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Perioperative management of awake craniotomy: Role of anesthesiologist

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ABSTRACT

Awake craniotomy is performed for resection of lesions located within or close to the eloquent areas of the brain. Both asleep-awake-asleep technique and conscious sedation have been used effectively for awake craniotomies, and the choice of optimal anesthetic regime is mainly as per the preferences of the anesthesiologist and surgical team. Propofol, remifentanil, dexmedetomidine, and scalp nerve block have been used successfully for intraoperative brain mapping. Appropriate patient selection, adequate perioperative psychological support, and proper anesthetic management for patients in every stage of surgery are essential for the safety and success of the surgery.

Key words: Awake craniotomy; Neuroanesthesia; Scalp block; Motor mapping

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INTRODUCTION

Awake craniotomy is a type of neurosurgical procedure in which the patient is deliberately kept awake during the whole surgical process or a portion of the surgery.[1] Sir Victor Horsley is considered the pioneer in awake craniotomy, as he was the first to perform it in 1886 to localize the epileptic focus with cortical electrical stimulation. Currently, it is most commonly used to map and resect the tumor in vitally important brain areas such as the motor and language cortex where imaging is not sufficient.[2] The prime goal of awake craniotomy is to resect the lesion as much as possible without excising the functional brain tissue. Awake craniotomy allows the neurosurgeon to maximize tumor resection along with maximum preservation of neurological function.[3]

The various advantages of awake craniotomy are summarized in Table 1.

Common indications and contraindications are given in Table 2.

ANESTHETIC GOALS

- To maintain patient cooperation by provision of optimal analgesia, sedation, anxiolysis, and a comfortable position and preventing side effects such as nausea, vomiting, and seizures.
- To achieve homeostasis with a safe airway, adequate ventilation, and hemodynamic stability.
- To ensure minimal interference with ECoG recordings during epilepsy surgery.

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Table 1: Advantages of awake craniotomy

Surgical	Anesthetic
• Better preservation of motor and speech function • Shorter hospitalization • Reduced cost of care • Reduced postoperative neurologic deficits	• Avoidance of mechanical ventilation • Avoidance of the adverse impact on immunity associated with general anesthesia • Less nausea, vomiting

Table 2: Indications and contraindications of awake craniotomy

Indications	Contraindications
1. Tumor resection in the vitally important area of the brain (motor cortex, sensory cortex, and language cortex-Broca's and Wernicke's area) 2. Epilepsy surgery 3. Deep brain stimulation surgery 4. Stereotactic brain biopsy	1. Patient refusal (absolute contraindication) 2. Inability to lay still or cooperate 3. Obesity 4. Obstructive sleep apnea 5. Difficult airway 6. Chronic cough 7. Expected massive blood loss 8. Language barrier

PREOPERATIVE ASSESSMENT

The success of an awake craniotomy depends mainly on patient cooperation and surgical team expertise.[4] Hence, appropriate patient selection and preparation are essential. Preoperative visits provide an excellent opportunity to create a rapport with the patient and encourage trust and familiarity. It is known that proper preoperative counseling gives higher patient satisfaction and should be individually tailored to the patient.[5] During the preoperative visit, the anesthesiologist should discuss the procedure with the patient so that he feels comfortable intraoperatively. The discussion should include the rationale for awake craniotomy, the steps of the procedure, the expected degree of pain and discomfort, the tasks required for testing, and the possibility of adverse events. Occasionally, the patient is helped by prior visit to the theater and visualizing the environment and equipment involved. In short, patients should be prepared psychologically in addition to medical optimization. Sometimes evaluation by neuropsychologists is required if the lesion involves speech and language centers, and their baseline responses to picture cards are assessed and recorded.Preoperative assessment also involves a full assessment of the patient's co-morbidities, which should be optimized beforehand to decrease intra-operative failure of the awake technique. It is also important to document the presenting complaints, like seizure type and frequency or the presence of preoperative neurological deficits.

PREMEDICATION

The premedication modality should be individualized and given based on the patient's clinical condition. The aim is to achieve anxiolysis without causing excessive sedation. Benzodiazepines may interfere with electrocorticography recording and are hence are avoided.[6] Anticholinergics are not preferred as the anti-salivation effect may be inconvenient for awake patients.[7] Opioid administration and traction of the dura or cerebral vessels may cause nausea and vomiting. antiemetic prophylaxis with ondansetron should be given.[8]

INTRAOPERATIVE MANAGEMENT

- Theatre preparation
  The plan for anesthesia and surgery should be well communicated to all the members of the theater team. The operating table should be made comfortable for the patient. The operating theater temperature should be optimized for patient comfort. Staff numbers should be minimized intraoperatively to avoid extra noise and patient anxiety. Consideration should also be given to the operating theater layout (Figure 1). The ability to communicate with and access the patient should be maintained at all times.[9] To keep the noise level inside the theater to a minimum, display signs such as "Awake craniotomy in progress" should be placed on theater entrances. Ice-cold saline should be readily available to irrigate the brain in cases of intraoperative seizures.

- Monitoring
  Standard ASA monitors, i.e., electrocardiograms, pulse oximeters, non-invasive blood pressure (BP), and temperature monitors, are used. An invasive arterial line can be used for beat-to-beat BP monitoring and ABG analysis. Large-bore peripheral intravenous access is sufficient. Sometimes, a central venous catheter may be inserted in cases where there is a possibility of major hemodynamic disturbances. Ideally, monitors should be placed on the same side as brain lesions

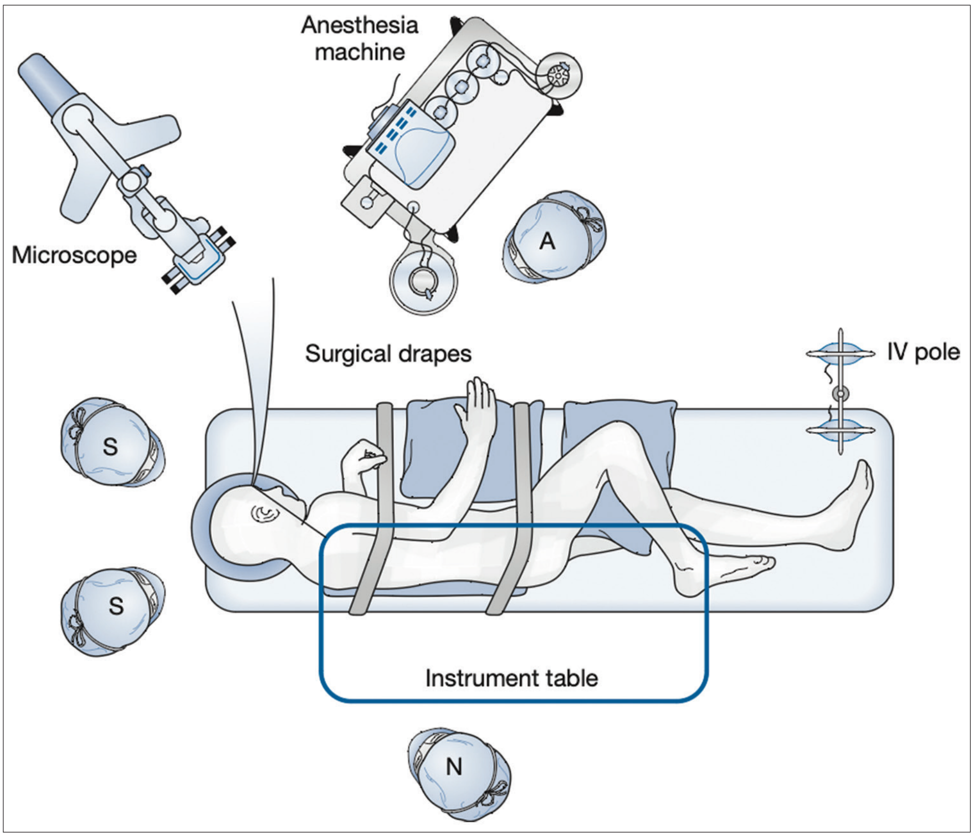

Figure 1: Proposed layout of operation theatre for awake craniotomy. A-anesthesiologist, S-surgeon, N-neurologist

to avoid interfering with contralateral sensorimotor monitoring. A processed EEG monitor (e.g., BIS) may be used to regulate the depth of anesthesia, which facilitates rapid awakening for intraoperative testing.[10] Urinary catheterization can cause discomfort for the patient. When urinary catheterization is not used, the judicious use of fluids must be considered. Carbon dioxide monitoring ($ETCO_2$) is also desirable and can be done by fixing the probe near the nostrils or with integrated probes present in the nasal cannula. The carbon dioxide levels may be used to confirm ventilation.

- Patient positioning
  The patient can be positioned supine, semi-sitting, lateral, or semi-lateral. The main goal of positioning is patient comfort and complete access to the patient throughout the surgery. Proper padding of pressure points should be ensured.

- Anesthesia technique
  For convenience, the awake craniotomy procedure can be divided into 3 phases (Table 3):

1. Opening phase: craniotomy and exposure of the brain,
2. Resection phase: cortical and subcortical mapping and excision of the brain lesion
3. Closing phase: hemostasis and closure of the craniotomy wound.

The patient should be awake and cooperative during stage 2. The rest of the surgery can be done under local anesthesia, sedation, or general anesthesia.

There is no recognized protocol on the best anesthetic regime for awake craniotomies.[3]

The commonly used anesthesia techniques are the asleep-awake-asleep technique, the asleep-awake technique, or the conscious sedation approach.

However, the general principles are common to all, i.e., maximum patient comfort, prevention of nausea and vomiting, which can increase intracranial pressure, hemodynamic stability, and the use of short-acting drugs that allow rapid control of a patient's conscious level.

- Conscious sedation (awake-awake-awake)
  Here, the patient is kept awake throughout. Moderate sedation is given during the initial stimulating portions such as the insertion of Mayfield pins, skin incision, bone flap removal, and dural opening. Sedation is stopped or decreased during cortical mapping and reinstituted for closure. The aim of sedation is

to keep the patient responsive to verbal or tactile stimulation with a patent airway. Excessive sedation may cause airway obstruction, hypotension respiratory depression, and apnea. Airway obstruction can also lead to hypercapnia, and increased intracranial pressure with a "tight" brain. On the other hand, a patient who is not adequately sedated will be uncomfortable and anxious.

Low-dose propofol (50–150 mcg/kg/min) and/or remifentanil (0.01–0.05 mcg/kg/min) infusions titrated to effect can be used for sedation. Benzodiazepines can depress the electrocorticography readings and are hence avoided during awake craniotomies that involve electrocorticography.

Dexmedetomidine has emerged as a suitable sedative agent for awake craniotomy.[11] It is used in a dose of 0.5–1 mcg/kg IV bolus followed by a titrated infusion of 0.3–0.7 mcg/kg/h. The main advantage of dexmedetomidine is that it does not cause respiratory depression. Furthermore, it does not interfere with electrocorticography. However, it can cause hypotension and bradycardia.

- General anesthesia (GA) with intraoperative awakening (asleep-awake-asleep): in the beginning, GA is induced, and the airway is often secured with endotracheal intubation or laryngeal mask airway (LMA).[12] For the stimulating part of the surgery, i.e., skull pinning, craniotomy, and dural opening, the patient is kept under general anesthesia. Once the dura is open, the patient is awakened so that they can cooperate during cortical mapping.

  As soon as the mapping is done, GA is induced again. If an endotracheal tube is used, the patient may cough or be agitated during the transition to the awake phase, resulting in brain swelling and interference with surgery. Whereas LMA produces less stimulation and a smoother transition from one phase to the next, it is preferable to endotracheal intubation. However, LMA may get displaced intraoperatively, requiring emergency intubation.

The advantages of this technique include a secured airway and, hence, the ability to control carbon dioxide concentrations. It is also better to achieve greater depth of anesthesia during the painful parts of the surgery.

Either total intravenous anesthesia using propofol and remifentanil infusion or a rapid-acting inhalation agent like sevoflurane can be used. Dexmedetomidine may be used as an adjunct.

- Scalp block

  Scalp block helps to maintain hemodynamic stability, decreases the stress response to pain, and thus makes the procedure tolerable, particularly during the awake phase.[13] It is performed by infiltrating local anesthetics into seven nerves on either side of the scalp (Figure 2). These nerves include the supraorbital nerve, supratrochlear nerve, zygomaticotemporal nerve, auriculotemporal nerve, lesser occipital nerve, greater occipital nerve, and greater auricular nerve (Table 4). Drugs used included bupivacaine, levobupivacaine, and ropivacaine of varying concentrations with and without epinephrine. This block may be inserted with the patient sedated or after anesthetic induction.

NEUROPSYCHOLOGY/CORTICAL MAPPING/RESECTION

A quiet and calm environment should be maintained for patient awakening. Usually, it is upon emergence that several complications can occur, for example, pain from pins or discomfort from prolonged immobility, agitation or nausea, and vomiting. It is important to tackle these issues quickly and effectively.

The main aim of cortical or brain mapping is to localize the eloquent areas of the brain through direct electrical stimulation of the cerebral cortex by electrodes. These are the areas involved in speech, language, and motor abilities.

Any alteration of speech, language, or motor function should be communicated to the surgeon. Surgeons proceed with resection only after the cortex has been functionally mapped by this process.

Table 3: Phases of awake craniotomy

Opening phase	Resection phase	Closing phase
Awake	Awake	Awake
Asleep	Awake	Asleep
Asleep	Awake	Awake

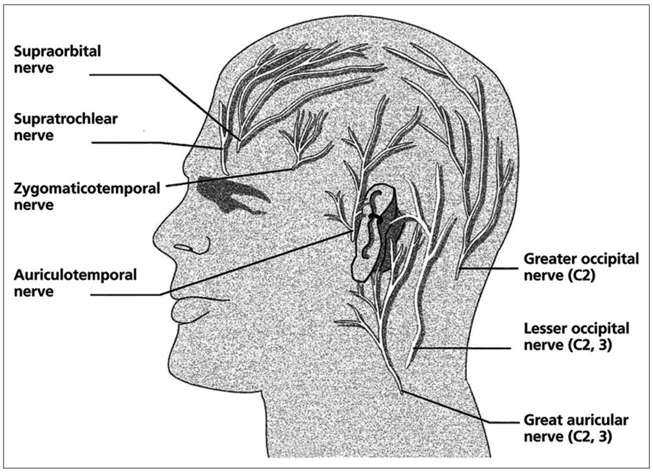

Figure 2: Nerves blocked in scalp block

Table 4: Scalp block technique

Nerve	Block technique
Supraorbital nerve and Supratrochlear nerve	Needle is inserted medial to the supraorbital notch and perpendicular to the skin till it hits bone then 2 mL of LA is injected. From the same puncture point needle is then directed medially, and another 2 mL LA is injected above the eyebrow line to target supratrochlear nerve.
Zygomaticotemporal nerve	Needle is inserted at the lateral edge of the supraorbital margin and LA is infiltrated till the distal side of zygomatic arch. Infiltrate 2 mL of LA superficial and 2 mL deep to temporalis muscle.
Auriculotemporal nerve	Inject 2 mL of LA 1 cm anterior to the tragus at the level of zygoma. Palpate superficial temporal artery to avoid intra-arterial injection.
Greater occipital nerve	Inject 3 mL of LA is injected midway between the occipital protuberance and the mastoid process. Palpate occipital artery and inject LA medial to it.
Lesser occipital nerve	3 mL of LA is infiltrated along superior nuchal line, 2–3 cm lateral from greater occipital nerve injection site.
Great auricular nerve	2 mL of LA is injected about 1.5 cm posterior to the auricle at the level of the tragus.

LA: Local anesthetic

INTRAOPERATIVE COMPLICATIONS

1. Seizures
   It occurs most commonly during stimulation for brain mapping.[14] Most of these are focal, brief, and resolve spontaneously, whereas others are generalized. First-line treatment is stopping the stimulation and irrigation of the brain with sterile iced saline. Propofol bolus (10–20 mg IV) or midazolam (1–2 mg IV) can be administered if iced saline is ineffective.

2. Nausea and vomiting
   Ondansetron, dexamethasone, and propofol are suitable drugs to manage nausea and vomiting.

3. Airway obstruction
   It may happen due to excessive sedation, causing hypoxia and hypercarbia. Nasopharyngeal airways may relieve airway obstruction, but assisted ventilation and intubation with an endotracheal tube or LMA may be needed.
   An emergency plan for airway control has to be in place at all times, and this can be challenging as the patient's head is fixed in head pins.

4. Air embolism
5. Failed awake craniotomy
   Awake craniotomy is considered a failure if conversion to GA is required or if adequate mapping or monitoring could not have been achieved. Failed awake craniotomies occur in about 2% (0–6%) of awake craniotomies and may be minimized by appropriate patient selection.[14]

AREAS FOR FUTURE RESEARCH

More research should be done related to the comparison of GA versus MAC for the pre-mapping phase, the prevention and treatment of emergence delirium, the impact of different modalities of airway management, and the impact of anesthetic agents on brain tumor outcomes.

CONCLUSION

The management of awake craniotomy is unique and requires dedicated teamwork of both neuroanesthetists and neurosurgeons. It can be conducted under either conscious sedation or asleep-awake-asleep technique. The most important aspect is that the patient should be fully awake and cooperative during the testing phase. To conclude, proper patient selection, perioperative psychological support, and appropriate anesthetic management in every stage of surgery are essential to conduct the procedure safely and successfully.

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