

## REVIEW ARTICLE

# Anesthesia for awake craniotomy – how do we perform it?

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**Summary**

Awake craniotomy is a neurosurgical procedure that is used for the safe removal of intracranial lesions near Broca's and Wernicke's speech areas. During this procedure, speech mapping is done. Its use demands anesthesia for awake craniotomy, which includes different possibilities for the management of anesthesia with awake patients at the moment of tumor removal. There are two widely accepted concepts: "awake-awake-awake", when the patient is consciously sedated ("awake") throughout surgery, with lighter or deeper sedation (monitored anesthesia care), or "asleep-awake-asleep", when the patient is introduced into general endotracheal anesthesia while opening the skull, but is awake during lesion removal and asleep during closure. Our protocol is a form of "asleep-awake" concept, with general endotracheal anesthesia for craniotomy and awake patients during and after lesion removal (including skull closure).

**Keywords:** awake craniotomy, anesthesia, speech mapping, "awake-awake-awake", "asleep-awake-asleep"



## INTRODUCTION

Awake craniotomy is a neurosurgical procedure that is used for the removal of intracranial lesions (tumors, arterio-venous malformations, epileptogenic foci) near speech areas (1). During removal, speech mapping is performed to preserve these areas (Broca's and Wernicke's areas) (2). For these procedures, it is necessary to perform anesthesia for awake craniotomy (3,4).

Anesthesiologists have several options to perform this procedure. Monitored anesthesia care ("awake-awake-awake") is an anesthetic approach in which the patient experiences varying levels of anesthesia depth during a neurosurgical procedure. During speech mapping, anesthesia must be lightened or paused to allow the patient to fully awaken (5). "Asleep-awake-asleep" is an anesthetic protocol in which the patient is introduced into general endotracheal anesthesia as usual (6,7). After craniotomy and dura mater incision, anesthesia is lightened, and the patient wakes up. The patient is fully awake during the speech mapping procedure. After tumor removal, the patient remains awake or lightly sedated ("asleep-awake") (1) or can be reintroduced to general anesthesia (6,7).

### Benefits of awake craniotomy

Compared to neurosurgical interventions in general endotracheal anesthesia, awake craniotomy provides complete tumor removal with preserved neurological functions (3,8). Additionally, these patients have fewer ICU days, shorter intrahospital stays, and better survival (1-3).

### Contraindications to awake craniotomy

Contraindications to awake craniotomy are different. The main contraindication is an uncooperative patient and the patient's rejection of the procedure (1,3). Relative contraindications include the presence of comorbidities such as uncontrolled hypertension, comorbidities related to safe airways (chronic obstructive lung disease, sleep apnea, morbid obesity), and tumor characteristics (large and highly vascular tumors) (9,10).

## AWAKE CRANIOTOMY PROTOCOL

At Neurosurgery Clinic, University Clinical Center of Serbia, Belgrade, awake craniotomy intervention was started in 2017. We developed our protocol for anesthesia in these patients. This protocol can be classified as "asleep-awake" with induction into general endotracheal anesthesia, awakening before tumor removal, and awakening during tumor removal and skull closure or Dexmedetomidine use for agitated and restless patients (7,9).

After a neurologist and neuropsychologist prepare the patient for intraoperative speech testing (speech mapping) (10,11), he/she is admitted to our clinic.

### Premedication

On the day of the neurosurgical intervention, the patient will get premedication before the transfer to the operating theater. It consists of benzodiazepine, Diazepam, in a dose of 10mg intramuscularly (IM). Atropine in a dose of 0.5mg IM should be considered because of side effects, but it has antisialogogue which is desirable for awake craniotomy. The antibiotic for antimicrobe prophylaxis which we use is a cephalosporin belonging to the 1st or the 3rd generation (Cefazolin, Ceftriaxone) intravenously (IV). Patients should also take their oral antiepileptics.

After admission to the operating theater, the patient is prepared for induction into general endotracheal anesthesia (GA) (10,12). One intravenous cannula is placed into the arm's peripheral vein. ECG monitoring, non-invasive blood pressure measurement, and pulse oximetry were initiated. Bispectral index (BIS) monitoring for the level of consciousness follow-up is started (1,2,4).

Before induction, Ondansetron 4mg IV (antiemetic action), Metilprednizolone 40-80mg IV (anti-inflammatory action), Pantoprazole 40mg IV (decreased risk of regurgitation), and Lidocaine 40mg IV (blunted response on endotracheal intubation) are administered.

### Induction

After 3-minute preoxygenation with a mask, induction into GA is initiated with the following doses of anesthetics and relaxants: Midazolam 2.5-5mg IV, Fentanyl 50-100µg IV, Propofol 1.5-2mg/kg IV, Rocuronium 50-70mg IV. When conditions for endotracheal intubation are met, the patient is intubated with an armored tube of the appropriate size. Controlled mechanical ventilation is initiated with capnography. After the fixation of the tube with sticky tapes, the throat pack is performed for additional securing of the tube position. Before starting the intervention, intraoperative heating of the patient is initiated to prevent hypothermia and intraoperative shivering (13,14).

### Maintenance

When the patient is induced into GA, an additional intravenous cannula is placed together with an arterial cannula into the radial artery and a urinary catheter. BIS value is maintained between 40 and 60.

The patient is positioned on the right (in most cases) or the left side, with the head fixed by Mayfield pins. Intubation in the case of failed emergence should be possible in that position (1-3). The eyes are protected with pads. The skin points of pin placement are infiltrated by sub-

cutaneous 2% Lidocaine injections (2ml for every point). A bilateral scalp block with 0.25% Bupivacaine and Epinephrine 1: 200 000 is done (with a total of 30 ml of solution), then a Mayfield frame is placed for head fixation (15). Seven nerves on either side of the scalp are infiltrated with local anesthetic: supraorbital nerve, supratrochlear nerve, zygomaticotemporal nerve, auriculotemporal nerve, lesser occipital nerve, greater occipital nerve, and greater auricular nerve (15). After infiltration, the operative field is cleaned and disinfected, and the head is covered with sterile drapes.

Anesthesia is maintained with a continuous infusion of Propofol at 75-200 µg/kg/min and Remifentanyl at 0.2-0.3 µg/kg/min, with a BIS value of 40-60, from the skin incision until the skull is fully opened and the dura mater is incised (16,17). Prior to incision, the dura mater is soaked with 2% Lidocaine solution (1). Once the brain cortex is exposed, the patient is prepared for awakening

## Emergence

Emergence (awakening) is the most complex part of anesthesia in these patients. The infusion of Propofol and Remifentanyl is discontinued. We wait for an increase in BIS value to 80, then the dose of Flumazenil 0.2 mg IV (reversion of residual Midazolam action) is administered. If the patient exhibits insufficient breathing, Naloxone is administered intravenously at a dose of 0.2 mg. When the patient is awake, obeys commands, and breaths sufficiently, extubating is performed. Following extubation, the patient is oxygenated using a nasal cannula, while capnography is simultaneously monitored with Capnostream (16). Hemodynamic stability is maintained, as well as appropriate oxygenation.

If emergence fails, we should consider intubation of the patient by video laryngoscope. The operation is continued without speech mapping.

After tumor removal and during the closure of the

skull, the patient stays awake or can fall into spontaneous sleep until the end of the intervention. If the patient is agitated or disturbed, continuous infusion of Dexmedetomidine (2,7,9) can be initiated in a dose of 0.2-0.7 µg/kg/h. If the patient is hypertensive, a bolus of 12.5 mg IV Urapidil can be administered followed by continuous infusion of an average dose of 9 mg/h (1-3). If seizures occur after awakening, cold normal saline irrigation of the brain should be done. If cold saline irrigation is ineffective for seizure cessation, boluses of Propofol 10-20 mg IV or Midazolam 1-2 mg IV should be administered (1). Endotracheal intubation should be considered in these cases.

After the speech test is finished and extirpation of the intracranial lesion is completed, the closure of the skull is initiated. Additional dura mater irrigation with 2% Lidocaine can be done. In case of pain, a Remifentanyl infusion at doses of 0.01-0.05 µg/kg/min can be initiated, and nonsteroidal anti-inflammatory analgesics or Tramadol 50 mg IV may also be administered. After dura mater closure, antiepileptic Phenobarbitone 220 mg IM is administered. At the end of the operation, the patient is transferred to the intensive care unit for postoperative monitoring.

## CONCLUSION

Anesthesia for awake craniotomy can be managed in different ways. The “asleep-awake” protocol provides good conditions for neurosurgical intervention (awake and cooperative patient for speech mapping) and can influence functional outcomes.

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## ANESTEZIJA ZA KRANIOTOMIJU U BUDNOM STANJU- PRINCIPI IZVOĐENJA

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### Sažetak

Kraniotomija u budnom stanju je intervencija koja se koristi tokom operacije intrakranijalnih tumora blizu Brokine i Vernikeove govorne zone. Tokom ove intervencije vrši se mapiranje govornih zona. Kraniotomija u budnom stanju zahteva anesteziju za kraniotomiju u budnom stanju koja uključuje različite mogućnosti za njeno izvođenje, pri čemu je pacijent budan tokom ekstirpacije tumora. Postoje dva opšte prihvaćena koncepta za izvođenje anestezije: engl. *awake-awake-awake*, pri čemu

je pacijent budan ali u plićoj ili dubljoj sedaciji sve vreme tokom hirurške intervencije (engl. *monitored anesthesia care*) ili engl. *asleep-awake-asleep*, kada je pacijent uveden u opštu endotrahealnu anesteziju za samu kraniotomiju (otvaranje) ali je budan tokom same ekstirpacije tumora, a u anesteziji je tokom zatvaranja. Naš protokol je oblik engl. *asleep-awake* koncepta, sa opštom anestezijom tokom kraniotomije i budnim pacijentom tokom i posle ekstirpacije tumora i zatvaranja lobanje.

**Ključne reči:** kraniotomija u budnom stanju, anestezija, mapiranje govora, awake-awake-awake, asleep-awake-asleep

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