Nonopioid Anesthesia for Awake Craniotomy: A Case Report

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Awake craniotomy is becoming more popular as a neurosurgical technique that allows for increased tumor resection and decreased postoperative neurologic morbidity. This technique, however, presents many challenges to both the neurosurgeon and anesthetist. An ASA class II, 37-year-old man with recurrent oligodendroglioma presented for repeated craniotomy. Prior craniotomy under general anesthesia resulted in residual neurologic deficits. An awake craniotomy was planned to allow for intraoperative testing for maximum tumor resection and avoidance of neurologic morbidity.

The patient was sedated with propofol, and bupivacaine was infiltrated for placement of Mayfield tongs and skin incision. Following exposure of brain tissue, propofol infusion was discontinued to allow for patient cooperation during the procedure. Speech, motor, and sensory testing occurred during tumor resection until resection stopped after onset of weakness in the right arm. The propofol infusion was resumed while the cranium was closed and Mayfield tongs removed. The patient was awake, alert, oriented, and able to move all extremities but had residual weakness in the right forearm.

Awake craniotomy requires appropriate patient selection, knowledge of the surgeon's skill, and a thorough anesthesia plan. This case report discusses the clinical and anesthetic management for awake craniotomy and reviews the literature.

Keywords: Anesthesia, awake craniotomy, opioid, propofol.

Awake craniotomy for tumor resection presents many challenges for the neurosurgeon and anesthetist. Surgery performed on brain tissue poses an inherent risk of permanent neurological deficit, especially for tumor resection involving the eloquent cortex. Awake craniotomy allows for intraoperative speech, motor, and sensory testing, with the goal of maximum tumor resection while avoiding postoperative neurological morbidity.[1-4] The anesthetic management for this surgery must provide sedation, analgesia, respiratory and hemodynamic control, and a responsive, cooperative patient for neurologic testing intraoperatively.[1]

Case Report

A 37-year-old, 69-kg male was scheduled for a left frontal awake craniotomy for resection of recurrent grade 2 oligodendroglioma. The patient was diagnosed 5 months earlier after sudden onset of seizures, and the initial resection of tumor was done under general anesthesia 4 months earlier. Postoperatively the patient suffered weakness of the right hand and right-sided facial numbness. Current preoperative assessment revealed residual facial numbness, but the patient was otherwise neurologically intact. Medications included levetiracetam, 5 mg twice a day, for seizure prophylaxis. The patient reported a minor seizure 16 days earlier. Laboratory results were reviewed and were within normal limits. Preoperative vital signs were a pulse rate of 78/min and blood pressure of 110/58 mm Hg. An 18-g intravenous (IV) catheter was inserted in the right hand. Premedication included glycopyrrolate, 0.2 mg IV; metoclopramide, 10 mg IV; and ranitidine, 50 mg IV. The right naris was prepared with phenylephrine drops, and a 7.5-mm nasal airway with 5% topical lidocaine was placed in case tracheal intubation would be needed during the operation.

The patient was transported to the operating room (OR). Standard monitors were placed, including electrocardiography (ECG), noninvasive blood pressure monitoring, pulse oximetry, and capnography. A simple oxygen face mask was placed, with 6 L/min of oxygen. Propofol, 100 mg IV, was administered, followed by continuous infusion at 150 µg/kg per minute titrated to a respiratory rate of 12 to 14/min. A 20-gauge right radial arterial line was placed for continuous intraoperative monitoring of blood pressure. An indwelling urinary catheter was inserted for patient comfort during the lengthy operation and for diuretic administration. Cefazolin, 1 g IV, was given for infection prophylaxis.

Somatosensory and motor evoked potential monitoring was instituted. Ten minutes before pinning of the patient's head in Mayfield tongs, 0.25% bupivacaine with epinephrine was infiltrated by the neurosurgeon at the pin sites. The patient was positioned with a right tilt and sniff position was achieved to help facilitate a patent airway. A tent was created under the drapes to allow visualization and communication with the patient. The surgeon infil-

Awake craniotomy indications	Benefits
Supratentorial tumors, eloquent cortex (motor strip cortex, Broca and/or Wernicke area; sensory cortex)	Optimal tumor resection
Intractable epilepsy	Improved tumor diagnosis
Deep brain nerve stimulator	Resection of tumor that is otherwise inoperable
Arteriovenous malformation	
Aneurysms	

Table 1. Operative Considerations

trated 0.25% bupivacaine with epinephrine into the scalp surrounding the entire surgical site before incision. Dexamethasone, 10 mg IV, and mannitol, 1 g/kg IV, were administered to help facilitate surgical exposure of the brain. Vital signs before incision were a pulse rate of 73/min and blood pressure of 95/57 mm Hg. Blood pressure after skin incision and during craniectomy remained stable, with a systolic range of 95 to 108 mm Hg over a diastolic range of 50 to 60 mm Hg; pulse rates were 70 to 80/min. The propofol infusion was stopped after craniectomy and the brain tissue was exposed. Stereotactic monitoring was employed to help identify tumor margins.

A neuropsychologist performed speech testing after the patient awakened. The patient was asked to squeeze the anesthetist's hand intermittently and move his feet. The patient remained alert and oriented throughout the awake portion without speech impairment. Blood pressure remained 98 to 110/51 to 62 mm Hg, and pulse rate ranged from 71 to 79/min. Seventy minutes into resection the patient complained of persistent weakness of the right hand and arm, prompting the neurosurgeon to stop tumor resection. The propofol infusion was resumed and continued until the cranium was closed and the Mayfield tongs removed. Ondansetron, 4 mg IV, was administered for prophylaxis of postoperative nausea. The patient was awake by the time the head dressing was complete. Immediate neurologic assessment was completed in the OR and was repeated on arrival to the recovery room.

The patient was alert and oriented to person, place, time, and situation, and he was able to move all extremities but had residual weakness in the right hand and forearm. The patient had no pain, and vital signs remained stable, with blood pressure 114/56 mm Hg and pulse rate 81/min. Oxygen saturations throughout the entire case were 100%. No airway obstruction or complications occurred. The patient remembered portions of the intraoperative testing but stated he was comfortable throughout the operation.

The patient's postoperative course was uncomplicated, with the exception of residual right hand and forearm weakness. Vital signs remained stable and the patient complained of minor head pain on postoperative day 1 that was treated with hydrocodone initially and then acetaminophen until discharge. The patient was discharged home on postoperative day 4.

Discussion

Resection of tumor in the eloquent cortex of the brain has an inherently high risk of postoperative neurologic morbidity. Modern technological advances in magnetic resonance imaging (MRI) and the use of intraoperative motor strip testing, ultrasound, and stereotactic monitoring have helped to decrease postoperative neurologic deficits.[2-4] Intraoperative wake-up testing or awake craniotomy is becoming increasingly more popular to aid in resection of tumors within the eloquent cortex. Historically, awake craniotomy was used for epilepsy surgery, which often involves resection of the temporal region of the brain where the eloquent cortex is located, but additional surgical procedures have shown benefit from this technique[1] (Table 1).

Awake craniotomy poses unique challenges, especially for the anesthetist, who is faced with an unprotected airway and limited access to the patient due to positioning and pinning of the head.[1] Therefore, appropriate patient selection is of utmost importance for this method. Patients must be cooperative, have a thorough understanding of the procedure, able to lie still for an extended time, and not have profound existing neurologic deficit. Patients who are obese, have esophageal reflux, sleep apnea, and difficult airways are not good candidates for this type of craniotomy procedure (Table 2). Lastly, patients must desire to proceed with this plan.[1]

Patients require sedation or general anesthesia until the brain is exposed and again at the end of surgery while the cranium is closed. Multiple anesthetic techniques have been described in the literature without identification of a superior technique.[1-4] The anesthetic technique used must provide adequate sedation and analgesia, maintenance and control of respiratory and hemodynamic parameters, and an awake and cooperative patient during neurologic testing.[1] Early techniques employed local anesthetic at the incision site or scalp nerve blocks with the addition of IV fentanyl or midazolam. Variations of this technique use droperidol or a propofol infusion. Patients were given oxygen via nasal cannula or face mask. This combined local anesthetic and IV sedation technique has a high potential for complications related to an unprotected airway, including obstruction and desaturation as reported in the literature.[1-4] This technique is

Inclusions	Relative exclusions
Normal airway examination	Obesity, BMI > 40 kg/m^2
Able to lie still for extended period	Obstructive sleep apnea
Cooperative	Symptomatic GERD
	Altered mental status
	Communication barrier (language, profound dysphagia)
	Extreme anxiety
	Large vascular tumor or substantial dural involvement

Table 2. Patient Selection Criteria
BMI indicates body mass index; GERD, gastroesophageal reflux disease.

Goals = 4 As	Emergency preparedness/OR setup
Adequate sedation	Airway: available ETT, oral/nasal airways, LMA, fiberoptic scope
Analgesia	Breathing: $ETCO_2$, O_2 delivery, direct visualization of patient
Awake cooperative	Circulation: ± arterial line/CVP, hemodynamic support, transfusion ready
Airway, respiratory, and hemodynamic control	Monitors: ECG, oximetry, BP, $ETCO_2$, temperature, CVP, Foley catheter
Anesthesia options	**Additional OR setup**
SAS = sedate-awake-sedate	Patient comfort: pillows, padding, temperature control
AAA = asleep-awake-asleep	Minimize noise/movement
With or without local anesthetic infiltration	Sign on door "Awake Patient"

Table 3. Anesthesia Considerations
OR indicates operating room; ETT, endotracheal tube; LMA, laryngeal mask airway; $ETCO_2$, end-tidal carbon dioxide; CVP, central venous pressure; ECG, electrocardiography; BP, blood pressure.

still used by some, with increasing use of propofol infusion and opioids together.[1,3] Propofol decreases the cerebral metabolic rate, reduces cerebral blood flow, and also has anticonvulsant and antiemetic effects. All of these factors benefit patients undergoing craniotomy surgery.[5]

Dexmedetomidine, a selective α_2 adrenoreceptor agonist, is being increasingly used to provide sedation and analgesia for awake craniotomy. Benefits of dexmedetomidine are that it does not cause respiratory depression, as is possible with other anesthetic agents, and it reduces intraoperative and postoperative anesthesia requirements; however, hypotension and bradycardia have been noted.[6-8] Case studies report that patients are easily aroused by verbal stimuli, whereas some report concerns of impaired neurocognitive testing, even after stopping the dexmedetomidine infusion for extended periods, delaying tumor resection or resulting in cancellation of the case. These reports also use a wide dose range of dexmedetomidine infusion and various combinations of other drugs, including opioids and midazolam.[7] A case report by Moore and colleagues[7] discussed the successful use of dexmedetomidine as a rescue drug during awake craniotomy that avoided conversion to general anesthesia in a restless patient. The literature reveals no consistent use pattern for dexmedetomidine, which may explain the wide variability of clinical outcomes.[6-8]

Another technique known as asleep-awake-asleep uses a laryngeal mask airway (LMA) or an endotracheal tube (ETT).[1] Recent retrospective case review shows an increased use of LMAs for awake craniotomy surgery. Anesthesia is initially induced with propofol and an opioid infusion, such as remifentanil, and an LMA is placed. This allows for spontaneous breathing and for positive pressure ventilation should it be needed. At the appropriate time during the surgery, anesthesia is stopped, the LMA is removed, and intraoperative neurologic testing is performed. After the awake portion is completed, anesthesia is induced once again, and the LMA is reinserted until the end of surgery.[1] Patients not appropriate for LMA may have a nasal ETT placed, which is removed for the wake-up period and then reinserted with the use of a fiberoptic bronchoscope. The advantage of this technique is that it does provide airway protection and an ability to provide a deeper level of anesthesia for the patient during the most painful and stimulating parts of the surgery (Table 3). This is beneficial if the surgeon does not provide adequate infiltration of local anesthetic at the sites of the incision or Mayfield tongs.[1]

The use of opioids is controversial owing to the sedative and respiratory depressant effects that occur with their administration. This can interfere with providing an awake, cooperative patient and lead to brain swelling due to hypercarbia.[1,5,9] In clinical practice, some anesthesia professionals believe intraoperative opioids are unnecessary in craniotomy surgery because manipulation of brain tissue is painless.[10] Pain associated with craniotomy is superficial at the incision site and meninges, suggesting a somatic versus visceral origin for this pain. Therefore, it could be inferred that hemodynamic changes normally attributed to pain, such as increased heart rate and blood pressure, may in fact be caused by catecholamine release from sympathetic fiber stimulation of the brain parenchyma.[10,11] Hence, during tumor resection patients can be awake and performing various speech and motor tests without pain. This physiology supports the use of an awake craniotomy technique in which analgesia is administered during scalp incision and craniectomy, the time when pain fiber stimulation occurs.

Anesthetic management of this case followed a traditional awake craniotomy by administering a propofol infusion for sedation and administering oxygen through a simple face mask. No sedative or opioid drugs were given and the patient was pain free, which further supports that brain parenchyma may lack pain receptors. The surgeon did an extensive and thorough infiltration of local anesthetic before head pinning and incision. This provided anesthesia at the incision, where nerves are located. Avoidance of opioids and sedatives decreased the risk of airway complications from concomitant use with propofol. The patient still received analgesia but without the respiratory depressant effects of systemic opioids. The technique used also provided for a very fast intraoperative wake up and an alert and cooperative patient with no anesthetic complications to facilitate the extensive intraoperative neurologic testing during tumor resection.

Several factors influenced the decision to choose this approach to awake craniotomy versus the asleep-awake-asleep technique. Patient factors included a good airway on examination, appropriate weight, no history of esophageal reflux, and willingness to cooperate with directions from the anesthesia care team. Additional important factors included a surgeon known to be very skilled at performing this surgery, good local anesthetic infiltration at the incision site, and additional attention to patient needs and OR setup (see Table 3). Lastly, the surgeon, anesthesia team, and patient all had a thorough understanding of the surgical and anesthesia plan and agreed to proceed.

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