ACR White Paper on Radiation Dose in Medicine: Three Years Later

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The benefits of diagnostic imaging are immense and have revolutionized the practice of medicine. The increased sophistication and clinical efficacy of imaging have resulted in its dramatic growth over the past quarter century. However, the evolution of imaging has also resulted in a significant increase in the population's cumulative exposure to ionizing radiation and a potential increase in cancer risk. The ACR, an advocate for radiation safety since its inception in 1924, convened the ACR Blue Ribbon Panel on Radiation Dose in Medicine in 2006 and issued 37 recommendations for the College to address these issues. This report updates the status of these recommendations.

Key Words: Radiation dose, radiation safety, radiation risk, radiation exposure, radiations, exposure to patients and personnel

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INTRODUCTION

Ionizing radiation has been used for diagnostic purposes in medicine for more than a century. The benefits of noninvasive or minimally invasive procedures are integral to modern patient care and greatly exceed the associated risks. The development of remarkable equipment such as multidetector row CT and the increased utilization of x-ray and nuclear medicine imaging studies have transformed the practice of medicine as imaging studies increasingly replace more invasive, and often more costly, techniques for any number of indications. However, this dramatic evolution of imaging into the widespread diagnostic and therapeutic role it now occupies in medicine has also resulted in a significant increase in the population's cumulative exposure to ionizing radiation and a potential increase in cancer risk.

Factors such as (1) more advanced, more accurate technology; (2) fear of litigation; (3) increased need for immediate diagnosis and patient throughput in busy clinical settings; (4) increased patient demand; and (5) a lack of radiation safety training for nonradiologist providers have contributed to the significant growth in imaging utilization.

Expanding international and federal interest in, and scrutiny of, radiation dose from imaging procedures prompted the ACR to appoint the Blue Ribbon Panel on Radiation Dose in Medicine in 2006 to assess the issue and to recommend an action plan for the College that would reinforce its long-standing commitment to radiation safety. The diverse panel, chaired by one of us (E.S.A.), included academic and private practice radiologists, medical physicists, representatives of industry and regulatory groups, and a patient advocate. The panel's "American College of Radiology White Paper on Radiation Dose in Medicine" was published in the May 2007 issue of *JACR* [1].

That report offers an extensive set of recommendations designed to counteract medical and societal trends that might contribute to unnecessary radiation exposure that Americans may experience because of overuse or misuse as these beneficial technologies advance. Its 37 specific recommendations addressed key issues such as

- educating stakeholders in radiation safety principles;
- appropriately utilizing imaging to minimize any associated radiation risk;
- standardizing radiation dose data to be archived during imaging for ultimate use in defining good practice;
- developing and implementing maximum radiation dose estimate pass-fail criteria for the ACR CT Accreditation Program;
- supporting the current multiorganizational effort to improve radiology resident training in medical physics;
- including in the ACR Practice Guidelines and Technical Standards additional considerations for special radiosensitive populations, such as children and potentially pregnant women;
- encouraging radiology practices to define a surveillance mechanism to identify patients with high cumulative radiation doses due to repeated imaging so that alternative imaging techniques may be considered; and
- working with patient advocacy organizations to more effectively communicate the potential radiation risks and health benefits of imaging procedures.

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Although most of the recommendations call for specific actions on the part of the ACR, several encourage radiology practices and departments to take a more proactive approach to radiation safety.

PROGRESS

Since the publication of the white paper, 30 of the 37 recommendations have been completed or are in progress. Each recommendation's status is outlined in Table 1 [2-7].

RECENT ATTENTION TO MEDICAL RADIATION

A number of important developments have occurred since the publication of the 2007 white paper, validating the panel's recommendations and making them even more critical. These include scientific reports, articles in the public media, and increased scrutiny by the US government. It is worthwhile to itemize just a few of these developments:

- Scientific reports
  - A 2009 National Council on Radiation Protection and Measurements [8] publication, *Ionizing Radiation Exposure of the Population of the United States*, reported a 7-fold increase in radiation exposure to the population of the United States from medical radiation since the early 1980s. In addition, the contribution that medical radiation makes to the US population's per capita average annual exposure grew from 15% in the early 1980s to 48% in 2006.
  - In a 2009 paper, Fazel et al [9] showed that myocardial perfusion imaging alone contributed to >22% of the total effective dose from medical imaging studies, while CT of the abdomen, pelvis, and chest accounted for nearly 38%.
  - Mettler et al [10] reported in 2009 that the per capita annual effective dose from medical procedures in the United States is among the highest in the world. Although the United States has about 4.6% of the world's population, it accounts for about 12% of all radiologic procedures and about half of all nuclear medicine procedures performed in the world.
  - In a 2009 report, Smith-Bindman et al [11] pointed out that radiation doses from commonly performed diagnostic CT examinations were higher and more variable than generally reported and called for the standardization of CT protocols.
  - Berrington de Gonzalez et al [12] estimated that approximately 29,000 future cancers could be related to CT scans performed in the United States in 2007.
- Public media
  - In 2008, a television news story described an incident in which a 2-year-old child underwent a 1-hour-long CT scan [13]. The child experienced a burn across his face and is likely at increased risk for cataracts and cancer.
  - In 2009, the *Los Angeles Times* reported that 260 patients had been exposed to high doses of radiation during CT brain perfusion scans at one institution during an 18-month period [14]. Many patients experienced temporary hair loss; some may be at higher risk for cataracts.
  - In early 2010, the *New York Times* ran a series of articles on treatment errors in radiation oncology [15-20], highlighting individual patient experiences that, in several cases, resulted in death.
- Government
  - In February 2010, the US Food and Drug Administration [21] announced an initiative to reduce unnecessary radiation exposure from CT, nuclear medicine studies, and fluoroscopy.
  - Also in February 2010, the Subcommittee on Health of the US House of Representatives Committee on Energy and Commerce held hearings on medical radiation [22]. One of us (E.S.A.) represented the ACR on an invited panel that included representatives from the American Society for Radiation Oncology, the American Association of Physicists in Medicine, the American Society of Radiologic Technologists, and the Medical Imaging and Technology Alliance.

Although some of these reports have raised considerable debate among experts, all of these issues have raised the awareness among radiology professionals, referring physicians, and especially patients.

IMAGE GENTLY

The Alliance for Radiation Safety in Pediatric Imaging was formed in 2007 as a coalition of health care organizations dedicated to promoting safe, high-quality pediatric imaging nationwide [5]. The alliance was organized under the leadership of the Society for Pediatric Radiology, with the American Society of Radiologic Technologists, the ACR, and the American Association of Physicists in Medicine included as founding organizations. The primary objective of the alliance is to raise awareness in the imaging community of the need to adjust radiation dose when imaging children, with an ultimate goal of changing practice. The resulting Image Gently™ campaign initially focused on CT safety but has broadened its scope to address other radiologic imaging, including interventional radiology, computed radiology, fluoroscopy, and nuclear medicine.

Table 1. Current status of recommendations of the ACR Blue Ribbon Panel on Radiation Dose in Medicine

Panel Recommendation	Current Status
Measurements	
1. Replace term "dose" with "dose estimate" in ACR publications as they are revised.	In progress: all ACR quality and safety documents.
2. Develop a national database for radiation dose indices.	In progress: Dose Index Registry currently under development; pilot has been completed with one vendor; results presented at the 2009 annual meeting of the RSNA [2]; pilot test with multiple vendors is ongoing.
Referring physicians	
3. Educate Liaison Committee on Medical Education and the AAMC of need to introduce medical students to radiation exposure in medical imaging.	Pending pamphlet or lecture(s) development.
4. Prepare learning materials for use by students.	Under discussion.
5. Work with the American Medical Association to ensure the wide dissemination and enactment of its Council Report on Diagnostic Radiation Exposure.	In progress.
6. Request CMSS to address the issue of radiation exposure during medical imaging to its member societies.	Dr Amis made a presentation titled "Radiation Dose in Medicine: Basics for Referring Physicians" to the CMSS Forum (April 25, 2008). A major session, "Radiation Exposure in Imaging: Do We Have a Problem?" was held during the CMSS annual meeting (October 21, 2009). Dr Amis gave a background presentation highlighting the relationship between exposure to x-rays, especially during CT scanning, and the lifetime risk for developing cancer. This was followed by a presentation on Image Gently by Marilyn Goske, MD. The final part of this session was a presentation by Paul Sierzenski, MD, on the forces that drive the significant use of CT scanning in the emergency department. The session was well received. In an introduction to the session, Dr Amis requested that CMSS representatives take the message to their respective specialty societies and disseminate it as broadly as possible.
7. Add RRLs to Appropriateness Criteria®.	Appropriateness Criteria with RRLs introduced on ACR Web site (http://www.acr.org/ac; October 2008). RRLs are routinely updated. "Incorporating Radiation Dose Assessments Into the ACR Appropriateness Criteria®" by Beth Schueler, PhD [3], published.
8. Ensure that the Appropriateness Criteria can be integrated into physician order entry systems for real-time guidance.	Under discussion. Original plans need to be modified based on the CMS demonstration project underway as a result of the MIPPA legislation.
9. Sponsor summit with emergency medicine leaders to develop consensus guidelines for imaging conditions in which CT might be overutilized.	The ACR cosponsored an SPR symposium, "Building Bridges Between Radiology and Emergency Medicine: Consensus Conference on Imaging Safety and Quality for Children in the Emergency Setting," with emergency physicians (February 23-24, 2008). The ACR cosponsored an NCRP workshop, "Computed Tomography in Emergency Medicine: Ensuring Appropriate Use," with the AAPM, the CDC, the EPA, Landauer, and the ACEP (September 23-24, 2009). The outcome of this workshop was an agreement for the leadership of radiology and emergency medicine to proceed with development of consensus guidelines for the use of CT in a few common clinical conditions often seen in the emergency setting (eg, ureteral colic, suspected pulmonary embolism): http://www.ncrponline.org/PDFs/CT_presentations_9-09.pdf.
Radiologists	
10. Support multiorganizational efforts to improve radiology resident training in medical physics.	The ACR published a radiation dose Case in Point (January 7, 2008): http://3s.acr.org/cip/CaseView.aspx?CaseId=TFYBnyKLU7o%3d.
11. Include additional questions on radiation safety in annual in-training examination.	Questions on dose routinely included on ACR in-training examinations (2008).
12. Request ABR to consider at least one self-assessment module on patient safety (to include patient dose) every 10 years as part of MOC.	In progress. ACR Patient Safety Online Self-Assessment Module released (September 4, 2007): http://www.acr.org/SecondaryMainMenuCategories/ACRStore/Sams-online.aspx. The ACR participated in an ABR-sponsored summit, "Radiation Safety: Development of Practice Quality Improvement Projects" (August 2008).
13. Develop and implement maximum radiation dose estimate pass-fail criteria for the ACR CT Accreditation Program.	Pass-fail dose criteria implemented (January 1, 2008).

Table 1. Continued

Panel Recommendation	Current Status
14. Make CT scanning protocols available on the ACR Web site and review and update them on a routine basis.	The CT Accreditation Program's Clinical Image Quality Guide current recommended protocols (http://www.acr.org/accreditation/computed/qc_forms/image_guide.aspx) are being updated. Protocol to adjust techniques in pediatrics available on the Image Gently™ Web site: http://www.pedrad.org/associations/5364/files/Protocols.pdf; links on ACR's "Radiology Safety" page.
15. Request that the editor of *JACR* add a regular column on patient safety (including radiation exposure issues).	More than 15 articles or features related to radiation dose issues have been published in *JACR* since January 2008 (5 in the June 2008 issue alone).
16. Create a prominent "Safety" link on home page of the ACR Web site.	Complete: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/RadSafety.aspx.
17. Include additional considerations for especially radiosensitive populations in ACR Practice Guidelines and Technical Standards.	A new guideline, the ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women With Ionizing Radiation [4], was published (October 2008). Image Gently initiative [5] (cosponsored by the ACR, the SPR, the ASRT, and the AAPM) launched (January 22, 2008); goal to educate radiologists about reducing dose to children from CT: http://www.imagegently.org.
18. Encourage radiology practices to record fluoroscopy times, compare them with benchmarks, and evaluate outliers as part of an ongoing QA program.	An updated guideline, the Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures [6], was published (October 2008).
19. Encourage radiology practices to define a surveillance mechanism to identify patients with high cumulative doses from repeated imaging.	Steven Birnbaum, MD [7], a blue ribbon panel member, published a *JACR* article on topic. Further activities under discussion.
Technologists	
20. Encourage radiology practices to provide regularly scheduled in-service training on radiation safety issues for technologists.	The ACR and ASNR Statement on CT Protocols and Radiation Dose (December 2009) recommended that CT staff members maintain CT-specific continuing education that focuses on patient safety. Work with ASRT through Image Wisely to develop materials for technologists (see recommendation 27).
21. Phase in a requirement that at least one technologist per accredited CT site hold an advanced registry in CT.	The ACR Committee of Accreditation chairs decided that all programs will recommend that accredited facilities have at least one technologist that holds an advanced/specific registry in the modality accredited (January 2009).
22. Phase in a requirement that at least one technologist per accredited nuclear medicine site hold an advanced registry in nuclear medicine or certification by NMTCB.	The ACR Committee of Accreditation chairs decided that all programs will recommend that accredited facilities have at least one technologist that holds an advanced/specific registry in the modality accredited (January 2009).
23. Continue support of the Consistency, Accuracy, Responsibility and Excellence in Medical Imaging and Radiation Therapy Act.	Ongoing.
Patients	
24. Collaborate with RSNA to install prominent "Safety" link on the RadiologyInfo home page.	Complete: http://www.radiologyinfo.org/index.cfm?bhcp=1.
25. Review and update RadiologyInfo material on the risks and benefits of imaging procedures regularly.	Ongoing.
26. Install a prominent "Safety" link on the ACRIN home page that will lead patients to information on risks and benefits of participating in current ACRIN research protocols.	Under discussion.
27. Work with patient advocacy organizations to communicate more effectively the potential radiation risks and health benefits of imaging procedures.	The ACR and RSNA have formed a joint task force to address radiation exposure associated with medical imaging in adults. This task force, whose initiative is titled "Image Wisely" and which has already begun deliberations, plans to develop techniques to communicate imaging risks and benefits to radiologists, radiologic technologists, and eventually, the public.
Medical physicists	
28. Work with the AAPM to develop a credentialing program for nonradiologist physicians who use fluoroscopy.	The ACR has offered to work with the AAPM on this project and will have a radiologist review and provide feedback when complete.

Table 1. Continued

Panel Recommendation	Current Status
29. Commissions on Education and Medical Physics should develop more effective teaching methodologies for medical physics in support of AAPM-RSNA initiative on physics education for radiology residents.	The ACR is currently participating in the AAPM-RSNA initiative on physics education.
30. Implement a periodic review and update of *Radiation Risk: A Primer*.	Task force (led by Louis Wagner, PhD) established under the ACR Commission on Medical Physics to update the primer into a question-and-answer Web site format prepared for 3 separate audiences: radiologists, referring physicians, and the public.
Vendors	
31. Work with NEMA to encourage vendors to ensure that their application specialists are familiar with imaging protocols and emphasize ALARA standard for new equipment.	Through Image Gently, working with MITA to develop safety education modules for application specialists and customers.
32. Work with NEMA to encourage vendors to adopt a standardized approach describing exposure indices for computed radiography and digital radiography.	Through Image Gently, working with MITA and the IEC to encourage the implementation pediatric-specific dose estimates in CT displays and in digital radiography. The Alliance for Radiation Safety in Pediatric Imaging held a vendor workshop on computed radiography/digital radiography (February 2010).
33. Continue working with NEMA to encourage vendors to standardize digital equipment using ionizing radiation so that it automatically captures complete dose information for each examination.	In progress; DICOM has approved standards for CT (October 2007); will take several years to implement.
Regulatory agencies, accrediting bodies, and third-party payers	
34. Approach the FDA and the NRC seeking input on how it can better support their efforts to minimize unnecessary radiation exposure.	The ACR met with the FDA in 2009 to discuss mutual dose reduction activities. The ACR met with the head of the FDA's Center for Devices and Radiological Health to discuss partnering opportunities on radiation dose issues as well as the FDA's plans to issue a statement on their dose reduction initiatives (January 2010).
35. Continue work with CRCPD task force developing "Suggested State Regulations for Control of Radiation" document, and encourage its member states to uniformly adopt appropriate regulations.	Ongoing. The ACR helped the CRCPD develop its position statement, "CT Protocol Reviews" (October 20, 2009): http://www.crcpd.org/Positions_Resolutions/Healing_Arts/HA27.pdf.
36. Encourage the Joint Commission to apply its existing credentialing and privileging standards to nonradiologist physicians who wish to use fluoroscopy.	
37. Encourage third-party payers to develop a process for identifying patients who have frequent imaging examinations using ionizing radiation and to provide feedback on these patients to their referring physicians.	Blue Cross Blue Shield of Western New York began a radiation safety initiative with National Imaging Associates.

Note: AAMC = Association of American Medical Colleges; AAPM = American Association of Physicists in Medicine; ACEP = American College of Emergency Physicians; ALARA = as low as reasonably achievable; ASNR = American Society of Neuroradiology; ASRT = American Society of Radiologic Technologists; CDC = Centers for Disease Control and Prevention; CMSS = Council of Medical Specialty Societies; CRCPD = Conference of Radiation Control Program Directors; DICOM = Digital Imaging and Communications in Medicine; EPA = Environmental Protection Agency; FDA = US Food and Drug Administration; IEC = International Electrotechnical Commission; MIPPA = Medicare Improvements for Patients and Providers Act; MITA = Medical Imaging and Technology Alliance; MOC = Maintenance of Certification; NCRP = National Council on Radiation Protection and Measurements; NEMA = National Electrical Manufacturers Association; NMTCB = Nuclear Medicine Technology Certification Board; NRC = US Nuclear Regulatory Commission; QA = quality assurance; RRL = relative radiation dose level; RSNA = Radiological Society of North America; SPR = Society for Pediatric Radiology.

IMAGE WISELY

The ACR and the Radiological Society of North America established the Joint Task Force on Adult Radiation Protection to build on the success of the Image Gently campaign. The primary mission of the joint task force is to raise awareness among providers of the need and the opportunities to eliminate unnecessary imaging examinations and to lower the amount of radiation used in necessary imaging examinations to only that needed to capture optimal medical images. The task force has expanded into the Alliance of Imaging Professionals and is developing a campaign, called Image Wisely, to

- create educational resources for radiologists, medical physicists, and technologists who provide medical imaging care within the United States, and
- communicate the availability of these educational resources using a wide variety of electronic and print media and through networking with affiliated health care organizations, educational institutions, and government agencies.

CONCLUSIONS

Although the radiology community and the public media have helped raise the radiation awareness of radiology professionals, referring physicians, and patients, more still needs to be done. The Alliance for Radiation Safety in Pediatric Imaging's highly successful Image Gently initiatives and the new Alliance of Imaging Professionals' Image Wisely movement will further these efforts.

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