AWAKE CRANIOTOMY ~~GUIDE –~~ A *QUICK OVERVIEW*

Preoperative Area:

- Establish rapport early. Avoid term "awake" craniotomy; instead, highlight that sedation will be titrated according to procedure goals and to maintain comfort. This is a team effort (patient, surgeons, anesthesiologists, nurses)
- Reiterate the anesthetic goals– we want them to be alert and able to participate during mapping
- Confirm home AED dose and if taken on day of surgery
    - AED prophylaxis and any additional Keppra doses should be discussed with surgeons and neuromonitoring (IOM) team during the huddle
- Acetaminophen 975mg po before transport (Alternative: IV intraoperatively~~op~~)
- Establish IV access (large bore catheter not initially needed)
- Titrate small doses of midazolam (0.5-1.0 mg boluses to max of 2 mg)
- ~~Consider meperidine (5-10mg boluses to max of 50 mg) during transport to OR and shortly after arrival~~

Intraoperative (Before awake testing):

- Apply monitors ASAP in OR, check for bradycardia and conduction defects
- Consider Dexmedetomidine load (0.5 mcg/kg-1.0 mcg/kg over 10 minutes) followed by infusion, OR, infusions of propofol (20-120 mcg/kg/min) and remifentanil (0.001-0.005 mg/kg/min).
- ~~Give Dexmedetomidine load (0.5 mcg/kg-1.0 mcg/kg over 10 minutes)~~
    - ~~Start when patient gets on OR table. Delay any intervention until half of the load is in~~
- Ondansetron (4 ~~8~~ mg IV) and aprepitant (32 mg IV) early in the case (can be given in the preoperative area, but definitely prior to dura manipulation)
    - ~~Repeat as needed every six hours throughout the case~~
- Alert the patient in advance of uncomfortable events (foley insertion, local anesthesia injection): supplement with small doses of propofol/fentanyl
    - Most attendings use 20-30 mg of propofol for these events. Beware of disinhibition, airway obstruction, or apnea
    - Warn patient about drill vibration and noise in advance, encourage them to keep their mouth open to prevent teeth chattering
- Maximize patient comfort (consider patient positioning, moist sponge for dry mouth)
- For lateral positioning, consider Lidoderm patch on the dependent shoulder (over or near deltoid)
- Placement of additional IV after patient is well sedated. Arterial line should be considered at this time but is not required in otherwise uncomplicated awake craniotomies.
- ~~Insert arterial line and additional IV after patient is well sedated~~
- Local anesthetic is your friend (pin sites, surgical incision)
- Ensure that you are visible to the patient after setup is complete
    - Use a triangle or instrument stand to keep the drapes off the patient's face.
    - Consider nasal cannula with CO_2 monitoring (Salter) ~~instead of~~or ~~a~~ face mask, using benzoin and Tegaderm to secure to the face)
- Continue ~~dexmedetomidine~~ infusions (propofol, remifentanil, or dexmedetomidine)~~(0.2-0.7 mcg/kg/hr)~~
    - Slowly decrease ~~dex~~ infusion rate during exposure~~opening~~
- Administer loading Keppra dose prior to opening of the dura
- ~~Consider small doses of fentanyl or a remifentanil infusion during opening of the dura~~
- Stop all medications and infusions as bone flap comes off. Remifentanil infusion can be continued until dura is opened
    - Goal of anesthetic is to avoid confounding the language mapping with sedatives

Intraoperative (Awake phase):

- Be prepared for possible seizure activity with propofol and midazolam in line
- Coordinate with the IOM team regarding sedation, mapping, and cortical activation

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Intraoperative (Post-awake phase):

- After monitoring is complete, consider:
  - ~~Reinitiation of propofol, remifentanil, or dexmedetomidine infusions~~
  - ~~Possible to repeat dexmedetomidine load (0.25 mcg/kg over 10 minutes)~~
  - ~~Repeat dexmedetomidine load (0.25 mcg/kg over 10 minutes)~~
  - ~~Meperidine/fentanyl/hydromorphone in small doses~~
- Most patients are exhausted and fall asleep with little intervention; consider music as a distractor or holding the patient's hand
- Plan induction and airway management if converting to GA for intraoperative MRI

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Overall Goals:

- Optimize patient outcome through greatest extent of tumor resection
- Minimize functional deficits with the aid of neuromonitoring

Indications for "Awake" Craniotomy:

Speech/language mapping (most common):

Intra-operative direct brain stimulation to map the eloquent areas of brain (Wernicke's and Broca's areas) in relation to lesions (tumors or epileptic foci)

Endpoint: speech disruption or arrest to help determine safe extent of resection

Motor mapping:

Intra-operative direct brain stimulation to determine lesion location in relation to primary motor cortex (Brodmann's area 4)

Endpoint: twitching of muscles of face, arm, or leg, detected by visual inspection of movement and/or motor evoked potentials

Advanced cardiac and/or pulmonary disease:

Co-morbid conditions conferring significant risks of general anesthesia.

Surgeon/patient preference:

Surgeon and/or patient preference
Lesions needs to be easily and quickly resectable, superficial, avascular

Contraindications for the "Awake" Craniotomy:

- Patient Refusal
- Difficult Airway or Intubation (Known or Anticipated)

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- Patient Unable to Cooperate (Baseline cognitive or behavioral dysfunction)
- Communication Barriers
    - Usually secondary to tumor, stroke, or other neurologic process
    - Mapping can be safe and successful with the aid of an interpreter if English is not the primary language. Can also use an interpreter for patients who speak multiple languages

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Basic Functional Anatomy:

Broca's Area (Brodmann Area 44 & 45)

- Brain region associated with *speech production*
- Location: cortex of the dominant frontal lobe (inferior frontal gyrus)
- Dominant lobe is the left in 95% of right-handed individuals and 70% of left-handed individuals. This can be confirmed by functional MRI
- Damage characterized by hesitant and fragmented speech, with little grammatical structure
- Testing causes speech interruption when patient asked to name items
    - Broca's Aphasia, aka, Expressive aphasia

Wernicke's Area (Brodmann Area 22)

- Brain region associated with *language comprehension*
- Location: cortex of the dominant temporal lobe (posterior aspect of superior temporal gyrus)
- Damage characterized by superficially fluent, grammatical speech
- Testing disrupts use or understanding of more than the most basic nouns and verbs
    - Wernicke's Aphasia, aka, Receptive aphasia

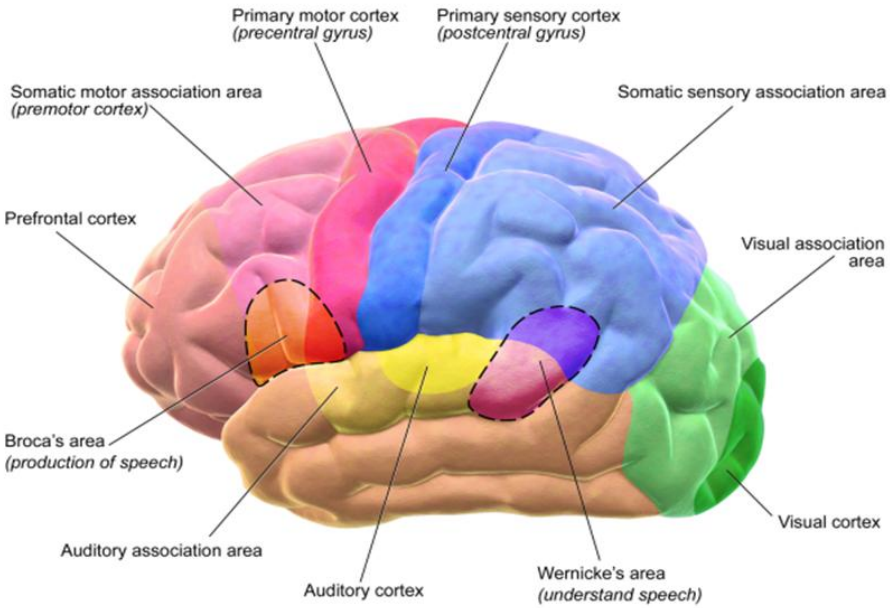

Image 1. Brain surface anatomy

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Primary Motor Cortex (Brodmann Area 4)

- Brain region associated with *motor production*
- Location: precentral gyrus of the frontal lobe
- *Homunculus*: Latin for "little person", used to describe the distribution and representation of fibers within primary motor (red) and sensory (blue) cortex (Image 2)
- Damage characterized by weakness on contralateral side
- Testing causes inability to move the affected area

Primary Somatosensory Cortex (Brodmann Areas 1-3)

- Brain region associated with *sensation*
- Location: postcentral gyrus of the parietal lobe
- Damage characterized by lack of sensation in affected region
- Testing causes increase in latency or decrease in amplitude of somatosensory evoked potentials (SSEP)

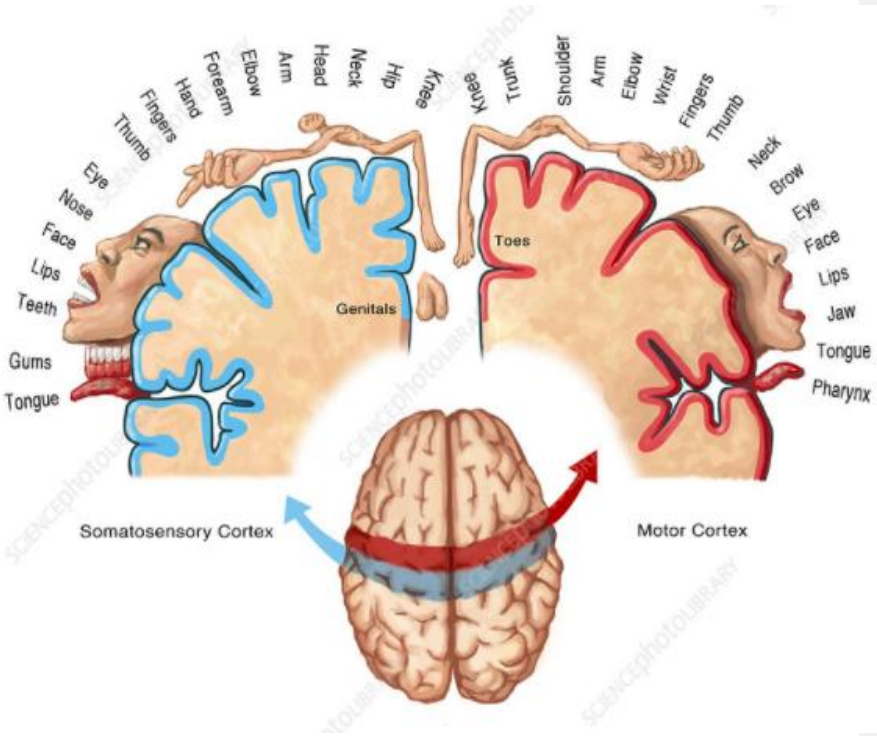

Image 2. Cortical homunculus: motor (red) and somatosensory (blue)

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Anesthetic Management:

Patient Selection:

- Needs to be cooperative, highly motivated, and understand the goals of the procedure
- Must understand the management of sedation appropriate to achieve those goals
- Airway must be manageable under the drapes
- Patient must be able to communicate with providers; ensure access to hearing aids and reading glasses
    - If patient is bilingual or English is not their primary language, the case can be done with the help of an interpreter

Preoperative Assessment:

- Establish Rapport: this is essential for a positive experience and outcome
- Avoid the terminology "awake" craniotomy; instead, like a MAC, discuss with the patient that sedation levels will vary as needed throughout stages of surgery
- Airway exam: assess for neck flexion/extension, other features of difficult airway. Review records of prior anesthetics, if available.

Intraoperative Approach:

Three Phases of Surgery:

1) Pre-Awake/Testing Phase:
    a. Can be done either awake with sedation or under general anesthesia with an ET tube or LMA. At MGH, typical practice is awake with sedation.
    b. Deepen sedation for placement of Foley catheter, local anesthetic injection, and Mayfield head holder (consider small doses of propofol (10-30 mg)). It is essential to avoid airway obstruction or respiratory depression

2) Awake/Testing Phase:
    a. Important to limit sedation to allow for mapping. Provider should reduce or discontinue sedation when bone flap is removed or dura is opened

3) Post-Awake/Testing Phase:
    a. After completion of testing, can continue under sedation or induce general anesthesia
    b. Patients tend to be tired, often fall asleep by themselves
    c. If planning on post-resection intraoperative MRI, induce GA and intubate patient while "in pins." Consider using intubating LMA

Anesthetic Management

Airway:

- Consider impact of rigid head fixation, "pins". Head position must accommodate:
    - Surgical exposure
    - Patient's ability to participate in functional testing
    - Airway access for effective mask ventilation and LMA insertion

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- Position a triangle and/or instrument stand to uncover face and facilitate access to airway
- For oxygen delivery, utilize a Salter nasal cannula with capnography monitoring or face mask (benzoin and Tegaderm to secure to face, since nasal cannula cannot loop posterior to ear on operative side)
- Have an LMA readily available for emergency insertion
    - Trachea can be intubated through the LMA

Image 3. Positioning of instrument stand and triangle to allow access to airway and participation in functional testing

Sedation and Medications:

- Patient MUST be awake and interactive for functional testing shortly after the dura is opened
- Administer antiemetics upfront (nausea from dura manipulation/narcotics)
- Avoid mannitol & furosemide (dehydration/thirst are poorly tolerated)

1) Propofol (titrate small doses, e.g. 10-20 mg)
    a. Advantage: fast onset/offset
    b. Disadvantage: disinhibition, respiratory depression, airway obstruction
2) Remifentanil
    a. Advantage: fast onset/offset
    b. Disadvantage: respiratory depression
3) Fentanyl
    a. Advantage: fast onset of analgesia
    b. Disadvantage: respiratory depression, dose dependent
4) Midazolam (titrate small doses; e.g. 0.5 mg)
    a. Advantages: anticonvulsant, sedation without much respiratory depression
    b. Disadvantage: slow offset
5) ~~Meperidine~~
    ~~a. Advantage: analgesia, euphoria~~
    ~~b. Disadvantage: respiratory depression, slow offset~~
        ~~i. Metabolite may provoke seizures in large doses~~

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~~6)~~5) Dexmedetomidine
   a. Advantage: sedation without respiratory depression
   b. Disadvantage: slow onset/offset (load over 10 minutes), hemodynamic side effects (bradycardia, heart block, hypertension with loading dose, hypotension occasionally seen after loading)

MGH Typical Plan:

Preoperative Area:
- Acetaminophen 975mg po before transport (if missed, consider IV intraoperatively)
- Establish IV access (large bore catheter not initially needed). I
- Titrate small doses of midazolam (0.5-1.0 mg boluses to max of 2 mg) ~~and meperidine (5-10 mg boluses to max of 50 mg)~~ during transport to OR and shortly after arrival

Intraoperative (Pre-awake testing):
- Apply monitors ASAP in OR; check for bradycardia and conduction abnormalities
- Consider Dexmedetomidine loading (0.5 mcg/kg-1.0 mcg/kg over 10 minutes) OR initiation of infusions of propofol (20-120 mcg/kg/min) and remifentanil (0.001-0.005 mg/kg/min).
  - ~~Delay any intervention until patient receives half of the load~~
- Ondansetron (4 ~~8~~ mg IV) and Aprepitant (32 mg IV) early in the case (can be given in the preoperative area, but definitely prior to dura manipulation)
  - Repeat as needed every six hours throughout the case
- Predictable uncomfortable events (foley insertion, local anesthesia injection): supplement with small doses of ~~meperidine/~~propofol/fentanyl
  - Most attendings use 20-30 mg of propofol for these events. Beware of disinhibition, airway obstruction or apnea
- For patients in lateral position, consider placement of Lidoderm patch on dependent shoulder (over or near the deltoid)
- Placement of ~~Insert arterial line and~~ additional IV after patient is well sedated. Arterial line should be considered at this time but is not required in otherwise uncomplicated awake craniotomies.
- Continue infusions (Dexmedetomidine ~~infusion (~~0.2-0.7 mcg/kg/hr, remifentanil, or propofol); slowly decrease infusion rate during exposure ~~opening~~
- Stop all infusions as bone flap comes off. Remifentanil infusion can be continued until dura is opened
  - ~~Consider small doses of fentanyl or remifentanil for opening the dura~~
  - ~~Consider preparing a remifentanil infusion in advance~~
  - ~~Stop Dexmedetomidine infusion and all other medications as bone flap comes off~~

Intraoperative (Awake phase):
- All medications and infusions should be discontinued for this phase if tolerated by patient

Intraoperative (Post-awake phase):
- After monitoring is complete, consider:

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    - Repeat dexmedetomidine load (0.25 mcg/kg over 10 minutes)
    - ~~Midazolam in small doses~~
    - ~~Meperidine/fentanyl/hydromorphone in small doses~~Reinitiation of propofol/remifentanil infusions
- Most patients are exhausted and end up falling asleep with little intervention during this phase
- Plan induction and airway management if converting to GA for intraoperative MRI

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Intraoperative Challenges and Potential Problems

1) Seizure: direct stimulation of cortex during mapping can lead to a seizure
    a. Confirm preoperative AED regimen and AM dose
    b. Load AEDs early, confirm total dose with neuromonitoring team and surgeon
    c. Iced saline on scrub table during intraoperative mapping; primary treatment for cortical activation or early seizure activity
    d. Small doses of propofol (10-20 mg) or midazolam (1 mg) for sustained seizure activity after iced saline; should be in line during mapping
2) Bleeding
3) Air Embolus
    a. Negative pressure respiration; may present with cough or dyspnea
4) Respiratory Depression or Airway obstruction
    a. Avoid oversedation
5) Patient Discomfort
    a. Nausea
    b. Thirst
    c. Dura is difficult to anesthetize with local anesthetic; consider brief remifentanil infusion
    d. Alert the patient in advance of uncomfortable events (foley insertion, local anesthesia injection, drill vibration and noise)
        i. Consider small boluses of propofol for these
6) Bradycardia
    a. Can progress to sinus arrest, especially during retraction of the dura