## Stereoelectroencephalography in Presurgical Evaluation of Focal Epilepsy

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#### Why Stereoencephalography?



- The only technique that provides direct access to electrophysiological recordings in the seizure onset zone, when located in deep brain structures
- Allows determination of the depth of epileptogenic areas
- Requires insertion of depth electrodes (7-14)
- Electrode placement is achieved through stereotactic techniques



Stereotaxy



- Uses a 3D coordinate system to locate brain structures
- Requires a stereotactic positioning device
- Multi-modal imaging (CT, MRI, Angiography etc) that allows visualization of patient anatomy and co-registration with the stereotactic frame

#### Electroencephalographic depth recordings



## Spatial scale of scalp, cortical and depth recordings



- Scalp EEG requires a ~7cm<sup>2</sup> patch having synchronous activity
- ECoG and SEEG require ~10mm<sup>2</sup> of cortex
- Microwires, a sphere having R~150μm

After Worrell et al, Progress in Neurobiology, 2012

#### Goals of SEEG investigation

- Confirming that brain regions suspected of being involved in seizure onset and propagation show the expected ictal pattern.
- Delineating the border of the epileptogenic zone as precisely as possible, to perform the minimum cortical resection.
- Assessing whether the complete removal of the epileptogenic zone will be possible or not by performing stimulation mapping of the eloquent areas.
- Evaluating the precise relationships between an anatomical lesion (when present) and the epileptogenic zone.



- A Amygdala; B Anterior Hippocampus; C Posterior Hippocampus;
- E Entorhinal Cortex; U Superior Temporal Gyrus; D Retrosplenial cortex;

I – Temporal Pole; O - Orbitofrontal; F - Fusiform gyrus; R – Rolandic Operculum; W – Wernicke;

Stereotactic planning Preoperative MRI with contrast – Patient anatomy, vasculature



#### Stereotactic planning

#### Angiography

 Virtual angiography from contrast-enhanced MRI through3D Frangi vesselness filtering



#### Safe electrode placement



Safety index:0.83 Traj 6: S Frangi scales or[0.851.35] 3D smoothing or=2.00

#### Safe electrode placement



#### Stereotactic frame – Leksell



# Stereotactic devices StarFix techology, FHC Inc No adjustable components



#### Stereotactic devices

#### StarFix, personalized fixture



#### Personalized Stereotactic Frame

#### Advantages:

- Simplicity no adjustable parts, thus minimizing risk of human error
- Reduces OR time with a factor of two
- Two-step procedure (anchor implant, actual surgery) spaced one to two weeks
- Surgical planning can be performed in the generous interval between the two steps. It does not have to be performed the day of the surgery
- Frame coordinates match anatomical coordinates (centered on MCP and aligned with mid-plane), making targeting more consistent across patients.

# Electrode Implantation Percutaneous Hole Drilling Dura Electrocoagulation Anchor placement Stylet insertion Electrode Insertion





## Postoperative CT Verification of electrode position, hemorrhages





- B01-B03 Hippocampus
- B04-B05 –
   Parahippocampal gyrus
- B06-B08 WM
- B11-B12 Middle
   Temporal Gyrus (T2)

#### SEEG Recordings and Stimulation

- 1-3 weeks video EEG monitoring
  - Continuous recording using wireless amplifier



- Several ictal events captured
- Various stimulation protocols for:
  - Eliciting responses characteristic to inter-ictal or ictal patterns
  - Functional mapping of eloquent cortex, to delineate the area that can be resected with minimal deficit

#### R7-R8 Broca's area

speech arrest on stimulation (f=50 Hz, I=2mA)



## O2-O3 Orbitofrontal Cortex Low amplitude Delta



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#### P10-P1 - Parietal













## F2-F3 Fusiform Gyrus inter-ictal spikes



#### Seizure onset on SEEG

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#### Time-frequency map



#### Seizure propagation

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#### **Electrical Stimulation**

- Stimulation protocols:
  - 1 Hz, 3 ms biphasic pulses, 1-5 mA, 40 s
  - 50 Hz, 1 ms biphasic pulses, 1-3 mA, 5 s



# Electrical Stimulation A1-2 (Amygdala), 50 Hz, 1 ms biphasic pulses, 1-3 mA, 5 s – seizure reproduction



#### 10. Tailored resections



### Temporal lobe pole resection



#### Conclusions

Despite its complexity, SEEG method can provide invaluable information regarding:

- 3-D localization of the seizure onset zone in deep brain structures
- propagation paths of the ictal discharges
- functional mapping of eloquent cortex for delineating the resection

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  - University Emergency Hospital, Bucharest
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