Picture Archiving and Communication System Activities at the Mayo Clinic Rochester

Byrn Williamson

This report summarizes Mayo Clinic Rochester's experience with a picture archiving and communication system (PACS) to date and discusses the principles that have guided implementation.

Copyright © 1998 by W.B. Saunders Company

IN 1989, MAYO CLINIC ROCHESTER began working with IBM to develop a digital archive to preserve raw image data from computed tomography (CT) and magnetic resonance imaging (MRI) examinations.¹ Before this project, magnetic tapes were used to store these data, but numerous issues were encountered, including excessive space requirements and occasional unreadable tapes. The system that was developed includes multiple workstations and a network constituting a mini-picture archiving and communication system (PACS). This system is still in use and currently contains more than 8 terabytes of data that consist of more than 30 million images.

The development of the digital archive provided valuable experience with PACS technology, but this archive was not designed to provide all of the functionality of a complete PACS system. To evaluate the feasibility of implementing a campus-wide PACS, in 1994 we embarked on pilot projects with three of the leading PACS vendors. One system was installed in our Community Medicine Radiology Department,² a plain-film practice serving local patients, another was installed in the Neonatal and Pediatric Intensive Care Units at Saint Marys Hospital, and a third system was implemented in a portion of the plain-film, outpatient skeletal radiology practice. After a period of evaluation, in 1997 Mayo Clinic Rochester selected one of the PACS systems to replace the other pilot systems and be expanded into other areas of our practice, including all intensive care units, additional skeletal examinations, and the outpatient pediatric radiology practice. In parallel with our

implementation of PACS in selected areas of our practice, we have developed software to allow viewing of digital images on low-cost personal computer (PC)-based workstations in clinicians' offices. This software, named QREADS,³ has been installed on more than 5,000 workstations throughout our medical center and is in daily use.

The Radiology Department is currently investigating the feasibility of implementing a filmless radiology system throughout the Mayo Rochester campus by the year 2002. A number of issues must be resolved before such a system can be implemented, including system capacity and the reengineering of numerous radiology processes and procedures. Nevertheless, it now appears certain that the Mayo Rochester practice will be filmless within the next few years.

MAYO ROCHESTER PACS PRINCIPLES

A number of principles have emerged during our PACS experience to date. Some of these principles were adopted at the beginning of our experience, and others emerged as we gained experience with the systems. We do not claim originality for these principles, nor do we suggest that they are applicable to all radiology practices. Nevertheless, they have served us well.

Phased Implementation

A few fortunate radiology departments have the opportunity to build and equip completely new facilities designed for filmless operation. Mayo, like most other radiology departments, is faced with implementing PACS in an existing facility. Furthermore, no existing system currently has the capacity to provide filmless radiology services to our entire campus and manage our annual examination volume of more than 750,000 examinations, so we have no choice but to convert our department in stages. Phased implementation also allows us to work out the necessary changes in practice required by filmless radiology.

Solve Existing Problems

We have chosen to implement PACS in areas where our manual systems were unable to satisfy all our needs. For example, there was a need for

From the Department of Diagnostic Radiology, Mayo Clinic, Rochester, MN.

Address reprint requests to Byrn Williamson, MD, Mayo Clinic, Department of Diagnostic Radiology, 200 First St SW, Rochester, MN 55905.

*Copyright © 1998 by W.B. Saunders Company
0897-1889/98/1104-2007\$8.00/0*

faster turn-around for examinations from the Urgent Care Center and the Orthopedic Clinic. There was also a need to provide radiology coverage for examinations from the Urgent Care Center outside the radiologist's normal duty hours. The improvement in clinical service provided by PACS in these circumstances has been much appreciated by our clinical colleagues and has increased support for wider implementation of the system.

Images and Reports Released Together

Traditionally, our department has not allowed radiographs to leave the department until they have been interpreted and a printed report affixed to the film jacket. This process typically takes 2 to 4 hours from the completion of the examination. The implementation of electronic imaging systems raises the possibility that clinicians could have access to images before review and interpretation by a radiologist. Although exceptions may exist, in our practice, we feel the patient is best served if images and reports are released simultaneously.

On-Line Interpretation

Our desire to release images and reports simultaneously requires that examinations be interpreted expeditiously. In fact, Mayo has been using on-line interpretation for more than 40 years.⁴ Approximately 70% of our reports are produced by direct dictation of the report to a transcriptionist in the x-ray reading room. Conversion to an electronic system involves the replacement of the film view box by a PACS workstation and the replacement of the transcriptionist's typewriter by a radiology

information system (RIS) workstation (Fig 1). When the radiologist selects a case to be interpreted, the PACS automatically signals the RIS to open the record for that examination. The radiologist can view the report on a "slave" monitor as it is transcribed, and when the report is complete and verified by the radiologist, the transcriptionist finalizes the report. The RIS then makes the report available to clinicians electronically.

RIS is the Master Database

In our film-based practice, the RIS manages data about all aspects of our practice, including patient demographics, examination data, the location of hard-copy images, and the interpretation of examinations. As we transform our film-based practice to a filmless department, the RIS will continue to manage data for all examinations, both film-based and electronic, and will function as the master data base of our practice. The fact that we share the same RIS with Mayo facilities in Jacksonville, FL, and Scottsdale, AZ, allows us to share radiology information between sites and will allow us to share images in the future.

Tight RIS/PACS Integration

RIS and PACS were developed to address different needs and have generally been supplied by different vendors. In general, RIS were designed to automate clerical functions such as registration and scheduling, tracking of patients and examinations, film library functions, exam interpretation, and compiling management data. In contrast to the text data managed by RIS Systems, PACS are designed

Fig 1. On-line transcription of radiology reports in PACS reading room. Transcriptionist's RIS workstation displays the report for the examination being viewed on the PACS workstation. Note the "slave" monitor that allows the radiologist to view and approve the report in real time.

primarily to manage images. Despite the traditional separation of RIS and PACS functions, a useful PACS system is dependent on RIS functions to operate effectively. Figure 2 presents a simplified schematic of the interfaces between our RIS and PACS systems, as well as several other important interfaces.

The RIS receives patient data and electronic orders from other institutional systems and in turn transmits this information to the PACS. In the event that an examination is canceled after being scheduled, the RIS transmits this information to the PACS system.

The RIS notifies the PACS system when a patient arrives for an examination. The PACS system transmits patient demographic information to the computed radiography (CR) system and receives the images produced by the CR system. The PACS system notifies the RIS when an examination has been completed.

When the radiologist displays an examination to be interpreted on the PACS workstation, the PACS notifies the RIS so that the examination context is displayed on the transcription workstation. Once the interpretation is complete, the examination is finalized in the RIS and notification is relayed to the PACS system.

When interpreted examinations are displayed on a PACS workstation, the PACS system retrieves the x-ray report from the RIS and displays it along with the images.

The development of these interfaces has been time-consuming and expensive, but we have found this tight integration to be essential in our practice.

Worklists/Workflow

In a film-based radiology department, there is little confusion about the work that each radiologist is to perform, because only a single copy of each image is produced. In general, a radiologist is presented with a stack of films or a series of examinations on an alternator, and there is little danger that multiple radiologists will interpret the same examination. Because electronic images can be viewed simultaneously by multiple radiologists, some means must be used to prevent confusion about the examinations available to be interpreted. In addition, it is useful for examinations to be sorted for interpretation by the appropriate subspecialty radiologist. Our system uses worklists to accomplish these functions. Information about ordering location, patient age, and type of examination allows automatic assignment of examinations to the appropriate worklists. Examples of our worklists include Unread Urgent Care Examinations, Unread Pediatric Examinations, Unread General Examinations, and examinations interpreted by residents requiring approval by a staff radiologist.

"Any Image, Anytime, Anywhere"

The United States military's Medical Diagnostic Imaging Support (MDIS) project⁵ enunciated the goal of making any image available wherever it was needed, whenever it was needed. Because of the large number of outpatients seen at Mayo Clinic Rochester and the mobility of patients, staff, and residents, we feel that rapid availability of images at any workstation on our campus is a requirement

Fig 2. Simplified schematic of RIS/PACS interfaces and several other important interfaces.

for our PACS system. In the current state of technology, this requirement necessitates centralized management of images with rapid delivery to any workstation on demand, rather than prefetching images to individual workstations where they are likely to be required.

Images in the Electronic Medical Record

PACS systems have traditionally been viewed as dedicated systems whose purpose was to display images (and possibly reports) inside the radiology department and in selected locations throughout the hospital or medical center, but it is inefficient and expensive to present images to clinicians on dedicated imaging workstations. The full realization of the benefits of a PACS system requires the delivery of radiology images and reports to clinicians as part of an electronic medical record. Clinicians generally prefer to view radiology images along with other pertinent information about the patient includ-

ing laboratory data, history and physical examination, operative reports, and progress notes.⁶ Accordingly, Mayo Clinic Rochester has developed and implemented the QREADS software to display radiology images and reports on clinician workstations as part of the electronic medical record.

CONCLUSION

The implementation of a PACS system is a complex undertaking. Implementation of such a system at Mayo Clinic Rochester is further complicated by our large annual examination volumes, the movement of physicians and outpatients throughout our large campus, and the large number of individuals participating in radiologic and clinical care of our patients. The principles discussed here have been adopted to facilitate implementation of a PACS system in our complex environment. Depending on circumstances, they may also be applicable to other environments.

REFERENCES

1. Hangiandreou NJ, Williamson B, Gehring D, et al: Current status of the joint Mayo Clinic-IBM PACS project. *Proc Int Soc Optical Engineering* 2165:519-526, 1994
2. Hangiandreou NJ, King BF, Swenson AR, et al: Picture archive and communication systems implementation in a community medicine practice. *J Digit Imaging* 10:36-40, 1997 (suppl 1)
3. Erickson BJ, Ryan WJ, Gehring DG: READS: A radiology-oriented electronic analysis and display station. *J Digit Imaging* 10:67-69, 1997 (suppl 1)
4. Williamson B Jr, Plenge BJ: The human transcriptionist: The standard for speech recognition systems. Carlsbad, CA, Symposia Foundation, *Computer Applications to Assist Radiology*, Proc S/CAR 92, 1992, pp 352-356
5. Goeringer F, Leckie R: U. S. Military medicine: PACS, telemedicine & personal digital assistant devices. Carlsbad, CA, Symposia Foundation, *Computer Applications to Assist Radiology*, Proc S/CAR 94, 1994, pp 279-285
6. Williamson B Jr, Hangiandreou NJ: Images in the electronic medical record. Carlsbad, CA, Symposia Foundation, *Computer Applications to Assist Radiology*, Proc S/CAR 96, 1996, pp 41-49