EPILEPSY SURGERY- SURGICAL PROCEDURES

When to consider epilepsy surgery ?

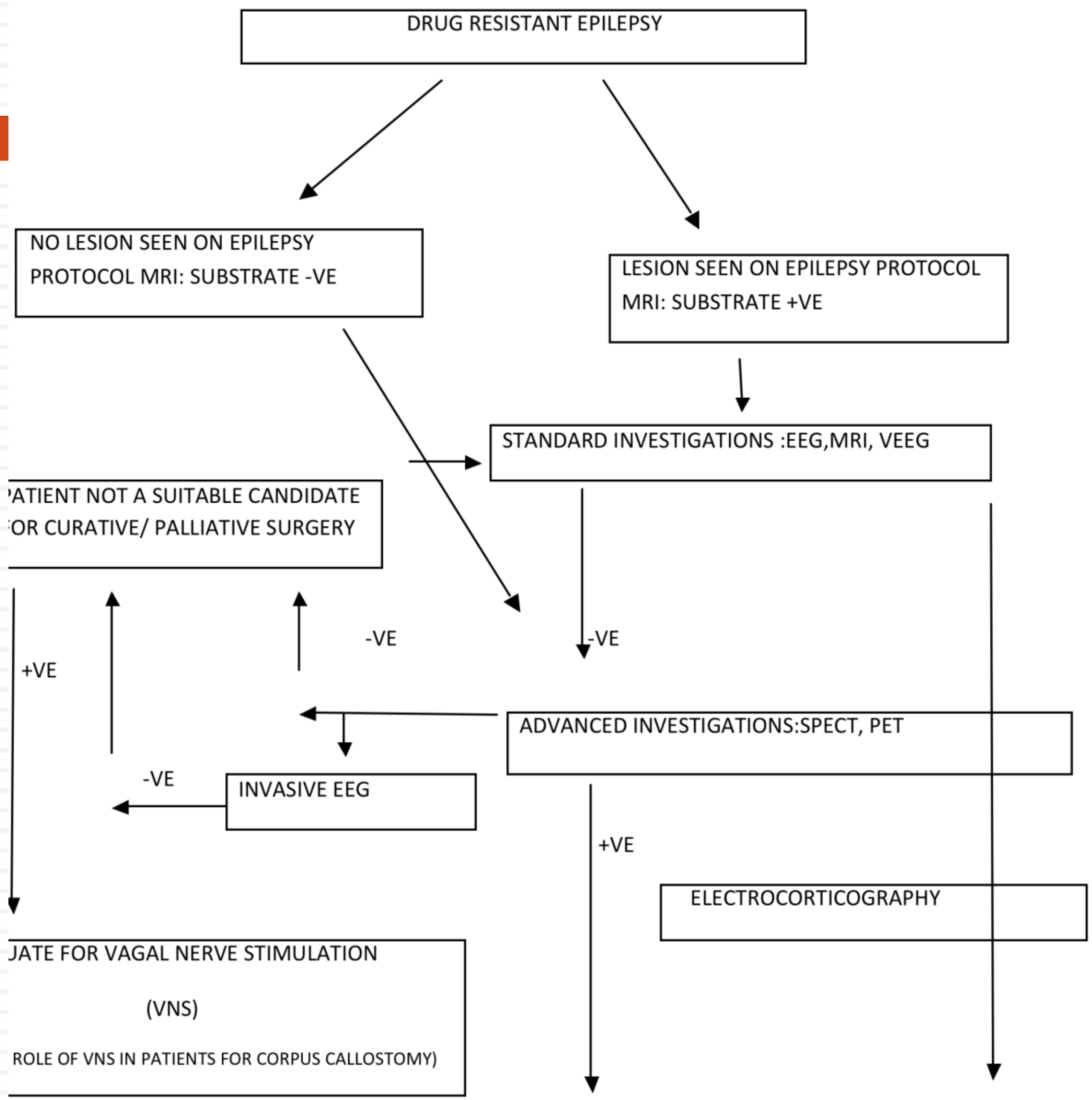
- Persistent Seizures despite adequate pharmacological treatment

Drug resistant epilepsy may be defined as failure of adequate trials of two tolerated and appropriately chosen and used AED schedules (whether as monotherapies or in combination) to achieve sustained seizure freedom.

Definition of drug resistant epilepsy: Consensus proposal by the ad hoc Task Force of the ILAE Commission on Therapeutic Strategies :Patrick Kwan:Epilepsia, **(*):1–9, 2009

Medically Intractable Epilepsy

- GEMIND
  - Epilepsy not controlled by 2 or more appropriate AEDs in optimal dosages
  - Adults (16years and above) who continue to have seizures even after 2 yrs of treatment
  - Paediatrics – MIE can be labelled earlier if
    - Epileptic encephalopathy
    - Infantile spasms
    - Catastrophic onset of epilepsy
    - Seizure frequency > 1/month
    - Disabling seizures


DRUG RESISTANT EPILEPSY
NO LESION SEEN ON EPILEPSY PROTOCOL MRI: SUBSTRATE -VE
LESION SEEN ON EPILEPSY PROTOCOL MRI: SUBSTRATE +VE
STANDARD INVESTIGATIONS :EEG,MRI, VEEG
ATIENT NOT A SUITABLE CANDIDATE OR CURATIVE/ PALLIATIVE SURGERY
-VE
-VE
+VE
ADVANCED INVESTIGATIONS:SPECT, PET
-VE
INVASIVE EEG
+VE
ELECTROCORTICOGRAPHY
JATE FOR VAGAL NERVE STIMULATION
(VNS)
ROLE OF VNS IN PATIENTS FOR CORPUS CALLOSTOMY)

Goals of Epilepsy Surgery

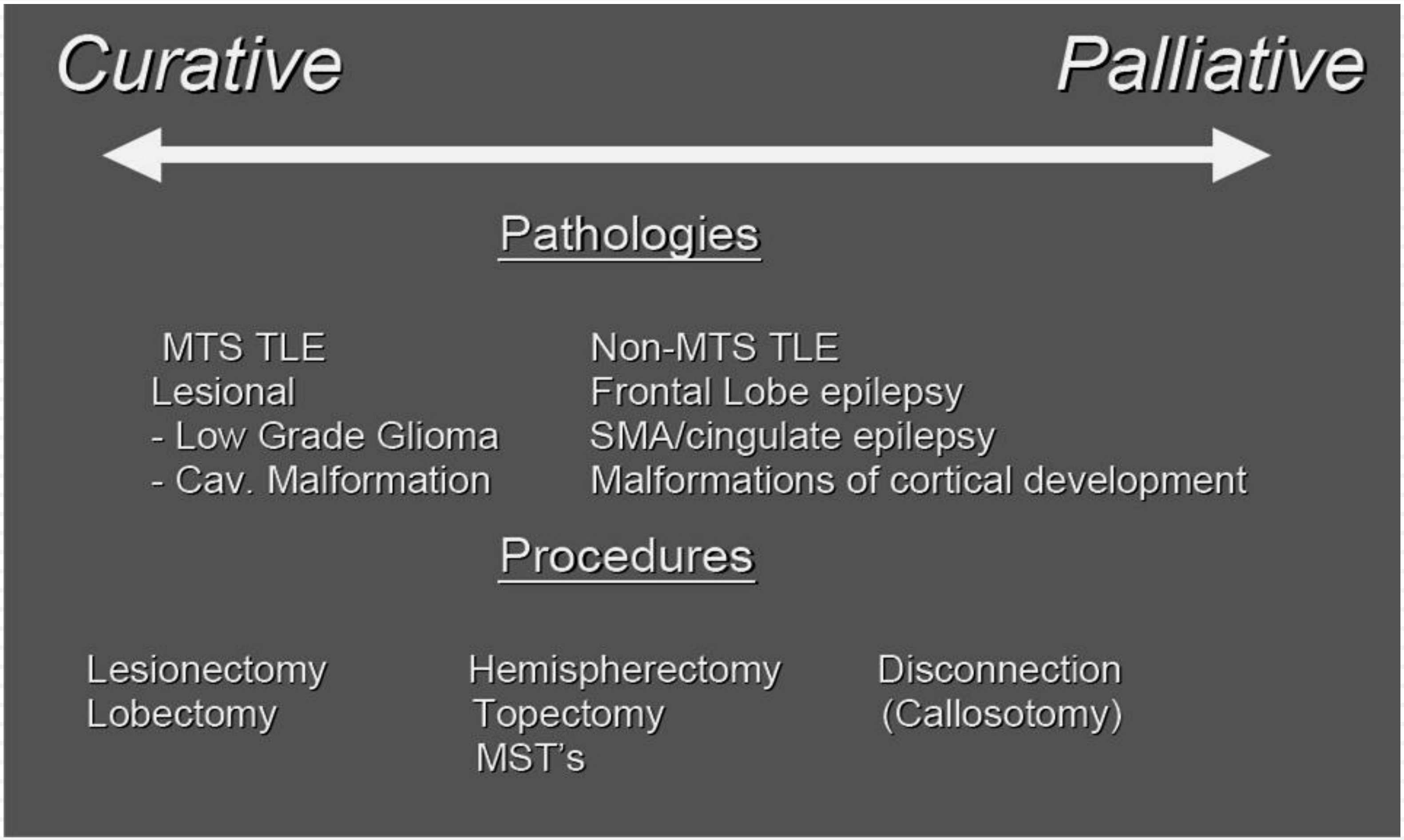
- Seizure-free
  - Remove sufficient amount of functionally-irrelevant tissue
- No reduction in neurological function
  - Memory
  - Language
  - Motor, sensory, visual
- Improve QOL
  - Correlates directly with seizure-free state

Epilepsy Surgery: Principles

- Determination of medical Intractability
- Identify the region of seizure onset
- Evaluate the consequences of resecting this tissue
- Surgical Resection

Surgical Approaches for Epilepsy

Resective Surgery	•Temporal lobe resections (anteromedial selective amygdalohippocampectomy); • Extratemporal resections; •Lesional resections; •Anatomic or functional hemispherectomy
Disconnection surgery	Corpus callosotomy; Multiple subpial transections; Keyhole hemispherotomies
Radiosurgery	Mesial temporal lobe epilepsy; hypothalamic hamartomas
Neuroaugmentative surgery	Vagal nerve stimulators; Deep brain stimulation
Diagnostic surgery	Depth electrodes; subdural strip electrodes; subdural grids


Curative
Palliative
Pathologies
MTS TLE
Lesional
- Low Grade Glioma
- Cav. Malformation
Non-MTS TLE
Frontal Lobe epilepsy
SMA/cingulate epilepsy
Malformations of cortical development
Procedures
Lesionectomy
Lobectomy
Hemispherectomy
Topectomy
MST's
Disconnection
(Callosotomy)

A randomized controlled trial of surgery for temporal lobe epilepsy

- Utility of temporal lobe surgery for intractable epilepsy vs. Continued treatment with antiepileptic drugs Wiebe et al, NEJM 2001
- Prospective, randomized, controlled trial
- Eighty patients randomized to surgery or medical treatment for one year
- At one year, those undergoing surgery had a much higher rate of seizure freedom (58% versus 8%)
- Significantly better quality of life

Techniques of Temporal Resection

- Temporal "lobectomy"
  - Anterior temporal lobectomy (ATL)
  - Anteromedial temporal resection (AMTR)
  - Tailored (ECoG with or without speech mapping)

- Selective medial resection
  - Amygdalohippocampectomy
    - Transcortical
    - Trans-sylvian

Anterior Temporal Lobectomy (ATL)

- Anterolateral temporal lobe (4-4.5 cm from temporal tip along middle temporal gyrus)
- Amygdala
- Uncus
- Hippocampus
- Parahippocampal gyrus - to level of collicular plate

Anterior Temporal Lobectomy (ATL): Complications

- Hemiparesis-1.25%,due to damage of the perforators to the anterior choroidal artery.
- A contra lateral superior quadrantanopsia from damage to the Meyer loop.
- Infection occurs in 2% .
- Cranial nerve III or IV palsies are in up to 20% of cases.
- Verbal memory problems particularly in speech-dominant temporal lobe resection.

Anteromedial Temporal Resection (AMTR)

- Spencer et.al. 1984
- Resect anterior 3-3.5cm of middle and inferior temporal gyrus
- Amygdala
- 3-4cm of hippocampus
- Parahippocampal gyrus

Anteromedial Temporal Resection (AMTR)

- Indications - Candidates for AMTR have the following:
  - Complex partial seizures with semiology typical of mesial temporal lobe epilepsy.
  - MRI evidence of unilateral hippocampal atrophy and increased T2-weighted signal.
  - Unilateral temporal lobe hypometabolism on PET scans.
  - EEG confirmation that seizures begin over the temporal area ipsilateral to the hippocampal atrophy or PET scan evidence of hypometabolism in anteromedial temporal region.

Selective Amygdalohippocampectomy

- Treatment of MTE
- Tissue sparing operation with removal of mesial temporal structures
  - Uncal portion of amygdala
  - Anterior portion of hippocampus
  - Portion of parahippocampus gyrus

- Approach:
  - Transcortical -via middle temporal gyrus (Niemeyer 1958)
  - Transsylvian – (Wieser and Yasargil 1982)

Prognostic Factors and Outcome after Different Types of Resection for Temporal Lobe Epilepsy

Clusmann H, Schramm J, Kral T, Helmstaedter C, Ostertun B, Fimmers R, Haun D, Elger CE

J Neurosurg 2002;97:1131–1141

- 321 patients who underwent surgery for TLE between 1989 and 1997
- Mean follow-up - 38 months
- Five factors predictive for good seizure control ($p < 0.1$):

  1) Clear abnormality on MR images;

  2) Absence of status epilepticus;

  3) MR imaging-confirmed ganglioglioma or DNET;

  4) Concordant lateralizing memory deficit; and

  5) Absence of dysplasia on MR images

- No significant differences regarding different resection types performed for comparable lesions.
- Neuropsychological testing - better postoperative results after limited resections especially in
  - Attention level,
  - Verbal memory,
  - Calculated total neuropsychological performance.

Lesionectomy

- Surgical resections aimed at curing epilepsy by removing structural brain lesions:
  - Malformations of cortical development, low-grade neoplasms, vascular malformations
- Surgical approach depends on lesion location
- Intraoperative ECOG

Intra-operative electrocorticography in lesional epilepsy

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ELSEVIER

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- Delineate margins of epileptogenic zone,
- Guide resection
- Evaluate completeness of resection
- ECoG correlated significantly with clinical improvement
  - Sensitivity: 100% (95% CI; 96—100%);
  - Specificity: 68.3% (95% CI; 51.8—81.4%)
- Positive predictive value: 89.9%

Neocortical Resection

- Resection of cortex outside medial temporal lobe
- Boundaries of resections determined by ECOG
- Suspected regions of epileptogenesis may involve eloquent cortex
- Mapping of cortical function during diagnostic work-up
  - Extra-operative techniques: fMRI, MEG
  - Mapping by intraoperative cortical stimulation
- In the absence of pathological abnormalities, extratemporal resections represent the poorest outcome.

Hemispherectomy

- Dandy in 1923 – malignant glioma
- Indication: Seizures arising over most of one hemisphere
- Severe hemispheric damage during development processes:
  - Sturge-Weber
  - Perinatal Infarcts
  - Hemimegalencephaly
  - Rasmussen's Encephalitis
- Failed functional hemispherectomy patients
- Goal:
  - Remove or disconnect all of cortex of one hemisphere from the rest of the brain.

Anatomical Hemispherectomy

- Ideal candidate
  - Contralateral hemiperesis
  - Hemianopsia
- Timing of surgery
  - Body weight of 10kg

Anatomical Hemispherectomy

- Cure most patients of their seizures
- Progressive worsening of the neurological status of the patients a few years after surgery (an average of 8 years after surgery), leading to death in up to 30–40% of the patients.
- Iron deposits on the brain surface, with a membrane lying over the hemispherectomy cavity

  “superficial cerebral hemosiderosis”

Oppenheimer DR, Griffith HB: Persistent intracranial bleeding as a complication of hemispherectomy. J Neurol Neurosurg Psychiatry 29:229–240, 1966

Functional Hemispherectomy

- 1970s by Rasmussen
- 1990 -2 different approaches were described
  - Vertical approach was described by Delalande and colleagues
  - Lateral approach was described by Villemure et al
- Common goal of all of the hemispherotomy
  - Interruption of the corpus callosum
  - Internal capsule and corona radiata,
  - Mesial temporal structures
  - Frontal horizontal fibres.

Rasmussen's functional hemispherectomy

- Four steps
  - Temporal lobectomy including hippocampus
  - Suprasylvian central block
  - Transventricular callosotomy
  - Frontal and parieto-occipital disconnections

Hemispherotomy for intractable epilepsy

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- Total 19 pts (2001-2007)
- Follow up 32-198weeks
- Engel's class I outcome- 18pts and class II in 1 pt
- Postoperative power improved in 3 pts rest had same as preop power
- Cognitive functions improved in all patients

Disconnection Procedures

- Corpus Callosotomy
- Multiple Subpial transections

Disconnection Procedures: Callosotomy

- Introduced in 1940 by van Wagenen and Herren
- Transection of corpus callosum: anterior 70-90%
- Rationale: disruption of rapid spread of certain seizures from one hemisphere to the other

- Seizures responding better
  - Drop attacks
  - Atypical absence
  - GTC seizures
- Complications
  - Surgical complications
  - Disconnection syndrome - Alien hand syndrome

Multiple Subpial Transections

- Developed to treat epilepsy arising from cortex that cannot be resected (eloquent area).
- Rationale:
  - A cortical island wider then 5 mm or with horizontal connections larger then 5mm is required to support paroxysmal discharge.
  - Disruption of horizontal connections within cortex that are vital for synchronizing neural activity, without affecting ascending and descending fibres.

Multiple Subpial Transections

- Small hook cuts through gray mater leaving pia and surface vessels intact.
- Transections at right angles to long axis of gyrus at 5mm intervals.

Vagal Nerve Stimulation:

- FDA approval of VNS in 1997 as adjunctive therapy in patients 12 years of age and older.
- Mechanism of action of VNS not clear.
- Desynchronizing electroencephalography activity.
- VNS → NTS → LC → Hypo/amygdala.
- Indications for VNS
  - Medical therapy has failed and
  - Patient unsuitable candidate for resection

Vagal Nerve Stimulation:

- Standard pacemaker generator
  - Houses a lithium battery and electronics
  - Implanted in a subclavicular pocket
- Lead wire
  - Tunnelled into left carotid sheath via a transverse or longitudinal neck incision
  - Spiral endings of the leads attached to left vagus nerve
  - Left vagus is used due to a lower percentage of efferent fibres to the atrioventricular node

Vagal Nerve Stimulation:

- Seizure Control
  - 35–45% of patients have decreased frequency of seizures exceeding 50%
  - ~ 2% become seizure free
- Complications
  - Infection - 5–7%
  - Vocal cord paralysis ~ 1% of patients
  - Hoarseness, cough, dyspnea, nausea, and obstructive sleep apnea.

Brain Stimulation for Epilepsy

- General concept: disrupt the seizure- generating network to prevent initiation of seizures or terminate seizures underway.

- Target of stimulation
  - Partial epilepsy: seizure focus or components of network necessary for propagation
  - Generalized epilepsy: seizure-generating network

Target structures for deep brain stimulation

- Cerebellum
  - Inhibition of thalamic nuclei by modulating the activity of efferent cerebellar nuclei
- Thalamus
  - Centromedian nucleus
  - Anterior nucleus -the central relay station of the limbic system, is closely connected both to the hippocampus and also to extensive areas of the neocortex
- Subthalamic nucleus and Caudate nucleus
- Epileptic focus

Anticonvulsive mechanisms

- Inactivate neurons by blocking depolarization,
- Reduce the recruitability of neurons on the basis of the rhythmic activity they induce
- Activation of inhibiting neurons and their projections,
- Changes in the properties of networks (desynchronization, antikindling effects)

Stimulation Paradigms

- "Open loop"
  - continuous or cyclical stimulation
- Responsive "Closed loop"
  - Delivered in response to the onset of a seizure
  - Seizure detection: identification of onset or occurrence of actual seizure
  - Seizure predication: identification, in advance, that a seizure will probably occur
- "Patient-activated stimulation"
  - Stimulation initiated by patient or caregiver when they feel or see a seizure

Complications

- Infection rates of 6.1%
- Misplacement of electrodes in 4.4%
- 0.5% to 1% for symptomatic bleeding
- Electrode breakage in1.8%
- Skin ulcerations in 1.3%

Radio surgery for epilepsy

Why radio surgery?

- Selective temporal resections are effective
- Morbidity is low, but not zero
  - Infection
  - Neuropsychological change
  - Blood loss (intra-operative, post-operative)
  - Other focal neurological deficits
- Medical contraindications of open surgery
- Some patients are afraid of surgery

Indirect evidence for efficacy

- Tumors
  - Radiation and radiosurgery reduces seizures
  - Hypothalamic hamartomas
- AVMs

MECHANISMS OF GAMMA IRRADIATION

- Neurons them selves are resistant to radionecrosis.
- Vasculature and glia are sensitive.
- Endothelial damage to small blood vessels and astrocytic reactions.
- Neuronal damage results from ischemia caused by vascular inflammation.
- Other hypotheses suggest that irradiated neuronal circuits undergo neuromodulation that renders an anticonvulsant (or, sometimes, a paradoxically proconvulsant) reaction.

- Radiation directed at
  - Temporal portion of the amygdala,
  - The anterior 2cm of hippocampus and
  - Adjacent parahippocampal gyrus
- Total volume within 50% isodose line between 5.5 and 7.5cc
- Dose 20-24Gy to 50% isodose line

Complications of radiosurgery

- Initial increase in auras
- Headaches
- Visual field deficits (52% of patients) - mostly quadrantanopia
- Long waiting period before effect

Intracranial EEG recordings

- INDICATIONS:
  - Seizures are lateralized but not localized.
  - Seizures are localized but not lateralized.
  - Seizures are neither localized nor lateralized (e.g. stereotyped complex partial seizures with diffuse ictal changes).
  - Seizure localization is discordant with other data.
  - Relationship of seizure onset to lesion must be determined (e.g. dual pathology or multiple intracranial lesions).

Indications for invasive monitoring

- Temporal lobe seizures-
  - Doubtful side
  - Normal MRI
  - Bilateral pathology
  - Discordant non-invasive testing
- Extra-temporal seizures-
  - Definition of extent of epileptogenic area
  - Cortical mapping

TYPES OF ELECTRODES

- Depth
- Strip
- Grid electrodes

Depth Electrodes

- Depth electrodes are multi-contact, thin, tubular, rigid or semirigid
- Made of platinum and insulated shaft is polyurethane impregnated with barium
- Number of contacts per electrode 4-12
- Recording from deep structures

Subdural Strips and Grids

- Intracranial strip electrodes are a linear array of 2-16 disk electrodes embedded in a strip of silastic.
- Grid electrodes are parallel rows of similar numbers of electrodes that can be configured in standard or custom designs.
- Hybrid subdural electrodes containing macro- and microelectrode arrays

- Grid and strip electrodes are designed to be in direct contact with brain neocortex.
- Electrodes are placed in the subdural space.
- Occasionally be used in the epidural space.

Complications of intracranial monitoring

- Depth Electrodes-
  - Haemorrhage –1-3%
  - Infection –Intracranial abscess
  - Misplacement
- Subdural Strips-
  - Haemorrhage
  - Infection –meningitis
- Subdural Grids-
  - Infection –bone flap
  - Raised intracranial pressure

Cortical Mapping

- To define the location of the epileptogenic cortex & to determine its relationship to functional cortex.
- Mapping the cortex underlying an implanted grid electrode(Luders, 1989; Lee, 1988).
- Cortical stimulation is performed using commercially available constant current generators.
- Performed by selecting 2 adjacent electrodes (1-cm intervals) because bipolar stimulation provides more precise control of current flow.
- Bipolar pulses at 50 Hz are used for language, motor, and sensory mapping.
- a clinical neurophysiologist reviews the ECoG during stimulation to ensure that any disruption of neurological function is due to the stimulation and not an after discharge.

Thanks …