QIBA Newsletter

Quantitative Imaging Biomarkers Alliance RSNA

December 2010 • Volume 2, Number 4

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QIBA MISSION
Improve the value and practicality of quantitative imaging biomarkers by reducing variability across devices, patients and time.

QIBA CONNECTIONS

Quantitative Imaging Biomarkers Alliance (QIBA)

QIBA Wiki

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Daniel C. Sullivan, MD
RSNA Science Advisor

IN MY OPINION

Why a Quantitative Imaging Curriculum Should be Included in Residency Training Programs

By JOHN M. BOONE, PhD, FAAPM, FSBI, FACR

Practicing radiologists today learned their craft in a largely qualitative educational landscape, and for many clinical settings the differential diagnosis which is the standard qualitative reporting procedure will remain the heart and soul of the radiology report. However, the future of radiology reporting will gradually embrace quantitative metrics, providing critical information in an increasing number of radiology settings. Therefore, it is essential that residency programs begin to teach both the necessity of quantitative reporting techniques, and develop the infrastructure by which quantitative reporting can be achieved.

The Need for Quantitative Radiology

Oncologic imaging is the most obvious example where quantitative image metrics such as tumor diameter, volume, standard uptake value, or vascular permeability are necessary in treatment response assessment. With the proliferation of 3D volume imaging techniques, image data sets are now rich with quantitative information, which will eventually have important diagnostic value in general radiology practice-well beyond oncology. In addition to anatomic metrics, functional data are available on all 3D modalities when injected agents are used. These data, determined by the interpreting radiologist in many cases using automated software tools, will lead to more definitive and ultimately more accurate diagnostic conclusions.

The explosion in biological discovery in the last two decades has led medicine down a path from art to science, and this will continue. Radiology must follow this trend to keep pace with the sophistication of referring physicians, and quantitative imaging is an important signpost on this journey. With the promotion of reimbursement slogans such as "evidence-based medicine" and "pay-for-performance," a quantitatively based radiological diagnosis is a necessary component in the radiology report of the future. Now that this door has been opened for us, we in the radiology community-including residents-need to step through it and become part of this process.

How to Get There

Although patient images currently reside on PACS and the radiologist's text report resides on the radiology information system (RIS) at most institutions, this dichotomy will gradually erode as PACS and the RIS become more integrated. The radiology report of the future will be an electronic document (e.g., web page) where the radiologist's text report is supported by embedded key images, movies with rotating maximum intensive projections of anatomy with overlaid functional information, quantitative measurements detailed and highlighted, color bar charts showing differential diagnostic probabilities based on quantitative and qualitative findings, radiation dose estimates for X-ray and gamma ray procedures, and a Twitter link to the radiologist in case a quick electronic consultation is wanted. But how do we get there?

We need to work with our IT departments to break down artificial barriers between computer systems-we did it with PACS/DICOM, we can do it again. We have the tools: voice dictation, the DICOM structure reporting object, emerging software for image segmentation, spreadsheet software with linked drop-down menus, word processing tools for putting it all together, and conversion software to prevent alteration. We need radiology vendors to step up to the plate and provide effective and efficient integrated software tools to advance the information (quantitative and qualitative) content and clinical value of the radiology report.

Building a reporting infrastructure is necessary for quantitative imaging to happen, but developing the science to support quantitatively pertinent radiological reporting is a project that clinical academic radiologists can and should embrace. I suspect that much of the quantitative reporting data is already in the heads of experienced radiologists. Peer-reviewed literature in radiology generally does a good job at reporting statistically justified quantitative data such as sensitivity, specificity, etc. Radiologists read these papers and assimilate them into their subjective minds, but

the data are right there in the literature to convert into a drop-down menu which would facilitate a more quantitative reporting tool.

By combining numerous sources of statistically meaningful peer-reviewed clinical data with decision support tools such as multiple regression analysis, fuzzy logic or neural networks, quantitative data in the literature can be used to create a quantitative reporting tool[1] (QRT). Given the breadth and depth of imaging in medicine, numerous quantitative reporting tools will be necessary for each clinical subspecialty. Not only do we need to teach radiology residents quantitative reporting, we should capitalize on their computer-savvy upbringing to help create the quantitative report systems that will be the essential tools of their future careers.

Reference:
[1] Neural Networks in Radiological Diagnosis II. Interpretation of Neonatal Chest Radiographs. *Invest Radiology* 1990; 25:1017-1023. Gross G.W., et al.

John M. Boone, Ph.D. is professor of radiology and biomedical engineering at the University of California, Davis, and is vice-chair of radiology (for research). His research interests focus on the development of breast imaging systems, primarily breast CT, on computer modeling of imaging systems and dose distribution, and on quantitative imaging. He is a member of the QIBA Steering Committee and was a primary investigator on the original Imaging Response Assessment Teams (IRAT) program.

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ANALYSIS TOOLS & TECHNIQUES

The Challenges of Making fMRI Reproducible

By JAMES VOYVODIC, Phd

Functional MRI (fMRI) has become a commonplace tool for basic research studies of brain function, and it has great potential for becoming an important clinical imaging procedure. Currently, however, the only routine clinical application of fMRI is for localization of critical brain regions (e.g. speech and motor areas) in treatment planning for brain surgery.

A major obstacle to broader clinical application is the fact that standard fMRI methodologies tend to produce results that are difficult to quantify and are not highly reproducible. Multiple scans of a single individual performing the same behavioral task typically produce similar brain activation maps,but with significant variability in the details of active regions identified in different scans[1].This lack of reproducibility has made it difficult to assess confidence in the accuracy of individual maps, to standardize quantification of fMRI results, or to perform rigorous validation testing of clinical fMRI procedures.

There are three fundamental reasons why reproducibility is a problem in fMRI. The first is that fMRI is an inherently indirect method for mapping brain function. It is based on mapping regional changes in the blood oxygen level-dependent (BOLD)

MR signal, which is highly correlated with changes in brain activity[2].The BOLD signal is also sensitive, however, to other factors that contribute to variability in blood flow or blood oxygenation. For example, changes in anxiety or arousal levels, recent consumption of cigarettes or alcohol, and vascular disease or brain tissue pathology can all affect the coupling between neuronal functional activity and the observable BOLD signal.

The second major obstacle to reproducibility is the fact that fMRI analysis methods tend to identify active brain regions based on the statistical significance of the task-dependent BOLD signal compared to task-independent signal fluctuations. Because task-dependent signals are typically comparable in magnitude to physiological noise levels, signal averaging is usually essential.

The problem with reproducibility arises because traditional fMRI mapping defines "active" brain regions based solely on the statistical significance of the averaged signal-to-noise ratio rather than on the BOLD signal itself. Again, this means that factors such as attention, anxiety, or scan duration that affect the noise level will produce variability in fMRI map results, even if the task-evoked pattern of brain activity is constant.

The third major obstacle to reproducibility is the fact that brain function is inherently complicated and changing. Even the simplest reading task involves many brain regions including vision, eye movement, and language comprehension areas. Moreover, the spatial pattern of brain activity levels change if the person changes how he performs the task or simply as the same task becomes easier with practice.

For fMRI to become a reliable biomarker of brain activity, these reproducibility problems must be addressed. Empirical studies are needed to better understand the relationship between specific clinical task behaviors and brain activity and between brain activity and other components of BOLD signals.

Most importantly, we need improved statistical analysis methods that use statistical significance to assess confidence while providing relatively noise-independent quantitative maps of activity-dependent BOLD signal levels.

Reference:

[1] Reproducibility of fMRI at 1.5T in a Strictly Controlled Motor Task. *Magn. Reson. Med.*, 2004; 52:751-760. Liu J.Z, et al.
[2] Neurophysiological Investigation of the Basis of the fMRI Signal. *Nature,* 2001; 412:150-157. Logothetis N.K., et al.

James Voyvodic, PhD, is an associate professor of radiology and neurobiology at Duke University Medical Center in Durham, N.C He leads the clinical fMRI research effort and is actively involved in developing real-time image analysis and data quality assessment algorithms.

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FOCUS ON

RSNA 2010: Quantitative Imaging/Imaging Biomarkers and QIBA Meetings and Activities

RSNA Awarded $2.4 million NIBIB Grant for Quantitative Imaging

RSNA has been awarded a two-year, $2.4 million contract from the National Institute of Biomedical Imaging and Bioengineering (NIBIB) to support RSNA's quantitative imaging and biomarkers programs-specifically the Quantitative Imaging Biomarkers Alliance (QIBA), formed in 2008 to advance quantitative imaging and the use of imaging biomarkers in clinical trials and practices.

The contract provides $1.2 million each year to support a coordinated effort to establish an infrastructure for the collection and analysis of imaging biomarker data. The long-term objective is to establish processes and profiles leading to acceptance by the imaging community, clinical trial industry and regulatory agencies of quantitative imaging biomarkers as proof of biology, changes in pathophysiology and surrogate endpoints for changes in the health status of patients.

RSNA 2010: QIBA Meetings and Quantitative Imaging

QIBA held a working meeting at RSNA 2010 that provided attendees with a recap of significant accomplishments for the year. These include:

- the award of a two-year contract to RSNA by the National Institute of Biomedical Imaging and Bioengineering (NIBIB) to support the ongoing work of QIBA
- increased visibility achieved, in part, by publication of the MITA (Medical Imaging Technology Assessment) White Paper, *Why QIBA is a good thing for Radiology in General, and the Imaging Manufacturers in Particular,* and reflected by an overwhelming interest in and attendance at the RSNA Special Interest Session, *Imaging Biomarkers for Clinical Care and Research*
- convening a workshop on standards for imaging endpoints, jointly sponsored by SNM, RSNA and the FDA
- continued work on QIBA CT, MR and PET profiles which include standardized protocols
- acceptance for publication by *Radiology* of two QIBA-related articles, "A Collaborative Enterprise for Multi-Stakeholder Participation in the Advancement of Quantitative Imaging," and "Quantitative Imaging Test Approval and Biomarker Qualification: Inter-related but Distinct Activities."

The Quantitative Imaging Reading Room

RSNA 2010 featured *The Quantitative Imaging Reading Room*. This educational showcase featured 23 educational exhibits that provided visual and experiential exposure to quantitative imaging and biomarkers through exhibitor products that integrate quantitative analysis into the image interpretation process. Participants learned through hands-on exhibits featuring informational posters, computer-based demonstrations and Meet the Expert presentations scheduled throughout the week.

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QI/IMAGING BIOMARKERS IN THE LITERATURE

PubMed Search on Quantitative Imaging in the Residency Curriculum

Each issue of QIBA Quarterly will feature a link to a dynamic search in PubMed, the National Library of Medicine's interface to its MEDLINE database. Click here to view a PubMed search on "why quantitative imaging curriculum should be included in residency training programs."

For additional information concerning quantitative imaging and structured reporting related to this topic, please click here.

Take advantage of the My NCBI feature of PubMed that allows you to save searches and results and includes an option to automatically update and e-mail search results from your saved searches. My NCBI includes additional features for highlighting search terms, storing an e-mail address, filtering search results and setting LinkOut, document delivery service and outside tool preferences.

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