and cost-effectiveness of intraoperative imaging in high-grade glioma resection; a comparative review of ALA, fluorescein, ultrasound and MRI. *Photodiagnosis Photodyn Ther* 2016;16:35-43.
- Hall WA, Kowalik K, Liu H, Truwit CL, Kucharczyk J. Costs and benefits of intraoperative MR-guided brain tumor resection. *Acta Neurochir Suppl* 2002;85:137-42.
- Gandhe RU, Bhave CP, Kakde AS, Sathe KA. Unanticipated difficulty in an anticipated difficult airway in the neurointervention suite: A Case Report. *J Neuroanaesthesiol Crit Care* 2018;5:190-2.
- Pinosky ML, Fishman RL, Reeves ST, Harvey SC, Patel S, Palesch Y, *et al.* The effect of bupivacaine skull block on the hemodynamic response to craniotomy. *Anesth Analg* 1996;83:1256-61.
- Gandhe RU, Bhave CP, Kakde AS, Gedam NT. Transient facial nerve palsy after scalp block for awake craniotomy: A case report. *Indian J Case Rep* 2018;4:369-71.
- Bebawy JF, Bilotta F, Koht A. A modified technique for auriculotemporal nerve blockade when performing selective scalp nerve block for craniotomy. *J Neurosurg Anesthesiol* 2014;26:271-2.
- Ghinda D, Zhang N, Lu J, Yao CJ, Yuan S, Wu JS. Contribution of combined intraoperative electrophysiological investigation with 3-T intraoperative MRI for awake cerebral glioma surgery: Comprehensive review of the clinical implications and radiological outcomes. *Neurosurg Focus* 2016;40:E14.
- Manohar N, Palan A, Deora H, Boyina RJ, Balasubramaniam A, Kambaduru P. Thermal injuries during intraoperative magnetic resonance imaging: Mechanisms and prevention. *J Neuroanesthesiol Crit Care* 2019;2019:1-3.
- Goebel S, Nabavi A, Schubert S, Mehdorn HM. Patient perception of combined awake brain tumor surgery and intraoperative 1.5-T magnetic resonance imaging: The Kiel experience. *Neurosurgery* 2010;67:594-600.
- Kamata K, Maruyama T, Iseki H, Nomura M, Muragaki Y, Ozaki M. The impact of intraoperative magnetic resonance imaging on patient safety management during awake craniotomy. *J Neurosurg Anesthesiol* 2019;31:62-9.
- Maldaun MV, Khawja SN, Levine NB, Rao G, Lang FF, Weinberg JS, *et al.* Awake craniotomy for gliomas in a high-field intraoperative magnetic resonance imaging suite: Analysis of 42 cases. *J Neurosurg* 2014;121:810-7.

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