Suggestions for topics suitable for these Point/Counterpoint debates should be addressed to Colin G. Orton, Professor Emeritus, Wayne State University, Detroit: ortonc@comcast.net. Persons participating in Point/Counterpoint discussions are selected for their knowledge and communicative skill. Their positions for or against a proposition may or may not reflect their personal opinions or the positions of their employers.

The physics components of the ACR MRI Accreditation Program are overly tedious and beyond what is needed to ensure good patient care

Wlad T. Sobol, Ph.D.
Radiology Department, University of Alabama Birmingham, Birmingham, Alabama 35249-6830
(Tel: 205-934-3932, E-mail: wts@uab.edu)

Moriel S. NessAiver, Ph.D.
Simply Physics, 5816 Narcissus Avenue, Baltimore, Maryland 21215
(Tel: 410-982-6599, E-mail: moriel@simplyphysics.com)

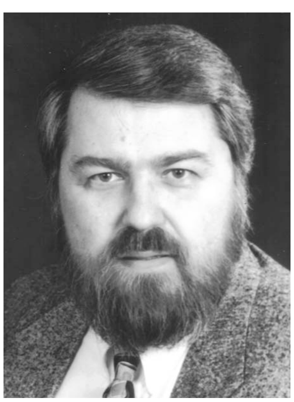
Colin G. Orton, Ph.D., Moderator

(Received 5 June 2008; accepted for publication 6 June 2008; published 8 July 2008)

[DOI: 10.1118/1.2952358]

OVERVIEW

MRI systems, like any other imaging technologies, suffer from loss of good image quality if not properly tested and maintained. Also, like other imaging systems, this reduction in image quality might be too subtle to be realized by the users, yet could be sufficient to put patient care at risk. The assurance of good image quality is the goal of the physics tests prescribed in the American College of Radiology (ACR) MRI Accreditation Program. These physics tasks were initially simply recommendations but, over the years, they have evolved into requirements which some believe are overly tedious and beyond what is needed to ensure good patient care. This is the topic debated in this month's Point/Counterpoint debate.



Arguing for the Proposition is Wlad T. Sobol, Ph.D. Dr. Sobol received his Ph.D. degree from the Jagiellonian University in Cracow in 1978 and is currently Professor of Radiology in the Department of Radiology at the University of Alabama in Birmingham. He was a member of the Board of Editors of *Medical Physics* for several years, served on or chaired several AAPM committees, and was Co-Director of the 2001 Summer School. Dr. Sobol is a Diplomate of the American Board of Radiology in Diagnostic Radiological Physics and the American Board of Medical Physics in Magnetic Resonance Imaging Physics and is a Fellow of the AAPM.

Arguing against the Proposition is Moriel S. NessAiver, Ph.D. Dr. NessAiver received his Ph.D. in Biomedical Engineering in 1988 from the University of Southern California where his research focused on MRI surface coil intensity correction methods. From 1989 to 1994 he was a senior scientist at Picker responsible for developing their cardiac MRI program and holds six patents on cardiac imaging techniques. In 1994 he joined the University of Maryland School of Medicine. While there he authored the book "All You *Really* Need to Know About MRI Physics." He is a past member of the ACR MRI Accreditation Physics committee. His company, Simply Physics, has been providing MRI quality control services for the past seven years.

FOR THE PROPOSITION: Wlad T. Sobol, Ph.D.

Opening Statement

Let me start by saying that I am not against ACR accreditation programs. To the contrary, while I have never been a part of an official ACR body in charge of an MRI accreditation program (MRAP), I have stayed very close to the project since its onset and helped nurse it along in various ways. Thus, I am quite familiar with both its structure and history. When the MRAP started, it did not require a physics expert's participation. Periodic system testing was recommended, but scope and methods were left entirely to the judgment of the

 0094-2405/2008/35(8)/3419/3/$23.00

local team. As time went by, the program requirements[1] evolved dramatically and physics components went from recommended and descriptive to required and prescriptive. This worries me.

The origins of the tests, currently required by the ACR MRAP as components of yearly physics surveys, date back to the late 1980's when a group of starry-eyed enthusiasts set out to formulate descriptions of basic MRI performance tests.[2] At about the same time, the manufacturers developed some specifications for basic assessment of MRI equipment's performance.[3] From today's point of view, most of these efforts look quaint and obsolete, dwarfed by 20 years of spectacular progress in MRI technology. This is okay, since these tests were never meant to be prescriptive; they were intended to provide helpful suggestions and guidance. This point of view has always been clearly stated in the ACR's own standards.[4]

The structure of all current ACR accreditation programs is based on the ACR mammography accreditation program. This has some serious consequences for the ACR MRAP. While mammography machines in use today have a very uniform design and offer only a few user-adjustable parameters, MRI scanners are vastly more differentiated and require scores of user-defined parameters to operate. Most of these parameters are platform-specific and are not implemented even across vendors' own product lines. Furthermore, neither the ACR nor MRI manufacturers provide tools needed to run the ACR-prescribed tests. As a result, "MR physicists" are forced to devise their own methods *ad hoc*. This is a challenging task because, at a user level, these tests are trivial to implement on some MR machines, but they prove very difficult, if not downright impossible, to run on others.

Finally, MR vendors' own internal test tools and tests have evolved, over the years, into a set vastly superior to anything that an end user can accomplish using a scanner graphical user interface (GUI) and a simple phantom. This leads to an interesting *gedanken* scenario: what is supposed to happen when the physicist's test, performed using methods that might be unsuitable for the evaluated unit, fails? Obviously, the system engineer will then run a set of tests using internal service tools. What if all these tests pass? A showdown is bound to expose the embarrassing inadequacy of the physicist's methods.

Given this situation, it is best to leave the authority over the scope and methodology of MRI system testing to the MRI experts in the field. The ACR MRAP guidelines may define recommended tests and demand written explanation from the expert for any observed variances, but the accreditation body should stay away from prescribing tests for which it has no authority to ensure proper implementation.

AGAINST THE PROPOSITION: Moriel S. NessAiver, Ph.D.

Opening Statement

Not only are the requirements for the physics components of the ACR MRI Accreditation Program as outlined in the most recent ACR's MRI Quality Control Manual[5] not overly tedious, I submit that they do not go far enough to ensure both good patient care and a good return on investment for the owner of the MRI scanner. The single most time-consuming task required of the MRI physicist is the yearly performance test. It is the goal of this yearly task to ensure that the magnet has good homogeneity, the gradients are properly calibrated, each and every RF coil is working at peak performance, and all of the components work together as a harmonious whole.

The single biggest omission by the ACR Accreditation Program is not requiring that each channel of every phased array RF coil be tested. Today's phased array coils can have up to 64 channels and can cost upwards of $100 000. If one channel is not working properly, an image can look "OK" but the small region covered by the bad channel can have significantly reduced signal-to-noise ratio (SNR). Most physicists only look at a single composite image which can result in problems being missed. As a case in point, I once tested a four-channel knee coil which produced a very uniform composite image with an SNR of 274. However, when I examined the individual channels, two channels had SNR values of 200 while the other two channels had SNR values of only 45. The coil was replaced and the new coil had SNR values of 220 in each channel and a composite SNR of 430. This gain in SNR would allow the site to use a 14 cm FOV instead of a 17.5 cm FOV.

Over the last 3.5 years I have performed 174 yearly performance tests on 98 different magnets. I performed more than 3000 separate tests on roughly 1500 different RF coils, half of which were phased array coils. Of those 174 system tests, in only 18 (10.3%) did I encounter no deficiencies of any kind. An additional 19 (for a total of 21.3%) only had minor deficiencies that did not affect image quality, meaning that a full 78.7% of all of the systems I tested had deficiencies that directly affected image quality. I encountered a total of 144 phased array coils (19.2%) with significant problems. Utilizing software I wrote for analyzing phase difference images, I found 22 systems (12.6%) with homogeneity problems. Between 10 and 20% of the scanners suffered from each of the following problems: excessive RF noise, excessive ghosting, poor gradient calibration, poor hard copy (film) and soft copy performance. I also found that one vendor's turbo spin-echo (TSE) sequences had slice thicknesses that were all 18-23% thicker than specified while another vendor's were 20%–25% thinner.

A thorough yearly performance test can take 8–14 h but this is a small price to pay to ensure the highest quality images that patients, and magnet owners, have every right to expect.

Rebuttal: Wlad T. Sobol, Ph.D.

Somewhat to my surprise, my fellow debater appears to argue for the same solution, namely, that the physicist testing MRI equipment should be allowed to select both the scope and methodology of yearly surveys and acceptance testing. However, while Dr. NessAiver argues for the right to *expand* the testing methodology, I argue for the rights to *narrow* the scope and *modify* the methodology.

It is no secret that MRI coil management is currently in bad shape due to rapid transition into the complex domain of multichannel, phased array designs. Unfortunately, currently there are no public algorithms for testing the multichannel coils, no accepted baseline performance specifications, no established tools, and no adequate phantoms. Thus, it is impressive to see a testimony of a skilled MRI expert who advocates devising (undocumented) proprietary interfaces, forging through data extraction protocols, and developing custom software tools to analyze the results. But to require such performance from an average MRI physicist is unrealistic at best.

Then there is an issue of economics. Routine coil configuration management and performance testing is included in most service PM programs. Few facilities would consider it fiscally responsible to ask the physicist to replicate this task. I, for one, would prefer to have an option of *checking* the service engineer's PM results, making sure that all coils perform within the vendor's own standards.

I believe Dr. NessAiver may be leaning a little towards the infamous "academic bias," as he seems to advocate an environment where nothing matters but the performer's virtuosity. I just want to help people by making their jobs a little easier and making the scanners perform a little better. To do this effectively, I need the freedom of tailoring the scope of my services to the environment in which I find myself. My dream is to be a part of the solution, not a part of the problem.

Rebuttal: Moriel S. NessAiver, Ph.D.

I certainly agree with many of the points that Dr. Sobol raised. MRI scanners are more complicated to operate than any other modality and the manufacturers do not provide adequate tools for typical users to evaluate scanner performance. This is why I perform all data analysis on my laptop using software that I have personally developed. While it is true that some manufacturers have developed sophisticated testing tools, it has been my experience that their specs are often so generous as to be nearly useless. I also agree that the scope and methodology of MRI system testing should be left to the MRI experts in the field, however those experts *should* be MRI physicists with years of actual hands-on experience.

Dr. Sobol proposed a thought experiment where the physicist performs a test of his own design in which the system fails while the service engineer, using the vendor's tools, says it passes. This has happened to me. I use a 32 cm sphere and my own software to map out magnet field homogeneity and one time I claimed that a certain magnet failed this test. The service engineer, however, using only a 24 cm sphere, said it passed. After the engineer reviewed my analysis, he agreed to bring in a shim rig and measure it over a 40 cm volume. The magnet *then* failed the vendor's spec.

It is incumbent upon us, the MRI physicists, to be the sites' third-party advocates to the manufacturers. The very fact that close to 80% of all scanners that I have tested have had problems that adversely affected image quality is enough of a reason to justify the periodic evaluations required by the ACR. If we need to develop our own tools, so be it. Just because a task is difficult, doesn't mean we shouldn't do it.

[1] American College of Radiology, *MRI Accreditation Program Requirements* (ACR, Reston, VA, 2008). Available at http://www.acr.org/accreditation/mri/mri_reqs.aspx.

[2] J. G. Och, G. D. Clarke, W. T. Sobol, C. W. Rosen, and S. K. Mun, "Acceptance testing of MRI systems: Report of AAPM NMR Task Group No. 6," Med. Phys. **19**, 217–229 (1992).

[3] National Electrical Manufacturers Association, *Determination of Signal-to-noise Ratio (SNR) in Diagnostic Magnetic Resonance Images MS 1-1994*, NEMA, Washington, DC, 1994. Updated version MS 1-2001 available at http://www.nema.org/stds/ms1.cfm.

[4] American College of Radiology, *ACR Technical Standard for Diagnostic Medical Physics Performance Monitoring of MRI Equipment*. (ACR, Reston, VA, 2004). Available at http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/med_phys/mri_equipment.aspx.

[5] J. C. Weinreb, R. A. Bell, G. D. Clarke, L. K. Hedges, J. B. Kneeland, R. R. Price, *Magnetic Resonance Imaging (MRI) Quality Control Manual*, (ACR, Reston, VA, Revised 2004).