

# Anaesthesia Management for Awake Craniotomy

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Published 1 November 2022



## KEY POINTS

- Awake craniotomy is commonly indicated for resection of tumours near or within the eloquent areas of the brain to maximize tumour resection while preserving the vital neurological functions.
- Efficient scalp anaesthesia is the cornerstone for a successful awake craniotomy procedure.
- The use of dexmedetomidine for sedation during awake craniotomy is gaining popularity due to its analgesic and sedative properties with minimal respiratory depression.

## INTRODUCTION

Awake craniotomy (AC) is required for neurosurgical procedures when the patient is needed to be awake and cooperative during certain stage of the procedure. The history of AC dates back to ancient times when trepanation of the skull was used to treat epilepsy or to allow the escape of evil air, as revealed in archaeological findings.<sup>1</sup>

In modern history, Sir Victor Horsley performed the first AC in London in 1886 to excise an epileptic focus after brain stimulation. In the 20th century, Wilder Penfield—who was one of the pioneers in neuroscience—developed a technique of intermittent sedation and analgesia to facilitate intraoperative identification of epileptogenic foci and their excision.<sup>1,2</sup>

This tutorial discusses the rationale for using AC for brain surgery, perioperative management of the patients, theatre preparation, the different anaesthetic techniques, and the adverse events during AC.

## INDICATIONS

Intraoperative electrical stimulation of the brain and cognitive monitoring of the awake person is the “gold standard” for cortical and subcortical mapping of vital neurological functions, such as motor, sensory, speech, and cognitive cortices.<sup>3</sup> AC is mostly indicated for excision of brain tumours near the eloquent areas of the brain to help achieve maximal resection of the tumour without compromising vital neurological functions (Table 1). This can reduce postoperative morbidity and improve the prognosis, which is directly related to the extent of tumour resection.<sup>4</sup>

AC is also used to minimise anaesthesia-induced interference during surgeries requiring intraoperative electrocorticography, such as during excision of epileptic foci, or to confirm the location of implanted electrodes during deep brain stimulation

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### Indications

- Resection of brain tumours near or within the eloquent areas
- Deep brain stimulation
- Epilepsy surgery
- Resection of intracranial vascular lesions supplying functionally important areas of the brain

### Contraindications

- Absolute
  - Confusion or cognitive disorders
  - Preoperative dysphasia and inability to communicate
  - Patients who cannot stay still (eg orthopnoea)
  - Prone positioning
- Relative
  - Morbidly obese patients
  - Patient with poorly controlled seizures
  - Trypanophobia (needle phobia) and patients with low pain threshold
  - Chronic cough
  - Obstructive sleep apnoea
  - Anticipated difficult intubation

**Table 1.** Indications and Contraindications for Awake Craniotomy<sup>3,5,6</sup>

procedures during microelectrode recording and macro-stimulation.<sup>5</sup> Cortical mapping can also be useful during resection of certain intracranial vascular lesions near critical areas or supplying important territories.<sup>6</sup>

## ADVANTAGES

AC has several nonsurgical benefits over craniotomy done under general anaesthesia, especially when patients are selected appropriately. It can be associated with less postoperative nausea and vomiting, shorter hospital stays, and reduced hospital costs.<sup>3</sup> It may allow for enhanced recovery after craniotomy with same-day discharge.<sup>3</sup> Improved patient satisfaction and postoperative pain were also observed in patients who underwent AC.<sup>3,7</sup>

## PREOPERATIVE PATIENT ASSESSMENT AND PREPARATION

The success of AC depends on appropriate patient selection. Apart from patient refusal, most contraindications to AC are relative and summarized in Table 1. The preoperative assessment is the ideal time to establish a good rapport with the patient, to explain the procedure in detail, and to answer patient questions.

Information leaflets and videos help relieve patient anxiety surrounding the procedure and give them an idea about what to expect on the day of surgery. The neurophysiologist and speech/language therapist usually meet the patient before the surgery to provide training on the tasks they have to perform intraoperatively.

Plasma levels of anticonvulsants should be checked before the surgery to ensure therapeutic efficacy. Steroids and antiepileptics should be continued as scheduled, although the morning dose of antiepileptics is usually omitted on the day of AC for epilepsy surgery.<sup>5</sup> Further details about perioperative management for craniotomy can be found in ATOTW 466 (“Anaesthesia for Craniotomy and Brain Tumour Resection”).<sup>8</sup>

## INTRAOPERATIVE MANAGEMENT

### Patient Positioning

Correct patient positioning is crucial during AC to ensure appropriate communication with the patient during cortical mapping.<sup>6</sup> The head and neck of the patient should be kept in a relatively neutral position to enable the patient to vocalize for language testing and swallow secretions comfortably. Extreme neck rotation or flexion can complicate airway management by making intubation or insertion of supraglottic devices more difficult and should be avoided.

### Theatre Preparation

Theatre preparation focuses on keeping the patient comfortable throughout the procedure to reduce the risk of failure of cortical mapping and the need for conversion into general anaesthesia. The operating table should be configured with adequate padding. Forced-air warming device as well as fluid warmers should be used to avoid hypothermia and intraoperative shivering.

During cortical mapping, the forced-air warmer is turned off to enable the patient to communicate clearly without the additional noise. The theatre temperature is turned up so that the patient remains warm during this period.

The use of transparent drapes is recommended, especially for claustrophobic patients.<sup>5</sup> A different theatre layout is usually used during AC. The theatre bed is turned 90 degrees to the anaesthesia machine to allow access to the patient by the neurophysiologist and the anaesthetist.<sup>9</sup> Again, to keep the noise level to minimum, warning signs such as “Awake craniotomy in progress” should be placed on theatre entrances to limit unnecessary staff flow. Additionally, the patient can request to have their mouth moistened for comfort and to prevent coughing whilst their head is secured in pins.

Ice-cold saline should be readily available on the scrub trolley for the surgeon to irrigate the brain in case of intraoperative seizures. Propofol should be readily available in case cold irrigation fails to terminate seizures.

## INTRAOPERATIVE MAGNETIC RESONANCE IMAGING

AC can be conducted in the interventional magnetic resonance imaging suite. Repeated imaging is obtained intraoperatively to determine the extent of tumour resection or the position of implanted devices.<sup>3</sup> Providing anaesthesia in this suite has its own challenges to ensure safety of the patient and staff, such as avoidance of ferromagnetic equipment, use of extralong ventilator tubing and infusion lines, and use of hearing protection devices.<sup>10</sup>

## MONITORING

Besides routine monitors, an arterial line is often needed. Wide-bore intravenous access is essential, and all lines should be inserted on the ipsilateral side of the brain lesion if possible. This is to ensure that testing, such as upper/lower limb movement on the contralateral side can be done with ease. Monitoring depth of anaesthesia, such as with the bispectral index, can be helpful to adjust the level of sedation or anaesthesia and to allow faster patient awakening for cortical mapping.<sup>11</sup> The use of urinary catheters is institution-specific as they can add to patient discomfort. However, if a urinary catheter is not placed, careful intraoperative fluid management must be initiated.

## LOCAL ANAESTHESIA

The pain-sensitive structures during craniotomy are the scalp, the periosteum, and the dura. The pia mater and the small cerebral vasculatures also receive trigeminal nerve supply. The scalp has a rich nerve supply arising from the trigeminal nerve

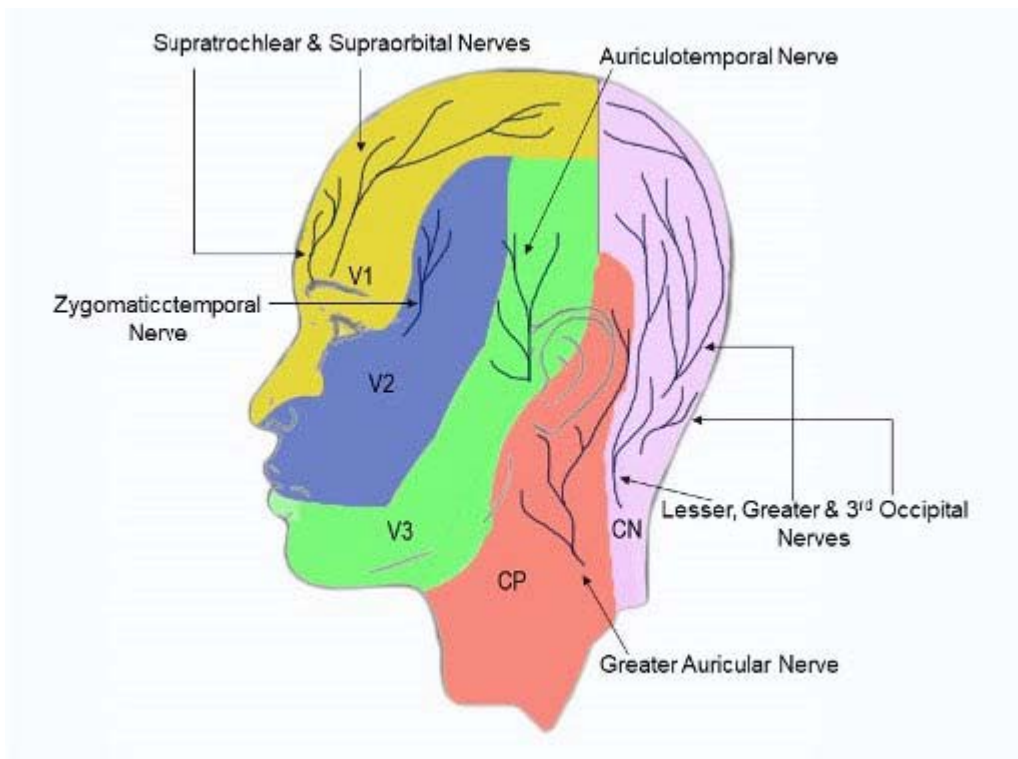


Figure 1. Nerve supply of the scalp. (Source: ATOTW 480: “Scalp Block Techniques and Applications.”)

Technique	Description
Direct nerve block	<ul style="list-style-type: none"> <li>Block of individual nerves supplying the scalp using landmark technique</li> <li>Requires smaller dose of LA</li> <li>May be superior for prolonged surgery</li> <li>Requires training (11 blocks for optimal skills)</li> </ul>
Ring block	<ul style="list-style-type: none"> <li>Circumferential infiltration of LA around the scalp</li> <li>Technically easier than direct scalp block</li> <li>Requires larger dose of LA (40-60 mL) so it can increase the risk for toxicity, especially in patients with low body weight</li> <li>Does not provide anaesthesia deeper to temporalis fascia</li> </ul>
Surgical-site field block	<ul style="list-style-type: none"> <li>Injection of LA around Mayfield frame pins site as well as surgical site</li> <li>LA is injected in the dura using tuberculin test syringe</li> <li>Can supplement inadequate block</li> <li>Has similar analgesic efficacy to scalp block</li> </ul>

**Table 2.** Different Techniques for Providing Local Anaesthesia (LA) of the Scalp<sup>5,6,12</sup>

supplying the anterior two thirds, and cervical spinal nerves (C2 and C3) supplying the posterior one third (Figure 1).<sup>5</sup> Local anaesthesia (LA) of the scalp is the cornerstone for successful awake craniotomy.<sup>3</sup> Patients with an effective scalp block will be comfortable and cooperative with minimal sedation during the surgery.

Different regional techniques have been described to provide LA to the scalp, but data are insufficient to support the superiority of one technique over another. The different techniques for scalp blocks are described in Tables 2 and 3 but combination of technique is common (eg, direct nerve block plus incision site infiltration). Bupivacaine, levobupivacaine, or ropivacaine are the commonly used LAs. Adrenaline in a concentration of 1:200 000 is usually added to LA solution to reduce the vascularity of the scalp and hence systemic LA absorption.<sup>5</sup> Refer to ATOTW 480 on scalp block techniques.

## ANAESTHESIA TECHNIQUES

Awake craniotomy procedure can be divided into 3 stages:

1. craniotomy and exposure of the brain,
2. cortical and subcortical mapping and excision of the brain lesion, and
3. haemostasis and closure of craniotomy wound.

The patient needs to be awake and cooperative during stage 2. The stages before and after can be performed under local anaesthesia, sedation, or general anaesthesia.<sup>13</sup> The commonly used anaesthesia techniques are the asleep–awake–asleep technique, the asleep–awake technique, or the conscious sedation approach.<sup>11</sup>

Scalp Nerve	Block Technique
Supraorbital nerve and Supratrochlear nerve	<ul style="list-style-type: none"> <li>Needle is inserted 1 cm medial to the supraorbital notch and perpendicular to the skin till it contacts bone then 2 mL of LA is injected</li> <li>Needle is then directed 1cm medially, and another 2 mL LA is injected above the eyebrow line to target supratrochlear nerve</li> </ul>
Zygomaticotemporal nerve	<ul style="list-style-type: none"> <li>Needle is inserted at the lateral edge of the supraorbital margin and LA is infiltrated till the distal side of zygomatic arch</li> <li>Infiltrate 2 mL of LA superficial and 2 mL deep to temporalis muscle</li> </ul>
Auriculotemporal nerve	<ul style="list-style-type: none"> <li>Inject 2 mL of LA 1 cm anterior to the tragus of the ear at the level of zygoma</li> <li>Palpate superficial temporal artery to avoid intra-arterial injection</li> </ul>
Greater occipital nerve	<ul style="list-style-type: none"> <li>Inject 3 mL of LA is injected midway between the occipital protuberance and the mastoid process</li> <li>Palpate occipital artery and inject LA medial to it</li> </ul>
Lesser occipital nerve	<ul style="list-style-type: none"> <li>2 mL of LA is infiltrated along superior nuchal line, 2-3 cm lateral from greater occipital nerve injection site</li> </ul>
Great auricular nerve	<ul style="list-style-type: none"> <li>2 mL of LA is injected about 1.5 cm posterior to the auricle at the level of the tragus</li> </ul>

**Table 3.** The Specific Nerves Targeted During Direct Scalp Block. LA indicates local anaesthesia.<sup>5,12</sup>

## ASLEEP-AWAKE-ASLEEP TECHNIQUE

As its name would suggest, the patient initially receives general anaesthesia during the preparatory phase till opening of the dura. The patient is awakened for cortical mapping and neurophysiological monitoring. After completion of lesion resection, the patient is reanaesthetised during the third stage till the end of the surgery.

Total intravenous anaesthesia using target-controlled infusion of propofol and remifentanyl is commonly used during the first stage of the surgery; dosage can be guided by careful titration during induction and use of intraoperative electroencephalogram monitoring. Target-controlled infusion technology is safe and can provide better drug titration to match individual needs with better cardio-respiratory stability.<sup>13</sup>

An alternative technique would be using volatile anaesthetic and remifentanyl infusion. Total intravenous anaesthesia can have several potential advantages such as reduction of nausea and vomiting, smooth emergence, and short awakening times.<sup>3</sup> It can also allow positive-pressure ventilation without the use of a muscle relaxant. Supraglottic airway devices (especially second-generation devices such as the ProSeal laryngeal mask or i-gel) are commonly used to secure the airway as they reduce the incidence of coughing and gagging during emergence from anaesthesia.<sup>5</sup> They can be easily inserted to secure the airway while the patient's head is in fixation pins during emergency situations or to re-anaesthetise the patient at the third stage of the procedure.<sup>14</sup> After dural opening, the anaesthesia is stopped and the patient is awakened for neurophysiological monitoring and cortical mapping.

The advantage of the asleep-awake-asleep technique includes better control of the airway and ventilation and ensuring patient unawareness during the painful part of the procedure.<sup>11,13</sup> In the case of longer procedures (> 4 hours), asleep-awake-asleep might be a better option since the patient is more likely to cooperate with intraoperative testing if they are unconscious during the preparatory phase.<sup>3</sup> Once the surgical resection is complete, the patient is again anaesthetised using total intravenous anaesthesia and a supraglottic airway can be reinserted if needed.

A modification of this technique is asleep-awake approach, in which the patient is kept awake after brain lesion excision till closure of craniotomy wound. The patient anxiety usually lessens after lesion resection and mild sedation will be required to keep the patient reassured. It is recommended to supplement analgesia at that stage to ensure that the patient stays comfortable. This technique avoids airway manipulation while the head is fixed with pins in the Mayfield frame.<sup>5</sup>

## CONSCIOUS SEDATION

The goal of the conscious sedation technique is to provide different levels of sedation depending on the stage of surgery while maintaining spontaneous ventilation and airway control during the procedure.<sup>11</sup> Deeper levels of sedation are needed during the scalp block and initial craniotomy phase till dural opening. Sedation is then stopped or reduced for cortical mapping and testing. Once resection is complete, sedation is deepened to ensure patient comfort during the surgical closure. Sedation levels must be adjusted according to an individual's needs as both oversedation and undersedation carry increased risk to the patient. Optimal sedation levels render a patient tranquil and able to give quick and clear response during mapping to provide meaningful neurological feedback with minimal hypoventilation and CO<sub>2</sub> retention.<sup>3</sup>

Dexmedetomidine infusion (Table 4) or a combination of propofol and remifentanyl target-controlled infusions are commonly used to provide sedation for AC. Dexmedetomidine is a selective  $\alpha_2$  adrenoceptor agonist that is gaining popularity during AC. It has a sympatholytic action as well as sedative, opioid-sparing, and some analgesic effects without significant respiratory depression. Also, it has minimal interference on neuronal functions and cortical mapping<sup>3,5,13</sup>. It can provide a comparable sedation efficacy to propofol and remifentanyl infusion with fewer respiratory adverse events.<sup>15</sup>

Supplemental oxygen can be given by nasal prongs with an end-tidal CO<sub>2</sub> sampling channel. There is a growing interest in using high-flow nasal oxygen in anaesthesia and intensive care, which can provide a higher ratio of arterial oxygen partial pressure to fractional inspired oxygen (PaO<sub>2</sub>/FiO<sub>2</sub> ratio) than conventional oxygen therapy and might reduce respiratory-related complications during AC.<sup>16</sup> Oxygen delivered via high-flow nasal cannulas is humidified and warmed, which can add to patient tolerance and comfort.

Initial phase	<ul style="list-style-type: none"><li>• Loading 0.5-1 <math>\mu\text{g}/\text{kg}</math> over 10 minutes</li><li>• Maintenance: 0.2-1 <math>\mu\text{g}/\text{kg}/\text{h}</math></li><li>• Fentanyl 50-200 <math>\mu\text{g}</math> can be used to supplement analgesia if needed</li></ul>
Cortical mapping phase	<ul style="list-style-type: none"><li>• 0.1-0.4 <math>\mu\text{g}/\text{kg}/\text{h}</math></li></ul>

**Table 4.** Dexmedetomidine Infusion Protocol for Conscious Sedation Approach<sup>3,5,11</sup>



Adverse Event	Reported Incidence (%)
Intraoperative seizures	3-16
Cardiovascular instability	17-24
Postoperative neurological dysfunction	12-23
Airway obstruction/hypoventilation	7-16
Cerebral oedema (“tight” brain)	7-14
Awake craniotomy failure (conversion to general anaesthesia)	2
Nausea and vomiting	0-9
Other rare complications	
Venous air embolism	
Intracerebral injection of local anaesthesia	
Airway oedema	

**Table 5.** Perioperative Adverse Events and Reported Incidence During Awake Craniotomy<sup>3,5,11</sup>

## AWAKE TECHNIQUE

An alternative approach to AC relies only on effective LA without any sedation. This technique needs a highly motivated patient and short surgical time to be successful. Short-acting opioids such as remifentanyl or patient-controlled analgesia can be used to supplement analgesia.<sup>17</sup> Creating a good harmony within the operating room team, ensuring psychological support of the patient, and encouraging verbal and nonverbal communication are effective ways to avoid sedation during AC.<sup>3,18</sup>

## COMPLICATIONS

AC is generally safe and well tolerated with low complication rates. Complications associated with AC are listed in Table 5. Failure of AC is uncommon (2%) and occurs mainly due to inadequate communication with the patient during the procedure, inappropriate patient selection, or persistent intraoperative seizures.<sup>5</sup> Patients with bronchial asthma, remifentanyl infusion, or prolonged surgery have been found to experience increased incidence of complications during AC.<sup>19</sup> Cortical electrical stimulation during AC can induce focal or generalized seizures in about 8% of the cases but rarely results in AC failure.<sup>3,19</sup> Seizures are usually self-terminated after stopping the stimulation or irrigation of the surgical field with ice-cold saline. Propofol or a thiopental bolus can be used to terminate persistent seizures but securing the patient’s airway might be needed if large doses are used.

Oxygen desaturation can result from airway obstruction or hypoventilation due to oversedation. It is more common with regimes using propofol and remifentanyl infusions.<sup>3,5</sup> Simple manoeuvres, such as jaw thrust, sedation adjustment, and oxygen supplementation are usually sufficient to resolve the problem. Different airway adjuncts including fibre-optic and video laryngoscopes should be readily available in case securing the airway is emergently needed. Laryngeal mask insertion has been found to have the highest success rate with shorter insertion time to secure the airway while the head is fixed in the Mayfield frame.<sup>14</sup>

Cerebral bulging (tight brain) may result from hypoventilation and CO<sub>2</sub> retention and may require titration of sedation or control of the airway. Mannitol might be needed to reduce the brain oedema and improve the surgical field but will require the presence of urinary catheterisation.

It is not uncommon for the trigemino-cardiac reflex to be triggered during scalp block or LA infiltration. It is usually self-limited by cessation of the stimulation but might need anticholinergic medications to treat severe bradycardia.

## SUMMARY

AC can carry many challenges for the patient as well as the anaesthesiologist. Different techniques have been described for anaesthesia and sedation management; however, good patient selection and preoperative preparation, effective local anaesthesia, and prompt treatment of intraoperative complications are crucial for successful and safe procedure.

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