Journal of Digital Imaging

Reviews in Radiology Informatics: Establishing a Core Informatics Curriculum

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The advent of digital imaging and information management within the radiology department has prompted the growth of a new radiology subspecialty: Radiology Informatics. With appropriate training, radiologists can become leaders in Medical Informatics and guide the growth of this technology throughout the medical enterprise. Radiology Informatics fellowships, as well as radiology residency programs, provide inconsistent exposure to all the elements of this subspecialty, in part because of the lack of a common curriculum. The Society for Computer Applications in Radiology (SCAR) has developed a curriculum intended to guide training in Radiology Informatics. This article is the first in a series presented by SCAR and the *Journal of Digital Imaging*, titled "Reviews in Radiology Informatics." The series is designed to sample from each of the major components in the Radiology Informatics Curriculum, to spark further interest in the field and provide content for informatics education.

KEY WORDS: Informatics, education, residents

COMPUTERS, INFORMATION TECHNOLOGY, and the management of digital information have already become an integral part of everyday operations in most radiology departments. Picture archiving and communication systems (PACS) are deployed at most academic centers, and many private practices are joining the ranks of the digital radiology revolution.[1] Efficient workflow in a digital radiology department, as well as integration with the other complex systems within an institution, requires thoughtful system design, knowledgeable administrative oversight, and expert practice management. The reliance on complex computer systems in the contemporary practice of radiology demands that the stakeholders in a department (especially radiologists and system administrators) have an understanding of this technology and the impact of these systems on clinical practice.

There are many aspects of digital imaging that are not usually included in the curriculum of a radiology residency. Installing and maintaining computer systems requires knowledge and a technical skill set beyond traditional radiologist training. Facilitating the proficient use of these systems, and training users such as radiologists and support personnel, requires yet another set of skills. Practice reorganization, workflow analysis, and technology assessment are also key processes in a digital practice. Finally, performing the research needed to improve the use of existing technology, or to develop new computer technology, is a key activity that benefits all of Radiology.[2]

Leadership in Informatics has traditionally come from internal medicine physicians. As PACS and image distribution have become enterprise initiatives, however, more radiologists have been assuming advisory and leadership roles within hospital Information Technology (IT) departments. Clinicians have become reliant on PACS, and they recognize

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Online publication 25 November 2004
doi: 10.1007/s10278-004-1030-6

that Radiology Informatics plays a critical role in hospital operations. The specialty of Radiology must take steps to maintain and improve this relationship between radiologists and hospital leadership.

Although some of the technological advances in Radiology can be accomplished by people trained only IT, the greatest advances inevitably come from "bridging" individuals who have training in both radiology and IT. Just as IT professionals without specific training in radiology are prone to create systems poorly tailored to the intended users, physicians without IT training are prone to make unrealistic demands on the technology, and to poorly communicate their specific clinical requirements.

The need for radiologists who have IT skills, and who can lead the discipline of radiology in the application of technology, has led to the creation of a new subspecialty: Radiology Informatics. A few fellowship programs have been established to provide specific training to those radiology residents who have an interest in this burgeoning field, and several individuals have already taken advantage of these training opportunities.[3] Unfortunately, the scope of a dedicated Radiology Informatics fellowship and the specific curriculum elements for this training have not been defined. The educational topics covered in the existing Radiology Informatics fellowship programs, as well as the style and emphases of the training itself, differ substantially from one institution to another. Tellingly, even the name of the subspecialty fellowship is inconsistent, with some fellowship directors preferring "Imaging Informatics" or "Electronic Imaging Technology" instead of "Radiology Informatics".[4]

There are other fields of study that overlap with Radiology Informatics. For example, Medical Informatics has been an established specialty for many years, and some of the knowledge base that is critical to Radiology Informatics can be found within general Medical Informatics or Bioinformatics curricula. However, the needs of a radiology department are far more specific than a general Medical Informatics syllabus can address. Furthermore, Radiology is experiencing practical changes at a pace that outstrips most of Medical Informatics, rendering many of the standard texts obsolete.

In addition to the need for subspecialized Radiologist Informaticians, it is also increasingly necessary for all practicing radiologists to have at least a passing familiarity with the technology and integrated systems that their professional lives depend upon. This common, basic level of understanding, similar in nature to the basic science and imaging physics required in residency training, is needed by all radiologists and must be explicitly defined so that radiology residents and practicing radiologists have a structure upon which to base their learning objectives and goals. Residents in training will require a well–defined Informatics curriculum as a key aspect of their basic science education, especially given the changes in technology that can be expected during their careers, the impact of this technology on their daily practice, and the more immediate academic benefits of this knowledge. To emphasize the importance of Informatics to radiology residents, questions about information technology are to be included on future written boards examinations.

The Education Committee of the Society for Computer Applications in Radiology (SCAR) has identified the lack of a standardized curriculum in Radiology Informatics as a substantial impediment to the teaching of this subject matter at both the fellow and resident levels. Thus, SCAR has begun an initiative to create a curriculum that outlines the relevant topics within Radiology Informatics.

RADIOLOGY INFORMATICS CURRICULUM

The fully–detailed SCAR Radiology Informatics Curriculum is available on the SCAR Web site (www.scarnet.org). The curriculum is intended primarily as a guide for subspecialty training in Radiology Informatics, but it is intentionally organized such that general radiologists (ie, residents and practicing radiologists without Informatics training) can focus on the elements in the curriculum that are most applicable to their needs. Similarly, IT professionals hired by radiology departments will find portions of the curriculum applicable to their daily responsibilities. Radiology technologists

Table 1. Outline of SCAR Radiology Informatics Curriculum

1. Information Technology
   - –Servers and Databases
   - –Networks
   - –Mission –Critical Infrastructure
   - –Storage and Archiving
   - –Security
2. Clinical Informatics
   - –Information Systems
   - –Workflow and IHE
   - –PACS
   - –Image Processing
   - –Image Display
   - –Reporting Systems
   - –Communication Modes
3. PACS Administration
   - –Systems Management and Integration
   - –Technology Assessment
   - –Business Models and Economics
   - –User Management and Training
   - –Productivity and Efficiency
   - –Facility Design and Ergonomics
   - –Quality Control and Data Integrity
4. Academics
   - –Research and Statistics
   - –Education
   - –Management and Leadership

The detailed curriculum is available at the SCAR web site (www.scarnet.org).

can learn about changes to their role and workflow in a digital department. Administrators can gain an understanding of Informatics concepts that affect a radiology department, from individual patient care to the departmental and institutional impact of radiology systems. Business–related matters such as technology evaluation and practice reorganization will also be of interest. PACS administrators will find useful the portions of the curriculum relevant to the unique demands of maintaining these complex systems and understanding the impact of this technology on the mission–critical medical practice of a radiology department. It is expected that a fellowship–trained Radiologist–Informatician will be familiar with all segments of the complete curriculum, as well as topics of specific interest to an academic Informatician.

With all of these potential uses in mind, the SCAR group has organized the curriculum into four distinct subject areas (Table 1). The first section, Information Technology, delineates the aspects of computer systems and electronic technology pertinent to Radiology. The topics listed in this section are not specific to our field; instead, they represent a cross section of computer science that is frequently applied in Radiology.

The second section, Clinical Informatics, is the portion of the curriculum of greatest interest to radiologists who do not have Informatics training. Although many of the topics in this section are applicable to Medical Informatics in general, the emphasis is on topics pertinent to Radiology. Some of these subjects, such as Voice Recognition and 3–D Reconstructions, are familiar to most radiologists. Other topics represent behind–the–scenes infrastructure that allows radiologists to perform their daily routines, or up–and–coming technologies that may be considered routine in only a few years. Some topics, particularly those relating to softcopy display of images, are essential to image quality control and should be considered a critical aspect of a radiologist's training.

The third section of the curriculum concerns aspects of PACS administration. While these issues are usually addressed by a dedicated PACS administrator (or a team of administrators), a Radiologist–Informatician must understand these skills to support hiring decisions within the department and to assist in making critical PACS policy decisions. The Radiologist–Informatician frequently serves as a liaison between PACS administrators, vendors, and the other radiologists in the department. Fellowship training should provide the Radiologist–Informatician with the skills needed to serve on strategic implementation committees and to understand the ramifications of larger, enterprise–wide radiology initiatives.

The final section of the curriculum, Academics, addresses issues that are of concern primarily to Radiologist–Informaticians practicing in an academic setting. For example, research issues include not only research into Informatics topics, but also support of other researchers within the department of radiology, and support of non–radiologists in need of images for their research. Skills such as managing a Radiology Informatics group and edu-

cating future generations of Radiologist–Informaticians also fall into this category.

As with all subspecialty curricula, not every aspect of this curriculum will be taught at every institution, and not all radiology residents will be introduced to all pertinent topics. But the introduction of an established curriculum provides a basis from which residency and fellowship training programs can work to identify shortcomings within their own programs. Most Radiology subspecialty organizations have developed subspecialty curricula to provide guidance in developing or improving training programs.[5] It is our hope that the outline provided by the SCAR Radiology Informatics Curriculum will serve that purpose within this subspecialty.

As is typical for technology–based fields of knowledge, educational material in Radiology Informatics quickly becomes outdated as newer technology and applications become available. Presenting the SCAR Radiology Informatics Curriculum in a dynamically updated online format should help to provide the foundation for a core curriculum, while maintaining content that reflects the current state of the subspecialty. Furthermore, the curriculum is supplemented by links to online resources and a bibliography of published educational content. Ideally, the very technology that drives most educational materials into obsolescence will be used to keep the curriculum current.

EDUCATIONAL MATERIALS

There are many educational opportunities for radiologists interested in Informatics. The annual SCAR meeting is perhaps the best venue for those who wish to learn the basics of the field, as well as for those who seek to keep abreast of the latest developments. Online resources are another excellent source of information. For example, SCAR has a series of introductory lectures available online for self-paced learning. Also available from SCAR are several published primers on topics in Radiology Informatics.[6] Information about IT concepts is readily available from a variety of online sources many of which are linked from the full online curriculum (www.scarnet.org).

While online resources provide a wide range of information, peer-reviewed publications such as books and journals supply a degree of reliability that is often lacking in other sources. The peer-review process of major journals such as the Journal of Digital Imaging (JDI) ensures that content has been verified by multiple experts. With this in mind, the Education Committee of SCAR, in conjunction with the JDI, has enlisted the assistance of many experts in the field of Radiology Informatics to write review articles that clarify and elaborate on the key issues of our subspecialty.

This article is an introduction to a series titled ''Reviews in Radiology Informatics,'' to be published serially in the JDI. The remaining articles in the series will provide in-depth reviews of specific topics within the Radiology Informatics curriculum. These articles are not intended to cover the entire subject matter of Radiology Informatics, but rather to touch upon key concepts and to spur interest. It is our hope that these articles will present enough basic information to pique the interest of general radiologists, but still have enough depth to educate those already immersed in the field.

Articles in this series will review such topics as Storage Technology, Image Display, Reporting Systems, Digital Security, Ergonomics, Teaching Files, and Informatics Research. These topics, among others, were selected to reflect the wide array of subject matter within Radiology Informatics, but to cover in detail only a few entries in the broader syllabus. Ideally, these articles will be supplemented by additional educational material both in the JDI and in other publications, as well as with online media, so that the subspecialty of Radiology Informatics can achieve (and exceed) the educational consistency demonstrated by other subspecialties in the field of Radiology.

REFERENCES

1. Samei, E, Seibert, JA, Andriole, K, et al: AAPM/RSNA tutorial on equipment selection: PACS equipment overview: general guidelines for purchasing and acceptance testing of PACS equipment. Radiographics 24:313-334, 2004

2. Reiner, BI, Siegel, EL, Siddiqui, K: Evolution of the digital revolution: a radiologist perspective. J Digit Imaging 16:324-30, 2003Dec;

3. Hirshorn D: Q&A: Radiologic Informatics Fellows. SCAR News.2002 Jan; http://www.scarnet.net/residents/residentmain.html#QA (accessed July 12, 2004)

4. Bartholmai, BJ, Erickson, BJ, Hartman, TE, et al: The electronic imaging technology specialist: the role of a new radiology subspecialty for the 21st century. J Digit Imaging 15(Suppl 1):184-188, 2002

5. Association of Program Directors in Radiology Residency Curriculum: http://www.apdr.org/directors/curiculum.htm (accessed July 12, 2004)

6. SCAR University Publications: http://www.scarnet.org/html/publications.html#SCAR U Publications (accessed July 12, 2004)