PACS and CR Implementation in a Level I Trauma Center Emergency Department

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Implementation of a picture archive and communication system (PACS) at a large teaching hospital is an expensive and daunting endeavor. The approach taken at the University of Alabama Hospitals has been to assemble an institution-wide system through focused integration of smaller mini-PACS. Recently a mini-PACS using Computed Radiography (CR) has been placed in the Emergency Department (ED) of a Level I Trauma Center completely replacing conventional screen-film radiography. This area of the hospital produces approximately 250 images per day and provides many challenging requirements: the need for rapid radiography; providing good image quality for difficult examinations with potentially uncooperative patients; reproduction of lost films to maintain availability of images to multiple consulting teams; and frequently unknown patient demographics. The PACS includes both vendor-supplied and in-house developed devices for image storage, distribution, and display. Digital images are produced using two photo-stimulable phosphor CR systems. Currently, all radiographic examinations are acquired digitally with production of a hard copy film as well as electronic distribution via the PACS. Interpretation of images is done primarily via hard copy with a goal of transition to soft copy interpretation. This paper discusses the functional requirements of the PACS and solutions to workflow issues arising in the ED.

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THE UNIVERSITY OF ALABAMA Hospital is a 908 bed teaching hospital, serving the local community and acting as a referral center for the state of Alabama. The Emergency Department (ED) consists of a 20 bed unit with an additional Walk-In Clinic for ambulatory patients. Approximately 37,000 radiological examinations are performed per year resulting in 250 individual images per day. Implementation of a mini-PACS CR system to acquire, archive, and display these digital images has produced a significant change in operations and has raised a number of workflow issues and challenges.

METHODS AND MATERIALS

A doctor's order for a radiological examination is entered into the Hospital Information System and subsequently transmitted to the Radiology Information System (RIS). An order request form is printed on a laser printer located in the ED. This request form contains separate bar codes for each piece of patient demographic information: Last Name, First Name, Middle Initial, Date of Birth, Medical Record Number, and RIS

Accession Number. This data can be entered into a Fuji ID Gateway PC (Fuji Medical Systems USA Inc., Stamford, CT) using a barcode wand. With the recent installation of an HL7 interface to the RIS, an HL7 ORM message is generated by the RIS and transmitted directly to the ID Gateway thereby eliminating the need for manual data entry. The ID Gateway displays a worklist of examinations to be performed by the technologist.

Demographic information from the ID Gateway is downloaded via a serial cable to a Fuji AC3-CS CR reader. Image and demographic information is transmitted via a DASM to a GE Advantage CRQA workstation (General Electric Medical Systems, Milwaukee, WI). From this workstation, images are automatically printed using Digital Imaging and Communication in Medicine (DICOM) Print class with a networked Imation DryView 8700 printer (Imation Enterprises Corp. Medical Imaging Systems, St. Paul, MN). In order to minimize downtime, two identical systems (ID Gateway, CR reader, QA workstation, and film printer) are in operation. After a quality control check by the technologist, digital images are networked with DICOM Storage class to an in-house developed Image Routing Workstation¹ for distribution to display workstations and storage device. GE Advantage Review workstations are used to display the digital CR images as well as CT examinations performed in the Radiology Department on ED patients. One display workstation is located within the ED with a second located in the Radiology Department. A GE Advantage Cluster Storage System is used for long term storage of digital images.

RESULTS AND DISCUSSION

A natural concern in this area of the hospital is the speed and reliability of any system which has an impact upon patient care. As with any equipment there are balancing factors to consider such as cost and size. To minimize the time needed to produce a film it would be desirable to have a processor docked directly to the CR reader, but this increases the minimum space needed at a given location. Having a separate networked film printer allows for greater flexibility in equipment placement. Our installation of the CR equipment was initially in a temporary area to enable the conventional dark-room and wet film processor to continue normal operation. This temporary space did not have adequate plumbing facilities and to install them

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would have caused a major disruption in ED operations. Therefore the decision was made to use a dry networked printer. To compare CR system speed with the conventional darkroom two tests were performed. For a single 14" × 17" chest image the time from insertion of the cassette into the CR reader to film drop from the printer was 180 seconds. For the darkroom the time from the closing of the darkroom door to the film drop from the processor was on average 108 seconds. In order to more closely approximate a trauma situation, a second test was run to determine the time needed to produce a series of 8 images of varying sizes (8" × 10", 10" × 12", and 14" × 17"). For the CR system the time from insertion of the first cassette to the drop of the final film was 5 minutes and 48 seconds. For the darkroom the amount of time needed was 3 minutes and 53 seconds. Clearly a slight delay is incurred by using the CR system. However the digital images were all available at the QA workstation within 3 minutes and 30 seconds, leading to the possibility of soft-copy digital display in less time than the production of hard-copy film through the use of a darkroom and wet film processor.

An initial request by ED clinicians was for a means of prompt notification that an exam had been performed and images were ready for viewing. An application was developed to display a listing of recently performed examinations in a central area of the ED. This software was written in C with the XView Application Programmer's Interface toolkit and is run on a Sun SparcStation 2 UNIX workstation. The workstation quickly became known as the "Airline Terminal" because of its similarity to a monitor at an airport listing arrived flights. This application receives DICOM Storage Class messages and extracts patient demographic information from the message header. The display includes the patient name, medical record number, examination type, and time the examination was performed. The examination list is automatically updated with the most recent image appearing at the top of the screen and the oldest image being deleted from the bottom of the screen. With a quick glance at the monitor, the clinician can easily tell whether an image is available for viewing.

A major goal in the design of this system was to maintain the extremely low historical level of downtime for the darkroom film processor. This was achieved primarily through redundancy in

equipment. The original installation of equipment occurred in April of 1997 with only one film printer. An additional networked printer was designated as the backup printer and located in the main Radiology Department 6 floors above the ED. Although the printer uptime was 99.5% over a seven month period, occasional glitches in the DICOM Print Server which receives the images from the network as well as occasional film jams emphasized the need for a second film printer to be located within the ED. Since installation of this second film printer the system uptime has been over 99.9% with the only system downtimes occurring due to the structural failure of a countertop on which three computers were sitting and a lost connection between both ID Gateways and their respective CR units that may have been related to testing of the emergency electrical power system.

A large concern in most Emergency Departments involves the issue of missing films. Figure 1 shows statistics from our RIS as to the percentage of examinations completed by the technologist but unread by a radiologist. Although hard copy film continues to be lost, with the archiving of images digitally these examinations can still be read soft-copy by a radiologist and reprinted or displayed digitally for use by clinicians. Installation of the CR system occurred in April of 1997 and this corresponds to a decrease in the unread exam rate which reached a low of 2% in October and November of 1997. Current work involves the installation of a voice recognition/dictation system to improve the report turnaround time as well as the identification of workflow processes to eliminate all unread examinations.

The rate of repeat films in the ED is shown in Fig 2. In order to minimize the time to produce a hardcopy film image, the QA workstation automatically prints every image that it receives without requiring manual intervention. For several examinations, such as the swimmer's view and odontoids, it has proven difficult to standardize upon one set of image processing parameters to provide an adequate hardcopy image for the general population of patients. Often these examinations require the technologist to manually manipulate the digital image through windowing and leveling and subsequent reprinting. Therefore for some portion of the CR repeat films, it is a case of only reprinting the film while for the conventional screen-film system

Fig 1. Percentage of Unread ED Radiological Examinations versus time. Each data point represents the percentage of unread examinations 10 days after the end of a 15 day period (1st through 15th or 16th through 31st).

Fig 2. Emergency Department Film Repeat Rate versus Time for the conventional darkroom with wet film processor and CR system with dry film printer.

all repeats involved an additional exposure to the patient. Current work is underway to further quantify this problem and to reduce the need for this manual manipulation to reduce repeat film printing and improve technologist productivity.

CONCLUSIONS

Successful implementation of a Computed Radiography based mini-PACS in a Level I Trauma Center Emergency Department has been accomplished through careful system design and attention to workflow processes. As with any new system,

adequate training of technologists, radiologists, and clinicians is crucial in gaining physician acceptance. The presence of digitally archived images that can be rapidly retrieved has now made it possible for comparison images to be used thereby improving diagnosis and patient care. Equipment redundancy is critical to minimize system downtime and maximize performance. The problem of lost images has been eliminated and future work will examine the reductions possible in film reprinting and examination repeats in order to minimize both cost and patient dose.

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