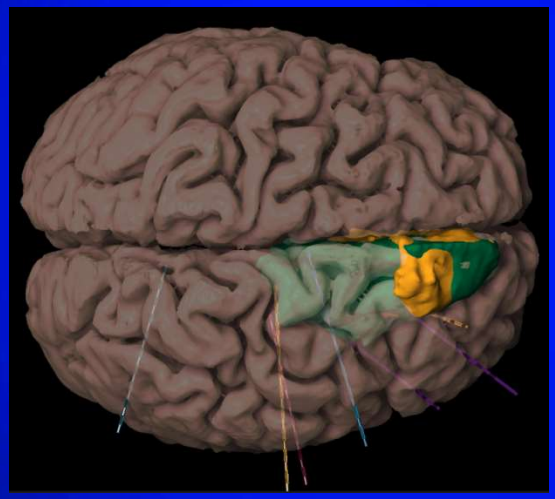
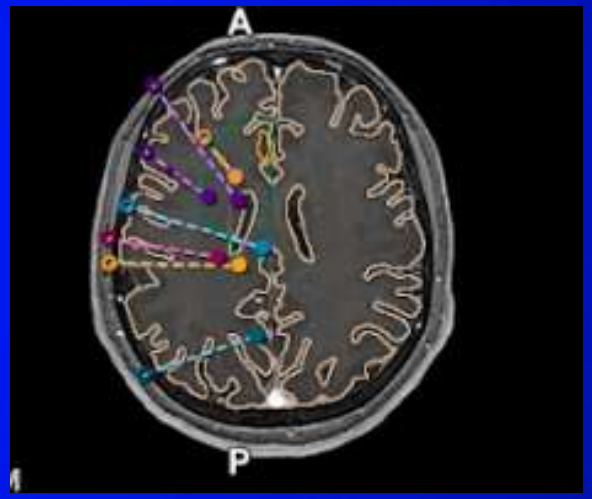
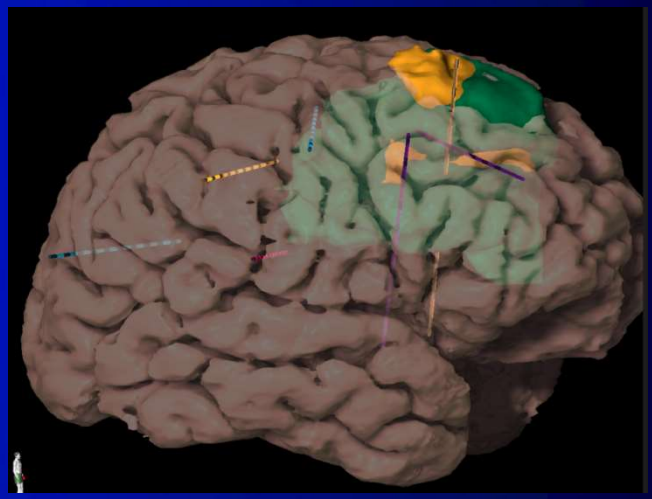
Stereoelectroencephalography (SEEG)







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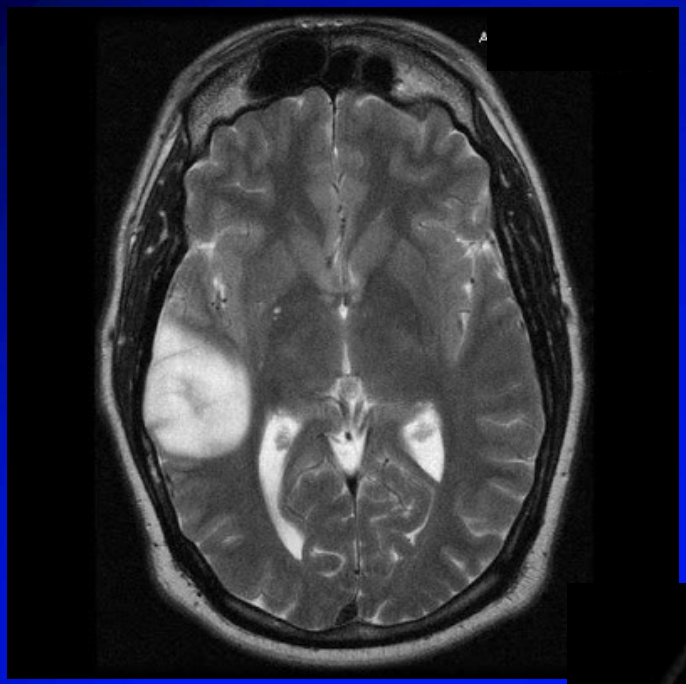
Epilepsy Surgery

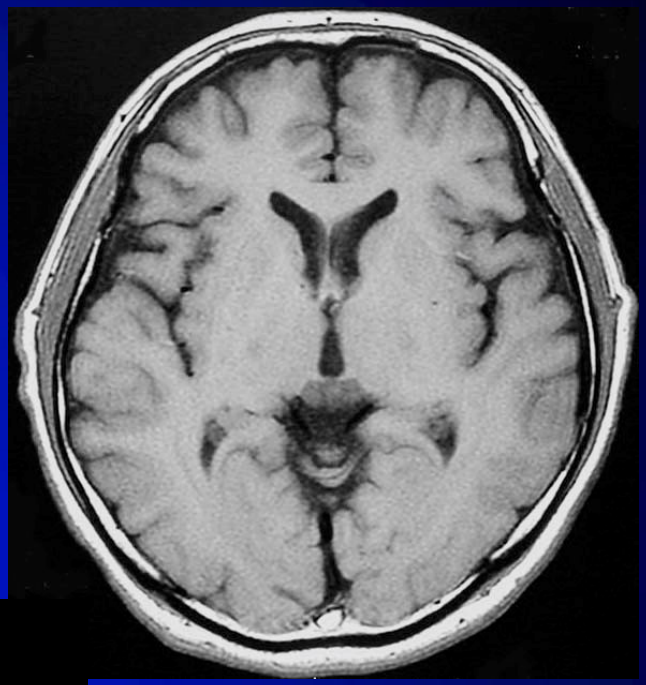
- 1/3 of patients will be refractory to AEDs
- Epilepsy surgery is widely accepted as the most effective therapeutic option in a selected subset of these patients
- Seizure freedom, or improvement of seizure control, is the desired and most commonly reported outcome.

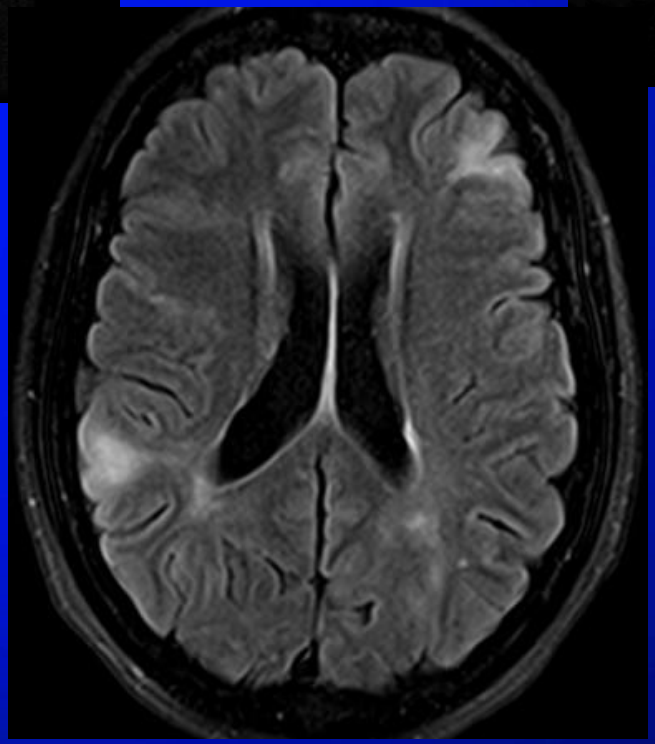
Selection of ideal candidates for epilepsy surgery

- Drug-resistant epilepsy
- Seizures causing significant disability and impaired quality of life
- Epileptogenic zone can be localized
- Acceptable risks and benefits of epilepsy surgery

Epilepsia. 2010 Jun;51(6):1069-77







Indication of invasive evaluation in Epilepsy surgery

- MRI-negative case
- Electroclinical and MRI data discordance
- Multiple, in part discordant lesions
- Overlap with eloquent cortex

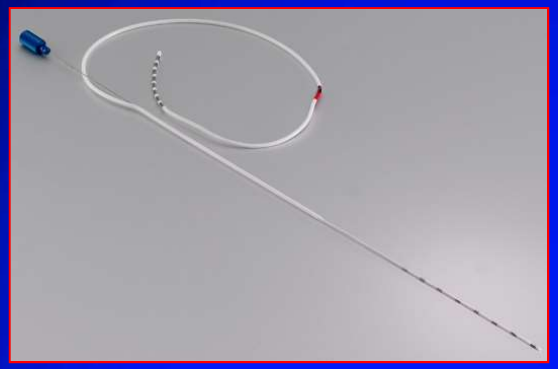
Invasives and SEEG: Present to past

- At present, subdural grid and strip monitoring is the most common invasive monitoring method used in the US
- SEEG has been used in Europe for the last 60 years
- First SEEG case in the US was performed at the Cleveland Clinic in March 24 2009

Outline

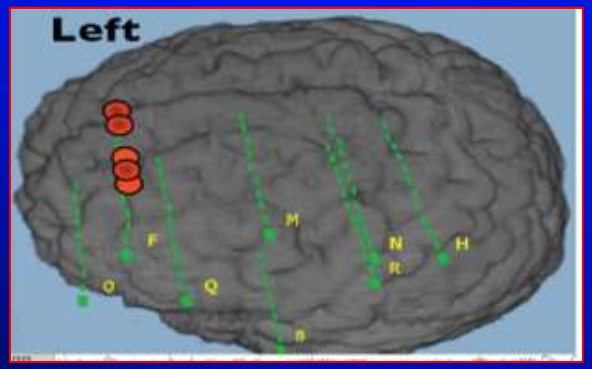
- What is SEEG?
- SEEG concepts
- The potential candidates for SEEG
- Workflow of SEEG process
- Case scenarios
- Safety and outcome

Stereoelectroencephalography (SEEG)



- **Three-dimensional exploration of the brain using depth electrodes**

- **Implant of cerebral structures with the precision of stereotactic methodology**

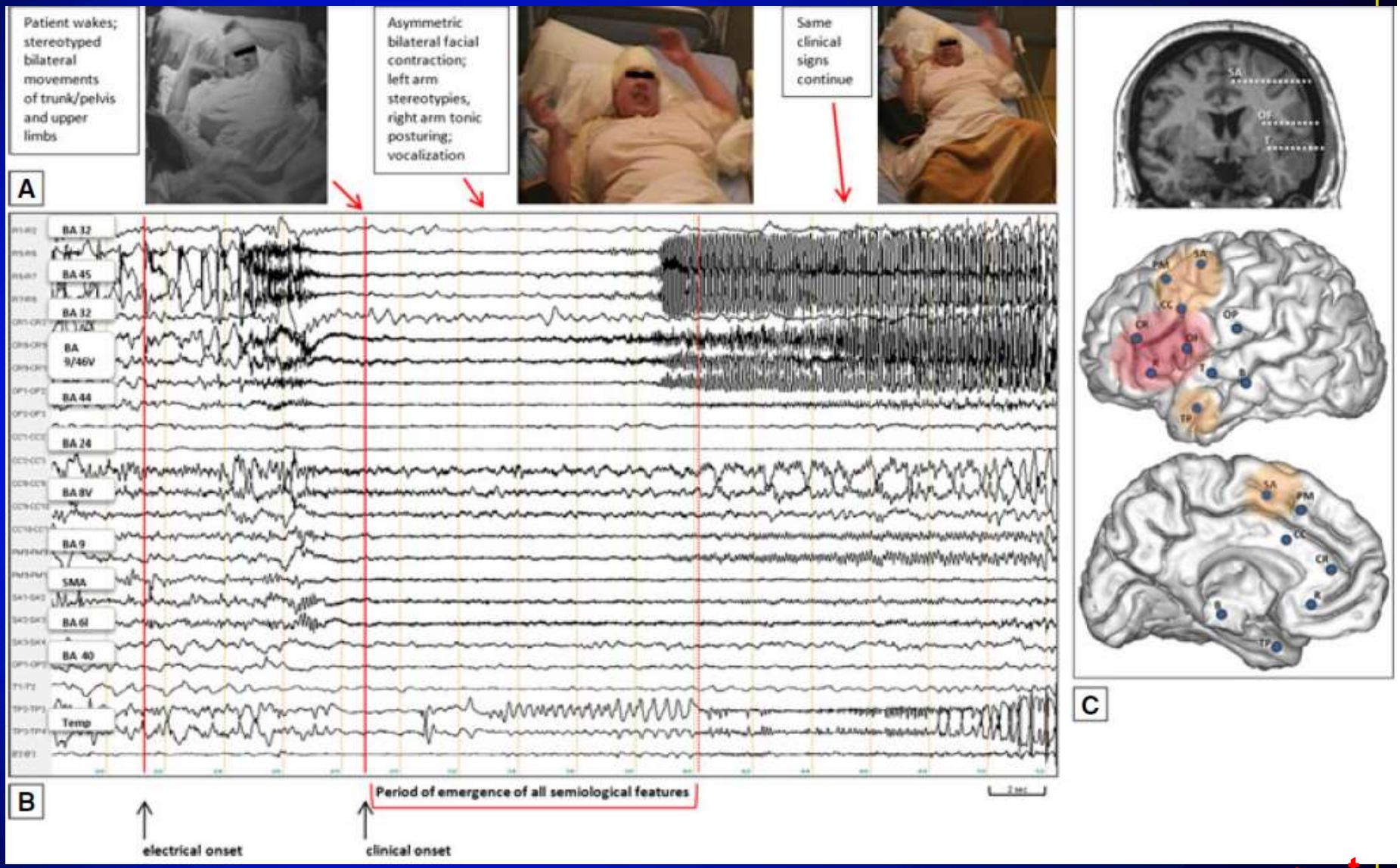


- Very precise sampling and easier to reach deep areas of cortex

SEEG ≠ Depth electrodes

- Size
- Anatomo-Electro-Clinical correlations
- Epileptic network

Anatomo-Electro-Clinical (AEC) correlations



Bonini F, et al. Epilepsia 2014

How can we generate an AEC network hypothesis?

- The gold standard techniques for the localization of the epileptogenic zone (scalp EEG and video recordings of the seizure semiology) are sufficient to approximate the location of the epileptogenic zone and to generate an AEC network hypothesis

Siegel AM. Neurosurg Rev. 2004;27(1):1–18.

Case 24-year-old right handed female

- Onset Age: 2 years
- EPILEPSY CLASSIFICATION : Right hemisphere focal epilepsy
- ETIOLOGY : Unknown
- ASSOCIATED CONDITIONS : None
- PREVIOUS NEUROSURGERY :
  - Right anterior temporal lobe resection JAN 2003 (Miami Children's) and habitual seizures returned within 3 weeks
  - VNS implantation JAN 2010

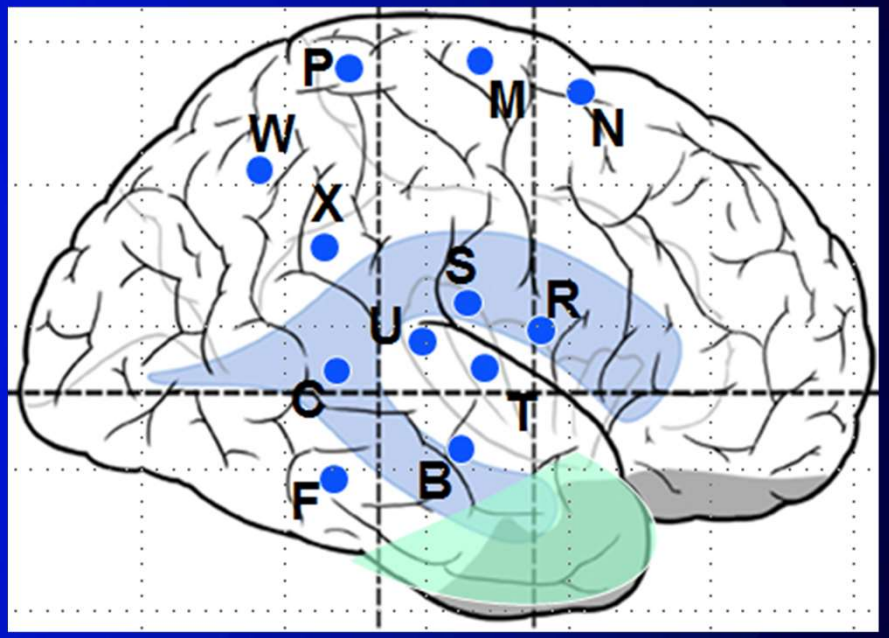
Seizure Description

- Seizure Description and Frequency: Patient reports having a constant tingling sensation throughout her body during wakefulness.
- Mother reports that patient's left arm stiffens and she may start grunting or appear as if holding her breath. Patient states that she remains aware of the left arm movement with most seizures, but loses awareness beyond this point.
- Of note has hx of sinus bradycardia during some seizures with documented R-R interval of 3.2 sec in-between sinus beats during the slowest HR. No hx of syncope or near-syncope in the absence of epileptic auras. Normal EKG and ECHO with normal cardiac structure and physiologic tricuspid regurgitation. A 3-second asystole was noted during one seizure 2 years ago
- Frequency: Axial tonic seizures almost every other night. Progression to GTC at least twice a month. +TB no UI. No hx of status epilepticus.

SEEG implantation

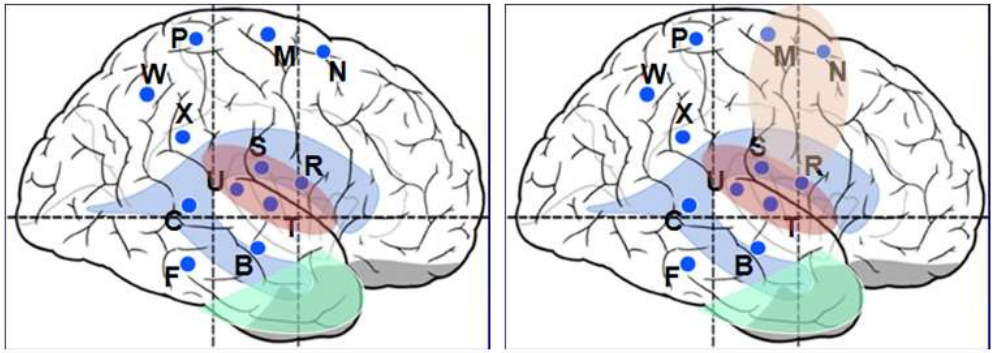
Semiology:

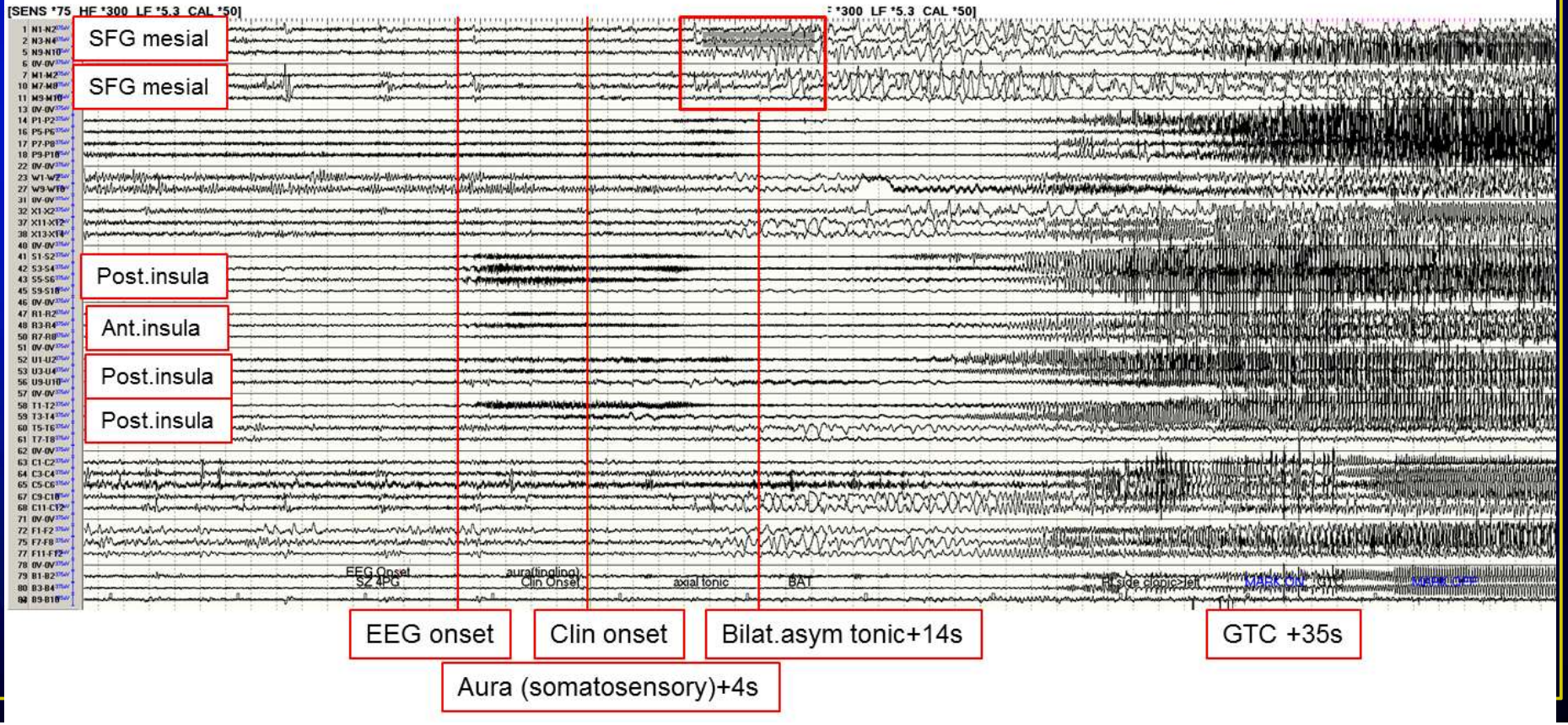
- Somatosensory aura
  - Right SS1
  - Right SS2
  - Right posterior Insula
- Bilateral asymmetric tonic
  - SMA
- Grunting
  - Frontal opercular, insular regions
- Hx of sinus bradycardia
  - Ant.insula
  - Mesial temporal
- Loss of consciousness
  - Temporal
- GTC



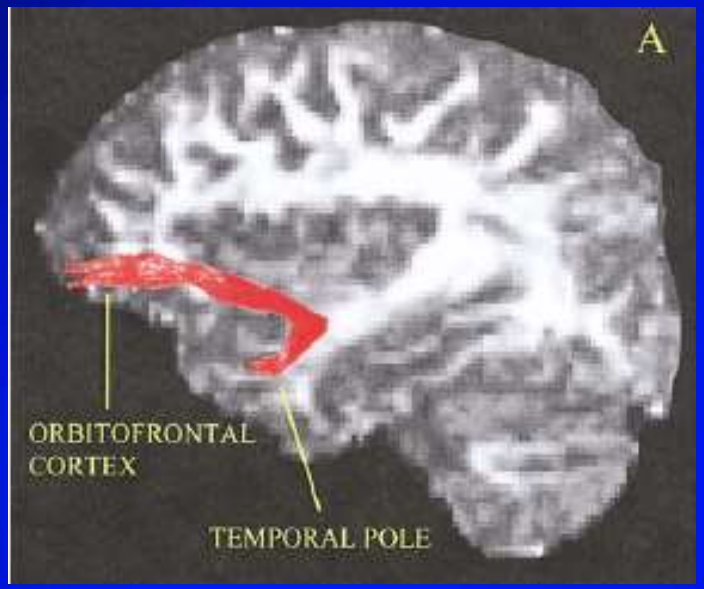
Insular-Opercular (Post.perisylvian hypothesis)

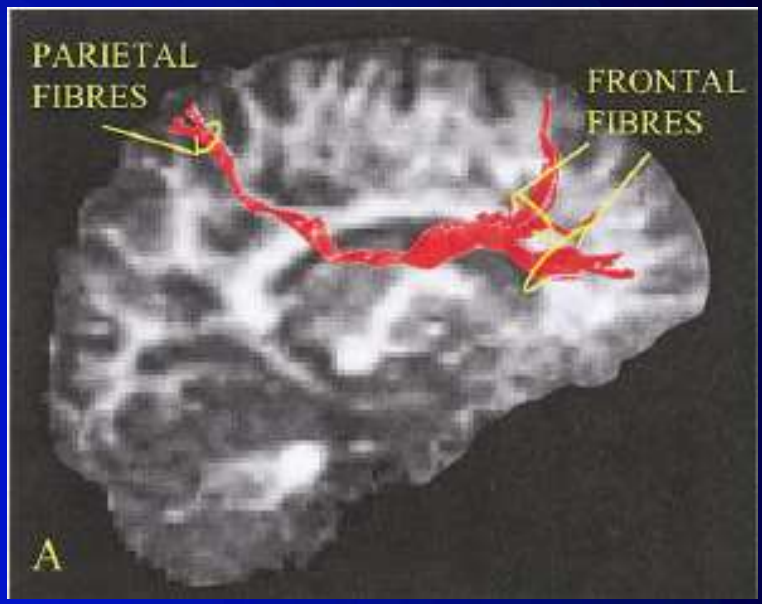
Anatomo-electro-clinical (AEC) correlations

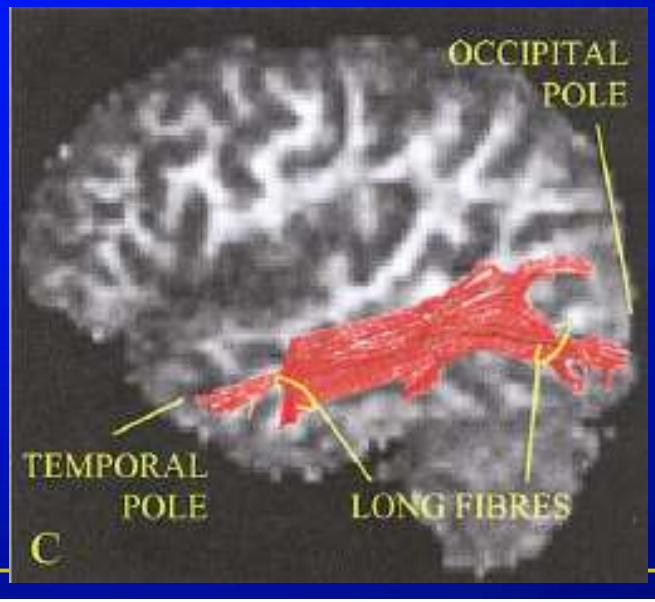




Brain Connectivity



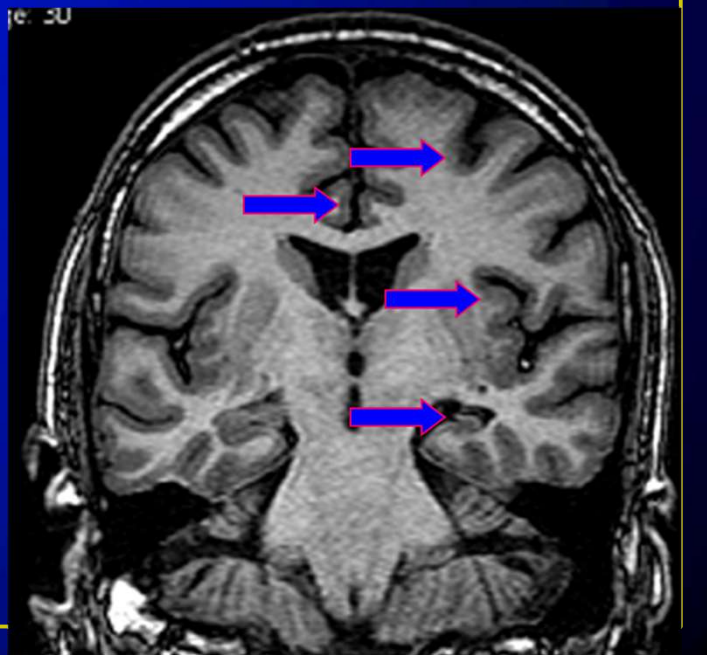




Who are the candidates for SEEG?

- Specific selection criteria:
  - the possibility of an EZ that is deep-seated or difficult to cover with subdural electrodes
  - the need for bihemispheric explorations
  - presurgical evaluation suggestive

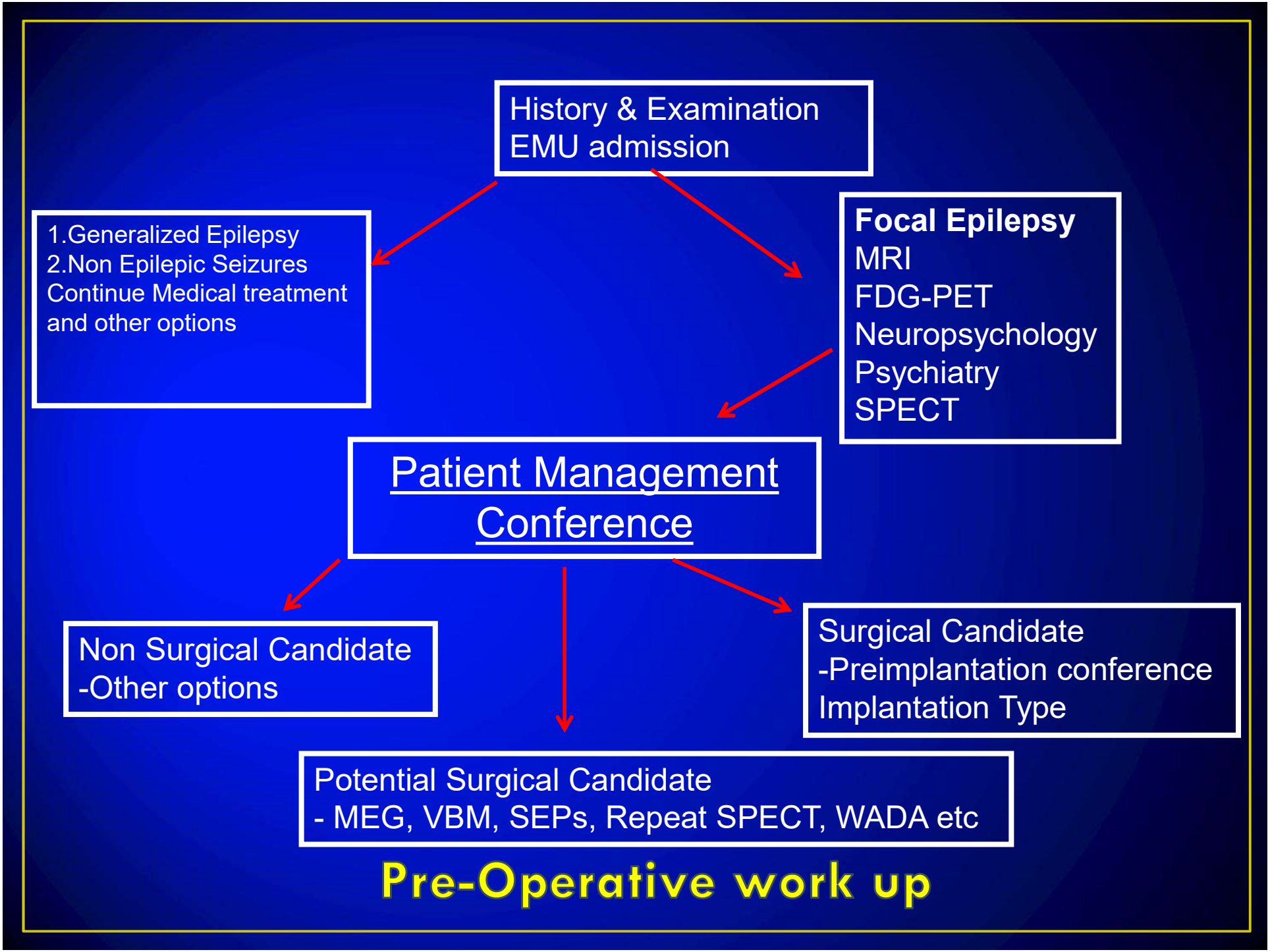
  of a functional network involvement in the setting of a nonlesional MRI.



Neurosurgery 75:258–268, 2014

- Case

Workflow of SEEG process


History & Examination
EMU admission
1.Generalized Epilepsy
2.Non Epilepic Seizures
Continue Medical treatment
and other options
Focal Epilepsy
MRI
FDG-PET
Neuropsychology
Psychiatry
SPECT
Patient Management Conference
Non Surgical Candidate
-Other options
Surgical Candidate
-Preimplantation conference
Implantation Type
Potential Surgical Candidate
- MEG, VBM, SEPs, Repeat SPECT, WADA etc
Pre-Operative work up

Pre-implantation Conference

- No standardized targets for electrode implantation
- Individualized cases- based on clinical semiology, scalp EEG, and anatomy
- Unilateral and/or bilateral implantation
- Limited number of electrodes and brain sampled (no more than 15 electrodes in total)
- NETWORKS!

SEEG map examples

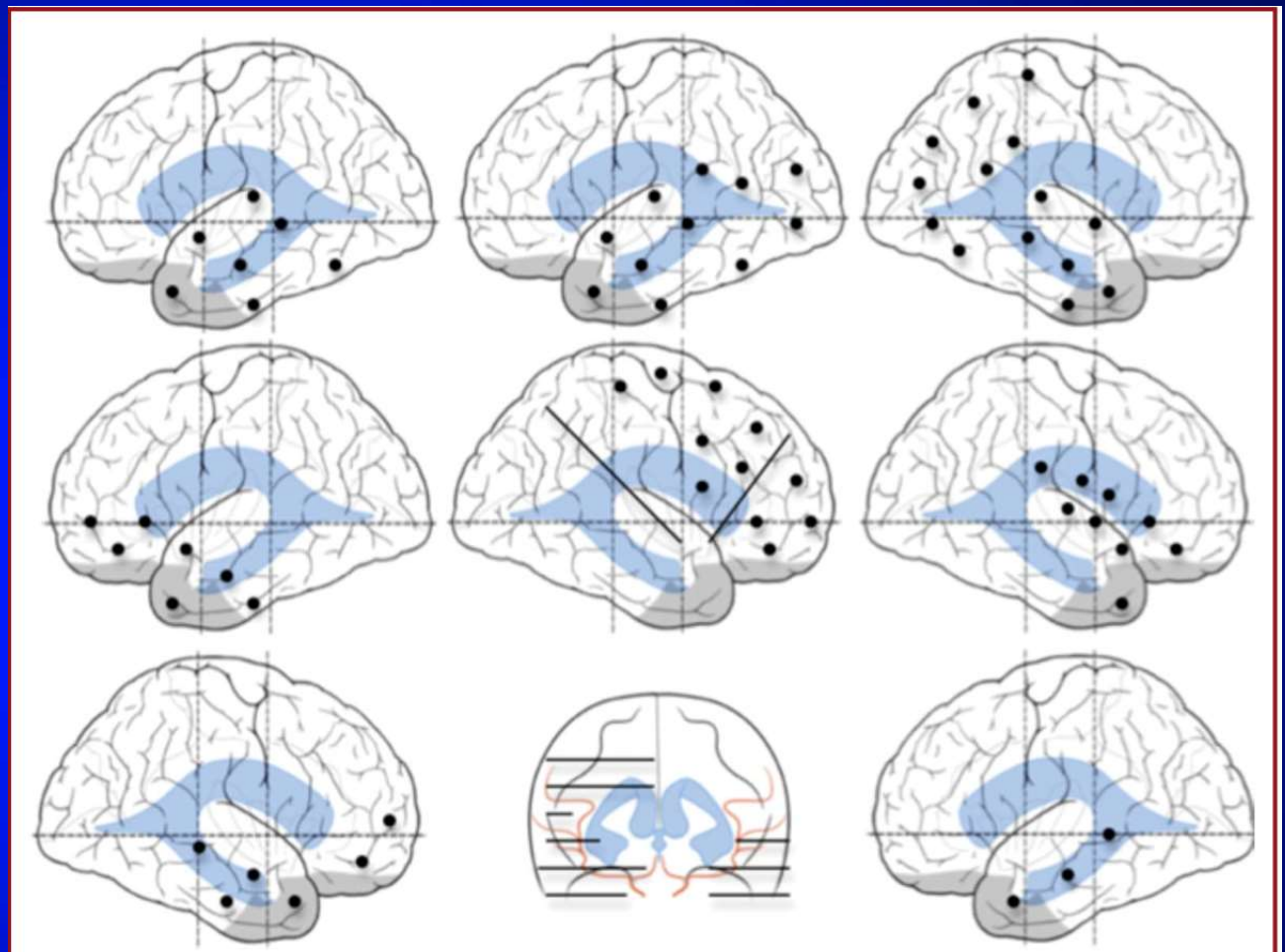
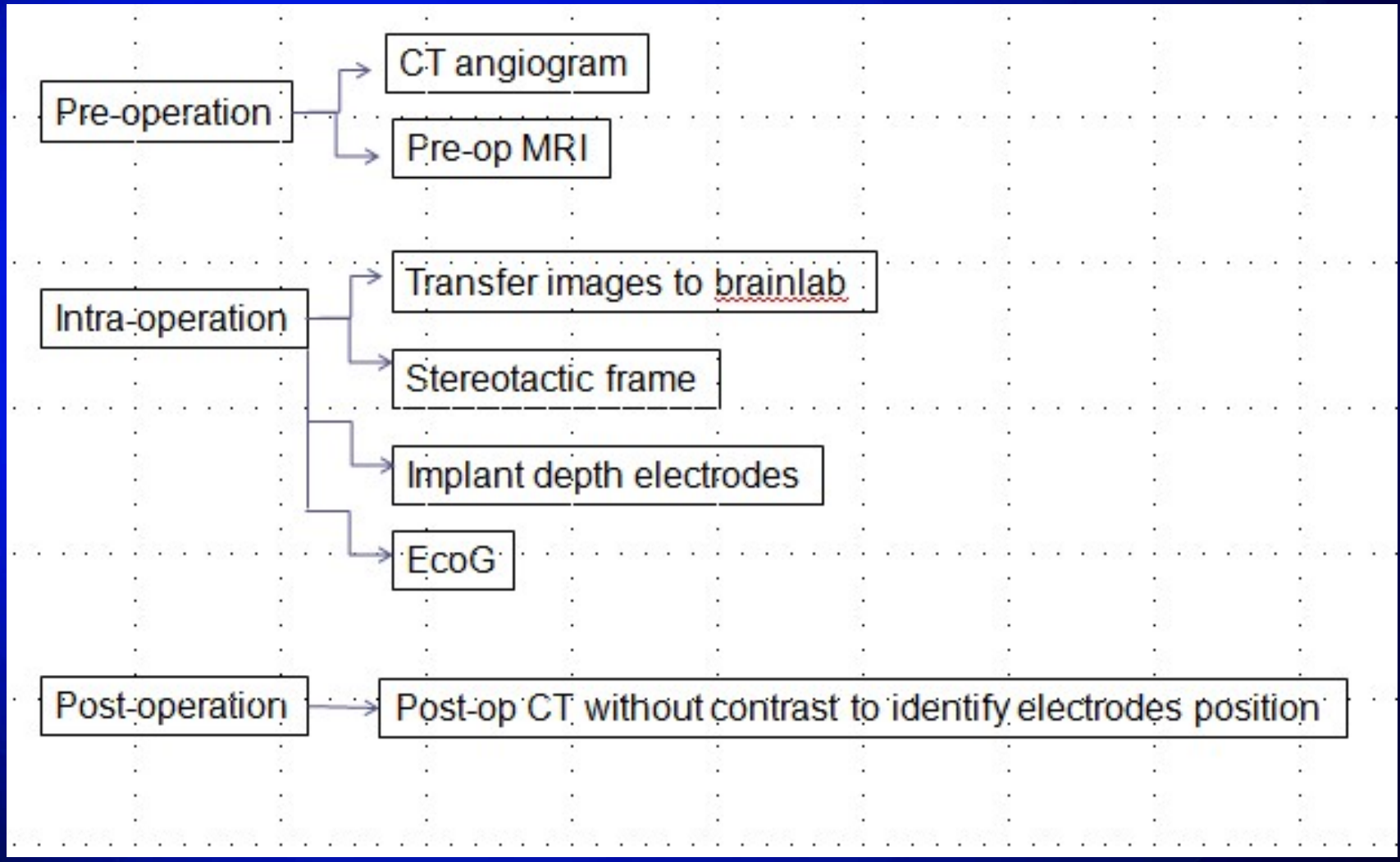
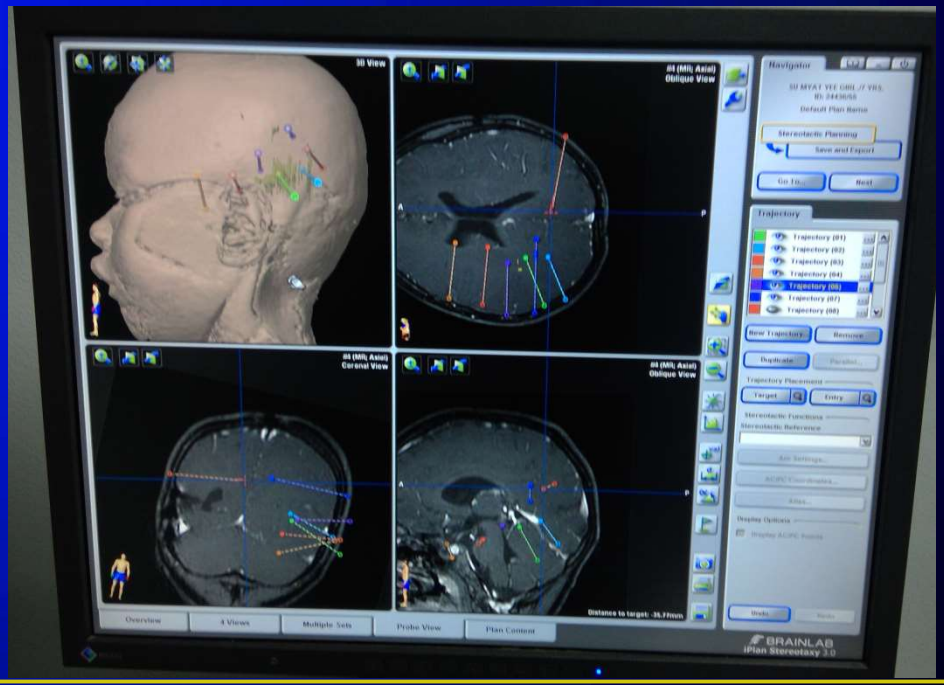


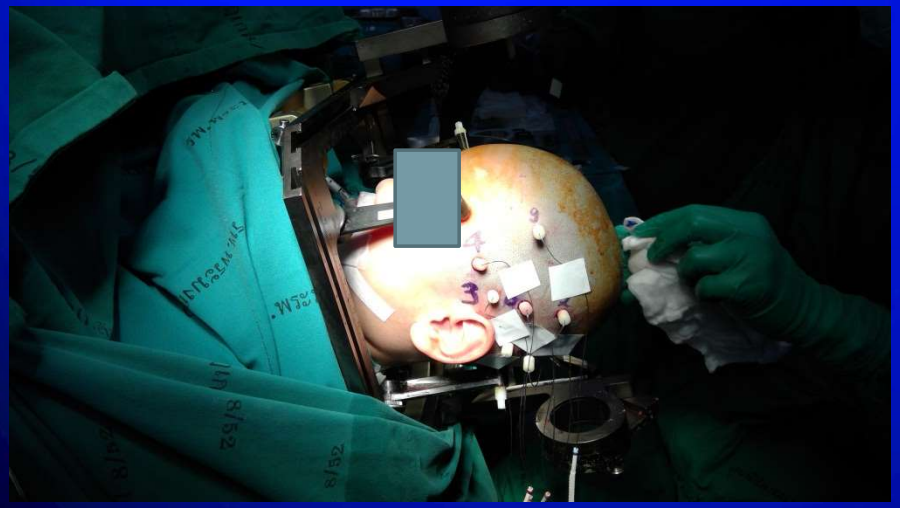
FIGURE 1. *Patterns of stereoelectroencephalography (SEEG) implantations in our studied pediatric group. Black dots represent the entry point of SEEG electrodes, implanted in orthogonal fashion. Black lines represent electrode trajectories. Top row, from left to right: temporal, temporal-occipital, and temporal-occipital-parietal patterns. Middle row: frontal-temporal, frontal-parietal-insular, and perisylvian patterns. Bottom row: bilateral temporal and right frontal implantations.*

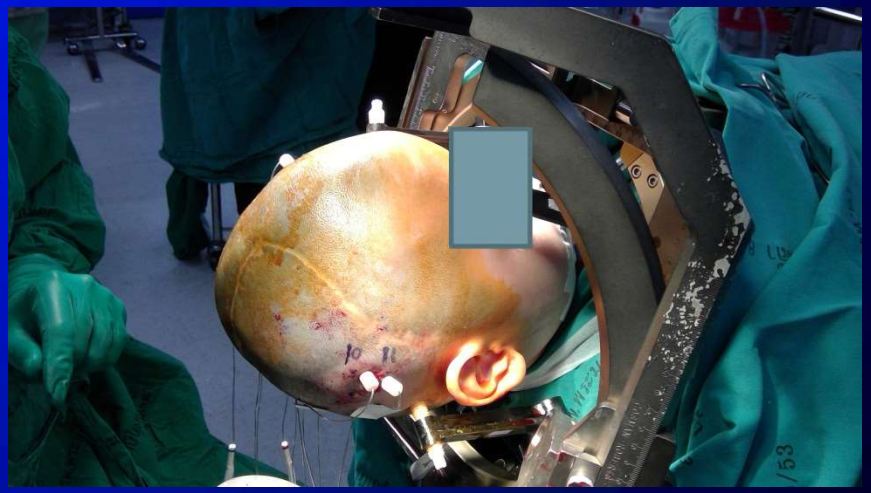
Gonzalez-Martinez et al. Neurosurgery 75:258–268, 2014

Workflow of SEEG process




3D View
Navigator
Stereotactic Planning
Trajectory
Overview
4 Views
Multiple Sets
Probe View
Plan Content
BRAINLAB
iPlan Stereotaxy 3.0





Safety and Outcome

Safety

- Safe procedure- low complications
- No large craniotomy
- Reduced risks of meningitis, raised ICP
- Same day ward admission (No ICU)
- Discharge day post explantation
- More comfortable to the patient

Is SEEG safe? A systematic review and meta-analysis of stereo-electroencephalography–related complications

*Jeffrey P. Mullin, †Michael Shriver, *Soha Alomar, †Imad Najm, †Juan Bulacio, †Patrick Chauvel, and *‡Jorge Gonzalez-Martinez

Epilepsia, 57(3):386–401, 2016
doi: 10.1111/epi.13298

- Reported the results of a meta-analysis evaluating 30 articles reporting 121 surgical complications related to SEEG insertion and monitoring
- The overall complication rate of SEEG was found to be very low (pooled prevalence 1.3%, 95% CI 09–1.7%)
- Based on meta-analyses comparison, SEEG safety profile seems to be significantly more advantageous compared to other invasive monitoring techniques
- The most prevalent risk in SEEG was found to be hemorrhagic complications (pooled prevalence 1.0%, 95% CI 0.6–1.4%)

SELECTION CRITERIA FOR DIFFERENT METHODS OF INVASIVE MONITORING IN MEDICALLY REFRACTORY FOCAL EPILEPSY

Clinical scenario	Method of choice	Second option
▪ Lesional MRI: Potential epileptogenic lesion is superficially located near or in the proximity of eloquent cortex. ▪ Nonlesional MRI: Hypothetical EZ located in the proximity of eloquent cortex.	SBG	SEEG
▪ Lesional MRI: Potential epileptogenic lesion is located in deep cortical and subcortical areas. ▪ Nonlesional MRI: hypothetical EZ is deeply located or located in noneloquent areas.	SEEG	SBG with depths
▪ Need for bilateral explorations and/or reoperations	SEEG	SBG with depths
▪ After SDGs failure	SEEG	SBG with depths
▪ When the AEC hypothesis suggest the involvement of a more extensive, multilobar epileptic network	SEEG	SBG with depths
▪ Suspected frontal lobe epilepsy in nonlesional MRI scenario	SEEG	SEEG

The 6th edition of Wyllie's Treatment of Epilepsy: Principles and Practice

SEEG conclusion

- Established chronic invasive EEG technique
- Stereotactic precision of implantation
- 3D mapping of the brain and mesial structures
- Better understanding of connectivity (eg Parieto-frontal)
- Safer, better tolerated technique, esp previous surgery
- Limited sampling of cortex/ Limited functional stimulation/ mapping
- Needs specialist knowledge and training
- Anatomo-electro-clinical correlation

Thank you for your attention