Awake craniotomy

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Anaesthetic techniques for awake craniotomy have been evolving over many years and include local anaesthesia and sedation or true asleep–awake–asleep techniques using general anaesthesia with intra-operative wake-up. The key advantage of awake techniques is the ability to assess the patient's neurological status during surgery, although this benefit has to be balanced against the loss of control of ventilation and assurance of immobility. However, the use of short-acting anaesthetic agents provide good operating conditions for the neurosurgeon whilst ensuring intraoperative cooperation from a comfortable patient. It is well tolerated by patients and minor procedures can be performed as a day case or with one overnight stay. The neuroanaesthetist plays a key role in the perioperative management of this challenging procedure.

Indications

Indications can be anatomical, physiological or pharmacological. In addition, awake techniques are widely used for stereotactic brain biopsy in many parts of the world.

Anatomical

Space occupying lesions in or adjacent to eloquent areas of the cortex can most safely be excised in an awake patient, providing continuous reassurance to the neurosurgeon that essential neurological function is not being compromised. Intraoperative cortical stimulation maps eloquent cortical areas and allows accurate planning of resection margins. The use of such techniques has facilitated excision of tumours in the sensory and motor speech areas in the dominant hemisphere and sensorimotor cortex in either hemisphere that might otherwise be considered inoperable. However, recent advances in high resolution functional magnetic resonance imaging (fMRI) will reduce the requirement for this type of awake neurosurgery.

Physiological

Stimulation or lesion generation of deep brain nuclei (e.g. the subthalamic nucleus) is increasingly undertaken for intractable movement disorders such as Parkinson's disease and dystonias. Accurate intraoperative location of the stimulating electrodes can most easily be confirmed in awake patients.

Pharmacological

Epilepsy surgery is performed using awake techniques when intraoperative electrocorticography (ECoG) is required to define the resection margins. Although ECoG is possible under carefully controlled general anaesthesia, all anaesthetic agents affect the ECoG to a greater or lesser extent and there are circumstances when an awake technique is the best and safest option.

Contraindications

These are summarized in Table 1. Careful patient selection is key and high levels of motivation and meticulous preparation are prerequisites to the success of awake intracranial procedures. Confusion and communication difficulties (e.g. severe dysphasia) are absolute contraindications and extreme anxiety or an exaggerated response to pain are relative contraindications. Anatomical contraindications include low occipital tumours requiring the prone position and lesions with significant dural involvement (potentially painful during resection). Patients must also be able to lie still for many hours and systemic physiological and anatomical factors, such as orthopnoea and joint pain, may limit the ability of a patient to withstand awake craniotomy. Finally, awake techniques are not suitable for procedures being performed by an inexperienced neurosurgeon.

Table 1 Contraindications to awake craniotomy

Confused patient
Communication difficulties
Extreme anxiety
Low occipital tumour (prone position)
Significant dural involvement (painful)
Inability to lie still for many hours
Inexperienced surgeon

Key points

Awake craniotomy is the technique of choice for certain neurosurgical procedures, including excision of lesions from eloquent cortical areas and procedures for epilepsy and movement disorders.

It is a safe, well tolerated procedure; careful patient selection is the key to success.

It depends upon adequate local anaesthesia combined with appropriate sedation or an asleep–awake–asleep technique using general anaesthesia.

Loss of airway control and the inability to control ventilation can lead to complications.

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Preoperative assessment

The preoperative visit should be used to identify neurological deficits and intercurrent medical problems. In epileptic patients, the type and pattern of seizures, as well as previous and current anticonvulsant therapy should be noted and any complications of therapy identified. Blood drug concentrations should be checked and medication continued up to and including the day of surgery. Premedication is rarely prescribed and depressant drugs are avoided in all patients. In patients scheduled for epilepsy surgery, benzodiazepines should always be avoided to minimize effects on intraoperative ECoG.

The preoperative visit should also be used as an opportunity to prepare the patient psychologically for awake surgery. Details of the procedure should be explained and procedures with the potential to cause discomfort (e.g. dural opening) are described. The patient is reassured that the procedure should be entirely painless and that they should communicate any discomfort to the neuroanaesthetist immediately. The possibility of nausea during traction on the temporal lobe and the risk of intraoperative seizures in those in whom cortical stimulation is planned should be highlighted. If an asleep–awake–asleep technique is planned, the patient should be told what to expect during emergence from anaesthesia.

Intraoperative procedure

As with any awake technique, delays and technical problems in the operating theatre should be avoided. Staff should be made aware of the presence of an awake patient by signs on all entrances into the theatre and noise should be kept to a minimum. The operating theatre becomes a crowded place and staff movement should be restricted and a calm atmosphere maintained at all times.

I.V. and arterial cannulae are inserted under local anaesthesia. Continuous direct arterial blood pressure monitoring, ECG and pulse oximetry are initiated. Separate, dedicated i.v. cannulae should be inserted for fluid replacement and sedation. Placement of a urinary catheter is necessary for prolonged procedures. Patient comfort is very important and the operating table should be adequately padded and attention paid to head and limb positioning. It is usually preferable to allow the patient to position themselves on the operating table before institution of sedation or anaesthesia so that they may lie in the most comfortable position. If a Mayfield head fixator is used, adequate local anaesthesia should be applied prior to application of the pins. Surgical drapes should be positioned allowing the anaesthetist constant and unimpeded access to the airway whilst preserving a sterile field. The use of clear drapes reduces the feelings of claustrophobia.

Local anaesthesia

Whether sedation or an asleep–awake–asleep technique is chosen, the provision of adequate local anaesthesia using regional, field and dural blocks is essential. During brain biopsy or mini-craniotomy, infiltration of local anaesthetic into the relevant area of scalp and pericranium, and later onto the dura, is all that is required. However, for a formal craniotomy, the neurosurgeon must perform field blocks of the scalp, using combinations of lidocaine and bupivacaine with epinephrine. The skin, scalp, pericranium and periosteum of the outer table of the skull are all innervated by cutaneous nerves arising from branches of the trigeminal nerve. Subcutaneous infiltration with local anaesthesia in the manner of a field block or over specific sensory nerve branches, blocks afferent input from all layers of the scalp. The skull can be drilled and opened without discomfort to the patient (no sensory innervation) but the dura is innervated by branches from all three divisions of the trigeminal nerve, the recurrent meningeal branch of the vagus, and by branches of the upper cervical roots. It must therefore be adequately anaesthetized with a local anaesthetic nerve block around the nerve trunk running with the middle meningeal artery, and also by a field block around the edges of the craniotomy. Local anaesthetic solutions deposited around the middle meningeal artery should not contain epinephrine. The early part of the craniotomy (i.e. until dural opening) may be distressing for the patient because of incomplete local anaesthesia or noise from power tools; it may be appropriate to use i.v. sedation or general anaesthesia during this phase of surgery.

Sedation techniques

In the past, sedation techniques have relied upon incremental fentanyl (with or without droperidol) titrated against sedation level and respiratory rate to provide conscious sedation. More recently, infusions of propofol in conjunction with fentanyl have been used with great success and target-controlled infusion of propofol has been recommended. During epilepsy surgery, patient-controlled sedation with propofol is associated with a lower incidence of intraoperative seizures but a higher incidence of transient respiratory depression. Most recently, remifentanil has been used in conjunction with propofol to provide sedation and analgesia during awake craniotomy. This is rapidly becoming the technique of choice because it is safe and easy to use and has a minimal risk of respiratory depression if carefully titrated and monitored. Pharmacokinetic simulations have demonstrated that changes in infusion rates of propofol and remifentanil are quickly followed by changes in effect site concentrations, which correspond well with the desired clinical changes in patient sedation and analgesia.

α_2-Adrenoreceptor agonists have potential application during awake craniotomy because they provide analgesia and sedation that is easily reversed with verbal stimulation; there is no risk of respiratory depression. Dexmedetomidine (highly specific α_2-adrenoreceptor agonist) has been used as an adjunct during awake epilepsy surgery to provide sedation and analgesia sufficient to complete cortical mapping and tumour resection.

Airway management is generally uneventful during awake craniotomy under sedation, although the use of a soft nasopharyngeal airway to maintain airway patency has been described.

However, sedation inevitably runs the risk of apnoea and airway obstruction and patient position is crucial; the lateral position is least likely to result in airway obstruction. Equipment for emergency airway control should be available throughout awake craniotomy and options include endotracheal intubation under direct vision, blind nasal intubation, fibreoptic nasotracheal intubation and insertion of a laryngeal mask airway (LMA).

Asleep–awake–asleep technique

Some patients are not able to tolerate craniotomy with sedation alone and general anaesthesia with intraoperative wake-up is an alternative. Numerous combinations of drugs and airway adjuvants have been used for asleep–awake–asleep procedures; historically, this technique has relied upon the use of droperidol and midazolam in a spontaneously ventilating patient. However, this combination of drugs resulted in prolonged and unreliable intraoperative wake up times as well as the risk of airway obstruction. The introduction of propofol improved the safety profile of the asleep–awake–asleep technique and provided more predictable intraoperative wake-up. As with sedation for awake craniotomy, a combination of propofol and remifentanil infusion is now the technique of choice because it allows titratable levels of anaesthesia and fast and reliable wake up. The safety of the technique can be further improved by the use of bispectral index monitoring to guide target-controlled infusions.

Airway control

A nasopharyngeal airway was used in early descriptions of awake craniotomy but is insufficient to maintain airway control during general anaesthesia. The combination of propofol and remifentanil allows the use of an LMA because it permits manipulation and control of the airway with minimal risk of coughing and without the need for neuromuscular blockade. Several techniques using the LMA for airway control have been described, but the most applicable uses the LMA only during the asleep phase, thereby allowing full patient participation during the awake phase. Spontaneous ventilation via an LMA has been recommended but this does not allow control of arterial blood gases and hypercapnia is a feature of this technique. Use of the ProSeal LMA represents an improvement on the conventional LMA for controlled ventilation (and control of Pa_{CO_2}) without the need for intubation during the asleep phase. After completion of the initial craniotomy, after dural opening, the dose of remifentanil is reduced to allow return of spontaneous respiration. The propofol infusion rate is then reduced or stopped and the LMA removed as the patient wakens. After resection of the lesion, propofol and remifentanil are recommenced and the LMA reinserted as anaesthesia is recommenced for closure of the craniotomy. Using this technique, the LMA can be removed and repositioned with ease and there is minimal risk of coughing and straining. An alternative technique, keeping the LMA *in situ* for the entire procedure has been described, but this offers little advantage and is associated with a higher incidence of complications. The technique relies on the preoperative agreement of a communication system with the patient to facilitate intraoperative (non-verbal) communication with the LMA in place. However, it is associated with an unacceptable incidence of coughing and restlessness necessitating intraoperative endotracheal intubation. A modified endotracheal tube that allows topical airway anaesthesia has also been utilized during asleep–awake–asleep procedures. After opening of the craniotomy, anaesthesia is discontinued and lidocaine injected into the airway via a catheter that is spirally attached to the endotracheal tube. After the awake phase of surgery, the patient is re-intubated using a fibreoptic laryngoscope or an endotracheal tube changer. This overly complicated technique has a significant risk of coughing on removal or reinsertion of the tube and is unlikely to find a niche during awake craniotomy. The use of airway instrumentation of any sort brings the risk of coughing or straining and subsequent vomiting during lightening of anaesthesia or sedation and, for this reason, simple LMA techniques are most appropriate.

Complications

These are summarized in Table 2. Seizures develop in 16–18% of patients (most commonly during epilepsy surgery) and nausea and vomiting in 8–50% during awake craniotomy. Dysphoric reactions may also occur, risking loss of control in a patient with an open craniotomy. Respiratory depression, caused by sedative and analgesic infusions may lead to brain swelling if untreated. Airway obstruction is a risk in all sedated patients and has been discussed earlier. The use of the LMA minimizes the risk of loss of airway control during anaesthesia in asleep–awake–asleep procedures and has a lower incidence of complications than other, more complicated, methods of airway control. Air embolism during awake craniotomy, possibly related to over-sedation and the generation of high negative intrathoracic pressures secondary to airway obstruction, has been described. Pulmonary aspiration is also a rare consequence of intraoperative vomiting in the unintubated patient.

However, awake craniotomy is a safe procedure overall with no mortality or morbidity related to the anaesthetic technique reported in a review of over 1000 patients. It is also a procedure that is well tolerated by the average adult patient with only a 2–6% requirement for conversion to general anaesthesia.

Table 2 Complications of awake craniotomy

Seizures
Nausea and vomiting
Dysphoric reactions
Respiratory depression
Airway obstruction
Air embolism
Pulmonary aspiration
Conversion to general anaesthesia

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See multiple choice questions 139–143.