DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTES OF HEALTH

NATIONAL ADVISORY COUNCIL FOR BIOMEDICAL IMAGING AND BIOENGINEERING

Summary of Meeting[1]

September 13, 2010

The National Advisory Council for Biomedical Imaging and Bioengineering (NACBIB) was convened for its 24th meeting on September 13, 2010, at the Bethesda Marriott Suites in Bethesda, Maryland. Dr. Roderic I. Pettigrew, Director of the National Institute of Biomedical Imaging and Bioengineering (NIBIB), presided as Council chairperson.

In accordance with Public Law 92–463, the meeting was open to the public from 9:15 to 11:45 a.m. for review and discussion of program development, needs, and policy. The meeting was closed to the public from 1:00 p.m. to 3:30 p.m. for consideration of individual grant applications.

Council members present:
Dr. Philip Alderson, Saint Louis University, St. Louis, MO
Dr. Richard L. Ehman, Mayo Clinic, Rochester, MN
Dr. Gary H. Glover, Stanford University, Stanford, CA
Dr. Hedvig Hricak, Memorial Sloan-Kettering Cancer Center, New York, NY
Dr. Cherri Pancake, Oregon State University, Corvallis, OR
Dr. Buddy Ratner, University of Washington, Seattle, WA

Ad Hoc members present:
Dr. William Grimson, Massachusetts Institute of Technology, Cambridge, MA
Dr. Nola Hylton, University of California, San Francisco, CA
Dr. Etta Pisano, Medical University of South Carolina, Charleston, SC

Council member present via conference call:
Dr. Mae C. Jemison, Biosentient Corporation, Houston, TX

Ad Hoc member present via conference call:
Dr. Ronald Arenson, University of California, San Francisco, CA

Ex officio members present:
Dr. Anne Plant, National Institute of Standards and Technology, Gaithersburg, MD
Dr. James G. Smirniotopoulos, Uniformed Services University of the Health Sciences, Bethesda, MD
Dr. Andrew Watkins, Centers for Disease Control and Prevention, Atlanta, GA

Council members absent:
Dr. Percival McCormack, University of Illinois at Chicago, Chicago, IL
Dr. David Skorton, Cornell University, Ithaca, NY

Ex officio members absent:
Dr. Francis Collins, National Institutes of Health, Bethesda, MD
Dr. John McGrath, National Science Foundation, Arlington, VA
Dr. P. Hunter Peckham, U.S. Department of Veterans Affairs, Cleveland, OH
Ms. Kathleen Sebelius, U.S. Department of Health and Human Services, Washington, DC

[1] For the record, it is noted that members absent themselves from the meeting when the Council is discussing applications (a) from their respective institutions or (b) in which a conflict of interest may have occurred. This procedure only applies to applications that are discussed individually, not to "en bloc" actions.

Executive Secretary:
Dr. Anthony Demsey

Also present:
NIBIB staff present for portions of the meeting:
Mr. Angelos Bacas
Dr. Richard A. Baird
Ms. Sheila Barrett
Ms. Angela Burks
Ms. Barbara Cantilena
Ms. Patty Clements
Dr. Zohara Cohen
Ms. Shirley Coney-Johnson
Dr. Richard Conroy
Ms. Zoe-Ann Copeland
Ms. Nancy Curling
Ms. Chris Ann Darby
Mr. Jeff Domanski
Mr. Antoine Durham
Dr. Henry Eden
Ms. Angela Eldridge
Ms. Kathryn Ellis
Dr. Zeynep Erim
Ms. Shirley Finney
Ms. Carol Fitzpatrick
Dr. David George
Ms. Marie Gill
Ms. Pam Glikman
Dr. Valery Gordon
Dr. Ruth Grossman
Dr. John Haller
Dr. John Hayes
Ms. Eunica Haynes
Dr. William Heetderks
Dr. Lori Henderson
Mr. Shabriya Horton
Dr. Rosemarie Hunziker
Dr. Thomas Johnson
Ms. Mary Beth Kester
Dr. Peter Kirchner
Dr. Brenda Korte
Dr. Richard Leapman
Dr. Albert Lee
Dr. Guoying Liu
Dr. Hector Lopez
Dr. James Luo
Dr. Alan McLaughlin
Mr. Todd Merchak
Mr. Larry Morton
Mr. Joe Mosimann
Dr. Peter Moy
Dr. Grace Peng
Dr. Karen Peterson
Dr. Roderic I. Pettigrew
Ms. Mary Pitonak
Dr. Mary Rodgers
Ms. Stephanie Sabourin
Dr. Belinda P. Seto
Mr. Shaun Sims
Ms. Casey Stewart
Dr. Manana Sukhareva
Ms. Florence Turska
Ms. Stacy Wallick
Mr. Kwesi Wright
Dr. Yantian Zhang
Dr. Ruixia Zhou

Non-NIBIB NIH Employees:
Dr. Eileen Bradley, Center for Scientific Review

Non-NIH Federal Employees:
None

Members of the public present for portions of the meeting:
Dr. Andrea Baruchin, Foundation for the National Institutes of Health
Ms. Renee Cruea, Academy of Radiology Research
Dr. Bruno DeMan, GE Global Research Center
Ms. Allyson Harkey, NOVA Research Company
Mr. Eugene Kobayashi, Washington CORE
Mr. Jericho Laparan, Event Technology Solutions
Mr. Vhic Mata, Event Technology Solutions
Mr. Jason Michelitch, National Capital Captioning
Dr. Norbert Pelc, Stanford University
Ms. Gloria Romanelli, American College of Radiology

I. Call to Order: Dr. Anthony Demsey

Dr. Demsey called to order the 24th meeting of the National Advisory Council for Biomedical Imaging and Bioengineering. He reminded attendees that the morning session of the meeting was open to the public, welcomed attendees, and introduced Dr. Pettigrew, who formally welcomed all participants.

II. Director's Remarks: Dr. Roderic Pettigrew

A. New Members

Dr. Pettigrew introduced a new member to the NACBIB, Dr. Hedvig "Hedi" Hricak, Chair of the Department of Radiology at Memorial Sloan-Kettering Cancer Center, who has been instrumental in the application of MRI and CT in genitourinary cancers. Three ad hoc members were also introduced: Dr. William Grimson holds appointments as a professor of computer science and engineering at the Massachusetts Institute of Technology and a lecturer in radiology at Harvard Medical School and Brigham and Women's Hospital. Dr. Nola Hylton is a professor of radiology and Director of the Breast MRI Research Program at the University of California, San Francisco, and is well known for her research on the development and clinical optimization of MRI for breast cancer imaging, diagnosis, and staging. Dr. Edda Pisano is Dean of the College of Medicine at the Medical University of South Carolina, the first woman to hold this position, and is well known in the field of digital mammography.

B. Dr. Philip O. Alderson

Dr. Pettigrew recognized the achievements of Council Member Dr. Philip O. Alderson, recipient of the American Roentgen Ray Society's (ARRS) highest award, the Gold Medal for Distinguished Service to Radiology. Dr. Alderson received the award during a ceremony held at the 2010 ARRS Annual Meeting.

C. Application Increases

At the January 2010 NACBIB meeting, Dr. Pettigrew noted a significant increase in the level of high-scoring NIBIB grant applications compared to January 2009; this increase has continued through comparisons of the May 2009/May 2010 and September 2009/September 2010 applications.

D. Inclusion of Clinical Image Data in Electronic Health Records Conference

In July, a program within the American Reinvestment and Recovery Act (ARRA) of 2009 issued meaningful use regulations for health care providers to receive incentive payments for using electronic health records; updates were issued in August. Current regulations do not include clinical image data. To address this need, in early 2011, NIBIB will host a conference on Inclusion of Clinical Image Data in Electronic Health Records.

E. Summit on Diagnostic Radiology Performance/Radiation Dose

The Summit on Diagnostic Radiology Performance/Radiation Dose, co-sponsored by NIBIB and the Coalition for Imaging and Bioengineering Research, will convene members of the diagnostic community leadership to assess the current state of radiation levels and techniques used across the country and to define research needs and future directions to optimize the benefit-to-risk ratio of this technology. Dr. Pettigrew anticipates participation from all major organizations, associations, and institutions in the field, including the American Association of Physicists in Medicine, the Radiological Society of North America, the Academy of Radiology Research, the American College of Radiology, industry, and the U.S. Food and Drug Administration. The Summit is planned for early winter 2011.

F. Partnership With India

In 2008, NIBIB signed a partnership with the Department of Biotechnology in India and subsequently co-hosted a workshop to bring scientists from the two countries together. An initiative has begun to support collaborations between scientists from both countries with the goal of developing low-cost medical techniques for diagnosis and therapy in underserved populations and settings. The initiative was announced at the first U.S.-India Joint Commission meeting held in Washington, DC, this summer, and

will supplement funding of NIBIB researchers to collaborate with Indian scientists and engineers for up to 25 percent of the initial grant amount. India will provide funding for its researchers.

G. NIH Update

In June, the NIH Director announced a $10 million investment to support a National Institute of Environmental Health Sciences study of the potential health impact of the British Petroleum (BP) Gulf oil spill. BP has subsequently announced its intention to add $10 million to this funding pool. The Gulf Long-term Follow-up Study (GuLF) is set to begin in late fall 2010 and will monitor approximately 20,000 workers and volunteers for health effects. On September 9, NIH released a notice of intent to issue a Request for Applications for consortia of university-community partners to address health issues of concern to Gulf Coast residents.

H. Human Embryonic Stem Cell Update

Dr. Pettigrew briefly reviewed recent legal events surrounding Federal funding of embryonic stem cell research. A preliminary injunction was issued August 23, 2010, that prohibited NIH from funding any human embryonic stem cell research or training that involved embryonic stem cells. Subsequently, NIH suspended issuance of all pending related awards, peer review, and acceptance of applications proposing use of human embryonic stem cells. The Department of Health and Human Services filed a notice of appeal and stay motion on August 31. The U.S. District Court of Appeals granted a temporary stay of the original order on September 9 and requested a briefing on September 20 in order to make a more definitive decision on the appeal.

I. Research in the News

ABC News recently reported on the successful efforts of NIBIB-supported researcher Dr. Jeremy Mao to use endogenous cells to regenerate joints. Unlike past research that employed exogenous cells to develop an implantable construct, Dr. Mao's method recruits precursor endogenous stem cells to regenerate synovial joints.

A group at the Massachusetts Institute of Technology, led by Drs. Faisal Kashif, Thomas Heldt, and George Verghese, has developed a technique using non-invasive physiologic modeling to safely measure intracranial pressure in patients with traumatic brain injury.

NIBIB intramural researchers have been working on a trans-NIH project titled "Imaging Molecules to Cells" that aims to identify temporal-spatial relationships at the molecule level. Standard imaging techniques cannot examine single-molecule events, as opposed to ensemble events. Examining single-molecular events allows scientists to observe heterogeneous populations, directly study asynchronous reactions, and observe the influence of local environments. Dr. George Patterson has developed several techniques to image single molecules, including photoactivatable location microscopy (PALM), which uses green fluorescent proteins that can be activated by exposure to laser light at a specific wavelength. Application of this concept to live imaging has been challenging because the high-intensity illumination required to achieve high-resolution images over time can be destructive. Dr. Hari Shroff and colleagues have developed a high-resolution optical imaging instrument that allows *in vivo* imaging of mitosis in a very small structure.

III. Inverse Geometry CT and Other Strategies for CT Dose Reduction: Drs. Norbert Pelc and Bruno DeMan

Dr. Pettigrew introduced Drs. Pelc and DeMan, of Stanford University and General Electric (GE) Global Research, respectively. Dr. Pelc, a former NACBIB member, is well known in the imaging and diagnostic physics communities for making advances in computed tomography (CT), ultrasound, and digital technologies. Dr. DeMan is Director of the CT and X-ray Research Laboratory at GE Global Research.

Drs. Pelc and DeMan presented the Inverse Geometry CT project, a NIBIB-funded collaboration between Stanford University and GE Global Research Center aimed at significantly reducing radiation exposure

during CT examinations. Dr. Pelc acknowledged the work of students and faculty at both institutions, noting that some early experiments were performed in conjunction with NovaRay.

Evolution of CT

Over the last 30 years, CT has seen phenomenal technological improvement. CT angiography, cardiac imaging, and dynamic imaging—especially brain perfusion studies and perfusion studies in oncology—have fueled growth and speed of multidetector technology. The latest instruments scan an entire volume in a single rotation, with the radiation source orbiting around the patient rather than translating the patient through the bore. Unfortunately, single-orbiter scanners create cone-beam artifacts, which are phantoms consisting of alternating layers of high and lower density material that result in image distortions. In addition, as CT use has increased, patient exposure to radiation has become more of a concern.

Multi-Spot Inverse Geometry

To lower radiation exposure and avoid cone-beam artifacts, Dr. Pelc and his colleagues turned the geometry of a conventional CT scanner upside down. The inverse geometry CT scanner rotates completely during a scan, illuminating different source spots at different times and from different directions. As a result, the radiation source is better distributed and the detector is disturbed to a lesser degree.

Dr. DeMan outlined a 3-step strategy to reduce radiation dosage when developing a new CT system. First, x-rays are controlled; second, every x-ray that travels through a patient is detected; and third, efficient data processing is used to achieve the best possible images.

To control x-rays, the inverse geometry CT system employs a *bowtie filter*—a rigid piece of metal in front of the x-ray tube. After initial studies with the filter, Dr. DeMan created a *virtual bowtie* filter with multiple radiation sources that controls the intensity of each pulse. Profiles can be optimized such that the detected flux is uniform regardless of the object shape or size, or angle of irradiation. Users can minimize the effective dose to sensitive organs. In simulations with the conventional bowtie, Dr. DeMan reduced peak variance by 57 percent. For the same dose with the virtual bowtie, peak variance was reduced an additional 61 percent.

To ensure detector efficiency—the second step for dose reduction—the system synergistically combines existing techniques. By avoiding anti-scatter grids and reflectors, using smaller cell size to allow for natively higher resolution, and using photon-counting detectors, the system can reduce dosage by 25 to 75 percent, depending on exact anatomy and application.

Efficient image reconstruction is achieved through a combination of commercially available statistical and iterative reconstruction algorithms. These include (1) noise models that focus on the statistics of measurement; (2) object models that use prior knowledge of the object; (3) system optics that model the prediction with fully iterative reconstruction; and (4) physics models. Merging aspects of all four types of algorithms led to significant noise reduction and up to 50 percent dose reduction.

Advantages of the inverse geometry CT include the ability to scale the axial coverage over the entire object (e.g., head, heart) without undue suffering to the patient, while controlling cone-beam artifacts. The lateral distribution of the source array corrects for some of the non-uniform spatial resolution issues found with conventional scanners. The virtual bowtie tailors the intensity incident on the object to obtain the best image quality without radiation overdosing.

Challenges of inverse geometry CT include x-ray flux. This flux occurs as each x-ray source illuminates the detector and a small fraction of the intensity leaks through the collimator, making it difficult to obtain very large numbers of x-rays quickly. Additionally, each x-ray source is a stationary anode, unlike the rotating anodes of conventional x-ray sources. Solutions to these challenges include using higher power to sustain more sources, shorter pulse times, and lower duty cycles. The virtual bowtie allows the user to distribute available power and time to x-ray sources that require extra intensity.

Next Steps

The project's next step is to complete the 32-source upgrade, which is funded by an ARRA supplement from NIBIB. In addition, the team will characterize image quality, implement the virtual bowtie, explore a possible combination with statistical reconstruction, and demonstrate potential advantages of dose efficiency, reduced cone beam artifacts, and uniformity of spatial resolution. In the long term, Dr. Pelc plans to integrate a photon-counting detector into the system and explore dedicated configurations for specific applications.

Dr. Pelc is implementing a stationary-source system in which the source array could be distributed around the patient and remains stationary while the detector array and one or more collimators rotate. Rotations at one-tenth of a second might be possible.

Research Directions

Dr. Pelc stressed the need for better evidence regarding the effects and risks associated with low radiation dose and encouraged NIBIB to seek high-quality proposals that address low-dose exposure, and the importance of studying how to use existing instruments with lower radiation exposures to achieve desired diagnostic results.

Statistical reconstruction approaches commonly used in positron emission tomography (PET) systems are now being used in CT to improve image quality. Dr. Pelc encouraged support for studies of evaluation techniques to help the research community better quantitatively characterize performance of new reconstruction algorithms. Dr. Pelc also urged support for development of higher dose efficiency instruments, new components (e.g., detectors), and optimal use of x-ray spectra that reflect the differences in x-rays.

Discussion

To geometrically calibrate the system, Dr. Pelc and his colleagues used phantoms (plastic beads and a wire), created fit parameters, and estimated the geometry of the scanner. At this point, they assume that the geometry is reproducible and fixed. Heat is another concern, but oil could be used to conduct heat away from the array through the gantry heat exchanger.

This technology is potentially useful for diagnostics and therapy. With modifications, it could be used for therapeutic radiation and for tomosynthesis, a digital image capture and processing combined with the detector motion of a conventional scanner. Research teams at the University of North Carolina, Chapel Hill are investigating different source array combinations for therapy and altering the detector so it can be used for tomosynthesis.

In the inverse geometry system, the source arrays are almost at the edges; the worst cone-beam artifacts are in the middle of the image. Dr. Pelc does not yet know how severe the artifacts are. Adding another row of scanners every two to five centimeters could eliminate further artifacts.

The work of Drs. Pelc and DeMan has the potential to make CT scanners more dose efficient.

IV. Review of Council Procedures and Regulations

Dr. Demsey noted for the record that a quorum was present for this Council meeting. Council members Drs. Mae C. Jemison, Percival McCormack and David J. Skorton were unable to attend. Dr. Jemison joined via telephone for the closed session.

Dr. Demsey welcomed visitors, members of the science press, and members of scientific society constituencies, including Ms. Renee Cruea of the Academy of Radiology Research and the Coalition for Imaging and Bioengineering Research and Ms. Gloria Romanelli of the American College of Radiology. He thanked Ms. Carol Fitzpatrick and Ms. Pam Glikman for meeting logistics.

A. Council Regulations, Policies, and Procedures

Dr. Demsey summarized elements of the Government in the Sunshine Act and the Federal Advisory Committee Act that govern all Advisory Council meetings. These Acts require the U.S. Department of Health and Human Services to open Advisory Council meetings to the public except when proprietary or personal information is discussed. To comply with these regulations, the NACBIB meeting is open to the public for all but the review of individual grant applications. Dr. Demsey reviewed conflict of interest, confidentiality, and lobbying guidelines.

B. Future NACBIB Meeting Date

The next NACBIB meeting is scheduled for Monday, January 24, 2011, at a site to be determined. Dr. Demsey asked Council members to inform him about conflicts with upcoming meeting dates.

C. Approval of the May 21, 2010, NACBIB Meeting Minutes

A motion to approve minutes of the May 21, 2010, NACBIB meeting was forwarded, seconded, and approved unanimously.

V. Report of the Strategic Plan Workgroup: Dr. Richard Ehman

At its most recent meeting, the Strategic Plan Workgroup reviewed a Program Announcement for Technologies for Healthy Living. This PAR encourages development of technologies for monitoring personal motion, vital signs, and other physiological measures in order to provide data for use by patients and providers to improve care, particularly for patients with chronic illness, and to extend wellness. The Workgroup expressed enthusiasm for this PAR, which could have significant impact on traditional health care, wellness, and chronic disease management.

The workgroup also reviewed a draft of the revised Strategic Plan. This draft contains basic elements that will be expanded, including a revised mission statement explicitly outlining biomedical imaging and bioengineering as NIBIB's main focus. A vision statement is also in development. Six goals were outlined for NIBIB:

1. To improve the diagnosis, treatment, and prevention of disease through development of emerging biomedical technologies.
2. To enable patient-centered health care through the development of health informatics, mobile health, and point-of-care technologies.
3. To transform advances in medicine at the molecular and cellular levels into therapeutic and diagnostic technologies.
4. To develop medical technologies that are low-cost, effective, and accessible to everyone.
5. To prepare a new generation of interdisciplinary engineers, scientists, and providers for the challenges and demands of future biomedical technology-based research.
6. To expand public knowledge of the medical, social, and economic value of biomedical imaging, bioengineering, bioinformatics, and biomedical technology.

Strategies for accomplishing each goal were outlined. The workgroup provided feedback for the draft and commended NIBIB leadership and staff for developing the document.

Dr. Gary Glover emphasized that the workgroup was particularly excited about the Technologies for Healthy Living PAR and its goal to make data available to patients in the home to improve wellness and alert them to potential problems as they arise, as distinct from giving that data to providers. This also might be a good theme for the NIBIB to highlight in the Strategic Plan.

VI. Adjournment

The open session of the NACBIB meeting was adjourned at 11:45 a.m.

VII. Closed Session

The grant application review portion of the meeting was closed to the public in accordance with provisions set forth in Section 552b(c)(4) and 552b(c)(6), Title 5, U.S. Code and 10(d) of the Federal Advisory Committee Act, as amended (5 U.S.C. appendix 2). The closed session was adjourned at 3:30 p.m.

Certification:

We certify that to the best of our knowledge, the foregoing minutes and attachments are accurate and complete.[2]

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Anthony Demsey, Ph.D.
Executive Secretary,
National Advisory Council for Biomedical Imaging and Bioengineering
Director,
Office of Research Administration
National Institute of Biomedical Imaging and Bioengineering

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Roderic I. Pettigrew, Ph.D., M.D.
Chairperson,
National Advisory Council for Biomedical Imaging and Bioengineering
Director,
National Institute of Biomedical Imaging and Bioengineering

[2] These minutes will be approved formally by the Council at the next meeting on January 24, 2011, and corrections or notations will be stated in the minutes of that meeting.