Lesionectomies, Lobectomies, Hemispherectomies... A Chance to Cut is a Chance to Cure!

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Disclosures

• I receive no money from industry.
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Objectives

• Explore various surgical options for medically refractory epilepsy.
• Review pertinent anatomy.
• Understand common complications related to surgery for epilepsy.
Epilepsy Surgery Basic Principles

- **Elective** surgery designed to reduce and/or eliminate seizures in pharmaco-resistant patients while minimizing risk of neurologic deficits.

- Design of surgery (cortical removal) based on EEG, semiology, anatomy (lesion) and often limited by cortical function.

- Other tests include MEG, SPECT, PET, intracranial EEG

- Outcomes approach 65% seizure freedom at 10 years.

- Most remain on anticonvulsant therapy.
Indications for Surgical Referral

• Pharmacoresistant: fail two drugs
• Ongoing seizures!
• Sooner the better:
  – 1 million people in US are candidates
  – 2000-2013 6200 cases performed
  – No increase in surgical referrals over past two decades.

Engel J. The Current Place of Epilepsy Surgery. Curr Opin Neurol April, 2018
Surgical Treatment of Epilepsy

• Classifications
  – Temporal vs. extratemporal
  – Hemispheric
  – Lesional vs. non-lesional
  – Adult versus pediatric

• Procedures:
  – Lesionectomy
  – Lobectomy
  – Multi-lobar
  – Hemispherectomy
  – Stimulation
Lobectomy

- Removal of a larger region ("lobe") of cerebral cortex defined by anatomic boundaries.
- Limited by functional cortex and unacceptable deficits.
- Examples include temporal and pre-frontal lobectomies.
- Large lobectomies becoming less frequent as imaging and invasive EEG serving to define more restricted resections.
Temporal Lobectomy

• Developed 1930’s to 50’s (Penfield/Jasper/Baldwin).
• Most common surgery performed world-wide.
• Characteristic syndrome (MTLE) with reproducible pre-operative data, surgical strategy, and post-operative outcomes.
• Exact surgical technique varies from center to center with little medical evidence to suggest one over another.
Class 1 Evidence Demonstrating Clear Benefit to Surgery


Resection Techniques Depend on Hypothesis

Mesial temporal lobe epilepsy from MTS
• Corticoamygdalohippocampectomy (“standard resection”)
• Amygdalohippocampectomy (“selective resection”)
• Ablations (MRI guided laser ablation, SRS)

Neocortical temporal lobe epilepsy
• Tailored resection plus/minus standard mesial resection based on EEG, ECoG, SEEG, other non-invasive data

Lesional temporal lobe epilepsy
• Use of lesionectomy plus/minus mesial structures. Mapping when appropriate
Cortico-amygdalo-hippocampectomy: Surgical Technique

• Removal of mesial TL structures most important, including amygdala, hippocampus, and parahippocampus.

• Amount of temporal neocortex removed less important for outcome*; of questionable importance for neuropsychology.

• Dominant resections associated with decline in naming and short-term memory.

• Selective resections designed to minimize neuropsychological impact from dominant TL surgery.

Corticoamygdalohippocampectomy

- 4.5 cm lateral resection dominant
- 5.5 cm lateral resection non-dominant.
Arterial/Venous Anatomy
Subpial aspiration technique

- Identify collateral sulcus to enter ventricle
- Protect ventricular roof & choroid plexus
Subpial Suction Technique

- Preserves the microcirculation of adjacent gyrus
- Allows resection immediately adjacent to functional tissue
  - Exception may be nearby language cortex (Haglund et al)

*Figure 4A. The initiation of lobectomy by subpial isolation of the temporal operculum by suction.*
Important Landmarks

• Sylvian Fissure
• Vein of Labbe
• Insula and inferior limiting sulcus (circular)
• Collateral Sulcus
• Temporal horn
• Choroidal point
• Tentorial Edge
• Choroid plexus and fissure
Ant Choroidal Artery arises from ICA and travels through perimesencephalic cistern to enter temporal horn at plexal point. Perforators to posterior limb IC, optic tract/LGB, and thalamus
ATL Complications

• Mortality estimate 0.01

• Morbidity: estimate 0.17
  – most common were psychiatric and cognitive declines including verbal/visual memory and depression/psychosis/anxiety

• Visual field deficits underreported (30-40%)

• Permanent neurological deficits like hemiparesis, dysphasia/aphasia less common

Brotis et al, Stereotact Funct Neurosurg 2019
Selective Amygdalohippocampectomy

- First described in 1958 by Niemeyer
- Goal is minimal disruption of lateral cortex in the setting of pure MTS
- All approaches disrupt temporal stem except subtemporal.
- Doesn’t address “dual pathology” in temporal lobe
Surgical View: SAH

Smaller incision and craniotomy, less manipulation of temporals m., more difficult to remove amygdala and uncus.
Types of Resective Surgery

• Hemispherectomy
  – Anatomic
  – Useful for hemimegalencephaly, failed disconnectives
  – More risk of hydrocephalus
  – Disconnective
  – Less risk hydrocephalus, blood loss
  – More risk for failure

Extratemporal Resections
Special Challenges: ETLE

• Heterogeneous group (30-35% of large neurosurgical series) of mostly lesional epilepsies.

• Localization/Lateralization.
  — Rapid propagation of seizure activity
  — Wide range of seizure types, lack of consistent semiology

• Large epileptogenic area.

• Involvement of functional cortex.
Surgical Approaches

• Dependent on region of brain involved.
• Dependent on presence of lesion.
• Is pre-operative data in agreement with hypothesis?
• Patient expectations and motivation are paramount and should be discussed in detail prior to surgical journey.
Frontal Lobectomy/Multi-Lobar Resections

• Uncommon in adults other than a “salvage” operation
• More common in pediatrics with MCD
• Limited by eloquent cortex
• SMA/peri-rolandic
• Frontal Eye fields
Posterior "absolute" resection limit is precentral sulcus (12). Increased risk of a neurologic deficit.
Mesial frontal lobe is a complicated area in which surgery often leads to supplementary motor area “syndrome”

Surgical Techniques for Eloquent Cortex

• Motor Stimulation: no muscle relaxation, monitor EEG, start low current and increase, ice water and anticonvulsant available

• Somatosensory evoked potential identification central sulcus

• Awake craniotomy: allows real time feedback during eloquent resections, language mapping
Lesionectomy

• Definition: focal resection of a pre-determined abnormality in the brain presumed to be the cause of the epilepsy.

• Lesionectomy without electrophysiological monitoring (pre-op data concordant: e.g. cavernoma, tumor).
  – Lesionectomy plus margin of cortex?
  – Likely never just the lesion gets resected.

• Lesionectomy (cortical resection) based on radiological and EEG data from EcOG or extra-operative monitoring (pre-op data discordant, eloquent location, MCD).
Hand Motor
Hand Sensory
Face motor
Face sensory
Ictal onset
Learning Points: Lesionectomy Plus

- Pathology was FCD Type IIB
  - Balloon cell dysplasia is MRI apparent lesion
  - Ictal onset on boundary of lesion (Type I dysplasia)
- Focal resections of lesional tissue in eloquent cortex; MCD, neoplasm, cavernoma can be undertaken with acceptable risk given appropriate monitoring.
Modern Hemispherectomy Techniques

• Basic categories include **anatomic** removal of hemisphere, and **disconnective** approaches (including functional hemispherectomy, hemispherotomy and variants).

• Trend to smaller craniotomies and less cortical resection to improve peri-operative course and avoid long-term complications.

• Has modern neurosurgical technology changed how we approach these patients?
  – Most important contribution has been **magnetic resonance imaging**
  – Technical advancements are helpful (microscope, intraoperative stereotaxy, lighting, etc) as strong dependence on anatomy and technique to resect/disconnect abnormal hemisphere.
Anatomic Hemispherectomy

- Most series report resection of hemisphere leaving behind basal ganglia and thalamus.

- Although popularity has declined, the technique has remained an effective treatment with no recent evidence of SCH (increased risk of hydrocephalus).

- Indicated for hemimegalencephaly as primary surgery and for failed disconnective procedures.
Disconnective Hemispheric Procedures

• FH and variants: All share leaving “disconnected tissue” behind to prevent hydrocephalus and reduce operative time and risks.

• Outcomes comparable to anatomic technique across etiologies (except perhaps HM cases?).

• Carries highest risk of reoperation if seizures persist or recur.
Factors in Tailoring Surgical Treatment

• Anatomy of hemisphere to be disconnected:
  – Presence of gray-white anomalies (distortion of normal anatomy)
  – Hemispheric size
  – Ventricular size/ presence of porencephalic cyst
  – Posterior basal frontal lobe dysplasia
  – Corpus Callosum

• Etiology:
  – MCD/HM most challenging

• Body weight/age of patient
Morbidity and Mortality

- Mortality 0.28%
- Infection: 3%
- Hydrocephalus:
  - Pre-op shunts: 15
  - Post-op shunts (new): 27 (11%)
- Hemorrhagic: 34% coagulopathic, 1 post-op hemorrhage requiring evacuation, 1 intraventricular hemorrhage treated medically
- Ischemic: 1 return to OR for temporal lobectomy
- Aseptic meningitis: 70% (steroids and post op CSF drainage)
Corpus Callosotomy

- Palliative technique useful for multi-focal or rapidly generalizing seizures
- Atonic seizures leading to sudden falls (drop attacks)
- Thought to work by preventing inter-hemispheric spread
- Recent meta-analysis 1742 patients, 18.8% completely seizure free, 55.3% free from drop attacks. Both were more common in those undergoing complete versus partial callosotomy and in those with history of infantile spasms, duration<15 years, and normal MRI. No significant relationship was seen between extent of callosotomy and disconnection syndrome.

Chan et al, J Neurosurg 130:1193-1202, 2019
Technique

• Anterior “2/3” versus complete: ideal extent unknown

• Center bicoronal incision on coronal suture

• Parasagittal craniotomy on right side (consider use of MRI with gd to localize and avoid draining veins (Trolard)

• Gently develop interhemispheric plane to follow to callosum. Identify and avoid injury to pericallosal arteries.

• Divide with suction-bipolar technique

• Adverse effects 8-12 percent; most common transient LE weakness, transient weakness or mutism, infection (Chan, 2019)
1: Rostrum; 2: Genu; 3: Anterior midbody; 4: Central midbody; 5: Posterior midbody; 6: Isthmus; 7: Splenium
Epilepsy Surgery: Take-Home Message

• All surgical procedures for epilepsy are designed to interact with the Epileptogenic Zone i.e. Measure it, Remove it, or Stimulate it.

• Patients average 20 years before surgical referral!

• EPILEPSY SURGERY IS UNDERUTILIZED