Automated Examination Notification of Emergency Department Images in a Picture Archiving and Communication System

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This study compares the timeliness of radiology interpretation of Emergency Department (ED) imaging examinations in a picture archiving and communication system (PACS) before and after implementation of an automated paging system for notification of image availability. An alphanumeric pager for each radiology subspecialty (chest, pediatrics, bone, neuroradiology, and body) was used to alert the responsible radiologist that an ED imaging examination is available to be viewed on the PACS. The paging system was programmed to trigger off of the PACS database when an image is received on the appropriate radiology display station. The pager message includes the radiology accession number and examination description (such as chest, two-view, or c-spine, etc). The PACS paging tool performance was assessed by calculating the time elapsed, for each ED imaging examination, from the Time Imaged to the Time of Interpretation, where the Time Imaged is the actual image completion time measured at the imaging modality, and the Time Interpreted is the time a radiology interpretation is rendered to the ED, and is measured from the Radiology-to-ED fax time stamp. These measures were analyzed pre- and post-paging system implementation to determine any impact of the automated notification tool on radiology service turnaround time. Results show an improved radiology response time from image completion to interpretation rendered to ED clinicians, down from hour(s) to minutes, with the automated paging examination notification system. Examinations are read by the appropriate radiology specialty section in a more timely fashion, and fewer cases go unread by radiology.

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IN THE TRADITIONAL film-based radiology department, a radiologist is made aware of an imaging examination requiring interpretation in one of several ways. Typically, a requisition is placed at the alternator where the film is hung, or with the film jacket, which is brought to the radiology reading room. A radiology technologist or film librarian may bring the study films to the radiologist to be read, and in cases of extreme urgency, the referring clinician, resident, or nurse may hand-carry the films to the reading room for an initial so-called "wet read."

In a picture archiving and communication system (PACS), there is no obvious yet unobtrusive indicator that a new unread examination is available to be viewed at the display, particularly in the urgent or intensive care environments in which

patient procedures occur spuriously rather than as a constant flow. Radiology information system (RIS) parameters such as examination completion may not provide an accurate time-stamp in those situations in which the urgency of the case may preclude prescheduling of the examination. Introduction of an automated paging notification system that triggers off of the PACS availability time may result in improved image interpretation turnaround time, as well as ensure that the appropriate radiology service reads the case. The purpose of this study is to compare the timeliness of radiology interpretation of Emergency Department (ED) examinations in a PACS before and after implementation of an automated paging system for notification of image availability.

METHODS

Alphanumeric pagers for the following radiology subspecialties were used to alert the responsible radiologist at the University of California at San Francisco (UCSF) that an ED imaging examination is available to be viewed on the PACS: thoracic or chest radiology, pediatric radiology, musculoskeletal or bone radiology, neuroradiology, and gastrointestinal (GI) and genitourinary (GU) or body radiology. The paging system was programmed to trigger off of the PACS database when an image is received on the appropriate radiology display station. Using the RIS information in the digital imaging and communications in medicine (DICOM) header pertaining to examination name and type, as well study accession number, the appropriate radiology subspecialty pager is activated. The pager message sent includes the radiology examination accession number, examination description (such as chest, two-view, or c-spine, etc), and the total number of images contained in the study.

The PACS paging tool performance was assessed by calculating the time elapsed, for each ED imaging examination, from the Time Imaged to the Time of Interpretation, where the Time Imaged is the actual image completion time measured at the imaging modality, and the Time Interpreted is the time a

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radiology interpretation is rendered to the ED, and is measured from the Radiology-to-ED fax time stamp. These measures were examined over a 1-month period pre- and post-paging system implementation, and analyzed to determine any impact of the automated notification tool on radiology service turnaround time.

In addition to recording the Time Imaged and the Time of Interpretation, the following measures were also taken, although they remain unaffected by the introduction of the paging system: the Time Ordered, the Time Available, the Time Viewed, and the Time Dictated. The Time Ordered is the time a study order is placed in the RIS. The Time Available is the time the complete imaging examination is available for reading on the appropriate PACS display station as measured from the PACS database, and is the event used to trigger the paging system. The Time Viewed is recorded from the radiology display station database and the Time Dictated is measured from the time-stamp recorded in the RIS. Synchronization corrections were made for differences in system clocks.

RESULTS

An automated notification system was implemented for imaging examinations performed on ED patients. The system pages the appropriate radiology specialty section based on the examination description, alerting the radiologist that an image is available to be read on the PACS.

Analysis of results show an improved radiology response time from image completion to interpretation rendered to ED clinicians, in many cases down from hour(s) to minutes, with the automated paging examination notification system. It was also noted that examinations are being read by the appropriate radiology specialty section in a more timely fashion, and that fewer cases are going unread by radiology. This was especially true in the pediatric radiology and GI-GU/body radiology sections.

Unfortunately, after 1 week of implementation of the automated paging system, radiologists either lost the subspecialty pagers or stopped responding to them. As a result, the timeliness of radiology performance fell back to the pre-paging system pattern of longer and more widely varying image interpretation turnaround times by radiology. Table 1 shows the mean and standard deviation of the time elapsed from the Time Imaged to the Time Interpreted as averaged over a typical week's time prior to implementation of the automated paging tool for notification of an imaging examination in a PACS, and the initial week following implementation during which the paging system was consistently utilized.

Table 1. Time Elapsed From Time Imaged to Time Interpreted, Calculated Before and After PACS Paging Tool Implementation as Averaged Over 1-Week Periods (mean $\pm$ SD)

	Pre-paging (in minutes)	Post-paging (in minutes)
Time elapsed from		
Time Imaged to		
Time Interpreted	90.05 $\pm$ 77.47	40.05 $\pm$ 20.86
Minimum	9	15
Maximum	299	78

DISCUSSION

In a PACS, there is no obvious yet unobtrusive indicator that a new unread examination is available to be viewed at the display, particularly in the urgent or intensive care environments in which patient procedures occur spuriously rather than in a constant flow. Introduction and use of an automated paging notification system that triggers off of the PACS availability time can result in improved image interpretation turnaround time, as well as ensure that the appropriate radiology service reads the case. In addition, fewer cases may go unread by radiology.

The notification tool can be particularly useful for the radiology sections that experience a lower volume of cases to interpret from the ED, and cases occurring at random times. Examples of such sections at UCSF where the ED is not a trauma center include the pediatric and body radiology sections, whereas the chest radiology section typically experiences a higher and more constant volume of ED imaging examinations. The chest section infrequently left ED studies unread during the pre- or post-paging system implementation, but did modify their behavior with the paging system, albeit briefly, to interpret imaging examinations immediately upon completion and availability on the PACS. Without the automated notification system in place, the chest section typically read-out groups of studies at multiple times during the day, sometimes hours after image creation and availability on the PACS.

This is an example of practice re-engineering that demonstrates the need for adequate interfacing to and integration of a radiology or hospital information system with a PACS. It also exhibits the difficulties encountered in changing practice behaviors.