

Anaesthesia for awake craniotomy

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Abstract

Awake craniotomy is a neurosurgical procedure during which the patient remains awake as a whole or during some part of the surgery. Although not a new procedure, it has regained its importance since last two decades following the advent of newer drugs along with improvised techniques. The role of anesthesiologist during this procedure is of paramount importance. In this review, we discussed the anesthetic management during awake craniotomy and re-emphasized on the avoidance of intraoperative untoward events with appropriate patient selection.

Key words: Awake craniotomy, complications, dexmedetomidine, monitored anesthesia care, propofol

INTRODUCTION

“Awake craniotomy” by definition, means the craniotomy where a patient remains awake during whole or part of the surgery. It is not a recent concept as Horsley more than a century back first undertook awake craniotomies under local anesthesia.^[1] Later, Penfield used it for surgical excision of intractable epilepsy.^[2] In 1959, De Castro and Mundeleer introduced the concept of neuroleptoanalgesia.^[3] Since then different combinations of neuroleptics and opioids have been used for this procedure. Silbergeld *et al.* published the first data on the use of propofol infusion for sedation during awake craniotomy that became very popular.^[4] During last two decades, awake craniotomy has become a frequent procedure even in children. In general, there are two reasons for performing neurosurgery with patient being awake: (a) For procedures that involve intraoperative functional cortical mapping, (b) during intraoperative electrocorticography (ECoG) for localization of epileptic foci; craniotomy under local anesthesia minimizes the

impact of anesthetics on these recordings. In short, the advantages of awake craniotomy may include better preservation of language function and prediction of a seizure-free outcome. It also ensures faster recovery, short hospital stay, low cost of surgery, reduced incidence of oxidative stress, postoperative pain, nausea and vomiting.

CANDIDATES FOR AWAKE CRANIOTOMY

Awake craniotomy may be carried out in patients undergoing following procedures:^[5]

- During epilepsy surgery
- Excision of lesions such as tumors or arteriovenous malformations adjacent to eloquent areas of the cortex in the dominant hemisphere (e.g. Wernicke’s sensory speech area in temporal lobe, Broca’s motor speech area and motor strip in the frontal lobe)
- For stereotactic surgery
- Deep brain stimulation (DBS) surgery for Parkinson’s disease
- Interventional pain procedures such as pallidotomy, thalamotomy
- Neuroendoscopic procedures involving ventriculostomy, endoscopy, excision of small lesions.

PREOPERATIVE EVALUATION

It involves routine assessment and investigations as determined by the patient’s medical condition. It is crucial that the anesthesiologist develops a good

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personal rapport with the patient and gives a detailed explanation of the procedure including potential intraoperative discomforts such as pain during local anesthetic (LA) infiltration, loud noise of the drill during burr-hole, episode of nausea and vomiting. Patient's cooperation is of paramount importance in order to evaluate language, memory and motor skills. Patients who are uncooperative and noncommunicative due to altered sensorium or otherwise are absolute contraindications for this procedure [Table 1].^[5,6] Patients who are with anticipated difficult airway may have problems during the intraoperative period that may subject the anesthesiologist to a very difficult airway scenario. Children are psychologically unfit to undergo this procedure although individual development of the child should be considered.^[7] Similarly, patient with highly vascular lesions which may bleed profusely during the intraoperative period, obese patients with a history of obstructive sleep apnea, and those with chronic cough due to which brain may present with brain bulge should be refrained to undergo a craniotomy in the awake state. Specific clinical evaluation should include an assessment of airway, data on epilepsy (type and frequency, anti-epileptic medications and serum concentrations), history of nausea and vomiting, features of raised intracranial pressure (ICP) in patients with brain tumors, and risk of hemorrhage (antiplatelet medication and type of lesion).^[5]

ANAESTHETIC GOALS

It encompasses: (1) Maintaining patient co-operation by provision of optimal analgesia, sedation, anxiolysis, and comfortable position, and prevention of side effects such as nausea, vomiting, and seizures; (2) achieving homeostasis with safe airway, adequate ventilation, and hemodynamic stability; (3) ensuring minimal

Table 1: Contraindications for awake craniotomy

Absolute	Relative
Uncooperative patient	Low tolerance to pain
Diminished levels of consciousness	Obese patients
Mental retardation	Chronic cough/wheezing
Profound dysphasia/language problem	Uncontrolled seizures
Anticipated difficult intubation	
Highly vascular lesions with significant dural involvement	
Low occipital lobe lesions	
Obstructive sleep apnea	
Children <10 years	
Medical conditions preventing to lie down for many hours	

interference with ECoG recordings during epilepsy surgery.^[7]

PREMEDICATION

There is no general consensus regarding premedication. The decision should be taken based on patient's clinical condition. The goal is to achieve anxiolysis without the oversedation. Benzodiazepines may cause respiratory depression and interference with ECoG recording. However, midazolam remains the most commonly used benzodiazepine because of its short duration of action.^[8] The other alternative is clonidine, a α_2 agonist, which is shown to be efficacious even for controlling hemodynamic responses during various painful stages.^[9] It is administered at a dose of 2-3 $\mu\text{g}/\text{kg}$ orally 1 h before arrival in the operating room. Anticholinergic administration is debatable as the anti-salivation effect may be troublesome for awake patients. Opioid administration and traction of dura or cerebral vessels may induce nausea and vomiting^[6] predisposing the patient to the risk of aspiration and increased ICP. Hence, anti-emetic prophylaxis with either ondansetron or metoclopramide should be given as a precautionary measure.

MONITORING

Standard monitors include electrocardiogram, blood pressure, pulse oximeter, respiratory rate, body temperature, and end-tidal carbon dioxide via nasal prongs/mask which provide supplemental oxygen. Urinary catheter is usually avoided, however, if required (especially in prolonged procedure); it should be inserted after the patient is sedated. Arterial and central venous cannulation under local anesthesia may be carried out whenever the massive blood loss is expected. Bispectral index (BIS)^[10] or spectral entropy^[11] may be used to guide infusion of intravenous sedatives and analgesics.

PATIENT POSITIONING

The main goal of positioning the patient should be to ensure patient comfort, an accessible airway, and to avoid obstruction to the airway during sedation.^[12] The patient for awake craniotomy is normally placed supine with head slightly rotated to the opposite side of the lesion, lateral, or semi-lateral positions. Care must be taken for adequate visibility of the patient to the neuroanesthesiologist during intraoperative functional testing. A closed circuit video monitoring has been described which allows the neurosurgeon and a neurologist to see and hear the patient during the testing. During the stimulation of the posterior speech center the patient is asked for "naming objects" demonstrated. This process is carried out which many a times the neuroanesthesiologist.

INTRAOPERATIVE MANAGEMENT

The patient should be placed on extra-thick foam mattress on operating table with carefully padding of pressure points. Skull pins may be used to minimize head movements after infiltration of LAs at pin sites. Otherwise, patient's head may be placed on padded horse shoe head rest. Whole body should be covered with a forced air warming blanket with adjustment of air temperature according to patient's comfort. The patient should be draped with the objective of providing an open environment at the same time maintaining integrity of the surgical field. The drapes should not obscure patient's face; it reduces risks of claustrophobia, allowing eye-to-eye contact with the anesthesiologist. Placement of a urinary catheter should be ensured before administration of mannitol. In contrast to procedures performed under general anesthesia (GA), the administration of additional crystalloid solution to compensate for the central sympathetic depression or systemic vasodilatation is rarely needed during craniotomy with local anesthesia.

ANAESTHETIC TECHNIQUES

Local anesthesia of scalp

Anesthetic care includes various scalp blocks which may be regional scalp block, ring block, or field block with LA agents. In regional scalp block, six nerve blocks on one or both sides of the scalp are performed, which includes: Auriculo-temporal, zygomatico-temporal supraorbital, supratrochlear, greater occipital and lesser occipital nerves.^[12] For ring block, LA infiltrated circumferentially around the scalp, starting from mid-forehead, levels of superior auricular sulcus and the occiput and repeating it on the opposite side two inches apart to complete the ring. Field block involves LA infiltration along incision lines for the scalp flap.^[13]

The LA must ensure 6-8 h duration of block. The 40-60 ml of anesthetic volume is used for infiltration. Bupivacaine is the most commonly used LA in the literature. However, ropivacaine and levobupivacaine appear to be safer about the toxicity.^[14] The use of adrenaline (5 µg/ml, 1:200,000 dilutions) both minimizes acute rises in plasma concentration and maximizes the duration of block.

Monitored anesthesia care

It is a specific anesthetic protocol that includes careful monitoring and support of vital functions. Here, the anesthesiologist administers sedatives, analgesics, and hypnotics, provides psychological support and manages the clinical problems. There is always a preparedness to convert to GA, if the situation arises. It is the most frequently used technique for the management of

awake craniotomy, especially for minimally invasive procedures such as brain biopsy, DBS surgery, etc., Spontaneous ventilation is maintained throughout the procedure while providing supplemental oxygenation through a nasal prongs or a plastic face mask.

Neuroleptoanalgesia is a traditional technique where a combination of fentanyl and droperidol is administered to achieve sedation and analgesia. However, introduction of propofol favored better clinical management of the patients. Herrick *et al.* proposed patient-controlled sedation with propofol as a valid alternative to neuroleptoanalgesia.^[15] Since that time, neuroleptoanalgesia has become almost obsolete in the field of awake craniotomy. Now-a-days, propofol is widely used because of its easy titrability, and rapid recovery with clear-headedness. Apart from its anti-emetic and anti-convulsant properties, it decreases the cerebral oxygen consumption and reduces ICP. It can be administered using target-controlled infusion (TCI) technique with an effect-site concentration (Ce) between 1 and 2 µg/ml. Moreover, the propofol sedation does not interfere with ECoG recording if the infusion is stopped 15-20 min before recording.^[16] A background infusion of 50-150 µg/kg/min with intermittent bolus of 0.5-1 mg/kg provides excellent sedation, however, analgesia must be provided with supplemental narcotics and scalp infiltration. Some anesthesiologists employ propofol sedation (without opioids) along with local anesthesia of scalp and can still achieve good pain control. Recently, fentanyl has been replaced with low-dose remifentanyl (0.05-0.1 µg/kg/min, Ce 1-3 ng/ml if TCI protocol is used). Remifentanyl has favorable pharmacokinetics with easy titrability and rapid dissipation of the effects. At a low-dose infusion, it does not interfere with ECoG.^[17] However, it is yet to be available in India.

Dexmedetomidine (α_2 agonist) seems to be an attractive alternative or adjunct to the currently used anesthesia techniques. Compared with clonidine, dexmedetomidine has 8 times greater affinity for α_2 receptors and a short half-life. It has sedative, analgesic and anesthesia sparing effects. Moreover, it does not suppress ventilation and has been used as the sole agent for the awake phase of craniotomy. Generally, a loading dose of 1 µg/kg/h over a period of 10 min followed by infusion rate of 0.1-0.7 µg/kg/h is administered for procedural sedation. During cortical mapping an infusion of 0.1-0.2 µg/kg/h is maintained.^[18]

In a recent study, Sokhal *et al.* retrospectively analyzed 54 patients who underwent awake craniotomy over a period of 10 years.^[19] Infusions of either propofol or dexmedetomidine were given to achieve conscious sedation. The incidence of respiratory and hemodynamic complications were found comparable

in the both groups ($P > 0.05$). There was less incidence of intraoperative seizures in patients who received propofol ($P = 0.03$), possibly due to anti-epileptic activity, when compared to dexmedetomidine group.

Asleep-awake-asleep technique

Asleep-awake-asleep (AAA) technique consists of GA before and after brain mapping with or without involvement of an airway device at start and end of the procedure.^[20] It has three phases; the first part is performed under GA and controlled ventilation. Anesthesia is induced with propofol and a short-acting opioid like fentanyl or remifentanyl. Nitrous oxide, volatile anesthetic agent or low-dose infusion of propofol-fentanyl may be used for maintenance of anesthesia. In the second phase, anesthetics are discontinued and spontaneous ventilation is allowed to make the patient awake for functional and electrophysiological testing. In the third phase, GA is induced in the similar fashion as described in the first phase. A variant approach has been described consists of two-phase technique namely "AA technique."^[21] Here, in the second phase the patient remains awake or sedated for the rest of the procedure even after the testing is completed.

Various airway devices are used to achieve controlled ventilation for above techniques. Usually, a laryngeal mask airway^[22] or an endotracheal tube is used. However, AAA technique has also been carried out with the use of cuffed oropharyngeal airway and nasal mask with biphasic positive airway pressure.^[6] Recently, i-gel was used successfully, in seven patients undergoing awake craniotomy by AAA technique, both for securing the airway and positive pressure ventilation.^[23]

Hansen *et al.* evaluated the actual need for sedatives and opioids during awake craniotomy when cranial nerve blocks, presence of a contact person and therapeutic communication is ensured.^[24] They observed sedation was not required for any of those patients except for the treatment of seizures. Hence, they felt psychological support might be more helpful than the pharmacological approach and named the procedure as "awake-awake-awake technique."

Nevertheless, the vast majority of patients feel satisfied with this procedure irrespective of the anesthetic technique followed.^[25] Although 30% patients recall considerable pain and 10-14% experience strong anxiety during the procedure. Hence, benefits and disadvantages of this procedure should be considered, while planning for awake craniotomy keeping patient's interest in mind.

INTRAOPERATIVE COMPLICATIONS

The complications may be anesthesia-related such as airway obstruction, desaturation/hypoxia,

hypertension/hypotension, brain swelling, tachycardia/bradycardia, nausea/vomiting, shivering, LA toxicity, pain, and poor patient co-operation/agitation.^[5,6] The surgical complications may include seizures, aphasia, bleeding, brain swelling, and venous air embolism.^[26] Most seizures, focal or general, self-terminate or are terminated by ice solution (Ringer's lactate) irrigation. Generalized seizures are less frequent and should be treated with benzodiazepine infusions.

INDIAN EXPERIENCE

As per literature, the practice of awake craniotomy in Northern India was started in the early 2000s.^[27] Sinha *et al.* analyzed their experience from Southern India in 42 patients.^[28] All these patients underwent awake craniotomy under conscious sedation using fentanyl and propofol with an accepted rate of complications. Surprisingly, conflicting results on surgical outcome was reported by Gupta *et al.* from Northern India.^[29] They compared prospectively tumor resection under general versus local anesthesia awake surgery considering complete removal of the tumor without inflicting neurological deficits as the end points. The conflicting results were probably due to rigid selection criteria strictly restricted to "lesions of eloquent area" and also, to steep learning curve in carrying out these procedures. There are reports of few cases mentioning improvised monitoring care in the form of BIS or entropy to assess the level of sedation.^[10,11] Recently, Indian media continues to draw attention regarding this technique as more centers with dedicated neurosurgery facility are performing awake craniotomy successfully.

CONCLUSION

The management of awake craniotomy is challenging. The success of this procedure depends on multi-disciplinary team involving neurologists, neurosurgeons, neuroanesthesiologists, neurophysiologists, and competent operating room personnel apart from a co-operative patient. With the advent of newer technologies such as intraoperative magnetic resonance imaging, infrared cameras (detect functionally active areas of the cortex) as well as image-guided surgery, complex operations can be undertaken easily making awake craniotomy an attractive alternative to general anesthesia.

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