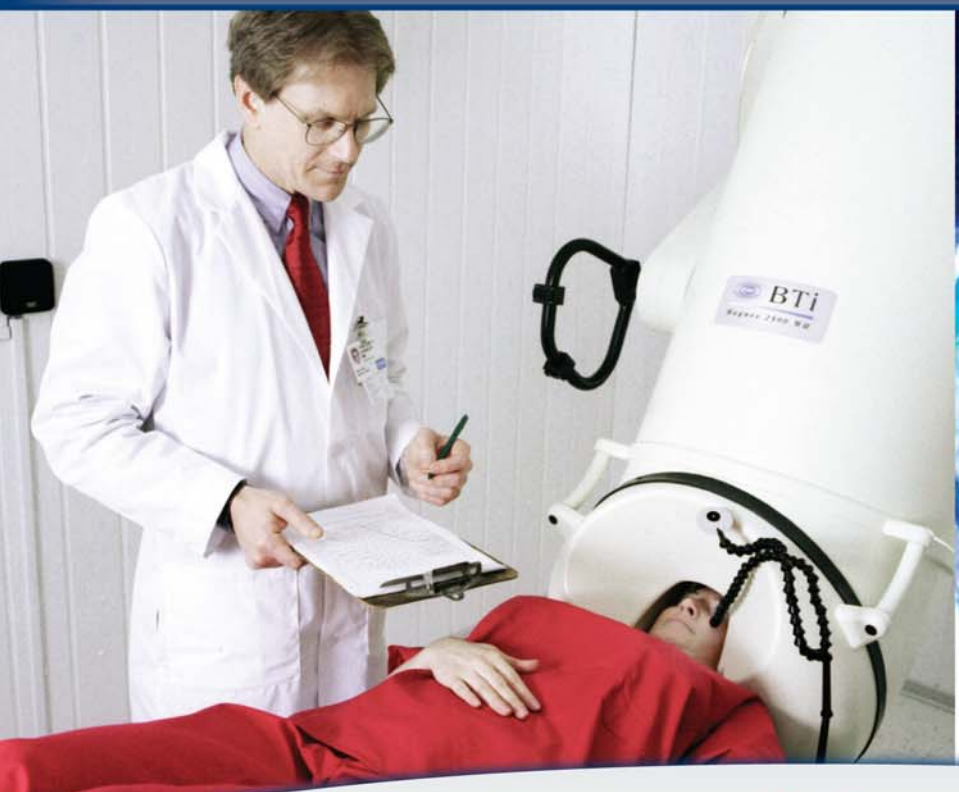
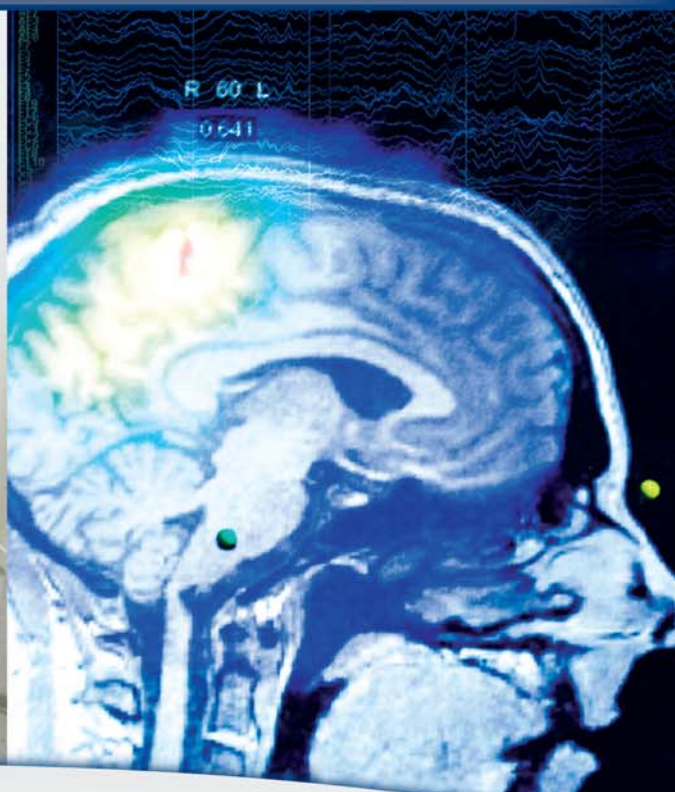
6th Annual ACMEG Conference | San Antonio, TX | February 9

ACMEGS CONFERENCE 2012





ACMEGS

AMERICAN CLINICAL MEG SOCIETY

Welcome to San Antonio!

On the behalf of the Organizing Committee and the ACMEGS Board, I hope that you enjoy your visit to San Antonio, its culture, food and people.

This is our 6th annual conference of the ACMEGS and the third joint meeting with the American Clinical Neurophysiology Society (ACNS). The goal of this format is to save ACMEGS members who are also associated with ACNS one trip to a conference, as well as to spark some interest with members of ACNS who are not so familiar with MEG technology and its clinical applications. After all, MEG is a neurophysiological method.

As usual, we moved the business meeting and the MEG-Economics part to the morning part of the meeting to encourage interested ACNS members to join us subsequently for the scientific presentations.

The past year was another very successful year for our society, characterized by two cardinal achievements: (1) the publication of the clinical practice guidelines, and (2) the coverage decision by the BCBS Association that triggered positive policy changes of a multitude of their affiliates.

We will have a very interesting scientific program this year with eight presentations delivered by experts in the field of clinical MEG, and we are very glad to welcome among them Dr. Ikeda from Japan, Dr. Rampp from Germany as well as Dr. Otsubo and Dr. Florin from Canada.

Our conference aims to provide an informal and friendly atmosphere for discussing and exchanging recent clinically relevant studies that might lead to new clinical MEG indications. In addition we want to enable you, our members, to promote the appropriate use of Magnetoencephalography. And we want to empower you to work closely with national and local health insurance carriers and governmental regulatory bodies to ensure accurate and successful reimbursement.

Welcome to San Antonio and I hope you will enjoy the conference and our traditional society dinner at the end of a day filled with lectures and discussions.

Sincerely,

Michael E Funke, M.D., Ph.D.
President, American Clinical Magnetoencephalography Society

Organizing Committee:
Anto Bagic, University of Pittsburg, Pittsburgh PA
Susan Bowyer, Henry Ford Hospital, Detroit MI
Richard Burgess, Cleveland Clinics Foundation, Cleveland OH
Michael Funke, University of Utah, Salt Lake City UT
Robert Knowlton, University of Alabama, Birmingham AL
Jeffrey Lewine, MIND Research Network, Albuquerque NM

PROGRAM

Thursday, February 9, 2012

8:00 am **Arrival / Breakfast Reception**

8:45 am **ACMEGS Presidential Address 2012**
Welcome and Introduction (Michael Funke, Salt Lake City, UT)

9:00 am **Business Meeting (for ACMEGS members only)**
a. Financial Report (Anto Bagic, Pittsburgh PA)
b. Public Relations Committee (Susan Bowyer, Detroit MI)
c. New Business / Elections
d. Reimbursement/Coverage update (Michael Longacre, Crofton, MD)

10:00 am **Workshop on MEG High Frequency Activity in Epilepsy**
- **Detection of vHFO with Vector Beamformer and Accumulated Wavelet Analysis (**Doug Rose, Cincinnati OH)
- **High Frequency Oscillations**
  (Hiroshi Otsubo, Toronto ON)
- **Correlates of epileptic high frequency oscillations in MEG source spectral statistics** (Manoj Raghavan, Milwaukee WI)
- **Towards New Markers for Epilepsy MEG Evaluation**
  (Esther Florin, Montral QC)

12:00 pm **Lunch / ACMEGS Photo shooting**

1:30 pm **Poster Session**

2:00 pm **Workshop on MEG Slow and Ultra-slow Frequency Activity in Epilepsy**
- **Wide-band EEG/MEG analysis for epilepsy: An overview**
  (Aiko Ikeda, Kyoto JP)
- **Cerebral Electromagnetic Infraslow Activity**
  (Ernst Rodin, Salt Lake City UT)
- **Slow Brain Activity (ISA/DC) Detected by MEG**
  (Susan Bowyer, Detroit MI)
- **Epileptic slow activity in MEG** (Stefan Rampp, Erlangen DE)

4:00 pm **Coffee Break**

4:30 pm **Meeting Adjourn**

5:45 pm **ACMEGS Dinner at Boudro's, Volume II (205 N. Presa at Charles Court)**
(8 minutes from the hotel, see walking map at the end of the booklet)

Michael Funke

Presidential Address 2012

Michael Funke, M.D., Ph.D.
Department of Neurology, University of Utah, Salt Lake City, UT

ACMEGS
AMERICAN CLINICAL MEG SOCIETY

6th Annual Society Meeting

San Antonio

February 9, 2012

Becoming the . . .
AMERICAN CLINICAL MEG SOCIETY

National Tele-Conferences
- June 16, 2004 (8 participants from 6 institutions
- August 9, 2004 (Boston Dinner Meeting @ BIOMAG)
- July 21, 2005 (15 participants from 10 institutions)

Chain of Events
- August 17-18, 2005 (APC Panel meeting, Baltimore)
- December 3, 2005 (MEG user meeting @ AES in Washington)
- April 25, 2006 (Incorporation of ACMEGS in Boston)
- August 25, 2006 (1st open meeting @ BIOMAG in Vancouver)

AMERICAN CLINICAL MEG SOCIETY

AMERICAN CLINICAL MEG SOCIETY

5th Clinical and Economic Workshop

New Orleans, February 3, 2011

A fabulous ISACM . . .

3th ISACM

November 3-5, 2011

Las Vegas

Cardinal Accomplishments in 2011

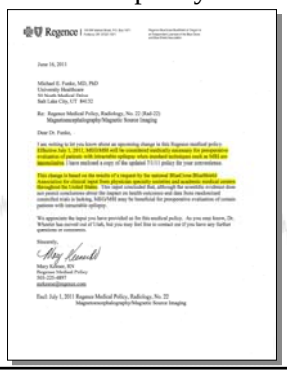
- Clinical Practice Guidelines (CPGs) were published!
- BCBS Association released positive MEG policy!

BCBS Association policy #6.01.21

Effective: July 1, 2011

ACMEGS team:

- Anto Bagic
- Michael Funke
- Robert Knowlton
- Michael Longacre



Accomplishment #1

- BCBS Association with positive MEG policy!
  - Sustained team effort with AAN since 2009
  - Critical analysis of negative policies
  - Invitation to review “Wellpoint” policy

Accomplishment #1

- Coverage in excess of 25 million members
- Additional 8.1% of US population
- Currently covered: 172 million members
- 56% of US population (including Medicare)

2010
- United Healthcare, CIGNA
- Coverage for 42.6 million members
- Additional 14% of US population

2009
- AETNA, WellPoint, BCBS MI, BCBS NE
- 57.4 Mio members
- 16% of US population

Accomplishment #1

- This has a significant and tangible effect on all clinical MEG centers:
  - Improved access for patients
  - Improved revenue stream
  - Decreased number of denials
  - Decreased need for expansive appeals

Accomplishment #2

- Clinical Practice Guidelines (CPGs) published!
  (chair: Anto Bagic)
  - Culmination point of two years of sustained effort
  - Committee of 11 society members involved
  - World Premier - First Clinical Practice Guidelines for MEG
  - Endorsed by ACNS Council
  - Published August 2011, Journal of Clinical Neurophysiology
  - Results in multiple new educational initiatives

Other Accomplishments in 2011

- Presence at national and international meetings
  - AAN, April 2011, Honolulu
  - ISACM, November 2011, Las Vegas
  - AES, December 2011, Baltimore
- New Initiatives

Other Accomplishments in 2011

- 1st ACMEGS Board Retreat
  - October 29-30, Cleveland
  - New Initiatives
    - Educational initiatives (doers, producers, requestors, consumers)
    - Website enhancements
    - Newsletter

Other Accomplishments in 2011

- 1st Meeting with ASET & ABRET
  - December 4, Baltimore (11 participants)
  - Dialogue & first initiatives

Other Accomplishments in 2011

- Society management services recruited!
  - Utilize ACMEGS resources more effectively
    - Membership recruitment & retention
    - Meeting event planning and management
    - Financial management
    - CME compliance
    - ACMEGS Head Quarters

Accomplishments 2009 - 2011

- Insurance coverage rose dramatically by 125 million members
- MEG revenue code established
- Holding CMS accountable for fair reimbursement
- Establishing Clinical Practice Guidelines
- New educational initiatives on the way
- Teaming up with other societies (ACNS, AAN, ASET, ABRET)
- Presence at national/international meetings
- Markedly improved fiscal situation of society
- Membership significantly increased
- Society Management Service since 9/2011
- Society in good standing with Commonwealth of MA
- 1st Board Retreat in 2011
- (And we have a logo too!)

Today ACMEGS represents . . .

- Expanding professional organization with highest level of competence in practice of clinical MEG and clinical credibility
- Professional organization with most comprehensive knowledge and competence in MEG reimbursement & coverage in the US
- Professional organization that collaborates successful with other national professional organizations, including AAN, ACNS, ASET, ABRET

Challenges and Goals in 2012

- 2nd Clinical MEG course (CME)
- MEG Fellowship
- Startup training for new clinical MEG centers
- Present ACMEGS at relevant meetings
- Outreach to MEG/EEG techs (ASET/ABRET)
- Outreach to patient advocacy groups
- Fair MEG reimbursement by CMS

Mark your calendar . . .

18th BIOMAG

August 26-30, 2012

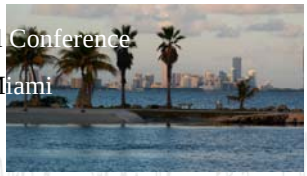
Paris, France

Call for abstracts, deadline March 15, 2012!

Mark your calendar . . .

7th ACMEGS Annual Conference

February 9, 2013 – Miami



8th ACMEGS Annual Conference

February 6, 2014 – Atlanta

Acknowledgments

- Unrestricted educational grant from

- Active participation of ACMEGS members
- **Jackie Coleman, Haley Burns & Michael Deegan!**

Words of Caution

- Please do not share with each your institutional reimbursement rates and your billing rates.
- Sharing such information could be considered collusion and could have legal ramifications for you and the society.

Enjoy the Meeting!

ACMEGS BUSINESS MEETING

1. Financial Report — Anto Bagic

2. Public Relations Committee — Susan Bowyer

3. New Business
   - Election of two new Board Member
   - Annual Meeting 2013
   - Other

Anto Bagic

ACMEGS _ Financial Report FY 2011

Anto Bagic, M.D.
Department of Neurology, University of Pittsburgh Medical Center, Pittsburgh, PA

NOTES

Susan Bowyer

ACMEGS Public Relations Committee – Report FY 2011

Susan Bowyer, Ph.D.
Henry Ford Hospital, Detroit, MI

ACMEGS
AMERICAN CLINICAL MEG SOCIETY

Public Relations Committee

Susan Bowyer, PhD, Chair
Anto Bagic, MD
Ajay Niranjan, MD
Michael Longacre

www.acmegs.org

ACMEGS

ACMEGS WEB site

Coming soon
Podcasts

Wednesday January 18, 2012 5:39PM

Last updated on Tuesday, January 10, 2012 4:17:39 PM

0350

Recommend This Site

American Clinical Magnetoencephalography Society

Home | Objectives | What is MEG | Practice Guidelines | Benefits of ACMEGS Membership | Membership & Conference Registration | Annual ACMEGS Conference | MEG Course | News & Links | Clinical MEG Locations | History and Accomplishments | Health Insurance Codes | Contact Us

Benefits of ACMEGS Membership

ACMEGS

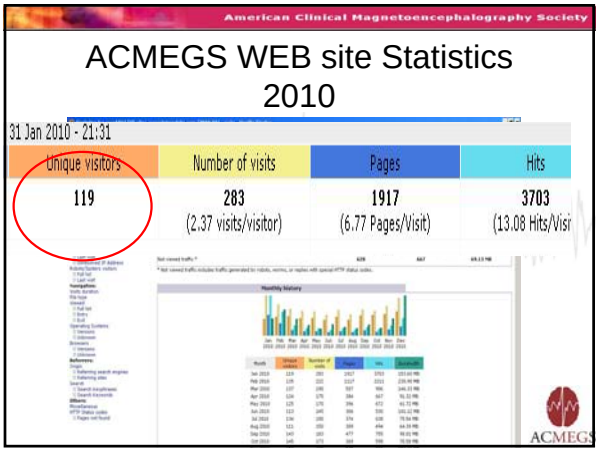
Benefits of Membership

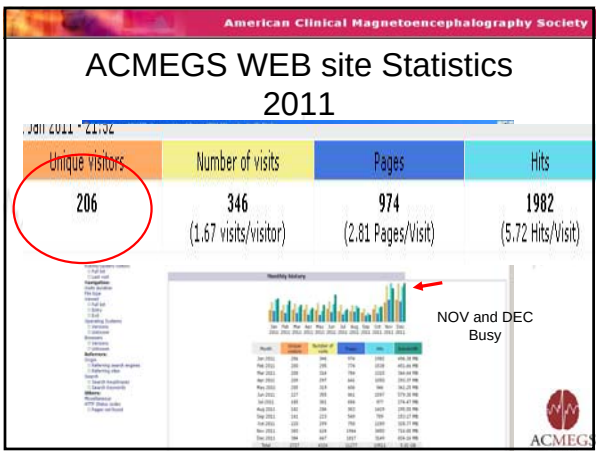
In the healthcare environment of today ACMEGS membership has value.

- ACMEGS organizes and sponsors a yearly clinical and economic workshop that highlights recent changes in the finances of a new or growing clinical MEG site.
- Create a clinical MEG community, both online and in the real world.
- ACMEGS acts as the united voice of clinical MEG centers and maintains a national focus in the areas of clinical guidelines, government regulation and third party reimbursement.
- ACMEGS is continually seeking opportunities to promote the specialized services of MEG centers, and to improve coverage and payment for services in both the public and private insurance arenas. Acting on behalf of clinical MEG centers, the ACMEGS directs efforts in the establishment of CPT codes and relative values, Medicare coverage policies, and public health programs to encourage early intervention, accurate diagnosis and comprehensive treatment for patients.
- ACMEGS maintains relationships with key government, scientific and charitable organizations and decision makers on matters affecting patient care.

ACMEGS


American Clinical Magnetoencephalography Society
Clinical Guidelines for MEG
Editorials
Practice Guidelines
Papers
Setting the standard of clinical MEG care
ACMEGS


American Clinical Magnetoencephalography Society
ACMEGS WEB site Statistics
2010
31 Jan 2010 - 21:31
Unique visitors
Number of visits
Pages
Hits
119
283
(2.37 visits/visitor)
1917
(6.77 Pages/Visit)
3703
(13.08 Hits/Visi
ACMEGS


American Clinical Magnetoencephalography Society
ACMEGS WEB site Statistics
2011
Unique visitors
Number of visits
Pages
Hits
206
346
(1.67 visits/visitor)
974
(2.81 Pages/Visit)
1982
(5.72 Hits/Visit)
NOV and DEC
Busy
ACMEGS

American Clinical Magnetoencephalography Society

ACMEGS Country Hits

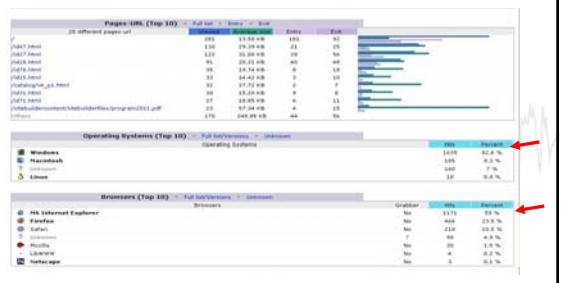
2010

2011

ACMEGS

American Clinical Magnetoencephalography Society

ACMEGS WEB Browsers



ACMEGS

American Clinical Magnetoencephalography Society

ACMEGS WEB Statistics

Days of the month

Days of the week and hours

Thursday!

5PM!

ACMEGS

American Clinical Magnetoencephalography Society

ACMEGS visitors
Who you are!

ACMEGS

American Clinical Magnetoencephalography Society

Presence at Meetings

- Neurology conferences aimed at Epileptologists (Brochures, Chocolates, Banners)
  - AAN
  - AES
  - ACNS/ACMEGS
- Neurosurgery conferences (future)
  - AANS
  - ASSFN
  - CNS

ACMEGS

American Clinical Magnetoencephalography Society

ACMEGS Future

- Patient
  - MEG brochure
  - Patient outreach
- MEG users
  - Job postings
  - Certification for MEG technologists (ASET & ABRET)
  - Clinical fellowships in MEG
  - Webinars
  - Case studies

ACMEGS

Michael Longacre

Reimbursement Roundup – Successes, Opportunities, Challenges

Michael Longacre
Executive Director, ACMEGS

ACMEGS
AMERICAN CLINICAL MEG SOCIETY

6th Annual Society Meeting
San Antonio
February 8-9, 2010

Michael Longacre
Executive Director

ACMEGS
AMERICAN CLINICAL MEG SOCIETY

Reimbursement Roundup
Successes
Opportunities
Challenges

Successes

BlueCross BlueShield of Alabama
HIGHMARK. Blue Cross Blue Shield
We want you to know® Aetna
Horizon.
WELLPOINT
HUMANA.
HCSC
UnitedHealth Group
Cigna.
Anthem.

Successes

Blue Cross Blue Shield Association policy #6.01.21

- Magnetoencephalography for the purpose of determining the laterality of language function, as a substitute for the Wada test, in patients being prepared for surgery for epilepsy, brain tumors, and other indications requiring brain resection, may be considered **medically necessary**.
- Magnetoencephalography/magnetic source imaging as part of the preoperative evaluation of patients with intractable epilepsy (seizures refractory to medical therapy) may be considered **medically necessary** when standard techniques, such as MRI, are inconclusive.
- Magnetoencephalography/magnetic source imaging is considered **investigational** for all other indications.

Successes 2010

TOP 20 Commercial Health Plans

Company	Enrollment
UnitedHealth Group	**32,702,445**
WellPoint Inc.	**30,622,381**
Aetna Inc.	**16,318,625**
Health Care Service Corp.	12,218,623
Cigna Healthcare Inc.	9,922,135
Kaiser Permanente	8,532,951
Humana Inc.	**8,486,913**
Health Net Inc.	**6,180,395**
Highmark Inc.	**5,182,186**
BlueCrossBlueShield of Michigan	5,011,359
Coventry Health Care Inc.	**4,762,000**
Emblem Health Inc.	4,035,710
Medical Mutual of Omaha	3,929,677
WellCare Group of Companies	3,537,777
Independent BlueCross	3,480,168
BlueShield of California	**3,474,951**
Horizon BlueCrossBlueShield	**3,474,951**
CareFirst Inc.	3,044,880
BlueCrossBlueShield of Massachusetts	**3,012,396**
BlueCrossBlueShield of Alabama	**2,971,869**

Successes 2012

TOP 20 Commercial Health Plans

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Successes

ACR Appropriateness Criteria®

Radiologic Procedure	Rating	Comments	RRL
Variant 1: Chronic epilepsy, poor therapeutic response. Surgery candidate.			
MEG/MSI	5	Data probably equivalent to BOLD and SPECT	None
Variant 2: New onset seizure. ETOH, and/or drug related.			
MEG/MSI	2		None
Variant 3: New onset seizure. Aged 18-40 years.			
MEG/MSI	2		None
Variant 4: New onset seizure. Older than age 40.			
MEG/MSI	2		None

Rating Scale: 1=Least appropriate, 9=Most appropriate

Last review date: 2006

Successes

American College of Radiology
ACR Appropriateness Criteria®

Last Review Date: 2011

Clinical Condition: Seizures and Epilepsy

Variant 1: Medically refractory epilepsy; surgical candidate and/or surgical planning.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	8		O
MRI head without and with contrast	8	See statement regarding contrast in text under "Anticipated Exceptions."	O
FDG-PET head	7	May be helpful in preoperative planning.	☢☢☢☢
CT head without and with contrast	6		☢☢☢
MRI functional (fMRI) head	6	May be helpful in preoperative planning.	O
MEG/MSI	6	May identify IOZ in nonlesional patients (normal MRI), can provide confirmatory localization information, may guide placement of iEEG. May substitute for invasive testing, and may be useful when other tests are discordant.	O
Tc-99m HMPAO SPECT head	5	May provide confirmatory localization information.	☢☢☢☢
CT head without contrast	5		☢☢☢

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation Level

Successes

NUBC

National Uniform Billing Committee

On August 11, 2009, ACMEGS appealed to the National Uniform Billing Committee to grant MEG a unique revenue code. The committee unanimously granted our request and created a new revenue code category 086x – Magnetoencephalogy (MEG) **effective April 1, 2010**.

Challenges

MAGNETOENCEPHALOGRAPHY (MEG)
MEG reimbursement in a Hospital Outpatient setting will receive a significant decrease for CY 2012. The primary MEG code is proposed to receive a 26% decrease and the two additional MEG codes a 7.63% decrease. The grid below provides a comparison between the CY 2011 and the CY 2012 FINAL billing codes and corresponding reimbursement rates for Hospital Outpatient centers performing MEG studies.
MEG Summary

MEG Summary					
APC	CPT	Description	2012	2011	% Change
67	95965	MEG, spontaneous	$2,520.30	$3,408.69	-26%
65	95866	Evoked single	$902.53	$977.12	-7.63%
65	95967	Evoked, each add	$902.53	$902.53	-7.73%

Challenges

Here is an example of how CMS will use hospital charges in setting the APC rates. Assume a hospital marks up its charges over its costs by a factor of 200 percent. That is, the hospital charges $300 for a service estimated to cost $100. (Medicare knows each hospital's cost to charge ratio since hospitals submit an annual cost report that identifies the costs and charges at a departmental level.) Thus, if Medicare receives bills for, say, a CT scan, at a charge of $1,500, Medicare would estimate that this hospital's costs for providing CT are one-third of that or about $500.

Challenges

It is, therefore, critical that hospitals charge appropriately for MEG. We suspect that part of the problem may be reluctance by hospitals in marking up this costly service to the same degree that other imaging codes are marked up. Some hospitals also may not fully understand the costs of providing MEG and use the same charge as is now assigned to an MRI without considering the substantially higher costs associated with MEG. Whatever the reason, these artificially low charges inevitably will lead to an underestimate of the costs of the service by Medicare, which is likely to also adversely affect the rates paid by other payers.

It is, of course, up to each individual hospital to set its own charges. At the same time, it is important for hospitals that provide MEG services to understand the impact of those charges on Medicare's outpatient payment rates. We encourage hospitals to take into account the costs of providing MEG services and consider their cost to charge ratio in setting the charges for these services.

Activities

- Comments; Medicare Cost report
  - Addition of separate line item for MEG on the cost report
- Letter to Senator Robert F. Bennett
  - *We respectfully request a letter be sent to the Director of CMS appealing the decision in CMS-1414-FC that concerns MEG*
- Letter to Dr. Edith L. Hambrick, M.D., J.D. (CMS)
  - *Our request is for a fair calculation of reimbursement based solely on the MEG cost data provided. Our contention is that this can't be determined today given that MEG and EEG both share a revenue code and the same line item on the Medicare Cost Report. If our contention is in error then we would like to understand why it is in error. This is why we are asking to sit down with you and your representatives and discuss this matter.*

2012 Key Goals

1. CMS – Partner with AAN
2. Commercial Payor Reimbursement Report
3. Support MEG Centers with Regional Carriers
4. Advocacy Groups – Increase MEG awareness
5. Represent ACMEGS in Washington, DC

ACMEGS in 2012

- What are your key concerns?
- Questions

Douglas Rose

Detection of vHFO with Vector Beamformer and Accumulated Wavelet Analysis

Douglas Rose, M.D.
Department of Pediatrics, University of Cincinnati, Cincinnati, OH

Detection of vHFO with Vector Beamformer and Accumulated Wavelet Analysis

Douglas F Rose, M.D.
Medical Director, CCHMC MEG Center

Jing Xiang, M.D., Ph.D.
Scientific Director, CCHMC MEG Center

Cincinnati Children's Hospital Medical Center
University of Cincinnati

Overview
High Frequency Oscillation Bandwidths

- Nomenclature for bandwidths and upper and lower bounds of each bandwidth of interest still evolving
- Gamma
  - Low
  - High
- Ripples
- Fast ripples

Evidence for Presence of VHFO in Human Brain

- Invasive studies
  - Animal
  - Human
- Non-invasive studies
  - EEG
  - MEG

Inherent Difficulties in Recording and Localizing

- Difficulties to record very high frequency oscillations (VHFO) by non-invasive modalities
  - Small amplitude
  - Localized sources
  - Superficial and deep
- Difficulties to localize VHFO if detected.
  - Poor signal to noise ratio (SNR)
  - Not necessarily associated with recognizable spikes
- Distinguish normal and abnormal VHFO
- Validate that VHFOs are associated with abnormal neurophysiology; Validate that localization of VHFOs is clinically useful, e.g., localize an ictal onset zone

Limiting Factors

- Limits
  - Digitization rate to filter with low pass at up to 1500 Hz
  - Background noise power
  - Localizing algorithm
- Possible solutions
  - May need to digitize at rates 2000-6000 if use 2xNyquist value for waveform definition
  - May need to average data (spontaneous?) or utilize some version of a spatial filter
  - May need localizing algorithm that could handle multiple sources and that handles low SNR

VHFO at CCHMC

- Work done by Jing Xiang, MD, PhD and colleagues at his lab
- Fortunate to have MEG instrument with max A/D of 12 KHz per channel, so can record 6 KHz per channel without difficulty
- Vector beamformer implemented
- Accumulated wavelets for spectral analysis instead of Fast Fourier Transform (FFT) or Short Time Fourier Transform

available at www.sciencedirect.com
ScienceDirect
www.elsevier.com/locate/brainres
BRAIN RESEARCH

Research Report

Neuromagnetic correlates of developmental changes in endogenous high-frequency brain oscillations in children: A wavelet-based beamformer study

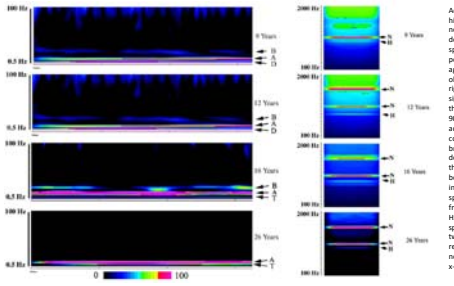
Jing Xiang[a,b,*], Yang Liu[a], Yingying Wang[a], Rupesh Kotecha[a], Elijah G. Kirtman[a], Yangmei Chen[a], Xiaolin Huo[a], Hisako Fujiwara[a,b], Nat Hemasilpin[a,c], Ton deGrauw[b], Douglas Rose[a,b]

[a]MEG Center, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, OH, 45220, USA
[b]Division of Neurology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, OH, 45220, USA
[c]Division of Medical Engineering, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, OH, 45220, USA

Methods

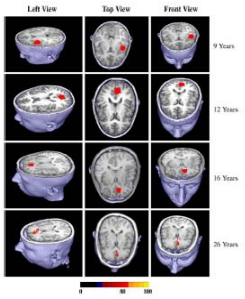
- 60 healthy children and 20 healthy adults
- 275-channel CTF MEG system
- MEG data were digitized at 12,000 Hz
- Frequency characteristics of neuromagnetic signals in 0.5–2000 Hz were quantitatively determined with Morlet wavelet transform
- Neuromagnetic activities in 8–12 Hz and 800–900 Hz were found to be the most reliable frequency bands in healthy children.

Accumulated spectrograms show low-frequency (0.5–100 Hz) neuromagnetic activity in the developing brain.



The four spectrograms show the spectral power from four participants aged from 9 years old to 26 years old (the age is indicated on the right). Noticeably, the dominant activity across all participants is alpha ("A") activity in 8–12 Hz. However, small children may show a strong delta ("D"), beta ("B") and theta ("T") activities. The outstanding developmental change is the decreasing of intermingled "beta" and "gamma" activities as well as the increasing of the clarity of the frequency bands. In all the spectrograms, Y-axis indicates a frequency range of 0.5–100 Hz. Since each accumulated spectrogram is a summary of two-minute recordings, an X-axis represents a time-window but not a real time-range.

Accumulated spectrograms show high-frequency (100–2000 Hz) neuromagnetic activity in the developing brain. The four spectrograms show the spectral power from four participants aged from 9 years old to 26 years old (the age is indicated on the right). Noticeably, the dominant signals across all participants are the noise ("N"). Signals in 800–900 Hz are considered as brain activities because they are consistently localized in the brain. The outstanding developmental change is that the intermingled activity becomes clearer with the increasing of age. In all the spectrograms, Y-axis indicates a frequency range of 1 00–2000 Hz. Since each accumulated spectrogram is a summary of two-minute recordings, an X-axis represents a time-window but not a real time-range. Thus, the x-axes are not indicated.



Magnetic source imaging shows the loci of spontaneous neuromagnetic activities in 800–900 Hz. Since the source activities may lie in different 2D planes for the participants, 3D magnetic resonance imaging is cut to show the location and shape of the neuromagnetic activities. The activity in the temporal regions is identifiable for a child at 9 years of age. The activity in the medial occipital is identifiable for a child at 12 years of age. The activity in the medial frontal region is identifiable for another two participants. Noticeably, the activities in the occipital and temporal cortices are identifiable in small children while the activities in frontal cortices are mainly identifiable in adolescent and adults

Epileptic Disord 2009; 11 (2): 113-25

Frequency and spatial characteristics of high-frequency neuromagnetic signals in childhood epilepsy

Jing Xiang[1,2], Yang Liu[1], Yingying Wang[1], Elijah G. Kirtman[1], Rupesh Kotecha[1], Yangmei Chen[1], Xiaolin Huo[1], Hisako Fujiwara[1,2], Nat Hemasilpin[1,3], Ki Lee[2], Francesco T. Mangano[3], James Leach[4], Blaise Jones[4], Ton DeGrauw[2], Douglas Rose[1,2]

Methods

Subjects:

•30 children with intractable epilepsy were studied using a whole head (MEG) system.

Signals:

•MEG data were digitized at 4 000 Hz for several 2 minute samples

Analysis

•Frequency and spatial characteristics of high-frequency neuromagnetic signals

•were analyzed using continuous wavelet transform and beamformer.

•3-dimensional magnetic resonance imaging (MRI) was obtained for each patient

•to localize magnetic sources.

Results.

•26 patients showed high frequency (100-1 000 Hz) components (26/30, 86%).

•19 patients showed more than one high-frequency component (19/30, 63%).

- Frequency range of high-frequency components varied across patients.
- Highest frequency band was identified around 910 Hz.

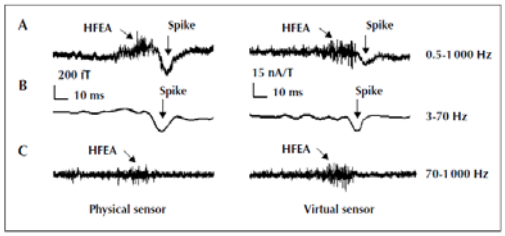
•Loci of high-frequency epileptic activities were concordant with the lesions identified by magnetic resonance imaging for 21 patients (21/30, 70%).

•MEG source localizations of high-frequency components were found to be concordant with intracranial recordings for

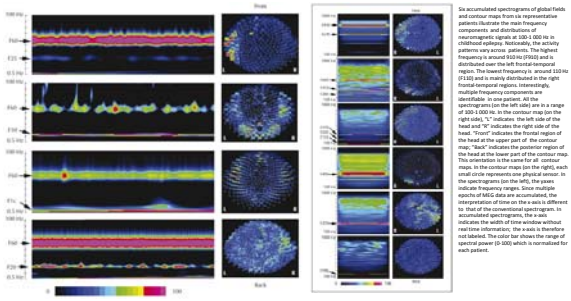
Conclusions:

•results demonstrated childhood epilepsy was associated with high-frequency epileptic activity in a wide frequency range.

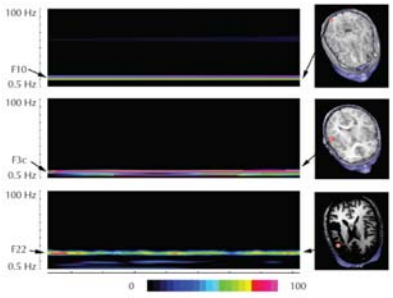
•Concordance of MEG source localization, MRI and intracranial recordings suggests that measurement of high-frequency neuromagnetic signals may provide novel approach for clinical management of childhood epilepsy.



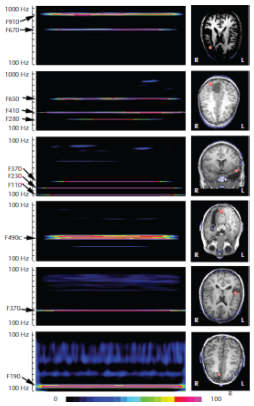
Waveforms of one MEG physical sensor and one virtual sensor data from a representative patient show high-frequency epileptic activity. The left column shows the waveforms of the physical sensor data ("Physical sensor"). The right column shows the waveforms of the virtual sensor data ("Virtual sensor"). The waveforms in row "A" are raw data at 0.5-1 000 Hz. The waveforms in row "B" are bandpass filtered with our routine setting (3-70 Hz) for detecting conventional spikes. The waveforms in row "C" are bandpass filtered with a new setting (70-1000 Hz) for detecting high-frequency epileptic activity ("HFEA"). The low- and high-frequency neuromagnetic signals are mixed in the raw waveform ("A"). The conventional spike can be clearly identified in the waveforms processed with a bandpass filter of 3-70 Hz. Noticeably, the high-frequency epileptic activity is identifiable just before the conventional spike ("Spike").



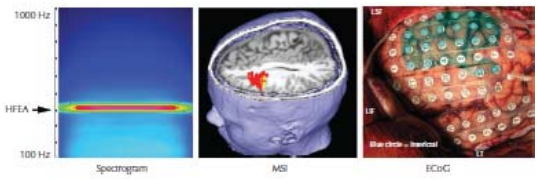
Four accumulated spectrograms of global fields and contour maps from four representative patients illustrate the main frequency components and distributions of neuromagnetic signals at 0.5-100 Hz in childhood epilepsy. The power-line noise (F60) is identifiable in all patients. Signals around 8-12 Hz (F10) are identified as alpha activity and are distributed around the occipital region. Signals around 0.5-7 Hz (F1c) are intermingled with activity around 0.5-3 Hz (delta) and 4-7 Hz (theta) and are mainly distributed in the left and right temporal regions. The activities around 20 Hz (F20) and 25 Hz (F25) show "periodic" patterns, which are probably caused by the "rhythmic burst" nature of the activity. The distributions of F20 and F25 are much more focal than that of F10 and F1c. All the spectrograms (on the left side) are in a range of 0.5-100 Hz. In the contour map (on the right side), "L" indicates the left side of the head and "R" indicates the right side of the head. "Front" indicates the frontal region of the head at the upper part of the contour map; "Back" indicates the posterior region of the head at the lower part of the contour map. This orientation is the same for all contour maps. In the contour maps (on the right), each small circle represents one physical sensor. In the spectrograms (on the left), the y-axes indicate frequency ranges. Since multiple epochs of MEG data are accumulated, the interpretation of time on the x-axis is different to that of the conventional spectrogram. In accumulated spectrograms, the x-axis indicates the width of time window without real time information; the x-axis is therefore not labeled. The color bar shows the range of spectral power, which is normalized for each patient.



Three accumulated spectrograms of virtual sensor data from three representative patients illustrate the main frequency components at 0.5-100 Hz in childhood epilepsy. Signals around 8-12 Hz (F10) are identified as alpha activity and are found in the occipital cortices. Signals around 1-6Hz (F3c) are intermingled with activity around 0.5-3 Hz (delta) and 4-7 Hz (theta) and are found in the right temporal cortex. The activity around 20-25 Hz is on the border of a lesion. All the spectrograms (on the left side) are in a range of 0.5-100 Hz. In the contour maps (on the right), the small red circles represent the loci of the virtual sensors. In the spectrograms (on the left), the y-axes indicate frequency ranges. Since multiple epochs of MEG data are accumulated, the interpretation of time on the x-axis is different to that of the conventional spectrogram. In accumulated spectrograms, the x-axis indicates the width of time window without real time information; the x-axis is therefore not labeled. The color bar shows the range of spectral power which is normalized for each patient.



Six accumulated spectrograms of virtual sensor data from six representative patients illustrate the main frequency components at 100-1 000 Hz in childhood epilepsy. The highest frequency is around 910 Hz (F910) and the loci of the virtual sensor are placed on the border of a lesion in the frontal cortex. The lowest frequency is around 110 Hz (F110) and the virtual sensor is placed on the border of a lesion in the temporal cortex. Interestingly, multiple frequency components are identifiable in one patient. All the spectrograms (on the left side) are in a range of 100-1 000 Hz. In the contour maps (on the right), the small red circles represent the loci of the virtual sensors. In the spectrograms (on the left), the y-axes indicate frequency ranges. Since multiple epochs of MEG data are accumulated, the interpretation of the time on the x-axis is different to that of the conventional spectrogram. In accumulated spectrogram, the x-axis indicates the width of time window without real time information; the x-axis is therefore not labeled. The color bar shows the range of spectral power which is normalized for each patient .



An accumulated spectrogram, magnetic source imaging ("MSI") and photograph of electrocorticography ("ECoG") from a representative patient show the concordance between MEG source localization of high-frequency epileptic activity ("HFEA") and ECoG (the "gold standard"). The accumulated spectrogram ("Spectrogram") reveals a high-frequency component around 410 Hz ("HFEA"; red line). The high frequency component is volumetrically localized to the left medial frontal area ("MSI"; red and yellow region). Intracranial recording ("ECoG") shows the same region (blue area). In the ECoG photo, "LT" indicates the left temporal cortex and "LIF" indicates the left inferior frontal cortex. The MSI and ECoG noticeably localize to the same area.

Noninvasive localization of epileptogenic zones with ictal high-frequency neuromagnetic signals

Case report

Jing Xiang, M.D., Ph.D.,[1,2] Yingying Wang, M.Sc.,[1] Yangmei Chen, M.D., Ph.D.,[1,3] Yang Liu, M.Sc.,[1] Rupesh Kotecha, B.Sc.,[1] Xiaolin Huo, Ph.D.,[1] Douglas F. Rose, M.D.,[1,2] Hisako Fujiwara, B.Sc.,[1] Nat Hemasilpin, M.S.E.E.,[1] Ki Lee, M.D.,[2] Francesco T. Mangano, D.O.,[2] Blaise Jones, M.D.,[4] and Ton deGrauw, M.D., Ph.D.[2]

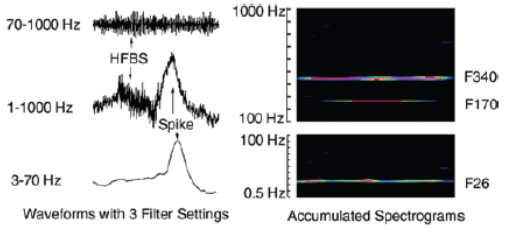
[1]MEG Center, [2]Division of Neurology, [3]Division of Neurosurgery, and [4]Department of Radiology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; and [3]Department of Neurology, the Second Affiliated Hospital, Chongqing Medical University, Chongqing, China

J Neurosurg Pediatrics 5:113–122, 2010

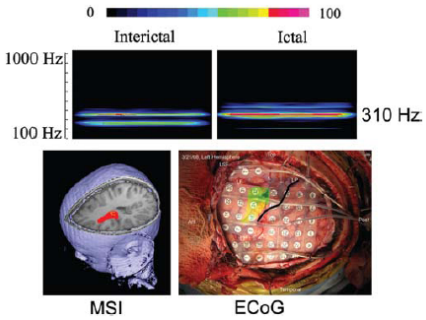
TABLE 1: Clinical semiology, neuroimaging, video EEG, intracranial ECoG recording, and MEG results*

Age (yrs), Sex	Semiology	Neuroimaging	Video EEG		ECoG		MEG (100–1000 Hz)	
			Interictal	Ictal	Interictal	Ictal	Interictal	Ictal
6, F	rt face & tongue twitching	lt frontal GWJ, lt temporal, PC, & PPCG	lt frontal & temporal	lt frontal & temporal	lt frontal, temporal, & PC	lt frontal & PC	lt frontal & PC	lt frontal & PC
11, F	rt finger tingling	lt frontal horn, PWM, splenium	lt CP	lt frontal	lt frontal & CP	lt frontal & CP	lt frontal & CP	lt frontal & CP
13, F	staring, head turning to rt, lt hand automatism	rt frontal SCWM	bilat frontal & temporal	lt CP	not done	not done	rt frontal	rt frontal
26, M	staring, rt side jerking	multiple tubers	nonlocalizing activity	lt temporal	lt temporal	lt temporal	lt temporal	lt temporal

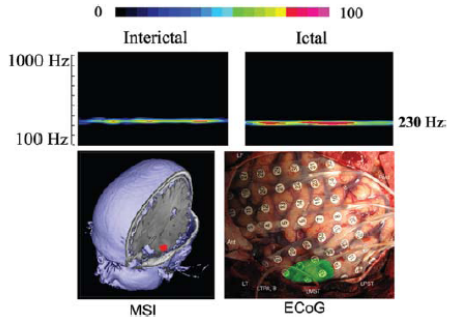
* CP = centroparietal; GWJ = gray white junction; PC = parietal cortex; PPCG = parasagittal pre- and postcentral gyrus; PWM = periventricular white matter; SCWM = subcortical white matter.



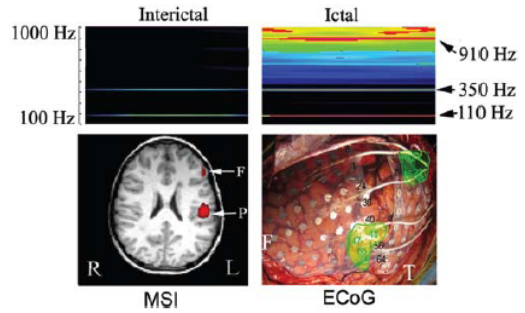
Waveforms and spectrograms from the same data set illustrating the basic principle of high-frequency signal analysis. ***Left:*** Waveforms with conventional band-pass filters. ***Right:*** Spectrograms with our new time-frequency analysis method. The waveform filtered with band-pass filters of 1–1000 Hz shows both low- *(Spike)* and high- *(HFBS)* frequency signals. The waveform filtered with band-pass filters of 70–1000 Hz shows only high-frequency signals *(HFBS)*, whereas the waveform filtered with 3–70 Hz shows only a low-frequency component *(Spike)*. High-frequency components are barely identifiable in waveforms. However, our new method reveals the high-frequency components clearly. Of note, our new method also reveals frequency components in low-frequency ranges. For example, the conventional spike *(Spike)* in the waveforms is clearly identifiable as strong brain activity around 26 Hz *(F26)*. The *F340*, *F170*, and *F26* indicate increases of spectral power around 340, 170, and 26 Hz, respectively.



Spectrograms, magnetic source image (MSI), and intracranial ECoG image demonstrating the frequency and spatial features of interictal and HFBSs. Ictal HFBSs (230 Hz; *Ictal* spectrogram) are localized to the left frontal temporal cortex *(red area)*. This irritable area has been confirmed by intracranial ECoG recording *(green area)*. Interestingly, the interictal HFBSs are also localized to the same area. The MSI is a summary of a 2-minute recording. In the accumulated spectrograms, the y axis indicates frequency range in 100–1000 Hz, and the x axis indicates the time window for multiple epochs of data.



Spectrograms, MSI, and intracranial recordings showing the frequency and spatial features of interictal and ictal HFBSs. The spectrogram of interictal MEG data *(Interictal)* and the spectrogram of ictal MEG data *(Ictal)* show the main high frequency components between the seizures and during the seizures. Noticeably, a component around 310 Hz is identifiable in both ictal and interictal spectrograms. The MSI shows the source location of neuromagnetic signals in 310 Hz in the left frontal cortex. There is no significant difference between the ictal and interictal activity in source localization. The intracranial ECoG recording shows the location of ictal-onset zone *(green area)* in the left frontal cortex. The results indicate that the localization of the high-frequency epileptic activity is concordant with the intracranial recording. In the accumulated spectrograms, the y axis indicates frequency range in 100–1000 Hz, and the x axis indicates the time window for multiple epochs of data.



Spectrograms, MSI, and intracranial recordings demonstrating the frequency and spatial features of interictal and ictal high HFBSs. The patient had tremulousness of the fingers of the right hand during MEG. Ictal HFBSs (910 Hz, ictal spectrogram) are localized to the left central-frontal region (*F arrow* in the MSI). This irritable area has been confirmed by intracranial recording (*the green area*: 47, 48 and 55 in the photograph). Interestingly, the interictal HFBSs are also localized to the left hemisphere (*P and F arrows* in the photograph) with neuromagnetic signals in 110 Hz and 350 Hz. In the MSI, *R* indicates right side and *L* indicates left side. The MSI is a summary of a 2-minute recording. In the photograph, *F* (without the arrow) indicates frontal region and *T* indicates temporal region. In the accumulated spectrograms, the y axis indicates frequency range in 100–1000 Hz, and the x axis indicates the time window for multiple epochs of data.

Difficulties for Prospective Validation

- Need to accurately identify intracranial localizations for high frequency activity corroborated with direct cortical recordings
  - Electrocorticography with grids/strips
  - Stereotaxic recordings with depth electrodes
- Limitations
  - Grids superficial but MEG records sulcal activity
  - Depth electrodes sample sulci but may have limited lateral distance sampling

Conclusions

- vHFO have been detected with intracranial recordings in humans
- At least one non-invasive methodology is available to record vHFO with MEG
- Retrospective studies showing 'co-localization' of inter/ictal vHFO and inter/ictal ECoG have been published.
- Prospective studies are needed.

Hiroshi Otsubo

High Frequency Oscillations

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High Frequency Oscillations

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The Hospital for Sick Children
University of Toronto, Ontario, Canada

Brain rhythm (Analog)

δ	0 - 3 Hz	**Berger's rhythm**
θ	4 - 7 Hz	
α	8 - 12 Hz	
β	13 - 30 Hz	
γ	30 - 80 Hz	

Fast oscillations
High Frequency Oscillations (HFO) >80 Hz

Brain rhythm (Digital)

δ	0 - 3 Hz	
θ	4 - 7 Hz	
α	8 - 12 Hz	
β	13 - 30 Hz	
γ	30 - 80 Hz	
Ripple	80 - 200 Hz	Normal HFO
		Epileptic HFO
Fast ripple	250 – 500 Hz	Epileptogenic HFO

Bragin, 2002

Questions

1. Which interictal HFOs represent the epileptogenic zone?
2. Ictal HFOs indicate the epileptogenic zone?
3. HFOs on MEG?

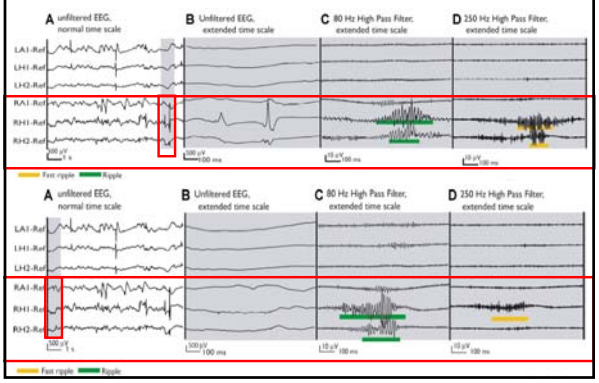
Question #1

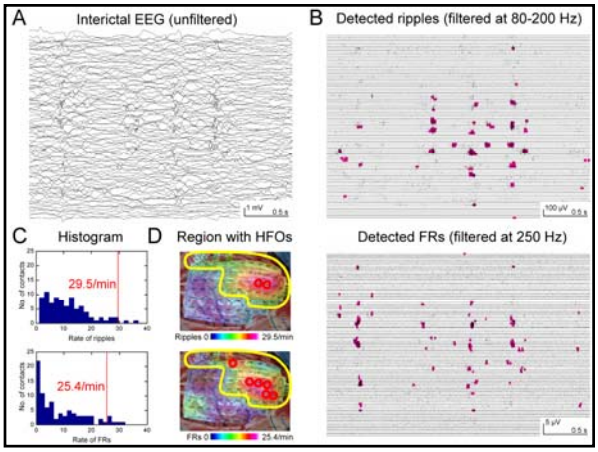
- Which interictal HFOs represent the epileptogenic zone?
  - Ripples, 80-200Hz
  - Fast ripples, >250Hz

4 types of interictal epileptic HFOs

1. Non-visible in spike
2. Non-visible independent from spike
3. Visibly superimposed with spike
4. Visibly independent from spike

Interictal HFOs with/without spikes





Ripples and Fast ripples (FRs)

- Ripples, 80-200Hz
  - inhibitory processes are preserved
- FRs, 250-500Hz
  - hyper-synchronous bursting of excitatory neurons
  - pathophysiologic phenomenon in epilepsy and seizure initiation
  - generating spontaneous seizures

Bragin.A, Engel.J.J,. *Epilepsia* 40:127-37, 1999

Pathological / Normal Ripples

- Pathological Ripples
  - a transient phenomena in early stages of epileptogenesis
  - development of FRs
  - only exist in the dentate gyrus
- Loss of critical inhibitory influences in epileptogenic regions
  - transition of normal Ripples to pathological FRs
- Normal ripples
  - future investigations into mechanisms of pathological FRs

Le Van Quyen M, et al.,J Neurosci. 2008;28:6104-10

Epileptogenic HFOs

- Cellular networks underlying FR generation
  - more localized than Ripple
- No significant difference in the amplitude distributions of Ripple and FR
- Multiunit synchronization was significantly increased during FR compared with Ripple
- FRs in the human brain
  - localized pathological events related to epileptogenesis

Bragin.A,. *Ann Neurol* 52: 407-15, 2002

Answer #1

- Interictal fast ripples (>250 Hz) are a marker of the epileptogenic zone that needs to be resected to achieve better seizure outcome
- Interictal ripples (80-200 Hz) are not related to the epileptogenic zone

Question #2

- Ictal HFOs indicate the epileptogenic zone?
  - HFO detection
  - Where
  - When
  - How about dynamics

Intracranial EEG seizure onset patterns in neocortical epilepsy
All patterns have various HFOs

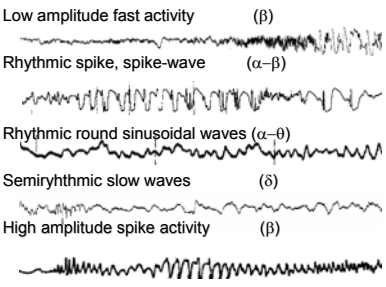
1) Low amplitude fast activity (β)

2) Rhythmic spike, spike-wave (α–β)

3) Rhythmic round sinusoidal waves (α–θ)

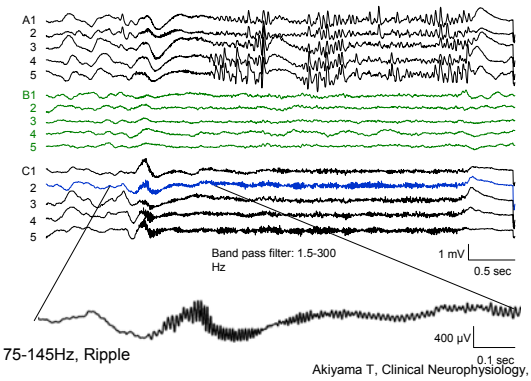
4) Semiryhthmic slow waves (δ)

5) High amplitude spike activity (β)



Lee SA, Spencer SS et al. Epilepsia 2000

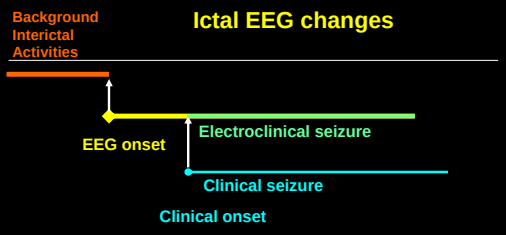
Ictal HFOs in spasms



75-145Hz, Ripple

Akiyama T, Clinical Neurophysiology, 2005

Evolution of seizure



Ictal EEG changes = **Preclinical**
Ictal EEG changes
Electrographical seizure
Ictal onset
+ **EEG changes associated with**
Clinical seizure
Ictal symptom

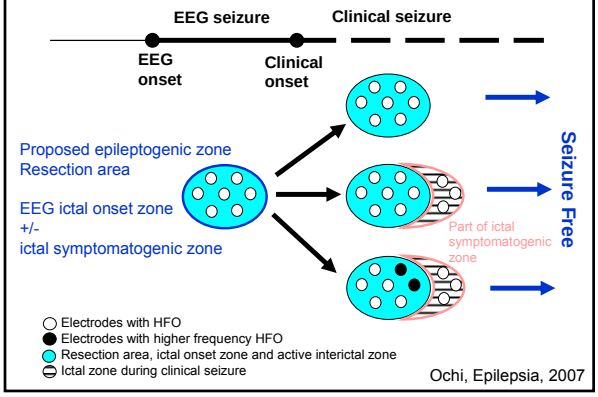
Epilepsia, 48(2):286–296, 2007
Blackwell Publishing, Inc.

Dynamic Changes of Ictal High-Frequency Oscillations in Neocortical Epilepsy: Using Multiple Band Frequency Analysis

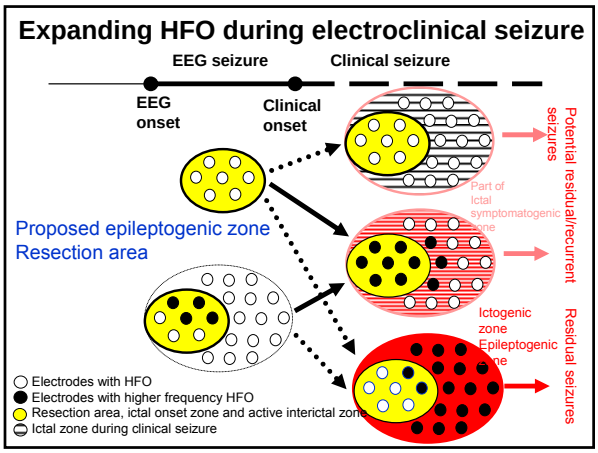
*Ayako Ochi, *Hiroshi Otsubo, *Elizabeth J. Donner, *Irene Elliott, *Ryoichi Iwata, *Takanori Funaki, *Yoko Akizuki, *Tomoyuki Akiyama, *Katsumi Imai, †James T. Rutka, and *O. Carter Snead III

- Patients who underwent resection of most of the confined ictal HFOs achieved the post-surgical seizure free outcome.
- Dynamic changes of ictal HFOs on the subdural EEG indicate subset of ictal brain activities to understand the epileptogenic network in patients with neocortical epilepsy.

Confined HFO during electroclinical seizure



Ochi, Epilepsia, 2007



Answer #2

- Patients who underwent resection of most of the confined **ictal** HFOs achieved the post-surgical seizure free outcome.
- Dynamic changes of **ictal** HFOs on the subdural EEG indicate subset of ictal brain activities to understand the epileptogenic network in patients with neocortical epilepsy.

Question #3

HFOs on MEG?

SEF and HFOs

Clinical Neurophysiology 122 (2011) 1906–1923

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Invited review

Exploring the physiology and function of high-frequency oscillations (HFOs) from the somatosensory cortex

Isamu Ozaki [a,*], Isao Hashimoto [b]

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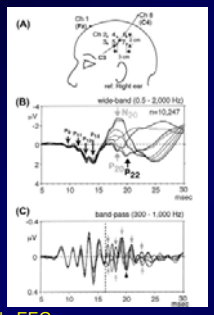
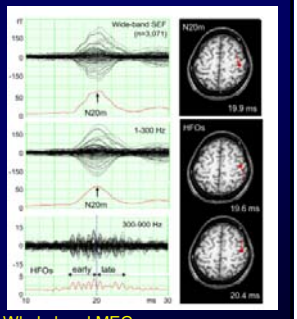
HFOs on EEG and MEG

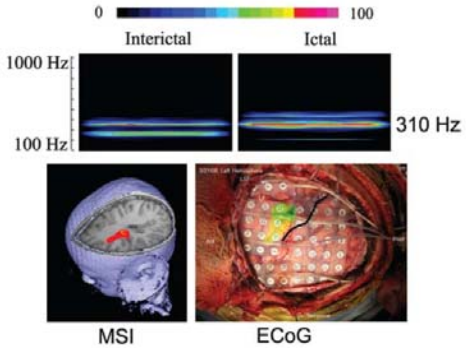


Scalp EEG
Ozaki et al., 1998, Clin Neurophysiol



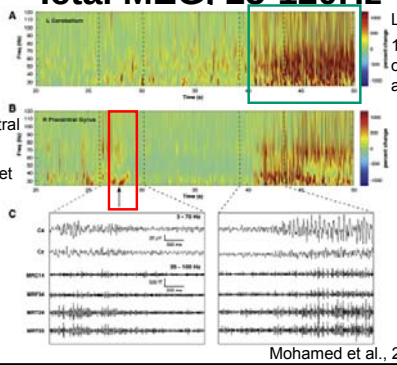
Whole head MEG
Ozaki & Hashimoto, 2011, Clin Neurophysiol

Ictal HFO on MEG



Xiang J, 2010 JNS

Time frequency analysis
Ictal MEG. 25-120Hz



L. Cerebellum

14sec after the onset, CbII activation start

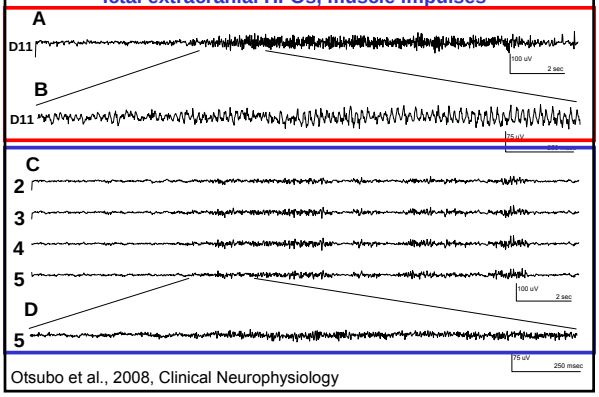
R. Precentral gyrus

Ictal onset 20-40Hz

Mohamed et al., 2011, Ep. Res.

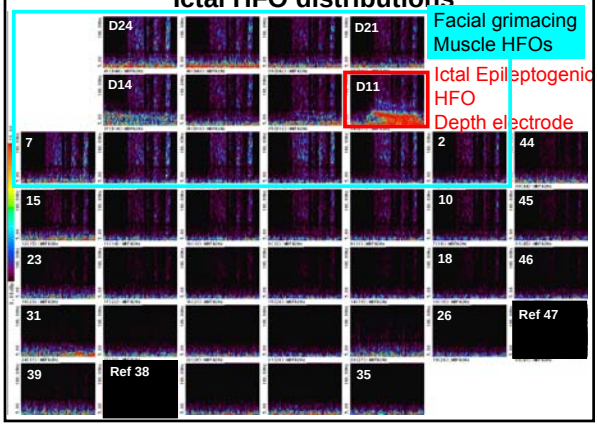
Ictal intracranial HFOs, epileptogenic discharges

Ictal extracranial HFOs, muscle impulses



Otsubo et al., 2008, Clinical Neurophysiology

Ictal HFO distributions



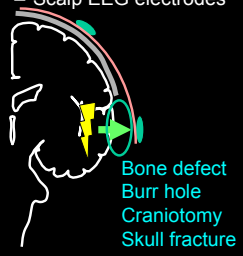
Facial grimacing Muscle HFOs

Ictal Epileptogenic HFO

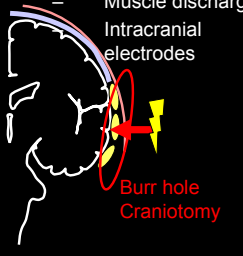
Depth electrode

Reverse Breach rhythm

Breach rhythm
- Higher amplitude discharges
- Scalp EEG electrodes



Reverse breach rhythm
- Muscle discharges
- Intracranial electrodes



Answer #3

- HFOs can be recorded on MEG
- Statistical analysis must be required
- Spatial filtering method to localize the locations of HFOs

Take Home Messages

- Epileptogenic high frequency oscillations (HFOs) = Fast ripple >250Hz
- Seizure onset zone;
  Interictal and Ictal HFOs > Interictal Spikes
- *Normal HFOs*
- *Extracranial HFOs*

Manoj Raghavan

Correlates of epileptic high frequency oscillations in MEG source spectral statistics

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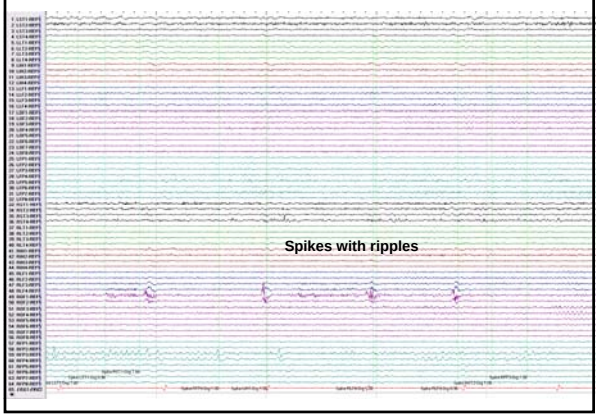
Correlates of epileptic high frequency oscillations in MEG source spectral statistics

Manoj Raghavan, MD, PhD
Comprehensive Epilepsy Program
Medical College of Wisconsin

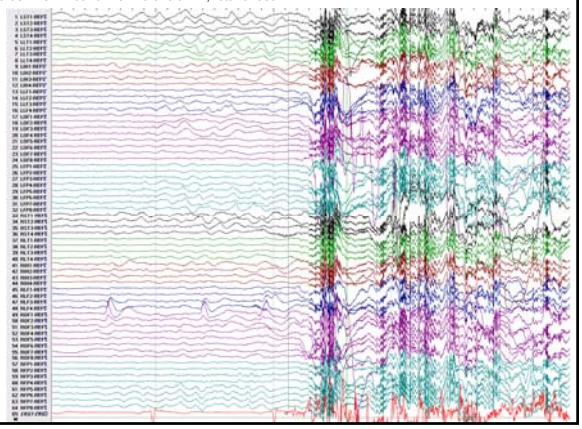
MEG & interictal markers of epileptogenic cortex

- MEG utility in epilepsy relies heavily on interictal abnormalities
  - ictal recordings are infrequent
- The traditional interictal marker
  - Interictal epileptic spikes: may sometimes be absent
- Alternative markers
  - Slow activity (delta / theta)
    - Lower specificity?
  - High Frequency Oscillations in iEEG
    - Ripples (80-200 Hz)
    - Fast Ripples (200-500Hz)
    - What about epileptic beta / low gamma?

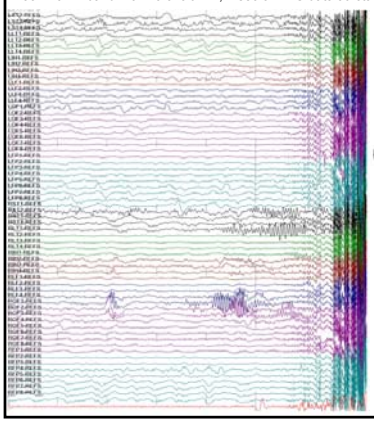
53-120 Hz band: 20 microvolt/mm, Interictals

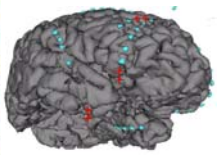


0.08-120 Hz band: 75 microvolt/mm, Ictal onset



53-120 Hz band: 10 microvolt/mm, 1 sec of EEG data at ictal onset





Non-invasive localization of either the spikes or HFOs would have greatly helped guide electrode placement

Localizing high frequency cortical oscillations using MEG

- Why MEG and not high-density EEG?
  - Magnetic fields not impeded by tissue/skull (but decrease with distance), while electrical currents are severely impeded
  - Scalp EEG signal loss is greater with increasing frequency due to decreasing phase-coherence across space (Pfurtscheller & Cooper 1975)→produces an ***apparent*** low-pass effect
  - Due to above factors, the1/f$^{\alpha}$ spectrum of EEG signals can drop below the EMG noise floor in the scalp at frequencies as low as 20 Hz (Whitham et al., Clin Neurophys, 2007)
- Physiological high-frequency activity has been documented up to several hundred Hz with MEG, but claims based on scalp EEG beyond 40 Hz are generally viewed with suspicion for good reason
- Source modeling is simpler with MEG due to simpler head-modeling requirements
  - Especially relevant in patients with lesions, skull defects, prior resections etc..
  - Higher spatial resolution

Can epileptic HFOs be localized using MEG?

- Source mixing at the sensors
  - out-of-phase cancellation of signals from across cortical generators could diminish the signal
  - could result in a signal whose dominant frequencies are not what is recordable at the cortex with ECoG
- While detection of functional high frequency oscillations benefits from signal averaging across trials, this is not an option for spontaneous oscillatory bursts (unless spike related)
- All oscillatory bursts are not pathological
  - How do we know we are seeing epileptic HFO activity?

The rest of this talk ….

- Quick overview of some approaches to detecting epileptic high frequency activity using MEG and some inherent pitfalls
- Describe one particular approach that we have been exploring in our lab
- Show some data comparing MEG findings based on our method, to intracranial EEG in a group of patients
- Finally, point out a couple of strategies that may increase the ability of MEG to localize aspects of high frequency activity that best correlate with seizure onset zones

MEG approaches to epileptic HFOs

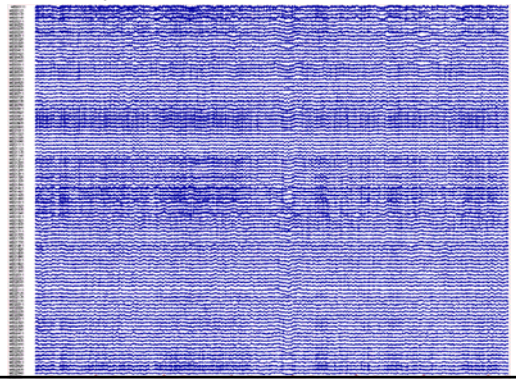
- Detection of spike related HFOs
  - spikes in MEG/EEG
  - spikes in simultaneous iEEG
- HFO detection in MEG sensor data → source estimation
  - Computationally tractable
  - Yield, sensitivity, specificity?
- Time-domain source estimation → HFO detection in source currents
  - Computationally expensive
- Seeking correlates to HFOs in background MEG source spectral statistics
  - Indirect measure
- Any method will need validation using iEEG

Some pitfalls in detecting HFOs

- Many extracerebral artifacts when high-pass filtered mimic “HFOs”
  - Sensor artifacts
  - EMG
  - Artifacts related to implanted devices / metal
- Physiological HFOs
  - High frequency activity (up to 600 Hz) normally accompanies cortical engagement
- Careful screening of the input data is advisable when using any automated analysis technique
  - garbage in → garbage out

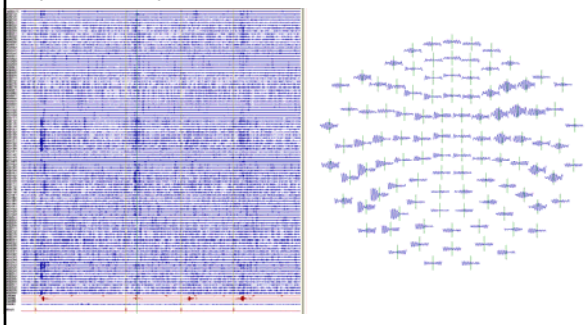
EMG artifacts w/o low freq components

Magnetometric tracings: 2-500 Hz

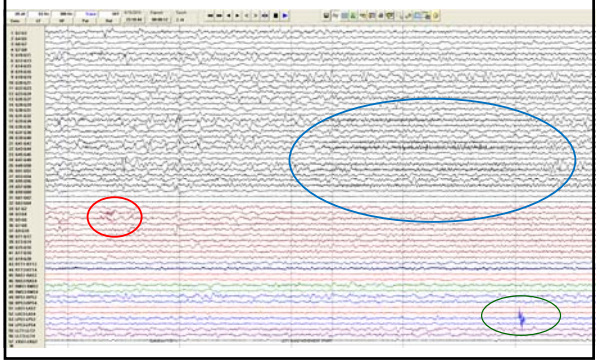


EMG artifact during hand motor task

Magnetometric tracings: 80-500 Hz

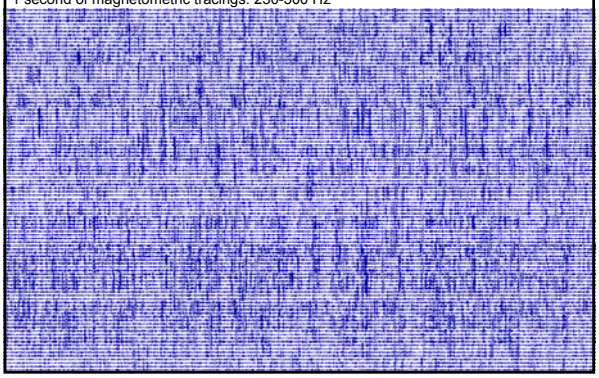


Functional VS epileptic VS artifactual “HFOs”



Fast ripples?

1 second of magnetometric tracings: 250-500 Hz



Characterizing the neuromagnetic background activity

- Our approach does not explicitly attempt to detect HFOs, but is intended to characterize the interictal background activity across several frequency bands
- In each frequency band, the analysis estimates the following quantities from resting MEG recordings
  - Spatial distribution of mean source power, μ
  - The standard deviation of source power over time, σ
  - The coefficient of variation of source power:

$$c_v = \sigma / \mu$$

- Frequency bands: 1-4Hz, 4-8Hz, 8-12Hz, 12-25Hz, 25-35Hz, 35-55 Hz, 70-110 Hz, 130-170Hz, 250-500Hz.

methods

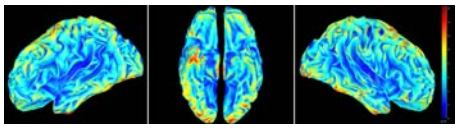
- MEG data
  - MEG recordings are performed using a 306-channel MEG system (Elekta Neuromag, Helsinki, Finland) at a sampling rate of 2000 Hz.
  - All samples of MEG recordings were subjected to automated artifact, EKG, and noise reduction using Signal Space Separation and Principal Component Analysis.
  - the data that subjected to analysis was further visually screened for artifacts
- Head modeling
  - patient-specific head models are constructed from each patient's T1-weighthed MRI data using automated segmentation and surface tessellation techniques.
  - source imaging is based on 15,000 elementary current sources constrained to the cortical mantle, with a source separation of ~ 3 mm.

methods contd..

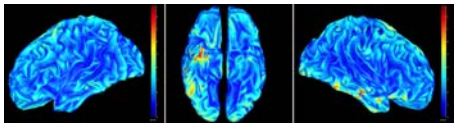
- From each subject
  - between 4 -7 minutes of artifact free MEG recording from an ***eyes-closed resting or asleep state*** is analyzed
- For each frequency band
  - the data is divided up into non-overlapping time-windows corresponding to ~ 10 periods of the band's center-frequency
- For each time-window
  - source imaging is performed using weighted L2 minimum norm in the frequency domain.
- For each cortical location in the brain model
  - μ, σ, and c_v (across time windows) is calculated from the source estimates
- Focal findings consistently observed in results from two independent MEG samples of >= 2 mins are considered significant

130-170 Hz

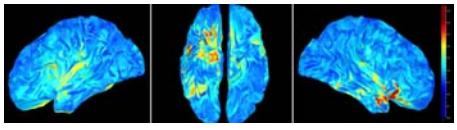
μ



σ



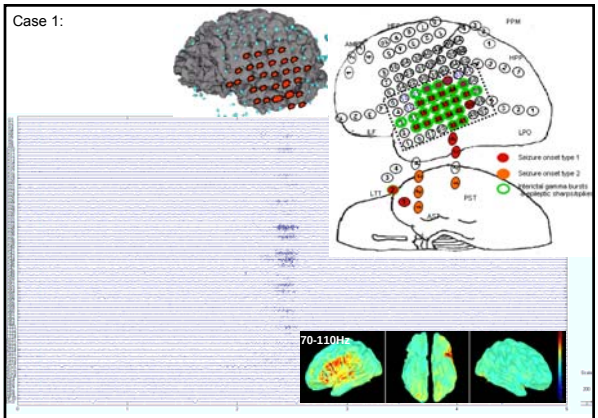
c_v



patients

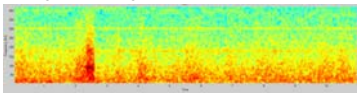
- 10 patients with medically refractory partial epilepsy, who had
  - undergone an MEG recording as part of a presurgical evaluation for epilepsy surgery
  - completed an invasive intracranial EEG (iEEG)study prior to undergoing a resective procedure
- patients were selected for retrospective analysis of the MEG background activity based on
  - the presence of robust, visually apparent, epileptic HFOs during iEEG recording
  - HFOs in at least 4 adjacent subdural recording electrodes

Case 1:

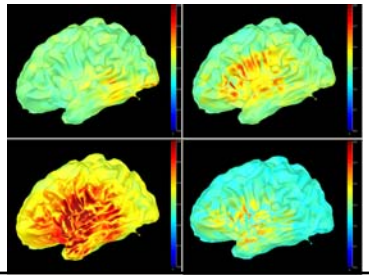


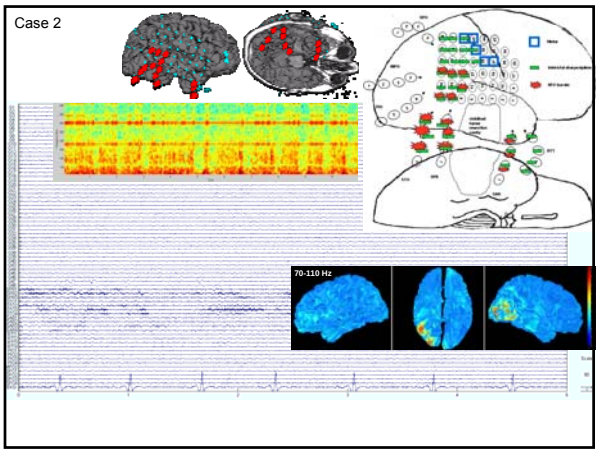
Case 1:

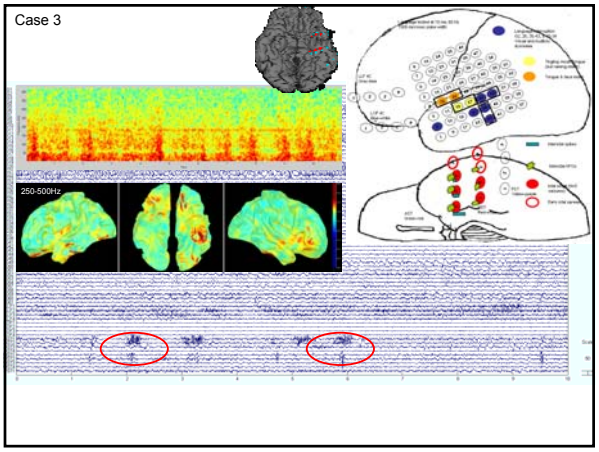
spectrogram of a single burst in iEEG

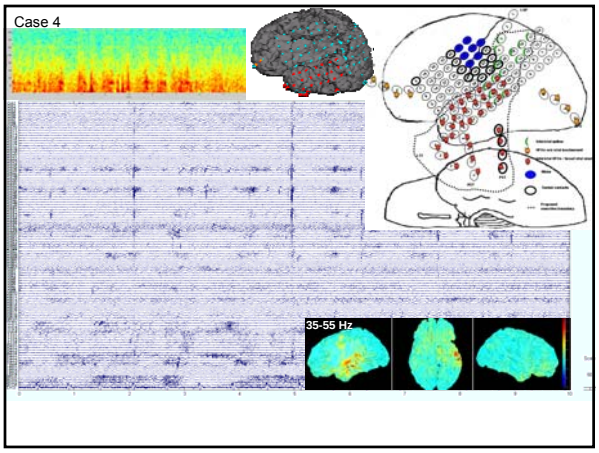


Coefficient of variation of source power

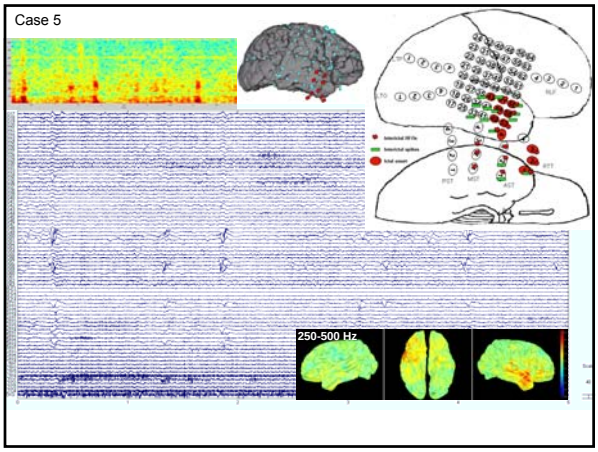



Case 2
70-110 Hz


Case 3
250-500Hz


Case 4
35-55 Hz

Case 5



results

- c_v shows significant focal abnormalities in one or more HF bands, concordant with location of iEEG HFOs in 7/10 patients
- In the remaining 3 patients: both *σ and μ* were significantly elevated in regions with iEEG HFOs making their ratio, c_v, insignificantly different from other regions
- Epileptic spikes were present in 7/10 studies: spike sources were concordant with iEEG seizure onset zones in 6/10 patients, and discordant in 1/10.
- In 3 of the patients with no epileptic spikes in MEG, c_v, localized HFO locations concordant with ictal onset zones.

results

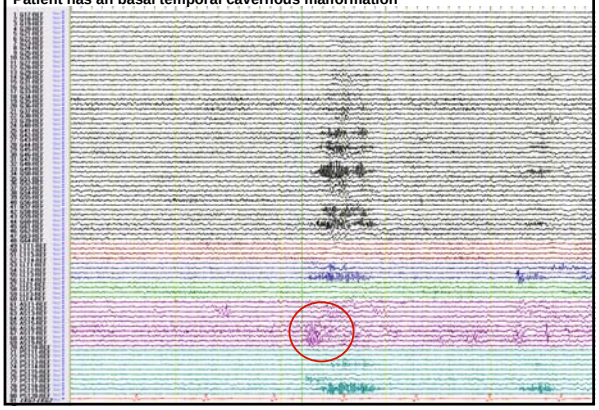
Case ID	Age at MEG	Gender	IOZ	iEEG-HFOs	Resection Zone	Engel class 6 mo	MEG Spikes
1	42	F	L AMT & TP (multifocal)	L PostT-TP	LATL+AH+LP	II	L AT & TP, indep RAT
2	30	F	No ictal data	RTPO	RTPO	II	RTPO
3	54	F	L AMT	L AMT	LATL+AH	I	None
4	31	M	L T-P (extensive)	L T-P (extensive)	LATL+AH+LP	I	L PostT-P
5	31	F	RAT	RAT	RATL+AH	I	None
6	37	M	LAT	LAT+RAT	L ATL	I	None
7	25	M	LP	LTPO	LP	I	LP
8	24	M	LAMT	LAT + LF	LATL+AH	I	LAT
9	44	F	No ictal data	R T-C-TO	RATL+AH	I	rare RP (meg only)
10	26	M	LAMT	LAT + LF	LATL+AH	I	None

Patients with significant focal c_v abnormality in at least one of four high frequency bands spanning 35 Hz – 500 Hz.

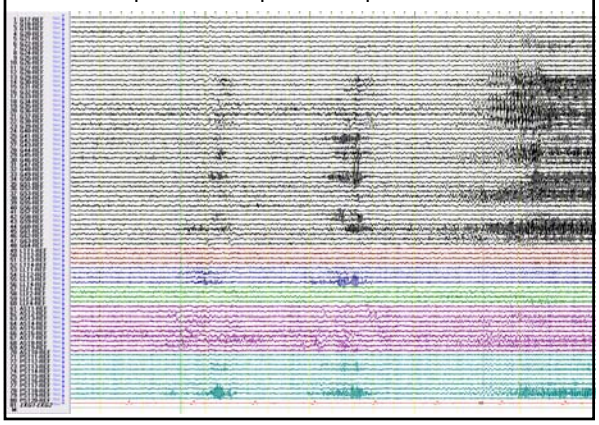
some further considerations…

- Are correlations between $\mathbf{c_v}$ and locations with HFOs on iEEG due to HFO bursts at the time of MEG recording, or simply an independent marker of abnormal cortical dynamics?
  - Simultaneous MEG-iEEG could answer this
  - Instances of high $\mathbf{c_v}$ without HFOs in that location would support this possibility
- Epileptic HFOs clearly become much more abundant in iEEG when antiepileptics are withdrawn (Zijlmans et al *Neurology* 2009)
  - Outpatient MEG studies performed while patients are on full doses of antiepileptics are very likely to have low yield
- When HFOs are extensive over a region, what features of HFOs best correlate with seizure onset zones.
- Our analysis used only a few minutes of MEG data
  - Yield may improve with longer samples depending on HFO abundance

Recurrent interictal HFO propagation pattern: basal temporal→frontal
Patient has an basal temporal cavernous malformation



Ictal HFOs: most prominent build-up is in frontal speech areas



conclusion

- MEG can provide non-invasive access to pathological high frequency oscillations in the cortex that are otherwise only recordable using invasive EEG recordings
- Statistical measures that capture variation of source power over time appear to localize regions with HFO bursts in some patients
- Measures based on automated analysis of data can be very sensitive to the presence of a variety of high-frequency artifacts, both physiological and non-physiological
- MEG methodologies for localizing epileptic high frequency activity need to be validated against iEEG findings
- MEG has the potential advantage of seeing activity across the whole brain, and not just where electrodes are located.

Acknowledgements

- Sylvain Baillet, PhD
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- Wade Mueller, MD

Esther Florin

Towards New Markers for Epilepsy MEG Evaluation

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Towards New Markers for Epilepsy MEG Evaluation

Esther Florin
Research Associate
MEG Research
Montreal Neurological Institute
McGill University

Open issues

1) Clinical significance of MEG depends on specific physiological markers

- Example: interictal spikes, slowing, HFO bursts, etc.
  - ✓High-yield is not a given (30% epileptic patients: no spikes)
  - ✓Deviation from normal variants: not always clear
- Suggest discovery-based approaches contrasting patient populations/individuals against normative databases

Open issues

2) Effectiveness of drug treatments is limited

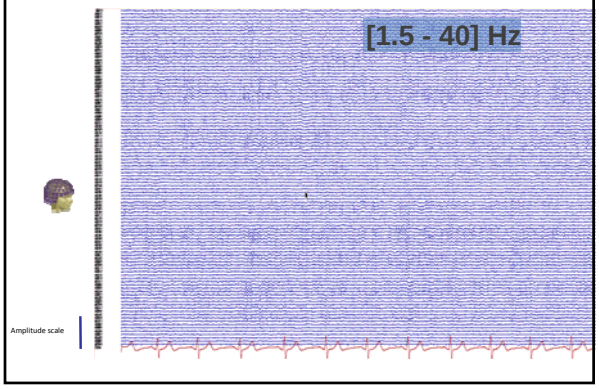
- Example: 35% anti-epileptic drugs regimen = ineffective
  - ✓Suggest MEG as a therapeutic tool:
    Neurofeedback

Outline

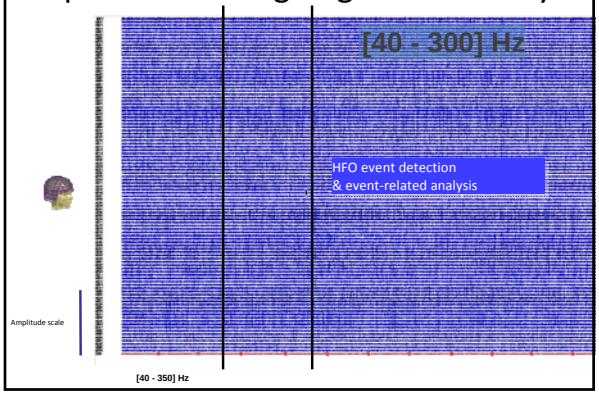
1) HFO detection with MEG
2) Non event-related source modeling
3) MEG as a therapeutic instrument through neurofeedback

HFO analysis with MEG

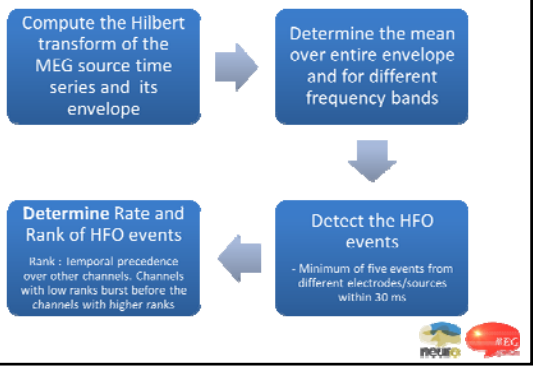
Spectrum of ongoing brain activity



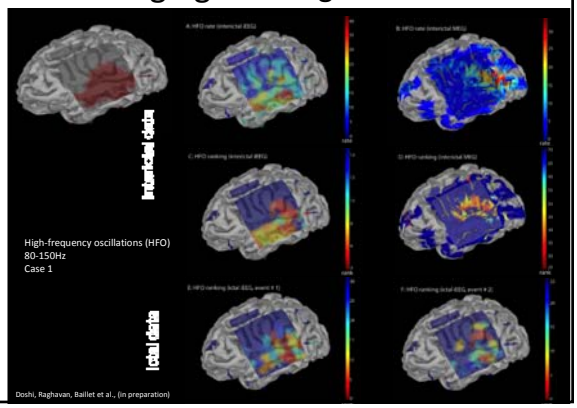
Spectrum of ongoing brain activity



Analysis of HFOs

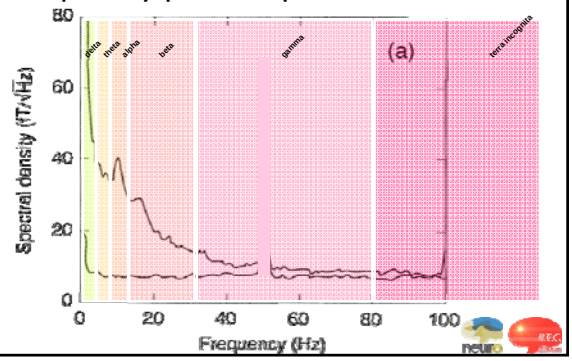


Imaging of HFO generators

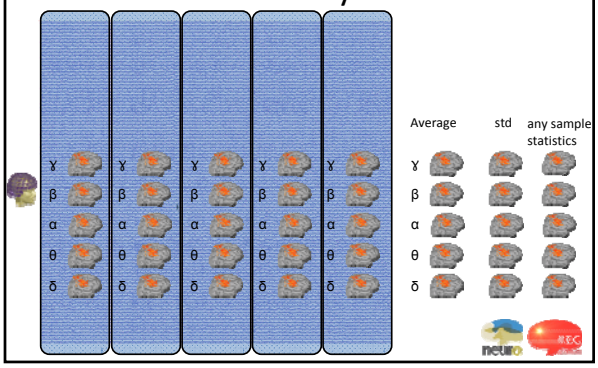


Non event-related source imaging

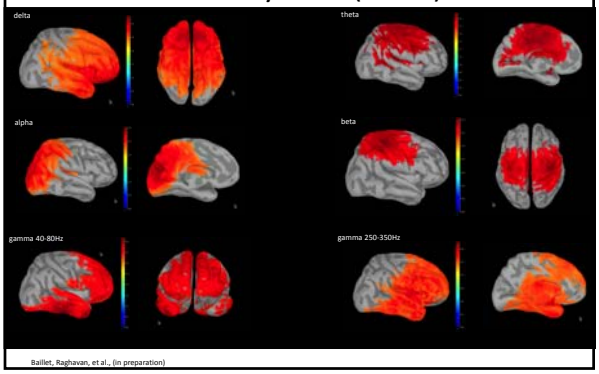
The resting brain: frequency power spectrum



Normative database of ongoing brain activity



Normative distribution of ongoing brain rhythms (N=45)

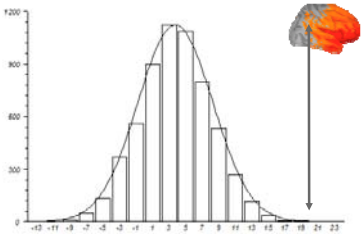


Baillet, Raghavan, et al., (in preparation)

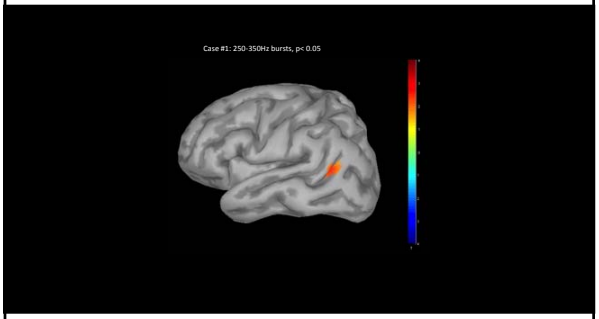
Assessing the likelihood of individual data as normal variant

Empirical distribution of local metric across normative database

Patient data

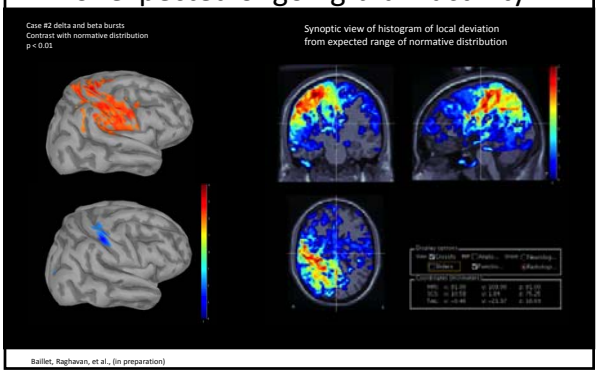


Interictal episodes as local alterations of expected ongoing brain activity



Baillet, Raghavan, et al., (in preparation)

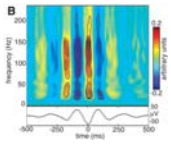
Interictal episodes as local alterations of expected ongoing brain activity



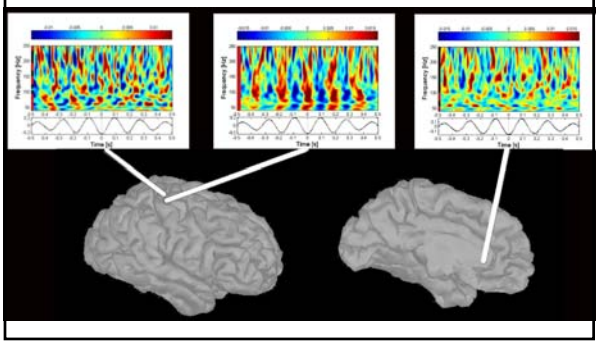
Baillet, Raghavan, et al., (in preparation)

Analysis of frequency components in healthy subjects

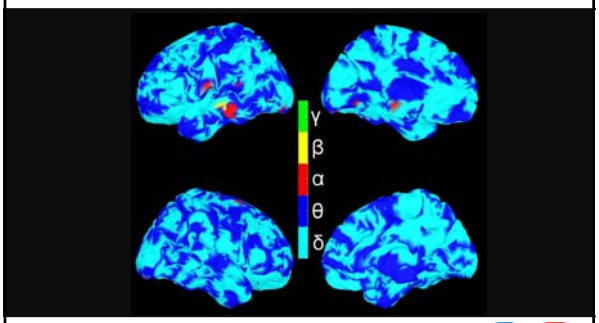
- Cross-frequency coupling as a possible mechanism for communication between different brain areas (Canolty 2006)
- Frequency components and distribution during rest not studied in healthy subjects



Theta-to-gamma coupling as a possible time marker in the default brain?

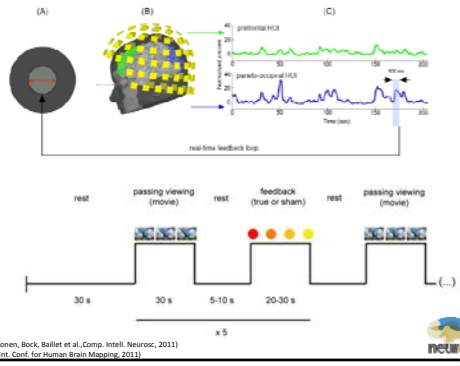


Group Results (N=6)



Neurofeedback with MEG

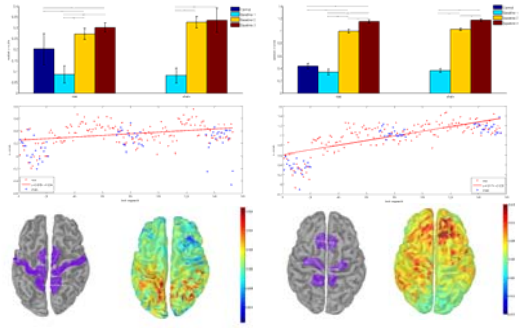
Concept and Paradigm



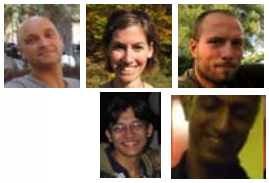
(Sudre, Parkkonen, Bock, Baillet et al.,Comp. Intell. Neurosc, 2011)
(Bock et al. , Int. Conf. for Human Brain Mapping, 2011)

Targeted training of regional brain activity

Subject 1 Subject 2



(Bock et al., in preparation)



Thank you.

3rd ACMEGS POSTER PRESENTATION

Functional mapping protocols for localizing motor and expressive language areas in children: The Hospital for Sick Children experience

Elizabeth W. Pang, Matthew J. MacDonald, Darren S. Kadis, Hiroshi Otsubo, Carter Snead
Division of Neurology / Program in Neurosciences and Mental Health, Hospital for Sick Children, Toronto, Ontario, Canada

MEG is gaining credibility in the clinical setting as a valid and reliable tool for pre-surgical functional mapping. Used in conjunction with fMRI, comprehensive maps of eloquent cortices can be drawn. In institutions with an MEG, it is routine to map primary somatosensory, auditory, visual and posterior-temporal (receptive) language areas. These applications have been well-documented and are included in recently published Practice Guidelines for clinical MEG [1]. Motor mapping (of hand, foot and mouth movements) is more challenging, as is the mapping of expressive, or inferior frontal, language areas. Several groups, including ours, have had success developing motor and frontal language protocols. We would like to report on our protocols, which have been designed specifically for application in a pediatric setting. We have adapted the typical self-paced finger tapping task, used in adults, to a less difficult task that can be completed by children, even children with motor deficits [2]. To localize expressive language, we have developed a picture-based naming / verb generation task which can be performed in children as young as 4 years of age [3-4]. Using these tasks, we have successfully localized motor cortex and inferior frontal language areas in children with focal epilepsy and brain tumours. In this poster, we present detailed descriptions of our testing parameters, as well as a case series demonstrating the applicability and accuracy of these protocols in our pediatric patients.

References: [1] Burgess, et al., 2011; [2] Pang, et al., 2009; [3] Kadis, et al., 2011; [4] Pang, et al., 2011.

Language mapping with MSI, Wada Test, and electrocortical stimulation (ECS) in a patient with medically refractory epilepsy

Zhang W, Risse G, Dickens D, Ritter F.
Minnesota Epilepsy Group, PA, Saint Paul, Minnesota

MSI language lateralization correlates with the Wada test in about 90% of epilepsy patients [1-2]. The finding of bilateral language in patients with right hemisphere seizure onset is extremely rare. We report a case of discordant language in the right hemisphere based on multiple mapping techniques.
The patient was a 13 yo right-handed male with a history of complex partial seizures since 5 yo. He had failed multiple anti-epileptic medications and was having 8-10 seizures/week at the time of surgery.

Structural MRI was normal. Video EEG indicated seizures had a lateralized onset from the right temporal or frontal region. MEG indicated that interictal activity did not cluster however was localized to the same areas. MSI language mapping, acquired with a word recognition task [2], demonstrated bilateral language function, while the Wada suggesting exclusive left hemispheric dominance. Intracranial electrodes recorded right temporal lobe onset seizures with interictal activity from right frontal lobe. ECS found speech arrest in the right superior temporal area consistent with MSI language mapping. Subsequent resective surgery of the right anterior temporal lobe including the hippocampus, while sparing the critical language area, was conducted. The patient has been seizure free since surgery on a single AED at 5 year follow-up. No significant postoperative deficits were identified.
Conclusion: Receptive language is possible in an epileptogenic right temporal lobe. Surgical resection in these cases should spare MSI and ECS language sites.

References: [1] Doss R et al, Epilepsia 50:2242-8, 2009; [2] Papanicolaou AC et al, J Neurosurg 100:867–876, 2004

Akio Ikeda

Wide-band EEG/MEG analysis for epilepsy: An overview

Akio Ikeda, M.D., Ph.D.
Departments of Neurology, Kyoto University School of Medicine, Kyoto, JAPAN

6th Annual ACMEGS Conference
(San Antonio, TX, USA, February 9, 2012)

Workshop on
MEG Slow and Ultra-slow Frequency Activity in Epilepsy

Wide-band EEG/MEG analysis for epilepsy: An overview

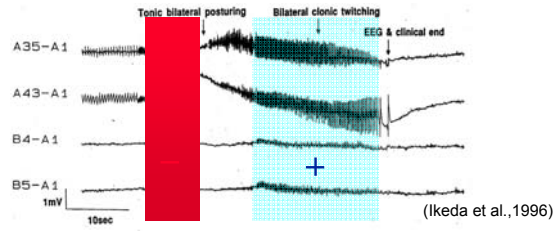
Akio IKEDA,MD, PhD
Departments of Neurology
Kyoto University School of Medicine,
Kyoto, JAPAN

Expression of epileptogenicity by EEG/MEG

1) By conventional EEG
spikes, sharp waves (pyramidal neurons)

2) By wide-band EEG (surrogate marker?)
DC shifts, slow shifts (pyramidal neurons, glia)
HFO or fast ripple activity (pyramidal neurons, ~~interneurons~~?)

Wide-band EEG in clinical invasive recording

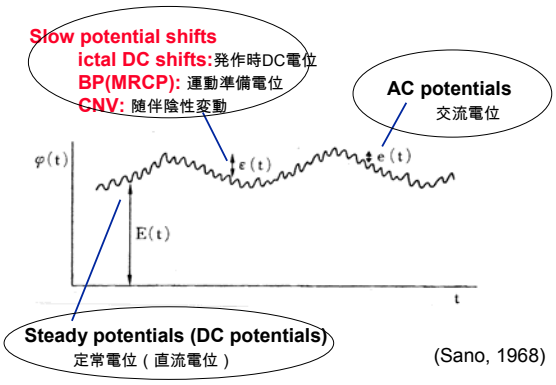


(Ikeda et al.,1996)

(Worrell et al., 2008)

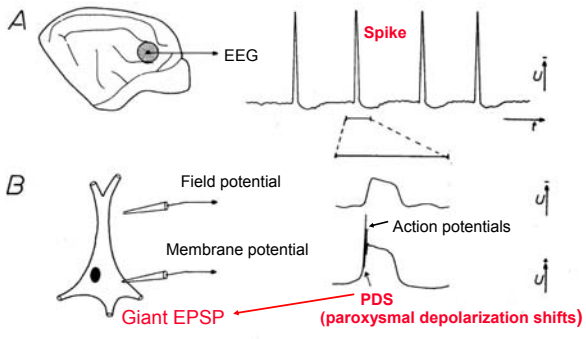
0.1Hz 1Hz 100Hz 1000Hz

Schema of brain potentials



(Sano, 1968)

Interictal activity by penicillin application



(Speckmann & Elger, 1987)

Application of LFF and HFF

Time constant (TC)
to filter out slow components

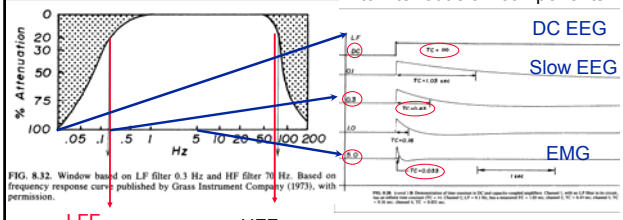


FIG. 8.32. Window based on LF filter 0.3 Hz and HF filter 70 Hz. Based on frequency response curve published by Grass Instrument Company (1973), with permission.

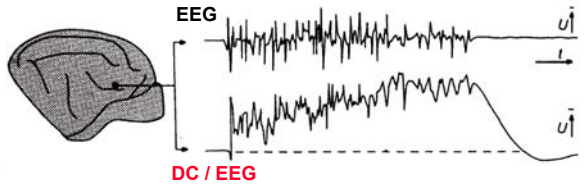
LFF
0.3 Hz
(TC=0.5 s)

HFF
70 Hz

TC x LFF=0.16(1/2π)

0.1 sec	1.6 Hz
1 sec	0.16 Hz
10 sec	0.016 Hz

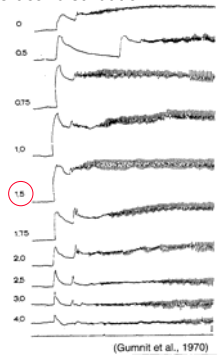
Ictal activity by pentylentetrazole



(Speckmann & Elger, 1987)

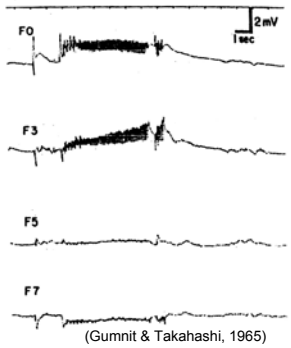
Animal experiment of DC shifts in penicilin focus

Vertical distribution



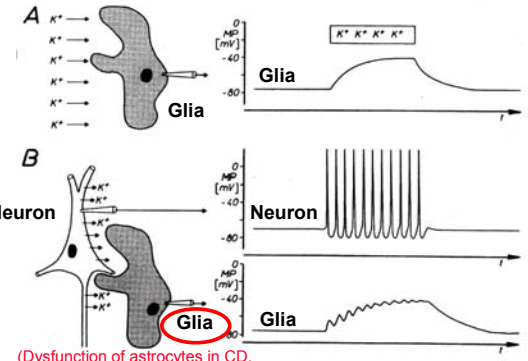
(Gumnit et al., 1970)

Horizontal distribution



(Gumnit & Takahashi, 1965)

Amplifying effects of glial cells on slow shifts



(Dysfunction of astrocytes in CD, Bordey et al., J Neurophysiol, 2001)

(Kuffler et al., 1966)

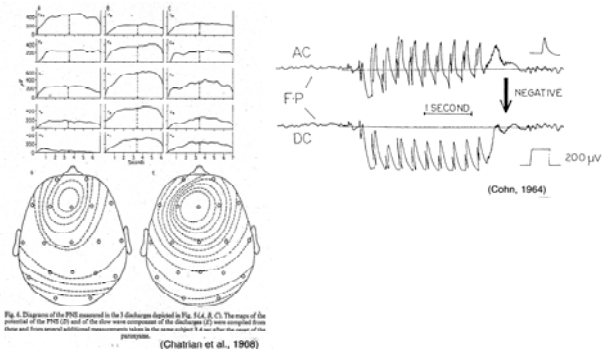
Ictal DC shifts

1) Animal models studied extensively in 1960s

2) Represent sustained paroxysmal depolarization shift (PDS) occurring in the epileptic neurons

3) Augmented by passive glial depolarization by increased extracelluar [K]

4) Little known about clinical significance in subdural recordings of human epilepsy



(Cohn, 1964)

(Chatrian et al., 1968)

Ictal DC (direct current) shifts

Also described as very slow, infra-slow, steady,

Recorded by

DC amplifier	DC shifts
AC (alternative current) amplifier	Slow shits

long time constant, i.e. 10 sec

small low frequency filter (LFF) i.e., 0.016Hz

Recording condition of ictal DC shifts

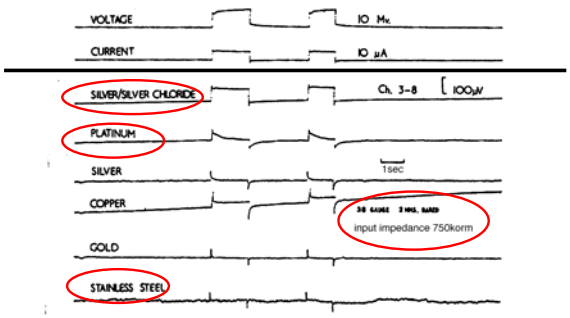
1) DC amplifier
   AC amplifier with opened LFF: 0.016 or 0.05 Hz
   (time constant of 5 or 10 sec)

2) huge input impedance of amplifier (>50 MΩ)

3) Non-polarized (reversible) electrodes
   Ag/AgCl for scalp recording
   platinum for subdural recording

4) Large recording surface, i.e., subdural electrodes rather than depth electrodes

Characteristics of various metallic electrodes
(10mV, 10μA square wave input)



Cooper R (1963) Electrodes. Amer J EEG Technol, 3, 91-101.

Patients and methods - (1)

24 patients with medically intractable partial epilepsy had prolonged video/EEG monitoring with invasive methods

17-60 years (mean: 30.0 ±12.1 years), M/F=12/12

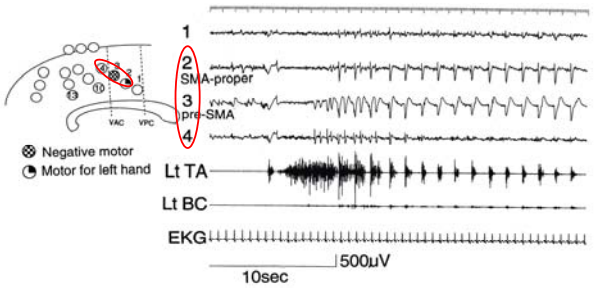
16: neocortical epilepsy
(9 FLE, 4 PLE, 3 Lateral TLE)
(7 cortical dysplasia, 6 tumor, 3 gliosis)

8: MTLE

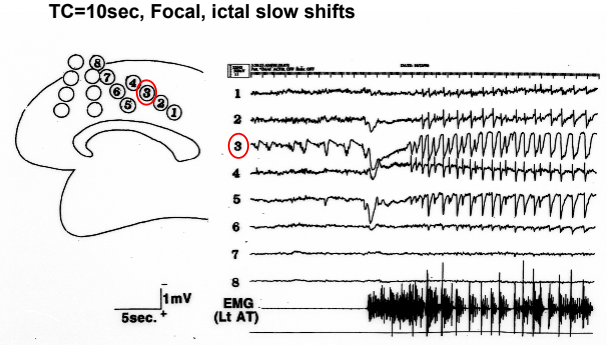
Subdural grid electrodes:

Platinum	23
Stainless steel	1

Subdurally recorded ictal EEG in Patient 1
TC=0.1sec



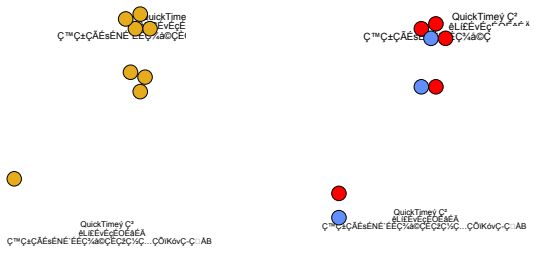
Subdurally recorded ictal EEG in Patient 1
TC=10sec, Focal, ictal slow shifts



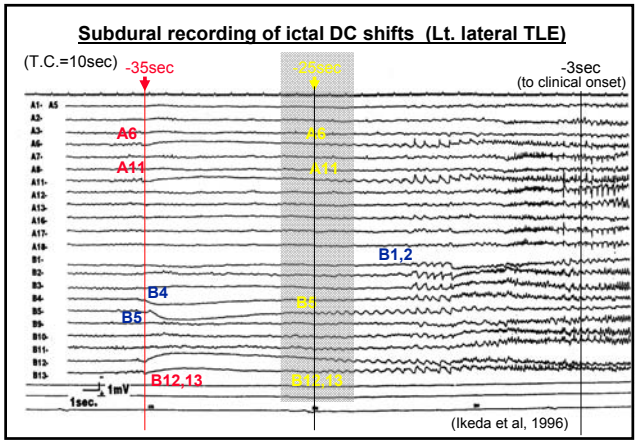
(Ikeda et al, 1999)

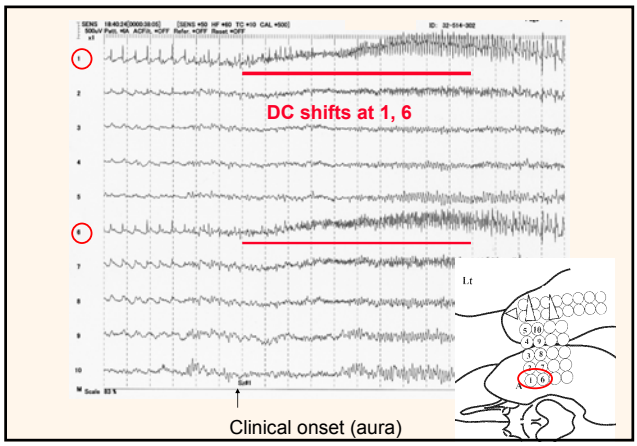
Lt lateral temporal lobe epilepsy(oligodendroglioma)

(T.C.= 0.1sec) (T.C.=10 sec)



(Ikeda et al.,1996)





Ictal DC shifts (subdural recording)

1) 23 out of 24 patients (96 %) showed ictal DC shifts. Incidence rate: 42~100% (87%) of seizures in each patient

2) Started simultaneously with "electrodecremental" pattern.

3) Located in a more restricted epileptogenic area (1-2 electrodes) as compared with conventional EEG

4) Mainly (in 21 out of 23 patients) negative in polarity

Ictal DC shifts (invasive recording): summary

1) Ictal DC shifts recorded by invasive electrodes, especially subdural ones, in humans were almost invariably recorded regardless of underlying etiology or epilepsy type.

2) Its more restricted localization could aid in delineating ictal onset zone clinically before surgery presumably as a core epileptogenic zone.

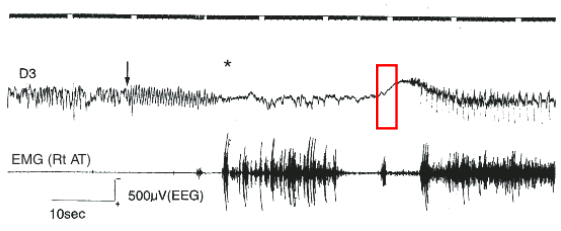
Rodin E, Modur P.
Ictal intracranial infraslow EEG activity.
Clin Neurophysiol. 2008;119:2188-200.

Kim W, Miller JW, Ojemann JG, Miller KJ.
Ictal localization by invasive recording of infraslow activity with DC coupled amplifiers.
J Clin Neurophysiol. 2009;26:135-44.

Modur PN, Scherg M.
Intracranial broadband EEG analysis and surgical outcome: case report.
Clin Neurophysiol. 2009;120:1220-4.

Ictal DC shifts recorded with subdural electrodes

Not always seen as the earliest ictal pattern.
When they occur after clinical onset or conventional pattern, it may simply reflect recruiting process in the middle of seizures.



(Ikeda et al, 1999)

Expression of epileptogenicity by EEG

1) By conventional EEG

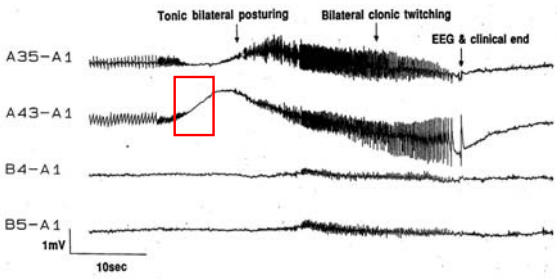
spikes, sharp waves (pyramidal neurons)

2) By wide-band EEG (surrogate marker?)

DC shifts, slow shifts (pyramidal neurons, glia)

HFO or fast ripple activity (pyramidal neurons, ~~interneurons~~?)

Ictal DC shifts recorded with subdural electrodes



(Ikeda et al., 1996)

Comparison between ictal DC shifts vs. HFO ?

invasive recording

- subdural electrodes
- sampling rate: 2000Hz
- LFF: 0.016Hz
- HFF: 600Hz

(Imamura et al, 2010)

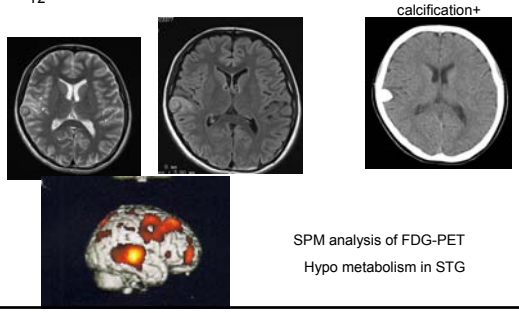
Imaging data

T2

FLAIR

CT

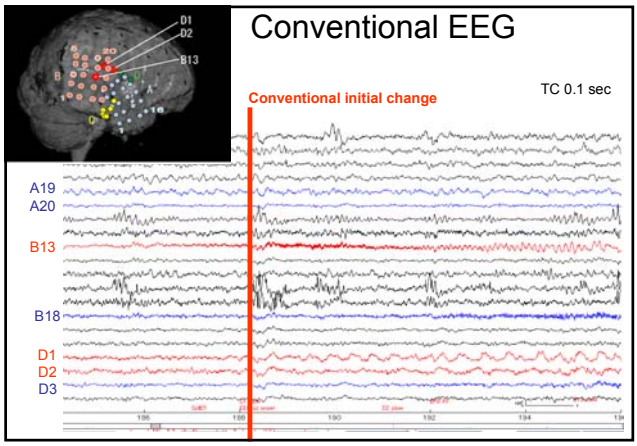
calcification+



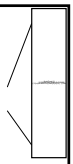
SPM analysis of FDG-PET

Hypo metabolism in STG

Conventional EEG



Ictal DC shifts vs. ictal HFO



B13

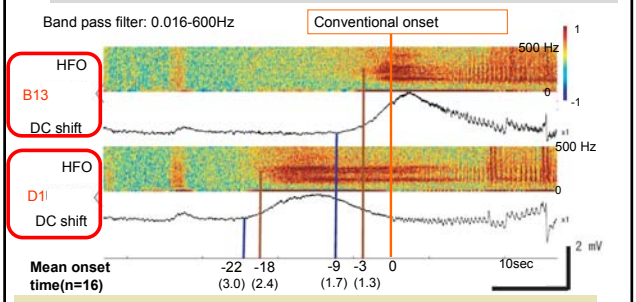
D1

D2

(Imamura et al, 2011)

Case 1

As compared with the conventional onset, DC shift occurred earlier by 22sec, HFO by 18sec.



DC shift →HFO→conventjonal ictal EEG onset
Pared T test P<0.0001

(Imamura et al, 2011)

Active role of astrocytes in epileptogenicity

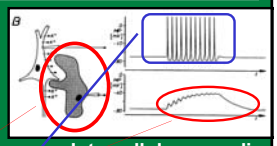
1) PDS occurred after suressing synaptic activity using TTX and voltage-gated Ca2+ channel blockers, suggesting an active role of astrocyte in generation of PDS. (Tian et al, Nature Med, 2005)

2) Astrocyte showed spontaneous oscillations, which can propagate as waves to neighboring ones. (Parri et al., 2001)

3) Glia and cortical neuron showed coherent activities during spontanous oscillation, and glial activity preceded epileptic slow oscillation in neurons (Amzica & Massimini, 2002)

Expression of epileptogenicity by EEG/MEG

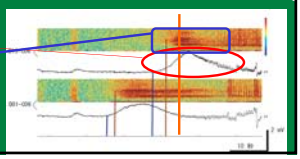
1) By conventional EEG
   spikes, sharp waves
   pyramidal neurons



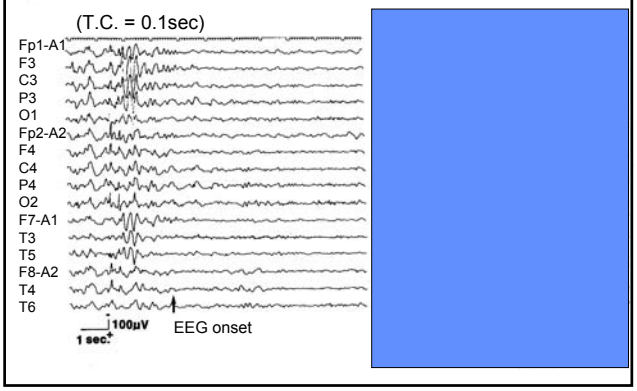
Intracellular recordin

2) By wide-band EEG (surrogate marker?)
   DC shifts, slow shifts
   pyramidal neurons
   glia
   fast ripple activity (HFO)
   pyramidal neurons
   ~~interneurons?~~

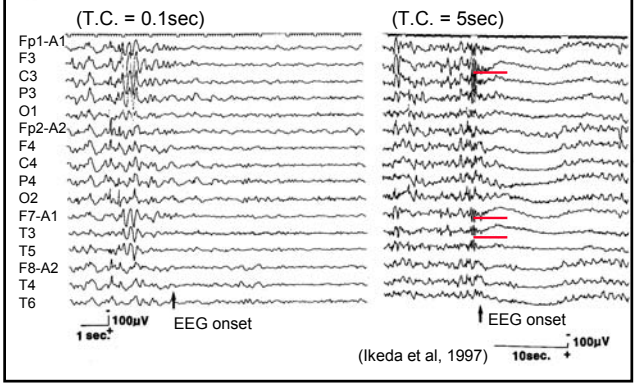
Subdural recordin



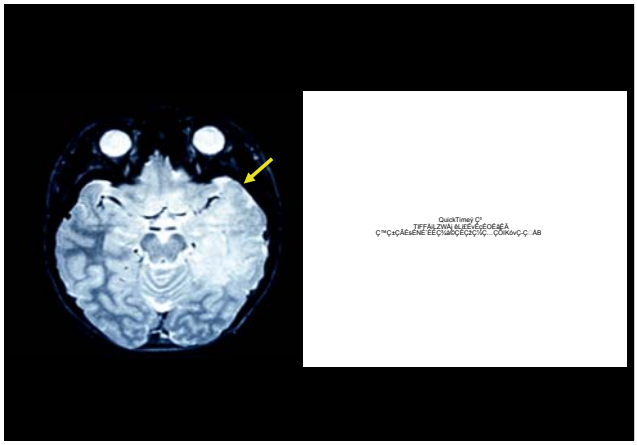
Scalp-recorded ictal EEG in tonic spasm (9 y.o.)



Scalp-recorded ictal DC shifts (9 y.o.)

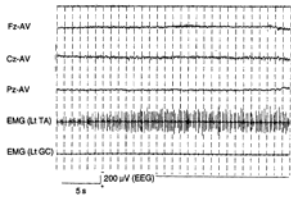


(Ikeda et al, 1997)

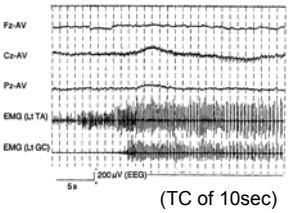


Scal-recorded EEG with Lt focal motor seizures

Short duration



Long duration



(TC of 10sec)

(Ikeda et al., 1999)

Ictal DC shifts (scalp recording)

1) Incidence rate: 14~40% (22%) in 73 seizures.
2) Detected particularly when seizures were clinically intense, but not in small seizures.
3) Closely related to "electrodecremental" pattern
4) Negative in polarity.

Ictal DC shifts (scalp recording): summary

1) Scalp-recorded ictal DC shifts have high specificity.

2) However, its low sensitivity or high vulnerability to movement artifacts or galvanic skin responses, is to be taken into account carefully clinically.

Recording condition of ictal DC shifts

1) DC amplifier
   AC amplifier with opened LFF: 0.016 or 0.05 Hz
   (time constant of 5 or 10 sec)

2) huge input impedance of amplifier (>50 MΩ)

3) Non-polarized (reversible) electrodes
   Ag/AgCl for scalp recording
   platinum for subdural recording

4) Large recording surface, i.e., subdural electrodes
   rather than depth electrodes

Collaborators

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Ernst Rodin

Cerebral Electromagnetic Infraslow Activity

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CEREBRAL ELECTROMAGNETIC INFRASLOW ACTIVITY

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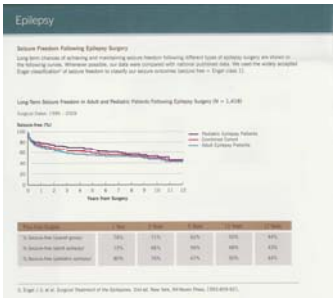
PURPOSE

To demonstrate:

- The reasons why the assessment of infraslow activity (ISA) is potentially important.
- That it can be recorded with conventional MEG/EEG systems.
- The difficulties in interpreting interictal data.
- The current limitations of the BESA software.
- To encourage further investigations

THE PROBLEM
Surgical Results Temporal lobe epilepsy



Gumnit and Takahashi 1965

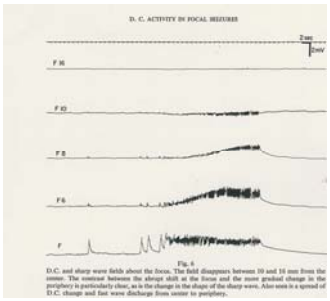


Fig. 6
D.C. and sharp wave fields about the focus. The field disappears between 10 and 16 mm from the center. The contrast between the abrupt shift at the focus and the more gradual change in the periphery is particularly clear, as is the change in the shape of the sharp wave. Also seen is a spread of D.C. change and fast wave discharge from center to periphery.

Caspers and Simmich 1966

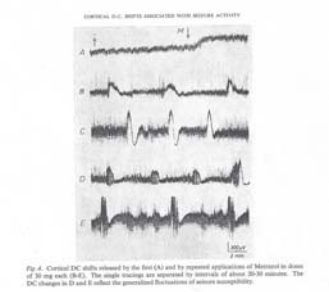


Fig. 4. Cortical DC shifts released by the first (A) and by repeated applications of Metrazol in doses of 30 mg each (B-E). The single tracings are separated by intervals of about 20-30 minutes. The DC changes in D and E reflect the generalized fluctuations of seizure susceptibility.

Very slow EEG responses lateralize temporal lobe seizures

An evaluation of non-invasive DC-EEG

S. Vanhatalo, MD, PhD; M.D. Holmes, MD; P. Tallgren, MSc; J. Voipio, PhD; K. Kaila, PhD; and J.W. Miller, MD, PhD

NEUROLOGY 2003;60:1062–1063

Editorial

DC-EEG recording

A paradigm shift in seizure localization?

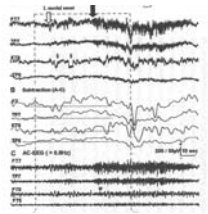
Terrence D. Lagerlund, MD, PhD; and Robert A. Gross, MD, PhD

Section of the Introduction

EEG techniques. It is well established by a large number of animal experiments,[1-4] and by early invasive recordings on humans,[5-7] that seizures are associated with very slow EEG responses called direct current (DC) potential shifts. They are, however, not detected by conventional clinical EEG techniques owing to high pass (i.e., low cut) filtering. Recording of these low frequencies requires a genuine DC-EEG amplifier and nonpolarizable (i.e., Ag/AgCl) electrodes.[8]

There are no published noninvasive DC-EEG recordings of human focal epilepsy. Some articles from the last 10 years have studied low-frequency fluctuations with conventional EEG amplifiers and arrays of polarizable subdural electrodes. One study[9] used stainless steel electrodes and found baseline shifts in only some seizures, whereas another group[10,11] used platinum electrodes (which have somewhat better low-frequency recording properties[12]) and observed highly localized ictal shifts that were congruent with but more localized than the AC-EEG. The latter study[11] also re-

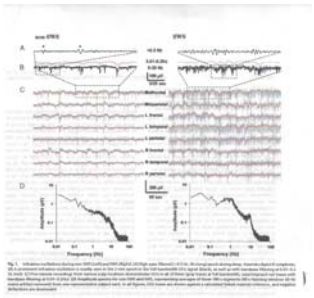
Fig. 3 “Proof” for DC need



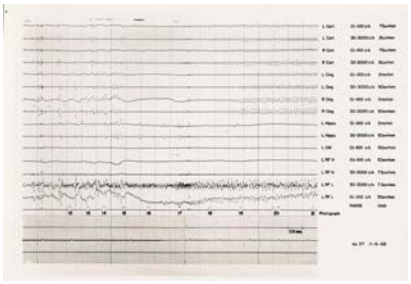
Vanhatalo et al. 2004
Infraslow oscillations in sleep

Human cortical activity has been intensively examined at frequencies ranging from 0.5 Hz to several hundred Hz. Recent studies have, however, reported also infraslow fluctuations in neuronal population activity, magnitude of electroencephalographic oscillations, discrete sleep events, as well as in the occurrence of interictal events. Here we use direct current electroencephalography to demonstrate large-scale infraslow oscillations in the human cortex at frequencies ranging from 0.02 to 0.2 Hz. These oscillations, which are not detectable in conventional electroencephalography because of its limited recording bandwidth (typical lower limit 0.5 Hz), were observed in widespread cortical regions. Notably, the infraslow oscillations were strongly synchronized with faster activities, as well as with the interictal epileptic events and K complexes. Our findings suggest that the infraslow oscillations represent a slow, cyclic modulation of cortical gross excitability, providing also a putative mechanism for the as yet enigmatic aggravation of epileptic activity during sleep.

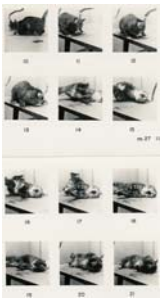
The essential data



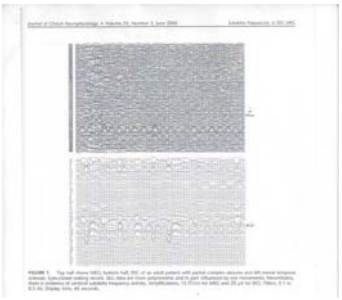
Cat Metrazol seizure
Rodin et al.



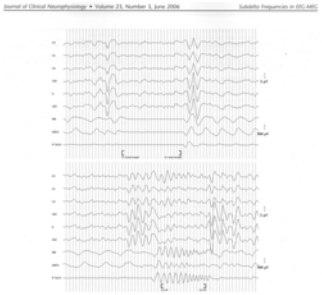
Electro-clinical Correlation



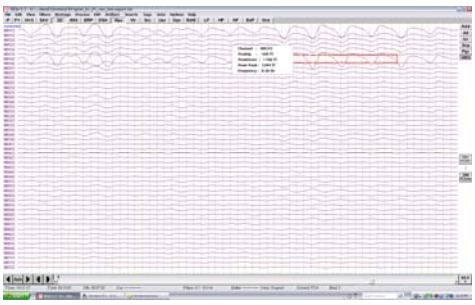
1 Minute LF 0.1 Hz HF 0.5 Hz
Rodin - Funke



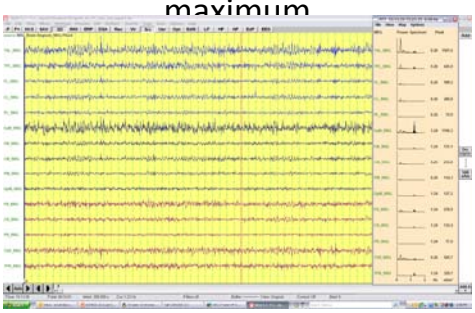
Apnea and HV
LF 0.1 Hz HF 0.9 Hz



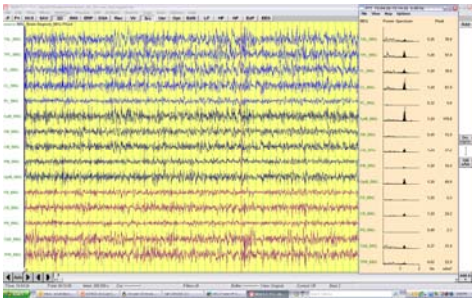
Cleveland Clinic Patient 1
1 minute LF 0.1 HF 0.5 Hz



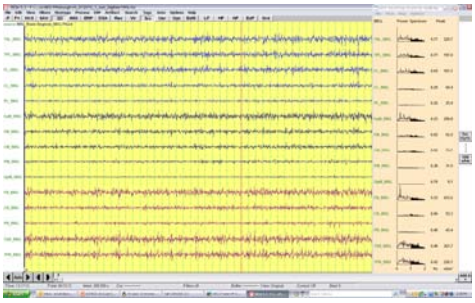
Same data 10 minutes source montage open filters FFT maximum



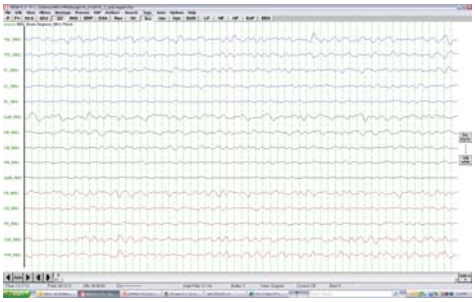
Cleveland Clinic Patient 2
Filters open Maximum FFT



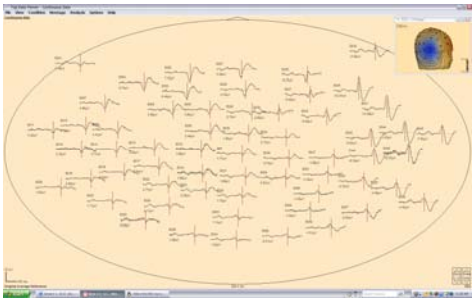
U of Pittsburgh 10 minutes MEG open filters FFT maximum



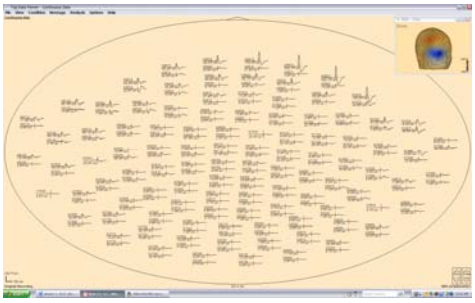
Same data LF open HF 0.1 Hz



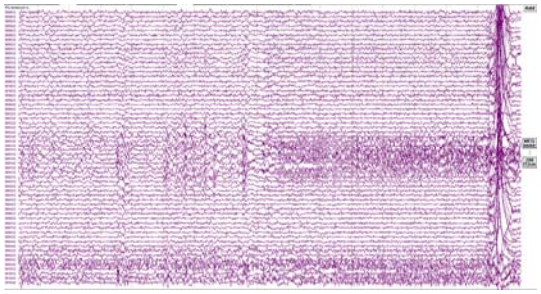
U of Utah26 spikes averaged
EEG LF 1 HF 70 Hz



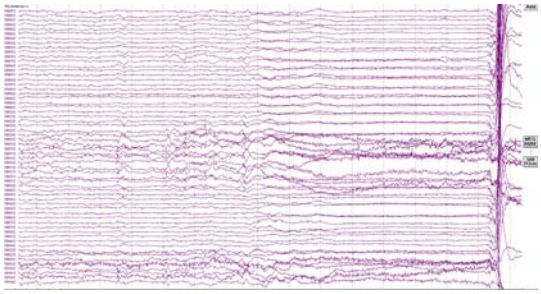
Same data MEG



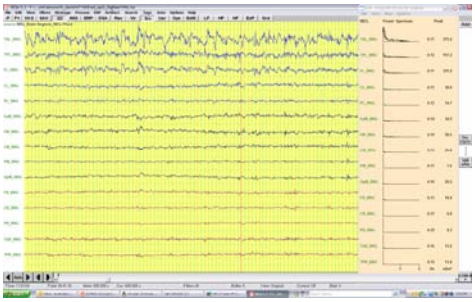
16 seconds MEG seizure onset
LF 5 Hz HF open



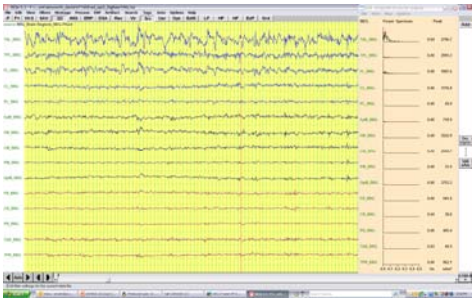
Same data open filters



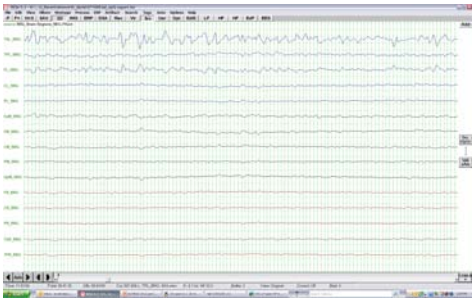
20 minutes source montage open filters; FFT LF 0.1 Hz HF 2 Hz



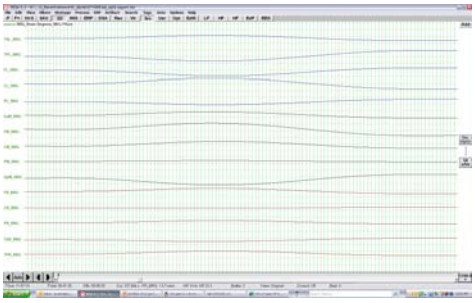
20 minutes open filters maximum power



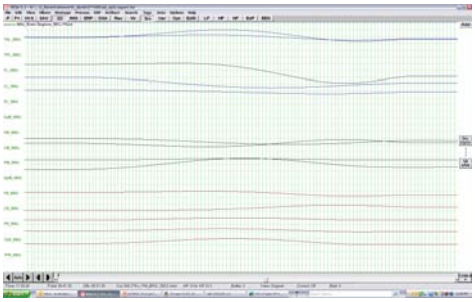
20 minutes LF open HF 0.1 Hz



20 minutes LF open HF 0.001 Hz



Next 20 minutes



Can this teach us something ?

Acknowledgements

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Rappelsberger P. PhD
Scherg M. PhD

Slow Brain Activity (ISA/DC) Detected by MEG

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Slow Brain Activity (ISA/DC) Detected by MEG

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Conflict of Interest & Biases: Disclosures

Conflict of Interest:

None

Biases:

American Clinical MEG Society
&
International Society for the Advancement of Clinical MEG

Infra Slow Activity (ISA) MEG

- Describes frequencies
  - Below 0.5Hz
- "Steady Fields" is another term to describe events that occur over along time
- Also sometimes referred to as Direct Coupled or Direct Current
- Are slow and sustained changes in the EEG voltage (Volts) or MEG magnetic flux density (Tesla) resulting from a change in the function or interaction of neurons, glia, or both.
- MEG maybe easier to characterize the ISA as there is no attenuation of the skull or artifacts from the electrode/skin interface which can also give rise to ISA.
- In ictal ISA MEG recordings, movement artifact has limited the utility of low frequency data. But with the advent of better signal processing we are now able to remove movement artifacts from the data.
- - Clean the Data better with out removing brain signal

First studies of DC MEG

- David Cohn First studied DCMEG in 1969 when he used a magnetometer to measure the DC fields of the heart.
- 2 types of DC MEG signals
  - normal electrophysiological process
  - injury currents
- He measured DC fields from many body parts, but these shifts only last a 10-30 seconds. (Normal)
  - Skin 5-15 pt/cm
  - Hair 10pt/cm
- In 1983 he used DC MCG to measured injury currents in the heart that lasted over 8 minutes. (Injury)

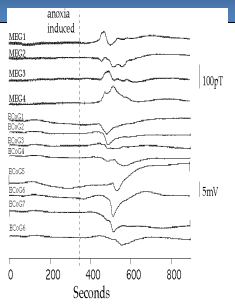
ISA/DC waves

We experience Delta (< 4Hz) activity when we are asleep.

Delta: Disruption, Destruction and Death

Very slow waves DC shifts (<0.01Hz) are the slowest, highest amplitude (magnitude) brainwaves.

Excessive DC shift activity is also associated with traumatic brain injuries, strokes, tumors, migraines, and coma.



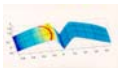
Bowyer et al, Biomag 1998

Cellular changes

- Partial epileptic seizures are characterized by excessively rapid synaptic activity from the zone of epileptogenesis.
- In order to counteract depolarization produced by action potentials, voltage sensitive potassium (K+) channels open and allow efflux of K+ into the extracellular space. Diffusion of the Ions causes a current to flow in the extra cellular environment as well as addition flows due to large currents in the dendrites because the neurons are electrically discharging.
- Post-ictally, there is excessive extracellular K+ which, if allowed to accumulate, inhibits further efflux of K+ from the neurons.
- Glial cells serves as a K+ buffer. The influx of K+ into glia produces ISA signals, which can be recorded by MEG.
- It is, therefore, expected that the ISA MEG signals induced by K+ flux will be greatest in the region of the zone of epileptogenesis where the greatest synaptic activity occurs and is temporally related to the ictus.
- Since ISA signals from epilepsy arise from the hyperexcitability of the cortical neurons, the level of excitability of the brain (the threshold for seizure induction) is expected to be related to the amplitude and duration of the ISA MEG signal.

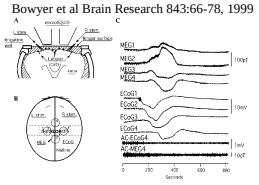
Spreading Cortical Depression (SCD)

Lissencephalic cortex (rabbit model)

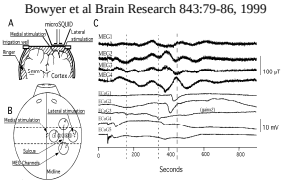


Gyrencephalic cortex (swine model)

Bowyer et al Brain Research 843:66-78, 1999



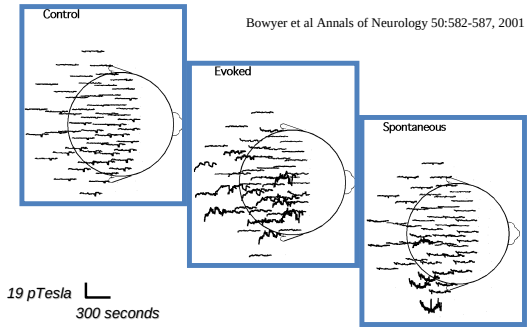
Bowyer et al Brain Research 843:79-86, 1999



- SCD is a wave of hyper excited neurons that depolarizes in a wave like fashion as it propagates across the cortical surface.
- SCD was constrained to propagate in a rectangular cortical strip perpendicular to the midline.
- This enabled us to correlate MEG signals to their underlying currents within the cortical strip.
- The propagation of SCD was monitored with ECoG.
- The currents giving rise to the MEG signals were perpendicular to the cortical surface and directed from the surface to deeper layers of the cortex.
- Strong MEG signals were observed as SCD entered the sulcus.

DC-MEG Waveforms of Migraine

Bowyer et al Annals of Neurology 50:582-587, 2001

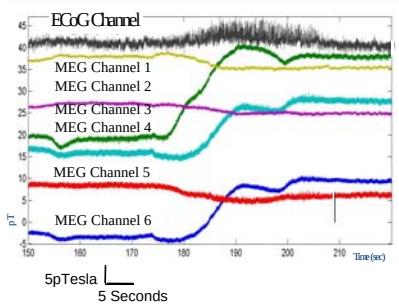


MEG detected ictal baseline shift in Animal model of Epilepsy

- Limbic status epilepticus was induced by intra-arterial (femoral) administration of kainic acid (10 mg/kg, in saline)
- Epileptic activity evolved within approximately 30 minutes of injection.
- MEG data were recorded with a six channel MEG system with first order gradiometers, (Tristan Associates model 606)
- Two picoTesla DCMEG shifts, lasting 10 to 20 seconds, were observed at the onset of epileptic spike train activity and status epilepticus.

MEG recorded ictal baseline shift in Epilepsy

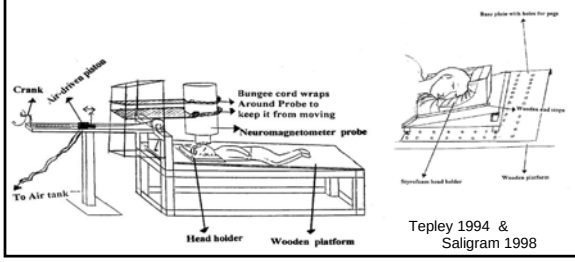
(Rat model)



MEG and EEG data from a kainic acid (KA) induced seizure in rat brain indicating magnetic field shift corresponding to onset of seizure seen in ECoG.

Measurements of the Absolute shifting MEG fields

- Change in patient position can be used to extract the absolute amplitude of the underlying Infra slow activity (ISA).



Tepley 1994 &
Saligram 1998

Measurements of the Absolute shifting MEG fields

Using this technique we found the percent change from baseline in the ISA MEG field was higher in the epileptic temporal lobe compared to the normal lode and high than in controls.

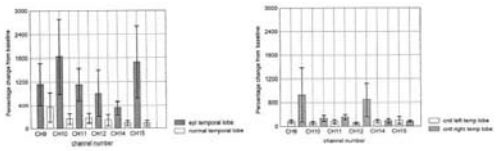


Fig. 3a. The percentage change from baseline in TLE subjects. Epileptic temporal lobe compared to normal lobe.

Fig. 3b. Percentage change from baseline in control subjects, right temporal lobe compared to left lobe

The difference between the interictally and post-ictally measured DC magnetic field shift was expressed as a percentage of the field shift measured interictally (baseline). For control subjects the difference between field shift measured on day 1 and day 3 was expressed as a percentage of day 1 (baseline) measurement

Saligram 1998

Measurements of the Absolute shifting MEG fields

- Using this technique we found the Highest percent change from baseline was in the Frequency range 1-4 Hz in patients

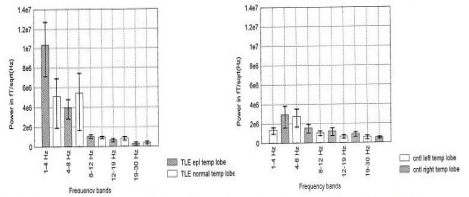


Fig. 4a. Comparison of the epileptic temporal lobe and normal temporal lobe, interictal to post-ictal difference in power in the five bands.

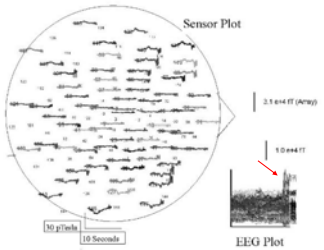
Fig. 4b. Comparison of the right temporal lobe and left temporal lobe, day 1 to day 3 difference in power in the five bands.

Saligram 1998

MEG detected ictal baseline shift in Human Patients with Epilepsy

- We have successfully recorded spontaneous seizures in 9 patients undergoing presurgical evaluation. Utilizing our 148 channel MEG system.
- These seizures happen while the patients were under anesthesia or they were subclinical, which means there was no body movement during the seizure.
- Retrospective analysis has shown MEG field shifts occurring preictally in 5 of 9 patients.
- Data Processing
  - Then the Reference channels are used to remove environmental artifact from the Magnetometer data.
  - The data are down sampled to 11Hz for ease of viewing 10-15 minutes of data.
  - The data are then filtered with either a Lowpass of 0.01 or 0.05 or a band pass of 0.001-4hz.

Patient #1

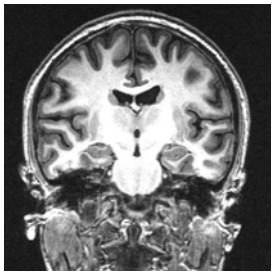


Sensor layout plot of selected MEG data showing 10 seconds of DC-MEG data. Data from the right and left frontal lobes indicate DC shifts of opposite polarity occurring prior to seizure onset. (Red Arrow in in AC- EEG plot indicates seizure onset).

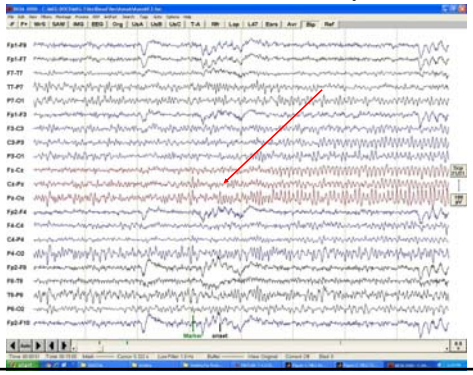
Patient #2

- 23 Year old
- Female
- Left motor Seizure
  - (move right foot)
- Left Cortical Dysplasia

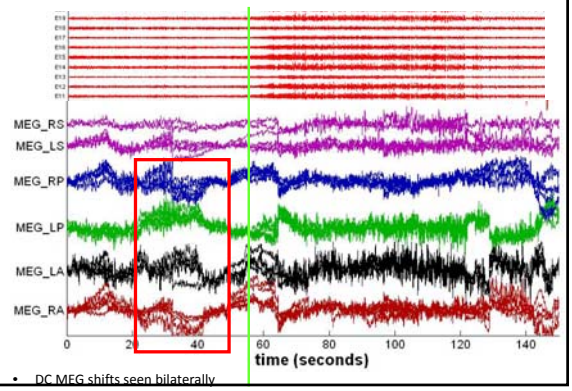
- Had a seizure during the MEG recording.



Seizure onset EEG Bipolar

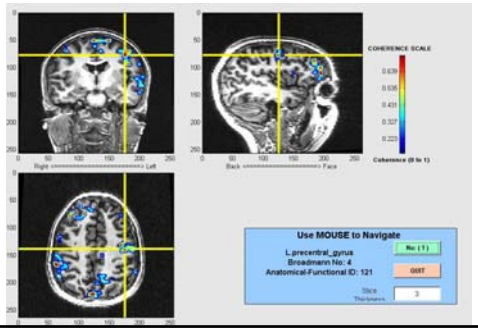


Patient #2



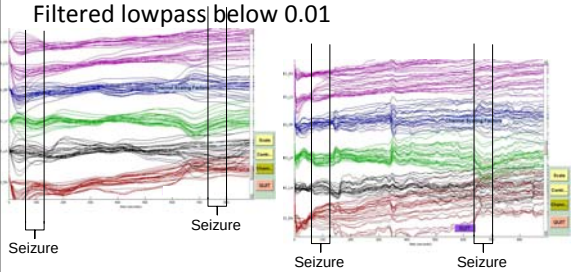
- DC MEG shifts seen bilaterally

Patient #2



DC MEG #2

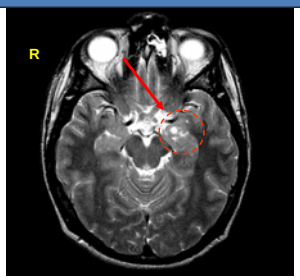
Filtered lowpass below 0.01



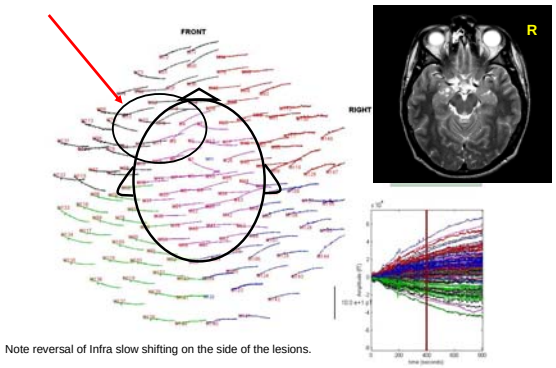
Filtered lowpass below 0.05

Lesion Patient #3

- 20 Year old
- Male
- Recent onset partial epilepsy
- MRI shows cystic mass in the left mesial lobe.
- A few sharp transients were detected in MEG.

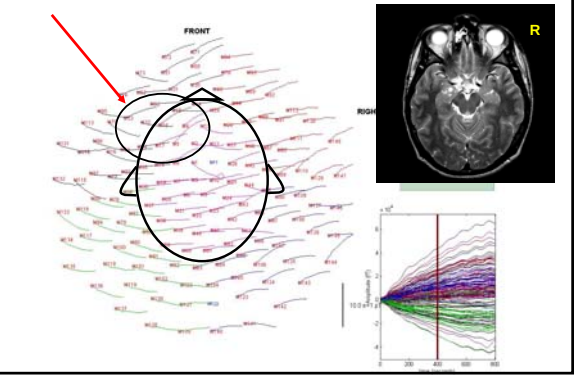


Patient #3 0-5Hz



Note reversal of Infra slow shifting on the side of the lesions.

Patient #3 0-.01Hz



Summary

- MEG detects the underling infra slow neuronal events of ictal onset non invasively.
- MEG data detects Infra slow activity from lesion.
- Absolute shifting MEG Field Amplitudes can be used to determine the laterality of Epilepsy.
- In the future, assessment of the level of neuronal excitability detected using Infra slow MEG may be correlated with the prognosis for pharmacological treatment.

Thanks to ALL My Colleagues

- Technologist --- Karen Mason MEG & R. EEG Technologist
  - •For collecting clean MEG data
- Graduate Students --- Uma Saligram & Barbara Weiland
  - •For extreme diligence on their Dissertations
- Neurologists --- Greg Barkley, David Burdette & Brien Smith
  - •For providing insights in to patient semiology
- Physicists--- John Moran
  - •For creating amazing MEG analysis programs

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Stefan Rampp

Epileptic slow activity in MEG

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Epileptic slow activity in MEG

Rampp S
Epilepsy Center (EZE) – University Hospital Erlangen, Department of Neurology

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Problem:
Patients without spikes in MEG/EEG recordings

- Stefan et al., 2004: 455 patients, 320 with spikes
  ~30% with no spikes
- Paulini et al., 2007: 105 patients, 72 with spikes
  ~31% with no spikes
- Knake et al., 2006: 67 patients, 48 with spikes
  ~28% with no spikes
- Iwasaki et al., 2005: 43 patients, 40 with spikes
  ~7% with no spikes

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Problem:
Patients without spikes in MEG/EEG recordings

Solutions?

- Prolonged recordings
- AED withdrawal
- Activation procedures

- Alternatives?
  - Coherence
  - High frequency activity
  - Slow wave
  - ...

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Slow wave

- Slow wave (~1-7Hz, Delta/Theta)/ Low Frequency Magnetic Activity (LFMA)
- Association with different pathologies has been shown:
  - Ischemic attacks (Stippich et al., 2000; Leistner et al., 2007)
  - Brain tumors (Kamada et al., 2001)
  - Alzheimer's disease (Fernandez et al., 2002)
  - Schizophrenia (Wienbruch et al., 2003)

⇨ What about epilepsy?

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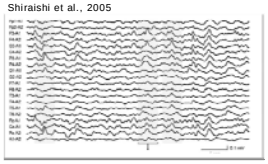
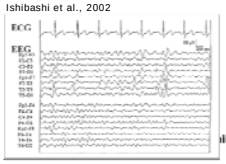
Focal slowing in epilepsy - What we know from EEG

- May be associated with epileptic foci: Temporal intermittent rhythmic delta activity
- More widespread than spikes
- May be (partially) identical with slow wave component of spike-wave patterns
- Limited diagnostic use

Shiraishi et al., 2005



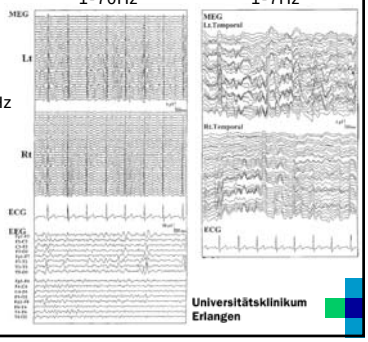
Ishibashi et al., 2002



Low Frequency Magnetic Activity : Ishibashi et al., 2002

- 29 patients
- MTLE, no additional brain lesions
- Selection of waves <7Hz

1-70Hz 1-7Hz



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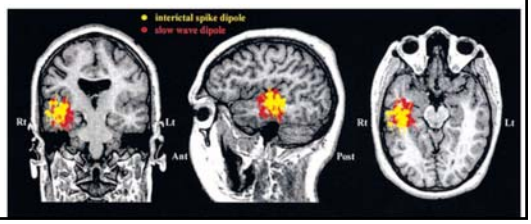
Low Frequency Magnetic Activity: Ishibashi et al., 2002

- Dipole localization:
  - No difference to spikes
  - No differences delta <-> theta
- But: Lateralized LFMA detected in only 58.6%

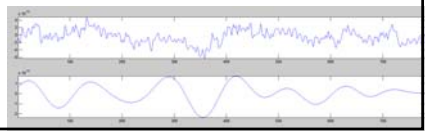


Low Frequency Magnetic Activity

- Methods to increase LFMA localization yield?
- Subtle LFMA?

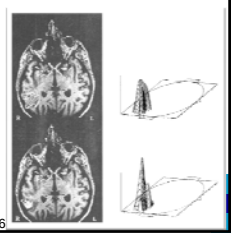
Slow wave in epilepsy: Kaltenhäuser et al., 2007

- MEG activity 2-6Hz
- Automatic procedure:
  - Bandpass-filter continuous MEG-data 2-6Hz
  - PCA of filtered data
  - Select only intervals with one dominant source
- Automatically selected segments did not always contain obvious LFMA



Slow wave in epilepsy: Kaltenhäuser et al., 2007

- Single dipole localization of selected interval
  => „Monofocality“ filter
- Dipole Density:
  - Dipole filtering (correlation >0.8)
  - Dipole distribution
- Characteristics:
  - pswd: percentage of total dipoles in one voxel
  - pswd >1%: voxels with >1%
  - ...



Vieth et al., 1996

Slow wave – an example

- Male patient, 26y
- Simple and complex partial seizures since the age of 19
- Polymicrogyria left frontal, parietal and temporal lobe hippocampal sclerosis on the left side
- Video-EEG, MR-Spectroscopy, MEG, FDG-PET, SPECT: left temporal focus

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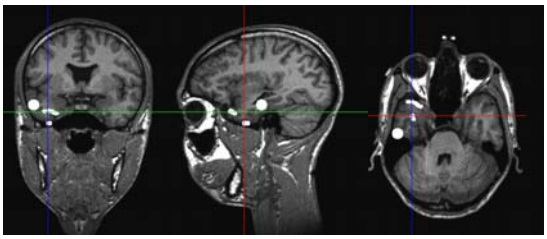
Slow wave - Localization



Spikes: small spheres
Slow wave maximum large sphere

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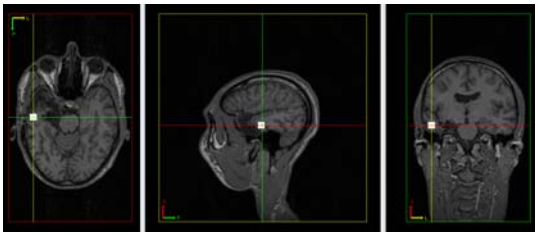
Slow wave - Localization

Tailored resection
Outcome: Engel 1b (2years post-OP)



Presurgical slow wave localization on post-OP MRI

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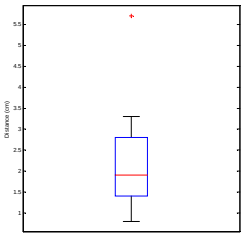
Slow wave in epilepsy: Kaltenhäuser et al., 2007

- 12 patients with TLE/ETLE
- 7 with epilepsy surgery
- Distance to spike localizations: 2cm
- (No difference TLE vs. ETLE)
- (No difference MRI+ vs. MRI-)



Boxplots with median, upper/lower quartile, extreme values

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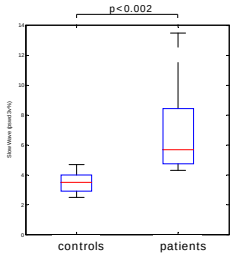
Slow wave in epilepsy: Kaltenhäuser et al., 2007

- 12 patients vs. 5 controls
- Significant difference in focal slow wave quantity
- Viability as a marker is unclear:
  - Low specificity (SW in tumors, schizophrenia, …)
  - Few patients so far



Boxplots with median, upper/lower quartile, extreme values

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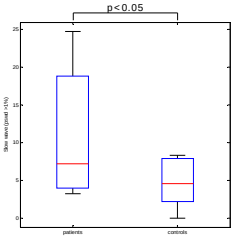
Slow wave in epilepsy: Kaltenhäuser et al., in preparation

- 12 patients with seizure freedom after surgery (Engel 1a, b)
- 10 controls
- Significant difference in focal slow wave quantity
- 50% of patients with focal increases
- If increase was present, localization within operated lobe



Boxplots with median, upper/lower quartile, extreme values

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Caveats

- Technical artefacts
- Eye blinks
- Sleep, drowsiness
- Other pathologies:
  - Ischemic attacks (Stippich et al., 2000; Leistner et al., 2007)
  - Brain tumors (Kamada et al., 2001)
  - Alzheimer's disease (Fernandez et al., 2002)
  - Schizophrenia (Wienbruch et al., 2003)
  - ...

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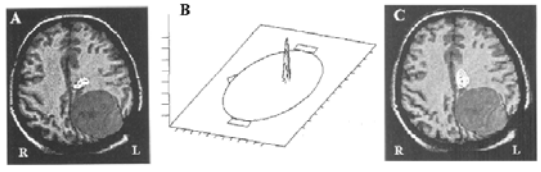
CAVE: Influence of lesions

Brain Topography, Volume 8, Number 3, 1996

Sources of Spontaneous Slow Waves Associated with Brain Lesions, Localized by Using the MEG

Juergen B. Vieth*, Helmut Kober*, and Peter Grummich*



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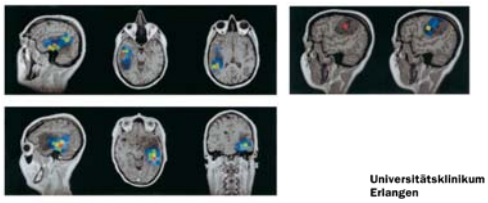
CAVE: Influence of lesions

Brain Topography, Volume 16, Number 2, Winter 2003 (© 2003)

Localization of Slow Wave Activity in Patients with Tumor-Associated Epilepsy

Johannes C. Baayen*, Arent de Jongh*, Cornelis J. Stam^, Jan C. de Munck*, Joost J. Jonkman^, Dorothée G.A. Kasteleijn-Nolst Trenité^b, Henk W. Berendse*, Anne-Marie van Cappellen van Walsum^, Jan J. Heimans*, Monica Puligheddu*, Jonas A. Castelijns#, and W. Peter Vandertop*



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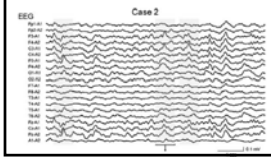
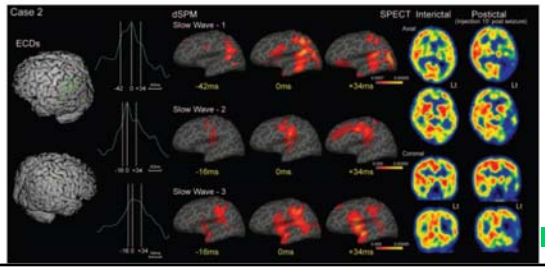
Lesion-independent slow wave? Shiraishi et al., 2005

- 3y old boy
- Clonic seizures of the right arm, twitching right lip, salivation
- **MRI normal**
- 2.5-3Hz interictal slow wave left



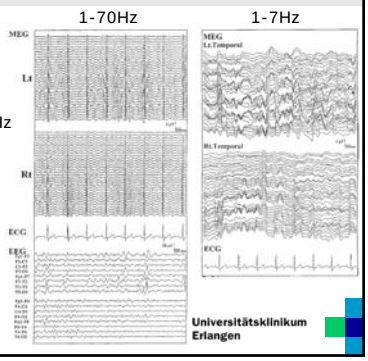
Lesion-independent slow wave? Shiraishi et al., 2005

- MEG slow wave and interictal SPECT in concordance with semiology
- No surgery



Lesion independent slow wave? Ishibashi et al., 2002

- 29 patients
- MTLE, no additional brain lesions
- Selection of waves <7Hz



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Conclusions

LFMA/Slow wave

- yield localizing information
- are detectable in patients with no spikes
- Localization results are comparable to spikes (more diffuse in some cases?)

- Specificity may not be optimal

…which eanbles more clinical applications

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AKNOWLEDGMENT

Grateful acknowledgment is made to the following organizations for their generous support of this workshop in the form of unrestricted educational grants.

EVALUATION FORM

Please identify yourself: ☐ Neurologist ☐ Neurosurgeon
☐ Radiologist ☐ MEG/EEG Technologist
☐ Other _____

Please rate each speaker's effectiveness in conveying the material of his/her presentation, using the scale below:

	⑤ Most & ① Least effective					Comments
D. Rose	⑤	④	③	②	①	_____
H. Otsubo	⑤	④	③	②	①	_____
M. Raghavan	⑤	④	③	②	①	_____
S. Baillet	⑤	④	③	②	①	_____
A. Ikeda	⑤	④	③	②	①	_____
E. Rodin	⑤	④	③	②	①	_____
S. Bowyer	⑤	④	③	②	①	_____
S. Rampp	⑤	④	③	②	①	_____

Please rate: ⑤ Very satisfied & ① Not satisfied					
Rate your overall satisfaction with the opportunity to network with colleagues.	⑤	④	③	②	①
Rate your overall satisfaction with the quality of this conference/workshop.	⑤	④	③	②	①
Please rate your satisfaction with the organization of the conference/workshop.	⑤	④	③	②	①
How would you rate the cost of registration versus what you personally got out of the conference?	⑤	④	③	②	①

What topics should be addressed at future meetings?

_____
_____

What features should be added to future meetings?

_____
_____

What features should be deleted from future meetings?

_____
_____

_____

Did you perceive commercial bias in any of the presentations? ☐ Yes ☐ No
Explain: _____

ACMEGS DOCUMENTS

- ACMEGS presentation to APC Panel
- AAN letter to APC Panel regarding MEG cost report
- Letter from ACMEGS members regarding MEG cost report

List the financial relationship of presenter(s), if any, with any company whose product, services, or procedures are under consideration.
I am the Director of the MEG Department at the University of Utah Medical and President of the American Clinical MEG Society. I am not affiliated nor represent with any manufacturer.
Physicians' Current Procedural Terminology (CPT) code(s) involved:
95965, 95966, 95967
APC(s) affected
067, 065
Description of the issue(s)
Current reimbursement does not reflect actual cost of procedure
Clinical description of the service under discussion *(with comparison to other services within the APC)*
MEG, spontaneous & averaged
Recommendations and rationale for change
Appropriate and fair reimbursement for MEG
Expected outcome of change
A reimbursement that reflects actual costs
Potential consequences of not making the change
Lack of patient access due to unsustainable economic resources

ACMEGS
AMERICAN CLINICAL MEG SOCIETY

Michael E Funke, M.D., Ph.D.
President
American Clinical MEG Society
729 Arapeen Drive, Salt Lake City, UT 84108
email: michael.funke@hsc.utah.edu
phone (801) 585-6840

American Clinical MEG Society

- ACMEGS appreciates the opportunity to address the Meeting of the Advisory Panel on Ambulatory Payment Classification Groups and commends CMS on its efforts to evaluate and improve the APC groups under the hospital outpatient prospective payment system.
- ACMEGS is a non-profit 501c6 trade association with a membership of more than 20 specialized clinical MEG centers in the United States. Founded in 2006 by physician-leaders committed to setting a national agenda for quality epilepsy care, ACMEGS educates public and private policymakers and regulators about appropriate patient care standards, reimbursement and medical services policies.

American Clinical MEG Society

- ACMEGS is committed to ensuring patient access to life-saving and life- enhancing devices in the most appropriate settings and supports a system with payment weights and payment rates that include sufficient resources to account for the costs of the medical technologies associated with hospital outpatient care.

Today's Objectives

- Acknowledgment from the Advisory Panel on Ambulatory Payment Classification Groups that current methodology for calculating an appropriate reimbursement rate for MEG is flawed.
- Address CMS's current belief that EKG, EEG and MEG are located in the same departments with facts to the contrary

Magnetoencephalography Reimbursement History

In 2005, MEG transitioned from a new technology APC to a clinical APC. The reimbursement for MEG has declined significantly since 2005. The actual reductions are:

CPT 95965 by 35% (2005: $5,250; 2011: $3,414) APC 67
CPT 95966 by 35% (2005: $1,450; 2011: $940) APC 65
CPT 95967 by 1% (2005: $950; 2011: $940) APC 65

2005 APC Advisory Panel Meeting

- In August 2005 MEG was brought to the attention of the APC Panel. It was our contention then, as it is now, that the cost data utilized to determine an appropriate reimbursement rate for MEG is not correct.
- At the conclusion of the presentation the panel recommended that *CMS maintain CPT codes 95965, 95966 and 95967, magnetoencephalography (MEG), in their 2005 new technology APCs. The panel also recommended that CMS collect more external data hospital data and provide a detailed review of the data for the Panel's consideration at its next meeting.*

CMS Responds to 2005 APC Panel Recommendation

- Regrettably CMS did not agree with the panel's decision and placed MEG in a clinical APC at a significantly lower reimbursement
- CMS further stated, "*As suggested by the APC Panel, we will continue to study the APC assignments for these procedures over the coming year and invite members of the public to submit any information they believe will be helpful to us.*"
- Those of us who presented that day felt that the panel agreed that there were disparities in the cost data and had challenged us to determine the reason for these errors.

CMS Responds to 2005 APC Panel Recommendation

CMS-1427-FC

Federal Register / Vol. 70, No. 217 / Thursday, November 10, 2005, page 685768579

In addition to the written comments we received on our proposed rule, hospital and manufacturer representatives made presentations to the APC Panel during its August 2005 meeting. At the time, the Panel recommended that CMS retain the MEG procedures in their current New Technologies APCs and that we collect more external data and provide a detailed review of the data for the Panel's consideration at its next meeting.

CMS Responds to Comments; Calculation of Reimbursement for MEG

CMS-1414-FC

Federal Register / Vol. 74, No. 223 / Friday, November 20, 2009 / Rules and Regulations / page 60448

We initially assigned MEG services to New Technology APCs based on the information available to us at the time about the expected hospital costs. For CY 2006, ***we believed*** *that we had sufficient claims data to enable us to make informed decisions regarding the proper clinical APCs for assignment of MEG services. We note that the volumes of claims for MEG services have remained stable since we moved them to clinical APCs in CY 2006. We have* ***no reason to believe*** *that the costs that we have derived from our standard cost estimation process for the CY 2010 OPPS fail to appropriately reflect the relative costs of MEG services in relation to the costs of other services paid under the OPPS,* ***nor do we have reason to believe*** *that payment at the rates under which these services were paid under the New Technology APCs in CY 2005 are justified.*

CMS Responds to Request for Separate Cost Line

CMS-1525-P

Federal Register / July 18, 2011/ Proposed Rules / page 64

To ensure the completeness of the revenue code-to-cost center crosswalk, we reviewed changes to the list of revenue codes for CY 2010 (the year of the claims data we used to calculate the proposed CY 2012 OPPS payment rates). For CY 2010, the National Uniform Billing Committee added revenue codes 860 (MEG; general classification) and 861 MEG. For purposes of applying a CCR to charges reported under revenue codes 860 and 861, we are proposing to use nonstandard Medicare cost report cost center 3280 EKG and EEG as the primary cost center and to use standard cost center 5400 (Electroencephalography (EEG)) as the secondary cost center. **We believe that MEG, which evaluates brain activity, is similar to EEG, which also evaluates brain activity, and that the few hospitals that furnish MEG are likely to furnish it in the same department of the hospital in which they furnish EEG services.**

CMS Responds to Request for Separate Cost Line

CMS-1525-P

Federal Register / July 18, 2011/ Proposed Rules / page 64

Therefore, we believe that the CCRs that we apply to the EEG revenue codes are more likely to result in a more accurate estimated cost for MEG than would the application of the hospital-specific overall ancillary CCR. For hospitals that report charges under revenue code 860 or 861 but do not report costs on their cost report under cost center 3280 or 5400, we are proposing to apply the hospital-specific overall CCR to the charges reported under revenue code 860 or 861 for purposes of estimating the cost of these services. We note that revenue codes with effective dates in CY 2011 are not relevant to this process because these new revenue codes were not applicable to claims for services furnished during CY 2010.

Problem

EKG, EEG & MEG are not located in the same hospital departments:

- MEG is located in a different facility
- MEG has separate management
- MEG's cost are significantly higher

MEG & EEG costs are indistinguishable as they share the same:

- Cost Line on the Medicare Cost Report
- *Revenue Code on the UB-04*

Facts – Fixed Costs

EEG

Unit price	$50,000
Service contract	$30,000
Helium (liquid)	N/A
Space (ft²)	bedside
Analysis support	N/A

MEG

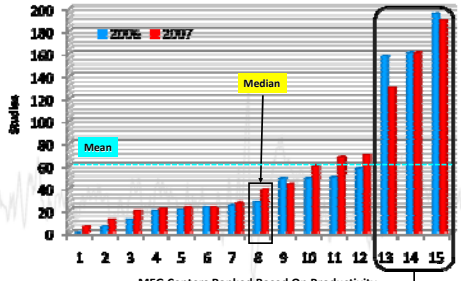
Unit price	$2,500,000
Service contract	$125,000
Helium (liquid)	$50,000
Space (ft²)	~1,000
Analysis support	Ph.D. (11 RVU/MEG)

CMS 2008 Claims Data

The chart below contains claims data (2008) referenced by CMS in calculating the 2010 OPPS proposed rule.

Procedure	EEG	EEG	EEG	EEG	MEG
APC	0213	0213	0213	0213	0067
CPT	95816	95819	95812	95813	95965
Utilization	37,894	40,938	3,401	1,180	25
Costs	$151.88	$164.06	$175.63	$257.73	$2945.61

Facts – Utilization (CPT 95965)



2006: 3 leading centers performed 512 (**61%**) studies
2007: 3 leading centers performed 478 (**54%**) studies

Bagic A, JClinNeurophysiol, 2011 (in press)

MEG & EEG costs are <u>indistinguishable!</u>

- Medicare Cost Report
  - Line 5400
    - Noridian (MAC) granted MEG Line 54.01 as a remedy
- Revenue Code UB-04
  - 0740 EEG (prior to April 1, 2010)
  - 086x – Magnetoencephalography (MEG) by National Uniform Billing Committee (NUBC)
    - NUBC also recommended that we request a separate line on the Medicare Cost Report

Facts - CCR Calculations

Facility	EEG CCR	MEG CCR
University of Utah Med Center	0.3199	0.7345
Wake Forest University Med Cnt	0.3370	0.8691
University of Pittsburg Med Cnt	0.0974	0.5844
Alexian Brothers Neuro Institute*	0.2138	0.4516
Average	0.2420	0.6599

* MEG operation is a joint venture, therefore only 50% of personnel cost are included

Questions for Panel

Have we presented enough evidence to document that the current methodology of calculating an appropriate reimbursement for 95965 (MEG) is flawed?

Does the Panel agree that MEG is not located in the same departments of EKG and EEG?

Thank You

ACMEGS appreciates the opportunity to bring this matter to the attention of **Advisory Panel on Ambulatory Payment Classification Groups** and ask that you recognize the unique challenges associated with MEG and support a fair calculation of an appropriate reimbursement rate.

August 30, 2011

Donald Berwick, MD, MPP
Administrator
Centers for Medicare and Medicaid Services (CMS)
Department of Health and Human Services (HHS)
Attention: CMS-1525-P
PO BOX 8013
Baltimore, MD 21244-1850

Submitted via electronic delivery on Regulations.gov

RE: **Medicare and Medicaid Programs: Hospital Outpatient Prospective Payment; Ambulatory Surgical Center Payment; Hospital Value-Based Purchasing Program; Physician Self-Referral; and Provider Agreement Regulations on Patient Notification Requirements; file code CMS-1525-P**

Dear Dr. Berwick:

American Clinical MEG Society is a non-profit 501(c)(6) trade association that includes the memership of more than twenty clinical magnetoencephalography (MEG) facilities in the United States. Founded in 2006 by physicians committed to setting a national standard for high quality care of patients with epilepsy, ACMEGS now advocates for all individuals with neurological conditions who would benefit from MEG by educating public and private policymakers and regulators regarding appropriate patient care standards, reimbursement processes, incentives, and disincentives, and related medical services policies.

ACMEGS strives to ensure that all individuals living in the United States who have neurological conditions receive the highest quality health care by offering magnetoencephalography that is affordable and accepted by insurance providers.

ACMEGS appreciates this opportunity to comment on the **Proposed Changes to the Hospital Outpatient Prospective Payment System and CY 2012 Payment Rates** (hereafter, CY12 HOPPS Proposed Rule) and commends CMS on its efforts to evaluate and improve the APC groups under the hospital outpatient prospective payment system.

AMERICAN CLINICAL MEG SOCIETY

Michael E Funke, M.D., Ph.D. | 729 Arapeen Dr. Salt Lake City, UT 84108 | T: 801.585.6840 F: 801.585.5420 | **www.acmegs.org**

Magnetoencephalography or MEG is a highly specialized, noninvasive procedure indicated for patients with severe, uncontrolled epilepsy that cannot be controlled through medication but may be controlled through surgery, and to assess intracranial tumor surgical options. MEG can localize the precise areas in the brain that are, despite the pathology, still healthy and functioning. This helps the surgeon to determine a successful surgical approach and also how aggressively to resect a given area. With a "roadmap" of which areas to avoid, the surgeon has a better chance of performing the procedure without affecting critical functions such as the senses, language and motor control. These functions are controlled from so called "eloquent cortex". For epilepsy surgery, MEG has the added benefit of being able to localize, with precise accuracy, the location(s) where the epileptic activity originates. This information is invaluable in determining if the patient is a good candidate for surgery and also to plan the operation itself.

Due to the importance of this technology in developing effective treatment strategies for these delicate patients, many of whom are Medicare beneficiaries, it is crucial that their physicians and surgeons have access to the critical information that only MEG can most accurately provide. However, we are concerned that CMS policy advanced in the CY12 HOPPS proposed rule related to MEG will continue to promote a strong disincentive for Medicare patients who need this testing to receive it.

Specifically, CMS proposes to place new revenue codes 860 and 861, created to specifically identify MEG, into nonstandard cost center 3280 (EKG/EEG) as the primary cost center and standard cost center 5400 (EEG) as the secondary cost center for purposes of applying a cost-to-charge ratio to charges under these revenue codes. This creates a scenario wherein the much higher costs and much lower utilization for MEG are overwhelmed by the substantially lower costs and exponentially higher utilization for EEG. As was noted by the American Academy of Neurology (AAN) in a letter to the agency in August of 2010, the effect of differentiating MEG from EEG CCRs would have a highly significant impact on the MEG CCR. Failure to do so causes Medicare payment for MEG to be so low that providers may not recommend it for those who might benefit from it.

Clearly, this is an unintended consequence of the nature of the HOPPS payment system, and while we understand that reasonable bundling of payments is a necessary function of the system, the disparities between EEG and MEG are far too great to ignore. **We strongly urge the agency to reconsider this policy and to establish a CCR for the MEG revenue codes that is consistent with the costs to perform the procedure.**

In its rationale for bundling MEG with EEG, CMS stated a belief that MEG is similar to EEG in that they both evaluate brain activity and that the few hospitals that furnish MEG are likely to do so in the same department in which they furnish EEG services. We respectfully, but strongly disagree with these blanket assumptions. First, it is true that MEG and EEG both measure brain activity, but the limited resolution and resulting lower accuracy for EEG necessitated the development of MEG for pre-surgical decision-making. EEG is simply too poorly sensitive for reliance when determining an intracranial surgical course of action.

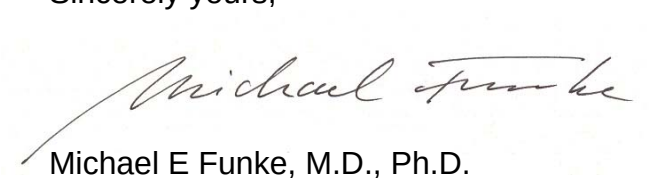
Thus, characterization of the technologies as virtually identical is an extreme oversimplification of the reality. MEG is highly specialized with respect to EEG and as you may know, is only indicated for a small number of potential patients by comparison; however, its utility is great for the few patients who need it.

Secondly, the assertion that MEG is likely performed in the same department as EEG is generally false. It is neither performed in the same areas as EEG and EKG, nor is it always located and/or managed through the same department within the hospital. This is due to the nature of the technology that requires its own space and does not allow it to be performed in the same areas as EEG and EKG testing. Contributing further to the differences between MEG and EEG/EKG equipment is that MEG requires magnetic shielding, a patient preparation area, dedicated and specialized power supplies, sometimes a specially reinforced floor, a separate exhaust system, and storage for liquid helium tanks.

As one may imagine, these requirements lead to a substantially different cost structure for MEG versus EEG/EKG. Additionally, the time for testing is significantly different, where the typical EEG/EKG requires 15-25 minutes, and the typical MEG scan takes approximately three hours to complete.

If EEG and/or EKG methods were sufficient to meet the needs of the typical MEG patient, there would be no need for MEG, but the reality is that MEG exists because EEG and EKG are insufficient to address the unique challenges of this select group of patients. We again urge CMS to consider these various factors in re-evaluating the appropriate CCR to use with MEG and to establish a CCR for MEG that appropriately reflects the cost of the technology to providers in its FY12 HOPPS Final Rule so that Medicare beneficiaries who need it will have access to this important technology.

Sincerely yours,



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August 30, 2011

Donald Berwick, MD, MPP
Administrator
Centers for Medicare and Medicaid Services
Department of Health and Human Services
Attention: CMS–1525–P
P.O. Box 8013
Baltimore, MD 21244–1850

Re: **Hospital Outpatient Prospective Payment; Ambulatory Surgical Center Payment; Hospital Value-based Purchasing Program; Physician Self-Referral; and Provider Agreement Regulations on Patient Notification Requirements**; file code CMS–1525–P

Dear Dr. Berwick:

The American Academy of Neurology ('AAN' or 'Academy') is the premier national medical specialty society for neurology representing more than 24,000 neurologists and neuroscience professionals, and is dedicated to promoting the highest quality patient-centered neurologic care. A neurologist is a physician with specialized training in diagnosing, treating, and managing disorders of the brain and nervous system such as Alzheimer's disease, stroke, migraine, multiple sclerosis, brain injury, Parkinson's disease, and epilepsy.

Magnetoencephalography (MEG), also known as Magnetic Source Imaging is the noninvasive measurement of the magnetic fields generated by brain activity: it is one of several neurophysiological tests used to localize brain function. Electroencephalography (EEG), like MEG, measures brain activity with millisecond resolution. Both are far more sensitive than PET and SPECT to rapid changes in brain activity. Such rapid changes occur during the propagation of a seizure. EEG can be recorded noninvasively like MEG but surface EEG has limited resolution: it usually has inadequate sensitivity for pre-surgical decisions. The value of MEG lies in its ability to provide either new and non-duplicative or supplemental information to existing localizing technologies. For AAN's complete review of the technology, visit: http://www.aan.com/globals/axon/assets/7052.pdf.

The AAN would like to provide comments on CMS' proposal to determine the proper cost to charge ratios (CCR) for MEG by using the nonstandard Medicare cost report cost center for EEG and electrocardiogram (EKG) services. The CCRs will then be used for the purpose of estimating the cost of providing MEG services and consequently, its reimbursement. The Academy feels there are specific differences between MEG, and EEG and EKG including:

- Where MEG services are performed
- The costs to run a MEG machine

MEG Labs Entail Greater Start-up Costs

The AAN would like to note the cost to form a MEG lab and a lab that provides EEG and EKG services to patients are significantly different. Our information indicates that MEG is not performed in the same area, nor always the same department, as EEG and EKG. In addition, there are significantly higher costs associated with beginning to provide MEG services. Specifically, MEG needs a separate space as it can't be given bedside, nor in a normal examination room like EEG and EKG. MEG needs its own space that will likely include:

- A shield from other magnetic sources
- A separate patient preparation area
- A specially reinforced floor
- Individual power supplies
- Its own exhaust systems, and
- Storage facilities for the liquid helium

The start-up costs to deliver MEG services are significant due to the need for more facilities particularly when compared to that for EEG and EKG–which only require the purchase of a new machine.

Costs to Provide MEG Services

There are also significant differences in the cost to run a MEG machine. For example, separate maintenance personnel must be hired or contracted for, and the liquid helium must be replaced regularly–generally on a weekly basis. Further, MEGs use different types of personnel to operate them than EEGs and EKGs, and take more time to develop a readable scan than either EEG or EKG machines. MEG scanners require physicists and engineers to provide proper services to patients. They will use mathematical modeling to translate the weak magnetic fields into an image, often an MRI, which can then be used for surgical guidance. EEG and EKG machines require only technologists. Furthermore, a MEG recording typically requires approximately three hours to complete. This is significantly longer than the fifteen to twenty-five minutes required for EEG and EKGs.

Because of these differences in start-up and operational costs, the AAN opposes CMS' proposal to use the nonstandard Medicare cost report cost center for EEG and EKG services to ascertain the proper cost

to charge ratio for MEG. The cost data for MEG should be calculated using actual MEG cost data instead of a substitute. MEG is significantly more expensive and its reimbursement should reflect that.

Thank you for your attention to the comments listed above. Should you have questions or require further information, please contact Mark Pascu, AAN Manager Regulatory Affairs at mpascu@aan.com or at 202-525-2018.

Sincerely,

Bruce Sigsbee, MD, FAAN
President
American Academy of Neurology

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August 10, 2010

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Chair, Ambulatory Payment Classification Advisory Panel
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Baltimore, Maryland 21244-1850
Email: CMS APCPanel@cms.hhs.gov

RE: Appropriate Payment Calculation for MEG by Adding a line on the MCR

Dear Dr. Hambrick,
The American Academy of Neurology ('AAN' or 'Academy') is the premier medical specialty society for more than 22,000 neurologists and neuroscience professionals dedicated to providing the highest quality patient-centered care for patients suffering from complex, chronic neurologic disease such as Alzheimer's, Parkinson's disease, ALS, and epilepsy. The AAN writes in support of the presentation by the American Clinical Magnetoencephalography (MEG) Society (ACMEGS) during the August meeting of the APC Advisory Panel to respectfully ask that CMS add a specific line for Magnetoencephalography (MEG) on the Medicare Cost Report (MCR) and recalculate an appropriate payment for MEG.

MEG, also known as Magnetic Source Imaging (MSI) is the noninvasive measurement of the magnetic fields generated by brain activity: it is one of several neurophysiological tests used to localize brain function. EEG, like MEG, measures brain activity with millisecond resolution. Both are far more sensitive than PET and SPECT to rapid changes in brain activity. Such rapid changes occur during the propagation of a seizure. EEG can be recorded noninvasively like MEG but surface EEG has limited resolution: it usually has inadequate sensitivity for pre-surgical decisions. The value of MEG lies in its ability to provide either new and non-duplicative or supplemental information to existing localizing technologies. For AAN's complete review of the technology, visit: http://www.aan.com/globals/axon/assets/7052.pdf.

Currently, there is no specific line item for MEG on the Medicare Cost Report (MCR) and MEG costs are combined with EEG on line 54 of the MCR. Therefore, the cost-to-charge ratio (CCR) for MEG cannot be distinguished. This has resulted in the costs for MEG—which are significantly higher—being diluted by the much lower costs (and much higher utilization) of EEG.

The isolation of MEG on the MCR results in a significant impact on its calculated cost-to-charge ratio (CCR). One facility petitioned Noridian (a Medicare Administrative Contractor), requesting a subscript to line 54 to account for MEG. The appeal was granted and line 54.01 was generated. The recalculated CCR for 2008 went from 0.3199 to 0.7345. In another institution, the recalculated CCR went from 0.3370 to 0.8691. In yet another institution the recalculated CCR was

0.5844. The delta in all instances is significant and would have a dramatic effect in determining the final Medicare reimbursement as well as setting future years payment rates. These differences prove the current methodology for calculating fair reimbursement for MEG is flawed.

Until recently, the recommended revenue code for MEG was the same revenue code for EEG. However, effective April 1, 2010, the National Uniform Billing Committee (NUBC) created a new revenue code category for MEG (086x). After creating the new revenue code, the NUBC—which included CMS representatives—highly recommended that ACMEGS and other interested groups also request that the APC Panel make the proposed modification above to the Medicare hospital cost report. Therefore the AAN respectfully requests that the APC panel create a separate line item for MEG on the MCR. Combined, the two changes will go a long way toward ensuring fair reimbursement for this procedure.

Thank you for your attention to these comments. Should you have questions or require further information regarding this issue, please contact Katie Kuechenmeister, AAN staff, by phone at (651) 695-2783 or by email at kkuechenmeister@aan.com.

Sincerely,

Robert C. Griggs, MD, FAAN
President, American Academy of Neurology

Cc: **Catherine M. Rydell, CAE**
Executive Director and CEO, American Academy of Neurology
American Academy of Neurology Foundation
AAN Enterprises, Inc.

Rod Larson
Chief Health Policy Officer, American Academy of Neurology

UNIVERSITY OF UTAH
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Clinical Neurosciences Center

Neurosciences Administration
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August 12, 2011

Centers for Medicare & Medicaid Services,
Department of Health and Human Services
Attention: CMS-1525-P
P.O. Box 8013
Baltimore, MD 21244-1850

To Whom It May Concern:

As one of the primary Neuroscience Centers of Excellence in the Intermountain West, a significant component of our organization is the Magnetoenchepalography (MEG) program. This use of this technology allows us to map brain activity by recording magnetic fields that naturally occur within the brain, localize regions of the brain affected by adverse pathology prior to surgical removal, research cognitive brain processes, as well as determine the functionality in various parts of the brain. In sum, it is a critical tool that is used in the regular clinical processes of a high-functioning Neuroscience program.

It is our understanding that there may be a change in the classification of this service from a CMS revenue code standpoint. It appears that despite the National Uniform Billing Committee's designation of specific revenue codes in 2010 for MEG (860 and 861), CMS is proposing to use nonstandard Medicare cost report cost centers (3280 (ECG and EEG) and 5400 (EEG)) to classify these technologies as similar, and therefore plans on "packaging" them together.

We fundamentally oppose this change, as there are significant differences between ECG, EEG and MEG. Please see below for a summary of these key differences:

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1) *Facility Differences:*

- At our facility, the MEG unit is housed in a different location than the EEG lab. Whereas EEG is a "bedside technology," and only requires a small examination room (roughly 100 sq. ft.), the MEG unit requires a completely different infrastructure. For example, the MEG unit itself is housed inside of a Magnetically Shielded Room (MSR) that even differs from the shielding strategies and materials employed in MRI. Our MSR weighs roughly 24,000 pounds, and requires a special structural floor to support it. Additional space requirements include space to house 3 separate electronics racks that support the scanner, a patient preparation area, and the storage space required for liquid Helium. In addition, MEG requires special electrical power installations and grounding, pneumatic airlines, and a Helium exhaust system. Overall, our MEG facility utilizes roughly 1300 sq. ft.

2) *Organizational Structure:*

- Within our health system, both MEG and EEG are designated by separate cost centers. They are both staffed and overseen by different clinical directors, and the technical staff associated with each is specialized in the operation of their respective pieces of equipment.

3) *Financial Requirements:*

- The purchase cost for a modern MEG system is approximately $3 million. Installation costs are roughly $1 million. The majority of MEG-related operational costs are not utilization based. For example, the cost for liquid Helium (100 liters/week) ranges from $40,000 - $50,000 annually, and the service contracts associated with the equipment can be anywhere from $100,000 - $125,000.

- In contrast, the capital cost for a single EEG machine ranges from $15,000 - $25,000. EEG can also be done at the bedside which represents a significantly lower cost requirement for infrastructure support.

- The MAC had granted a subscription line in the hospital cost report. Accordingly, the CCR for EEG in FY2010 was calculated as 0.699693, and was 1.287881 for MEG.

4) *Utilization Rates:*

- Because of these significant differences, there is a great disparity between the number of EEG units vs. the number of MEG units across the country.

- It should also be noted that EEG is a high utilization/low cost procedure, and that MEG is a low utilization/high cost procedure. Essentially, we believe that EEG could be considered a commodity, and MEG could not.

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5) Process:

- Clinical MEG recordings require 3 to 4 hours at least, and it actively involves not only registered technologists, but also engineers and often a Ph.D. While the administration of MEG laboratories obviously varies from institution to institution, these diagnostic tests are always run separately from Electroencephalography. Standard EEG's are recorded for approximately 30 minutes, and it takes less than 90 minutes to complete the entire appointment and interpretation. ECG's of course have absolutely nothing in common with assessment of brain function. ECG systems provide automated interpretation in most cases, and require only a few minutes to perform. *Needless to say, pairing MEG with ECG is not logical from any perspective.*

The American Academy of Neurology, the American Clinical MEG Society, and others have worked actively with the NUBC to establish separate revenue codes for MEG to distinguish the true Cost to Charge Ratio for MEG. Now that the revenue codes have been put in place, it is critically important for CMS to accept these codes and appropriately modify the Medicare Hospital Cost Report. The letter from Dr. Robert Griggs (attached), President of the American Academy of Neurology, to Dr. Hambrick, Chair of the APC Panel, concisely captures the essence of the issue. We strongly support the Academy's position as stated in his letter.

In summary, we strongly urge CMS to reconsider the proposed rule. MEG should not share the associated costs with EEG and ECG. MEG should be recognized solely by the revenue codes granted by the NUBC. The combination of the recently approved revenue codes with a separate line item on the cost report will go a long way toward ensuring fair reimbursement for MEG. Thank you for your consideration.

Sincerely,

William T. Couldwell, M.D., Ph.D.
Chair, Department of Neurosurgery
University of Utah Health Care

Stefan-M. Pulst, M.D.
Chair, Department of Neurology
University of Utah Health Care

Richard P. Shumway, MHA
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Enclosure

University of Utah Health Care
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Centers for Medicare & Medicaid Services
Department of Health and Human Services
Attention: CMS-1525-P, P.O. Box 8013,
Baltimore, MD 21244-1850.

Dear CMS Panel,

I am writing in response to the proposed change for Magnetoencephalography (MEG) to be moved to a new cost center shared with electroencephalography and electrocardiogram. I strongly oppose the change. From reading the proposed changes it appears that CMS suggests to use nonstandard Medicare cost report cost center 3280 (Electrocardiogram (EKG) and Electroencephalography (EEG)) as the primary cost center and to use standard cost center 5400 (Electroencephalography (EEG)) as the secondary cost center. This proposed change does not properly ensure a fair reimbursement for MEG. The costs associated with MEG are substantially different from EEG and EKG. MEG also has vastly different physical facility requirements, hospital management and associated support staff.

I have extensive experience with clinical MEG examinations and the financial requirements of such examinations. I am the Director of Clinical MEG Service at Massachusetts General Hospital in Boston Massachusetts, a role I have had that role for the past nine years. I am also a neuroradiologist in the Department of Radiology at MGH and have a research lab at the MGH-Martinos Center for Biomedical Imaging. I served as the president of the American Clinical Magnetoencephalography Society (ACMEGS) for three years 2006-2009. ACMEGS serves to educate governmental and private agencies to advocate for fair reimbursement of MEG, which has given me unique perspective on this. ACMEGS has worked with other associations, such as the American Academy of Neurology (AAN) and the Radiologic Society of North America (RSNA), in the past to help CMS understand the unique costs associated with MEG.

Using revenue codes for EEG fails to capture the differences in the true costs of MEG examinations (CPT codes 95965, 95966, and 95967). At MGH, the cost to charge ratio (CCR) is approximately 0.35 and has been that rate since we started billing for the examinations in 2006. The technical costs requirements for MEG are a couple of orders of magnitude greater than EEG or EKG. Our MEG is located in space provided by the Department of Radiology, which does not house any stand-alone EEG equipment. MEG requires a large space that has the capability to support a magnetically shielded room (MSR), with our space about 2000 square feet. The MSR at our institution required substantial floor structural changes and now is in a suite with space of approximately 900 square feet. The MSR cost $1.2 million in 2000. The MEG and the associated electronics were also $1.5. With the required build out and computers for analysis the total cost was well over $3 million. The Department is planning on buying a new MEG device, which will have a cost of about $2.2 million dollars.

The costs and space requirements of EEG are much less than this. EEG typically is in a neurology department and can be in a single standard examination room, or as a

portable device used at the bedside. The device costs about $30,000. It has no requirement of a MSR and does not require a large staff to maintain. The interpretation of the EEG is substantially less time consuming than an MEG examination.

MEG is a distinct exam with a very different cost structure compared to EEG or EKG. This requires a revenue scheme distinct from EEG and ECG. Before of the unique costs associated with MEG, the National Uniform Billing Committee added revenue codes 860 (Magneto- encephalography (MEG); general classification) and 861 (Magnetoencephalography (MEG)). Rather than change the MEG into the cost center and revenue code for EEG, we agree with the recommendation of the NUBC and, in line with the AAN recommendation, to grant MEG a separate revenue code. The NUBC revenue codes, in addition to a separate line item on the cost report, will ensure a fair assessment of the costs associated with an MEG examination.

MEG should not share the same revenue codes as EEG. I urge CMS to change this proposed rule change.

Please feel free to contact me with any questions or concerns. This is an important decision for those of us who depend on this critical technology and invite you to visit our facility if that will aid in making your decision.

Sincerely,

Steven Stufflebeam, M.D.

Richard C. Burgess, M.D., Ph.D.
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THE CLEVELAND CLINIC

August 8, 2011

Centers for Medicare & Medicaid Services,
Department of Health and Human Services,
Attention: CMS-1525-P,
P.O. Box 8013,
Baltimore, MD 21244-1850.

Gentlemen:

This letter is to strongly oppose the proposals to employ for Magnetoencephalography (MEG) a Cost to Charge Ratio derived from unrelated EEG and EKG services. As I understand it, despite the National Uniform Billing Committee's revenue codes for Magnetoencephalography (MEG) added in 2010 (860 and 861), CMS proposes to use nonstandard Medicare cost report cost center 3280 (Electrocardiogram (EKG) and Electroencephalography (EEG)) as the primary cost center and to use standard cost center 5400 (Electroencephalography (EEG)) as the secondary cost center. Apparently CMS believes that these revenue codes continue to reflect ancillary and supportive services for which hospitals report charges without HCPCS codes and that packaging them is appropriate.

Clearly the strategy of having MEG share the same revenue codes and costs associated with EKG and EEG does not come close to reflecting the reality of MEG costs. The only relationship between EEG and MEG is that they both are techniques for evaluating brain function, but beyond that they are substantially different, in ways that impact costs considerably:

1) Location and size of the MEG lab vs EEG lab. The facilities needed for recording an EEG consist of an ordinary small examination room (approximately 100 square feet at our institution) and an EEG machine (approximately $15,000 to $25,000 capital cost). No special facilities, beyond the usual medical air, suction, and oxygen, are required. Alternatively, EEGs and EKGs can be done at the bedside, thereby requiring even less infrastructure. For a MEG laboratory, very special infrastructure and facilities are required, along with considerably more space. Most important is the necessity for a Magnetically Shielded Room, area for storage and transfer of the required liquid helium, and a separate patient preparation area. Special electrical power, exhaust capabilities, floor reinforcement, etc are required, necessitating a footprint of 1000 square feet at minimum. At our institution, the build-out to accommodate the installation of the MEG cost approximately $1million. Because of their special requirements, MEG laboratories are not housed in the same areas as EEG or EKG; often they are in completely separate buildings under separate departmental administrations. The point is that EEGs and EKGs are commodities, considered "a dime a dozen", and that adding a new EEG or EKG is a small incremental

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investment, whereas the complexity of a MEG laboratory requires a very large investment in space, personnel, and operating costs. This enormous difference between MEG and EEG is reflected in the numbers of MEG labs vs EEG and EKG labs.

2) Costs required for Magnetoencephalography. Beyond the construction costs to build out an area for installation of the MEG and magnetically shielded room, the capital purchase costs of these items are in the neighborhood of $3 million. Whereas EEG and EKG machines can usually be serviced by the hospital's own clinical engineers and are replaced on a regular basis, maintenance of MEG machines is much more analogous to that for imaging equipment such as MRIs, with annual maintenance contract costs for MEGs running about $100,000 to $150,000 per year. Because MEG machines operate in a superconducting state, they must be refilled with liquid helium on a weekly basis, at an annual cost of $50,000 to $60,000 per year.

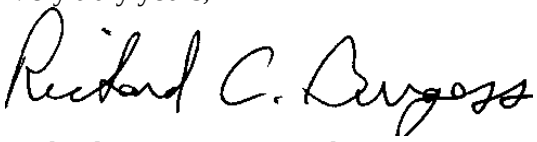
3) Clinical and administrative organization of MEG laboratories. The process of obtaining a MEG recording requires several hours at minimum, and it actively involves not only registered technologists, but also engineers and physicists. While the administration of MEG laboratories obviously varies from institution to institution, they are always run separate from Electroencephalography. EEGs are recorded for a standard time of 20 minutes, and take less than 1 – 1 ½ hours for the entire appointment and interpretation. EKGs, of course, have nothing whatsoever to do with brain assessment, provide automated interpretation in most cases, and require only a few minutes to perform. Needless to say, lumping MEG with EKG is ludicrous from all perspectives.

The American Academy of Neurology, the American Clinical MEG Society and others worked actively with the NUBC to establish separate revenue codes for MEG so that the true Cost to Charge Ratio for MEG could be distinguished. Now that the revenue codes have been put in place, it is critically important for CMS to accept these codes and appropriately modify the Medicare Hospital Cost Report. The letter (attached) from Dr. Robert Griggs, president of the American Academy of Neurology, concisely captures the essence of the issue. I am a member of the Academy and I strongly support the Academy's position as stated in this letter.

In summary, MEG laboratories are not located in EEG departments (and obviously not related to EKG), and should not share the same costs. A decision not to recognize MEG's distinct revenue code results in an inability to capture the true costs associated with MEG procedures. The CCRs applied to EEG revenue codes do not apply at all to MEG and do not reflect the work and fixed costs associated with magnetoencephalography.

I strongly urge you to reconsider the proposed rule. MEG should not share the same revenue codes and associated costs with EKG and EEG.

Very truly yours,



Richard C. Burgess, MD, PhD
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Scripps

8/22/11

Centers for Medicare & Medicaid Services
Department of Health & Human Services
Attention: CMS-1525-P
PO Box 8013
Baltimore, MD 21244-1850

RE: CMS-1525-P
Revenue codes 860 (Magnetoencephalography (MEG); general classification and 861 (Magnetoencephalography (MEG)).

To Whom It May Concern:

The proposed rule to apply a Cost-Charge-Ratio (CCR) for revenue codes 860 and 861, by comparing the MEG costs to Electroencephalagraphy (EEG) was developed under false assumptions. This proposed rule assumes that MEG and EEG are located and managed by the same department and have similar costs. This is certainly not the case at Scripps.

At Scripps, the MEG department is managed and located in the department of Radiology under Scripps Green Hospital. The EEG department, under Neurology, is managed by Scripps Clinic and is located in a building at the opposite end of the Scripps campus.

Unlike EEG, MEG is not mobile and in fact, needs a very expensive magnetically shielded room in order to operate. The average cost of an MEG scanner is in the same ballpark of an MRI scanner with similar expensive *required* preventive-maintenance contracts. In addition, MEG scanners, same as MRI scanners needs expensive cyrogenics (helium gas) in order to operate. Next to salaries and preventative-maintenance, helium comprises the largest percentage of costs for an MEG department – usually in the neighborhood of $50,000 per year.

There are no comparable costs for operating an EEG machine. The initial cost is considerably less, preventative maintenance is less and they do not require constant refilling of helium gas.

Please reconsider your proposal to lump MEG with EEG. The operating costs are just not the same!

Sincerely

Patti Quint, B.S. (R.T.) R.
Clinical Coordinator
Scripps MEG Lab

August 15, 2011

Centers for Medicare and Medicaid Services
Department of Health and Human Services
Attn: CMS-1525-P
C4-26-05
7500 Security Boulevard
Baltimore, MD 21244-18150

To Whom It May Concern:

This letter is to provide important feedback on the proposal to employ for magnetoencephalography (MEG), a cost to charge ratio that includes electro encephalography (EEG) and electrocardiography (ECG). I am the Director of the University of Alabama at Birmingham Health Services Foundation Magneto encephalography Laboratory (UAB-HSF MEG Lab), which provides diagnostic MEG services to much of the southeast.

This letter is in accordance with that written by Robert Griggs, President of the American Academy of Neurology. It is extremely important to make clear the large differences in MEG compared to EEG and ECG. MEG, also called magnetic source imaging (MSI), is a completely unique, non-invasive diagnostic brain-imaging test that is performed in either radiology or neurology departments, completely separate from EEG. The indications for MEG/MSI and EEG are not related. MEG/MSI is indicated only for special epilepsy surgery cases and preoperative cortical mapping surgical treatment of brain tumors and other lesions. Only a relatively small number of MEG/MSI exams are performed per year in the United States, on the order of several hundred to a couple of thousand. This estimate is several orders of magnitude less than EEG and ECG. In similar contrast, the time and cost for performing MEG/MSI is 10-20 times greater than EEG. These costs have been detailed in other letters addressing the proposed rule for combining MEG with EEG and ECG into one new cost-charge-ratio (CCR). These costs were also carefully calculated and reviewed by CMS when CPT codes were issued in 2003. The costs assessments were obtained from numerous sites and were very rigorous. This allowed CMS to devise reimbursement estimates that remain appropriate to this date.

The National Uniform Billing Committee (NUBC) added specific line item revenue codes for MEG (codes 860 and 861), such that the CCR would correctly reflect the unique costs of MEG. If the proposed rule change occurs, such that MEG is grouped with EEG and ECG, the CCR will be completely inappropriate relative to

the actual costs of MEG, leading to reimbursement that will make the technology unsustainable. We ask that this proposed rule change be reviewed carefully for its consequences to a remarkably valuable but special and small volume technology. We completely concur with the letter by Dr. Griggs from the American Academy of Neurology. We ask that CMS allow MEG be recognized solely by the revenue codes granted by the NUBC in 2010.

Sincerely,

Robert C. Knowlton, MD, MSPH
Associate Professor of Neurology
UAB School of Medicine
Director, UAB-HSF MEG Laboratory
Director, UAB Seizure Monitoring Unit
Director, Division of Epilepsy

RCK/va

UNM SCHOOL of MEDICINE

Department of Neurology

Dear Colleagues,

This letter is to express our concern over the CMS 2112 plan to apply a Cost-to-Charge Ratio derived from EEG and ECG services to Magnetoencephalography (MEG). In 2010, the National Uniform Billing Committee established revenue codes 860 and 861 for MEG. This was done in an effort to provide better capture of MEG costs and charges. Unfortunately, rather than trying to capture the true CCR for MEG procedures, it is our understanding that CMS is proposing to derive CCR information for MEG by using data from non-standard Medicare cost report centers 3280 and 5400. The indicated rationale for this strategy is that MEG, like EEG, measures brain activity and that MEG is likely to be administered in the same department and manner as EEG. This however is like suggesting the CCR for a skull X-Ray is the appropriate CCR for a brain PET examination. Just as PET is orders of magnitude more expensive and complicated than X-Ray, so too is MEG more complicated and expensive than EEG.

CMS believes that MEG is typically administered in the same manner and department as EEG services, but at most institutions these assumptions are invalid. For example, at our institution, the University of New Mexico, the MEG scanner used for the evaluation of our clinical patients is actually owned and operated by a completely independent organization, the MIND Research Network. We essentially rent the use of this scanner, and pay a premium, fixed rate per CPT-code, regardless of the level of reimbursement obtained by the hospital.

Differences between MEG and EEG are, in practice, enormous with respect to required facilities and expertise for data collection, processing, analysis and interpretation. An EEG system can be situated in most ordinary clinical examination rooms [~100 sqft of space], with a capital cost of under $20,000. Some EEG systems can even be transported and operated at bedside. In contrast, the footprint for an MEG lab is in excess of 750 sqft. The MEG unit must be operated in a specially designed magnetically shielded room, the installation of which often requires that the floor be reinforced. Costs for the MEG scanner, shielded room, and space build-out typically exceed $3 million, a key factor in limiting the proliferation of this valuable technology. Additional financial considerations are the differential operating and maintenance costs for EEG versus MEG. For EEG, yearly operating and maintenance costs are typically below $20K/system, with a hospital's biomedical support team typically providing routine service. In contrast, the specialized nature of MEG equipment demands an annual $100-150K service contract with the manufacturer. Liquid helium costs alone generally exceed an additional $50K/year.

EEG and MEG also require substantially different levels of technical and clinical expertise. A typical EEG examination involves 20-30 minutes of recording, as supported by a single technologist, with less than 90 minutes required for the entire appointment and physician interpretation. In contrast, MEG involves 30 minutes of preparation, and typically 60-120 minutes of recording, as supported by two technologists and persons with expertise in biophysics and engineering. Processing and analyses of MEG data generally requires 8-12 hours of effort by an advanced scientist [often a PhD, charged as part of the technical component of the examination], plus an additional 2-3 hours of professional time by a physician.

Whereas the CCR for EEG procedures is around 0.3 for most institutions, the actual CCR for MEG is typically above 0.5. Given this, it would be erroneous and detrimental to the advancement of this technology to apply a CCR derived from 3280 and 5400. We trust that the goal of CMS is to provide accurate cost assessments, and therefore strongly encourage reconsideration and amendment of the proposed rule so that the costs and revenues associated with an MEG examination are captured in an accurate manner.

Sincerely,

Bruce Fisch, M.D.
Professor of Neurology
Director Comprehensive Epilepsy Center
University of New Mexico Health Sciences Center

Jeffrey David Lewine, Ph.D.
Adjunct Associate Professor of Neurology
University of New Mexico Health Sciences Center
Assoc. Professor of Translational Neuroscience, Director Clinical MEG
MIND Research Network

UPMC | University of Pittsburgh Medical Center

University of Pittsburgh Physicians
Department of Neurological Surgery

UPMC Presbyterian
Suite B-400
200 Lothrop Street
Pittsburgh, PA 15213-2582
412-647-3685
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August 10, 2011

E. L. Hambrick, MD, JD, CMS Medical Officer,
Chair, Ambulatory Payment Classification Advisory Panel
7500 Security Boulevard
Mail Stop C4-05-17
Baltimore, Maryland 21244-1850
Email: CMS APCPanel@cms.hhs.gov

RE: Appropriate Payment Calculation for MEG by Adding a line on the MCR

Dear Dr. Hambrick,

Magnetoencephalography (MEG) is a non-invasive, functional imaging technique in which magnetic signals associated with the electrical activity of the brain are monitored externally on the scalp and recorded. This information is then superimposed on to an anatomic image of the brain from an MRI to produce a functional image. This procedure is referred to as magnetic source imaging (MSI). The advantage of MSI over EEG is that while measurements of electrical activities can be affected by surrounding brain structures, magnetic fields are not. The resulting image is accurate and has a very high resolution. Thus, MEG is a method of characterizing and localizing sources of neuronal activity within the nervous system by non-invasively measuring the magnetic fields produced by that activity.

There are two primary clinical indication of MEG: Localization of epilepsy focus and presurgical mapping for brain tumors. Magnetoencephalography (MEG) is a valuable noninvasive tool for presurgical mapping of sensory, motor, auditory, visual and language related critical brain regions. Surgery for brain pathologies (tumors, vascular malformations) in the vicinity of these regions requires a detailed mapping of cortical regions involved in critical functions to avoid further deterioration of function. Neurosurgeons rely on intraoperative electrocortical stimulation to recognize critical cortex at the time of surgery. Although electrocortical stimulation is the "gold standard" for intra-operative brain cortical mapping, this is not helpful for presurgical planning. Presurgical planning can only be performed through noninvasive functional brain imaging techniques such as magnetoencephalography (MEG). Currently MEG is used to record and localize sensory, motor, auditory, visual and language related critical brain regions. In summary MEG/MSI provides much needed pre-surgical guidance in patients

with brain tumors and vascular malformations. MEG enables a more reliable localization of critical brain areas compared with any other currently available technique.

While both EEG and ECG use surface recording of electrical signals form brain and heart respectively, MEG is designed to capture the magnetic field generated by neuronal current in real time. While most hospitals have several portable EEG and ECG machines, MEG is only available at limited facilities. MEG installation needs a high cost set up for its dedicated facility. There are several key differences that separate MEG from EEG technology.

1. EEG is primarily used to diagnose and document seizure activity. MEG is used for localization of seizure focus in patients suffering from refractory epilepsy as well as pre-surgical mapping for brain lesion in preparation for brain surgery.

2. EEG can be acquired at bed side using portable machines but MEG can only be performed in a dedicated MEG facility.

3. The set up of MEG is completely different than that of EEG and the costs involved with MEG are much higher than EEG. At our institution the UPMC brain mapping center which houses MEG is a stand alone facility. It is located on the first floor of UPMC hospital (PUH D144) and covers 1006 square feet of space with its own dedicated staff. The MEG unit is housed in a specially constructed magnetically shielded room (MSR) which is necessary as earths own magnetic field is about a million times stronger that brain signals.

4. The fixed costs involved with MEG operations is many fold higher than the fixed cost involved with a single EEG system. The fixed costs of MEG at our center is about $400,000. The fixed costs of MEG at our center include $125,000 for yearly service contract, $55,000 for yearly liquid Helium consumption (about 100 liters of liquid helium is needed every week to maintain a temperature of -269 ^{0}C for MEG sensors) and 220,000 for salary support for dedicated MEG scientist and staff. The depreciation of MEG unit is not reflected in this cost.

5. At UPMC the EEG operations are managed by the department of Neurology. The UPMC-MEG operations are managed by the Director of operations who reports to a multidisciplinary Oversight committee. The Oversight committee is comprised of members from departments of Neurology, Neurosurgery, Radiology, Rehabilitation Medicine, Center of Cognitive Neuroscience, University of Pittsburgh Dean's office, UPMC administrative leadership, and Carnegie Mellon University.

6. The calculated cost to charge ratio (CCR) for MEG is at our facility much higher than that of EEG and ECG. The CCR for MEG at UPMC is 0.243613. The CCR of EEG is 0.096058 and for ECG is 0.056407.

In summary we agree with the recommendation of the American Association of Neurology (AAN) that MEG should be considered as a separate entity from EEG as it is currently used and operated. MEG costs are considerably higher than EEG. We support the request that an APC panel create a separate line item for MEG on the Medicare cost report (MCR). In addition the National Uniform Billing Committee (NUBC) has created a new revenue code category for MEG (860 and 861). We would request CMS adopt theses new revenue codes. These two changes reflect the differences in the set up and costs involved with MEG acquisition.

We would be happy to have CMS representatives come to our center at UPMC to demonstrate the functioning of our MEG center.

Ajay Niranjan M.CH. MBA
Director of Operations
UPMC Brain Mapping Center (MEG)

L. Dade Lunsford, MD, FACS
Director, Center for Image Guided Neurosurgery
Director, Neurosurgery Residency Program

Lawrence Wechsler, MD
Chair, Department of Neurology

ACMEGS BYLAWS

BYLAWS
OF
AMERICAN CLINICAL MAGNETOENCEPHALOGRAPHY SOCIETY, INC., A NON-PROFIT CORPORATION

ARTICLE I
ORGANIZATION

1.1 The name and charitable purposes of the organization shall be as set forth in its Articles of Organization. In addition to the charitable purposes as set forth in the Articles of Organization, the organization may work cooperatively with other national and international magnetoencephalography (MEG), neurology, neurosurgery, and radiology organizations in determining how best to meet the clinical needs of MEG sites within the United States. These Bylaws, the powers of the organization and of its directors and officers, shall be subject to the Articles of Organization as in effect from time to time. The principal office of the organization in the Commonwealth of Massachusetts shall initially be located at the place set forth in the Articles of Organization.

1.2 The organization may have a seal which shall be in such form as the Board of Directors may, from to time to time, adopt or amend.

1.3 The organization may at its pleasure by a vote of the Members (as hereinafter defined) change its name.

1.4 The pronoun “he” or “his,” when appropriate, shall be construed to mean also “she” or “her” and the word “chairman” shall be construed to include a female.

ARTICLE II
MEMBERSHIP

2.1 Membership in this organization shall be open to those who support the purpose statement of the organization as set forth in the Articles of Organization and meet the qualifications set forth in Section 2.2. Continuing membership is contingent upon being up-todate on membership dues which shall be paid annually on or before September 1st of each year.

2.2 There shall be three (3) classes of membership in the organization; namely, a Site-Designated Member class, a General Member class and an Associate Member class.

A. “Site-Designated Members” are those individuals so designated by each clinical site that has paid its membership dues. Each site may designate up to 2 members. Only site-designated members are eligible to be members of the Board of Directors”.

B. "General Members" shall include those individuals involved in the clinical use of magnetoencephalography (MEG) alone or in combination with electroencephalograms (EEGs), magnetic resonance imaging (MRI) or computerized axial tomography (CAT) scans and possessing a medical degree (M.D.), a Ph.D. in one of the aforementioned fields, or some equal equivalent degree.

C. "Associate Members" shall include clinicians, or their clinical assistants, involved with the use of magnetoencephalography (MEG) alone or in combination with electroencephalograms (EEGs), magnetic resonance imaging (MRI) or computerized axial tomography (CAT) scan equipment and students with an interest in any of those fields.

2.3 Individuals wishing to join the membership of this organization for either the General or Associate class of membership shall apply for admission and be nominated by two (2) existing members of the member class for which membership is sought; provided, however, that those individuals identified as directors in the Articles of Organization as originally filed with the Massachusetts Clerk of the Commonwealth shall be automatically admitted into the Member class of this organization without further application. The Membership Committee shall review and recommend either admission or denial into the membership of this organization for each application submitted, after which the entire Board of Directors shall vote to accept or reject the Membership Committee's recommendation. The vote of the Board of Directors shall be final.

2.4 The dues for each membership class shall be reviewed and set annually by the Board and any proposed changes shall be voted on at the annual membership meeting.

2.5 Only those members who are current on their membership dues and are in the Members class shall be eligible to vote at any annual or special meetings of the membership.

ARTICLE III
MEMBERSHIP MEETINGS

3.1 The first annual membership meeting of this organization shall be held on August 26, 2006 and thereafter shall be held on such date as determined by vote of the membership at the prior year's annual membership meeting.

3.2 The Clerk shall cause to be mailed to every member in good standing at its address as it appears in the membership roll book in this organization a notice telling the time and place of such annual meeting.

3.3 Meetings of the membership may be held at such time and place, within or without the Commonwealth of Massachusetts, as shall be stated in the notice of the meeting or in a duly executed waiver of notice thereof. Notices of meetings shall be sent

to all members at their addresses as they appear in the membership roll book at least ten (10) days before the scheduled date set for such meeting. If mailed, notice is given when deposited in the United States mail, postage prepaid, directed to the member at such member's address as it appears on the records of the organization. Without limiting the manner by which notice otherwise may be given effectively to members, any notice to members given by the organization shall be effective if given by a form of electronic transmission consented to by the member to whom the notice is given. Any such consent shall be revocable by the member by written notice to the organization. Any such consent shall be deemed revoked if (1) the organization is unable to deliver by electronic transmission two consecutive notices given by the organization in accordance with such consent and (2) such inability becomes known to the Clerk or an Assistant Clerk of the organization, or other person responsible for the giving of notice; provided, however, the inadvertent failure to treat such inability as a revocation shall not invalidate any meeting or other action.

3.4 The presence of not less than a majority of the Members class shall constitute a quorum and shall be necessary to conduct the business of this organization; but a lesser percentage may adjourn the meeting for a period of not more than four (4) weeks from the date scheduled by these Bylaws and the Clerk shall cause a notice of this scheduled meeting to be sent to all those members who were not present at the meeting originally called. A quorum as herein before set forth shall be required at any adjourned meeting.

3.5 Special meetings of the members may be called by the President when he deems it for the best interest of the organization. Such notice shall state the reasons that such meeting has been called, the business to be transacted at such meeting and by whom it was called. At the request of a majority of the members of the Board of Directors or a majority of the Members class, the President shall cause a special meeting to be called but such request must be made in writing at least ten (10) days before the requested scheduled date.

3.6 No other business but that specified in the notice may be transacted at such special meeting without the unanimous consent of all present at such meeting.

ARTICLE IV
VOTING

4.1 When a quorum is present at any meeting, or electronically between meetings, the vote of a majority of the Members class present in person or represented by proxy shall decide any question brought before such meeting, unless the question is one upon which by express provision of the statutes or of the Articles of Organization a different vote is required in which case such express provision shall govern and control the decision of such question.

4.2 Unless otherwise provided in the Articles of Organization or these Bylaws, each member of the Members class shall at every meeting of the membership be entitled to

one (1) vote in person or by proxy, but no proxy shall be voted on after three (3) years from its date, unless the proxy provides for a longer period.

4.3 Unless otherwise provide in the Articles of Organization, any action required to be taken at any annual or special meeting of the membership of the organization, or any action which may be taken at any annual or special meeting of such members, may be taken without a meeting, without prior notice and without a vote, if a consent in writing, setting forth the action so taken, shall be signed by the members of the Members class having not less than the minimum number of votes that would be necessary to authorize or take such action at a meeting at which such members of the Members class were present and voted. Prompt notice of the taking of the action without a meeting by less than unanimous written consent shall be given to those members who have not consented in writing.

ARTICLE V
BOARD OF DIRECTORS

5.1 The business of this organization shall be managed by a Board of Directors consisting of six voting Directors plus the past president who is eligible to vote only in case of ties.

5.2 Only site-designated members will be eligible to serve on the Board. A site-designated member is a member that has been designated as eligible by a site that has paid its site-membership dues.

5.3 Each Board member will serve a three year term. Terms will be staggered accordingly, with new members voted into office during each year's annual business meeting as needed.

5.4 All members will be eligible to vote for the Directors.

5.5 During presidential years, the Board of Directors will internally choose who the next president shall be. The presidential term shall be three years, starting from the date of appointment.

5.6 The Board shall appoint, on an annual basis, a Treasurer and Clerk from among the current board members.

5.7 An individual may serve only one term as president. Members of the Board may serve two consecutive terms, if so voted by the general membership.

5.8 The Board of Directors shall have the control and management of the affairs and business of this organization. Such Board of Directors shall only act in the name of the organization when it shall be regularly convened by its president after due notice to all the directors of such meeting.

5.9 A majority of the members of the Board of Directors shall constitute a quorum and the meetings of the Board of Directors shall be held regularly as such dates and times as the Board of Directors may determine, but no less than quarterly. The Board of Directors may hold meetings, both regular and special, either within or without the Commonwealth of Massachusetts.

5.10 Each active director shall have one (1) vote and such voting may not be done by proxy. The past-president will cast the deciding vote in the case of a tie.

5.11 Special meetings of the Board may be called by the President on five (5) days' notice to each director by mail or forty-eight (48) hours notice to each director either personally or by electronic means of communications, including electronic mail and facsimile transmission; special meetings shall be called by the President or Clerk in like manner and on like notice on the written request of one (1) director.

5.12 Unless otherwise restricted by the Articles of Organization or these Bylaws, any action required or permitted to be taken at any meeting of the Board of Directors or of any committee thereof may be taken without a meeting, if all members of the Board or committee, as the case may be, consent thereto in writing, and the writing or writings are filed with the minutes or proceedings of the Board or committee.

5.13 Unless otherwise restricted by the Articles of Organization or these Bylaws, members of the Board of Directors, or any committee designated by the Board of Directors, may participate in a meeting of the Board of Directors, or any committee, by means of conference telephone or similar communications equipment by means of which all persons participating in the meeting can hear each other, and such participation in a meeting shall constitute presence in person at the meeting.

5.14 Unless otherwise restricted by the Articles of Organization or these Bylaws, any director may be removed, with or without cause, by a majority of the members entitled to vote on such directorship. Any director may resign at any time by giving written notice of resignation to the Board of Directors, to the President or to the Clerk. Any such resignation shall take effect upon receipt of such notice or at any later time specified therein. Unless otherwise specified in the notice, the acceptance of a resignation shall not be necessary to make the resignation effective.

5.15 Vacancies in the Board of Directors shall be filled by the members entitled to vote on such directorship.

ARTICLE VI
OFFICERS

6.1 The officers of the organization shall be chosen by the Board of Directors and shall be a President, a Clerk and a Treasurer, all of whom shall be site-designated Members. The Board of Directors may also choose one or more Assistant Clerks and

Assistant Treasurers. Any number of offices may be held by the same person, unless the Articles of Organization or these Bylaws otherwise provide.

6.2 The Board of Directors at its first meeting after each annual meeting of the membership shall choose a Clerk and a Treasurer from those members of the Board of Directors, and may elect one or more Assistant Clerks and Assistant Treasurers as the Board of Directors shall deem to be in the organization's best interests. Presidential appointments are for three (3) years.

6.3 The Board of Directors may appoint such other officers and agents as it shall deem necessary who shall hold their offices for such terms and shall exercise such powers and perform such duties as shall be determined from time to time by the Board.

6.4 No officer shall for reason of his office be entitled to receive any salary or compensation, but nothing herein shall be construed to prevent an officer or director for receiving any compensation from the organization for duties other than as a director or officer.

6.5 The officers of the organization shall hold office until their successors are chosen and qualify. Any vacancy occurring in any office of the organization shall be filled by the Board of Directors. Any officer elected or appointed by the Board of Directors may be removed at any time by the affirmative vote of a majority of the Board of Directors. Any officer may resign at any time by giving written notice of resignation to the Board of Directors, to the President or to the Clerk. Any such resignation shall take effect upon receipt of such notice or at any later time specified therein. Unless otherwise specified in the notice, the acceptance of a resignation shall not be necessary to make the resignation effective.

6.6 The President shall be the chief executive officer of the organization, shall have general and active management of the business of the organization and shall see that all orders and resolutions of the Board of Directors are carried into effect. The President shall preside at all meetings of the membership and of the Board of Directors at which he is present. The President shall have all powers and duties usually incident to the office of the President except as specifically limited by a resolution of the Board of Directors. T he President shall have such other powers and perform such other duties as may be assigned to him from time to time by the Board of Directors.

6.7 The Clerk shall attend all meetings of the Board of Directors and all meetings of the membership and record all the proceedings of the meetings of the organization and of the Board of Directors in a book to be kept for that purpose and shall perform like duties for the standing committees when required. He shall give, or cause to be given, notice of all meetings of the membership and special meetings of the Board of Directors, and shall perform such other duties as may be prescribed by the Board of Directors or President, under whose supervision he shall be. He shall have custody of the corporate seal of the organization and he, or an Assistant Clerk, shall have authority to affix the same to any instrument requiring it and when so affixed, it may be attested by his signature or by the

signature of such Assistant Clerk. The Board of Directors may give general authority to any other officer to affix the seal of the organization and to attest the affixing by his signature.

6.8 The Assistant Clerk, or if there be more than one, the Assistant Clerks in the order determined by the Board of Directors (or if there be no such determination, then in order of their election) shall, in the absence of the Clerk or in the event of his inability or refusal to act, perform the duties and exercise the powers of the Clerk and shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe.

6.9 The Treasurer shall have the custody of the corporate funds and shall keep full and accurate accounts of receipts and disbursements in books belonging to the organization and shall deposit all monies and other valuable effects in the name and to the credit of the organization in such depositories as may be designated by the Board of Directors. He shall disburse the funds of the organization as may be ordered by the Board of Directors, taking proper vouchers for such disbursements, and shall render to the President and the Board of Directors, at its regular meetings, or when the Board of Directors so requires, an account of all his transactions as Treasurer and of the financial condition of the organization. He shall exercise all duties incident to the office of Treasurer.

6.10 The Assistant Treasurer, or if there shall be more than one, the Assistant Treasurers in the order determined by the Board of Directors (or if there be no such determination, then in the order of their election) shall, in the absence of the Treasurer or in the event of his inability or refusal to act, perform the duties and exercise the powers of the Treasurer and shall perform such other duties and have such other powers as the Board of Directors may from time to time prescribe.

ARTICLE VII
COMMITTEES

7.1 The Board of Directors may create committees as needed, such as executive, audit, and public relations. There shall be one standing committee – the Membership Committee. Except for members of the Membership Committee, membership in any committee created by the Board of Directors may contain such numbers of Members and Associate Members as the Board of Directors may reasonably determine.

7.2 No less than three (3) directors of the Board of Directors shall be appointed by the Board of Directors and shall serve as the members of the Membership Committee.

7.3 The Membership Committee shall have responsibility for reviewing applications for admission and making recommendations with respect such applications to the full Board of Directors.

ARTICLE VIII

GENERAL PROVISIONS

CHECKS

8.1 All checks or demands for money and notes of the organization shall be signed by such officer or officers or such other person or persons as the Board of Directors may from time to time designate.

FISCAL YEAR

8.2 The fiscal year of the organization shall be fixed by resolution of the Board of Directors.

BOOKS AND RECORDS

8.3 The books of the organization shall be kept at such place as the Board of Directors shall designate by resolution.

ARTICLE IX
INDEMNIFICATION; LIMITATION ON LIABILITY

9.1 Each director and officer of the organization shall be indemnified to the fullest extent now or hereafter permitted by law in connection with any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative, by reason of the fact that he is or was a director or officer of the organization or is or was serving at the request of the organization as a director, officer, employee or agent of another corporation, partnership, joint venture, trust or other enterprise. Without limiting the generality of the foregoing, the organization shall indemnify each person within the scope of the foregoing to the extent to which it is given the power to do so by Section 8.56 of the Massachusetts Business Corporations Act of the Commonwealth of Massachusetts as in effect on the effective date of these Bylaws or as thereafter amended. To the extent permitted by applicable law, the organization shall have power to purchase and maintain insurance on behalf of any person who is or was a director, officer, employee or agent of the organization, or is or was serving at the request of the organization as a director, officer, employee or agent of another corporation, partnership, joint venture, trust or other enterprise, against any liability asserted against him and incurred by him in any such capacity or arising out of his status as such whether or not the organization would have the power to indemnify him against such liability under applicable law.

9.2 A director of the organization shall not be personally liable to the organization or its members for monetary damages for breach of fiduciary duty as a director except for liability (i) for any breach of the director's duty of loyalty to the organization or its members, (ii) for acts or omissions not in good faith or which involve intentional misconduct or a knowing violation of law, (iii) under Section 8.56 of the Massachusetts Business Corporations Act of the Commonwealth of Massachusetts, as the same exists or

hereafter may be amended, or (iv) for any transaction from which the director derived an improper personal benefit. If the Massachusetts Business Corporations Act hereafter amended to authorize the further elimination or limitation of the liability of directors, then the liability of a director of the organization, in addition to the limitation on personal liability provided herein, shall be limited to the fullest extent permitted by the amended Massachusetts Business Corporations Act. Any repeal or modification of this Article IX by the members of the organization shall be prospective only, and shall not adversely affect any limitation on the personal liability of a director of the organization existing at the time of such repeal or modification.

ARTICLE X
AMENDMENTS

10.1 These Bylaws may be altered, amended, repealed or added to by an affirmative vote of not less than a majority of the members entitled to vote thereon.

The dining room at Volume II has old limestone walls spiced up with swashes of neon, big antique wine barrels, and artwork from the Big Easy. Storefront windows filled with a tropical plants afford a view of Commerce Street activity. The Wine Room is a few steps away from the dining area. It's a wonderful place to enjoy pre-dinner cocktails. Volume II is located at 205 N. Presa at Charles Court. It is 0.4 Miles from the Marriot Rivercenter, a 8 minutes walk