CHAPTER

25

DIGITAL TEACHING FILES AND EDUCATION

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The learning process in radiology requires systematic study of a large knowledge base of medical images. The Residency Review Committee (RRC) for diagnostic radiology of the Accreditation Council for Graduate Medical Education (ACGME) mandates resident education and competency requirements. These requirements include core competencies stressing the importance of computer-aided applications in medicine and the use of online resources for educational and patient care purposes. Patient care requirements include the use of information technology (IT) to support both patient care decisions and patient education. Practice-based learning and improvement requirements demand that residents use IT to access online medical information and support their own education. As part of competency in professionalism, residents are expected to show ongoing professional development. Residency programs are expected to teach residents computer applications in radiology, practice management, and quality improvement.

Residency programs are also required to develop a system to assess and document residents' competence in these areas. ACGME requirements also state that "[t]eaching files (electronic or film) must be available for use by residents and these files should contain a minimum of 1000 cases that are *actively maintained* and *continually enhanced* with new cases" (emphasis added). This underscores the importance of addressing teaching file requirements during the transition to filmless imaging.

Traditionally, case-based hardcopy teaching files have been created from radiology studies of real patients. Such teaching files consist of radiology images accompanied by relevant clinical data and a short write-up of the pathological condition. Libraries of representative teaching files are highly desirable in radiology teaching programs, but the organization and maintenance of collections can become problematic.

With the advent of picture archive and communication systems (PACS), the acquisition, viewing, and organization of medical images for teaching and research should be simplified, because such data are digital from the start. Moreover, in the electronic environment, powerful and versatile tools have been developed and can be customized to maintain, organize, and search for images. However, no PACS vendor now provides a solution for the creation of electronic teaching files (ETF) as a commercial option. Hence, the potential for PACS as a teaching and research tool has not been maximized. Many teaching hospitals and universities have designed in-house solutions, employing a variety of methods to create their own ETF libraries.

MEDICAL IMAGE RESOURCE CENTER

The Radiological Society of North America (RSNA) has defined standards for a medical image resource center (MIRC). A set of extensible markup language (XML) schemas for information exchange, such as MIRC query, MIRC query result, MIRC site index, and MIRC document, have been developed. By complying with these schemas, individual teaching file servers around the world can be linked together through the World Wide Web to form a global MIRC community. Thus MIRC has the potential to become the worldwide standard for teaching and research data exchange, in the same way that the Digital Imaging and Communications in Medicine (DICOM) standards have been accepted and incorporated into PACS.

MIRC was originally conceived as a large, central database of images and related clinical information that would be maintained by the RSNA for open access by the medical imaging community. It soon became evident that a more effective strategy would be to leverage existing online electronic resources in addition to creating new ones. A decision was made to create a virtual community of medical image libraries that would benefit from a distributed index mechanism and also support a distributed search mechanism—in other words, to create a kind of radiologic Napster. The final result was MIRC, an open community of medical imaging libraries and teaching files from around the world, sharing information through a common query format. The system has evolved to provide support for a community of cooperating libraries that can be managed at multiple levels, ranging from an individual working at a laptop or personal computer (PC) to a level at which a user can access global content as if it were in a single library. The virtual libraries provide all kinds of digital information, including teaching files, clinical and technical documents, electronic presentations, and imaging datasets for research (Figure 25.1).

The objective of the MIRC project is to support the production, storage, indexing, and distribution of medical imaging resources, such as teaching files, scientific and technical documentation, research images and datasets, and clinical trials data.

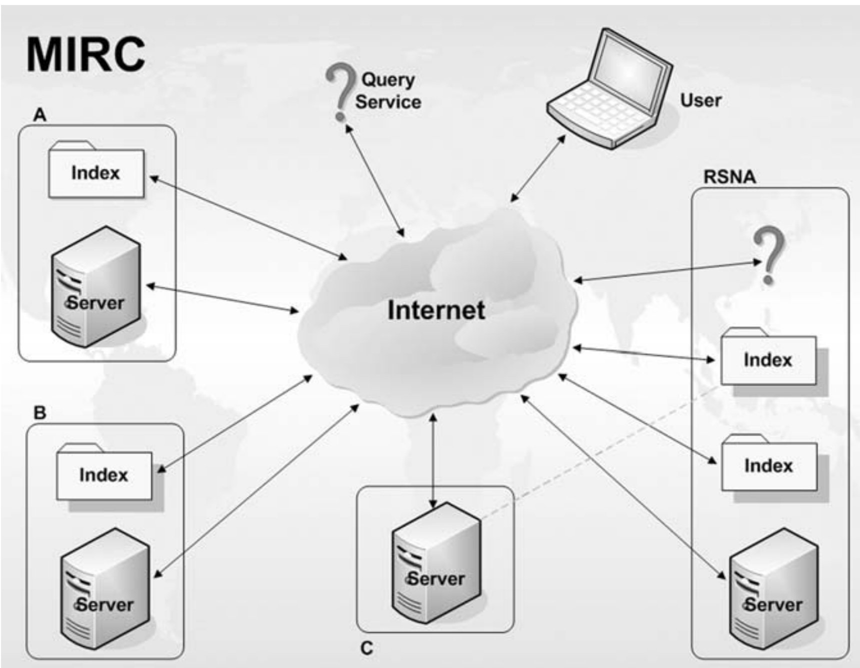

FIGURE 25.1

Medical image resource center (MIRC) community diagram.

Authors may use a MIRC-defined format to construct teaching files and other documents in a common structure that allows libraries to index the documents in medically meaningful ways (Figure 25.2). The RSNA has also developed a MIRC authoring tool, known as MIRCat, as well as a Web-based MIRC authoring service.

An indexing mechanism provides users great flexibility in searching the MIRC community. Users can perform free-text searches on the contents of documents, as well as structured searches on patient criteria (e.g., sex, age) or image criteria (e.g., modality, anatomical region, storage format, compression), all through a standard Web browser (Figure 25.3). Any MIRC site can function as either an access point for users (called a query service) or an indexed information library (called a storage service) or both. A query service provides a point of access to the entire MIRC community. It provides a query form to the user, distributes the search criteria to all selected storage services, collates the responses, and presents them to the user. A storage service responds to the query received from the query service, searches its index for documents meeting the search criteria, and returns abstracts and locations of the matching documents to the query service.

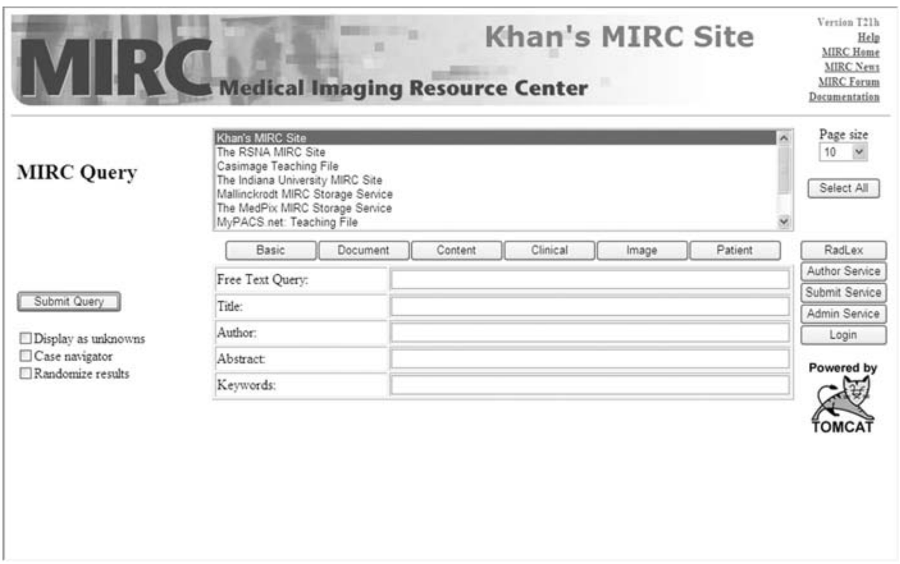

FIGURE 25.2

MIRC teaching file (mircTF) case display format.

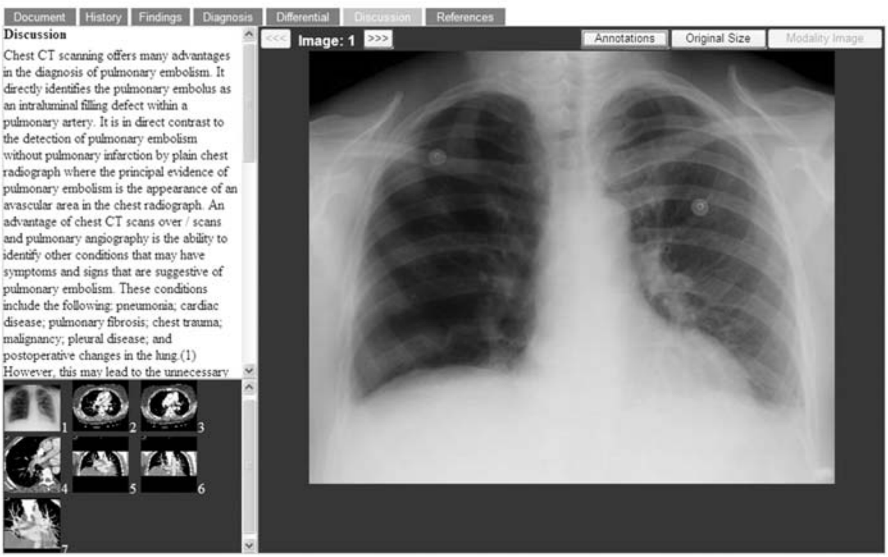

FIGURE 25.3

MIRC query page used to search through the MIRC community.

As of this writing, the international MIRC community includes 10 sites, from Switzerland to Singapore, accessible through the RSNA MIRC site, plus others running the RSNA MIRC software privately. The RSNA MIRC software now supports teaching files, research datasets, scientific and technical documents, and clinical trial image acquisition and distribution.

The current software release supports public, restricted, and private teaching files, all on the same server, allowing authors to use MIRC as a personal archive as well as a publication mechanism to group, department, and global audiences. The software now includes a server-based editor, facilitating online creation of teaching file cases and other documents without any special software on the author's system.

The current software release also includes a DICOM storage service that automatically creates clinical trial documents in response to the receipt of images from local modalities or participating clinical trial sites. It allows distribution of DICOM images to other participating clinical trial sites in a wide range of topologies. The clinical trial service also supports research dataset acquisition, with automatically created documents that can be edited through the author service. The service also allows capture of commentary on images and studies, making them more easily searchable. More information about MIRC is available at http://mirc.rsna.org.

OTHER TEACHING FILE RESOURCES

A wide range of online teaching file resources is available to radiologists in training or in clinical practice who want to increase their breadth of knowledge or who wish to use these resources as electronic decision support tools during daily practice or to anonymize and store interesting cases for departmental or personal teaching file collections. A simple search for the keywords "radiology teaching file" on http://www.Google.com at the time of preparation for this chapter yielded 81,100 hits. Some of the more popular teaching file resources are listed in Table 25.1.

TABLE 25.1
Selected Digital Teaching File Resources

Digital Teaching File	Web Address
MedPix	http://rad.usuhs.mil/index.html
MyPACS	http://www.mypacs.net
CasImage	http://www.casimage.com
EuroRad	http://www.eurorad.org
CTisUS	http://www.ctisus.com
BrighamRad	http://brighamrad.harvard.edu/
Auntminnie—Indiana University	http://www.auntminnie.com
Mallinckrodt	http://gamma.wustl.edu/home.html
American College of Radiology Learning File	http://www.learningfile.com
Thomas Jefferson Neuroradiology	http://popeye.rad.tju.edu:8080/mirc/query
University of California at San Francisco	http://128.218.59.127/
GlobalRad	http://www.globalrad.com

Source: Data from Branstetter BF, Siddiqui KM, Lionetti DM, Chang PJ. Defining a digital teaching file workflow: specifications for software development. *J Digit Imaging.* 2003;16(suppl 1):37–40.

SPECIFICATIONS FOR DEVELOPMENT OF TEACHING FILES

Despite advances toward an all-digital environment in academic radiology departments, the teaching file—perhaps the most distinguishing and tradition-honored feature of medical imaging pedagogy—has been slow to adapt to the full range of informatics possibilities. One complicating element has been the requirements imposed by compliance with the Health Insurance Portability and Accountability Act (HIPAA). Because most traditional teaching files are not sufficiently anonymized, they are noncompliant with HIPAA requirements. To get around this difficulty, many academic institutions have developed in-house digital teaching files (DTFs); Web-based and standardized formats have been developed for sharing cases between institutions. However, most PACS vendors have yet to incorporate DTFs directly into their PACS offerings. Without an easy teaching file solution integrated within the PACS system to allow users to create teaching file cases easily and effectively, user compliance and integration of teaching files into all-digital department academic activities will continue to pose difficulties.

INTEGRATING THE HEALTHCARE ENTERPRISE TEACHING FILE INFORMATION EXPORT PROFILE

The Integrating Healthcare Enterprise (IHE) initiative is a project designed to advance the state of data integration in health care. Sponsored by the RSNA and the Healthcare Information and Management Systems Society (HIMSS), it brings together medical professionals and the healthcare information and imaging systems industry to agree on, document, and demonstrate standards-based methods of sharing information in support of optimal patient care. A proposal for a teaching file information export profile is under consideration by the IHE that, once released, will address uniform methods for capturing information for teaching file cases across various PACS vendors.

Although the IHE profile will address workflow implications for creating a case at the PACS workstation, specific data captured for cases may differ for each user or institution. General format and data elements for a DTF are detailed in Table 25.2. Included in the following sections are proposed specifications that should be addressed by an ideal DTF software package; the focus is on the importance of workflow integration.

TABLE 25.2

General Format for Digital Teaching Files

1. Basic data elements for a DTF (mandatory fields)
   a. Patient name*
   b. Medical record number*
   c. Accession numbers*
   d. Category
      - Users should be permitted to develop their own tree structures for categorizing diseases, although using some standard terminology will make integration with other DTF solutions easier. Note that a patient may appear more than once, either because a disease fits 2 categories or because a patient has 2 diseases.
      - It is important to have a different field that defines or differentiates an adult from a pediatric patient. Simply defining a category for pediatric radiology may not be sufficient, because this would not divide the topics into anatomic- or system-based categories.
      - Some teaching file vendors fail to define a hematology/oncology category, which is important because some multisystem malignancies are not covered in other standard categories.
   e. Diagnosis
   f. Modalities
      - Included in “modality” is the encoding of detailed image attributes. For magnetic resonance, in particular, a list of pulse sequences should be generated. Ideally, this list would be generated automatically as part of the PACS integration. The list of modalities and possible attributes must continually expand to accommodate new technologies.
2. Secondary data elements (useful, but not mandatory)
   a. Keywords: Keywords are used to search or filter.
   b. User flags
      - An arbitrary number of flags should be available to users, and these should be user definable. Examples of user flags include “board review,” “follow up,” or “potential AFIP [Armed Forces Institute of Pathology] case.”
   c. Publication flag: To prevent duplicate publication within the medical literature.
   d. American College of Radiology code
   e. Patient gender
   f. Date of birth*
   g. Date of exam*
3. Key images: Access to the full examination should be maintained. Key images may differ when a patient appears more than once in the database.

Source: Data from Branstetter BF, Siddiqui KM, Lionetti DM, Chang PJ. Defining a digital teaching file workflow: specifications for software development. *J Digit Imaging.* 2003;16(suppl 1):37–40.

* Patient identifiers may be hidden or encoded, depending on the specific use.

TYPES OF TEACHING CASES

At an academic institution, there are many situations in which a physician needs a group of radiology studies to be stored together. Digital teaching files are widely discussed but are only one application of the more generic "case collection." Case conferences, teaching conferences, tumor boards, morbidity and mortality conferences, clinical research protocols, and board reviews are among the many uses for case collections. A complete DTF software package would focus on the needs of an institutional teaching file but be flexible enough to accommodate other uses. The critical element that is lacking in current DTF solutions is integration. Digital teaching file software requires an efficient workflow so that cases can be rapidly added to lists during readouts, with a minimum of interruption. Familiar authoring tools for annotation of images can be applied later when these will have less workflow impact. None of the current DTF solutions specifically addresses the usual academic reading room workflow, and most are not integrated with the PACS.

WORKFLOW INTEGRATION

Flagging a case for the teaching file should be an instinctive task, completely integrated into the workflow of the daily reading session. Flagged cases should be assigned an owner, who should be reminded at a convenient time that teaching file cases are available for processing. A 1-line description (e.g., "otosclerosis vs. Paget's") would be useful to direct the owner to the appropriate images while reviewing a case. The DTF database should be available on the same machine that displays the PACS images so that interesting comparisons and counterexamples can be used to reinforce cases during readout and so that users can benefit from the DTF as a decision support tool.

SHARING CASES WITH COLLEAGUES

In an academic setting, the identified PACS user is often the resident in training, but it is the attending radiologist who wants the cases stored. Similarly, a radiologist may find a case that would be of greater interest to a colleague than it is to him- or herself. It is critical that users be permitted to alert others to an interesting case at the time the case is chosen. This is another aspect of workflow integration.

PRIVATE FILES

Users may wish to keep individual cases private but make the rest of the teaching file available to trainees. Such private cases might include board review cases, test cases, or cases pending publication. Private cases should be interspersed with public cases within the category tree rather than relegated to a distinct section of the database.

PUBLIC FILES

Authorized users within an institution should have full access to “public” files for teaching purposes. Presentation of cases may be simple (a few key images) or complex (unknown cases for case-based learning). Anonymizing cases is critical for HIPAA compliance.

DIVISIONAL FILES

The divisional file is the digital counterpart of the conventional film-based teaching file. Cases in the divisional file have been contributed by members of that division for the purpose of teaching residents and fellows. Ideally, there is an individual gatekeeper from each division who verifies the quality and legitimacy of each case and prevents excessive duplication of content.

PUBLISHED FILES

Sharing of files across institutions provides greater opportunities for resident education, particularly in rare diseases. Sharing files for research collaboration is also desirable. Cases that are available outside an institution are considered “published cases.” This should not be confused with formal publication in the medical literature.

MEDICAL IMAGE RESOURCE CENTER COMPATIBILITY

Although many different teaching file indexing schemas are available, it is crucial that vendors and institutions adhere to a standard format for cross-compatibility and easy case querying. The RSNA MIRC project described previously is currently the only schema with the potential to be a worldwide standard for teaching file indexing and development. Any vendor DTF solution should have the capacity to comply with the MIRC document schema so that individual institutions can make anonymized public cases available for review to the entire radiology community when they choose to do so.

ELECTRONIC MEDICAL RECORD INTEGRATION

For a DTF system to provide a robust and crucial decision support role in day-to-day radiology practice, it is important that the system be able to communicate with multiple databases and information systems throughout the hospital. This will enable the DTF system to notify users when the status for a specific case is changed or some needed information is available to update the case.

HOSPITAL INFORMATION SYSTEM INTEGRATION

Using the IHE profiles, DTF software should be able to query the hospital information system (HIS) to obtain pathology results, laboratory results, and related data.

NOTIFICATION

Cases that have pending results (e.g., biopsies performed under image guidance) should be flagged. The system should poll for pending results on a regular basis and notify the owner of the case when results are received. Similarly, when a follow-up radiological examination is expected on an interesting case, the owner of the case should be notified when the follow-up images become available. The DTF system should be able to do this while keeping the cases anonymized, without compromising the patient's identity.

SUPPLEMENTAL IMAGES

Images from nonradiological modalities (endoscopy, pathology, or clinical images), as well as digitized images from outside sources (e.g., noninstitutional examinations), should be accepted by the DTF system. These supplemental digitized radiographic images may be supplied in a variety of formats (e.g., JPEG, GIF, TIFF, PNG, MPEG, AVI) but are best converted to a DICOM format with appropriate headers for ease of manipulation (e.g., window and level changes, etc.).

PERSISTENCE

Some cases, such as those for teaching conferences or planning conferences, are needed for only a short time. Others, such as teaching files, require permanent archiving. Institutions that archive old examinations must either exempt DTF cases from removal or make copies of the DTF cases in a separate section of the PACS.

ANONYMIZATION

HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY ACT

The Health Insurance Portability and Accountability Act (HIPAA) was designed to protect patient privacy by restricting access to identifiable patient information or protected health information (PHI) for treatment, planning, or operations only. These regulations explicitly define 18 demographic elements that might be used to uniquely identify a patient. Teaching files fall outside treatment, planning, or operations and are intended to be viewed by large numbers of trainees; therefore, they should not contain PHI. Most film-based teaching files were developed before the HIPAA regulations were formulated and contain identifiable data that may render them noncompliant. Patients should be assigned identification numbers unique to the DTF system. Because there is often a need to obtain additional data from the radiology information system (RIS) or HIS at a later time, the system must be able to decode the unique identifier for the purpose of querying the electronic medical record (EMR). Institutions and departments should specifically address these operational issues and their countermeasures in their local HIPAA policy. A complete description of patient care–related tasks and events should be in place to cover daily user interactions with the PHI for creating and updating teaching files. Some institutions request waivers from patients to allow the use of their PHI in teaching tasks. This strategy may satisfy HIPAA compliance locally, but disclosure of the PHI outside the covered entity may still be a HIPAA violation. In a similar process, a patient could conceivably sign away rights to privacy and PHI security and allow his or her studies to be shared over the Internet.

EXEMPTIONS

Some case collections, such as those for treatment planning conferences, may be exempt from anonymization so that clinicians can appropriately care for patients. Such collections should have limited persistence in the DTF database or be de-identified after a certain time period.

DEPTH

Some teaching files are thoroughly researched and include discussions of clinical presentation, lengthy differentials, and literature references. But sometimes the user needs only a pointer to find the case for future reference. The clinical information present in the different types of teaching file documents can be categorized as follows:

LIST

The list is a quick pointer to the case, with fields for diagnosis and keywords. No images are needed, and no annotation is performed.

KEY IMAGE

In this case, a few key images are selected. There may be annotation on those images, but no lengthy prose is associated. These are useful for quick examples to demonstrate a point during teaching rounds.

FULL DIGITAL TEACHING FILE

Complete teaching cases with images, history, findings, differential diagnosis, final diagnosis, discussion, and references are a staple of teaching institutions. The DTF software should support links to related teaching file cases or to Internet references.

QUALITY ASSURANCE

AUTHORIZATION

Full DTF cases should undergo review by a subspecialist before inclusion in the formal institutional teaching file. A division might allow any member to sponsor a teaching file or might assign a single individual to act as a gatekeeper. Robust review and notification tools are necessary to ensure that teaching file cases are reviewed in a timely manner upon submission.

PEER REVIEW

More than 1 expert may vouch for the quality of a single case. Secure tracking of cross-institutional peer review would allow users to assess the quality and accuracy of a published case.

USER REVIEW

Accuracy of material is not the only measure of the quality of a teaching case. Users should be able to rate the teaching quality of the case presentation.

The validity of the averaged results may be questionable, but this gives users further guidance when sifting through the myriad of cases that may eventually be available over the Internet.

AUTHORING TOOLS

INTEGRATION

Authoring tools need not be fully integrated into the PACS. When the PACS allows a case to be flagged for later processing, that processing can be performed at another site (back in the office or in the residents' lounge) by passing the information for the flagged case to the enterprise-wide, Web-based PACS viewer. This keeps high-end PACS resources free for readouts.

THIN AND THICK CLIENTS

Web-based thin clients have the advantage of universal availability and would be useful if users are expected to author cases from outside the institution.

Thin-client applications do not require a great deal of processing power and can be installed on almost any PC. A Web browser–based client eliminates the need to install the DTF application on various computers, because it can be accessed from anywhere using a standard Web browser. However, thick-client applications require much more processing power and therefore are available only at specialized workstations or beefed-up PCs. They may provide more robust and advanced image-processing tools and may be the preferred solution within an institution, although thin-client applications can provide equally robust tools.

IMAGE ANNOTATION

Original image data, without demographic or image attribute text, should be stored in the DTF. Annotations should be stored in a separate layer (or layers), so that they may be hidden during self-tests or teaching conferences. Vector encoding of annotations is generally more compact than raster encoding. Possible annotations should include at least key image ordering (the order in which images should be presented), arrows, circles, text, and measurements.

USER ROLES

TRAINEE

The turnover among trainees is high, and they are expected to create cases under the supervision of an attending imaging specialist. The attending can then take ownership of the case when the trainee leaves. Although this creates a small additional workload for the sponsoring attending at the time the case is created, it prevents interesting cases from being lost when the trainee leaves for another institution.

ATTENDING

Attending or staff radiologists have the highest level of access. This level of access may not be needed for individuals outside the radiology department, unless the DTF system also provides case storage solutions for other departments, such as cardiology, dermatology, or pathology. Departmental policy should govern the cases that are left behind when an attending leaves the institution.

RESEARCHERS

Researchers may make anonymous patient lists by utilizing a teaching file system as a research file system for a research project or clinical trials, but these cases should have a limited persistence that is directly related to the expected length of the research project. Appropriate institutional research board (IRB) consent should be secured before creating any list for research purposes.

POST-PROCESSING

CASE COLLECTIONS

Users should be able to conveniently group cases for teaching conferences or lecture preparation. These groupings can cross the boundaries of the category tree structure. Boolean searches incorporating keyword, diagnosis, American College of Radiology code, and/or user-defined fields are needed.

PRESENTATION TOOLS

The DTF software should provide tools to efficiently create case-based exams, assign teaching file creation (e.g., case of the week), and present cases in a classroom or conference setting. If these tools are Web based, they will be available throughout the institution and should obviate the need to hand carry media or hardware. Users, particularly medical students and residents, should be able to request full DTF cases from a given category to be presented as unknowns for the purpose of self-testing.

PUBLISH TO PRESENTATION SOFTWARE

Integration with established presentation software would allow a user to take, for example, all the key images from a case collection and send them into Microsoft PowerPoint (Microsoft Corporation, Redmond, Wash.) in a compatible image format, 1 image per slide, preserving annotation.

BURN A CD

The DTF solution should have the ability to quickly store case collections on CDs, either as key images only or as entire studies. A simple case viewer should also be burned on each CD for portability.

Maintaining an active teaching file is a requirement for the accreditation of radiology residency programs. Academic institutions should consider the importance of integrated teaching file software when choosing a PACS vendor. In the future, institutions should demand that vendors provide conformance with the IHE teaching file information export profile. The proposed software specifications for digital teaching files may be helpful to programmers and PACS vendors in understanding the functionality needed for DTFs in academic practice. The importance of workflow analysis and integration cannot be overemphasized.

IMAGING INFORMATICS EDUCATION

If one searches for the meaning of medical informatics, a number of divergent and confusing definitions can be found. One definition states that medical informatics is an emerging discipline focusing on the study, invention, and implementation of structures and algorithms to improve communication, understanding, and management of medical information. The end objective is the coalescing of data, knowledge, and the tools necessary to apply such data in the medical decision-making process. Another definition describes medical informatics as an evolving scientific discipline that deals with the collection, storage, retrieval, communication, and optimal use of health-related data, information, and knowledge. In the end, the common denominators in most definitions are information management and technology, which are at the core of informatics. For the imaging community, information management relates to medical images and extends to the manner in which imaging data are acquired, stored, distributed, interpreted, and communicated. Hence, the field of imaging informatics could be defined as being concerned with "management of information from the point at which a physician decides to order an imaging study to the point at which an informed interpretation of the results of that study are delivered back to the physician." An imaging informatician is an individual who bridges the knowledge and communication gaps among radiologists, physicists, and IT personnel. Although such a skill is not listed in most job descriptions for radiologists, it is becoming more and more important as imaging departments transition from film-based to filmless imaging, adopt and integrate

PACS with the HIS and RIS, and add new modalities that rely heavily on IT.

EVOLUTION OF IMAGING INFORMATICS AS A RADIOLOGY SUBSPECIALTY

Advantages that occur when 2 different institutions merge to form a new entity can result in much more rapid change over a given period of time than can be achieved by a single entity. When different scientific disciplines borrow from one another and combine to form a new specialty, this can also result in dramatic advances in a relatively short period of time.

From its origins in mathematics and military ballistics, digital technology has evolved to become an integral part of endeavors as diverse as communication, commerce, entertainment, and medicine. The field of computer science continues to evolve into a wide variety of subspecialties. It is becoming increasingly evident that just as amalgamation between the field of medicine and the study of the physics of the x-ray resulted in the field of radiology, the union between radiology and IT is resulting in a new specialty: imaging informatics.

This emerging subspecialty has practical applications that transcend the traditional modality/anatomic-based radiology subspecialties. As medical imaging undergoes a paradigm shift from traditional film-based to filmless operation, many of the traditional concepts of medical imaging become obsolete. The fundamental processes of image acquisition, display, storage, distribution, interpretation, and reporting undergo fundamental change with the implementation of digital imaging, PACS, advanced image processing, decision support tools, speech recognition, and structured reporting. With accompanying changes in image acquisition, larger and more complex imaging datasets are being created that bring new challenges for radiologists. One obvious example is the widespread adoption of multidetector computed tomography (CT), which has increased the number of individual CT images by 3- to 6-fold for routine studies. The radiologist who continues to review and interpret these imaging datasets in the conventional tile mode format will quickly become overwhelmed. Such challenges transcend all modalities, anatomic regions, and imaging subspecialties. The angiographer must cope with complex CT and magnetic resonance (MR) angiography, the breast imager with digital mammography and computer-assisted diagnosis (CAD) software, the oncologic imaging specialist with positron emission tomography (PET)/CT fusion datasets, and the chest specialist with dual-energy subtraction and tomosynthesis. The field of imaging informatics can address many of these challenges that transcend the various imaging subspecialties.

LATENT POWER OF IMAGING INFORMATICS

"Information is power," according to an old adage, but in the case of the radiology community, where do we go to acquire the information we will need to maintain power? With these new computer-based applications, many traditional concepts of image acquisition, archiving, interpretation, and reporting will disappear. If we are to maintain our power and role as medical imaging experts, we need to learn how technology and information management define the digital imaging practice. To accomplish this task, in-depth training is required and should begin during residency. Ironically, few if any radiology residency programs offer formal imaging informatics training, resulting in a distinct knowledge void among new radiology residency graduates. This is particularly detrimental in the private practice radiology community, which often relies on the most recently trained radiologists as champions of new technologies.

While some in the private practice radiologist community are lamenting their relative lack of expertise in imaging informatics, academic radiology is not far behind. Academic radiology has long been the bastion of radiology "purists," who define and set the standard of practice for the radiology community at large. When new modalities or applications are adopted, it is representatives from these academic programs who define how these new applications will become incorporated into everyday practice. This includes such mundane aspects as the establishment of exam protocols and indications and extends into broader areas, such as radiologist education and certification. Traditionally, these academic challenges have been assigned to the various modality and anatomic-based subspecialists within the academic ranks. When a new modality, such as magnetic resonance imaging (MRI), is introduced, a new breed of subspecialists is born from within the existing academic ranks. By the very nature of being an early adopter of this new technology and performing the pioneering research in its use, these academicians define the new subspecialty and serve as benefactors to the radiologist community at large.

The problem with imaging informatics is that research and education have not kept up with either the speed of development or the rapid implementation of the technology. Modality vendors market and sell multidetector CT scanners, for example, to customers who have almost no understanding of the fundamental change in the application and the challenges that will inevitably result. To date, little if any research has been performed to identify best-practice guidelines for this technology as it relates to optimal imaging plane, slice thickness, compression algorithm, or default display—essential elements in interpretation quality and effective workflow. The same vendors that sell these scanners also offer the same customers elaborate advanced image-processing workstations, but in many cases this only adds a layer of confusing options to the review/interpretation dilemma. Who is the responsible party for image processing and reconstruction? Is this the role of the technologist or radiologist? How can decision support software be incorporated into the process to facilitate improved diagnosis and workflow? Appropriate research has not been performed to answer these basic questions, and the result is that many imaging practitioners have expensive, data-intensive technologies but little understanding of their optimal use.

The same challenges within the imaging departments also extend throughout the filmless/paperless medical enterprise. With the implementation of the EMR and telemedicine, new challenges exist in terms of patient confidentiality, data security, and best-practice standards. These clinical issues go beyond the expertise and training of IT staff and must largely rest in the hands of medical experts. What other medical group is better equipped to address these challenges than radiologists? The key, of course, is to ensure that the radiologist community is well educated in all aspects of imaging informatics and takes a proactive role in related research.

MAKING THE CASE FOR INFORMATICS RESEARCH

The good news, however, is that nature abhors a vacuum, which creates unlimited opportunity for the willing (and naive). Residents and fellows in training have the unique opportunity to quickly become experts in this burgeoning discipline. A number of important research opportunities exist with great relevance and potential significance to the radiology community at large.

To date, the relative lack of awareness of imaging informatics within the radiology community has extended to radiology residents, whose role is to become the thought leaders of the profession in the near future. It is therefore critical that radiologists in training understand the clinical, economic, and political importance of this emerging subspecialty. To accomplish this, imaging informatics education and research must be prioritized within academic radiology programs. Imaging informatics research has the dual role of legitimizing the subspecialty as well as solidifying its place within the radiology domain. An intimate synergy exists between technology and research within radiology. Whoever controls the research controls the technology. And whoever controls the technology can dictate its clinical application. In the past, other medical specialties have effectively seized control of imaging technologies by co-opting research applications. One example can be seen in cardiac angiography and echocardiography, which were once the domain of the radiologist and are now firmly under the control of the cardiologist. It is therefore imperative that all radiologists, especially those in training, understand the long-term implications of what is at stake and the tremendous potential for those who embrace the challenges that lie ahead.

The best method to inform and create understanding of imaging informatics is to educate as many participants in the field as possible. Imaging informatics must become an integral part of resident education, and institutions and radiology departments must modify radiology residency curricula to incorporate informatics education. A suitable curriculum would describe the expected training issues through a 4-year radiology residency. Knowledge and experience should be imparted through didactic lectures, informal review of topics during reading sessions, review of journal articles, outside conferences, and self-study programs. Many informatics topics overlap directly with physics instruction and other imaging subspecialties, where modifications to existing curricula should be considered. Included here is a sample 4-year imaging informatics curriculum currently in place in the radiology department at Geisinger Medical Center (Danville, Penn.) (Table 25.3). This curriculum adheres to the ACGME guidelines for dividing the course of study to cover patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice.

This outline is designed to provide guidance for development of informatics curricula as they relate to resident education. More detailed training is needed when a professional chooses imaging informatics as a career. The curriculum for such training should incorporate more detailed understanding of digital imaging technologies as well as computer sciences. Multiple advanced fellowship programs are available to provide such training, and a list of current imaging informatics training programs is available on the Web site for the Society for Computer Applications in Radiology.

TABLE 25.3
Outline of Informatics Curriculum for Radiology Resident Education

First Year of Training

The resident entering the first year of residency should be encouraged to develop at least moderate general computer skills. Unlike clinical skills, the basic use of PACS, dictation, and information systems software can be performed without in-depth knowledge of structure and function. Because the use of these systems is essential for clinical tasks, the first-year curriculum should focus on practical use issues.

Patient Care

Basic use of the PACS workstation

Patient worklist functionality

Knowledge and use of RIS and HIS user interface

Medical Knowledge

Instructions on basic physics of MR, CT, general radiography, ultrasound, and nuclear medicine should be given and coordinated with the physics curriculum

Practice-Based Learning and Improvement

Use of the Internet as a decision support tool to search for knowledge from existing online education resources

Interpersonal and Communication Skills

Electronic communication skills, including personal and group e-mail

Basic instructions in use of Microsoft Word

Preparing and using PowerPoint for presentations

Clinical use of digital dictation, speech recognition, and structured reporting

Concise, meaningful, and accurate reporting of radiology findings

Professionalism

Patient privacy issues as they relate to electronic data

Ethical use of downloads

System-Based Practice

Use of RIS for accessing patient data

Use of HIS for accessing clinical information, messaging, patient orders, and progress notes

TABLE 25.3
Continued

Second Year of Training

Advanced and more sophisticated use of clinical PACS, dictation systems, and information systems should be stressed during the second year. Emphasis should be placed on increasing speed and efficiency in the use of these systems without distraction from image viewing. Basic informatics instructions should begin on multidetector CT issues, three-dimensional (3-D) workstation functions, and computed radiography/direct radiography and should be coordinated with the physics curriculum.

Patient Care

Clinical applications of 3-D/advanced image-processing workstation

Use of alternate PACS/human interface devices

Medical Knowledge

Principles of multidetector CT

Basic PACS architecture, central versus distributed files, thin-client, browser-based systems

Principles of network, bandwidth, and wireless connectivity

Principles of computed radiography

Practice-Based Learning and Improvement

Informatics as a subspecialty

Decision support: preparing and using personal and system teaching files

Interpersonal and Communication Skills

Reporting skills with emphasis on context, conciseness, and readability

Use of macros for radiology reporting

Professionalism

Knowledge of computer viruses and other potential issues related to public computer use

System-Based Practice

DICOM basics

Integration of PACS, speech recognition, RIS, and HIS

(Continued)

TABLE 25.3
Outline of Informatics Curriculum for Radiology Resident Education (*Continued*)

Third Year of Training

Instruction on informatics topics should be continued at the intermediate level. It is expected that knowledge and understanding of the underlying principles of informatics will enhance clinical use of workstations.

Patient Care

Principles of digital mammography

Decision support: use of computer-assisted diagnosis in mammography

Medical Knowledge

PACS storage issues: RAID, pre-fetch algorithms, future storage applications, cost comparisons

Principles of direct radiography

Practice-Based Learning and Improvement

Advantages and disadvantages of PACS, speech recognition, and structured reporting

Economic issues in PACS and informatics

Interpersonal and Communication Skills

Principles of speech recognition and structured reporting: advantages and disadvantages

Professionalism

HIPAA regulations as they pertain to radiology practice

Audit principles in PACS, RIS, and HIS

System-Based Practice

Basics of the IHE profiles

Failover strategies for image interpretation and reporting

Principles of teleradiology

TABLE 25.3
Continued

Fourth Year of Training

Advanced informatics topics should be taught in continuum from the previous year. Many topics in the fourth year can be customized for those residents with special interest in a specific clinical area, research topic, or informatics as a subspecialty.

Patient Care

Workstation design and ergonomics

Image display principles

Decision support: computer-assisted detection for chest CT

Medical Knowledge

Image compression principles, in particular as they relate to clinical interpretation

Advanced direct radiography applications: dual-energy subtraction, temporal subtration, tomosynthesis

Disaster recovery of images and other data

Practice-Based Learning and Improvement

Research opportunities in informatics

Future directions of image storage and interpretation

Interpersonal and Communication Skills

Future efficiencies in radiology reporting

Professionalism

Biometric security: log-in and password issues

System-Based Practice

Evaluation of PACS and other software for purchase

Use of requests for proposal

Principles of HL7 as these relate to imaging issues

Operation issues for healthcare IT as they relate to imaging

CONCLUSION

Imaging practitioners today are faced with the important task of making critical decisions concerning technology implementation and integration, radiologist workflow, imaging economics, and standards for quality and security. Demands for imaging services are at an all-time high, and the supply of qualified radiologists cannot keep up. The common denominator to addressing these needs is technology, which provides radiologists with an opportunity to improve quality, timeliness, and security of services. Unfortunately, technology is a double-edged sword. It must be used judiciously to succeed in maximizing potential benefit, but if used inappropriately might actually be deleterious.

Although radiology has always been technology driven, many of the new digital applications in medicine go beyond the experience and expertise of practicing radiologists. If radiology is to maintain a technology leadership role within the medical enterprise, additional computer-based training and expertise are required. New technologies will play an important role in future radiology practice and will require dedicated research to enhance integration and application of information technologies within the clinical imaging practice. This provides the foundation for imaging informatics as a new and uniting radiology subspecialty.

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