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Intraoperative Neurophysiologic Monitoring: Cranial Nerve Monitoring

Sarah Chandler, AuD

IONM Cranial Nerve Monitoring

- Employed by OR Monitoring Consultants, Inc.
- Audiology Online provides honorarium for teaching webinars.
- No other financial disclosures.

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IONM: Cranial Nerve Monitoring

- **An overview of the most common cranial nerve monitoring applications in the operating room.**
- **Techniques for recording, interpreting, and optimizing cranial nerve activity and function in the operating room.**

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IONM: Cranial Nerve Monitoring

- As a result of this course, participants will be able to:
  - Describe the two most common methods of monitoring cranial nerves in the operating room
  - Choose the most appropriate method of monitoring for each of the most commonly monitored cranial nerves
  - Name three or more challenges to obtaining good data for cranial nerves

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IONM Cranial Nerve Monitoring

- Cranial Nerve Anatomy
- Sensory vs. Motor vs. Mixed
- Basic Methods of Monitoring
- Matching Method to Specific Surgical Risks
- Challenges to Obtaining Good Data
- Questions?

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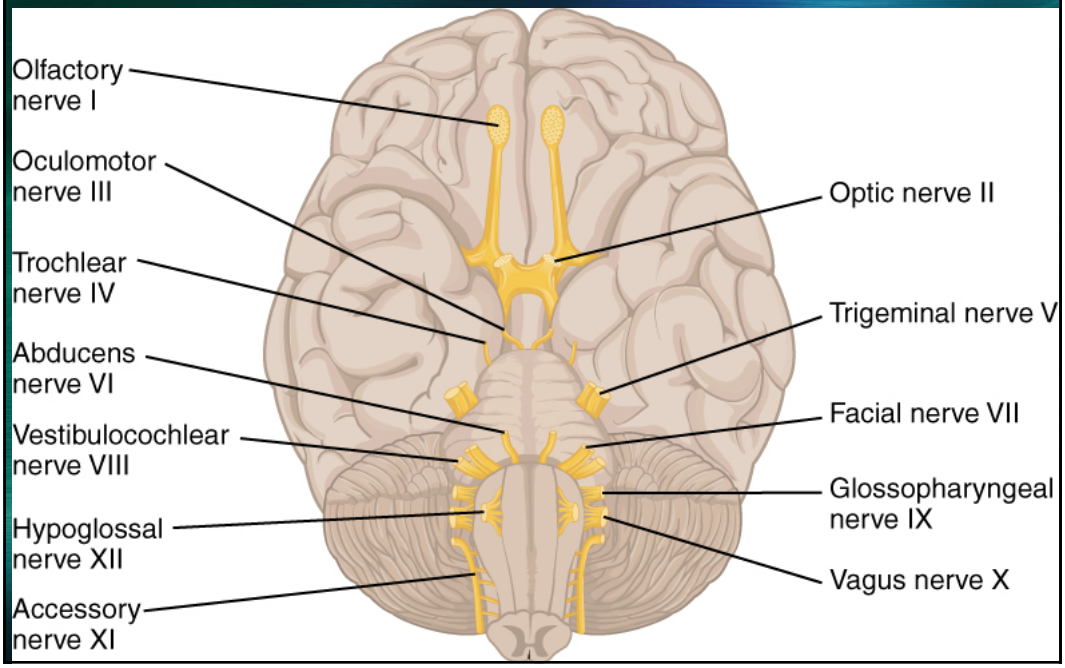
Cranial Nerve Anatomy



Cranial Nerve Anatomy (details)

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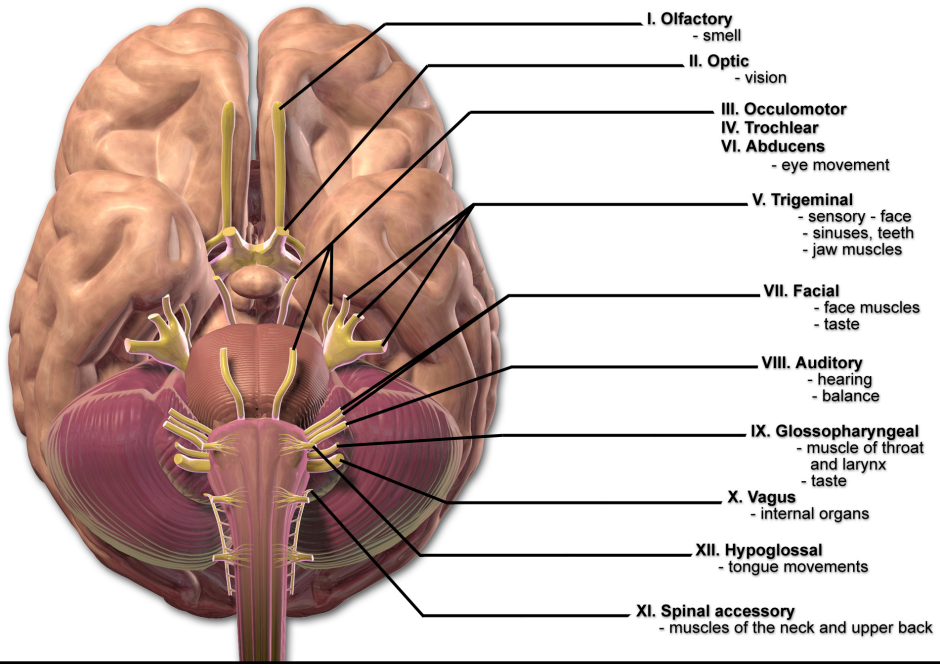

Sensory vs Motor vs Mixed

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- Sensory Nerves
  - Exclusively receive sensation and transmit towards brain
  - Sound*, Sight, Smell
- Motor
  - Exclusively receive motor impulses and send those to muscles
- Mixed
  - Some of both

*Essentially

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Sensory Nerves

- Injury does not create spontaneous potentials
- Must evoke a response in a sense organ to evaluate function
- CNII Visual Evoked Potentials (VEP)
  - Uncommon
- CNVIII Auditory Brainstem Response (ABR)
  - Common in Internal Auditory Canal and Brainstem tumor cases

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Motor Nerves

- When injured, action potentials occur and can be detected by electromyography (EMG)
- Simpler setup than Sensory Evoked Potentials

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Mixed Nerves

- EMG is easier, so it is generally used in cases of mixed nerves.
- Stimulation of the skin (sense organ) using dermatomes can be unreliable and has largely been abandoned.

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Basic Methods of Monitoring

PLEASE NOTE:

- Due to the target audience of AudiologyOnline.com and the intermediate level of this presentation, I have assumed all attendees have basic familiarity with the Auditory Brainstem Response and how to collect the response clinically.
  - AudiologyOnline.com has several excellent CE programs on ABR if you are unfamiliar with collecting an ABR.
  - For a review of basic acquisition and Analog/Digital Filtering of those signals, the first presentation in this series will be available as a recorded course in the near future.

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Basic Methods of Monitoring

- Evoked Potentials (EPs)
  - Evoke a response by stimulating a sensory organ and recording a single or averaged response following in the response chain, often at sites in the central nervous system
    - Visual Evoked Potentials (VEP)
    - Somatosensory Evoked Potentials (SSEP or SEP)
    - Auditory Evoked Potentials (ABR or AEP or BAER)
- Electromyography (EMG)
  - Detection of the electrical potential generated by muscle cells when the cells are activated.
- Transcranial Evoked Potentials (TcMEP or TCMEP)
  - Not commonly used in cranial nerve monitoring

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Basic Methods of Monitoring: Evoked Potentials

- Visual Evoked Potentials for CNII
  - Goggles with Flashing Lights
    - Uncommon
    - As opposed to checkerboard commonly used clinically
    - Eyes open for stim risks corneal abrasion
  - Keep unwieldy goggles steady
    - Tape fails and rubber band is in the way
  - Recorded over occiput and stimulated over eyes
    - Difficult to position in a way that both are steady and site of operation is available
  - Kodama, et al 2010 in Acta Neurochir indicated it may become more common, at least in Japan

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Basic Methods of Monitoring: Evoked Potentials

- Auditory Evoked Potentials (ABR/AEP/BAER)
  - Bilateral Insert Earphones for masked response
  - Use bone wax to keep in the ear, or tape if bone wax unavailable
  - Needle electrodes anterior to tragus and at Cz, can do Fpz (high forehead) if necessary
  - Limited access once procedure starts, so it has to be right the first time or you'll be crawling under a table with saliva dripping down

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Basic Methods of Monitoring: Evoked Potentials

- Auditory Evoked Potentials (ABR/AEP/BAER)
  - Only need 50-100 sweeps to see if you are getting responses, more is better
  - Latency shift usually occurs before amplitude drop
  - Alternating Polarity
    - Try Condensation to identify Wave V
    - Rarefaction if that doesn't work
    - Whatever you have at baseline, stick with it
  - Recording: 150-1500 Hz filter, 5µV sensitivity
  - Stimulus: 17.1/sec, 100µs, 80-100dBHL

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Basic Methods of Monitoring: Evoked Potentials

- Auditory Evoked Potentials (ABR/AEP/BAER)
  - Interpeak I-V widens as sensation reaches cochlear generators (I) at consistent timing, but area before brainstem (V) slows down signal due to:
    - Temperature shift from air
    - Temperature shift from irrigation
    - Stretching of nerve during exposure or tumor resection
    - Tearing of nerve while peeling away tumor
    - Cutting or "sacrificing" the nerve

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Basic Methods of Monitoring: Electromyography

- Anesthetized Patient should not be moving voluntary muscles (Anesthesia Provider)
- A pair of subdermal needle electrodes is placed in a single muscle, creating a circuit
- Await a polarity change (Action Potential)
- Polarity change (Action Potential) is created by:
  - Thermal Changes
  - Mechanical Activity
  - Electrical Stimulation
    - Either direct stimulation or nearby electrocautery

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Basic Methods of Monitoring: Electromyography

- Expected Responses: Good or Troubleshooting
  - No activity
    - Best case for patient
  - Electrical Artifact
    - Troubleshoot for electrical artifact (later slides)
  - Myogenic Artifact
    - Light anesthesia
    - Anecdotally, starts on frontalis or depressor first

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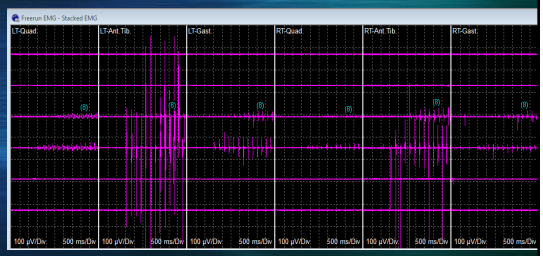
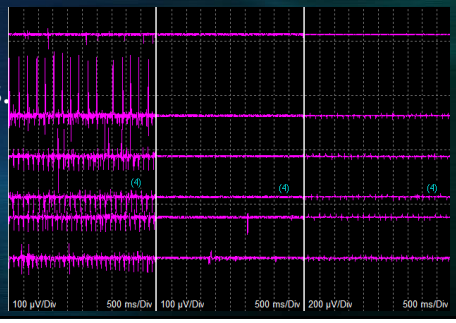
Basic Methods of Monitoring: Electromyography

Expected Responses: Injury

- Burst
  - Biphasic, single or just a few synchronous responses



- Training
  - Constant biphasic, even action potentials.
  - Sounds like popcorn popping



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Basic Methods of Monitoring: Electromyography

- Direct Nerve Stimulation
  - Forces an electrical potential
  - If response is seen in the corresponding muscle, the pathway is intact between site of stimulation and the muscle
  - You want to see a "Burst", but with a more reassuring cause
  - Stimulate at various points to check integrity
  - Especially important when injury may not be visually obvious, as with stretching and compression

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Basic Methods of Monitoring: Electromyography Sites

- V Trigeminal Nerve
  - Masseter
  - Temporalis
- VII Facial
  - Occipito Frontalis, Orbicularis Oculi, Orbicularis Oris, Buccinator, Mentalis, Depressor Labii
- X Vagus
  - Recurrent laryngeal branch, via Vocal Folds
- XI Spinal Accessory
  - Trapezius is common
- XI Hypoglossal
  - Tongue (rare, need hookwires and a willing physician)

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Matching Method to Risks

- Choose your Modality (EPs or EMG), based on sensory or motor/mixed nerve at risk.
- Choose your recording site for EMG based on which structures are innervated by that nerve.

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Matching Method to Risks: Mastoidectomy

- CNVII at risk where it exits the skull
- EMG of 4 branches is optimal, as all are at exit
  - Occipito Frontalis
  - Orbicularis Oculi
  - Orbicularis Oris/Buccinator
  - Mentalis/Depressor Labii

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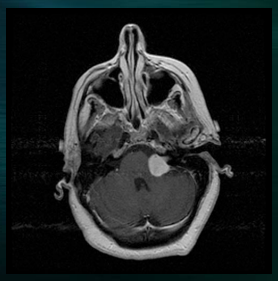
Matching Method to Risk: CPA Tumor Resection

- Acoustic Neuroma / Vestibular Schwannoma
- Retro-sigmoid approach
  - Surgeon gives up CNVII visual to save cochlea.
  - Goes in "blind" to position of CNVII
    - If middle ear is breached, conductive loss is created as space fills with irrigation and/or blood
- Translabrynthine approach
  - Hearing is sacrificed



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Matching Method to Risk: CPA Tumor Resection

- Acoustic Neuroma / Vestibular Schwannoma
- CNVII Both retrosigmoid approach and resection can endanger VII
  - EMG on 4 branches of Facial is optimal
  - If channels are needed for other monitoring, or other contraindication, at least a major upper and major lower branch
- CNVIII: Always endangered in these cases, but severity of danger depends on the approach
  - Assume monitoring for all retro-sigmoid approaches, ask surgeon if desired in translabrynthine approach

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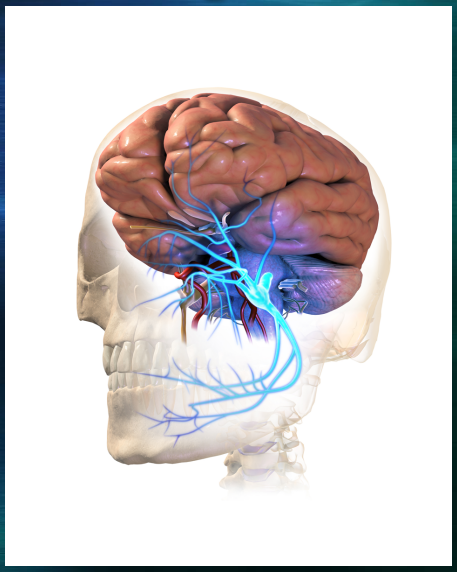
Matching Method to Risk: Trigeminal Neuralgia

- Also called tic douloureux, chronic pain of the face
- Compression of the nerve, causes pain sensations and can erode the myelin sheath
- Microvascular decompression
- Decompress the nerve and place a sponge between CNV and cause of compression



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Matching Method to Risk: Trigeminal Neuralgia

- Monitoring:
  - V – Masseter
  - VII – to differentiate between any irritation to the two nerves
    - Occipito Frontalis
    - Orbicularis Oculi
    - Orbicularis Oris/Buccinator
    - Mentalis/Depressor Labii

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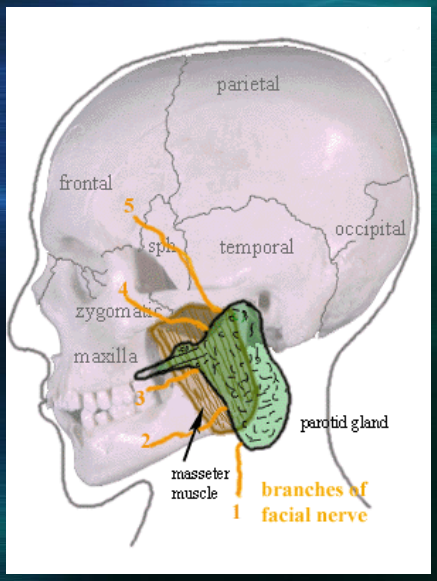
Matching Method to Risk: Parotidectomy

- Facial nerve runs through parotid, but does not innervate the gland.
- VII – to differentiate from surrounding tissue
  - Occipitofrontalis
  - Obicularis Oculi
  - Orbicularis Oris/Buccinator
  - Mentalis/Depressor Labii
  - Direct Nerve Stimulation vital
    - Use Direct stimulation by monopolar probe. Anode in Trapezius area.



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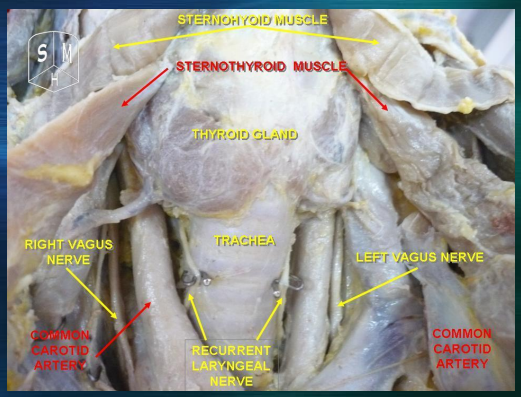
Matching Method to Risk: Thyroidectomy

- Recurrent Laryngeal Nerve Runs up to Thyroid gland
- Used to use hookwires in the vocal folds to monitor for activity.
  - Surgeons didn't want to place hookwires
  - Audiologists didn't want to place hookwires
  - Anesthesiologists didn't want to place hookwires
  - Risk of hematoma



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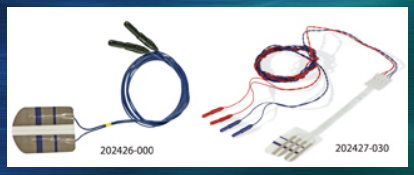
Matching Method to Risk: Thyroidectomy

- Apply surface electrode to endotracheal tube
- Surface electrode is more likely to slip, so proper security of the tube is even more vital than usual
- Can reference Left to Right in single channel or +/- on each side in dual channel
- Can be applied to typical tube, or purpose built into a tube (more expensive)



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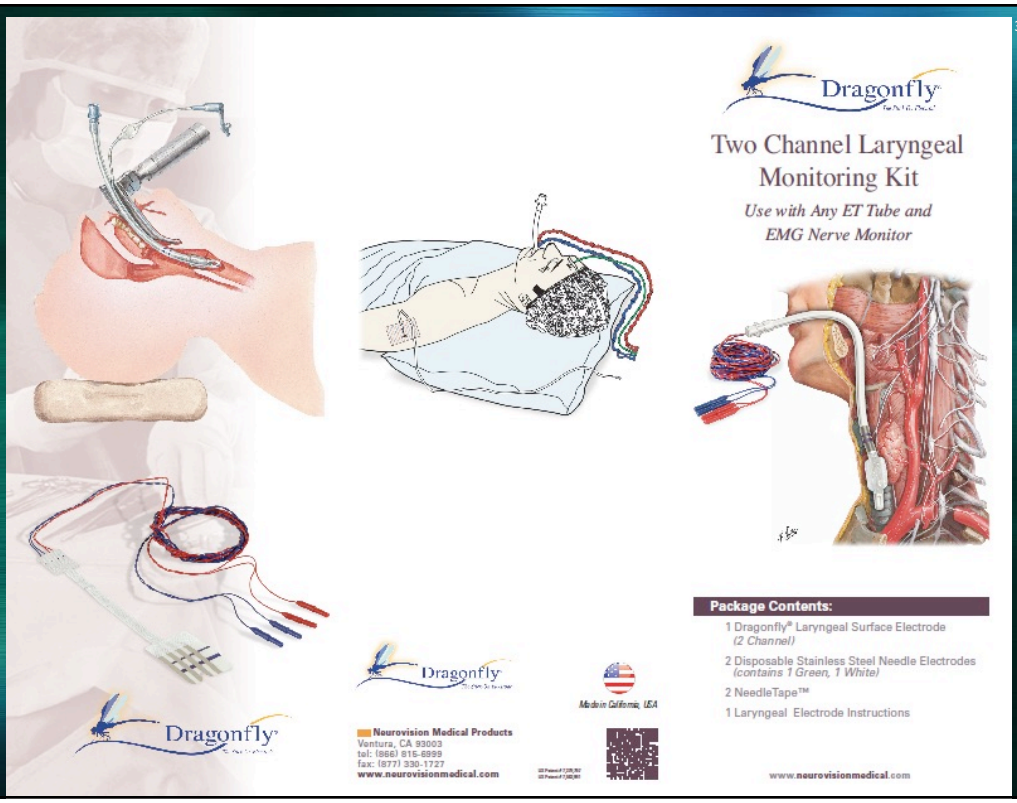

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Matching Method to Risk: Neck Dissection

- "Neck Dissection" on an order or OR schedule is a very broad term
  - A partial neck dissection may only endanger one or two nerves
- A discussion with the surgeon is vital to appropriate monitoring of neck dissections
  - Surgeons typically rely on provider to decide what is appropriate, but in this case, only the surgeon knows the actual areas that will be addressed
- Excessive monitoring may not be covered by insurance and includes invasive piercing of the skin that is not necessary or helpful

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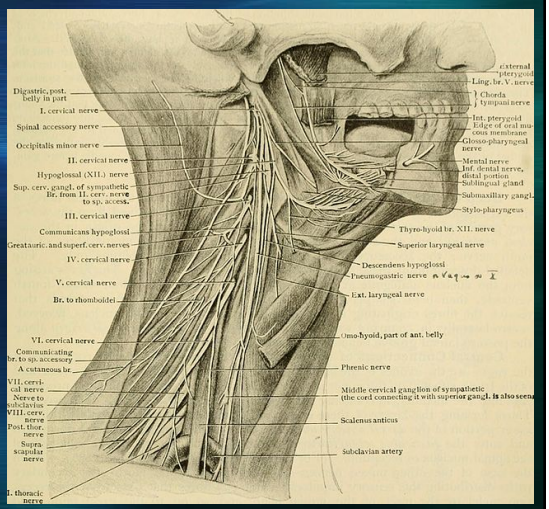
Matching Method to Risk: Neck Dissection

- V: Trigeminal
  - If very high up
- VII: Facial Nerve
  - Anywhere near jawline
- X: Recurrent Laryngeal Nerve
  - If anterior /near hyoid
- XI: Accessory
  - If mid-neck or below
- Again, vital to consult surgeon on what areas will be at risk



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Challenges in obtaining good data: The Ideal Room

- This room is ideal
  - (assuming the electrical circuit the lights are on is properly grounded and shielded)

- Nothing is plugged in
- No patient to cause problems
- Not sterile, so you can put your equipment anywhere

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Challenges to Obtaining Good Data

- Electrical
- Anesthetic
- Positioning
- Patient Factors
- Sterility

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Challenges to Obtaining Good Data: Electrical

Electrocautery

- Bovie
- Bipolar

- Exponentially larger electrical signal compared to sensory and emg readings
- Larger than ABR by 10^{10}

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Challenges to Obtaining Good Data: Electrical

Cords

- Parallel alignment can amplify field interference
- Reduce interference by using perpendicular crossing and space between cords that are active

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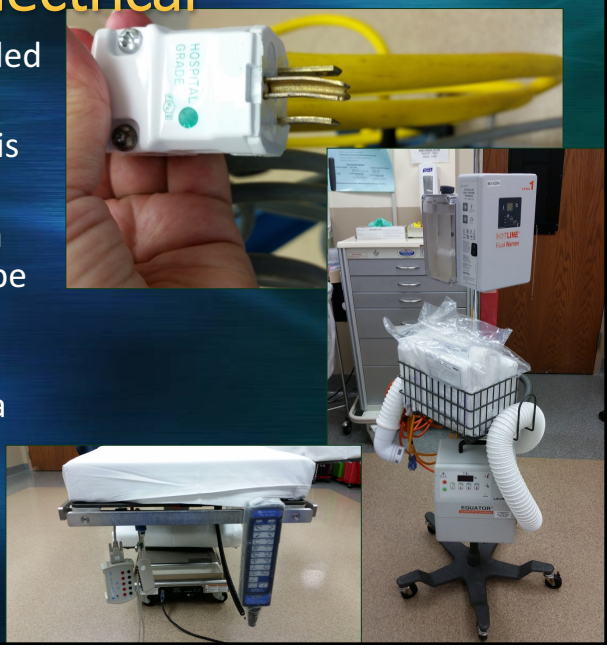
Challenges to Obtaining Good Data: Electrical

Poorly Insulated or grounded equipment

- A nearby fluid warmer is always suspicious
- Bed power cords take a beating and can often be partially plugged in, creating leakage
- Bed controls also take a beating and have only minimal shielding



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Challenges to Obtaining Good Data: Anesthetic

Disclaimer:

The following summary is not exhaustive and deals with only those anesthetic agents typically seen in the midwestern, suburban, private hospitals and surgery centers our practice serves.

For a more complete exploration of Anesthesia and it's effects on neuromonitoring, see Todd Sloan's papers.

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Challenges to Obtaining Good Data: Anesthetic

Anesthesia Team Goal:

- Unconscious state (and amnesia)
  - Stuff of nightmares
- Analgesia (lack of pain response)
  - Could cause reflexive actions
  - Increased blood pressure
- Muscle Relaxation
  - No one wants the patient to move while a sharp object is inside their body.

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Challenges to Obtaining Good Data: Anesthetic

Anesthesia Team Arsenal:

- Intravenous Drugs
  - Primarily Paralytic of interest for Cranial Nerves
- Inhaled Drugs
- Topical Drugs

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Challenges to Obtaining Good Data: Anesthetic

Anesthesia Team Arsenal:

- Intravenous Drugs
- Neuromuscular Blocking Agents
  - Need some relaxant to intubate, according to most anesthesia providers
  - Any residual relaxant (aka paralytic) reduces the ability of muscle fibers to react to action potentials
    - Succinylcholine
      - Depolarizing, fast, short acting
    - Rocuronium or Vecuronium
      - Non-Depolarizing, intermediate acting
      - reversed by neostigmine or sugammadex

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Challenges to Obtaining Good Data: Anesthetic

Anesthesia Team Arsenal:

- Intravenous Drugs
  - Neuromuscular Blocking Agents
    - Reduces myogenic interference in SSEP (cervical)
    - May be fine during some portions of long spine exposures, even with EMG
    - Short-acting use during intubation is ok, as long as it wears off
      - Some reports of common intubation paralytics not wearing off in a timely fashion
    - Check Train-of-Four
      - Looking for “4 twitches” in response to stim, at least most fibers are responding

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Challenges to Obtaining Good Data: Anesthetic

Anesthesia Team Arsenal:

- Inhalant
- Volatile Gasses
  - Isoflurane, Sevoflurane, Desflurane
    - Can wipe out any Visual Evoked Potential response
    - ABR very resilient

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Challenges to Obtaining Good Data: Anesthetic

Anesthesia Team Arsenal:

- Topical Drugs
- Spray analgesic in trachea for intubation
  - Lidocaine is tracheal anesthetic
    - Fine in most cases
    - Often an *auto-pilot* move
  - *Contraindicated* in monitoring CNX/Recurrent Laryngeal nerve

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Challenges to Obtaining Good Data

- Positioning
  - Surgeon and First Assist will have hands on patient's face to brace during retraction.
    - Electrode artifact occurs and looks like a burst
  - Insert Earphones wiggle out in side-lying positions
    - Use bone wax or a lot of tape
  - Your best spot for the stimulator box is right where the surgeon or first assist is leaning on the bed

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Challenges to Obtaining Good Data

- Patient Factors
- Temperature
  - Hypothermia can slow nerve transmission
  - Air in room in open site 68°F
  - Irrigation at "room" temperature

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Challenges to Obtaining Good Data

- Patient Factors
- Size
  - Reaching muscle tissue beneath fat pad is generally manageable in face and Trapezius
- Pre-operative function
  - Blind patient
  - Patient with hearing loss may not have a click ABR

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Challenges to Obtaining Good Data

- Sterility
  - Have to have everything taped/hung *under* drapes.
  - May need an extension for electrodes, if you cannot hang equipment closely
  - Use tegaderms for areas that will be in the surgical field. These can be prepped and the tegaderm will still keep them steady

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Questions?

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AAB-IOM

- **What is the Value of Specialty Board Certification in IOM for an Audiologist?**
- *Surgeons, patients, credentialing bodies, health care facilities and employers can be assured that the audiologist who has achieved AABIOM board certification in IOM possesses specialized education, training and experience beyond that required for entry into the general profession (e.g., Ph.D., Au.D.) as well as the Certificate of Clinical Competence in Audiology [CCC-A]. Board certified audiologists in IOM possess an advanced understanding in this sub-specialty in audiology. They have met rigorous educational, practice and examination requirements and are required to maintain their board certification by demonstration of ongoing continuing education, ethical professional standing and valid licensure to practice.*

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