Awake Craniotomy – Anaesthetic Challenges

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Introduction:

Awake craniotomy in which craniotomy and excision of tumour/epileptic foci or deep brain stimulation for various diseases will be carried out while the patients are being awake or in arousable sedation state. The neurological testing is carried out while the patients are awake to map the tumour area or epileptic foci which is on the or close to the eloquent area and then the resection of the tumour will be carried out. This concept was initially used to localize the epileptic focus in patients undergoing epilepsy surgery. With an advancement in neurosurgical techniques, neuroimaging, intraoperative cortical mapping, and anaesthesia techniques, the scope of awake craniotomy has expanded from epilepsy surgery to surgery for supratentorial tumours, vascular malformations, and for other lesions. It is the technique of choice for tumours involving eloquent cortical areas, for the epilepsy surgery and in surgery for the movement disorders. It is a safe, well-tolerated procedure; careful patient selection is the key to success. The decision to proceed with awake craniotomy is often made on a case-by-case basis after weighing the benefits and risks for every individual patient.

Benefits of awake craniotomy:

1. Increased tumour removal with better preservation of eloquent function in tumour surgery resulting less incidence of postoperative neurological dysfunction
2. Better localization of seizure foci with complete resection in epilepsy surgery
3. Reduces the hospitalization time and cost when it is performed routinely for some
neurosurgical procedure such as small tumour resection, ventriculostomy, and for functional neurosurgery.

4. Avoidance of general anaesthesia and its related complications such as nausea and vomiting, sore throat, dental injury etc.

**The challenges for an anaesthesiologist during awake craniotomy:**

1) To provide adequate analgesia and anxiolysis during the surgery especially during the painful parts of the procedure such as skull pinning, elevation of scalp flap from the periosteum, temporals muscle dissection, craniotomy, dural stripping, manipulation of temporal lobe or meningeal vessels.

2) Establishing airway patency with adequate ventilation while ensuring the patient comfort.

3) Maintaining the systemic and cerebral hemodynamic homeostasis.

4) Quick recognition of complications during surgery and its appropriate management

**Absolute contraindication to awake craniotomy:**

1. Patient refusal

2. Inability to lay still for any length of time or inability to lie flat (orthopnoea)

3. Inability to co-operate, for example confusion, low Glasgow Coma Scale

**Relative contraindication to awake craniotomy:**

**Patient factors:**

1. Presence of difficult airway

2. Presence of Obstructive sleep apnoea (OSA)
3. Presence of morbid obesity

4. Poor seizure control despite the multiple medications.

5. Severe anxiety disorder

**Surgical factors:**

1. Raised intracranial pressure

2. Highly vascular tumours where there is a risk of massive bleeding.

3. Tumours with extensive dural involvement. It can cause severe pain while resection and these tumours need duroplasty which prolongs the duration of surgery.

**Factors decreases the success of awake craniotomy:**

Presence of alcohol or drug abuse, chronic pain disorders, low tolerance to pain, anxiety, patients with significant dysphasia, confusion, or somnolence and psychiatric disorders are known to cause sedation failure during the procedure. The lack of understanding of the spoken language may be a problem, but it can be remedied with the presence of an appropriate translator. Although there are reports of safe use of awake craniotomy in paediatric patients, case selection should be more rigorous and based on the patients’ maturity and the individual risk–benefit assessment.

**Conduct of awake craniotomy:**

1. **Pre-anaesthetic evaluation:** Each patient undergoing awake craniotomy should be evaluated by an anaesthesiologist in the preoperative anaesthesia clinic (PAC) for optimization of the underlying medical co-morbidities and for providing opportunity for the anaesthesiologist to establish rapport and to provide counselling. The need for awake surgery and its benefits need to be discussed with the patient to reinforce the patient co-operation. Apart from the routine general, systemic and the neurological examination, a good preoperative
psychological preparation, explaining about the level of cooperation needed, and the realistic
description of the entire procedure with expected discomforts at certain time periods and
reassuring them that adequate analgesia and sedation will be provided during this time periods
will help them to tolerate the procedure well. The requirements for intraoperative cortical
mapping should be explained, and this involves performance of motor/memory and/or
language tests need to be informed. A well-conducted preoperative counselling can alleviate
the anxiety and improve their cooperation during the procedure. Occasionally, the patient is
taken to theatre before surgery to visualize the environment and equipment involved. In some
centre, patients are seen by the neuropsychologist or neurophysiologist before the surgery if
the lesion involves speech and language centres, and their baseline responses are assessed and
recorded.

2. Premedication: All the routine medications for the patient’s medical conditions, and the
medications specific for the neurological condition such as dexamethasone for treatment of
tumour oedema, and the anti-seizure medication all, need to be continued. Proton pump
inhibitor or H₂ receptor antagonist to reduce the gastric secretion and to reduce the gastric pH
should be given for all patients. Short acting benzodiazepines can be given for tumour resection
cases for anxiolysis. For epilepsy surgery it should be deferred because it can affect the seizure
foci localisation.

3. Preparation of the Operating room:

The operating room (OR) should be ready before the patient enters into the room. On the OR
doors, label containing “Awake Craniotomy going on” should be stuck to minimise the
unnecessary traffic into and out of the room and to maintain a calm environment. The necessary
airway equipment including the nasopharyngeal airway, classic or proseal laryngeal mask
airway, intubating LMA, ETT should be ready. The drugs which are needed for scalp block
and for sedation and analgesia to be loaded and labelled. The standard monitors such as electrocardiography, pulse oximetry, non-invasive blood pressure measurement, and end tidal CO2 monitoring and the invasive arterial line should be ready. The use of other monitoring modalities such as central venous catheter, indwelling urinary catheter, temperature and Bispectral index (BIS)/entropy depend on institutional practices and individual patient requirements.

4. Patient positioning:

Depending on the surgical requirements, the patient may be positioned supine, semi-sitting, or lateral. After giving scalp block, the head is usually immobilized with rigid pin fixation or occasionally placed on a donut-shaped gel pad. It is important to ensure that the patient is positioned comfortably prior to the procedure as they would remain in that position for several hours, with minimal adjustments possible subsequently. Discomfort from prolonged positioning is a common complaint among patients undergoing this procedure. Strategies to provide comfort include, adequate soft padding especially on pressure areas, placing pillows under the knees, avoiding excessive flexion, extension or turning of the neck, and maintaining normothermia. Surgical drapes should be placed such that they form a tent around the patient’s face and allows the anaesthesiologist access to the patient’s airway and to monitor for signs of distress. This “window” also facilitates communication between the medical team and patient during functional testing. A microphone can be placed near the patient’s face or a video camera used to record facial movements for the surgical team’s observation during functional testing.

5. Anaesthetic Technique:

There is no recognized, fixed anaesthetic regime followed for an awake craniotomy. Anaesthetic technique is often modified depending on the patient factors, pathology, tumour size, and its effect on the surrounding brain, length of surgery. There are three type of
anaesthetic technique are followed for an awake craniotomy. 1. “Awake throughout” 2. ‘Asleep-awake-asleep’ technique. 3. ‘Asleep-awake’, technique. In our centre we follow the awake throughout technique.

1. **Awake throughout technique**: In this technique, the patients are sedated during the scalp block and during the beginning of surgery till craniotomy. Then they are awake during the cortical mapping and tumour resection. Once the tumour resection or epileptic foci localisation is done, they will be sedated again. But the levels of sedation is varied throughout the procedure. Deep level of sedation is maintained during the painful part of the operation such as during the scalp block, pinning, temporalis muscle dissection, craniotomy, dural stripping, manipulation of temporal lobe or meningeal vessels. The patients are awake during mapping and the surgical removal of pathological brain and the sedation is restarted for the scalp closure. Patients are maintained on spontaneous breathing without the use of an airway device.

Since most patients are anxious while arriving to theatre, it is very important not to make them feel pain during the scalp block. If they feel excessive pain during the block, it is very likely that their co-operation during the entire procedure will be un-satisfactory and can cause failure of the procedure. Since the airway is under the control of the anaesthetist during the scalp block, it is better to maintain deep level of sedation during this time. After the scalp block, once they are positioned for surgery, they have to be awake to ensure whether he/she is lying down comfortably without undue stretch on the shoulder or neck or any other body part.

While the surgery is going on, the level of sedation should not be too deep to avoid the risks of airway obstruction which can lead to hypercapnia, hypoxia, and increased intracranial pressure with a ‘tight’ brain. At the same time, if the patients are too awake they will be uncomfortable and anxious.
In our centre, the most commonly used drugs for sedation are propofol infusion for sedation and the intermittent bolus dose of fentanyl for analgesia or Dexmedetomidine infusion (bolus and an continuous infusion) with fentanyl bolus. Soon after arrival to OR, Midazolam (1 -2 mg) is given to reduce the anxiety if they are coming for tumour surgery.

2. **Asleep-Awake-Asleep technique:** This technique involves induction of general anaesthesia and control of the airway with either a supraglottic device or an ETT. When neurocognitive testing and intra-operative mapping needs to commence, the anaesthetic drugs are either reduced or stopped and the airway device is removed, when the patient has regained upper airway reflexes and it is safe to do so. Once resection of the lesion is complete, general anaesthesia can be re-introduced and with re-insertion of the airway device. The advantages of this technique include the ability to control ventilation and therefore control carbon dioxide concentrations and prevent airway obstruction and hypoventilation. It also facilitates greater depth of anaesthesia during the painful parts of the surgery. The airway device most often used are the Proseal LMA™, or intubating LMA, standard laryngeal mask (LMA) or Supreme LMA™.

3. **Asleep- Awake Technique:** This technique involves induction of general anaesthesia and control of the airway with either a supraglottic device. When neurocognitive testing and intra-operative mapping needs to commence, the anaesthetic drugs are either reduced or stopped and the airway device is removed, when the patient has regained upper airway reflexes and it is safe to do so. Once resection of the lesion is complete, the sedation is restarted and patients are maintained on spontaneous respiration without using an airway device.

**Commonly used drugs for an awake craniotomy:** The commonly used drugs and its doses are given in Table 1.

**Table 1:** Commonly used anaesthetic agents and the dosages for awake craniotomy.
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<th>Agents</th>
<th>Bolus</th>
<th>Infusion</th>
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| Propofol     | 0.5-1.0 mg/kg      | Manual : 50-150 µg/kg/min  
TCI effect site (sedation): 2.4-4.8mcg/ml  
TCI effect site (mapping): 0.6-1.2mcg/ml |
| Remifentanil |                    | Manual infusion: 0.03-0.05mcg/kg/min  
TCI effect site (sedation): 2-2.8ng/ml  
TCI effect site (mapping): 1.6-2ng/ml |
| Fentanyl     | 0.5-1µg/kg         | 0.5 – 1 µg/ kg/hr                                                        |
| Alfentanil   | Bolus: 0.075mcg/kg | Manual infusion: 0.0015mcg/kg/min                                        |
| Sulfentanil  | Bolus: 7.5mcg/kg   | Manual infusion: 0.5mcg/kg/min                                           |
| Dexmedetomidine | 0.5-1 µg/kg over 15 minutes | Manual infusion : 0.2 -0.7 µg/kg/hr                                      |
| Midazolam    | 20-50 µg/kg        |                                                                          |

6. Challenges during cortical mapping and the surgical resection: During this phase, it is very important that the patient is fully awake and cooperative especially when there is complex speech and language and motor testing is planned. All sedation should be stopped well before the testing. Since dexmedetomidine does not cause cognitive impairment, also does not interfere with seizure foci localisation, this can be used during the awake craniotomy. Intraoperative seizure can occur while doing the cortical mapping, particularly in the vicinity of the motor cortex. This can be quickly stopped with cold saline irrigation of the brain. If this fails, a small dose of thiopentone or propofol can be used. Nausea and bradycardia may occur with deep cortical resection close to the midline. This can be treated by asking the surgeon to reduce traction and by administration of anticholinergics. It is better to employ a closed circuit video monitor to provide the surgeon with a clear view of the patient and amplification of the verbal responses. Awake testing may be required throughout the resection, for example with a tumour close to the motor cortex and this can be exhausting for patient and for the anaesthetist.
Intraoperative complication during awake craniotomy:

I. Respiratory Complications:

1. Hypoventilation/airway obstruction/apnoea due to heavy sedation leading to hypoxia, hypercapnia
2. Malposition of supraglottic airway devices such as LMA in the Asleep-awake-Asleep technique
3. Pulmonary aspiration during sedation
4. Conversion to General anaesthesia

II. Cardiovascular Complications:

1. Hypotension while administering bolus dose of Dexmedetomidine
2. Hypertension due to absorption of adrenaline from the scalp, due to anxiety, Dexmedetomidine bolus.
3. Bradycardia/tachycardia due to drug effect/the trigeminocardiac reflex

III. Neurological Complications:

1. Focal seizures, generalized seizures, or both
2. Focal neurological deficit
3. Brain swelling (‘tight’ brain)
4. Venous air embolism

IV. General

1. Nausea and Vomiting
2. Local anaesthetic toxicity
3. Agitation/restlessness

Postoperative care following awake craniotomy:

Following surgery, all patients are shifted to neuro high-dependency unit (NHDU) or neuro intensive care (NICU). Close neurological monitoring to be done similar to other craniotomy.
done under general anaesthesia as postoperative haematomas can develop, especially in the first 6 h after operation. Few patients may develop neurological deficit immediately following the surgery despite of nil intraoperative issues due to intraoperative handling and oedema formation, those patients need reassurance that this deficit is a transient one and will improve as the oedema settles.

Most patients are comfortable during the postoperative period due to the effect of scalp block. They just need intravenous paracetamol for analgesia every 6th hourly. Once the scalp block effect wears off, systemic pain relief is used. Opioids, such as codeine, morphine, or oxycodone, are used for this purpose.

**Performing a Scalp Block:** Six nerves are blocked bilaterally to completely anaesthetise the scalp: the supratrochlear, supraorbital, zygomaticotemporal, auriculotemporal, and the lesser and greater occipital nerves. To make the block successful, the anaesthesiologist should know the exact site of scalp flap so that, more drug can be deposited on the side of surgery. To increase the efficacy of the block, the drug has to be deposited close to the nerve also into the correct layer of scalp. A short, 23-25 Gauge needle is used for blocking the individual nerve. A 22 G spinal needle (Quincke) needle is used for performing the ring block. The Figure 1 is showing the innervation of scalp.

1. **The Supratrochlear nerve block:** It is blocked just above (1-2 mm) the supratrochlear notch and local anaesthetic is deposited just superficial to the periosteum.

2. **The supraorbital nerve block:** It is blocked just above (1-2 mm) the supraorbital notch and local anaesthetic is deposited just superficial to the periosteum.

3. **The temporal branch of the auriculotemporal nerve block:** It is blocked immediately posterior to the superficial temporal artery at the level of the auditory meatus. Injection is superficial and subcutaneous. Too deep an injection will produce facial nerve block.
4. **Zygomaticotemporal nerve block**: The main branch of the zygomaticotemporal nerve emerges from the temporalis fascia near the lateral border of the orbit, although many smaller deep branches ramify within the temporalis muscle. These small branches are especially important to block so as to cover temporally based flap incisions. Field infiltration above the zygoma through the temporalis muscle and almost down to the periosteum of the temporal bone will give a good result, without causing a facial nerve block. Up to 5 ml can be used on the operative side.

5. **The lesser occipital nerve block**: It can be blocked either deep or superficial to the fascia at the upper, posterior border of sternocleidomastoid.

6. **The greater occipital nerve block**: It is blocked subcutaneously by injecting along the middle third of a line between the mastoid process and the external occipital protuberance along the superior nuchal ridge. This injection will also reinforce the lesser occipital nerve block as it becomes subcutaneous.

Greater auricular and 3rd occipital nerve rarely encroach the surgical field of awake craniotomy.

**Local anaesthetics used for Scalp block:**

1. 2% Xylocaine
2. 0.5% Bupivacaine or 0.75% ropivacaine.

**Preparation of Drug for Scalp block:**

I usually take 10 ml of 2% Xylocaine and add 5 ml of saline to make 1.5% Xylocaine with that 5 µg/cc of adrenaline will be added (Total volume of Xylocaine 15 ml). About 1- 1.5 ml of this drug will be injected on the bilateral surpratrochlear, supraorbital nerves using 23 G needle. Then 2-3 ml of the same drug will be injected to block the Zygomatico temporal nerve on the side of surgery. Then 1-1.5 ml of drug will be injected to block the auriculotemporal nerve and
greater and lesser occipital nerve using the above mentioned landmarks only on the side of surgery. Then I will take 15 ml of 0.75% Ropivacaine and add 5 ml of saline to make it to 0.5% ropivacaine or 20 ml of 0.5 % Bupivacaine are then add 5 µg/kg of adrenaline into it. I will give 1 ml of drug (Bupivacaine or Ropivacaine) at each nerve site on the side of surgery except for the Zygomaticotemporal nerve (3 ml) and rest of the volume will be used for giving the ring block connecting the previous injection site and the on the opposite side. (Total volume of Bupivacaine or Ropivacaine is 20 ml). Since Xylocaine is given first, patients do not complain of pain during ring block. Before opening the dura, the surgeon will apply the 2% Xylocaine soaked paddy on to the dura for 3-5 minutes then only dural incision will be done.

For example, for 60 kg patient toxic dose of Xylocaine with adrenaline is 7 mg/kg. (420 mg) So, maximum dose of Xylocaine that can be used is 21 ml of 2% Xylocaine.

Toxic dose of Ropivacaine 3 mg/kg (180 mg) so I can take 36 ml of 0.5% Ropivacaine. Since we are using both Ropivacaine and Xylocaine, I will take only half of the toxic dose in each drug. (3.5 mg/kg that is 210 mg that is approximately 10 ml of 2% Xylocaine and 1.6 mg/kg of Ropivacaine that is 96 mg so, I can take 20 ml of 0.5 % Ropivacaine.
Figure 1: Showing the nerves supplying the Scalp:
Figure 2: Showing the line on which the Ring Block is performed

Figure 3: Eloquent areas of Brain

3a,b - Motor, Sensory cortex
3c – Broca’s and Wernicke’s speech areas.

Conclusions:

The success of awake craniotomy depends upon various factors such as careful patient selection, thorough preoperative evaluation and good preoperative counselling, solid rapport building, ensuring complete sedation and good analgesia during the painful part of the procedure, effective scalp block and by providing patient comfort during positioning, vigilant monitoring, preparedness to manage the complication, continuous team communication. Tight anaesthetic control and the meticulous performance of mapping procedures are essential to achieve the highest accuracy of cerebral localization results. Finally, experienced anaesthesiologist and surgeon are important to maximize the utility and safety of this procedure.

References: