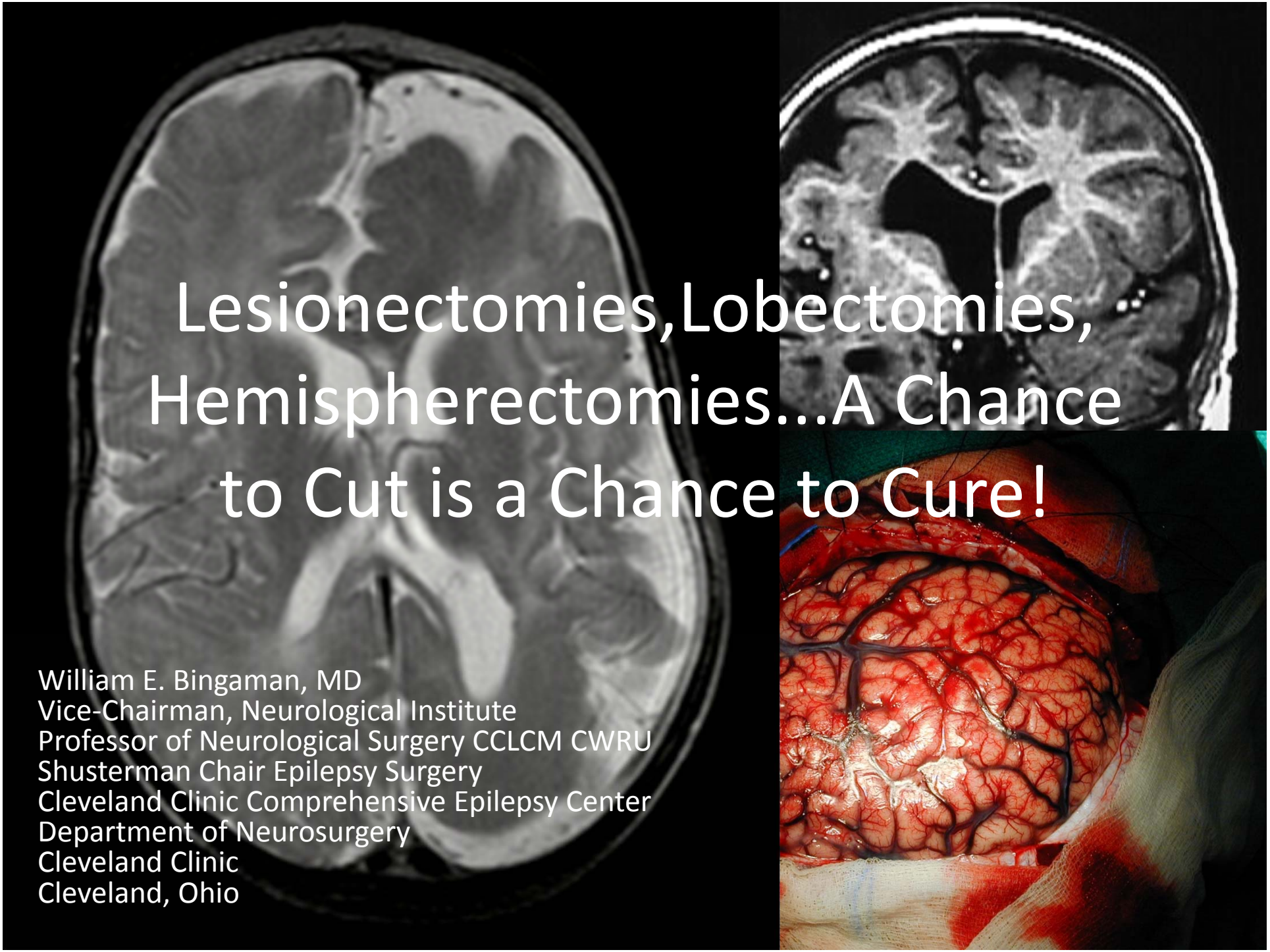

Lesionectomies,Lobectomies, Hemispherectomies...A Chance to Cut is a Chance to Cure!

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Disclosures

- I receive no money from industry.
- I have no conflicts of interest and don’t serve currently on executive committees or governing bodies.
- I own no healthcare stock.

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.

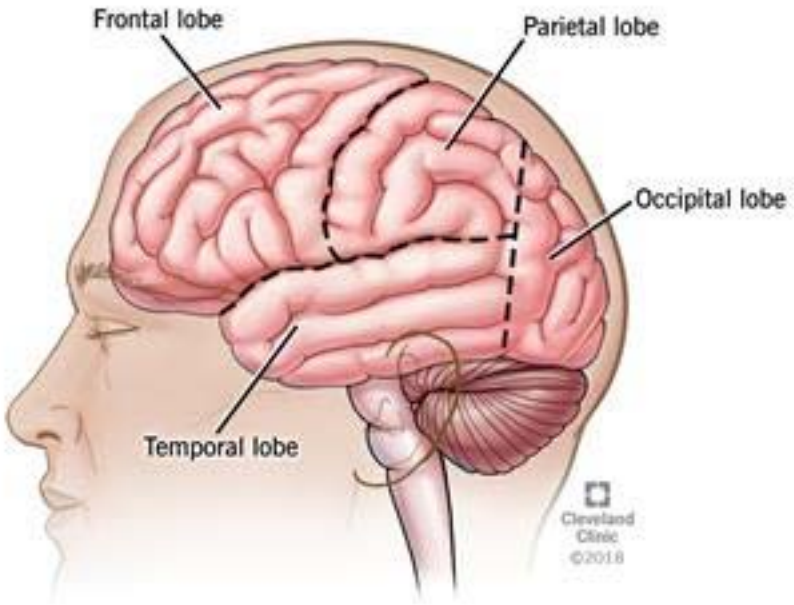
Indications for Surgical Referral

- 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

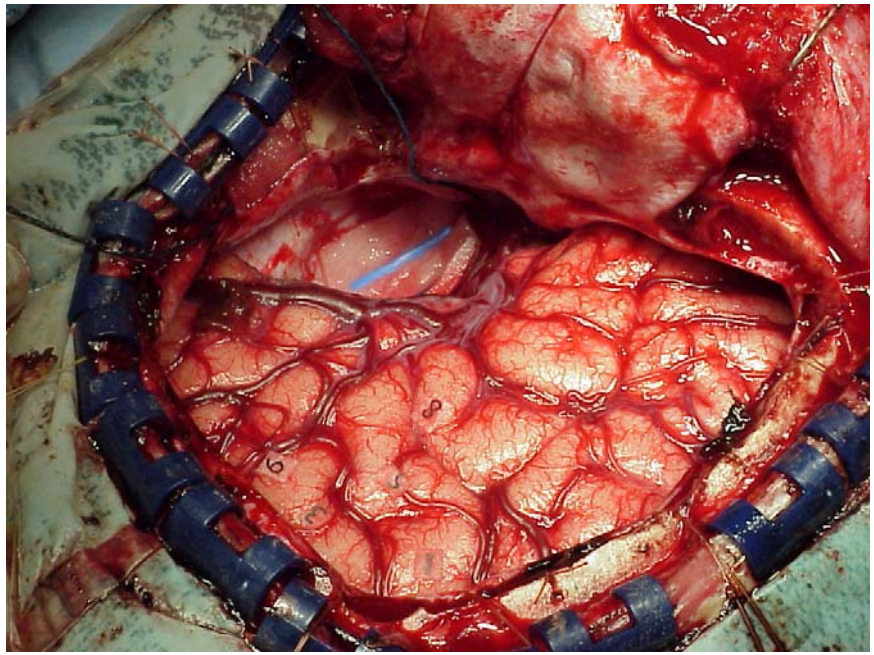
Surgical Treatment of Epilepsy

- 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

- Early surgical therapy for drug-resistant temporal lobe epilepsy: a randomized trial.*Engel J Jr, McDermott MP, Wiebe S, Langfitt JT, Stern JM, Dewar S, Sperling MR, Gardiner I, Erba G, Fried I, Jacobs M, Vinters HV, Mintzer S, Kieburtz K, Early Randomized Surgical Epilepsy Trial (ERSET) Study Group. JAMA. 2012 Mar 7; 307(9):922-30.*
- A randomized, controlled trial of surgery for temporal-lobe epilepsy.*Wiebe S, Blume WT, Girvin JP, Eliasziw M, Effectiveness and Efficiency of Surgery for Temporal Lobe Epilepsy Study Group. N Engl J Med. 2001 Aug 2; 345(5):311-8.*

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

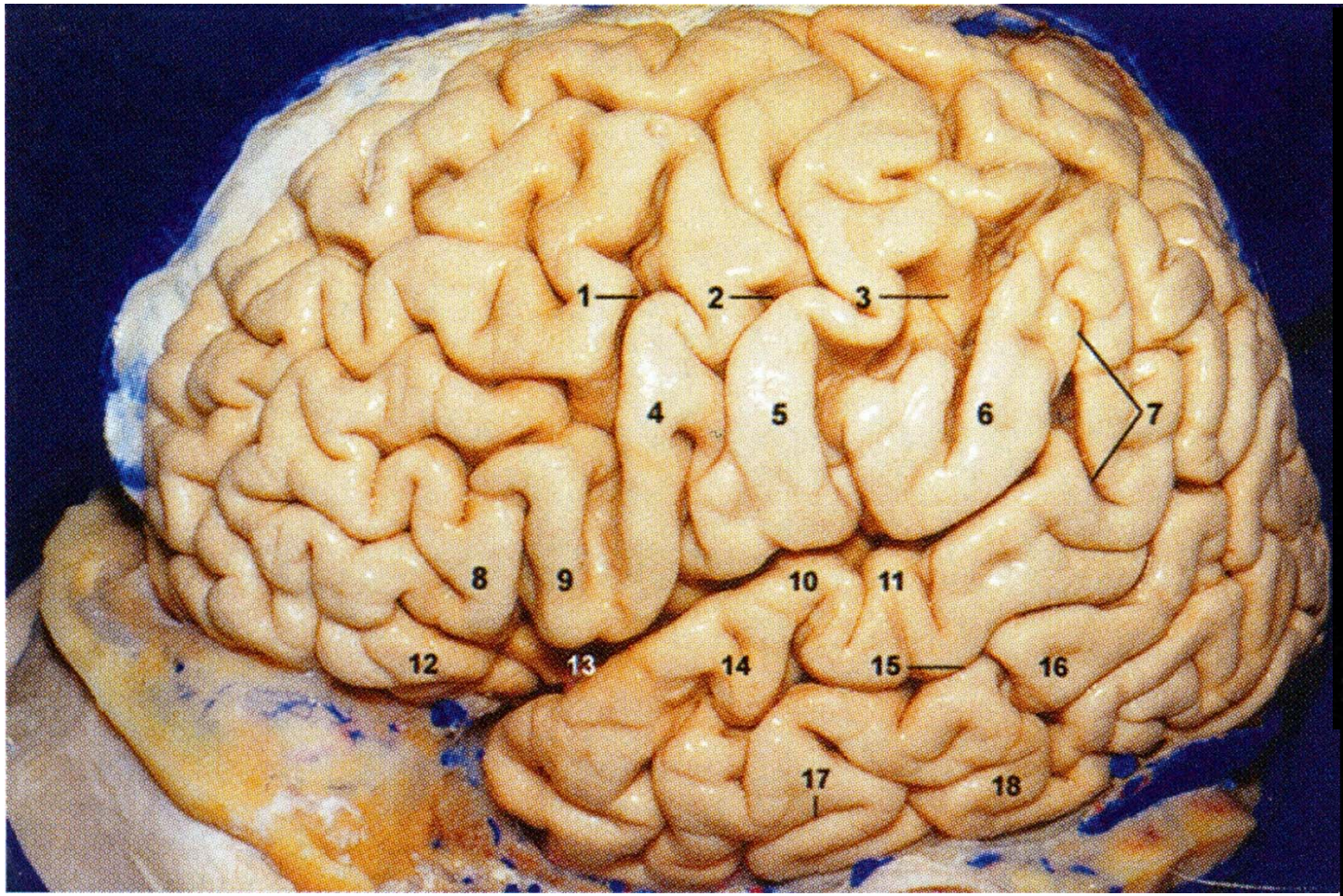
- Use of lesionectomy plus/minus mesial structures. Mapping when appropriate

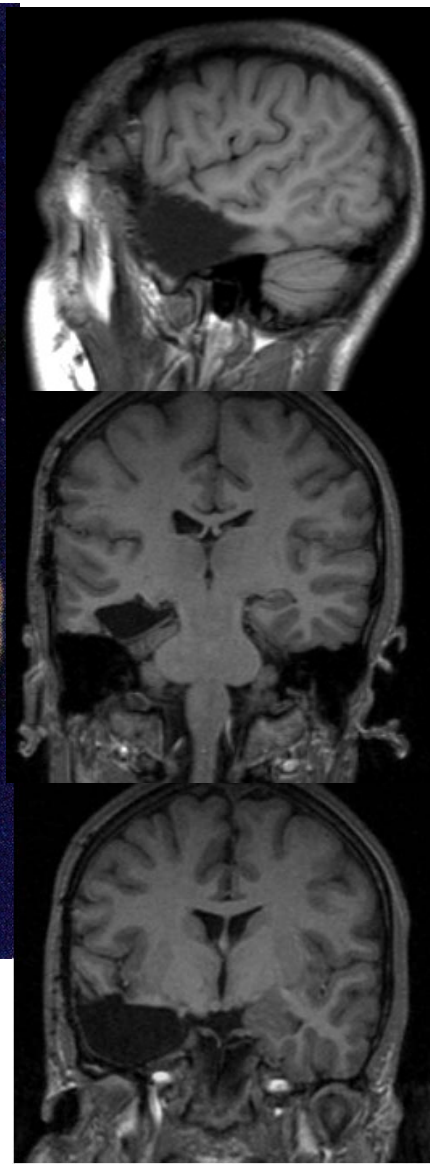
Cortico-amygdalo-hippocampectomy: Surgical Technique

- 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.

Wyler et al, Extent of Medial Temporal Resection on Outcome from ATL: A Randomized Prospective Study. Neurosurgery, November 1995.

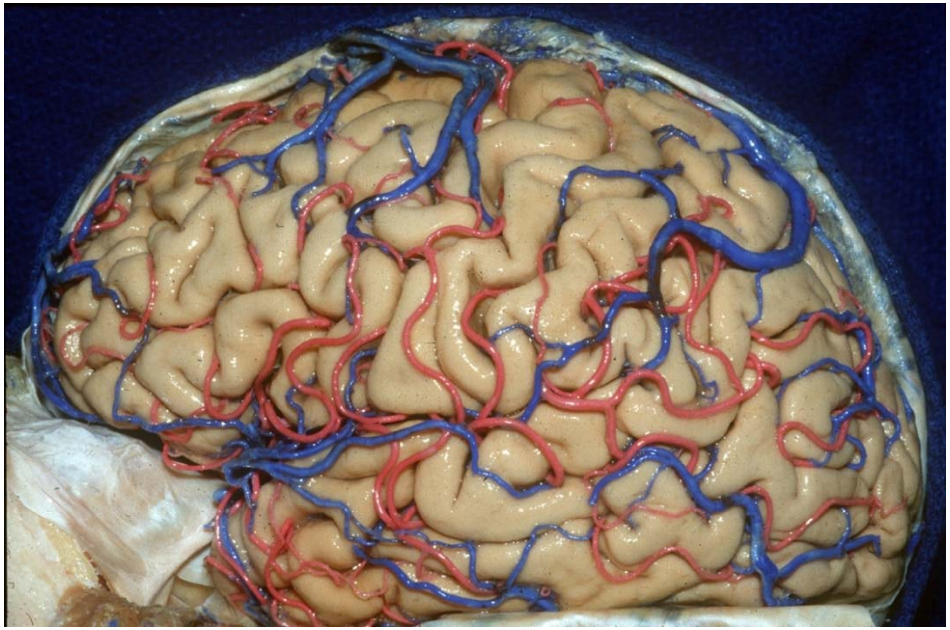
Corticoamygdalohippocampectomy

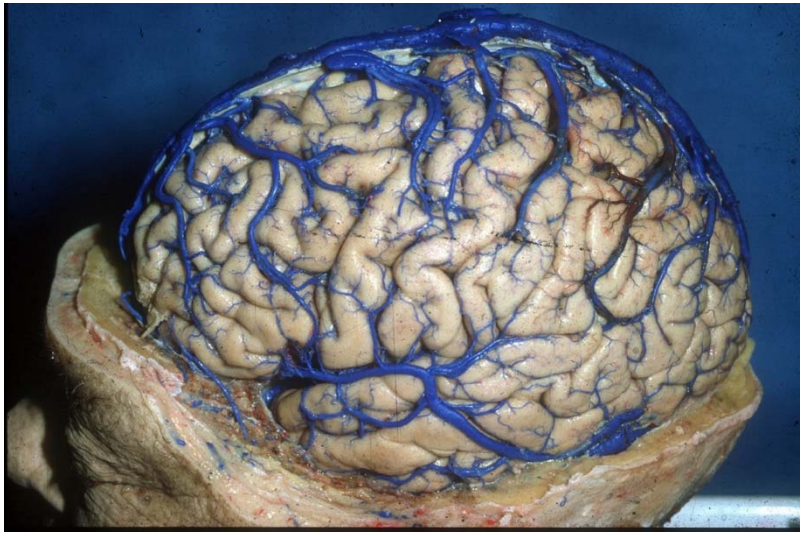


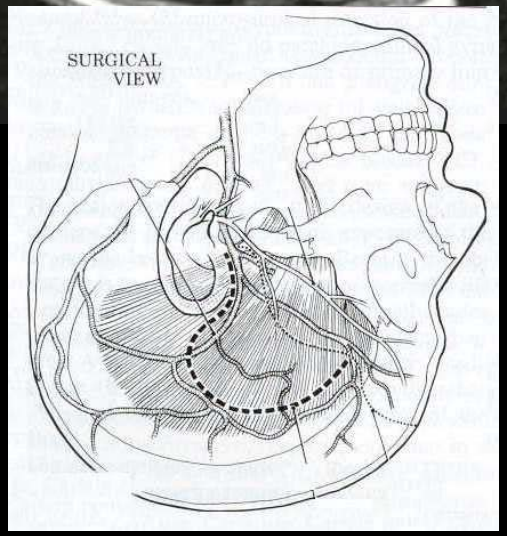


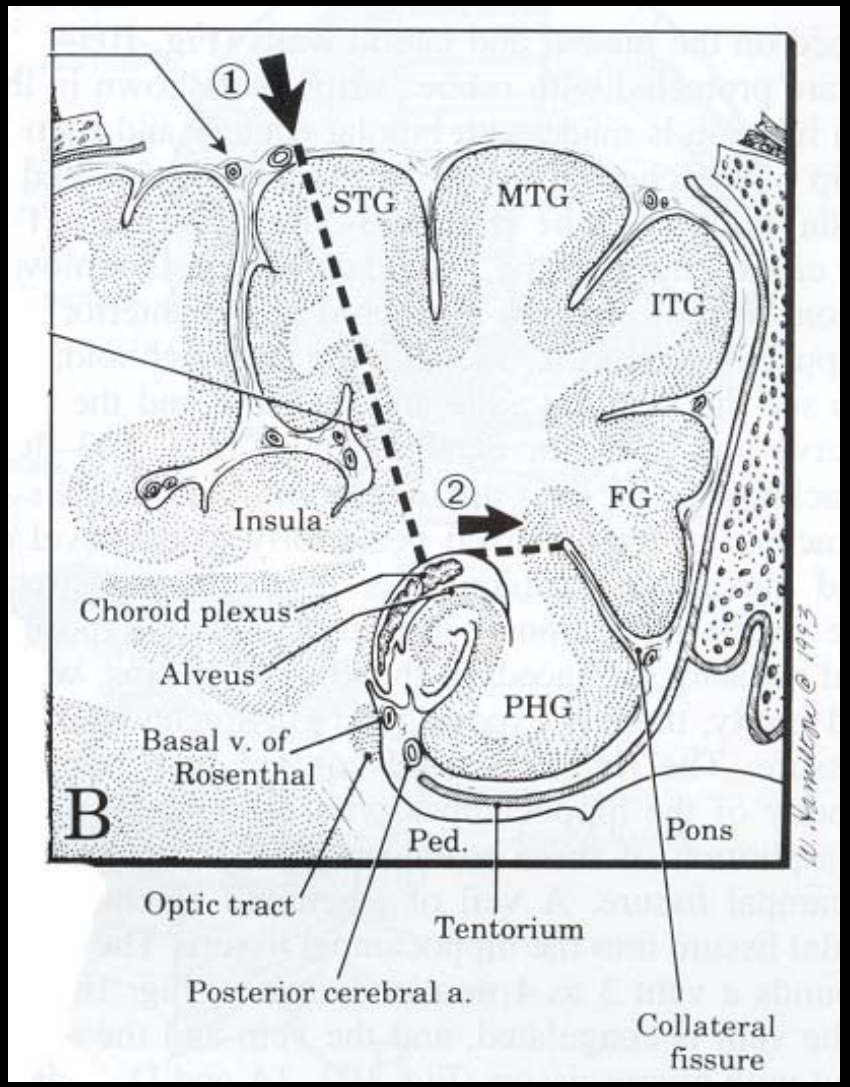
- **4.5 cm lateral resection dominant**
- **5.5 cm lateral resection non-dominant.**

Arterial/Venous Anatomy






SURGICAL
VIEW


①
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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)**

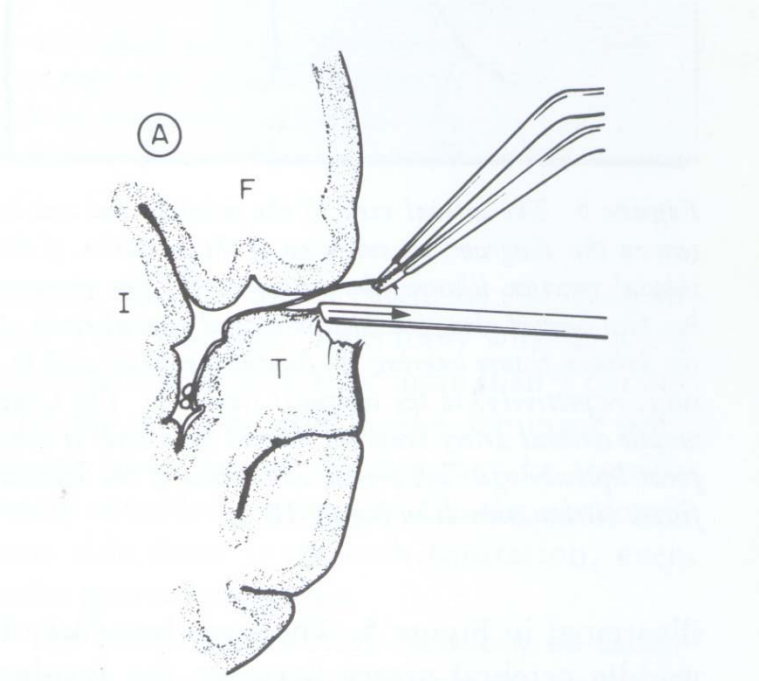
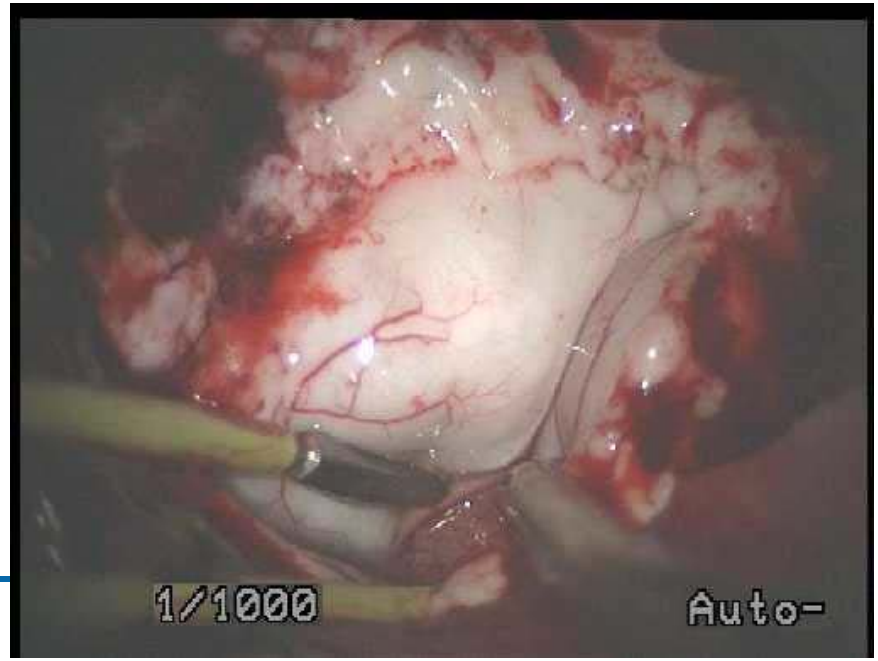
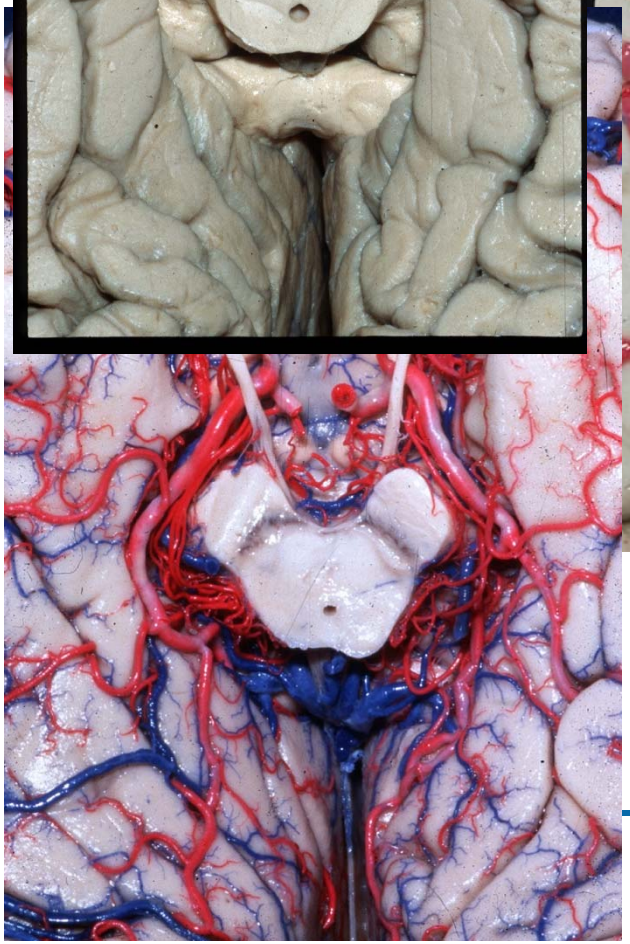


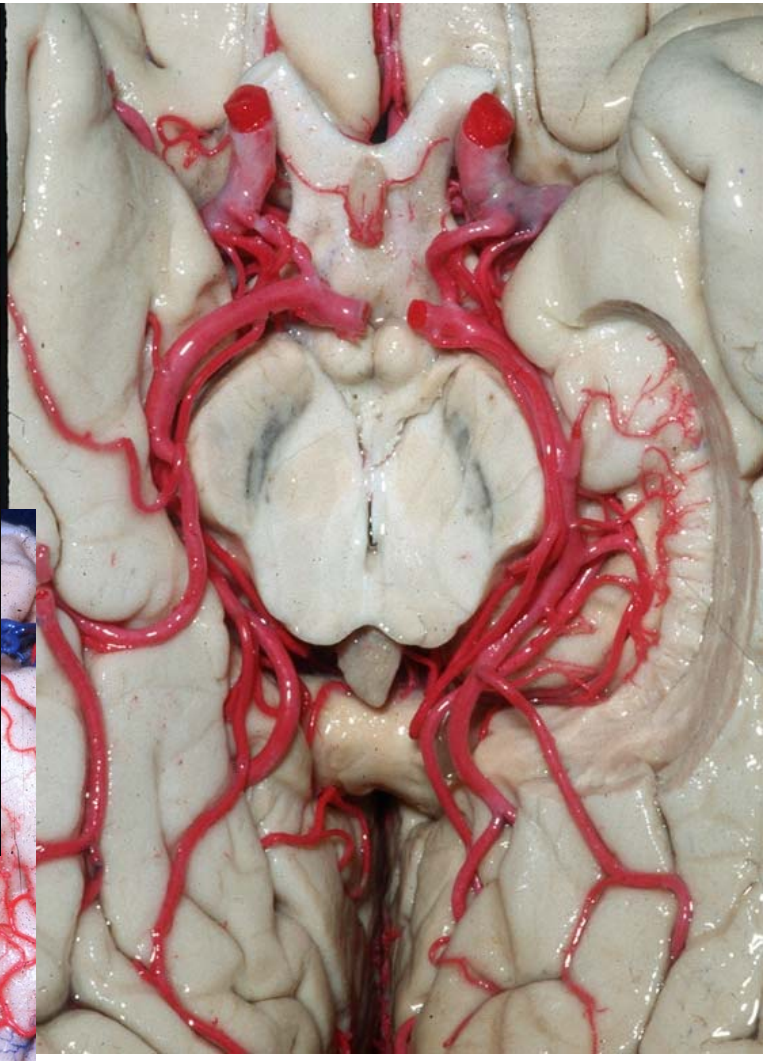
Figure 4A. The initiation of lobectomy by subpial isolation of the temporal operculum by suction.

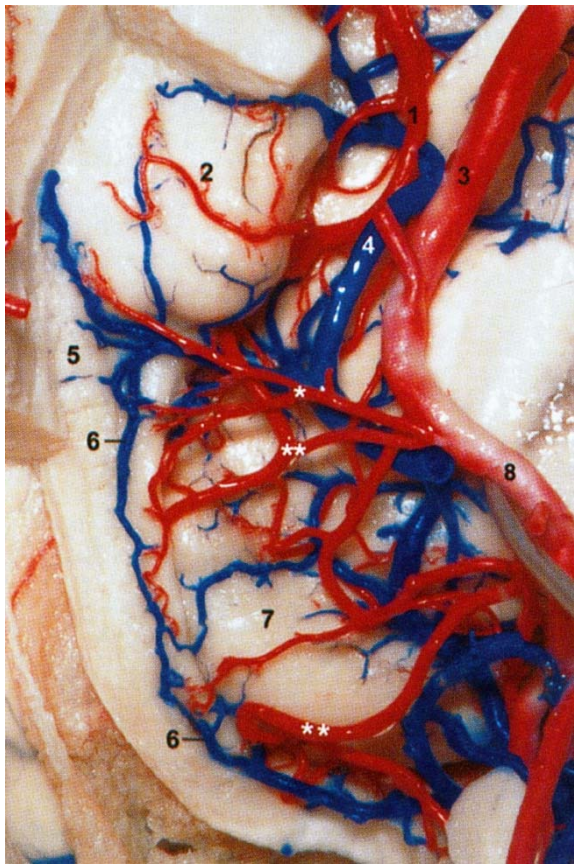
Important Landmarks

- Sylvian Fissure
- Vein of Labbe
- Insula and inferior limiting sulcus (circular)
- Collateral Sulcus
- Temporal horn
- Choroidal point
- Tentorial Edge
- Choroid plexus and fissure









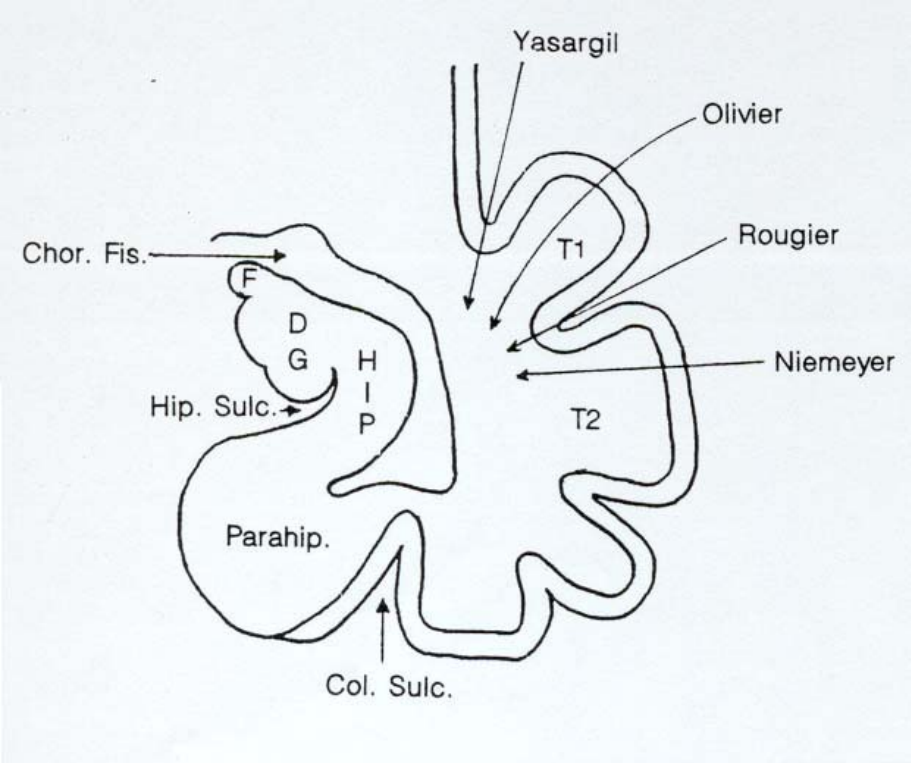
Ant Choroidal Artery arises from ICA and travels through perimesencephalic cistern to enter temporal horn at plexal point. Perforators to posterior limb IC, optic tract/LGB, and thalamus

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

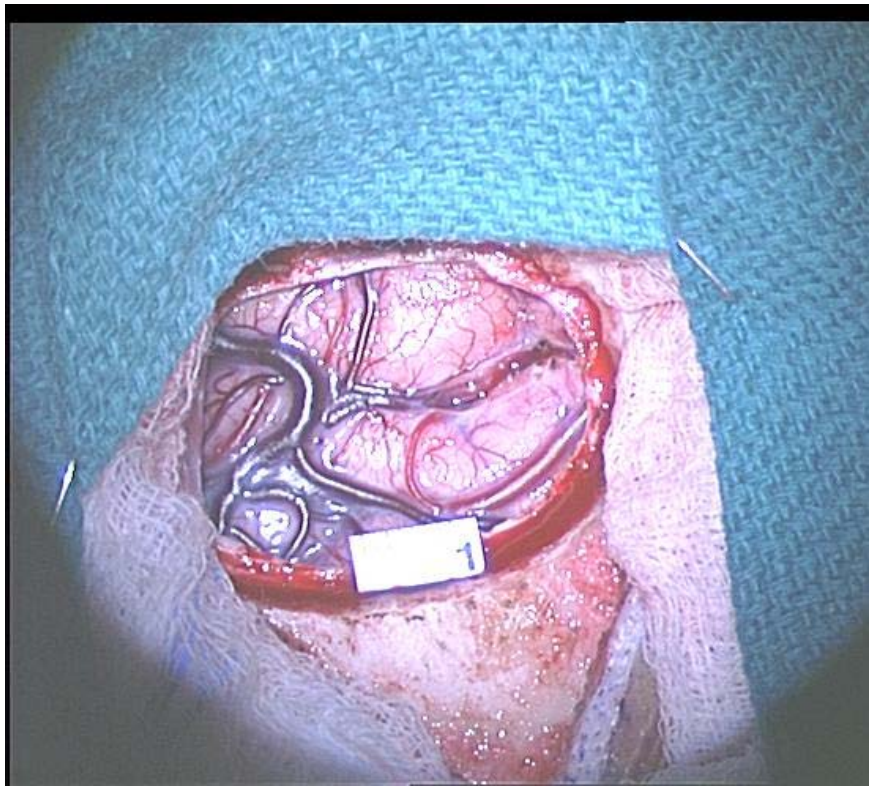
Brotis et al, Stereotact Funct Neurosurg 2019

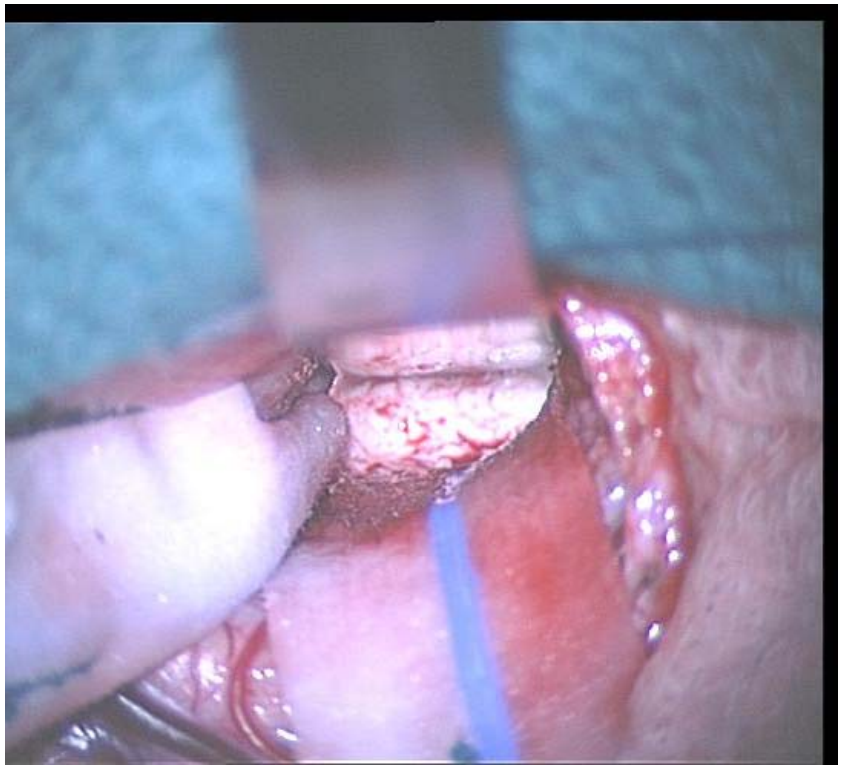
Selective Amygdalohippocampectomy



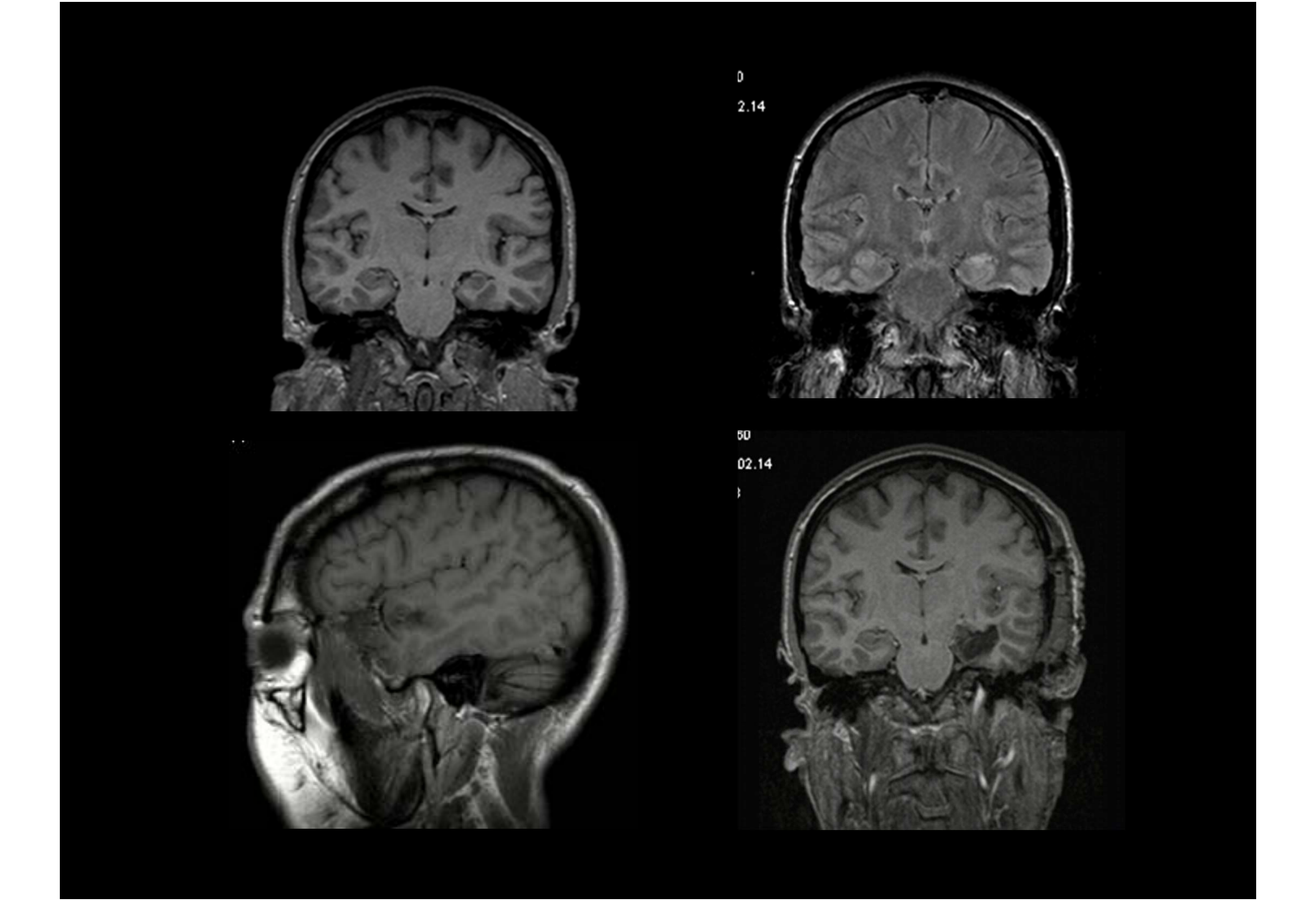
- First described in 1958 by Niemeyer
- Goal is minimal disruption of lateral cortex in the setting of pure MTS
- All approaches disrupt temporal stem except subtemporal.
- Doesn't address "dual pathology" in temporal lobe

Surgical View: SAH





Smaller incision and craniotomy, less manipulation of temporalis m., more difficult to remove amygdala and uncus.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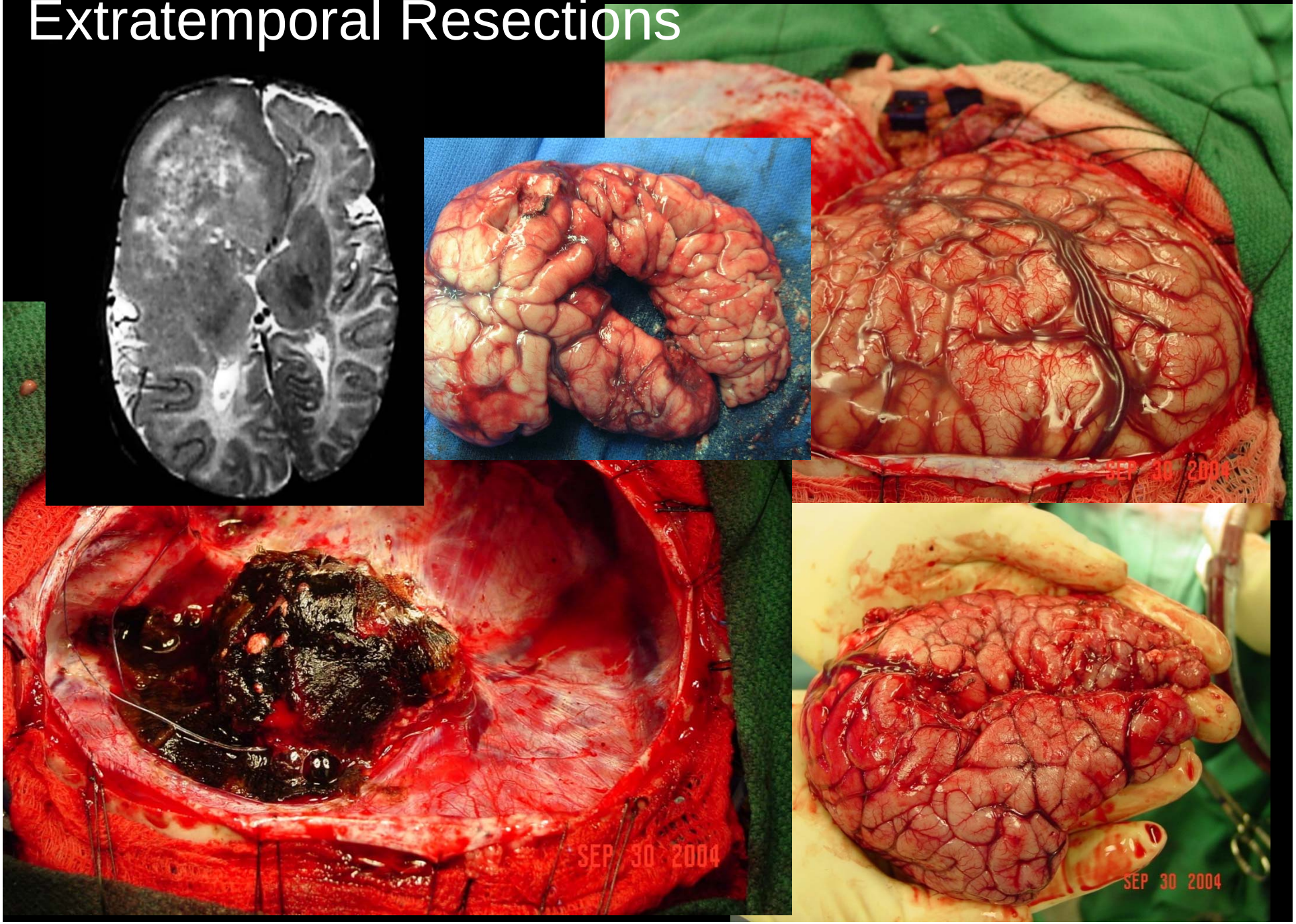
Extratemporal Resections



Special Challenges: ETLE

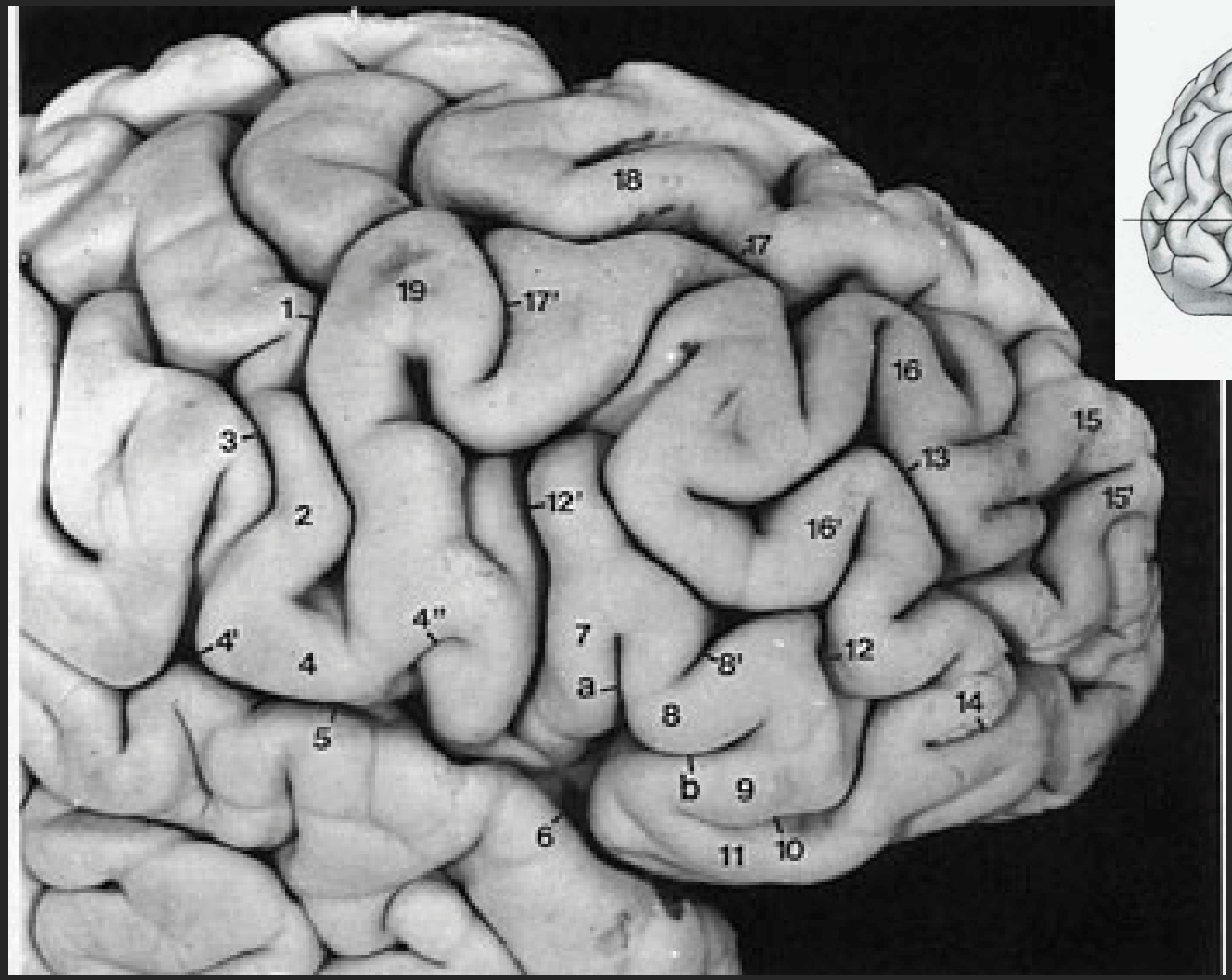
- Heterogeneous group (30-35% of large neurosurgical series) of mostly lesional epilepsies.
- Localization/Lateralization.
  - —Rapid propagation of seizure activity
  - —Wide range of seizure types, lack of consistent semiology
- Large epileptogenic area.
- Involvement of functional cortex.

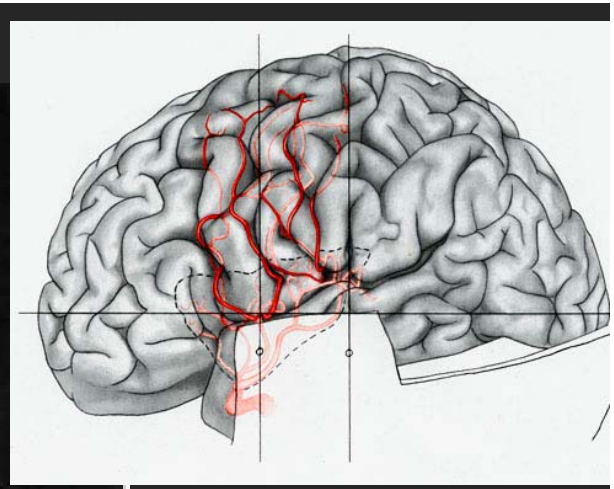
Surgical Approaches

- 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.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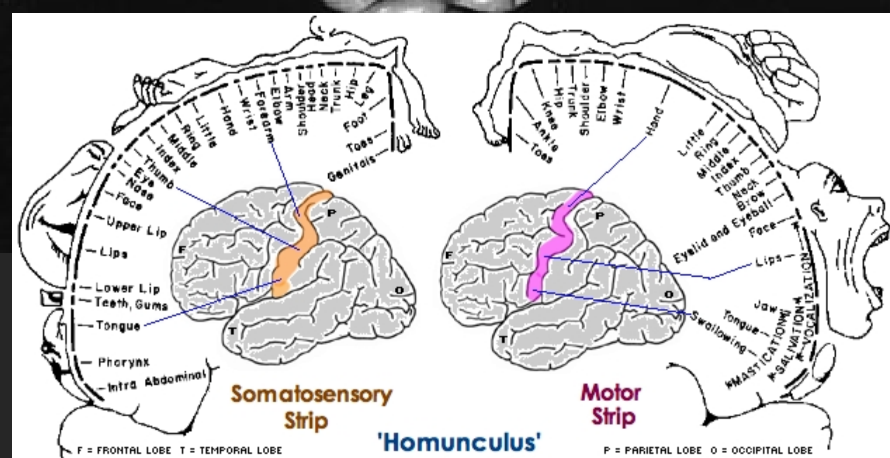
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Face
Upper Lip
Lips
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Teeth, Gums
Tongue
Pharynx
Intra Abdominal
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Toes
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Brow
Eyelid and Eyeball
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Lips
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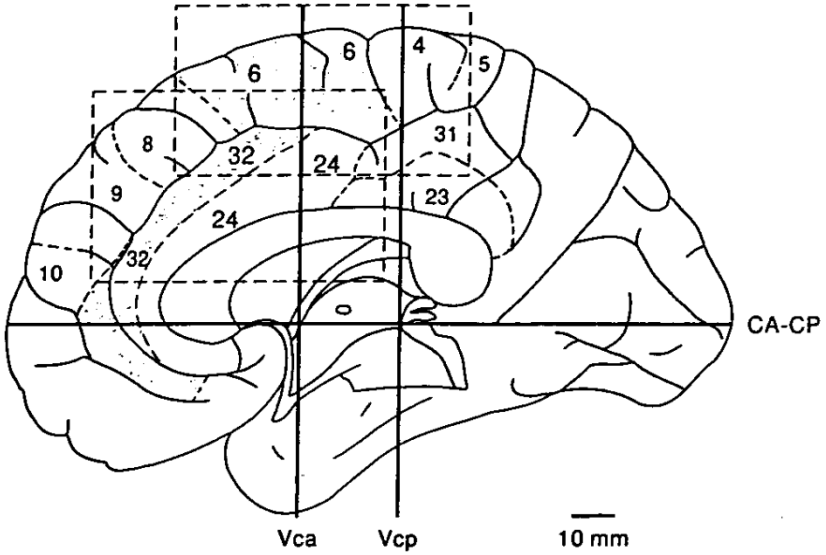
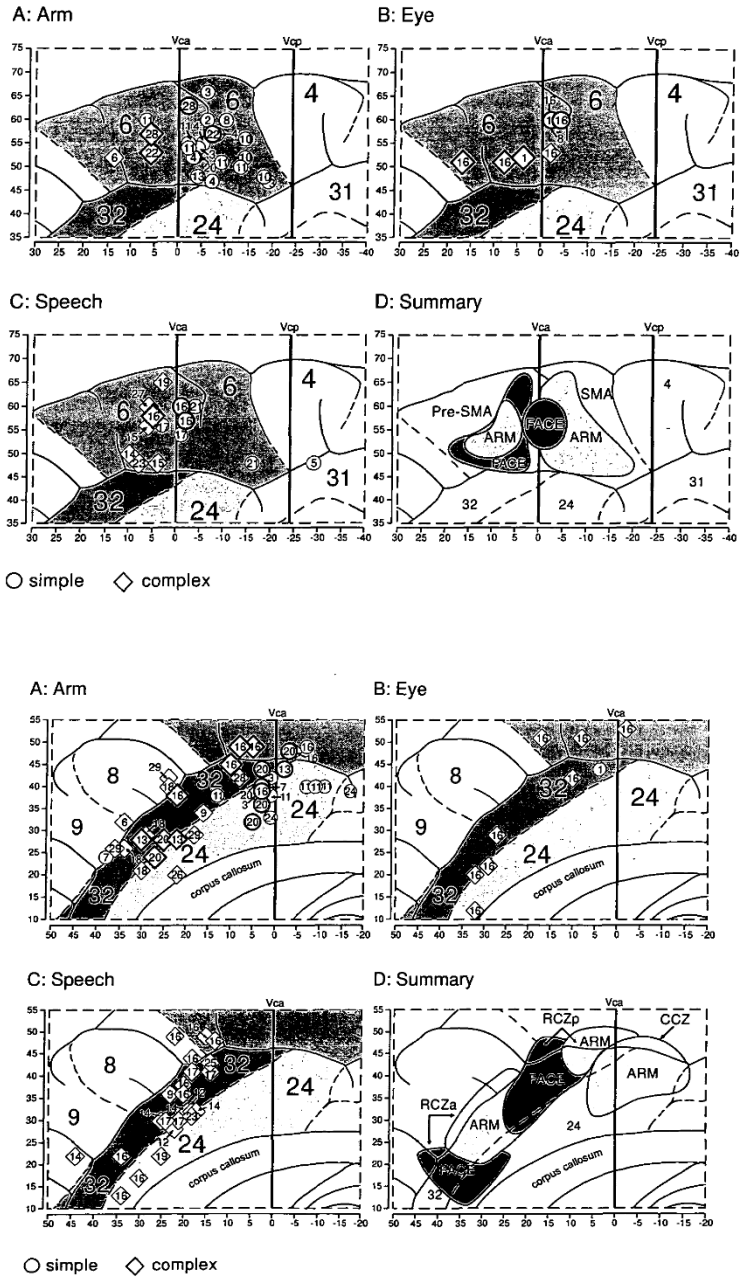
Tongue
Swallowing
MASTICATION
SALIVATION
VOCALIZATION
Motor Strip
'Homunculus'
F = FRONTAL LOBE T = TEMPORAL LOBE
P = PARIETAL LOBE O = OCCIPITAL LOBE

Mesial frontal lobe is a complicated area in which surgery often leads to supplementary motor area "syndrome"





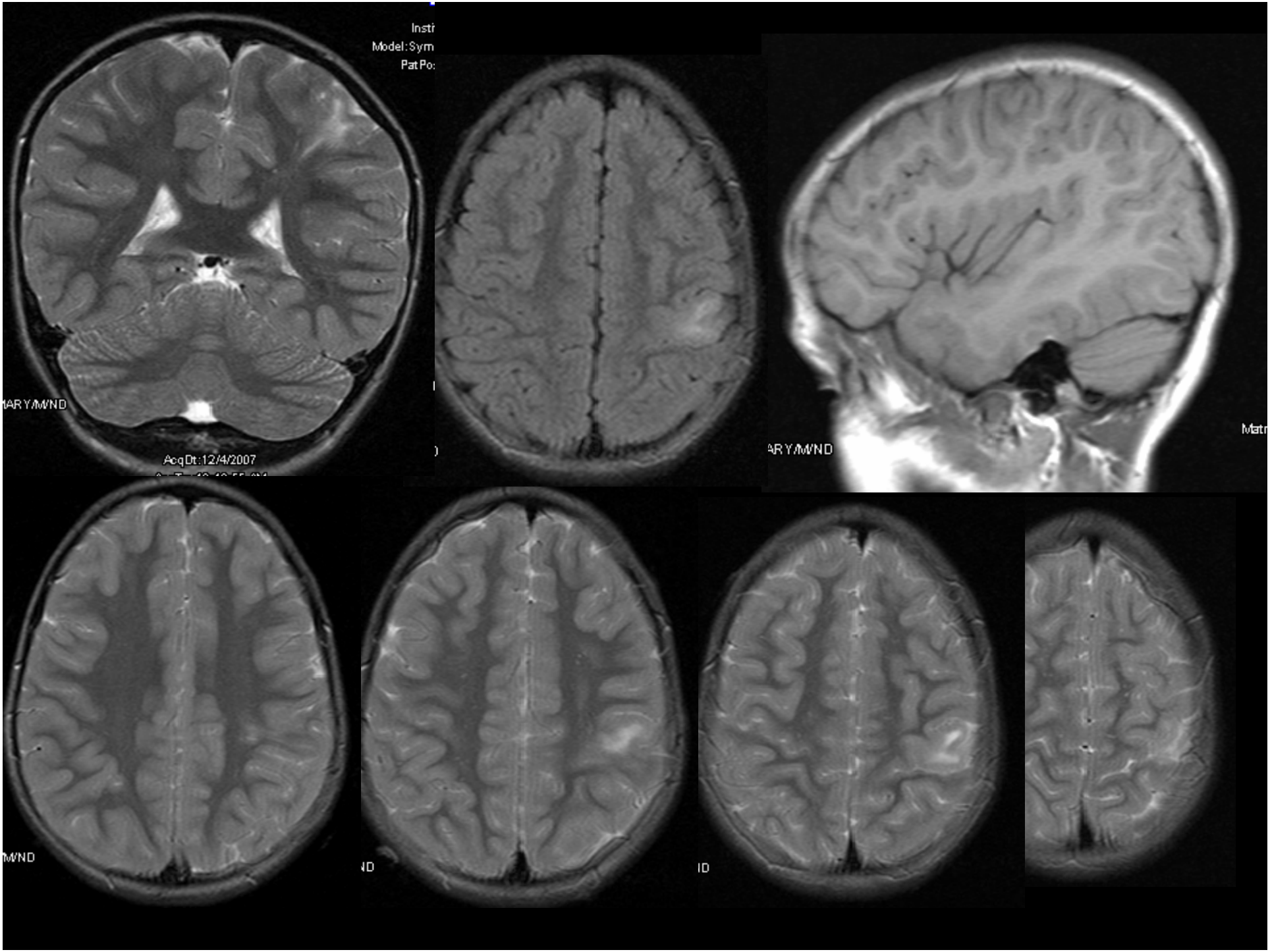
Picard N, Strick PL. Motor areas of the medial wall: a review of their location and functional activation. *Cereb Cortex*. 1996;6(3):342-353

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 disconcordant, eloquent location, MCD).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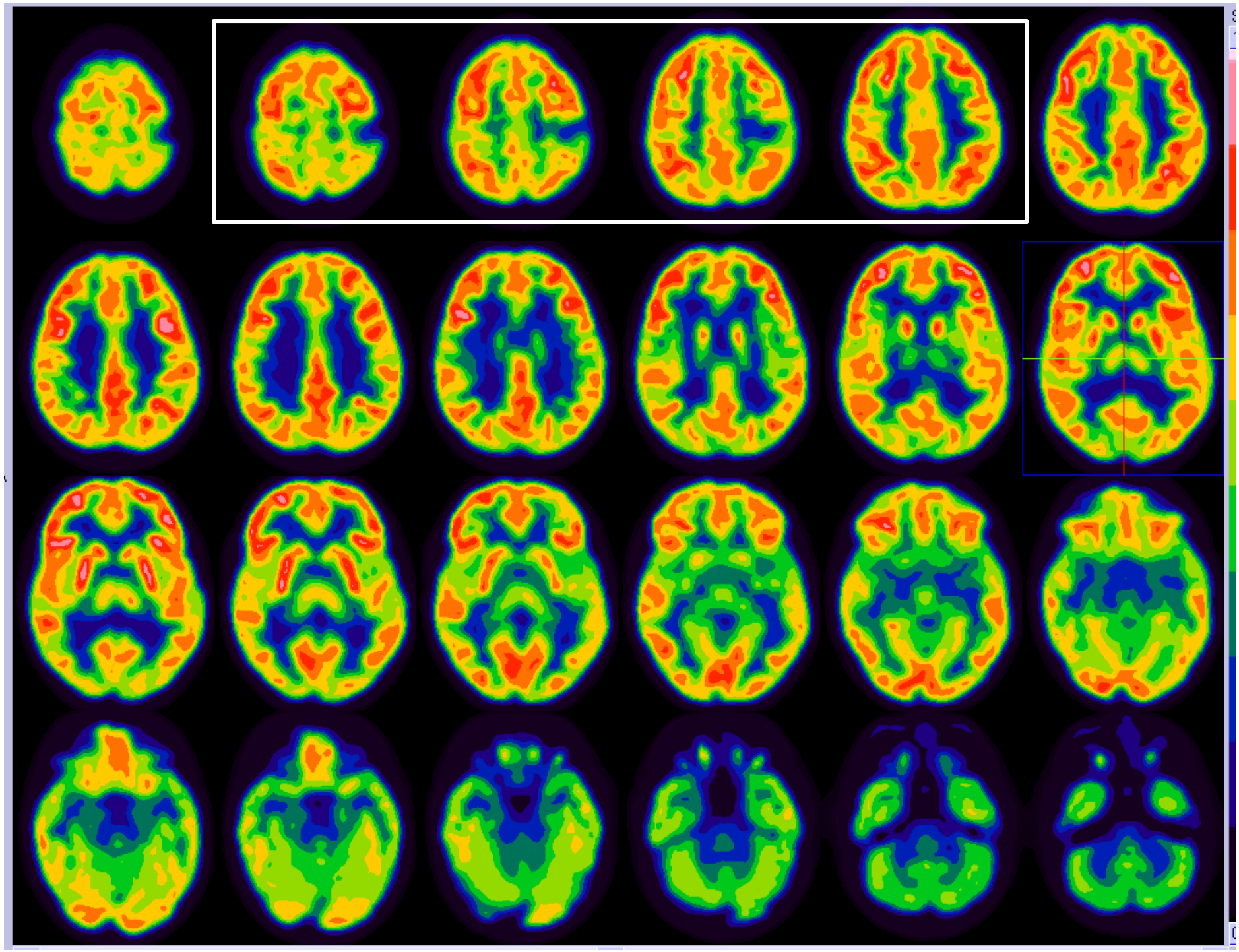
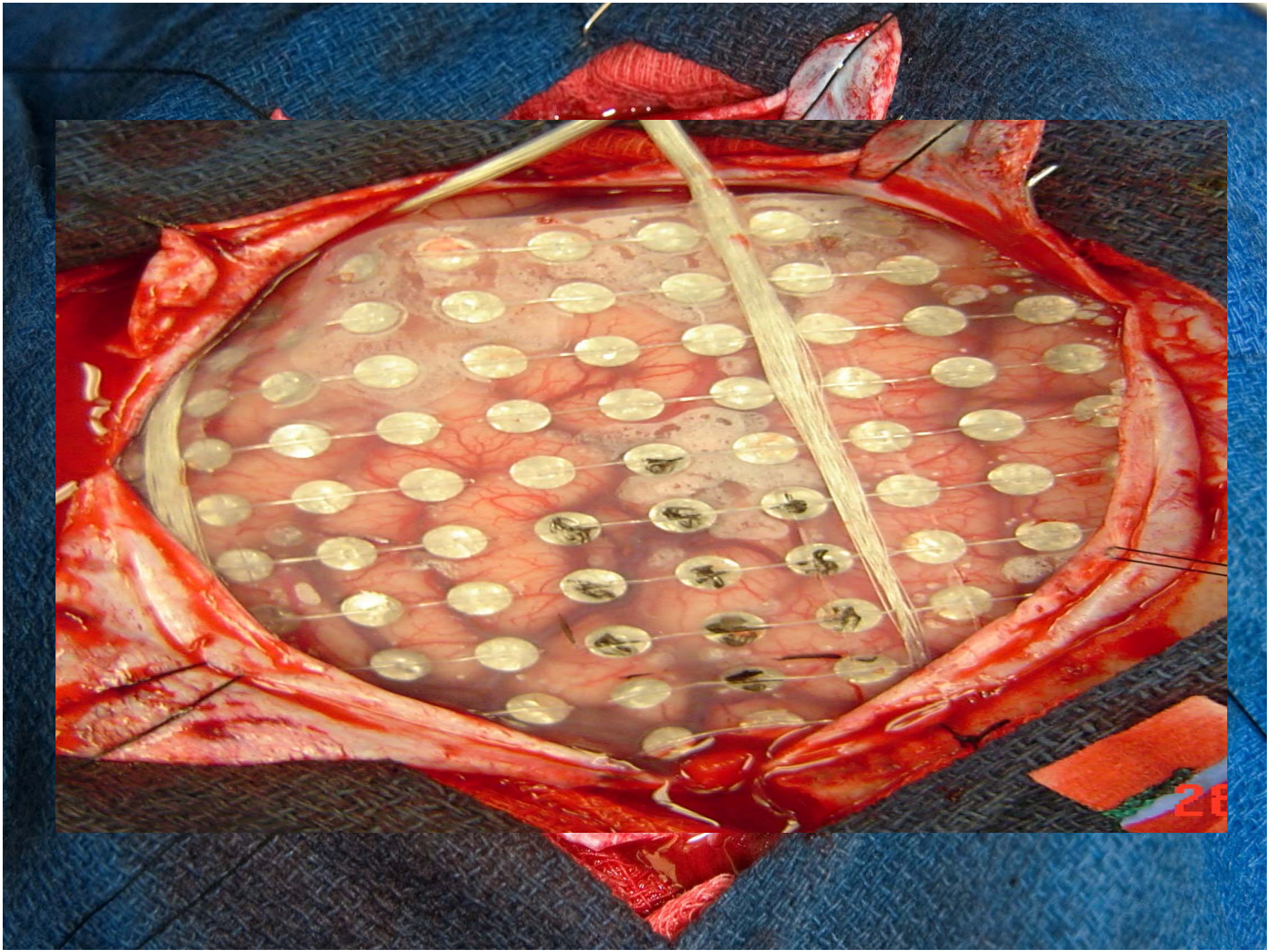
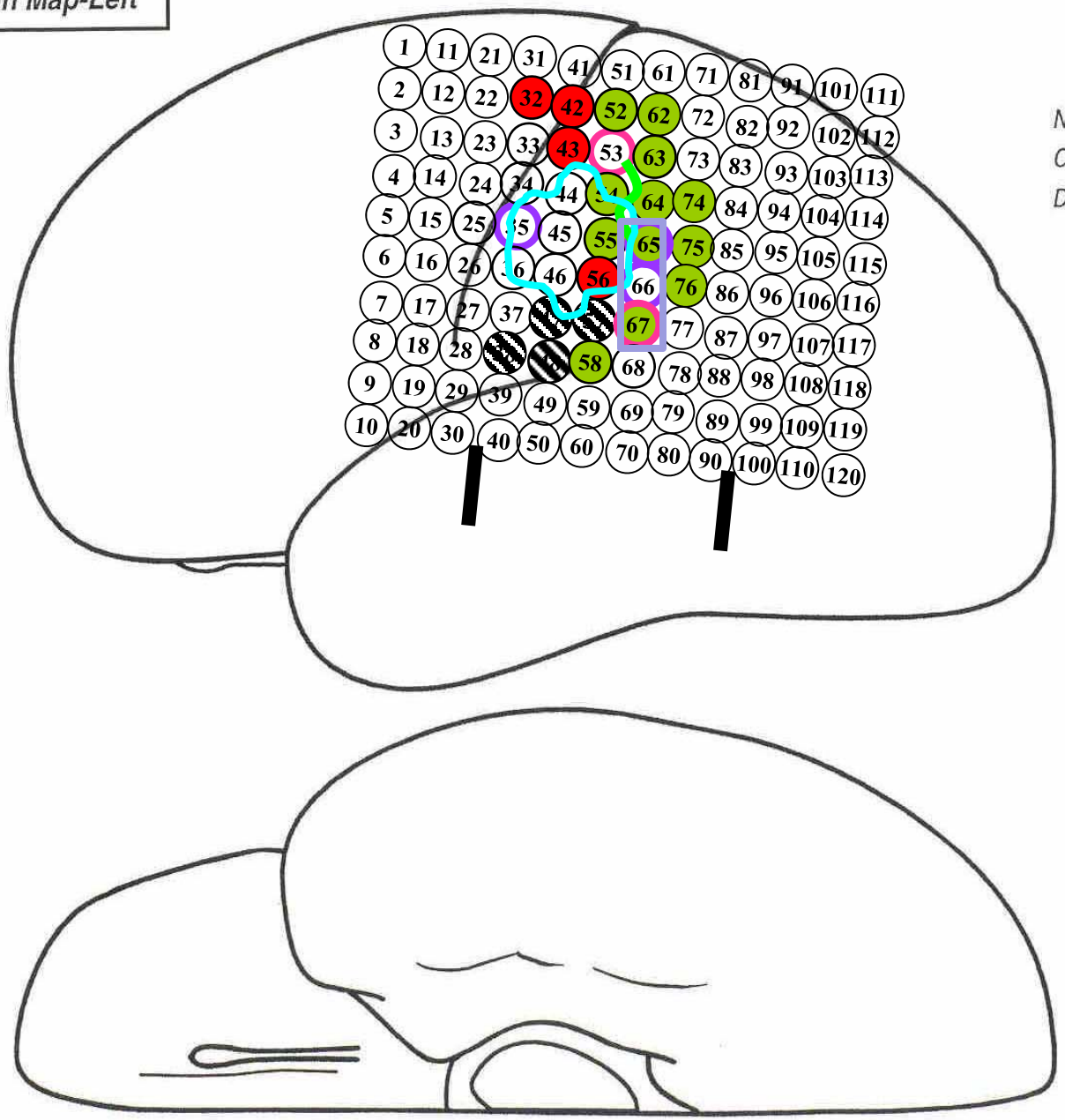




CORTICAL STIMULATION

Brain Map-Left



THE CLEVELAND CLINIC FOUNDATION

9500 Euclid Avenue Cleveland Ohio 44195

Comprehensive Epilepsy Program

Name: _____

Clinic Number: _____

Date: _____

Hand Motor

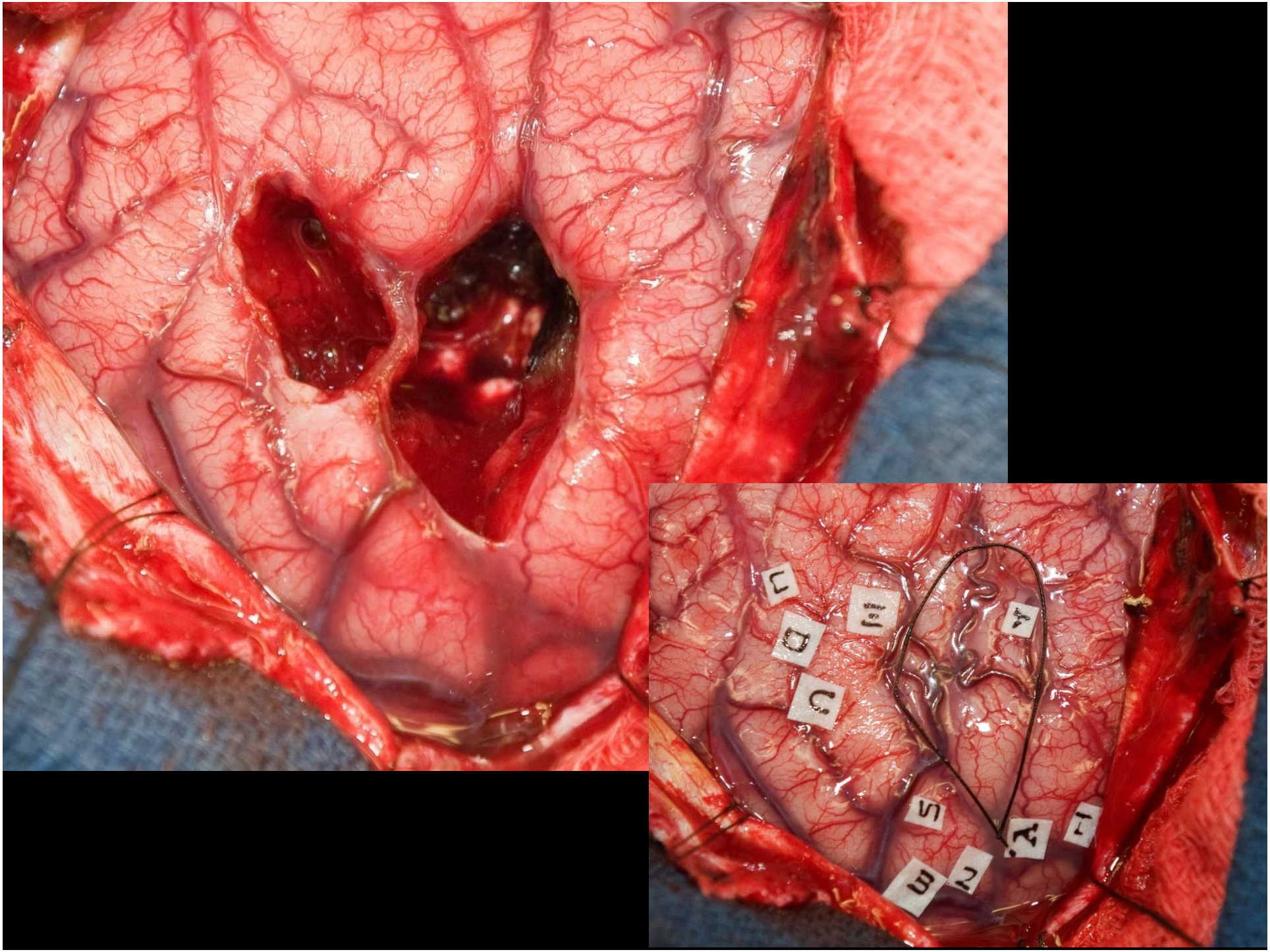
Hand Sensory

Face motor

Face sensory

Ictal onset

CCF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Learning Points: Lesionectomy Plus

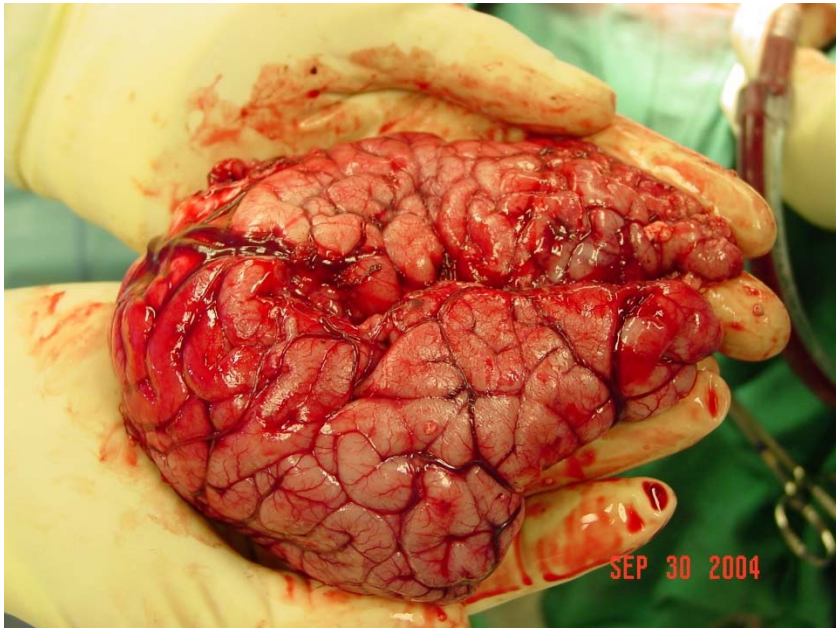
- Pathology was FCD Type IIB
  - Balloon cell dysplasia is MRI apparent lesion
  - Ictal onset on boundary of lesion (Type I dysplasia)
- Focal resections of lesional tissue in eloquent cortex; MCD, neoplasm, cavernoma can be undertaken with acceptable risk given appropriate monitoring.

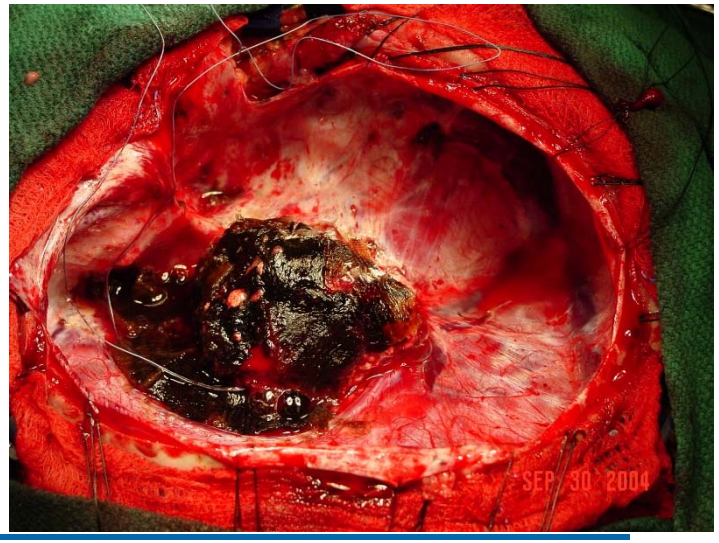
Modern Hemispherectomy Techniques

- 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

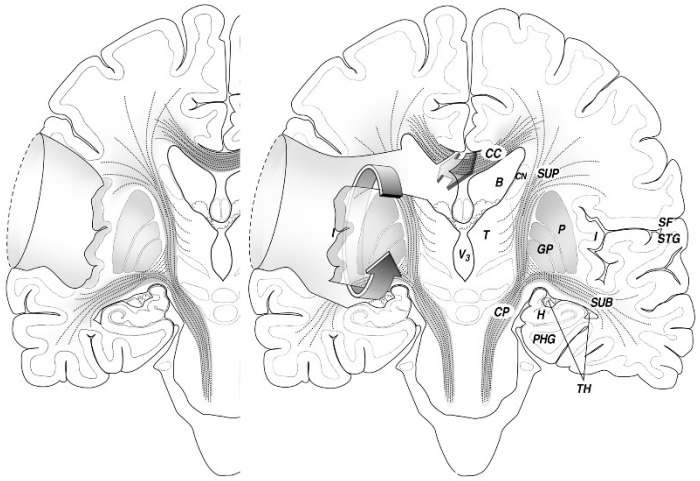
- Most series report resection of hemisphere leaving behind basal ganglia and thalamus.
- Although popularity has declined, the technique has remained an effective treatment with no recent evidence of SCH (increased risk of hydrocephalus).
- Indicated for hemimegalencephaly as primary surgery and for failed disconnective procedures.





Disconnective Hemispheric Procedures

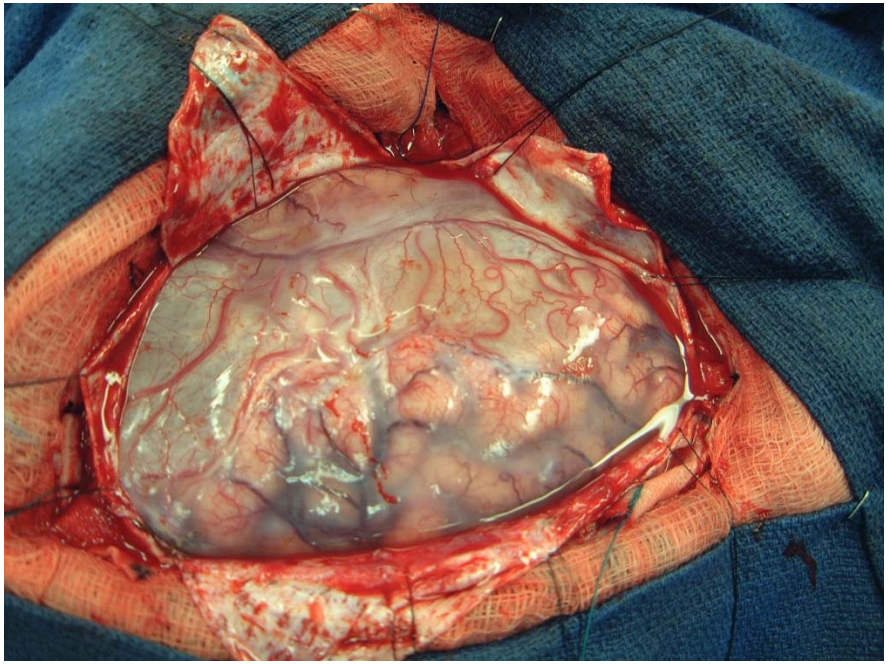
- FH and variants: All share leaving “disconnected tissue” behind to prevent hydrocephalus and reduce operative time and risks.
- Outcomes comparable to anatomic technique across etiologies (except perhaps HM cases?).
- **Carries highest risk of reoperation if seizures persist or recur.**



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)

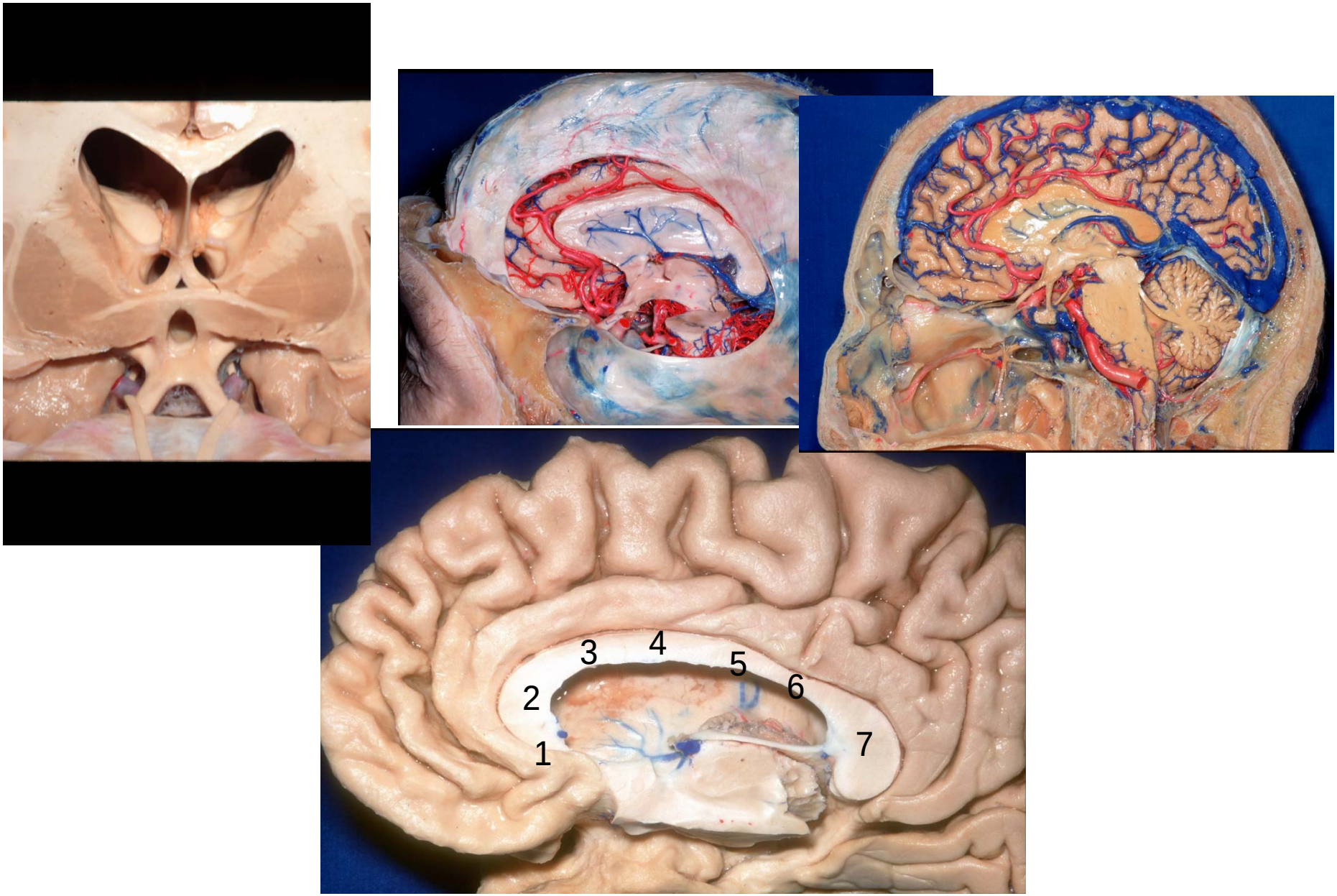
Corpus Callosotomy

- 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 l, 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)



Cleveland Clinic

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