Enhancing Availability of the Electronic Image Record for Patients and Caregivers During Follow-Up Care

Amit Mehta, Keith Dreyer, and James Thrall

Purpose: To develop a personal computer (PC)-based software package that allows portability of the electronic imaging record. To create custom software that enhances the transfer of images in two fashions. Firstly, to an end user, whether physician or patient, provide a browser capable of viewing digital images on a conventional personal computer. Second, to provide the ability to transfer the archived Digital Imaging and Communications in Medicine (DICOM) images to other institutional picture archiving and communications systems (PACS) through a transfer engine. **Method/materials:** Radiologic studies are provided on a CD-ROM. This CD-ROM contains a copy of the browser to view images, a DICOM-based engine to transfer images to the receiving institutional PACS, and copies of all pertinent imaging studies for the particular patient. The host computer system is an Intel based Pentium 90 MHz PC with Microsoft Windows 95 software (Microsoft Inc, Seattle, WA). The system has 48 MB of random access memory, a 3.0 GB hard disk, and a Smart and Friendly CD-R 2006 CD-ROM recorder (Smart and Friendly Inc, Chatsworth, CA). **Results:** Each CD-ROM disc can hold 640 MB of data. In our experience, this houses anywhere from, based on Table 1, 12 to 30 computed tomography (CT) examinations, 24 to 80 magnetic resonance (MR) examinations, 60 to 128 ultrasound examinations, 32 to 64 computed radiographic examinations, 80 digitized x-rays, or five digitized mammography examinations. We have been able to successfully transfer DICOM images from one DICOM-based PACS to another DICOM-based PACS. This is accomplished by inserting the created CD-ROM onto a CD drive attached to the receiving PACS and running the transfer engine application. **Conclusions:** Providing copies of radiologic studies performed to the patient is a necessity in every radiology department. Conventionally, film libraries have provided copies to the patient generating issues of cost of loss of film, as well as mailing costs. This software package saves costs and loss of studies, as well as improving patient care by enabling the patient to maintain an archive of their electronic imaging record.

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WITH THE ADVENT OF picture archiving and communication systems (PACS), the era of the filmless radiology department is becoming

a reality. The digital representation of classically film-based modalities has altered the clinical routines of many physicians, especially the radiologist. The advantages associated with PACS are discussed elsewhere.^{1,2} A disadvantage, though, lies with the limitation of portability of images to consultant and referring physicians.³ Although solutions exist for distribution of images within the enterprise, including web-based servers and central workstations, problems exist with the portability of images beyond these confines.

Conventionally, patients have been able to receive copies of their radiologic studies for personal archive or use by referring or consulting physicians. For this service, radiology departments have incurred costs associated with copying films and losing signed-out original films. At first glance, PACS does not serve to curb these costs. With the installation of a PACS, images are in a digital form; for the patient to take images to their referring physician involves additional processes. Costs, which necessitate budgeting within the PACS to perform this task, include the cost of film, printer consumables, printer time, and operator time.

We have developed a personal computer (PC)-based software package that allows portability of the electronic imaging record. This custom software enhances the transfer of images in two fashions. First, an end user, whether physician or patient, is provided with a browser capable of viewing digital images on a conventional PC. Second, the software package provides the ability to transfer the archived images to other institutional PACS via a Digital Imaging and Communications in Medicine (DICOM) link.

MATERIALS AND METHODS

The host computer system to view archived portable images is a Pentium 90-MHz PC with Microsoft Windows 95 software (Microsoft Inc, Redmond, WA). The test creation system is a conventional PC with Windows 95, 48 MB of random access memory, a 3.0 GB hard disk, and a Smart and Friendly CD-R 4006 CD-ROM recorder (Smart and Friendly Inc, Chatsworth, CA). This system is chosen as a development system because it is conventionally available in many radiology departments.

Once requested, the operator is responsible for selecting the appropriate patient records from the department PACS using the image library PC. Using custom software, these images are recorded onto the CD-ROM in standard DICOM format stripped

From the Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, MA.

Address reprint requests to Amit Mehta, MD, 8 Whittier Place, Suite 19D, Boston, MA 02114.

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0897-1889/99/1202-1022\$10.00/0

of any institution dependent factors, such as the medical record number. This CD-ROM is then provided to the patient or referring physician pending appropriate security protocols are fulfilled, including identification in the case of a patient or consent to acquire studies in that of a physician.

RESULTS

Patients are now able to receive a CD-ROM with copies of their radiologic studies. This CD-ROM contains copies of all pertinent imaging studies for the particular patient, an Internet web browser to view images, and a DICOM-based engine to transfer images to a receiving institutional PACS.

In our institution, we have tabulated different average sizes for each modality used (Table 1). Each CD-ROM disc can hold 640 MB of data. In our experience, this holds anywhere from 12 to 30 computed tomography examinations, 24 to 80 magnetic resonance examinations, 60 to 128 ultrasound examinations, 32 to 64 computed radiographic examinations, 80 digitized x-rays, or five digitized mammography examinations. The browser is 10 MB and is standard on each disc as the viewing software. The number of studies one disc can hold, as described, varies on the types of imaging studies chosen, as well as the number of images per study.

We have been able to successfully transfer DICOM images from one DICOM-based PACS to another DICOM-based PACS. This is accomplished by inserting the created CD-ROM onto a CD drive attached to the receiving PACS and running the transfer engine application. The application successfully will transfer the patient's images stored on the CD-ROM using DICOM transmission protocols to the receiving PACS as a foreign study. A foreign study ensures the receiving PACS does not try to incorporate these

images into their archive without specific instruction from the information system manager.

The cost associated with producing a CD-ROM disc for the patient is \$2 to \$4. This cost covers the cost of media, as well as a small portion of the operating expense. Compared with providing film-based copies to the patient at a cost of \$10 to \$20 per film, the patient can save upwards of \$20 to \$30 per study copied.

DISCUSSION

Providing copies of radiologic studies performed to the patient is a necessity in every radiology department. Conventionally, film libraries have provided original films, pending the patient or referring physician ensures their return. This creates the issues of costs of loss of films, as well as mailing, which are at times incurred by the radiology department. In cases where patients or referring physicians will not be returning films, copies are made and provided in a hospital film jacket or envelope.

Costs associated with printing copies of films include costs of film, envelopes, printers, and supplies needed for these devices. Many departments defer the costs of these services to the patient. A prime goal of implementing PACS is to eliminate costs associated with film production. Providing images to patients in an electronic format obviates the need to print copies of films, ultimately saving money. Second, it provides the patient with a permanent copy of the radiologic studies performed in their management of their health care. Last, the costs of producing a CD-ROM are negligible in comparison to that of printing multiple pieces of film, as discussed earlier. This serves to save the patient extra incurred charges, as well as the radiology department in operating costs.

In addition to these savings, global costs are reduced as radiologic studies that are repeated because of inavailability of previously conducted studies are eliminated. With the ability of this program to perform DICOM transfer from one compliant PACS to another, receiving institutions are not required to reperform studies that are not medically necessary if available on the patient's electronic image archive.

In the future, alternate forms of media will decrease the cost of producing a copy of the electronic image. Currently, smart cards are becoming a reality in parts of the country as a test medium

Table 1. Medical Image Sizes

Modality	Average Image Dimension (pixels)	Gray Level (bits)	Average Images/Exam	Average Size/Exam (MB)
Computed tomography	512 × 512	12	70	36.7
Magnetic resonance imaging	256 × 256	12	150	19.7
Ultrasound	512 × 512	8	30	7.8
Computed radiography	2048 × 2048	12	2	16.7
Digital radiography	2048 × 2048	12	2	16.7

for other applications. Once a storage medium as such becomes ubiquitous, each patient will be able to download onto a card, copies of all imaging studies performed in their management. This record will be easily accessible by referring physicians with smart card readers, likely installed for other purposes such as updating the patient's medical record. In the nearer future, we will see the creation of high-capacity, portable storage devices in the capacity ranges of 1.0 to 3.0 GB. Should these storage media become commonplace, radiology departments can explore issues of using these

as alternate forms of storage for patients requiring large amounts of studies in their record.

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