

Chirurgia dell'Epilessia

Principi generali

Peculiarità nel bambino

Bilancio Prechirurgico

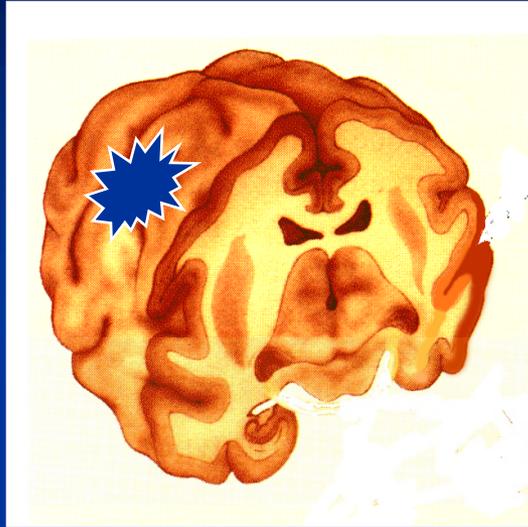
Valutazione Neurofisiologica Prechirurgica

Metodiche non invasive ed invasive

Tecniche chirurgiche

Casi clinici

Chirurgia dell'epilessia : perché ?



Prevalenza 4-10 / 1000
Incidenza 2-7 / 10000
(Sander et Shorvon, 1997)

Epilessie parziali 40-60 % (Hauser 1991)



Farmaco-resistenza 30-50%
(Hauser 1991, Engel et Shewmon 1993)



Indicazione chirurgica 30%
(Engel et Shewmon 1993)

70% liberi da crisi
(epilessie temporali)

Chirurgia dell'epilessia nel bambino

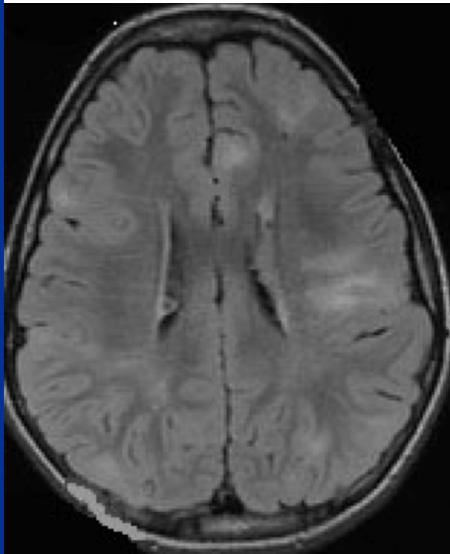
- ✓ Dal 9 al 24% dei bambini con epilessia di nuova insorgenza sviluppano farmaco-resistenza (Berg et al, 2006)
- ✓ Nei candidati chirurgici l'età di esordio crisi è < 2 aa
- ✓ Solo il 29% dei bambini candidati alla chirurgia vengono operati entro i 2 anni dall'esordio delle crisi (Harvey et al, 2008)
- ✓ Cause di tale ritardo sono: tendenza ad usare tutti i farmaci possibili, prolungati periodi di remissione,, timore di possibili deficit aggiuntivi, incertezze sull'outcome cognitivo post-chirurgico

Chirurgia dell'epilessia : **indicazioni**

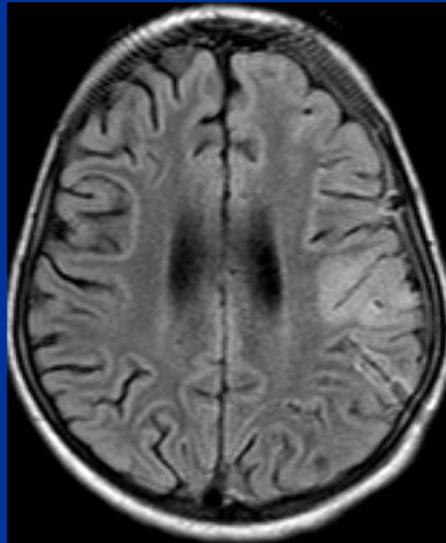
1. **Farmaco-resistenza**

- **Tipo di epilessia (sindrome)**
- **Età di esordio delle crisi**
- **Presenza o meno di una lesione cerebrale**

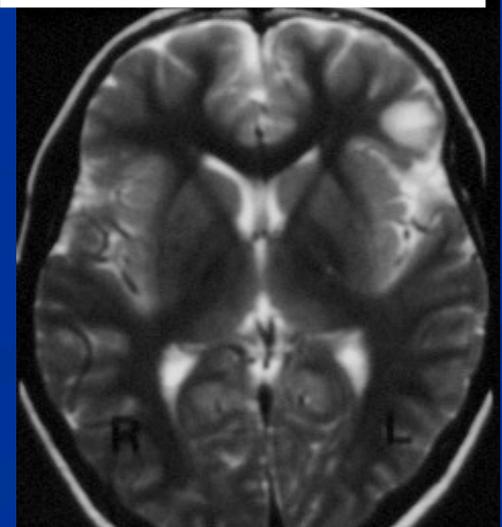
Sclerosi tuberosa



Displasia corticale



DNET



Chirurgia dell'epilessia : **indicazioni**

1. Farmaco-resistenza

2 . Severità dell'epilessia

frequenza delle crisi

tipo di crisi

stati di male

deficit associato

Eziologia

Effetti collaterale dei
farmaci



Vita di relazione

Vita scolare

Vita professionale

Chirurgia dell 'epilessia : **indicazioni**

1. Farmaco-resistenza

2. Crisi invalidanti

3. **Ipotesi Zona Epilettogena**

UNICA

BEN DELIMITATA

**RESECABILE IN ASSENZA
DI DEFICIT INACCETTABILI**



**BILANCIO
COSTI/BENEFICI**

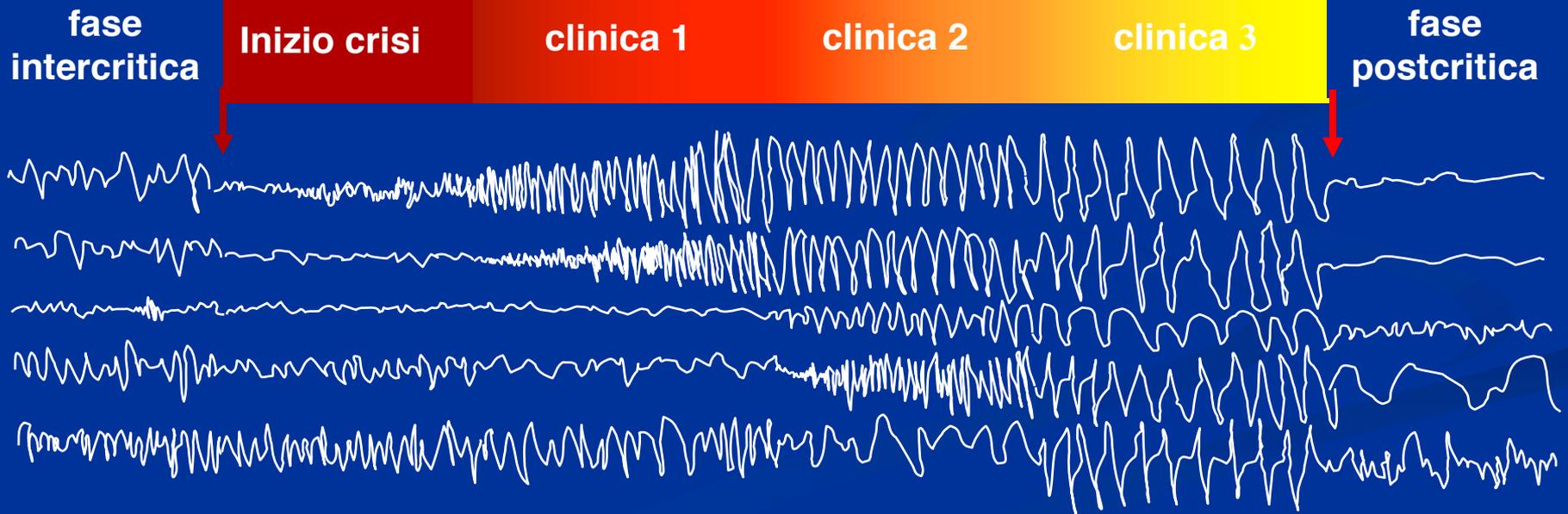
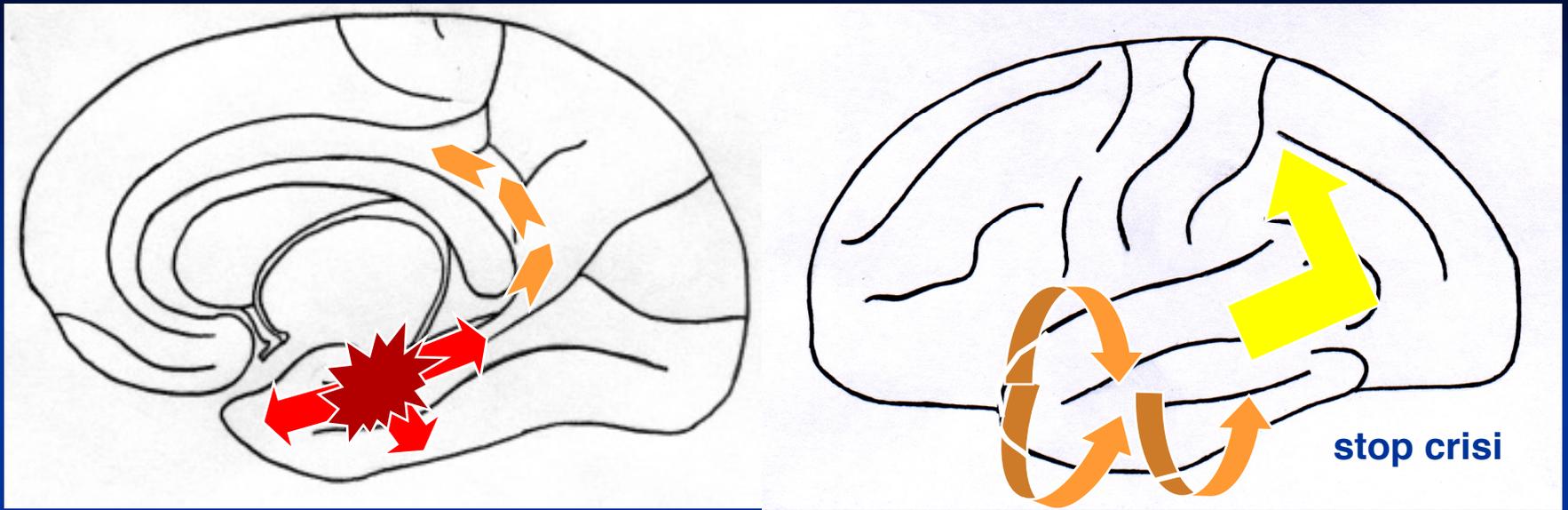
Correlazioni anatomo-elettrocliniche

Scuola franco-italiana

- ❖ **Zona lesionale:** onde lente
- ❖ **Zona irritativa:** anomalie intercritiche: punte, PO, PPO
- ❖ **Zona epilettogena:** zona di origine delle crisi e propagazione precoce, rimossa la quale si guarisce dalle crisi

Scuola americana

- ❖ **Lesione epilettogena:** alterazione strutturale
- ❖ **Zona di deficit funzionale:** attività lenta
- ❖ **Zona sintomatogena:** zona responsabile per sintomi
- ❖ **Zona origine delle crisi (SOZ):** necessaria e sufficiente a generare le crisi
- ❖ **Zona epilettogena:** concetto teorico, confermata da risultato intervento



Bilancio prechirurgico

**conseguenze
funzionali ?**

**limiti della zona
epilettogena ?**



Bilancio prechirurgico

Registrazione EEG non invasiva

Storia Clinica

RM encefalo

Valut neuropsicologica

RM funzionale

PET

Valut psicodiagnostica

Registrazione EEG invasiva

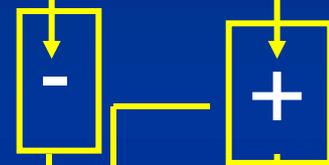
Bilancio prechirurgico non invasivo (fase 1)



Bilancio prechirurgico non invasivo (fase 1)



Neuropsi +/- RMN funzionale

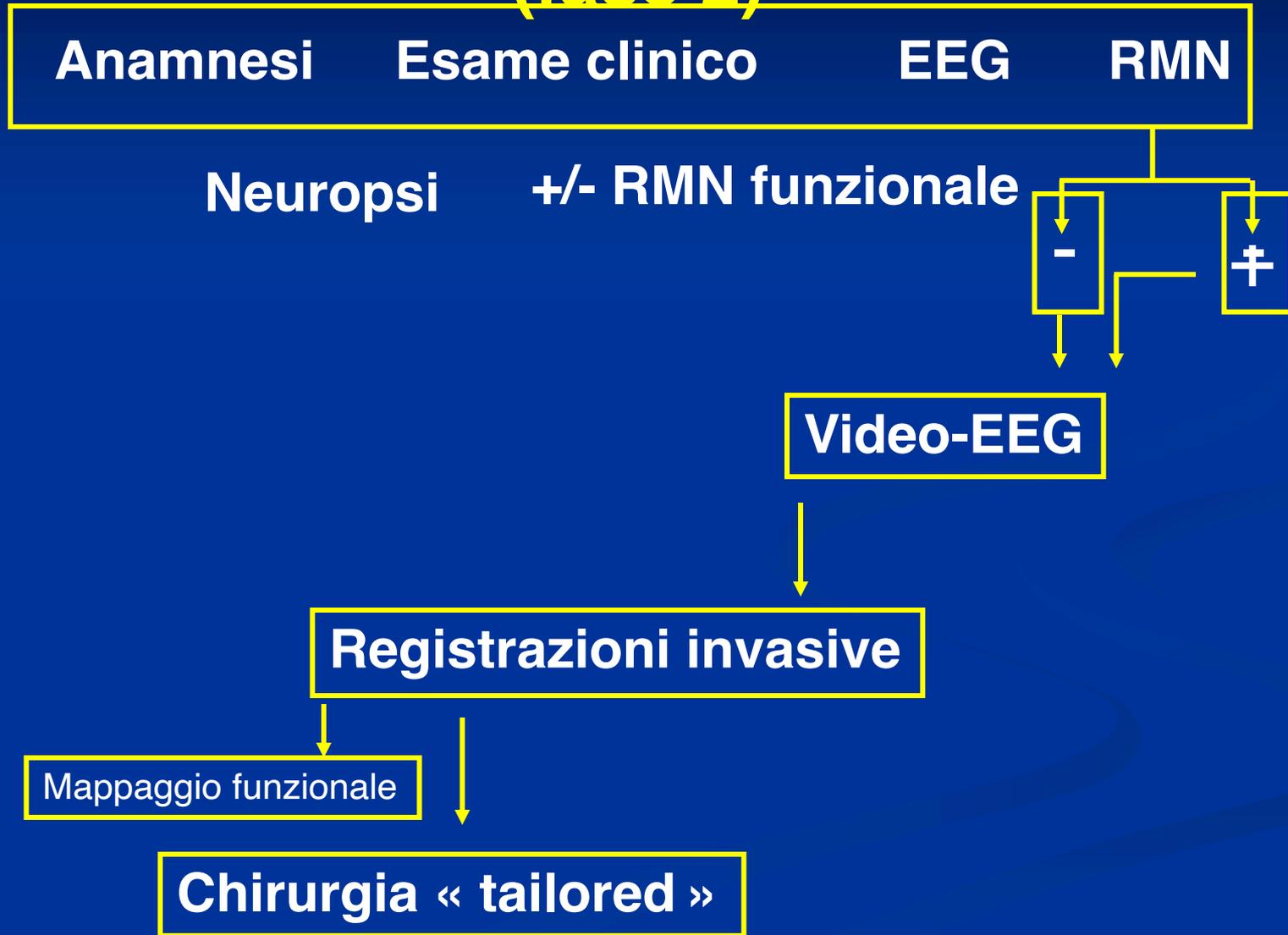


Video-EEG

Chirurgia « standard »

Lesionectomia

Bilancio prechirurgico invasivo (fase 2)

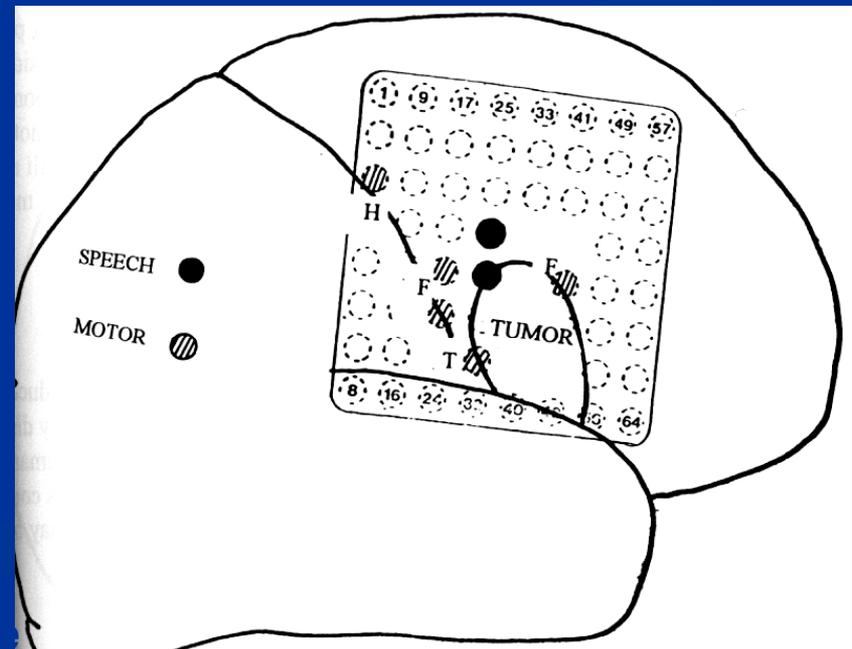
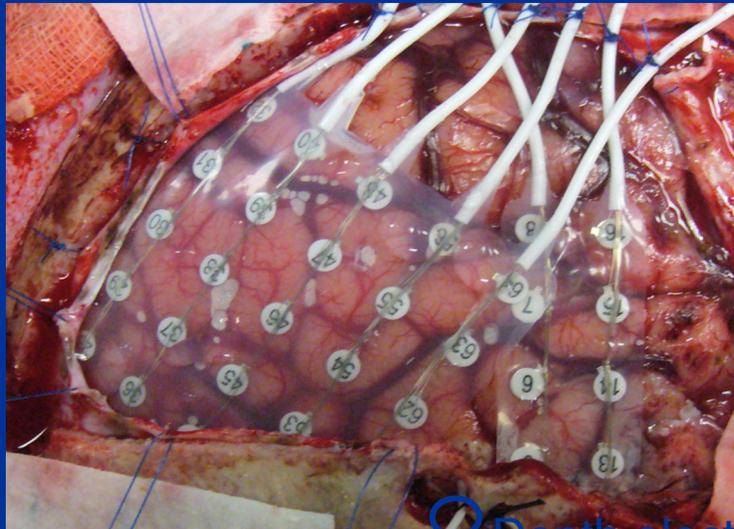
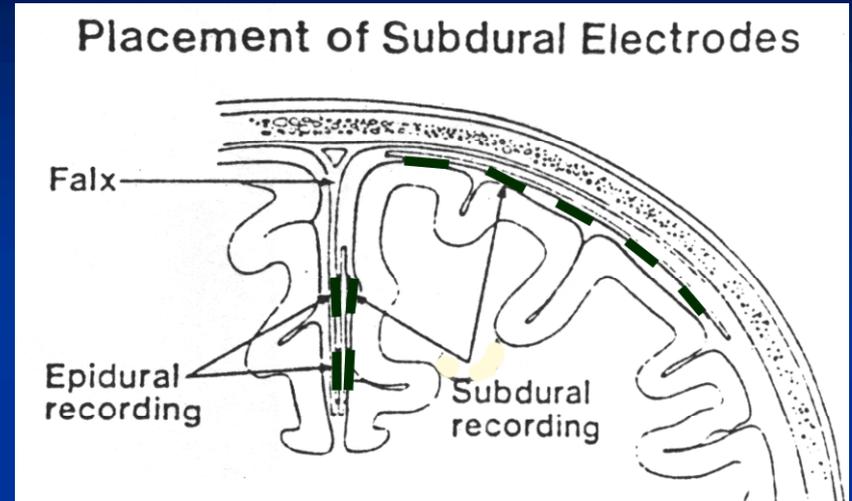
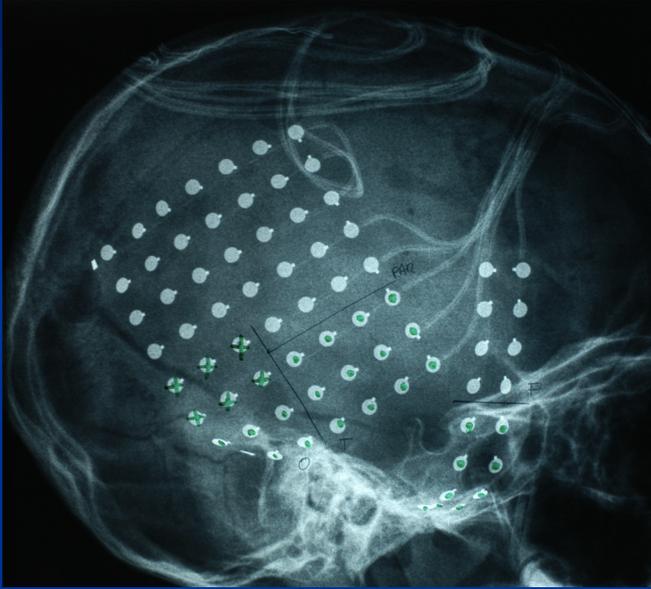


Bilancio prechirurgico invasivo fase 2

Quando indagini non invasive non sono sufficienti a determinare la strategia chirurgica

- RM negative
- Limiti mal definiti della lesione
- Dati contrastanti video-EEG e RM
- Mappaggio funzionale

Elettrodi (piattine) subdurali



Subdural Electrodes

Hardware Specifications

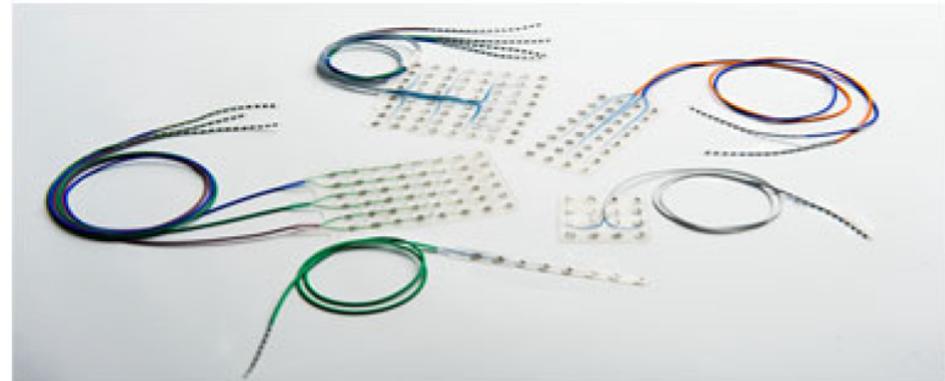
- 2-5mm diameter platinum-iridium contacts embedded in Silastic spaced 10mm apart
 - Each contact electrically isolated
- MRI-compatible
- Microwires can be interspersed among macro contacts
- Double-sided electrodes for interhemispheric recording

Background

Subdural Electrodes (SDE)

sEEG Electrodes

Selection of SDE vs sEEG



Subdural Electrodes

Implantation Procedure

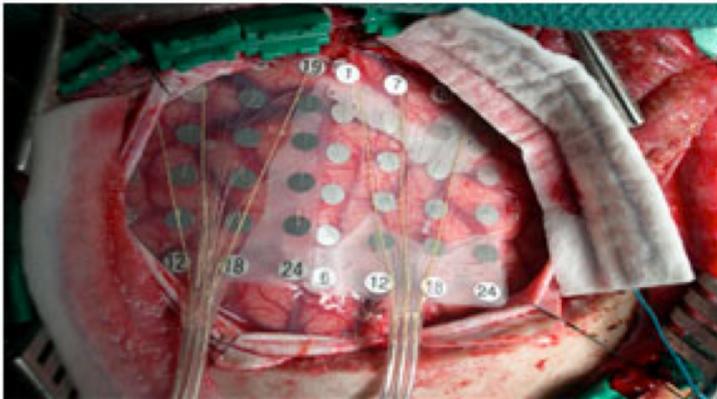
- Craniotomy for grid/strip electrodes
- Burr holes for strip electrodes
 - Advanced in subdural space over cortex not directly visible

Background

Subdural Electrodes (SDE)

sEEG Electrodes

Selection of SDE vs sEEG



Subdural Electrodes

Implantation Procedure

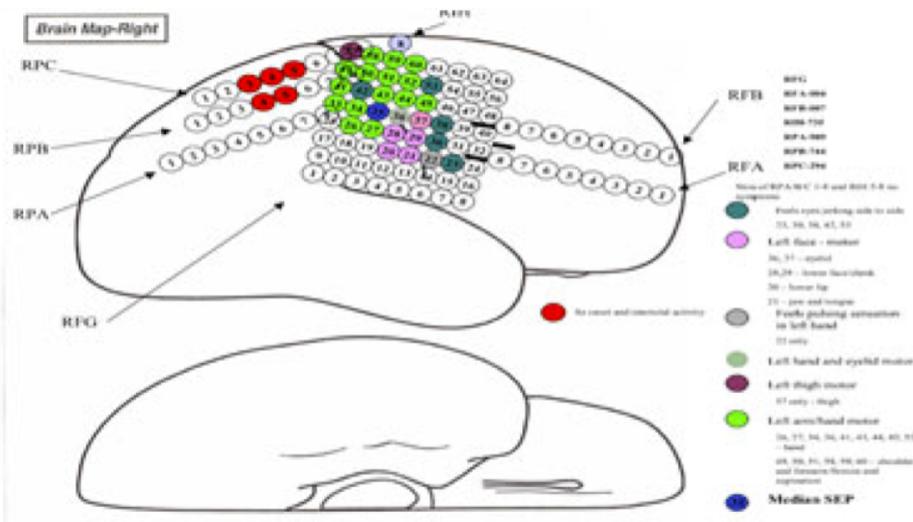
- Diagram of lead placement created
 - Mapping of the SOZ and neighboring eloquent cortex

Background

Subdural Electrodes (SDE)

sEEG Electrodes

Selection of SDE vs sEEG



STEREOELETTROENCEFALOGRAFIA (SEEG)

What is SEEG?

- Based on stereotactic techniques
- Electroencephalography



1958



Background
Subdural Electrodes (SDE)
sEEG Electrodes
Selection of SDE vs sEEG

Slide courtesy of Francesco Cardinale

What is sEEG?



Background
Subdural Electrodes (SDE)
sEEG Electrodes
Selection of SDE vs sEEG

“Crise comme un ensemble de signes déterminés essentiellement par une activité paroxystique dynamique à trajectoire le plus souvent multidirectionnelle”

Epileptogenic Zone:

the site of the beginning and of primary organization of the epileptic seizures

Stereo (solid, 3D) – ElectroencephaloGraphy

1965

Slide courtesy of Francesco Cardinale

STEREOELETTROENCEFALOGRAFIA (SEEG)

Neurophysiologie Clinique/Clinical Neurophysiology (2018) 48, 5–13



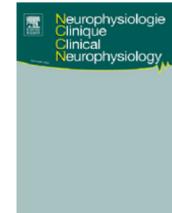
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COMPREHENSIVE REVIEW

French guidelines on stereoelectroencephalography (SEEG)



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Landr eⁱ, Axel Lebas^s, Louis Maillard^{t,u}, Aileen McGonigal^{d,e},
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Agn es Trebuchon^{d,e}, Louise Tyvaert^{t,u},
Maria Paola Valenti-Hirsch^{ad}, Luc Valton^{l,ai,aj},
Jean-Pierre Vignal^{t,u}, Paul Sauleau^{ak,al}

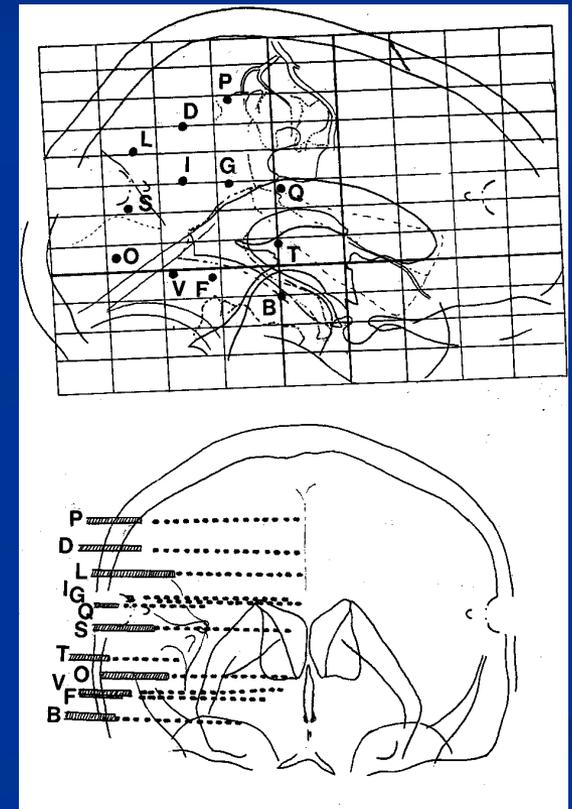
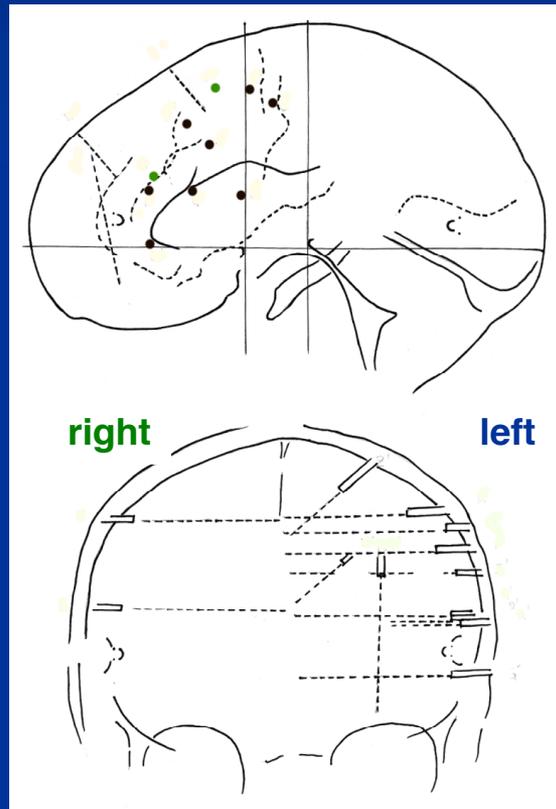
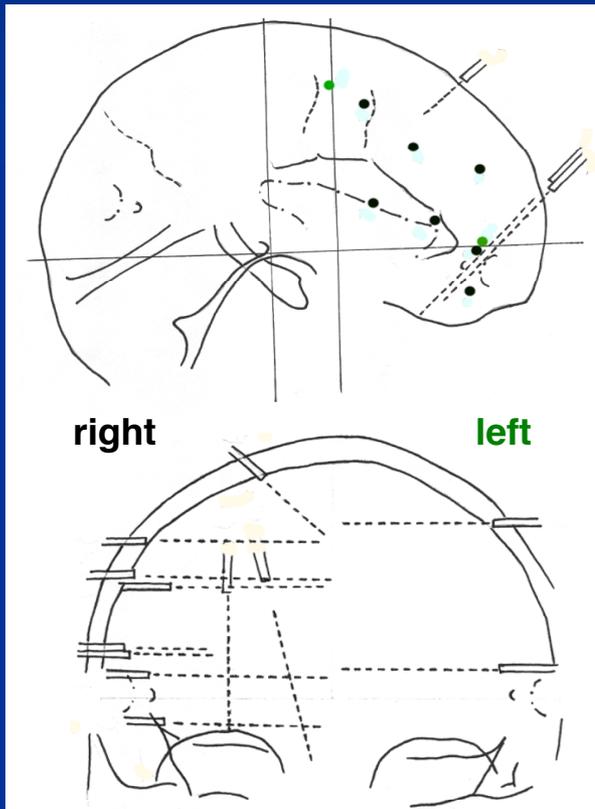
STEREOELETTROENCEFALOGRAFIA (SEEG)

- Elettrodi di profondità 0.8 mm di diametro
- Condizioni stereotassiche
- Esplorazione « su misura »
- Ipotesi Zona Epilettogena



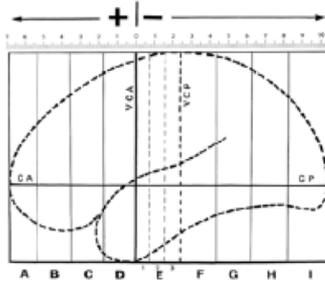
- ✓ analisi accurata prime manifestazioni cliniche
- ✓ analisi accurata prime modificazioni EEG

- Condizioni stereotassiche
- Esplorazione « su misura »

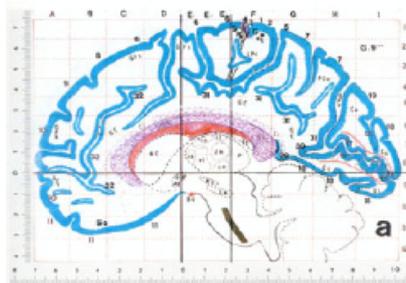


Rational implantation is a primary requirement

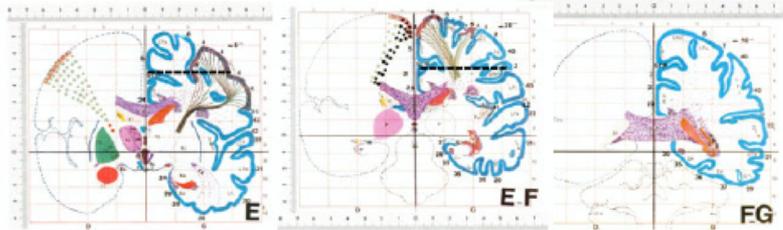
A referential stereotaxic anatomical system is needed: Talairach was the designer of SEEG



Anatomical reference



Talairach & Tournoux, 1988

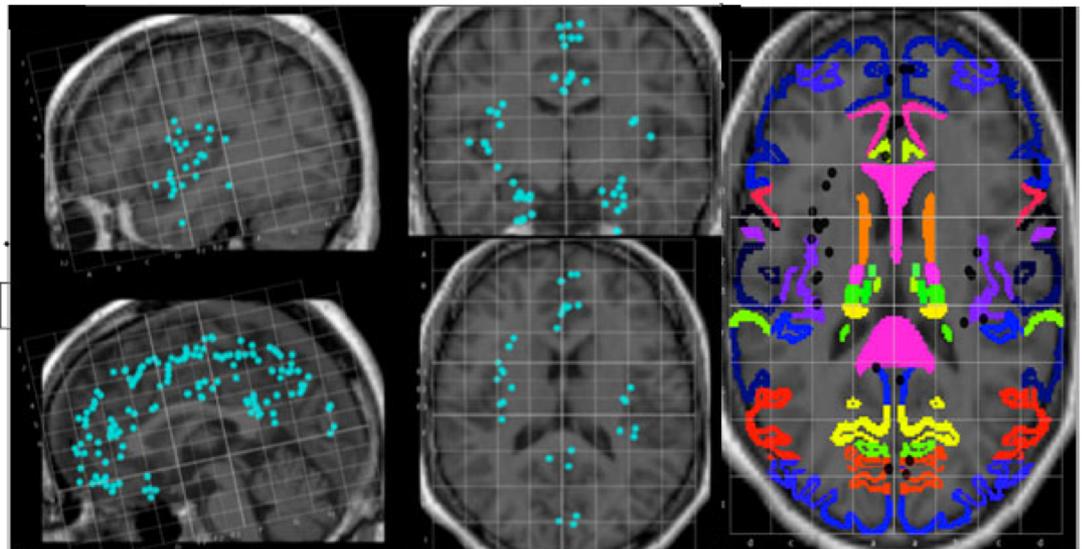
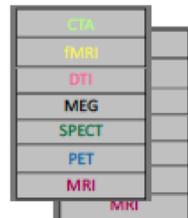


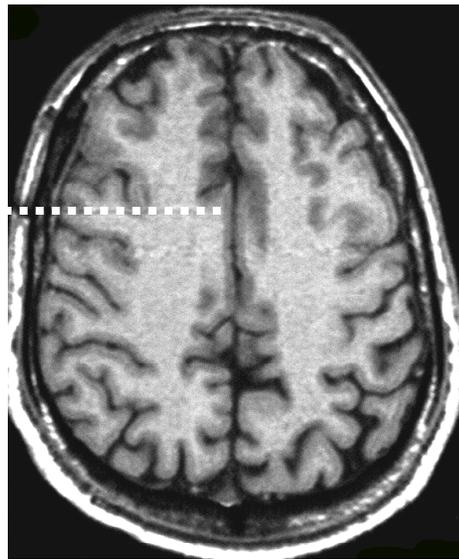
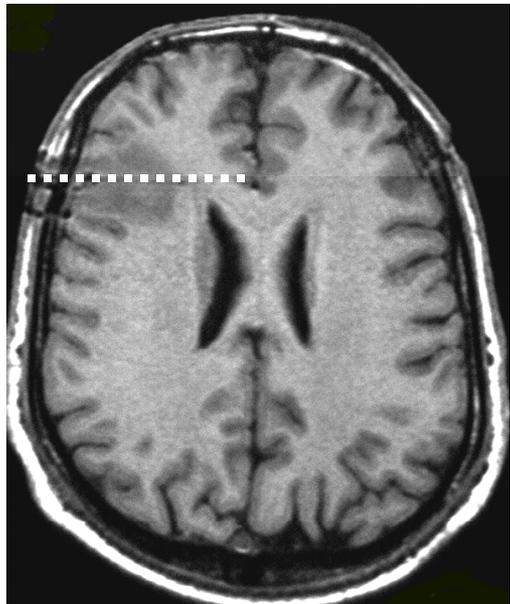
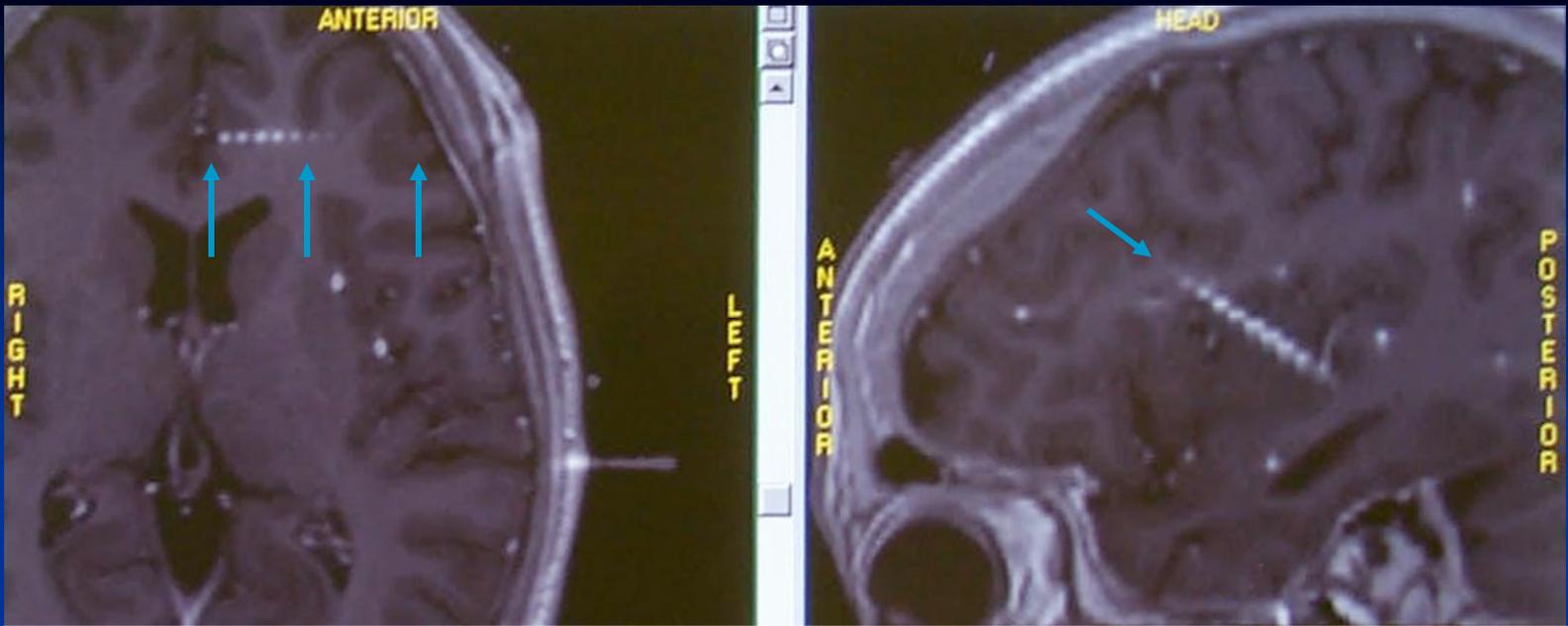
✓ I'm not a robot



- Condizioni stereotassiche
- Esplorazione « su misura »

Talairach referential system applied to imaging





Cortesia dott.ssa Minotti

• Ipotesi zona epilettogena

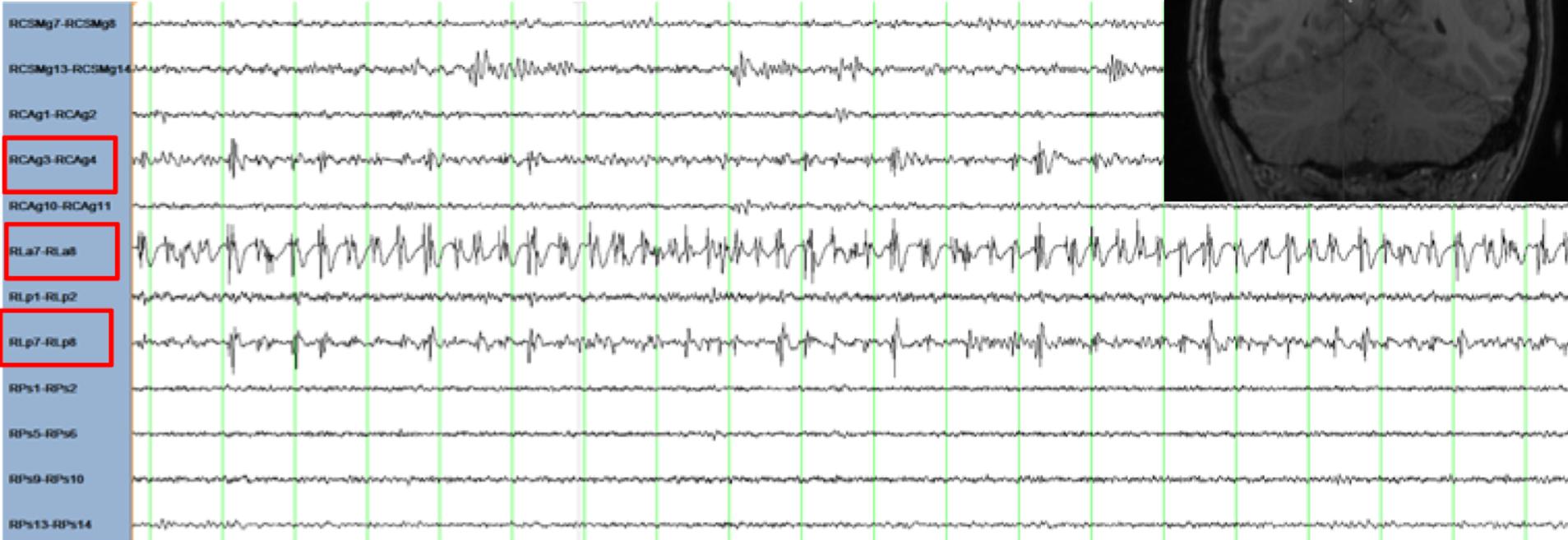
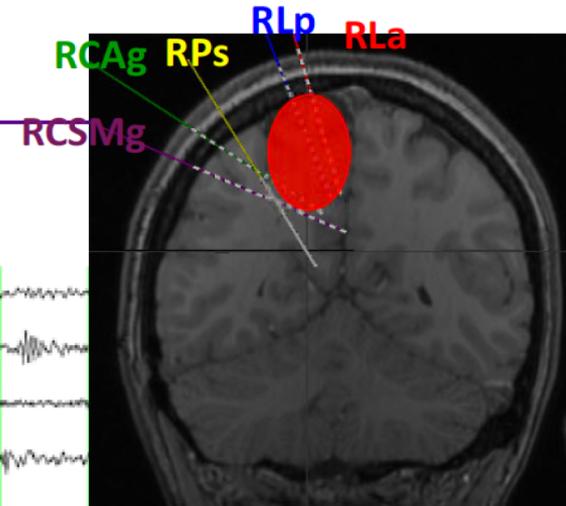
« La clairvoyance »

SEEG indications are limited to the cases :

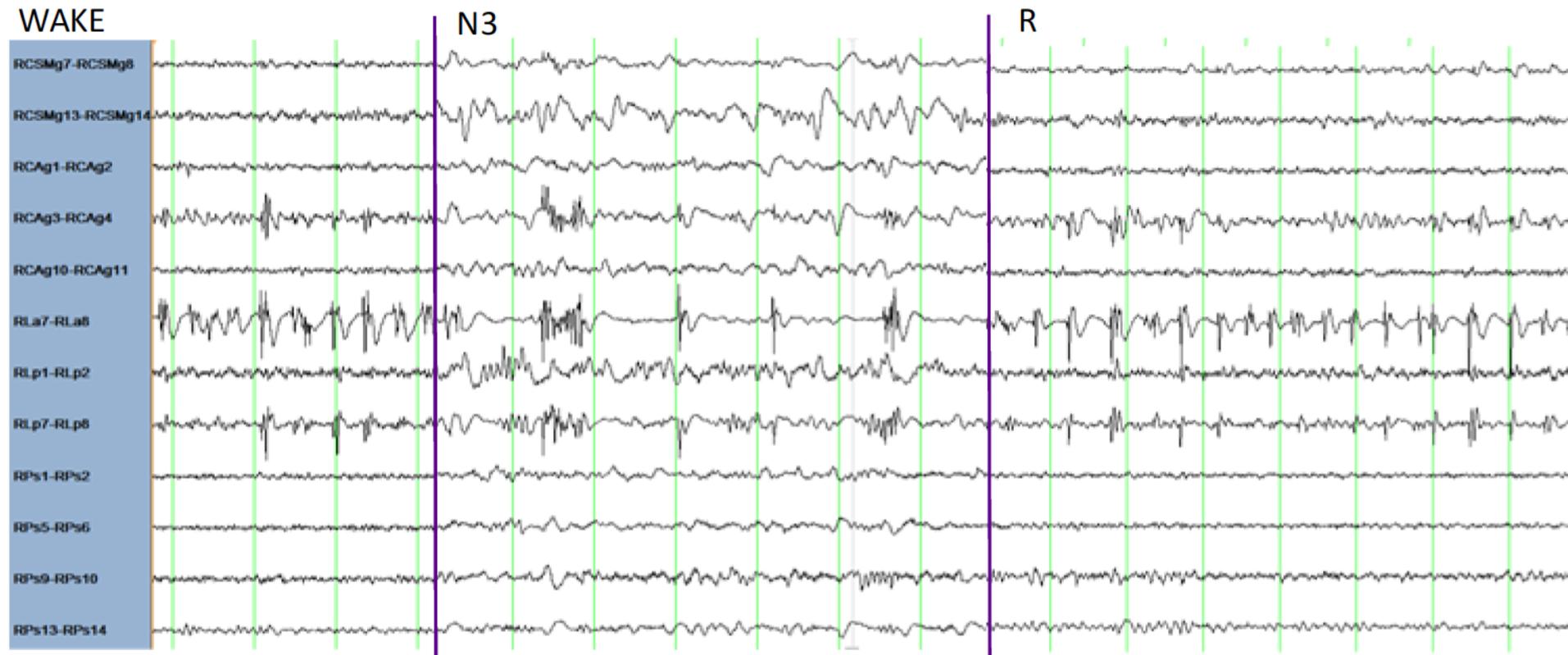
- With meaningful video-EEG clinical-electrical correlations
- With expressible hypotheses on the anatomical location on seizure onset and ictal organization
- Without evidence of neuropsychological conflict
- When rational and safe electrode implantation can be proposed



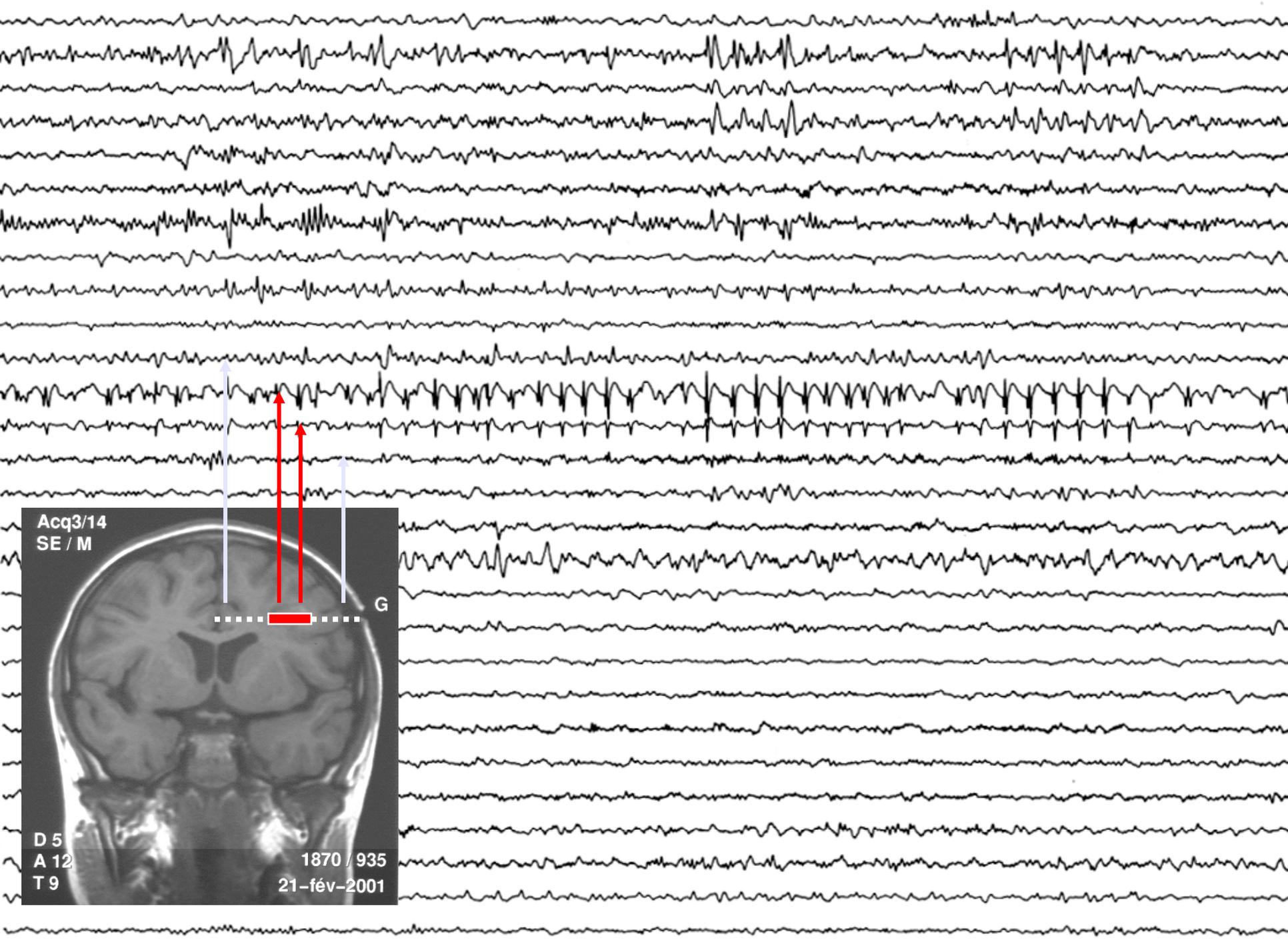
Spikes: Example A.D.



Spikes: changes across sleep-wake cycle



Identical sensitivity and time scale

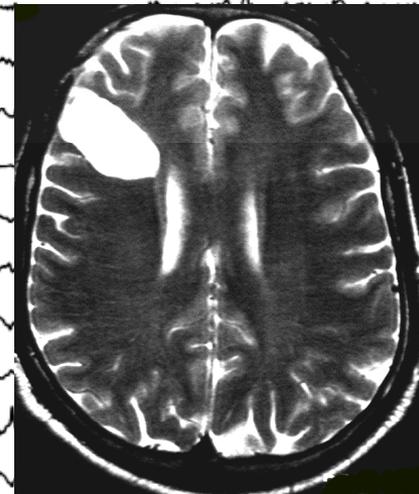
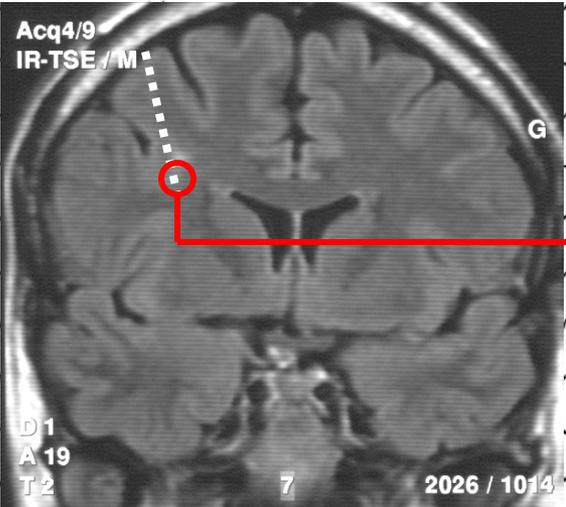
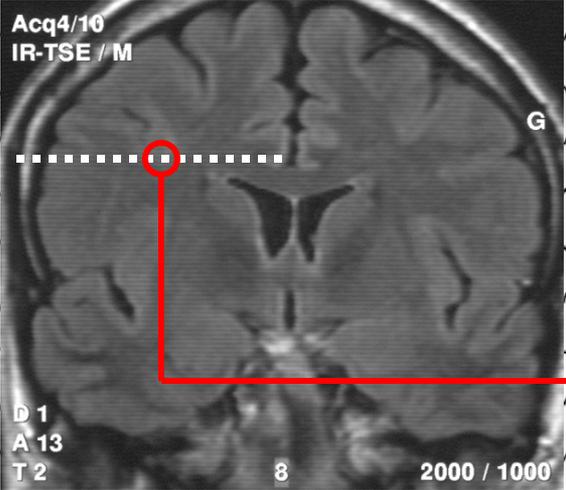


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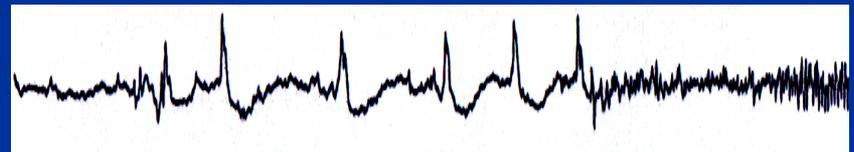


Possibili pattern critici:

- Low-voltage fast activity (LVFA),
- preictal spiking followed by LVFA,
- burst of polyspikes followed by LVFA,
- slow wave/DC shift followed by LVFA,
- sharp theta/alpha waves,
- beta sharp waves, rhythmic spikes/spike-waves, delta-brush.

LVFA occur in 79% of patients (soprattutto se displasia).

ATTIVITA RAPIDA BASSO VOLT AGGIO



Electrophysiological technical procedures

- After implantation of the electrodes in the operating room, SEEG recording is begun as soon as possible.
- Brain CT or MRI should be performed with the electrodes in place.
- The acquisition system must have at least 128 channels and ideally 256 channels.
- Care should be taken not to record with a 50 Hz filter, to avoid misinterpretation of sector artefacts that may make it difficult to detect low-voltage rapid discharges.
- When the number of contacts is greater than the number of available recording channels, the activity of each contact will be visualized before any selection of the contacts of interest. The contacts will be selected according to their site in the brain, with exclusion where necessary of contacts located in the white matter (non-consensual agreement, see the detailed chapter "Electrophysiological technical procedures").
- For the summary montage, the contacts exploring the white matter or located outside the brain will preferably be discarded.
- When the ground and the reference contacts are distinct, the reference will be chosen from the recording contacts located in the bone, the white matter or an accessible location on the scalp (between Cz and Fz).
- The ground contact will be located in the bone, in the white matter or an accessible cutaneous site (earlobe or extracephalic).
- In children, the reference contact and the ground contact will preferentially be contacts located in the white matter.

Stimolazioni corticali focali

Metodologia

- 1 hz, 40 sec, 3 mA, 3 ms
- 50 hz, 5 sec, 3 mA, 1 ms

Scopi

- Mappaggio funzionale
- Elicitazione crisi

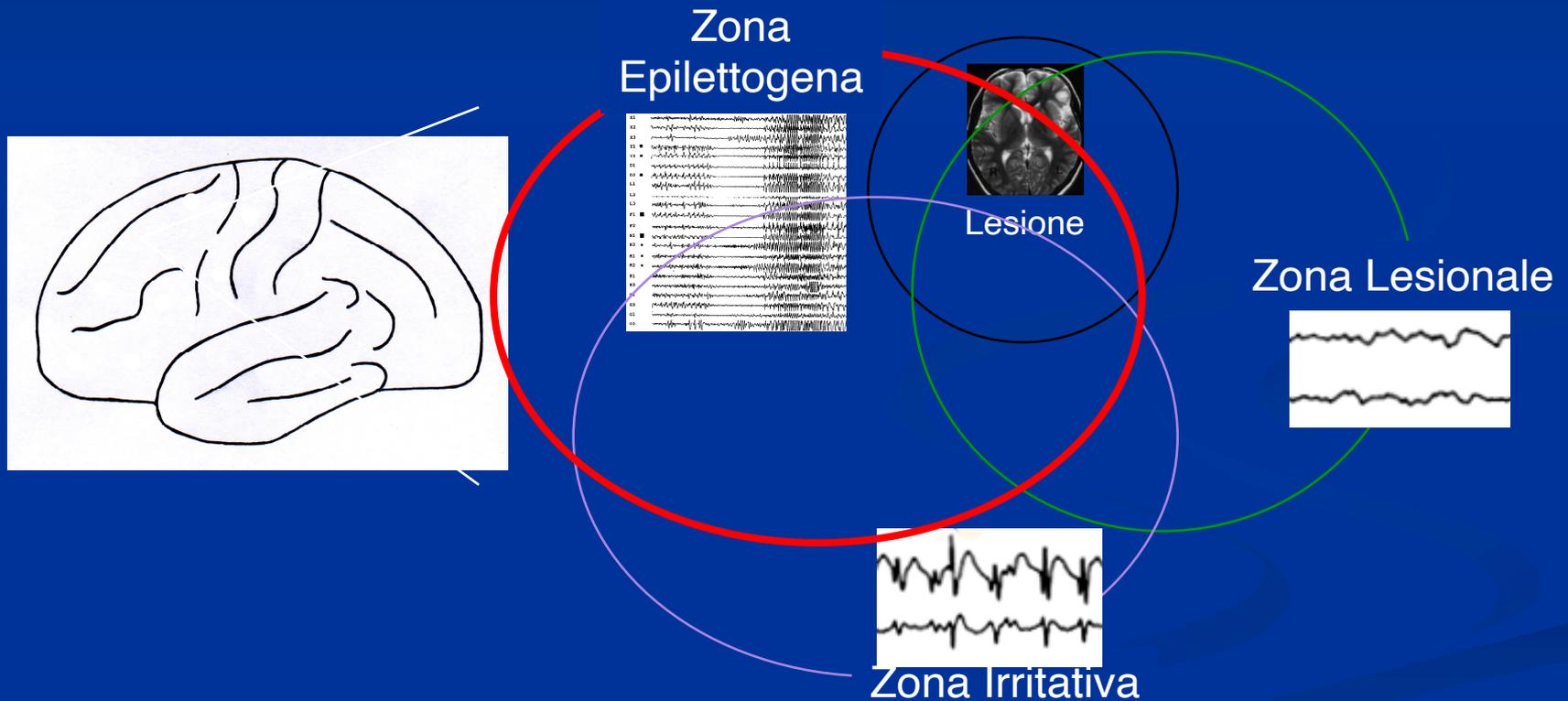
- Electrical stimulations are usually performed after recorded spontaneous seizures.
- Electrical stimulations are performed between two contiguous contacts of the electrode using bipolar and biphasic current.

- Shock stimulations are useful for triggering seizures, especially in the hippocampus and in focal cortical dysplasias, for functional mapping in particular of primary areas, and for study of functional connectivity.
- Train stimulations are useful for triggering seizures and for performing functional mapping.
- Train stimulations should be used with caution in the central region because of risk of triggering generalized tonic-clonic seizures; only short and low-intensity trains should be employed.
- It is important to wait between stimulations for electrophysiological activity to return to its baseline level.
- Functional mapping can be supplemented by the recording of evoked activities (evoked potentials or oscillatory activity) in response to certain stimuli.

Impact on Clinical Care and Practice

- DCS-S are very similar to habitual seizures, which could contribute to significantly reduce the duration of intracranial EEG investigation
- The elicitation DCS-S is a marker of favorable surgical outcome. Negative DCS responses might therefore be a red flag (?missed EZ)
- The removal of DCS-S sites and DCS-induced SOZ contributes to good surgical outcome.
- Both low and high frequency stimulation should be used, they may provide complimentary information.
- All the electrode contacts located within the grey matter should be stimulated to assess the most epileptogenic region.
- Perform DCS at the beginning of the implantation, at least 24 hours after the last spontaneous

Risultati SEEG



Team expertise as a limiting factor:

- SEEG is **not** depth EEG (LFP is the signal, connectivity is the framework)
- A multidisciplinary and close-knit team work is required
- The body of knowledge that is relevant to perform SEEG is not theoretical and bookish, but based on a real apprenticeship and training through mentoring
- There is no compendium, the learning curve is steep
- Indications for SEEG critically depend on the team's SEEG experience

Chirurgia dell'epilessia e FCD

- Etiologia più frequente in serie chirurgiche pediatriche
- Crisi focali o EE (spasmi o LG) , età di insorgenza crisi ed alla chirurgia <alle altre eziologie
- Outcome chirurgico: 60-75% seizure free, peggiore in FCD I rispetto a FCD II
- Fattori predittivi positivi: lobo temporale, resezione completa
- In casi selezionati necessarie indagini invasive
- Outcome cognitivo-comportamentale variabile

Spencer and Huh, 2008, Becker et al, 2006; Guerrini et al, 2015, Isler et al, 2017

Bilancio prechirurgico INVASIVO

Grid/strip

- Estesa copertura superficie corticale
- Consente Mappaggio corticale
- Possibile <1 anno di età
- Esplorazione bilaterale di complessa realizzazione
- Rischio infezioni

SEEG:

- Permette di esplorare strutture profonde (insula, ippocampo)
- Consente mappaggio corticale
- Elettrocoagulazione
- Problema Campionamento
- Rischio sanguinamento

Approcci combinati

TECNICHE CHIRURGICHE

Chirurgia ablativa

Lesionectomia

Corticectomia

Lobectomia

Amigdaloippocampectomia

Emisferectomia

Disconnessione

Disconnessione uni/multilobare

Emisferotomia

Callosotomia

Transezione subpiale

Chirurgia dell'epilessia : alternative

Anamnesi

Esame clinico

EEG

RMN

Neuropsico

+/- RMN funzionale

Nessuna chirurgia

Chirurgia palliativa

Stimolazione vagale o cerebrale

Video-EEG

Registrazioni invasive

Chirurgia « standard »

Chirurgia « tailored »

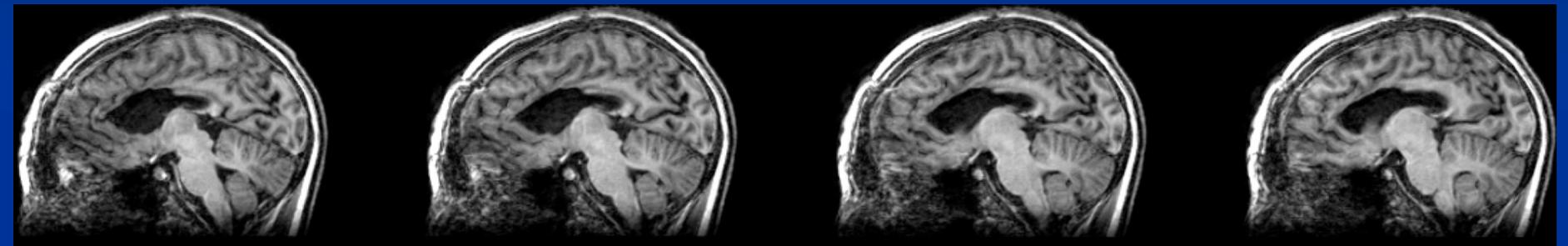
Exeresi lesione



Callosotomia

- ✓ Trattamento palliativo
- ✓ Parziale o totale sezione del corpo calloso.
- ✓ Le indicazioni comprendono crisi toniche, tonico-cloniche, atoniche che comportino cadute anche rovinose
- ✓ La callosotomia anteriore, più frequentemente praticata, si associa ad una sindrome da disconnessione anteriore

Postoperative MRI (18 ms after surgery)



Conclusioni

- ✓ Il trattamento chirurgico nel bambino rappresenta una soluzione terapeutica efficace per l'epilessia farmaco-resistente, se realizzata in ambiti specialistici e con un approccio multidisciplinare
- ✓ La chirurgia dell'epilessia del bambino non si può considerare come una semplice "estensione" delle procedure utilizzate negli adulti tenuto conto delle differenti eziologie e sindromi, del potenziale effetto deleterio delle crisi e dei farmaci sullo sviluppo cognitivo e, dei fenomeni di plasticità.