High Resolution Ictal SPECT: Enhanced Epileptic Source Targeting?

Marvin A Rossi MD, PhD
RUSH Epilepsy Center
Research Lab http://www.synapticom.net

Chicago, IL
USA

Medically-Refractory Epilepsy

- 500,000-800,000 individuals with epilepsy in the U.S.$^{1,2}$
- 100,000 epilepsy surgery candidates$^3$
- 4,500-5,000/yr epilepsy surgeries are performed
- 50,000+ VNS generators implanted to date

$^1$Hauser & Hesdorffer. (1990).

SPECT

Static tracers

$^{99m}$Tc-HMPAO (Ceretec)
$^{99m}$Tc- ECD (Neurolite)
$^{123}$I-IMP (Spectamine)
$^{123}$I-HIPDM

Diffusible Tracers

$^{133}$Xe, $^{127}$Xe

What is Gamma Camera SPECT?

- If images are taken at angular increments around a center of rotation, a 3-D cross-sectional image can be reconstructed.
- Multiple heads are used to increase the number of images per unit time.

Projection of Original Data
3. Filtering the Data

Spiral Scanning Focused Collimators
InSPira HD SPECT (NeuroLogica, Corp)

Scan Sequence
Focal spots describe an interleaved spiral. Each slice scans from in-to-out or out-to-in. Radial scan direction alternates with slice. Detector 'sees' activity in entire bore at each position of focal spot.

Single Photon Emission Tomography (SPECT)

1976-1984 Early tracers became available following development of first dedicated single head SPECT camera (Ronald Jaszczak)

~1984 Soon after, ictal SPECT scanning was incorporated into clinical practice.

~1986 Ictal SPECT was first attempted and compared with baseline interictal SPECT.

Peri-ictal Related Transient Blood Flow Changes

rCBF changes during temporal lobe seizures
Criteria Essential to performing Ictal SPECT:

1. Ictal SPECT must be performed in the video-EEG monitoring unit
2. The availability of the setup and team is critical from at least early morning to at least early evening. 24 hr vigilance is not possible.
3. Brain-perfusion tracer with consistent quality control as well as reliable delivery is critical
4. A reliable fast injector system should be available
5. Injecting Personnel must communicate closely with the EEG tech and patient/family
6. Excellent cooperation between the neurology and nuclear medicine department is crucial

Favorable Outcome Data Following Resection of Medically Intractable Focal-Onset Epilepsy

Lesional:
- Mesiol Temporal Lobe Sclerosis: 70-80%
- Temporal Neocortical: 60-70%
- Extratemporal: 40-60%

Non-Lesional:
- Temporal Neocortical: 30-50%
- Extratemporal: 20-30%

Subtraction Ictal SPECT Co-registered to MRI (SISCOM) 1998


Patient AM

Early Ictal Circuit
- Temporal lobe
- Amygdala
- Hippocampus
- Sylvian fissure
- Frontal lobe
- Orbitofrontal
- Mesial frontal

20-50% epilepsy cases have non-localizable epileptic sources or foci:

- Two focal-onset epilepsy categories are typically grouped:
  - Temporal Lobe Epilepsy (TLE)
  - Extratemporal Lobe Epilepsy (ETE)
  - Challenging due to rapid ictal propagation

- Therefore, the potential role of SISCOM is to identify:
  - Non-localizing lesions not detected with standard presurgical techniques (that is by MRI and scalp EEG)

Rush Medical Center Experience

- A total of 180 patients had 2 or more SPECT scans performed at our institution from Nov 2001 until April 2009
- Craniotomy +/- resection/transection n=30 (17%) (with follow up of 12 months or longer)
Discussion

- SISCOM can provide, non-invasive information for preoperative planning
- High concordance with intracranial recording in ETE patients with a localizing SISCOM without structural lesions on MRI
  - O'Brien et al, Ahnlide et al concordance predictive of improved surgical outcome (Engel's Class I,II)
  - Rush series (12 months)
    - TLE + ETE, 7/12 (58%)
    - ETE alone: 5/10 (50%)

How useful is SISCOM for epilepsy arising from outside of the temporal lobe with non-lesional MRI data?
- Data suggest that SISCOM may improve detection of the epileptogenic zone
- Concordance between SISCOM and site of resection may reflect overall outcome

Limitations

- Published data sets have used small patient populations
- A limited follow-up period
- AS IMPORTANTLY, What do we do about the subgroup of patients without MRI lesion and non-localizing SISCOM (What to do?)

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Anterior Insular Epileptic Source Associated with Bradycardia.
Next Steps…

- Higher resolution SPECT (ring scanners)
- Dynamic SPECT
- Activated SPECT mapping atlases
- Multimodal (addition of) DTI/MEG/PET

Patient RA Utilizing 2-Detector Gamma Camera

Preoperative Stereotypic Seizure Onset
SAS (2-Detector Gamma Camera) & DTI

Rossi et al. (2010). Predicting white matter targets for direct neurostimulation therapy. Epilepsy Research

Dynamic SPECT Imaging Protocol (InSPira HD SPECT)

Rossi et al, (2005), AES Abstract 3.169

Subtracted Activated SPECT (SAS) Mapping


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