Stereotactic Electroencephalography (sEEG) in the Pre-surgical Investigation of Refractory Focal Epilepsy

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American Epilepsy Society | Annual Meeting
Disclosure

No commercial interest
Learning Objectives

• Recognize the usefulness of sEEG as an invasive evaluation technique for defining the epileptogenic zone in candidates for epilepsy surgery
Invasive evaluation techniques in surgical candidates

• 5-10% of patients with epilepsy are candidates for epilepsy surgery and 25-50% of these patients will require invasive EEG studies (37,000 to 100,000 patients in USA alone)

• In the 1950th two “schools for invasive evaluation of surgical candidates with invasive electrodes emerged:
  – in Europe, Talairach and Bancaud developed the stereo EEG (s EEG) which analyses the brain in 3-D
Invasive evaluation techniques in surgical candidates

– in North America, however, Penfield and Jasper relied primarily on electrocorticography (ECoG) which led to the use of subdural electrodes, primarily a 2-D technique.
Invasive evaluation techniques in surgical candidates

• Surgically treatable focal epilepsy originates in the cortical grey matter. However, only 25-30% of the cortex is in the visible surface. In other words, 70-75% of the cortex is either deep seated or difficult if not impossible to access with subdural electrodes.
Symposium overview

• Drs. Giorgio LoRusso and Jonathan Miller are going to discuss respectively the European and the American approach to depth electrode insertion
• Dr. Gonzalez-Martinez will compare depth and subdural electrodes
• Drs. Philippe Kahane and Samden Lhatoo will present the use of depth electrodes for respectively mapping the epileptogenic zone and eloquent areas of the brain
• We will conclude with a round table and answering questions from the audience
References


“Stereo-EEG methodology: the European approach”
4th December 2012

Giorgio LoRusso, M.D.
Epilepsy Surgery Centre “C. Munari”
Niguarda Hospital, Milano Italy
Disclosure

No Commercial Interest
Learning Objectives

• Rationale of the original Talairach’s approach.

• Current 3D imaging-based SEEG methodology.
The Talairach’s methodology

• You have to know the Stereo TAXIC
  (three dimensional / arrangement)

• To perform a Stereo TACTIC
  – (three dimensional / touch) approach
Jean Talairach’s methodology
1949

Cerebral commissures

Vascular pathways

Ventriculography

Angiography

direct landmarks visualization

But how get the 3D.........?
The Talairach’s proportional grid

- The “Quadrillage”
“MR” in the pre MR era

inter-individual variability of cortical anatomy

approach based on a proportional reference system which used the intercommissural line identified by contrast ventriculography

Stereoscopic angiography
Current SEEG Implantation Technique

- Positioning of the guiding screws
  - Positioning of the robot
  - Positioning of the stop system on the drill to reach the internal wall of the skull
  - Drilling
  - Coagulation of the dura mater with a monopolar coagulating electrode
  - Positioning of the screw
- Implant of the electrodes (under X-Ray control)
  - Temporary introduction of the stylet
  - Introduction of the electrode
  - Tightening of the cap
New SEEG Implantation Accuracy (Sep 2008 - Nov 2011)

- 1050 electrodes

- Localization error at EP (median)
  - 0.78 mm (i.q. range: 0.49 - 1.08)
Safety (May 1996 - November 2011)
500 SEEG procedures

Major morbidity

<table>
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<tr>
<th></th>
<th>Surgical intracranial bleeding</th>
<th>Minor intracranial bleeding</th>
<th>Cerebritis</th>
<th>Hydrocephalus</th>
<th>Retained broken electrode</th>
<th>Psychotic event</th>
<th>Death</th>
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<tbody>
<tr>
<td>500 SEEG</td>
<td>5 (2 permanent hemiplegias)</td>
<td>10 (1 with status epilepticus)</td>
<td>2 (1 aseptic)</td>
<td>1</td>
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Neurosurgery, in press
Today from 2D to 3D

• Today the main diagnostic acquisition are 3D

But……THE SONG REMAINS THE SAME

First think stereotaxic and then stereotactic
Where are we recording from?
Neurophysiological individual localization
DTI-FT of the Cortico Spinal Tract
SEEG stimulation and motor evoked potentials
The relevance of the 3D exploration
The deep seated lesions

16 yrs. ♀
16 yrs. ♀

White-Grey matter boundary surface with FDG-PET overlay

The “inflated” representation
The neurophysiological label of the FCD
Case 1: 24 yrs. ♂
SEEG exploration

Periventricular Nodular Heterotopia

Rt 11 electr

Lt 2 electr
Periventricular Nodular Heterotopia

Case 1: 24 yrs. ♂
SEEG exploration
Periventricular Nodular Heterotopia

Case 2: 9 yrs. ♀
SEEG exploration
Periventricular Nodular Heterotopia

Case 2: 9 yrs. ♀
SEEG exploration

Red: the nodule
Violet-Green: the CST

QuickTime™ and a decompressor are needed to see this picture.
Periventricular Nodular Heterotopia

Case 2: 9 yrs. ♀
SEEG ictal recordings
Case 2: 9 yrs. ♀
SEEG guided thermocoagulation
Periventricular Nodular Heterotopia

Case 2: 9 yrs. ♀
SEEG guided cortical resection
Impact on Clinical Care and Practice

• SEEG is a methodology for invasive EEG recording
  • definition of the Epileptogenic Zone
  • functional cortical and subcortical mapping
  • thermocoagulation of the Epileptogenic Zone

• Accurate visualization of contact location (both cortical and subcortical) by multimodal imaging.

• Limited patient’s discomfort.

• After the removal of the electrodes, all the collected SEEG data are available for an accurate and thoughtful interpretation before