PACS and Unread Images

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In many circles, the justification for purchasing a picture archiving and communication system (PACS) has already been settled because of the proliferation of image data. A PACS is used to acquire medical images digitally from the various modalities, such as computed tomography (CT), magnetic resonance (MR) imaging, ultrasound, nuclear medicine, and digital radiography (1). The need to manage, transfer, and transport thousands of images effectively has led to medical and legal arguments for storing such data electronically rather than producing each image on film. Moreover, with the dissemination of imaging centers—as well as one’s referral base, which may extend beyond state or country boundaries—a PACS becomes an integral part of running an efficient department. The transfer of images to all-night reading stations for subsequent consolidation of emergency room coverage and the centralization of reading areas within a hospital or an enterprise-wide multisite radiology group, has also made life without PACS nearly impossible. Without the improvements in speed and bandwidth for the data transfer, however, these consolidations would be severely limited.

Nonetheless, at a local level, one must still justify the huge investment in capital for a PACS to the financial planners of a hospital or outpatient group practice. We are facing an ever-challenging situation of dwindling budgets, increasing cost pressure, and growing demands to increase the efficiency and quality of related services (2). Typically, reductions in film cost and film library personnel are cited as a means of “financing” the PACS. PACS eliminates the film-associated workload, which includes processing, filing, and manual retrieval of previous studies from film storage. These steps constitute a considerable part of the total radiology turnaround time (3). The economics of PACS are characterized by higher fixed costs for the digital infrastructure and lower variable or marginal costs related to savings in film and personnel (1).

Yet another source of savings in converting to a PACS is the greater capture of studies obtained within the department when film is not relied on as the primary means of viewing images. Heretofore, a common complaint in radiology departments was that clinicians would remove film images from the department before the radiologist could interpret them, rendering these examinations “non-billable” without the cost of refilming. This is a common occurrence in most emergency room radiography departments, where images may be sequestered by the treating physician before being accessioned for billing or accounting. Not only do patients lose an opportunity for expert radiologic interpretation, but these lost films typically will not be available for future comparative studies (4). Accountability for them is particularly problematic without an integrated radiology information system (RIS). The number of lost studies will theoretically be reduced after integration of the RIS and PACS. When the radiology team and referring clinicians have simultaneous access to all patients’ digital data, patient care will improve. Therefore, in addition to decreasing the number of unread images, the use of PACS should help decrease the overall report turnaround time, permitting referring clinicians to make swift decisions on treatment options and health care delivery (4).

At the Johns Hopkins Hospital, Baltimore, Md, the radiology department elected to implement the PACS in a piecemeal fashion because of funding considerations. For a time, the outpatient MR imaging service used a PACS and soft-copy reading to transfer and interpret images, while the inpatient MR imaging service continued to use hard-copy film reading. We were therefore able to compare the rates at which studies were lost with a PACS and remote reading (the outpatient service) and a film-based...
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MATERIALS AND METHODS

During late 2000, the neuroradiology division of our institution elected to transfer as soft copy the images resulting from all outpatient MR imaging studies, from our outpatient center to an inpatient central reading area. For 2 years previously CT scans from six sites in the central reading area had been read on a PACS with soft-copy interpretation of images. To increase divisional efficiency, the outpatient MR imaging service was integrated into this reading arrangement.

Two MR imagers are employed in the outpatient center: a GE Medical Systems Signa imager (Milwaukee, Wis) and a Siemens Medical Systems Vision imager (Erlangen, Germany). They are used from 7:30 AM to 5:30 PM each weekday but not on weekends. The service is 100% outpatient and more than 95% neuroradiology based. Studies are transferred through a hospital intranet based on an interface with the RIS, is printed twice daily for both inpatient and outpatient services and is used by the film librarians, the physicians, and the chief technologists to track and regenerate studies as needed. After 30 days, an imaging study that goes unreported is removed from the unread header list on both of the daily printouts and the Friday reporting number and is presumed to be nonbillable. A case in which studies are unread can therefore appear on a list for a maximum of 4–5 weeks.

In 2001, the lists of unread studies for each Friday for both the outpatient MR and the inpatient MR imaging services were available for 47 weeks. The 5 missing weeks were randomly dispersed throughout the year and in part accountable for by vacation times or computer downtime. We compared the values for the inpatient and outpatient MR imaging services between 1998 (the year before PACS was begun in our department) and 2001 (the year after PACS was integrated into outpatient MR imaging) to determine the effect of the PACS reading of the outpatient studies. The 1998 data, used as a control, were collected in the same way as the 2001 data, with 40 weeks of data available for 1998. The mean, median, and mode with standard deviation (SD) for unread studies were obtained for inpatient hard-copy and outpatient soft-copy MR services, and the data for each year from the two sites were compared by means of a two-tailed paired t test.

As stated previously, an unread study rotates off the Friday unread header list if it is 30 days old. In this way, we ensured that the same studies could not contribute to more than 4–5 weeks’ values and thereby skew the data. Additionally, as stated above, the printout of unread head-

(inpatient) service. We had the unique opportunity to study the rates of unread studies within the two settings for the years before (1998) and after (2001) the PACS was implemented. We hypothesized that conversion to the PACS and soft-copy reading would lead to a severalfold reduction in the rate of unread studies.
ers was used by film librarians each day to retrieve such studies either electronically or as film to reduce the list.

**RESULTS**

The mean number of unread studies each Friday for the soft-copy outpatient service in 2001 was 3.75 (SD, 3.88; median, 3; mode, 1; range, 0–16). In 1998 the mean hard-copy outpatient value was 2.33 (SD, 2.45; median, 2; mode, 0; range, 0–10). This reflects a 62% increase in the number of unread headers after PACS implementation. The mean number of unread studies each week for the hard-copy inpatient service was 21.53 in 2001 (SD, 9.36; median, 20; mode, 14; range, 10–53), compared with 28.32 in 1998 (SD, 14.26; median, 23; mode, 15; range, 12–78), reflecting a 24% decline.

A t test was performed to compare the differences from year to year and location to location. The difference in the number of unread studies between inpatient and outpatient services was statistically significant in both 1998 and 2001 (P < .001 for both years), with more unread headers on the inpatient side. There was a statistically significant drop in unread studies for the inpatient service between 1998 and 2001 (P = .014). On the outpatient side, there was an increase approaching statistical significance (P = .067) in the number of unread studies between 1998 and 2001. The difference in change between the two sites was significant (P < .01).

**DISCUSSION**

The integration of the PACS with the RIS addresses the issue of the missing or misplaced studies that would otherwise go unread. Previously, the retrieval of lost films was completed manually, and it was very time consuming because one had to search the hospital for lost films or electronically reload and refilm missing studies for interpretation. Studies comparing retrieval times for PACS and film-based systems have shown substantial reductions in retrieval times for the digital method, often down from several hours to mere seconds (5).

The results of our study demonstrated that the rate of unread studies was higher the year after the PACS was implemented in the outpatient MR imaging service than it was the year before implementation. In the same period, however, there was a reduction in unread headers for the hard-copy film-based system in the inpatient service. This was opposite to what we had predicted. While several factors could have biased our study, the discrepancy in the mean outpatient values (3.75 cases per week, up from 2.33) shows an unsettling trend.

Several factors were controlled for in this study. In both the inpatient and the outpatient settings, the MR imaging technologists entered the patient information into the RIS after completion of the MR imaging examination. The capture of the studies is therefore believed to be complete. Physicians are unable to report cases unless the patient information has been entered into the RIS, and the accession number must be included in all case-related dictation. Also, both the inpatient and the outpatient services had daily reporting of unread header lists that were used by film librarians to retrieve cases for 1998 and 2001. The outpatient and inpatient MR imaging technologists work as a unit with cross-coverage, and they both report to the central chief technologist, who administers both areas. The same neuroradiologist who was on the outpatient service covered the inpatient service each day. The same reporting mechanism for the Friday unread header list count was used, at the same time of day, for both the inpatient and outpatient services for the same years.

There were some differences between inpatient and outpatient settings, however, that could have contributed to the greater absolute number of unread headers in the inpatient service. For example, referring clinicians were more likely to remove inpatient acute studies from the reading board than outpatient studies. In addition, the inpatient studies included more sophisticated examinations, such as perfusion and functional MR imaging studies, which might be more likely to be lost in the daily workload. The number of images per patient examination was therefore expected to be greater on the inpatient side than on the outpatient side, where perfusion imaging, MR angiographic studies, and functional MR imaging examinations were less common. Another difference is that body MR imaging examinations were an important part of the volume on the inpatient side, while that on the outpatient side was entirely neuroradiologic. By comparing the same services for 2 years, 1998 and 2001, we hoped to address these issues.

Other differences may bias the results. The film librarians for the inpatient MR imaging service were different from those for the outpatient service. The MR imaging technologists assigned to the outpatient service in general were different from those on the inpatient service, although cross-coverage did occur. For the outpatient MR imaging service, a voice recognition system was used for dictating reports, whereas the inpatient service used medi-
cal transcriptionists. On the outpatient side the reports were signed off immediately after review by the attending radiologist using voice-recognition dictation, while on the inpatient side the interval from dictation to transcription averaged 12 hours and the delay from transcription to verification of the study averaged 6 hours. Again, these delays due to the transcription service on the inpatient side were hypothesized to favor a greater number of unread studies for hard-copy reading and do not explain the trends within each setting between 1998 and 2001.

What are the reasons for the observed increase in unread headers with use of a PACS? Why were there more unread studies in 2001 than in 1998? Some factors point to the importance of having a fully operational PACS integrated with the RIS. Both are still in development in our department as the PACS-RIS system is constructed division by division at our institution. Because of budgetary constraints, a department-wide PACS-RIS solution could not be funded, even though the costs of storage and infrastructure have decreased enough that the cost-effectiveness of the technology can be demonstrated positively for some larger institutions (1).

Unread headers could certainly be created by breakdowns in the numerous steps integrating the system. A study may be entered by a technologist but not transferred to the viewing workstation or the archive. It may be sent to the workstation or archive but have transmission errors resulting in its lack of receipt at the remote location. A study may be sent to the incorrect location, although many automatic routing schemes based on imager work lists are employed to prevent such occurrences. A study may be received at the imaging workstation but ignored.

As studies are reviewed and reports are dictated by the attending radiologist, they are marked as “signed off,” which eliminates them from the unread list on the workstation. A study may inadvertently be marked this way even though it has not been read yet. A report of the study may be transcribed with the voice-recognition dictation system but then not merged into the RIS, and therefore the study might still be listed as unread. Since the attending physician has electronically signed the report with the voice recognition system, he or she would assume that the study has been reported and would mark it at the workstation as signed off, thus unintentionally creating an unread header entry. Duplicate accessioning of studies may also occur if case studies, Current Procedural Terminology codes, or ICD-9 codes are revised after the fact and the initial study header is canceled or changed. The report dictated with voice recognition would be on a canceled or incorrectly headed entry, and the attending radiologist would unknowingly mark the case as signed off.

On the inpatient side, studies could appear on the unread header list if the images were removed by the clinicians, if the images were not hung on viewing boards or were mistakenly filed by the film librarians, if the attending physicians failed to read the studies, if the technologists failed to film the studies, or if there was an error in transcription. There are many human contacts and checks and balances with hard-copy reading, providing opportunities for someone (technologist, film librarian, physician, transcriptionist, or administrator) to discover the unread study. With a PACS-RIS solution, however, there are few human interfaces to point out the discrepancies between studies obtained and studies read.

It was impossible to review the unread header list retrospectively to determine the specific causes of unread studies from 1998 and 2001, since they were more than 30 days old when this report and survey were initialized. Nonetheless, a prospective analysis of 20 unread studies from 1 month in 2002 on the outpatient side showed that 50% of the unread header studies were due to lack of receipt at the imaging workstation caused by a “network error” or failure of the technologist sending the study. Thirty percent were due to physicians reporting and signing off on studies that then never reached the RIS, mostly because of incorrect headers (including incorrect accession numbers) or snafus in the voice recognition system. Ten percent of the unread studies had been marked as signed off even though no dictation had been performed. The remaining 10% represented errors in order entry, in which the wrong study, patient number, or dates were entered into the header information and the reported study on that patient had not really been performed.

In a perfect world, one would assume that a PACS-RIS solution would result in fewer cases unavailable for follow-up, as we had hypothesized at the inception of this study. It is highly likely that the number of MR imaging records lost in our department represents just a fraction of the total number of MR imaging examinations that remained unbilled and/or incomplete. Our study assumed that the entry of all examination orders was complete 100% of the time. However, during the course of an actual workday, it is not unusual for cases not to be accessioned by the technologist or clerical staff. Orders lacking headers would not be detected by the accounting system in which unread headers are tallied, since they would never have had headers entered. Such occurrences may
have skewed our data in favor of the inpatient imaging center, where chances are greater that a filmed study might be removed from the department before its header is entered. As one integrates order entry into the scheduling system, however, such occurrences are less likely.

The practical implications of our findings can be divided into information technology suggestions and personnel suggestions. Our information technology recommendations are as follows:

1. Piecemeal integration of PACS and the RIS may lead to inefficiencies that impair the system’s tracking mechanisms. Soft-copy reading without an integrated RIS may result in financial losses rather than the expected gains, if one does not account for the potential loss of studies in the system.

2. If headers are canceled or revised, the reports dictated under those accession codes will not be transferred automatically without explicit instructions and work orders coordinating the PACS and the RIS. This problem should be addressed.

3. Network glitches or downtime may result in insufficient data transfer. Backups must be allocated.

4. Automated transfer of studies through the end-examination command is preferable to reliance on personnel to send images separately and manually through the network.

5. As the daily queries for unread headers are constructed, the RIS should automatically send those unread studies back to the workstations for reporting.

6. Daily analysis of unread headers is recommended to identify systemic errors.

The PACS and soft-copy reading are expected to liberate personnel who would otherwise be filming studies, filing film images, and transporting studies from various locations. Our recommendations regarding better utilization of personnel include the following:

1. Some percentage of a single full-time equivalent should be devoted to discovering, retrieving, and accounting for any unread headers each day. If unread studies are reduced by 5 per day on a daily volume of 100 MR imaging studies (typical of our department), the savings will support one salaried employee.

2. An employee dedicated to transcription or voice recognition errors should be assigned to coordinate cases in which there have been changed or deleted headers, changed names (female X in the ER to “Jane Doe”), and/or errors in sign-off.

3. If automation of transfer of images cannot be performed on end-examination commands, then it is critically important to instruct technologists on the timely and uniform network commands to transfer images. They must be able to confirm the receipt and not just the sending of studies.

4. If gaps in the study completions are identified, then each site of imaging should manually fax a list of completed studies at the end of the day to someone in the department who can verify they were delivered to the right location and appropriately reviewed.

In conclusion, our results suggest that when one is trying to convince an institution’s financial officers of the advantages of purchasing a PACS, one should focus on the improved efficiency of technologists, physicians, and staff; reduced expenditures on film and personnel; and the ability to account completely for studies within the system. The costs associated with full PACS-RIS integration have been steadily decreasing. Because of continuing cost decreases for all forms of digital technology, this trend will continue to enable cost-effective solutions for many more hospitals and clinics (1). However, even in a well-run and integrated PACS-RIS enterprise, the system may break down at numerous points, resulting in unread studies. This problem seems to be amplified if the PACS and the RIS are funded and implemented piece by piece with no fully integrated tracking system to identify and flag potential pitfalls or losses. A rigid system of surveillance for unread studies during the turmoil of daily department functioning is critical. This is an argument for full integration of a PACS-RIS tracking system even though the initial start-up costs may seem prohibitive.

REFERENCES


