Updated Surgical Technique (Stereo-EEG) in Epilepsy Surgery

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Stereoelectroencephalography (SEEG)

- Jean Talairach & Jean Bancaud (1950s) at Hôpital Saint Anne, Paris
- Recorded electrical activity by intracerebral electrodes, implanted stereotactically in predefined cortical and subcortical structures.
Principle of SEEG methodology

“Anatomo-electro-clinical correlation”

• Hypothesis of preferential origin and spread of seizures (Ictal clinical picture, interictal, ictal scalp-EEG discharge)

• Spatiotemporal dynamic of seizure

• Presurgical and therapeutic surgical phases to be dissociated.

• Coordinate system based on AC-PC

• Individualized “Custom-tailored”
Essential rules for electrodes implantation

• Demonstrated brain regions suspected to be involved in seizure onset and early propagation show the expected ictal pattern

• Possibility the propagation of an ictal discharge generated elsewhere

• Delineating the border of the ‘epileptogenic zone’ > minimum cortical resection

• Investigation of eloquent areas relatively to the hypothetical ‘epileptogenic zone’

• Relationships between and anatomical lesion and the ‘epileptogenic zone’
SEEG

- Lesional zone
  - Abnormal slow-wave activity, alteration of background activity, electrical silence
- Epileptogenic zone
  - Ictal onset + early spread (primary organization of the epileptic seizures)
  - Fast synchronizing discharges that might involve a single region, or distinct but interconnected regions
  - Order and sequence of semiological elements must be view as a whole “Seizure pattern”
- Irritative zone (FCD, potential seizure onset zone)
Indications

- Drug resistant focal epilepsy
- Non-invasive investigations fail to correctly localize the epileptogenic zone
Specific criteria for SEEG

• Deep-seated or difficult-to-cover location of the epileptogenic zone (mesial structures of the temporal lobe, opercular areas, cingulate gyrus, interhemispheric regions, posterior orbitofrontal areas, insula, and depth of sulci)

• Failure of a previous subdural invasive study

• Extensive bihemispheric explorations

• Normal MRI

SEEG setup

• Epileptologist
• Epilepsy (+ stereotactic) neurosurgeon
• MRI (3T) + contrast
• Angio image (CTA, Angiogram)
• Stereotactic device (Frame-based, Frameless, Robot)
• Fluoroscopy
SEEG instruments

• Skin Probe
• Dura Probe
• Ruler
• Screw drivers
• (PMT, Adtech, DIXI)
Talairach technique

• Multiphase, complex-time-consuming

• Stereotactic neuroradiology
  • Talairach stereotactic frame + Angiography studies + 3D MR

• Placement of electrode placement [Orthogonal trajectories]

• Removal of electrodes
Cleveland Clinic

- Preop MRI
- Intraop Frame placement + Stereotactic DynaCT+ 3D digital subtraction angiography
- Ave planning time 33 mins, Implantation time 107 mins

Frameless stereotactic placement of depth electrodes

±SD from the intended target 3.0±1.9 mm

Frameless stereoEEG in epilepsy surgery

Mean error 3.6 mm

Robot-assisted SEEG

- ROSA
- Mean planning time 30 mins
- Mean operative time 130 mins
- Mean target error 1.7 mm
- Complication 4% (3 asymptomatic ICH)

Milano, Italy

- Neuromate
- 3-D T1-weighted MRI, O-arm 1000 system for 3-D DSA
- GA duration 315 (traditional), 330 (new workflow)
- Target point error 2.69 mm (traditional) 1.77 mm (new workflow)
- Major complication 2.4%
<table>
<thead>
<tr>
<th></th>
<th>Frame-Based SEEG</th>
<th>Frameless SEEG</th>
<th>Robotic SEEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need of Frame</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Need of intraoperative imaging</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Accuracy to target, mm</td>
<td>&lt;2</td>
<td>&gt;2</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Stability of tool delivery</td>
<td>Excellent</td>
<td>Reasonable</td>
<td>Excellent</td>
</tr>
<tr>
<td>Suitability for high-risk trajectories</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Uniformity of method</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Software</td>
<td>Varies among centers</td>
<td>Medtronic Stealth Station</td>
<td>ROSA, Neuromate</td>
</tr>
<tr>
<td>Restrictions to surgical field</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Flexibility to change plans intraoperatively</td>
<td>Limited</td>
<td>Good</td>
<td>Good</td>
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<tr>
<td>Ease of implementation with no specialist training</td>
<td>Limited</td>
<td>Good</td>
<td>Good</td>
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Extent of resection

• Anatomoelectro-clinical correlation
• Up to the non-involved electrode
• Up to eloquent cortex
• Functional anatomy
• Surgeon judgement (risks & benefits)
Complications (Meta-analysis)

- **SEEG-Surgical complication 1.3%**

<table>
<thead>
<tr>
<th>Complications</th>
<th>SEEG</th>
<th>SDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhage</td>
<td>1.0%</td>
<td>3.2-4%</td>
</tr>
<tr>
<td>Superficial infection</td>
<td>1.4%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Meningitis</td>
<td>0.6%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Permanent neurological deficits</td>
<td>0.6%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Transient neurological deficits</td>
<td>0.6%</td>
<td>4.6%</td>
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</tbody>
</table>

Thank you