Welcome to Atlanta!

On behalf of the Program and Course Committees and the ACMEGS Board, I hope that you enjoy your visit to Atlanta, its climate, food and people.

This is our 8th Annual Conference of the ACMEGS and the fifth 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 among the members of ACNS who are not so familiar with MEG technology and its clinical applications. After all, MEG is a neurophysiological method, and we have been enjoying a productive synergy with our sister society (ACNS).

As usual, we kept the Annual Business meeting and the MEG-Economics component to the morning session to encourage interested ACNS members to join us subsequently for the scientific presentations.

The past year was another successful year for our Society, during which we improved our administrative issues with the Commonwealth of Massachusetts, reached out to other related professional organizations (i.e. ACNS, AES, ASET, ABRET, etc.), sustained our Center membership and continued to work on enhancing the value of the Society to its members and the value of the MEG Centers to their institutions. To this extent, we also engaged in a conversation with the Research Triangle Institute that performs annual US News & World Report Hospital rankings. We will have a very interesting scientific program this year with six presentations delivered by experts in the field of clinical MEG, and we are very glad to welcome among them Dr. Fernando Maestu from Spain.

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 are dedicated to enabling you, our members, to promote the appropriate use of Magnetoencephalography. We wish 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 Atlanta 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,
Anto Bagiđ, MD, PhD
President, American Clinical Magnetoencephalography Society

Organizing Committee:
Anto Bagiđ, University of Pittsburg, Pittsburgh PA
Susan Bowyer, Henry Ford Hospital, Detroit MI
Richard Burgess, Cleveland Clinics Foundation, Cleveland OH
Michael Funke, University of Texas, Houston, TX
Paul Ferrari, University of Texas at Austin, Austin, TX
John Ebersole, Atlantic Neuroscience Institute, Summit, NJ
Gretchen Von Allmen, University of Texas, Houston, TX
2014 ACMEGS Conference
Thursday, February 6, 2014
Westin Peachtree Plaza • Atlanta, Georgia

8:00 AM  Arrival / Breakfast Reception

8:45 AM  ACMEGS Presidential Address 2014
Welcome and Introduction (Anto Bagic, Pittsburgh, PA)

9:00 AM  Annual Business Meeting (for ACMEGS members only)
- Minutes of February 7, 2013, Business Meeting (Anto Bagic, Pittsburgh, PA)
- Presidents Report (Anto Bagic, Pittsburgh, PA)
- Financial Report (Susan Bowyer, Detroit MI)
- Public Relations Committee (Susan Bowyer, Detroit MI)
- New Business
  - Elections
  - Changes to Bylaws (Michael Funke, Houston TX)
- Affordable Care Act (ACA) and MEG (Michael Longacre, Crofton MD)

10:00 AM  Current Issues and Enduring Questions in Clinical MEG
- Everything You Always Wanted to Know About Source Models (But Were Afraid to Ask) (John Moran, Detroit MI)
- Whole-Brain Functional Connectivity in Focal Epilepsy (Deepak Madhavan, Omaha, NE)
- Clinical Application of MEG Source Connectivity Analysis (Wenbo Zhang, Minneapolis MN)
- MEG Results in the Operating Theater: How We Do it (Anto Bagic, Pittsburgh PA)

12:00 PM  Annual ACMEGS Photo Shoot / Lunch

1:00 PM  Platform Presentations

2:00 PM  Towards a New Biomarker in Dementia
- Why and What Biomarkers are Ideally Needed (Jim Becker, Pittsburgh PA)
- First Results of the Multi-Center MAGIC-AD Study (Fernando Maestu, Madrid ES)

3:30 PM  Coffee Break

4:00 PM  Update on Educational Initiatives
- Update on MEG Fellowship Curriculum (Rick Burgess, Cleveland OH)
- Update on MEG/EEG Technologist Activities (Janice Walbert, ABRET & Judy Ahn-Ewing, ASET)
- Update on Clinical Startup Recommendations (Paul Ferrari, Austin TX & Ron Gordon, Vancouver BC)

4:30 PM  Meeting Adjourn

6:00 PM  ACMEGS Dinner at ECCO
40 7th Street NE Atlanta, GA 30308 - (404) 347-9555
Ecco features seasonally inspired European cuisine and is conveniently located in the heart of Atlanta’s thriving midtown neighborhood, Ecco—which was named a “Best New Restaurant in America” by Esquire and “Best New Restaurant” by Atlanta Magazine when it opened in 2006.
Presidential Address 2014

Anto Bagić, MD, PhD
(Pittsburgh, PA)

February 6, 2014; Atlanta, GA

1/37 Bagić A, 2014

Presidential Address

ACMEGS Year In Retrospect (1/5)

- Society in good standing with Commonwealth of MA.
- Center Members (15): (30 delegated members).
- Individual Members: 15 (7 full + 8 associate)
- Changed a management agency from S&S to EDI.

Society In Good Standing With The Commonwealth Of MA

- Administrative Issues
  - All resolved
  - Collective efforts:
    - ACMEGS Board
    - EDI (Milwaukee, WI)
    - Attorney in Boston
    - Accountant in Pittsburgh
Gregory L. Barkley, M.D.
Vice Chair for Clinical Affairs
Comprehensive Epilepsy Program
Henry Ford Hospital
Detroit, MI

Michael Longacre
National Account Director
Special Projects - Payer Markets
Assurex Healthcare Inc.
Mason, OH

The ACMEGS Wise Men
Continued productive relationship with the ACNS.

The 2nd Board Retreat (Pittsburgh, PA; May 12-14, 2013).

Informal interactions with Elekta representatives (AES, December 6-10, 2013).
ACMEGS Year In Retrospect (3/5)

• Continued efforts on increasing the value to our (center) members:
  – Web-based resources (policies, CPGs, cases, jobs, etc.).
  – Addressing individual center member concerns.
  – Assistance to the new sites.
  – Strategic decision not to get on the CMS radar.
  – Newsletter (Check it out and contribute!).
  – Website redesign (upcoming).
Sustained efforts on increasing the value of the MEG centers to their institutions:

- Supplementing the items on the previous slide.
- Improving billing practices.
- Monitoring insurance situation.
- Engaging with the RTI (US News & World Report).
- Promoting clinical MEG and ACMEGS at ACNS, AES (ACMEGS boot and Dr. M. Funke had a public presentation), ASET, AAN, and other relevant conferences.
Hi Dr. Bagić,

Thank you for your recommendation to consider the inclusion of Magnetoencephalography (MEG) / Magnetic Source Imaging (MSI) in the Best Hospitals rankings. We have reviewed the issue and discussed it at length with a number of our project advisors around the country. The general recommendation was that while MEG/MSI is helpful for some conditions, it is not used widely in practice or considered a standard of care for adult neurology and neurosurgery at this point in time. However, with the growing use of MEG/MSI in research and practice this may change in the near future. Therefore, we plan to track the use of MEG/MSI over the next few years and if it becomes more widely used and we may include it in future rankings.

If you have further questions or concerns, please feel free to contact us at BestHospitals@rti.org.

Marshica Stanley, MA
Best Children’s Hospitals Project
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709-2194
Phone: 1-866-309-4561

Marshica
ACMEGS Year In Retrospect (5/5)

- ACMEGS educational efforts and activities:
  - Annual Course (3rd yesterday).
  - Survey on the training opportunities (Dr. R. Burgess).
  - Upcoming discussion later today (Moderator: Dr. R. Burgess).
  - Are we ready for a fellowship concept?
  - MEG technologists survey (ASET).
  - Web-based resources.
  - Individual help.

The 3rd Annual MEG Course

The 1st ACNS MEG SIG

The Coming of Age of Magnetoencephalography

Chair: Anto Bagić, MD, PhD
Pittsburgh, PA

ACNS Annual Meeting 2013
February 9, 2013
Miami, FL
Speakers

Michael Wagner, PhD [Compumedics Germany GmbH (f)]
Seeking the Sources: Dealing with Ill-Posed Problems of MEG and EEG Source Localization

Richard C. Burgess, MD, PhD (Cleveland Clinic, Cleveland, OH)
Myths Meet the Evidence: Gleanings for Increasing the Credence of MEG in Modern Epileptology

Michael E. Funke, MD, PhD (HTHSC, Houston, TX)
What Do You Mean What I and How I feel? Current Role of MEG in Brain Mapping

Anto Bagić, MD, PhD (University of Pittsburgh, Pittsburgh, PA)
Quo Vadis Clinical MEG?

Tuesday June 25th
07:30-09:00, Hall 3
ACMEGS Elekta-sponsored Symposium

What can epileptologists expect from MEG?
Chair: Richard Burgess (USA)
Identifying the epileptogenic zone with MEG: myths and realities - Richard Burgess (USA)
Evoked magnetic activity for mapping of eloquent cortical functions - Michael Funke (USA)
Assessment of language and resting state connectivity analysis - Susan Bowyer (USA)
November 21, 2013 (10:00 – 11:00 EST)

Richard Burgess, MD, PhD

“What the referring physician needs to know about magnetoencephalography (MEG)”
Special Interest Group
December 9, 2013

MEG Navigates to Neurosurgeons:
A Trajectory of Success

Coordinator: Anto Bagić, MD, PhD
University of Pittsburgh, PA
Washington, DC

AES/MEG SIG:
MEG NAVIGATES TO NEUROSURGEONS: A TRAJECTORY OF SUCCESS
Program

• 15:45 – 15:50 Introduction
• 15:50 – 16:10 Andreas Alexopoulos, MD, MPH
• 16:10 - 16:20 Panel & Audience Discussion
• 16:20 – 16:40 Stefan Rampp, MD
• 16:40 - 16:50 Panel & Audience Discussion
• 16:50 – 17:10 Jorge Gonzalez-Martinez MD, PhD
• 17:10 - 17:15 Panel & Audience Discussion
What Is Ahead?

- Sustain the current efforts on all fronts.
- Escalate efforts on increasing (center) membership.
- Cultivate the relationship with the ACNS.
- Structure relationship with Elekta.
- Foster the relationship with the AES, AAN, ASET, ABRET, ISACM.
- Increase our presence at appropriate neurosurgical conferences.
- Facilitate collaborative efforts on clinical research leading to new potential indications for MEG.

http://www.biomag2014.org/

19th International Conference on Biomagnetism
August 24-28, 2014 Florence, Italy

Greetings

ISACM Symposium!

Free Early Bird Registration for the Residents and Fellows!

5th Biennial Meeting of
ISACM 2015
June 25-29, 2015
Helsinki, Finland

International Society for the Advancement of Clinical MEG
Tune Your Travel Plans

- ACNS 2014 Annual Meeting (February 7 - 9, 2014; Atlanta, GA).
- Biomag 2014 (August 24 - 29, 2014; Halifax, Canada).
- ISACM 2014 (August 24 - 29, 2014; Halifax, Canada).
- AES 2014 Annual Meeting (December 5 - 9, 2014; Seattle, WA).
- ACMEGS 2015 Annual Meeting (February 5, 2015; Houston, TX).
- ACNS 2015 Annual Meeting (February 3-8, 2015; Houston, TX).
- ISACM 2015 (August 24 - 29, 2014; Halifax, Canada).

Acknowledgments

- ACMEGS Members (Centers and individuals)
- ACMEGS Board Members
- Michael Longacre & Gregory R. Barkley
- Elekta Neuromag Oy
  - Unrestricted educational grant
- ACS
  - Synchronized meetings, CME approval, Sharing posters
- ASET/ABRET
  - Educational programs for technologists
- S&S Management Inc. (Jackie Coleman, Marie Westlake)
- EDI (since July 1, 2013: Megan Kelley)

Caution

- Please do not share your institutional reimbursement and billing rates.
- Sharing such information could be considered collusion and may have legal ramifications for you and the society.
Have a Productive and Joyful Meeting and Continue to Promote Clinical MEG, CPGs and ACMEGS!
Minutes of February 7, 2013, Business Meeting (Anto Bagic, Pittsburgh, PA)

Presidents Report (Anto Bagic, Pittsburgh, PA)

Financial Report (Susan Bowyer, Detroit MI)

Public Relations Committee (Susan Bowyer, Detroit MI)

New Business
  o Elections
  o Changes to Bylaws (Michael Funke, Houston TX)

Affordable Care Act (ACA) and MEG (Michael Longacre, Crofton MD)

Adjourn
New Business: Elections
New Business: Changes to Bylaws

___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________
_________________________________________________________________________________________________
Affordable Care Act (ACA) and MEG
Michael Longacre, Crofton, MD

Once again CMS has reduced the reimbursement for MEG. This presentation will focus on the potential reasons for this reduction and proposed remedies by individual MEG Centers, the AAN and the ACMEGS.
GIGO!

Michael Longacre
National Accounts Director
Special Projects – Payer Markets
Assurex Health Inc.

Core Principle

Garbage in, garbage out (GIGO) refers to the fact that computers will unquestioningly process unintended, even nonsensical, input data ("garbage in") and produce undesired, often nonsensical, output ("garbage out").

Disclaimer

• The focus of today's presentation/discussion is to encourage the accurate capturing of costs associated with the use MEG.
• The purpose of this presentation/discussion is to encourage the accurate reporting of costs to CMS which is their basis for a calculated reimbursement for MEG.

Reminder: At no time should actual charges for MEG be mentioned or discussed.
Costs for Hospital Outpatient Services

CMS reported costs for hospital outpatient services, by HCPCS code for CY 2014

<table>
<thead>
<tr>
<th>HCPCS Code</th>
<th>APC</th>
<th>Payment Rate</th>
<th>Total Frequency</th>
<th>Minimum Cost</th>
<th>Maximum Cost</th>
<th>Median Cost</th>
<th>Geometric Mean Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>95965</td>
<td>0065</td>
<td>$1,740.86</td>
<td>88</td>
<td>$500.51</td>
<td>$11,602.83</td>
<td>$1,675.51</td>
<td>$1,802.13</td>
</tr>
<tr>
<td>95966</td>
<td>0065</td>
<td>$1,740.86</td>
<td>49</td>
<td>$198.01</td>
<td>$7,249.64</td>
<td>$1,650.53</td>
<td>$1,738.13</td>
</tr>
</tbody>
</table>

(MEG CPT Codes

95965 Magnetoencephalography (MEG), recording and analysis; for spontaneous brain magnetic activity (eg, epileptic cerebral cortex localization)

95966 Magnetoencephalography (MEG), recording and analysis; for evoked magnetic fields, single modality (eg, sensory, motor, language, or visual cortex localization)

95967 Magnetoencephalography (MEG), recording and analysis; for evoked magnetic fields, each additional modality (eg, sensory, motor, language, or visual cortex localization) (list separately in addition to code for primary procedure)
The UB-04 is a uniform institutional billing claim form used by hospitals, clinics, ambulatory surgery centers, rehabilitation centers, etc.
Definitions

• **UB-04**: The UB-04 is a uniform institutional billing claim form used by hospitals, clinics, ambulatory surgery centers, rehabilitation centers, etc.

• **Revenue Code**: Revenue codes are 3-digit numbers that are used on hospital bills to tell payors either where the patient was (department) when they received treatment, or what type of item a patient might have received as a patient.

• **Chargemaster**: A chargemaster is a listing of every single procedure that a hospital can provide to its patients. Hospitals have chargemasters because it helps to make the process of charge capture and billing more smoother. Charge masters have more than procedures on them. Pharmaceuticals, supply charges, and even some room charges are on charge masters.

• **Cost Report**: The cost report is an annual report submitted by all facilities participating in the Medicare program. The cost information and statistical data reported must be current, accurate and in sufficient detail to support an accurate determination of payments made for the services rendered.

Revenue Codes for MEG

**Revenue Codes** (Department)

0860 - Magnetoencephalography (MEG) – General Classification

0861 – MEG

MEG Revenue Codes

This was accomplished with the addition of MEG specific revenue codes for 2012.

Key Terms

- UB-04 - The UB-04 is a uniform institutional billing claim form used by hospitals, clinics, ambulatory surgery centers, rehabilitation centers, etc.
- Revenue Code - Revenue codes are 3-digit numbers that are used on hospital bills to tell payors either where the patient was (department) when they received treatment or what type of item a patient might have received as a patient.
- Chargemaster - A charge master is a listing of every single procedure that a hospital can provide to its patients. Hospitals have charge masters because it helps to make the process of charge capture and billing move smoother. Charge masters have more than procedures on them. Pharmaceuticals, supply charges, and even some room charges are on charge masters.
- Cost Report - The cost report is an annual report submitted by all facilities participating in the Medicare program. The cost information and statistical data reported must be current, accurate and in sufficient detail to support an accurate determination of payments made for the services rendered.

Definitions
Charge

- The charge dollar amount represents the amount charged for the item and the amount that will appear on the patient’s detailed bill.
- The charge does not indicate the reimbursement amount.
- Some facilities prefer to use the term "price" instead of "charge."
- There is no magical formula to assist facilities with setting the correct charge for a procedure.
- The charge is usually based on how much a procedure costs to perform and marked up a set percentage to cover expenses.

Key Terms

- UB-04: The UB-04 is a uniform institutional billing claim form used by hospitals, clinics, ambulatory surgery centers, rehabilitation centers, etc.
- Revenue Code: Revenue codes are 3-digit numbers that are used on hospital bills to tell payors either where the patient was (department) when they received treatment, or what type of item a patient might have received as a patient.
- Chargemaster: A chargemaster is a listing of every single procedure that a hospital can provide to its patients. Hospitals have chargemasters because it helps to make the process of charge capture and billing more smoother. Chargemasters have more than procedures on them. Pharmaceuticals, supply charges, and even some room charges are on chargemasters.
- Cost Report: The cost report is an annual report submitted by all facilities participating in the Medicare program. The cost information and statistical data reported must be current, accurate and in sufficient detail to support an accurate determination of payments made for the services rendered.
Cost Report

The Medicare Cost Report is the core basis of Medicare payment system. For almost five decades the government has used the Cost Report to calculate payments to hospitals. So over the decades any good CFO would make sure that his charges maximized his governmental payments. Medicare and Medicaid usually make up 60% or the his total payments. Some 53 years ago charges became a substitute for statistics and cost accounting to estimate how much the government was going to pay you. Hospitals get paid based on DRGs, but still must do a Cost Report to justify the DRG amounts.

CMS Responds to ACMEGS Request for Separate Cost Line

CMS-1525-P
Federal Register / July 18, 2011/ Proposed Rules / page 64

....... 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.

CMS Responds to ACMEGS Request for Separate Cost Line

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.
Definitions

- **UB-04**: The UB-04 is a uniform institutional billing claim form used by hospitals, clinics, ambulatory surgery centers, rehabilitation centers, etc.

- **Revenue Code**: Revenue codes are 3-digit numbers that are used on hospital bills to tell payors either where the patient was (department) when they received treatment, or what type of item a patient might have received as a patient.

- **Chargemaster**: A chargemaster is a listing of every single procedure that a hospital can provide to its patients. Hospitals have chargemasters because it helps to make the process of charge capture and billing move smoother. Charge masters have more than procedures on them. Pharmaceuticals, supply charges, and even some room charges are on chargemasters.

- **Cost Report**: The cost report is an annual report submitted by all facilities participating in the Medicare program. The cost information and statistical data reported must be current, accurate and in sufficient detail to support an accurate determination of payments made for the services rendered.

MEG Center To Do List

Reach out to your administration:

- Obtain a copy of UB-04 for a Epilepsy Medicare patient.
  - CPT Code
  - Revenue Code
  - Reasonable Charges
Costs for Hospital Outpatient Services

CMS reported costs for hospital outpatient services, by HCPCS code for CY 2014

<table>
<thead>
<tr>
<th>HCPCS Code</th>
<th>APC 0065</th>
<th>Payment Rate</th>
<th>Total Frequency</th>
<th>Minimum Cost</th>
<th>Maximum Cost</th>
<th>Median Cost</th>
<th>Geometric Mean Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>95965</td>
<td>0065</td>
<td>$1,740.86</td>
<td>88</td>
<td>$500.51</td>
<td>$11,602.83</td>
<td>$1,675.51</td>
<td>$1,802.13</td>
</tr>
<tr>
<td>95966</td>
<td>0065</td>
<td>$1,740.86</td>
<td>49</td>
<td>$198.01</td>
<td>$7,249.64</td>
<td>$1,650.53</td>
<td>$1,738.13</td>
</tr>
</tbody>
</table>

For 2014, CMS finalized its policy to group all of the magnetoencephalography (MEG) codes (95965-95967) in APC 0065. The AAN disagrees with CMS’ decision to move MEG code 95965 from APC 0066 to APC 0065. We also do not believe that APC 0065 captures the cost of add-on code 95967. In fact, it appears that all of the costs for CPT code 95967 are lost since it is now packaged with CPT code 95966.

The cuts in reimbursements are dramatic and unsustainable for neurologists who perform MEG. The reimbursement does not cover the cost of doing business and are likely to impact patients’ access to this service. CMS should work with the AAN to develop a solution to this problem and assign more appropriate APCs—whether it is identifying existing APCs or developing new APCs.
ACMEGS To Do List

• Access MedPAR data base to determine accuracy of MEG claims.
• Continue our partnership with the AAN in dialogues with CMS to find potential solutions.
• Provide a resource to the MEG centers to assist in determining appropriate reporting of MEG on the UB-04, Chargemaster and Cost Report.

Thank you for your time and attention!

ICD-10

ICD-10 Implementation October 1, 2014
In discussions of MEG based analysis of brain activity, the topic of source models have traditionally been restricted to discussions of the merits of various forward modeling and source imaging techniques. These topics are important but highly technical and can require a high degree of nuance in their application to bioelectric imaging. Rather, important factors that underlies measurement of brain signals and subsequent construction of imaging methods are detailed. Then, the emphasis of the presentation shifts to source models which consist of interacting brain regions. In these models, most bioelectric source activity is determined by received signals from other regions. Thus, a network source model is mathematically constrained to account for these network interactions as well as explain the measured MEG data. In particular, a network source model is constructed where MEG coherence imaging is used to identify active network sites while fiber tract based connectivity determines the physical site-to-site connections. Clinical utility of this approach is demonstrated by identifying the site of an epileptic focus based completely on subsequent parameter analysis of the constructed epileptic source model network.
**BIOELECTRIC SOURCE SPACE**

Every thing you wanted to know about it? Better yet, some important things you should know

John E Moran PhD
Biomedical Physicist
Epilepsy Center
Cleveland Clinic

Sources of Electromagnetic Signals

EXTERNAL NUSANCE SOURCES:
- Distant sources: Elevators, trucks, cars, trains, power lines
- Near By Sources: Electrical Artifact: (stimulators, monitors) Magnetic Artifact: (teeth, etc)
- Bio-electric Artifact: (heart, eye movements)

BRAIN NETWORK SOURCES
- NUSANCE SOURCES
- Spontaneous Activity
- Event Related Activity
- INTERESTING SOURCES
- Spontaneous Activity
- Event Related Activity

Primary Guiding Factor of Source Space Analysis

ACHIEVE THE MEASUREMENT GOAL:
Reliably measure signals of interest as required as a basis for quantifying a specific feature of Brain Network Activity
Factors in achieving the goal

Sensor Type and Design: (Signal Sensitivity and Specificity)
- EEG, ECoG, MicroElectrodes,
- MEG (Magnetometer, Axial and Planar Gradiometer)

Auxiliary Signal Processing:
- Signal extraction and frequency band isolation
- Signal-to-Noise enhancement

Forward Inversion Methods:
- Spherical, BEM, FEM, homogeneous conductor?
- Cortical Surface Constraint versus Full Gray Matter Volume

Goal oriented Imaging Technique Selection: ECG, Beamformer, Current Density

Brain Network Analysis of imaged activity

MEG Sensor Configurations

The Elekta Neuromag sensor elements consists of two orthogonal planar gradiometers and one magnetometer coupled to a SQUID

The 4D Neuroimaging sensor elements consists of either axial gradiometers or magnetometers coupled to a SQUID

CTF utilizes axial gradiometers coupled to a SQUID

Planar Gradiometer   Axial Gradiometer   Magnetometer

Sensitivity of Sensors to Brain Source Location
Spherical Head Model:
Current Components

- Head Volume Sensitivity:
  - Magnetometer
  - Axial Gradiometer

Half-Sensitivity Volume (green)
Magnetometer > Gradiometer
Zero Sensitivity under sensor

Head Volume Sensitivity:
Planar Gradiometer (along axis)

Half-Sensitivity Volume (green)
Along the gradiometer axis
Zero Sensitivity loop between sensors
Head Volume Sensitivity:
Planar Gradiometer
(across axis)

Half-Sensitivity Volume (green)
Along the gradiometer axis
Zero Sensitivity between sensors

Sensor Sensitivity & Specificity
Magnetometer & Axial Gradiometer
- Significant Sensitivity to Deep Cortical Sources
- Large Half Sensitivity Volume is donut shaped with hole in center.
- No sensitivity to sources directly under sensor
- Gradiometer Sensitivity depends on coil separation.

Planar Gradiometer
- Significantly greater specificity to shallow sources under sensor
- Low sensitivity for deep sources
- Small Half Sensitivity Volume.

Planar Gradiometers and Axial Sensors Array
Utilize Information in Sensor Coupling to Neural Sources
(Neuromag configuration)
Magnetometer Array = Planar Gradiometer Array (mathematically equivalent)
Planar/Axial Gradiometer Array = Planar Gradiometer Array of Planar/Axial Gradiometers

Mathematical Equivalence utilized for:
- Artifact and noise suppression
- Extraction of signals of interest
- Imaging locations of activation
- Calculation of Brain Coherence


**MEG Imaging:**
The Magnetic Field Equation for Active Sources

\[ \mathbf{B} = \mathbf{GQ} \]

- \( \mathbf{B} = \) MEG DATA (*Known but corrupt*)
- \( \mathbf{Q} = \) Brain Electric Source Activity (*unknown*)
- \( \mathbf{G} = \) Gain matrix = \( \Delta \mathbf{B}/\Delta \mathbf{Q} \) (*unknown*)

(Many Sources generate the same MEG Data)

**MEG Imaging:**
The Active Source Equation for MEG data

\[ \mathbf{Q} = \mathbf{WB} \]

- \( \mathbf{B} = \) MEG DATA (*Known but corrupt*)
- \( \mathbf{Q} = \) Brain Electric Source Activity (*unknown*)
- \( \mathbf{W} = \) Imaging Weight matrix = \( \Delta \mathbf{Q}/\Delta \mathbf{B} \) (*unknown*)

(\( \mathbf{Q} \) depends on assumption to calculate \( \mathbf{W} \))
Strategies for calculating $W$

1. Optimize $W$ to satisfy Source Selectivity (beamformer)
2. Optimize $W$ to satisfy statistical goal or property
3. Optimize $W$ to satisfy combination of 1 and 2
4. Introduce added constraints:
   - anatomical constraints
   - number of source constraint (ECD)
   - mathematical uniqueness, stability
5. Recursive estimation, L norm (non-linear, focal $Q$)
6. Particle Filtering, Kalman Filter, $W(t)$, non-linear

Calculation of $W$: Calibration
After Estimating $Q$ by other means

$Q_e = WB_f \quad \Rightarrow \quad W = Q_eB_f^{-1}$

- $B_f =$ MEG Forward Data ($\text{Known}$)
- $Q_e =$ Brain Electric Source Activity ($\text{known}$)
- $W =$ Imaging Weight matrix $= \Delta Q/\Delta B$ ($\text{unknown}$)

ECD

Grover EM / Neuroradiol. 2006 Apr;77(2):161-6
MUSIC  Find Multiple Sites of Activity
(Brainstorm Software)  (SEF 120 msec)

BEAMFORMERS
Site Specific Imaging Filters of Independent Activity

Beamformer analysis of spike propagation of two MEG spike-wave complexes. Both showed predominant epileptic activity frontal mesial bilateral and perisylvian region, however propagation sequence was different (blue to cyan signifies increasing activity).

Activity propagated from left frontal mesial area to larger frontal areas including polar and basal, bilateral frontal and subsequently to perisylvian areas. (Stefan et al., 2009)

Extended Source Imaging
Minimum Norm, Focuss, MR-Focuss, others
Source Space: Network Analysis
Coherence Imaging utilizes FFT transform
Phase Synchrony Analysis narrow frequency band analysis of signal phase
Directed Network Analysis requires knowledge of physical connectivity and signal timing

Coherence Imaging

- Spontaneous Activity (Default Mode Network)
  - Persistently Active Network Sites
  - Long Data Study
  - Average Region Functional Network Connectivity
- Evoked Activity
  - Visualize Goal directed Network
  - Estimate Strength interaction
  - Forward and backward Information Flow requires Grainger
    Causality Analysis of Imaged Activity

Coherence Imaging

- 10 minutes of MEG data sampled at 508 Hz
- Filtered 3-50 Hz and Heart artifact removed
- Divided into 7.5 second intervals for imaging and coherence calculations
  - ICA for extracting neuronal bursts of brain activity
  - MR-FOCUSS/Coherence imaging for determining the global extent of the seizure network and the local spectrum of overall network coherence and connectivity.
- FFT with 256 point hanning window and 25% overlap
- Coherence results for all 7.5 second interval are averaged.
  - Multiple runs processed to check for stability of results
Diagnostic Utility

Fiber Tract Connectivity

Fiber Tract based Network Analysis

Physical Connectivity Network
  Connectivity by tract for 375 anatomical/functional sites

Functional Connectivity Sites
  Coherence and activity amplitude identify active sites

Directed Connectivity Strength
  Calculated for directly connected active sites
  Activity correlation lags used to define directionality

Unique Network Input
  Signal components not derived from network interaction
Coherence & maximum connection network

Unilateral Right Tinnitus high coherence Left Auditory Cortex

Note: Red & Orange in Left AC is most active.

Schizophrenia Network

Visualize direct and indirect connectivity between active regions

Identify Epileptic Zone
30 patients with good outcome (mark surgically removed tissue)
• ACHIEVE THE MEASUREMENT GOAL:
  • Reliably measure signals of interest as required as a basis for quantifying a specific feature of Brain Network Activity
  • Utilize appropriate signal processing to quantify the active network and network interactions.
  • Quantify features of the network that are of interest
Thank you for your interest

moranfh@gmail.com
The analysis of interictal epileptiform discharges (IEDs) using magnetoencephalography (MEG) is utilized for the localization of seizure onset zones in the presurgical planning of epilepsy patients. Additionally, resting-state functional connectivity analyses using the IED area may provide novel insight into the underlying brain networks. In this study, we evaluate whether chronicity of seizures is related to whole-brain functional connectivity metrics using the area of IED generation (derived from MEG) as the seed region. We found a positive correlation between the duration of seizures and beta-band functional connectivity between the epileptogenic zone and other brain areas. This suggests the presence of inhibitory GABAergic modulation of distal brain regions in response to chronic epileptiform activity. We are also trying to extend this concept to explore functional connectivity based relationships between intracranial EEG and MEG, in order to develop presurgical analysis protocols.
MEG Connectivity at UNMC

Deepak Madhavan, M.D.
Tony Wilson, Ph.D.
Hannah Kyllo, B.S.

Rationale

• Localization of Interictal Epileptiform Discharges (IEDs) using MEG is a reliable indicator of the epileptogenic onset zone
• IEDs have also been examined in the setting of resting state functional connectivity
  — Primarily using EEG/fMRI
  — Involvement of default mode network, thalamocortical circuits, etc.
• Goal of our study was to evaluate MEG resting functional connectivity
  — Using localized areas of IED generation as seed points
  — Relating to the time frame of each patients’ epilepsy
• We anticipated that whole-brain connectivity increased as a function of the age of the epilepsy
  — Recruitment of distal brain regions into the epileptic pathway due to chronic seizure activity

Data Acquisition

• 12 adults (4 female) with intractable CPS
  — Mean number of AEDs tried and failed: 5.67
  — Mean age: 40.58 years
  — Range of epilepsy duration: 40-408 months
• Sleep deprived MEG
  — Acquisition bandwidth 0.1-330 Hz
  — 1 kHz sampling rate
  — Noise reduction with signal space separation with temporal extension
Source Analysis

- Following tSSS, raw MEG signal was filtered 1-45 Hz
- IEDs localized using ECD from 204 gradiometer sensors
- ECDs overlaid onto MRI images
- Dipole clusters used as seed region for connectivity analyses
  - Phase coherence was computed using a dense grid of regional source spaced equidistantly and the IED area as the seed region.

Connectivity Analyses

- We examined the relationship between the duration of epilepsy and phase-locking value between the epileptogenic zone and all other brain regions within the delta (1.0-4 Hz), theta (4-7.0 Hz), alpha (8-14 Hz), and beta (14-30 Hz) frequency bands using Pearson-correlation analyses

Results

- Pearson correlation indicated that duration of epilepsy was positively correlated with the amplitude of beta-band functional connectivity between the epileptogenic zone and other brain areas
Discussion

• Why only the beta band?
  – Increased beta activity thought to be related to increased GABAergic modulation
    • Possibly due to increased inhibitory interneuron activity?
  – Presence of increased beta band functional connectivity could indicate cerebral mechanisms responsible for maintaining local and remote inhibitory environments for the endogenous control of seizures

Further Work

• Can connectivity measures be used to demonstrate relationships between seizure onset zones in intracranial EEG vs MEG?
• Can identification of ‘hyper-connected’ areas within the visually identified seizure onset zone be used for more focal ablative surgical approaches?

Intracranial EEG “Accounting”

• Isolated epileptiform spikes (IEDs) from intracranial EEG
• Measured correlation of time-frequency for each spike and ran coherence tests (with BESA software) using each electrode within the visually identified seizure onset zone as a seed for all other electrodes
• PLV was computed for signals between 4-50 Hz at a resolution of 2.0 Hz and 25 ms then averaged across time for each frequency bin
• Procedure was iterated using each electrode within the SOZ as the seed for PLV computation
• We then identified the frequency bins where the PLV was at least one SD above the grand mean, and computed the percent of frequency bins (per electrode pair) where this threshold was exceeded.
Lingering Questions

- Can we analyze connectivity measures using either MEG or intracranial EEG to isolate hyperconnected regions of the seizure onset zone?
  - Would focal ablation of these areas be necessary and/or sufficient in treating seizures?
  - Possible strategy for less invasive laser guided therapies

References
Thank You!
Current Issues and Enduring Questions in Clinical MEG

Clinical Application of MEG Source Connectivity Analysis

Wenbo Zhang, Minneapolis, MN

MEG/MSI has been approved for pre-surgical epileptogenic zone localization for more than 10 years. Epileptogenic zone can be defined by MEG when interictal magnetic fields clustered. However the MEG network study of epilepsy remains scarce, especially for neocortical epilepsy. eConnectome (Electrophysiological Connectome) is an open-source MATLAB software package for imaging brain functional connectivity from electrophysiological signals. It provides interactive graphical interfaces for EEG/ECoG/MEG preprocessing, source estimation, connectivity analysis and visualization. Connectivity from EEG/ECoG/MEG can be mapped over sensor and source domains. It is free for download at http://econnectome.umn.edu . Cases will be presented analyzed with the methodology. It provided a robust way to analyze source connectivity of MEG/MSI using directed transfer function (DTF) analysis. More case analysis should be done to better understand the clinical significance of DTF analysis. In conjunction with diffusion tensor imaging tractography, a more complete picture of interictal epilepsy network can be drawn.
Clinical application of MEG Source Connectivity Analysis

Wenbo Zhang, MD, PhD
Minnesota Epilepsy Group, PA,
Allina Health and Minnesota Children's Hospitals and Clinics
Adjunct Faculty of University of Minnesota

Yakang Dai, PhD,
Department of Biomedical Engineering,
University of Minnesota
Currently at the Chinese Academy of Sciences

Colleagues and Collaborators

Minnesota Epilepsy Group at Allina Health and Minnesota Children's Hospitals & Clinics
Deanna Dickens, M.D., Epileptologist, Adjunct Faculty of University of Minnesota
Jason Doescher, M.D., Pediatric Epileptologist, Adjunct Faculty of University of Minnesota
Brian Owens, Neurodiagnostic Technologist, IGS technologist

University of Minnesota, Department of Biomedical Engineering
Bin He, PhD, Distinguished McKnight University Professor, Medtronic-Bakken Endowed Chair, Director, Institute for Engineering in Medicine, Director, Center for Neuroengineering
Yakang Dai, PhD, Post-doctoral associate (currently Professor of Biomedical Engineering, Chinese Academy of Sciences)

All Patients from Minnesota Epilepsy Group
• Pediatric Epileptologists
  Michael D. Frost, Frank Ritter, Jason Doescher, Dimitros Arkilo
• Adult Epileptologists
  Patricia Penovich, Deanna Dickens, James White, Julie Hanna, Paul Atkinson, Michaela Chatman
**Clinical MEG/MSI**

- CPT 90955 Magnetoencephalography, recording and analysis for spontaneous brain magnetic activity (e.g. epileptic cerebral cortex localization)
- MEG: non-invasive testing between phase 1 and 2 for medically refractory epilepsy
- Guide subdural grid placement or other invasive procedure; or more ambitiously guide resection?!

---

**Interictal magnetic fields**

- Spikes with <70ms fast electromagnetic transients; sharps 70-120 ms followed by a slow wave lasting a few hundred ms
- Spikes propagate, could lead a seizure
- Cluster of interictal spikes indicate the epileptogenic zone
- Area of neurons simultaneously firing can be detected: 4-6 cm² for MEG; 6-10 cm² for EEG.
- At least 5000 neurons firing simultaneously for MEG to be detected.

---

**Interictal magnetic fields**

- “The Neurosurgeon wants to know both the seizure onset zone and the region of immediate cortical spread to determine the epileptogenic zone to be resected.” Rose et al. Front Neurol. 2013
- Primary epileptogenic zone or secondary?
- Patterns of interictal magnetic fields propagation?
- Defining the “quick spread zone” or remote propagation?
Techniques

• Equivalent dipole model of EEG/MEG. (Ebersole 1991, Sutherling 1989)
• Beamformer Analysis (Robinson and Vrba, 1999; Stefan 2009; Rose 2012)
• Minimum Norm Estimates (MNE) (Hämäläinen 1989, Tanaka 2010)
• Granger causality, directed transfer function (DTF) (Granger 1969, Kamiński and Blinowska 1991, Dai 2012)
• Other techniques: Frequency domain analysis, independent component analysis (ICA) (Malinowska 2013)

Method

eConnectome

http://econnectome.umn.edu

MATLAB-based, with GUIs
Support MEG/EEG/ECoG
Open-source, GPL

Electrophysiological Connectome
Connectivity analysis of the preprocessed MEG data can be performed.

Cortical sources can be reconstructed from MEG data and connectivity analysis can then be performed.

Connectivity patterns among MEG sensors and cortical regions of interest (ROIs) can be visualized over the MEG sensor surface and realistic cortical surface respectively.

The MEG source connectivity analysis was used to analyze interictal MEG spikes.
Cases Analyzed

- Five surgical cases from Minnesota Epilepsy Group including 2 temporal lobe epilepsy cases, 3 neocortical cases with multiple foci
- Neocortical cases: multiple epileptogenic foci and more interictal zones
- These are the most challenging cases clinically and for the connectivity study, especially neocortical cases
- The data (Y.D.) is analyzed without prior clinical knowledge

Temporal Lobe Epilepsy

- Majority of TLE is mTLE, few iTLE
- Mesial to lateral temporal lobe
- Temporal to frontal
- To Contralateral temporal lobe
- Ipsilateral frontal central cortex
Temporal lobe epilepsy

Frontoemporal spike - MNE approach
Frontoemporal spike- MNE approach

- The propagated frontal region: secondary, no-resection
- 4-86 ms means propagated to the secondary region
- More correlated with the path "mediated by uncinate fasciculus, which connects anterior temporal lobe and inferior frontal lobe (Makris and Pandya, 2009)."
- "spatiotemporal analysis of MEG spikes may provide more accurate information of spike propagation in our patients than EEG. It may be clinically useful in the presurgical evaluation of epilepsy."

Tanaka et al. Neuroimage. 2010

Temporal Lobe Epilepsy

There are 2 temporal lobe epilepsy cases in our group. Both primary foci were identified. Secondary or propagated regions include inferior frontal lobe and central region.
Temporal Lobe Epilepsy

- TLE patients included in our group: In 20 ms, the source propagated to 1. inferior frontal region. 2. central Rolandic region
- No DTI for these 2 TLE patients

Neocortical epilepsy

- Surgery Trend: temporal to extratemporal; adult to pediatric
- Extratemporal neocortical epilepsy is challenging
- Pattern of neocortical spike travel is different from that of the temporal spikes
- The neocortical seizure propagation varies depending on the lobe(s) of seizure onset (Dlugos and Sperling 2000)
Neocortical epilepsy

- In patient one, one spike identified 3 primary regions
- Maybe multiple regions active simultaneously
- Epileptogenic zones spread quickly?
- The independent epileptogenic zones interconnected through axonal tracts or cortical-cortical excitatory connectivity
Neocortical epilepsy

- Diffusion Tensor Imaging (DTI)-tractography demonstrated fibers more connected on epileptogenic region than the same region contra-laterally using similar volumes of interest in this patient
- The abnormal tracts may have facilitated the patient’s seizure
- Is this a phenomenon just in TSC patients or in other patients as well?
- Cortical-cortical propagation may co-exist too

Extratemporal neocortical

- Extratemporal neocortical extra-temporal neocortical z 23 ms between t1 and t2

Extra-temporal neocortical
Summary

- Source connectivity for interictal MEG spikes is feasible with directed transfer function analysis
- The source analysis identified the primary epileptogenic zones and the feature of their propagation
- eConnectome software is available for download at http://econnectome.umn.edu/
- More connectivity MEG/MSI study needed, especially neocortical epilepsy in conjunction with DTI tractography

Thanks for your attention!
Current Issues and Enduring Questions in Clinical MEG

MEG Results in the Operating Theater: How We Do It
Anto Bagic, Pittsburgh, PA
MEG Results In The Operating Theater: How We Do It

Anto Bagić, MD, PhD
Chief, Epilepsy Division
Chief Scientific Advisor, MEG Research
Director, UPMC MEG Epilepsy Program
Associate Professor, Neurology & Neurosurgery
Director, University of Pittsburgh Comprehensive Epilepsy Center (UPCEC)

February 6, 2014
Atlanta, GA

Disclaimers

- Unavoidable use of brand names for various products does not represent an endorsement or any preferential treatment.
- Sharing personal experience necessitates sharing a brand-specific procedure.
- No other specific personal disclosure pertaining to this presentation.

Outline

- Introduction: only 20 short years ago....
- Dizzy digital world (not all DICOMs are created equal?)
- Current reality: “all ingredients” ≠ a tasty meal
- Our institutional slippery road towards MEG merriment
- Implications on reporting – internal vs. external
- Flow of (external) MRTIs and MSIs at UPMC
- Surgical planning: example in Brainlab
- Summary & Conclusions
In Only 20 Short Years...

Over the past 20 years, radiology has seen tremendous advances in the field. In the past, radiologists relied on film for images, which required darkroom work and was time-consuming. Today, digital radiology has revolutionized the field.

Issues of Imaging:

Towards filmless and distance radiology

Over the past 20 years, radiology has changed dramatically. In the past, radiologists relied on film for images, which required darkroom work and was time-consuming. Today, digital radiology has revolutionized the field. The advantages of digital imaging are numerous: images can be viewed on monitors, printed, and stored electronically, reducing the need for film and darkrooms.


FRIEDMANN H.

Data fusion in medical imaging: merging multimodal and multipatient images, identification of structures and 3D display aspects

C. Barthet*, D. Leturque, L. Le Brequer, P. Lachmann, B. Galizia

Abstract

Data fusion in medical imaging can be seen into two main processes: multimodal fusion and multipatient fusion. This paper focuses on multimodal fusion, particularly on fusion of multimodality imaging systems in a clinical setting. The main contributions of the work presented here concern the implementation of multimodal 3D visualization techniques. The first contribution is the development of a framework for the design and implementation of a multimodal fusion system. The second contribution is the development of a tool for the visualization of multimodal data. The third contribution is the development of a technique for the registration of multimodal data. The fourth contribution is the development of a technique for the visualization of multimodal data. The fifth contribution is the development of a technique for the visualization of multimodal data.

*Corresponding author: C. Barthet. E-mail: c.barthet@univ-paris-diderot.fr

Keywords: medical imaging, multimodal fusion, multipatient fusion, 3D visualization, registration, visualization, clinical setting.


81
Intra-individual Image Fusion

Anatomical and Functional Imagery
- MRI  CT  2D/3D Angiography  SPECT  PET  EEG  MEG

Multimodality Registration
- Anatomical & Instrumental Framework
  - Skin Markers
  - Segmentation and Labeling
  - Geometrical Features
  - Statistical Features

Patient Data Base
- 3D Display/Interaction
- Multiple Objects/Volumes Display
- Graphics/Voxels Display
- Interactive Labeling
- Playback Procedures

Multimodality Registration
- Matrices
- Anatomical Labels

MEG or MSI & PACS in MEDLINE

January 3, 2014

- MEG & PACS => 5 hits/3 relevant (1993)
- MSI & PACS => 0 hits
- MEG & DICOM => 2 (2006 & 2009)
- MSI & DICOM => 0

• Indexing problem?
• Terminological turmoil?
• Benign neglect?
• Irrelevance?

Terminological Turmoil?

• "A direct neurophysiologic technique" vs. imaging method?
• "Neuroimaging modalities, such as functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), electroencephalography (EEG), and near infrared spectroscopy (NIRS), share similar application purposes, imaging protocol, analyzing methods, and data structure..." [Nakai et al. Magn Reson Med Sci. 2008;7(3):141-55.]

• Are MEG and MSI really synonyms?
• Are there implications for the field?
In conclusion, the modern combined PET/MR systems presently available have the potential to achieve almost optimal coregistration. Knowing the intrinsic limitations of such systems will facilitate future improvements in hardware and image processing.

Key points

• Rapid assimilation of external imaging into a PACS system is essential.
• But data distribution using portable media also carries some disadvantages.
• A DICOM data uploader incorporates studies from portable media to hospital workflow.
• Automated media handling or XDS should solve the steadily growing storage problem.
• Software improvements will facilitate the steady increase in the amount of CDs processed.

Impact of cross-enterprise data sharing on portable media with decentralised upload of DICOM data into PACS

K. V. C. S. Cann, K. C. Z. Woestenburg, J. Berkenkotter

Key points

• Rapid assimilation of external imaging into a PACS system is essential.
• But data distribution using portable media also carries some disadvantages.
• A DICOM data uploader incorporates studies from portable media to hospital workflow.
• Automated media handling or XDS should solve the steadily growing storage problem.
• Software improvements will facilitate the steady increase in the amount of CDs processed.
EIMS
(External Images Management System)

- Currently implemented at UPMC (Pittsburgh, PA)
- Locally developed software
- Any networked computer can be set to run it
- Authorized (via Active Directory authentication) users only
- Two Parts:
  - 1. Requesting Phase (May be done by many users)
  - 2. Filing Phase ("File Room" – done by the Radiology Support staff or other designated users) – interrogates and identifies files on a CD, proceeds with importing it after authentication
  - Takes any "native DICOM" images and imports in ClinicView

DICOM Wrapper

- Of the shelf or locally-developed solutions
- "Wraps" (DICOMizes) other types of files (images)
- "Wrap the image in a DICOM envelope and add important data that is required by the DICOM standard in order to enable all DICOM enabled applications to read and display the image correctly".*
- Examples: JPEGs (i.e. skin lesions, etc.), PDF (i.e. our PSM modalities, etc.), etc.

Illustration of DICOM element encoding in a DICOM data stream*

*The DICOM standard, Chapter 5.
About DICOM

DICOM — Digital Imaging and Communications in Medicine — is the international standard for medical images and related information (ISO 12052). It defines the formats for medical images that can be exchanged with the data and quality necessary for clinical use. DICOM is implemented in almost every radiology, cardiology, imaging, and laboratory system worldwide. It is also used in other medical domains such as ophthalmology and dentistry. With tens of thousands of imaging devices in use, DICOM is one of the most widely deployed healthcare messaging standards in the world. There are literally billions of DICOM images currently in use for clinical care. Since its first publication in 1993, DICOM has revolutionized the practice of radiology, allowing the replacement of X-ray film with a fully digital workflow such as the Internet has done for the platform for raw consumer information and services. In cardiology, DICOM has very effectively "changed the face of cardiac medicine." From the emergency department, to cardiac stress testing, to stroke center detection, DICOM is the standard that makes medical imaging work — for doctors and for patients.

1993 (ISO 12052)

What is DICOM?

DICOM is an international standard developed by the American College of Radiology and the National Electrical Manufacturers Association (NEMA) in 1993.

Who needs DICOM?

- Radiologists
- Imaging centers and specialists
- Physicians
- Hospitals
- Manufacturers of medical imaging equipment
- Academics in radiology
- Students and nurses
- Patients

Why Benefits From DICOM?

- Physicians have better access to images and images more efficiently
- Patients benefit from faster and more efficient care when the DICOM standard is used
- Paperless benefit from this faster and more efficient process through lower overall cost of care
Recapitulation Of My Workflow

1. Complete MEG-EEG analysis (In my case using Neuromag software suite)

2. Push MSIs from Mrilab to PACS:
   1. “File => Print” => a pop up window “Print what, where and how?”
   2. Qualitation: Export SELECTED (Exclude SCP_Points) can export also to DIP)
   3. Size: Constrain to square: CONVERSE
   4. Format: Gray-scale, Image & LineArt, Binary – selected

3. Click Export button at LLC => Output Options window pops up

4. Select Series and TYPE IN DICOM Accession Number generated by ImageCast (DO NOT SELECT
   “Use DICOM overlay planes”)

5. Select OK at LLC

3. Finalize TYPING (dictating option exists!) report on an Office PC

4. Complete reporting in ImageCast (a copy paste option used currently)

Outcome:
MSIs are available for exporting to any designated networked workstation as any other DICOM images.
Exporting MSIs from Mrilab to PCAS

Some Intricacies Remain...

Example Of MSIs Exported to PACS
Example Of PSM Exported to PACS

Example of Ictal SPECT

Example of Image Fusion:
MRI + MSI + Ictal SPECT
Example of Image Fusion:
MRI + MSI + SPECT Subtraction 1SD

Example of Image Fusion:
MRI + MSI + SPECT Subtraction 2SD

Example of Image Fusion:
MRI + MSI + SPECT Subtraction 3SD
Summary & Conclusions (1/2)

• Rapid progress towards filmless and remote radiology opened many new possibilities in an effective and creative use of imaging in clinical practice.

• Inspired researchers eliminated cardinal obstacles in multimodal image integration.

• “Multiple solutions” do not translate into a streamlined logistics for an easy integration of MEG/MSIs into PACS.

• Technology per se is not an obstacle in most institutions and instances.

• Enormous amount of energy and time is wasted unnecessarily on bringing the players to the table and making sure that everybody truly hears the same and commits.

Summary & Conclusions (2/2)

• Device vendors appear suboptimally disposed and “it is not that rare” that the devices produced by the same vendor don’t communicate seamlessly.

• Currently, in most places, invested MEG clinicians have to facilitate focused team efforts on eliminating final “remaining trivialities”.

• Your reasonable understanding of the big picture, and flexible persistence of forging a productive working relationship with hopefully equally flexible and enthusiastic local radiology staff coupled with a favorable IT environment remains necessary.

• At this point, there is no objective impassable obstacles for the complete and practical routine PACS integration of MSIs with all positive implications.

• This is one of the critical steps for further acceptance of MEG as a routine clinical tool among neurosurgeons that is necessary for the clinical MEG field’s survival and advancement.
Towards a New Biomarker in Dementia

Why and What Biomarkers are Ideally Needed
Jim Becker, Pittsburgh, PA

HIV disease includes a set of conditions referred to as HIV-Associated Neurocognitive Disorder (HAND); even a mild form of HAND can result in significant alterations in employment, medication adherence, driving ability and other aspects of daily life. Identifying the earliest indications of neuropathology is critical for the development of therapies. Unfortunately, there is no acknowledged neuroimaging biomarker that can identify the pathological substrate of HAND; the identification and differential diagnosis of HAND is limited to the clinical signs and symptoms. Our research team has been exploring the relative merits of magnetoencephalography (MEG) as a potential HAND biomarker, because it measures neuronal activity directly from the magnetic fields induced by neuronal currents. MEG does not rely on the blood-oxygen level dependent response to generate responses, and has the best tradeoff between spatial and temporal resolution of any current neuroimaging technology. MEG can identify individuals with HIV Disease, the MEG responses change with recovery from HIV-Associated Dementia, and the findings are stable over 6-months. Because MEG directly measures the activity of neuronal populations, it provides unique information regarding the pathophysiology of HAND that cannot be obtained from other neuroimaging modalities. Consequently, MEG should detect brain functional abnormalities prior to clinical symptomatology.
Conclusions

- In areas of the world with access to medical resources, the face of the epidemic of HIV Disease is changing.
- Among patients with appropriate medical care, factors other than HIV Disease are at least as important in determining the state of their brain health.
- Imaging biomarkers may provide an avenue to identify CNS dysfunction prior to the development of HIV-associated cognitive dysfunction.

HIV Disease – The First Report

- June 1981
- From October 1980 through May 1981, 5 homosexual men, who did not know each other and had no known common contacts, were treated for Pneumocystis carinii pneumonia (PCP) in Los Angeles. All 5 patients had previous or current cytomegalovirus infection and candidal mucosal infection.
The Multicenter AIDS Cohort Study (MACS)

- The Multicenter AIDS Cohort Study (MACS) is a four-site study of the natural and treated history of HIV infection among gay/bisexual men.
- Study participants were enrolled in three waves: 1984/85, 1987/90, and 2001/03. The MACS has tracked cognitive test performance among the study participants since 1984 using screening tools, and a sub-cohort has been followed with more detailed testing for 25 years.

MACS Cohort(s)

- Cohort 1 was the original sample of 4,954 men, and Cohort 2 was a “New Recruit Cohort” that focused on enrolling minority and special target groups such as the partners of the men in C1. Cohort 3 enrollment took place between October 2001 and August 2003 again focusing on recruiting racial/ethnic minorities as well as a special target group of uninfected men who had been censored from C1 in 1995.
Age at Death as a Function of HIV Serostatus and Recruitment Cohort

<table>
<thead>
<tr>
<th>Seronegative</th>
<th>Seropositive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Age at Death:</td>
<td>Median Age at Death:</td>
</tr>
<tr>
<td>81.8 (78-85)</td>
<td>43.9 (43-44)</td>
</tr>
<tr>
<td>71.7 (67-76)</td>
<td>69.1 (55-83)</td>
</tr>
</tbody>
</table>

Age at Death as a Function of HIV Serostatus and Recruitment Cohort

Adult HIV Prevalence Rate, 2011

Global HIV Prevalence Rate = 0.8%

NOTES: Data are estimates. Prevalence rates include adults ages 15-49. The estimate for Sudan represents data for South Sudan. An estimate was provided for Sudan and is <1%. SOURCE: Kaiser Family Foundation, www.aidsdatahub.org, based on UNAIDS, Report on the Global AIDS Epidemic: 2012.
HIV Encephalitis is Uncommon

Research Nosology for HIV-Associated Cognitive Disorders

CNS Abnormalities Persist in the Era of HAART

- Among patients with appropriate medical care, factors other than HIV Disease are at least as important in determining the state of their brain health.
- Elevated risk of all neurological diagnoses in HIV Disease.
- Subcortical and cortical tissue loss.
- Effects are independent of age.
- Independent effects of CVD and lung function on brain and cognition.
- Can alter cognitive test performance.
3-D Surface Maps of Basal Ganglia from MACS MRI Study

Surface Rendering of the Independent Effects of HIV Serostatus and Age on Grey Matter Volume

Predictors of Grey Matter Volume

- Race
- Tri Glycerides
- Total Cholesterol
- Serostatus
- Urine Protein/Creatinine ratio
- White Matter Lesions
- Age
- Grey Matter Volume

Correlation Coefficients:
- Race: .19
- Tri Glycerides: .57
- Total Cholesterol: .27
- Serostatus: .45
- Urine Protein/Creatinine ratio: .30
- White Matter Lesions: -.23
- Grey Matter Volume: -.42
- Age: -.23
Lung Function, HIV Status and Brain Structure (Morris, et al.)

Cardiovascular Risk Factors and Cognition in HIV Disease

<table>
<thead>
<tr>
<th></th>
<th>Psychomotor Speed</th>
<th>Delayed Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>4.8, (3.13 – 7.34)</td>
<td>3.0, (1.98 – 4.49)</td>
</tr>
<tr>
<td>Depression</td>
<td>2.0, (1.28 – 3.27)</td>
<td>1.5, (0.95 – 2.32)</td>
</tr>
<tr>
<td>Education</td>
<td>0.52, (0.34 – 0.79)</td>
<td>0.61, (0.274 – 0.618)</td>
</tr>
<tr>
<td>Carotid IMT</td>
<td>1.7, (1.08 – 2.74)</td>
<td></td>
</tr>
<tr>
<td>GFR</td>
<td>1.6, (1.00 – 2.66)</td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>0.66, (0.44 – 0.99)</td>
<td></td>
</tr>
<tr>
<td>Coronary Calcium</td>
<td>2.3, (0.921 – 5.61)</td>
<td></td>
</tr>
<tr>
<td>HIV Serostatus</td>
<td>0.76, (0.51 – 1.20)</td>
<td>0.59, (0.381 – 0.903)</td>
</tr>
<tr>
<td>HIV Viral Load</td>
<td>2.1, (1.30 – 3.45)</td>
<td></td>
</tr>
</tbody>
</table>

Intra-Individual Variability in HIV Disease (Hines, et al.)

- Focus on the study of *within-person* variability in cognitive functioning, otherwise termed intra-individual variability (IIV).
- Within-person differences in test performance observed across tasks at a single time point (dispersion), or on a single task across multiple time points (inconsistency).
- We examined dispersion in 147 MACS participants with MRI scans.
Regional Brain Atrophy Associated with Intra-Individual Variability

Regional Cerebral Blood Flow Measured with Arterial Spin Labeling MRI

Drug Use Increases

HIV Increases
Cerebrovascular Reactivity to 5% CO₂ (relative to room air)

Age Decreases Drug Use Increases

With Increased Survival Comes Older Average Age
- Concerns about prevalence of APOE ε4 allele
- Concerns about increased rate of β-amyloid deposition.
- The good news, so far:
  - Don’t worry, they’re not issues.

APOE*4 Allele Frequency in 2846 MACS Participants
Summary

- Elevated risk of all neurological diagnoses in HIV Disease.
- Subcortical and cortical tissue loss.
- Effects are independent of age.
- Independent effects of CVD and lung function on brain and cognition.
- Mediated pathways from HIV Disease to non-specific brain alterations and increased IIV.
- No increase in rate of APoe ε4 allele.
- No increase in rate of PiB retention.

Summary

- Abnormalities in brain structure and function persist in the era of HAART.
- What remains unclear is the extent to which this is a function of prior experience with uncontrolled viral replication, or whether these abnormalities put the individual at increased clinical risk for subsequent expression of other neurodegenerative diseases (i.e., reduction of brain reserve).
Biomarkers for HAND

- "current approaches to classification and diagnosis of this [CNS] dysfunction rely on syndromic definitions or measures of abnormality on neuropsychological testing in the background context of HIV-1 infection." Thus, "supplanting or augmenting these approaches with objective biologic measurements related to underlying disease processes would provide a major advance in classification, diagnosis, epidemiology, and treatment assessment". (Price, et al., 2007)
- We need to consider that structure follows function follows pathology.
- We may want to consider alternative methods to our current imaging technologies for identifying the earliest phases of HIV-related changes in the brain.

Magnetencephalography (MEG)

---

Whole Brain Delta Power as a Function of Age and Serostatus
Theta:Gamma Ratio as a Function of Global Impairment Rating

Focusing on two groups of sensors, where we found significant statistical differences

Functional Neuronal Network that Distinguished Serostatus
Mutual Information Values from Connectivity Analysis of Resting MEG

MI Values by Participant and Serostatus

Medical History

- 52 year old, right-handed black man
- HIV+ in October 2009 after diagnosis of PCP
- September 2009 first went to hospital with pneumonia
  - Fired from job
  - Became homeless
  - Not on treatment when came to Pittsburgh in March 2010
  - First seen at PACT 3/4/2010
Medical History, Con’t

- Initial diagnoses in March 2010 included:
  - PCP
  - Peripheral Neuropathy
  - HIV encephalopathy
  - Brain lesions secondary to PML, toxo or crypto
    - MRI scan read as normal for age
  - Diagnosed with HAD 4/21/2010
    - Enrolled in MEG study in May 2010

HIV Lab Values

<table>
<thead>
<tr>
<th>Measure</th>
<th>March 2010</th>
<th>May 2010</th>
<th>September 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD4+ Cell Count</td>
<td>12</td>
<td>232</td>
<td>256</td>
</tr>
<tr>
<td>Log10 HIV RNA</td>
<td>5.81</td>
<td>2.62</td>
<td>&lt;50</td>
</tr>
<tr>
<td>CD4 Nadir</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RNA Peak</td>
<td>5.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Changes in Neuropsychological Test Performance During Acute Recovery
Percent Brain Volume Change During Recovery - SIENA

Changes in Regional Brain Volumes

Change in MEG Identified Network Connectivity in P.G.
Summary

• MEG is reliable and stable in the absence of clinical change.
• Memory task is reliable and stable in the absence of clinical change.
• Resting State MEG signal shows mild changes related to HIV serostatus
  – But, shows larger and more pervasive links to cognitive status

Summary

• Functional connectivity analysis using mutual information reveals a network of connections that are significantly linked to HIV status, but not to cognitive functions.
• The network shows recovery of function with effective HAART in a single case.
• MEG appears to meet important prerequisites to serve as a biomarker for HAND.
Conclusions

• In areas of the world with access to medical resources, the face of the epidemic of HIV Disease is changing.
• Among patients with appropriate medical care, factors other than HIV Disease are at least as important in determining the state of their brain health.
• Imaging biomarkers may provide an avenue to identify CNS dysfunction prior to the development of HIV-associated cognitive dysfunction.

Thank you very much.
Towards a New Biomarker in Dementia

First Results of the Multi Center MAGIC AD Study

Fernando Maestu, Madrid, ES

In the last years, MEG field is experienced tremendous advances in its new clinical applications. Dementia is one of those where greater advances are taking place, especially in Alzheimer’s Disease (AD). In fact functional connectivity measures are being testing AD as a dysconnection syndromes. Thus, in the early stages of the disease Mild Cognitive Impairment patients showed increased synchronization and those that developed dementia showed higher synchronization than those that did not develop dementia. Correlations with anatomical connectivity and amyloidosis has been found as well. Despite of all these scientific evidence it was needed an international blind study. In an international multicenter study, we used magnetoencephalography and functional connectivity metrics to evaluate the ability to differentiate Mild Cognitive Impairment (MCI) from normal aging at the individual level. Data mining techniques were using for extracting features (links) to classify participants as MCI or controls using samples of already known patients and controls (learning stage) and from unseen data from five different centers. We identified a pattern of neuronal hypersynchronization; the features of the network that best discriminated MCI were fronto-parietal and interhemispheric. When this model was tested in an unseen sample the sensitivity was 1.00, specificity of .69 and overall total accuracy of .83. We report here the first use of neuronal functional connectivity data to discriminate between MCI patients and healthy elderly subjects at the individual level. The hypersynchronization pattern found in the MCI patients may be considered an early sign of synaptic disruption and a possible preclinical biomarker for MCI/AD.
First Results of the Multi-Center
MAGIC-AD Study

Fernando Maestú PhD
fernando.maestu@ctb.upm.es

Laboratory of Cognitive and Computational Neuroscience
(Center for Biomedical Technology) UPM-UCM

Center For Biomedical Technology
MEG!!

AD/MEG

Acetylcholine

Conversion

TAU

Animal models

Genetics

Multicenter-Study

SMC

Resting/memory

DTI/MEG

Amiloid
Functional connectivity in Mild Cognitive Impairment: Evaluating the Disconnection Hypothesis

Bajo R et al, Age, 2011
Bajo R et al, Brain Connectivity, 2012

Morrison JH and Baxter M, Nat Rev Neurosci, 2012
Functional Connectivity in Mild Cognitive Impairment During a Memory Task: Implications for the Disconnection Hypothesis


P<0.01 corrected

MCI > CTRL

Respuestas correctas

MCI patients (Aβ+/OAD1 family)

2 SD above the baseline

Bajo et al. (J Alzheimer's Disease, 2010)
Early dysfunction of functional connectivity in healthy elderly with subjective memory complaints

Ricardo Bajo • Nazareth P. Castilho • Maria Engracia Lopez •
Jose Maria Balle • Pedro Montejo • Mercedes Montenegro • Marcos Llanero •
Pedro Gili • Raquel Suberos • Ergunia Baykas • Mario Pinell • Sara Aart programme •
Francisco Del Peso • Fernando Masini
ANATOMO-FUNCTIONAL CONNECTIVITY: 
A MEG/DTI STUDY USING GRAPH THEORY ANALYSIS 

(Pineda et al, submitted)
Graph theory: MEG/DTI

- Combination of anatomic functional connectivity
- Is the functional connectivity architecture depending on the integrity of the white matter?

White Matter Integrity HA > MCIa

MCIa_Cluster

Correlation
The lower the anisotropy value the lower the tendency to show a SW architecture in fc-MEG data

Delta
Theta
Alpha
Beta
Gamma
1. Scopolamine is an acetylcholine muscarinic receptor antagonist.
2. Produces transient cognitive deficits: amnesia (episodic memory), resembling those observed in AD.
3. The drugs were administered 1 h before the measurements and the subjects were supervised for at least 8 h after the drug administration (glycopyrrolate was administered as well in a separate session).
4. All recordings were conducted between 8 a.m. and 12 a.m. with 1 week interval between the sessions to minimize the possible effects of circadian rhythms.

**PHARMACOLOGICAL MODEL OF DEMENTIA: SCOPOLAMINE**

Statistics

- Wilcoxon + permutation (1000)

Functional Connectivity:

- PLV

**Resting state FC Glycopyrrolate vs. Scopolamine (7 Subjects)**

<table>
<thead>
<tr>
<th>Glycopyrrolate vs. Scopolamine</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycopyrrolate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scopolamine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significant differences in PLV between electrode pairs for different frequency bands:

- Glycopyrrolate = Glycopyrrolate > Scopolamine
- Scopolamine = Scopolamine > Glycopyrrolate
TAU concentration has been associated with neuronal damage and cognitive impairment.

And

MEG-FC

The higher the pTau levels the higher the FC values.

p-TAU in the CSF

Delta pTau

Theta pTau

Precuneus

Cingulate

Middle

Right

Hippocampus

Calazone

Left

Spinal needle is inserted, usually between the 3rd and 4th lumbar vertebrae.
The higher the pTau levels, the lower the FC values.

Alpha pTau (R²=-0.51; p<0.05)

Beta pTau (R²=-0.52; p<0.05)

Gamma pTau (R²=-0.38; p<0.05)
FUNCTIONAL CONNECTIVITY AND GENETIC PROFILES

CARRIERS VERSUS NON CARRIERS OF APOE 3/4

(Cuesta et al. submitted)
- Elekta-Neuromag supported the annual meeting of the consortium
SUMMARY
- It has been examined differences in functional connectivity between MCI and healthy controls with MEG at the group level.
- In order for MEG to be useful, it must be able to detect abnormal function at the level of the individual patient.
- There were two goals to the present study:
  - To develop a model, using data mining techniques, that reliably distinguishes between MCI patients and healthy controls.
  - Test this model using an unseen dataset of MCI and control subjects acquired by the MAGIC-AD consortium.

Stages of the study
1. Training datasets (known subjects)
   - All data recorded (resting state) in Madrid
   - MEG Datasets: 83 MCI and 54 controls
2. Validation datasets (Unseen/ blind study)
   - Data recorded at five different MEG labs
   - MEG data sets: 24 MCI and 28 controls

Results of the data mining classification

<table>
<thead>
<tr>
<th>Madrid data</th>
<th>Internal validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted class</td>
<td>MCI</td>
</tr>
<tr>
<td>MCI</td>
<td>65</td>
</tr>
<tr>
<td>Control</td>
<td>13</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>83.33%</td>
</tr>
</tbody>
</table>
Results of the data mining blind classification

MAGIC-AD DATA
External validation

<table>
<thead>
<tr>
<th>Predicted class</th>
<th>MCI</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCI</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Control</td>
<td>1</td>
<td>11</td>
</tr>
</tbody>
</table>

- Sensitivity: 92.31%
- Specificity: 73.33%
- Accuracy: 82.14%
- PPV: 75.00%
- NPV: 91.67%
Inter-hemisph links achieving classification values

Results of the data mining blind classification
MAGIC-AD DATA
External validation (Second Round)

<table>
<thead>
<tr>
<th>Predicted class</th>
<th>Real class</th>
<th>MCI</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCI</td>
<td>11</td>
<td>4</td>
<td>73,33% PPV</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>9</td>
<td>100,00% NPV</td>
</tr>
</tbody>
</table>

100,00% 69,23% 83,33% Accuracy

Sensitivity Specificity

CONCLUSIONS

1. MEG is able to detect differences in functional connectivity profiles between MCI and control subjects across laboratories.

2. In the validation study a sensitivity of 96% and specificity of 72%, with a total accuracy of 83% (taking together the two MAGIC-AD samples) indicating the utility of MEG as a clinical tool.
CONCLUSIONS

3. MCI showed hypersynchronization of the fronto-parietal networks and interhemispheric connections

4. Where we are: increase the sample, conversion study, combination with biomarkers
Endocytosis is required for synaptic activity-dependent release of amyloid-β in vivo

John R. Cribbs1,2,7,8, Jay-Eun Kang1, Jiyoon Lee2,8, Fion R. Stewart2, Deborah K. Verges1,6, Liz J. Silvers1, Gordon B. Retzius2,7, Steven M. Nestor2,7,8, and David M. Holtzman1,6,7,8

Figure 5. Model of synaptic-dependent release of Aβ
(A) Depolarization of the synaptic terminal causes calcium influx leading to synaptic vesicle release. (B) Synaptic vesicle membrane recycling from the cell surface via clathrin-mediated endocytosis causes more APP to internalized (C). Within endosomes, BACE and β-secretase cleave APP to produce Aβ (D) which is secreted from the neurons into the brain ISF (E).

Levetiracetam suppresses neuronal network dysfunction and reverses synaptic and cognitive deficits in an Alzheimer’s disease model

Paul E. Sanchez1,6, Li Zhi3,4, Lauren Wirtz5, Keith A. Wood2, Anna G. On1, John R. Cribbs1,6, Nina-Diez-Sanchez1,6, Kathryn Hsu1, Qin-Guo Fu3,4, Jhing S. Rogn1, and Lauren Monte2,3,4,6,8

1Scripps Research Institute, 10550 North Torrey Pines Road, La Jolla, CA 92037, USA; 2National Institutes of Health, National Institute on Aging, National Institute on Aging, Baltimore, MD 21224, USA; 3National Institute of Mental Health, National Institute of Mental Health, Bethesda, MD 20892, USA; 4Department of Psychiatry, University of California, San Francisco, CA 94143, USA; and 5Department of Neurology, Washington University School of Medicine, St Louis, MO 63110, USA.
MEG

1. MCI showed higher synchronization than controls
2. Multicenter study was able to classify MCI and controls
3. Reduction of the acetylcholine activity lead to a profile of AD.
4. APO-4 allele decrease synchronization
5. Increases of the Tau protein and beta amiloide disrupts the organization of the functional networks
6. The white matter damage affects the functional networks

CONCLUSIONS
Update on Educational Initiatives

Update on MEG Fellowship Curriculum
Rick Burgess, Cleveland, OH
Update on MEG Fellowship Curriculum: Beyond ACMEGS and other short courses?

ACMEGS Annual Meeting
Atlanta Georgia
February 6, 2014

Consequences of the publication of the Clinical Practice Guidelines.

• The publication of CPGs* has helped to establish referring physicians’ expectations for a high level of quality in the interpretation and for practical utility from the results.
• Centers with MEGs are striving to practice according to these guidelines.


Number of MEG installations is expanding.

• The number of MEG centers has increased over the two years since publication of the guidelines.
• MEG laboratories can now be found even in community hospitals.
• There has been considerable migration of MEG laboratory directors (the musical chairs involved Albuquerque, Birmingham, Chicago, Houston, McGovern, Memphis, Milwaukee, Montreal, NIMH, Omaha, Orlando, St. Louis, USC, New Jersey, and Utah).
• Some clinical positions for MEG laboratories remain unfilled.
Trained individuals to run these new MEG laboratories are in short supply.

- Decision makers (department chairs, administrators, C-suite officials) are concerned about this shortage.
- Especially those contemplating the new purchase of a MEG system want to know where will the future magnetoencephalographers come from.
- This apprehension is one of the major obstacles to the growth of the field.

What is ACMEGS’s interest in these educational and staffing concerns?

- ACMEGS is actively involved in the education of people interested in MEG.
- What should ACMEGS do to encourage further education that will ensure that there is an adequate pool of qualified magnetoencephalographers?

Educational Training Opportunities: Definitions

- Fellowships
  - Postresidency or Second Fellowship, generally for young trainees
  - Requires some organizing, involvement of GME, and funding
  - ACMEGS likely has an important role

- Ad hoc education for potential MEG center directors
  - Short programs/observershps for seasoned EEGers/epileptologists
  - Usually arranged unofficially, person to person, customized to the
    time available (both teacher’s and student’s schedule)
  - ACMEGS unlikely to have any effect
Centers with MEG Training Programs:
Results of anonymous surveys sent to all centers who are institutional members of the ACMEGS (16)

<table>
<thead>
<tr>
<th></th>
<th>Formal programs</th>
<th>Informal programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of centers</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>No. of trainees/yr</td>
<td>0 - 2</td>
<td>0 - 3</td>
</tr>
<tr>
<td>No. Spont MEGs</td>
<td>50 - 100</td>
<td>“all depends”</td>
</tr>
<tr>
<td>No. SEFs</td>
<td>20 - 50</td>
<td>0 - 100</td>
</tr>
</tbody>
</table>

Duration of Training:

6 / 9 (67%) adjust the duration of training to suit the experience of the trainee

Minimum qualifications required for acceptance into training program:

- PhD degree
- Medical Degree (MD or DO)
- MD + NeuroResidency
- MD + NeuroResidency + Fellowship
What are the trainees doing?

- Full Responsibility
- Super EEGers
- Not Much

MEG Trainee Activity
(6 responses)

Exposure of Other Trainees
(11 responses)

Who is doing the clinical work?

No help from trainees
7/11 (64%)

Types of trainees who participate:

- Epilepsy Fellows
- Neurology Fellows
- Neurology Residents
- Neurosurgery Residents
- Other MDs

(5 responses)

What educational activities is the MEG laboratory director doing?

- MEG Training Program Director
- MEG Attending Supervising Directors
- Faculty-Short Course
- Faculty-Regular Lectures
- Faculty-Sporadic Lectures
- Faculty-Specific Lectures
- Faculty-Research Mentor

(10 respondents)
Survey Free - Text Comments.

- “Clinical training programs will proliferate when MEG centers become financially self-sustaining”
- “Would like to be a training site”
- “Would love to start a training program here”
- “MEG community should put major effort and resources into formalizing physician training”
- “Fully support the formation of 1-year ACGME-approved fellowship”
- “Survey fails to address particular needs of fully qualified directors or fellows on elective rotations who only want need to learn certain aspects or gain some appreciation”
- “MEG community should create a consensus as to training content, expectations, and program accreditation”

7 responses

What can ACMEGS do to promote the availability of qualified magnetoencephalographers?

- Present courses (such as our ‘Annual Course’)?
- Provide multi-day on-site training programs?
- Assist the manufacturers with start-up training?
- Develop guidelines for clinical fellowships?
- Continue to agitate / encourage appropriate individuals?

Does the additional training required demand a subspecialty fellowship?

“Additional background training of physicians interpreting clinical MEG and MEG–EEG studies should meet the minimal requirements for examination by the American Board of Clinical Neurophysiology (www.abcn.org) or the American Board of Psychiatry and Neurology Added Qualifications in Clinical Neurophysiology (www.abpn.com).”

A Bagic. ACMEGS Annual Course, February 2013, Miami Fla
Where do we go next?

- Just let things evolve for awhile and pick up later?
- Expand (double) the survey to non-ACMEGS centers?
- Obtain consensus within ACMEGS?
- Develop and publish fellowship guidelines?
- Put Training Guidelines on the web?
- Include MEG track in ABCN exam?
- Officially pursue development of non-ACGME fellowships?

Should ACMEGS generate Fellowship Training Goals?

- Young physicians find this technology clinically powerful and intellectually fascinating, and they are looking for good training programs.
- The most basic definitions of who, what, where, and how long, about MEG training do not exist.
- If non-ACGME fellowships are further developed will this have a positive influence:
  - On hiring?
  - On the entire field of clinical magnetoencephalography?

Key questions for Fellowship Training Goals.

- **Eligibility ---** Who are these clinical fellowships for?
- **Duration ---** What's the minimum duration? What about requests for mini-fellowships?
- **Content ---** Practice? Number of studies? Apprenticeship? Didactic?
- **Other Components ---** Just magnetoencephalography or coupled with epilepsy, etc?
- **Certification ---** Formal certification in future? At present, what does it take to get a letter of completion?
Formal Fellowship Options: UCNS.

- ACGME-approved MEG Fellowship extremely unlikely.
- It provides unified accreditation for non-ACGME fellowship programs.
- They have established patterns for accreditation and certification, and can provide guidance.
- Subspecialties may progress to ACGME, or remain under UCNS, e.g. Headache Medicine.

Speculating Based on Analogous UCNS Examples.

- Because of the possible historical pathways followed by physicians into MEG, our sub-specialty may emulate the trajectories taken by Sleep and Interventional Neurology.
  - Sleep fellows come from Neurology, Psychiatry, or Pulmonary.
  - Interventional fellows come from Neurology, Neurosurgery, or Radiology.
- Usually one or more of the primary boards will have to accommodate those fellows.
- Current ACGME leanings (at least as documented by CPGs) are that MEG will eventually be populated by neurologists with fellowship training in CNP or Epilepsy Medicine.

Acknowledgements.

- With thanks to the continuous stream of well-trained and hard-working Japanese MEG fellows at the Cleveland Clinic:
  - Masaki Iwasaki 2002-2004
  - Kazutaka Jin 2007-2010
  - Yosuke Kazataka 2010-2012
  - Susumu Ito 2012-2013
  - Hiroatsu Murakami 2013-
- And to the CCF Epilepsy Center Fellowship Director, Dr. Andreas Alexopoulos, for his undying support of the MEG Laboratory.
Update on Educational Initiatives
Update on Clinical Startup Recommendations
Paul Ferrari, Austin TX & Ron Gordon, Vancouver BC
AMERICAN CLINICAL MAGNETOENCEPHALOGRAPHY SOCIETY
2013 Annual Conference • February 7, 2013

Evaluation Form Summary

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 5 as most effective and 1 as least effective:

<table>
<thead>
<tr>
<th>Faculty</th>
<th>Most Effective</th>
<th>Least Effective</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Bagic</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dr. Paetau</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dr. Ebersole</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dr. Baillet</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dr. Von Allmen</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dr. Knowlton</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dr. Burgess</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Ms. Ahn-Ewing</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Ms. Walbert</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Alexopoulos</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Please rate using 5 as most effective and 1 as least effective:

| 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:
Driving directions to Ecco
1. Head **south** on **Peachtree St NE** toward **Ellis St NE**

2. Take the 1st left onto **Ellis St NE**

3. Turn left onto **Peachtree Center Ave NE**

4. Continue onto **Peachtree St NE**

5. Turn left onto **7th St NE**

   Destination will be on the right

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Map data ©2014 Google, Sanborn