

Progress toward Paperless Radiology in the Digital Environment: Planning, Implementation, and Benefits

Matthew D. Ralston, MD, Robert M. Coleman, MD, David M. Beaulieu, MD, Kristina Scrutchfield, RT (R)(CV), and Todd Perkins

A growing number of hospitals have installed PACS (Picture Archiving and Communications Systems) in order to improve patient care and to facilitate improved efficiencies. While eliminating films is commonly one of the first goals in planning a successful PACS implementation, eliminating the manual handling of paperwork can also produce a substantial benefit. We describe the process utilized at Maine Medical Center (MMC) to achieve a substantial degree of freedom from paperwork. Some of the benefits were expected, but some unexpected benefits also revealed themselves during this process.

KEY WORDS: PACS, Picture Archiving and Communications Systems, paperless radiology, PACS broker, peer review, speech recognition

PICTURE ARCHIVING AND COMMUNICATION SYSTEMS (PACS) offer several advantages to radiologists and radiology departments as they work to trim costs, improve patient care, and increase throughput and efficiency. During the planning and cost-justification process, most radiology departments focus on the substantial savings that may be achieved by limiting or eliminating hardcopy film production, transport, storage, and retrieval. But there are other potential savings and efficiencies to be gained by eliminating or limiting the use of manually handled printed paper in the day-to-day radiology department workflow. These potential gains from going “paperless” can be maximized by appropriate planning and implementation. We describe our progress thus far in achieving some measure of freedom from radiology paperwork, as well as some of the benefits that have resulted.

MAINE MEDICAL CENTER'S PROCESS AND EXPERIENCE IN APPROACHING THE PAPERLESS TRANSITION

In 2000–2001, Maine Medical Center (MMC) purchased and implemented a PACS, CR, and webserver system from a large commercial vendor. The PACS itself is Agfa IMPAX version 4.1. The MMC RIS system is Quadris, currently owned by Cerner. The RIS/PACS broker is Mitra. The dictation system is RTAS by Sudbury. The individual RTAS reading stations are connected by serial cables to the corresponding PACS workstations, allowing direct transfer of the RIS order number to the transcription station (more on this later). Dictated reports are transcribed by a pool of radiology transcriptionists into Physicians Desktop, a module of Quadris. Reports are stored in the RIS as well as in the Mitra broker.

Imaging is performed at several MMC sites within the Portland, ME, area, and all images other than mammography are interpreted from 23 PACS workstations. The MMC PACS is a cacheless system. Therefore, all examinations are equally available at all workstations.

The resulting 175,000 exams per year are interpreted primarily by subspecialty radiologists. There is a substantial disconnect between where

From the Department of Radiology, Maine Medical Center, 22 Bramhall St., Portland, ME, 04102.

Correspondence to: Matthew D. Ralston, MD, tel: 207-871-4391; fax: 207-799-5348; e-mail: ralstm@mmc.org

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radiologists are sited and where the imaging studies are performed, and the PACS system should ideally allow for virtually any study to be read from any location without the radiologist being tethered to the paperwork or the location where the images originated. In order to achieve this freedom from paperwork, considerable attention was paid to the flow of clinical and demographic information through the various stages of the process, from order entry to performance of the exam, dictation, transcription, and distribution of reports. Through an iterative process, we gathered lists of the types of paper forms that were generated in the pre-PACS environment as a routine, where those forms came from, what purpose they served, and where each paper form finally wound up (ie, trash can, in the film folder, sent to Medical Records, etc). In our pre-PACS environment, several pieces of the paper were traditionally stored in the radiology film jacket. For the most part, the traditional film jacket is no longer produced in the largely filmless PACS environment we have subsequently achieved. Since there is no longer a film jacket, we had to preplan for replacing the functionality and documentation that the film jacket paperwork provided in the pre-PACS environment.

Optimizing PACS, RIS, and Dictation/Transcription Systems for Paperless Transition

A modern PACS has (or should have) excellent capabilities for displaying new examinations in a user-friendly manner, prefetching and displaying pertinent prior examinations for comparison and providing access to prior reports. One would consider these features to represent baseline or core functionality for any modern PACS.

In order for radiologists to be able to forgo the hardcopy paperwork, however, the PACS functionality has to achieve an enhanced level of flexibility and consistency in the way it handles examinations, above and beyond the core functionality mentioned in the preceding paragraph.

One of the keys to eliminating paperwork is to eliminate the requisition form. It may sound like a simple thing to accomplish, but anyone

considering elimination of the requisition form needs to consider the many “meanings” or messages that this piece of paper has heretofore held for the radiologist. In the traditional paradigm, the requisition form is manually transported from the technologist who performs the exam to the radiologist who is expected to read that examination. The radiologist receiving this paper form in the traditional model might perceive several or all of the following things:

1. “This is my case of read.”
2. “Nobody else has this requisition, so no one else knows the case is ready to be dictated.”
3. “I know that the case is undictated because I am the only person who knows that the case is ready to dictate, and I am the only person who holds the requisition. And I don’t recall having dictated it yet. So, it must be undictated.”
4. “I need the order number (from the RIS) off this requisition in order to start the dictation. If I fail to key in this number correctly, then the case may not be transcribed. If it is not successfully transcribed, someone from transcription will approach me in a week or two to redictate the case.”
5. “Once I have dictated the case, I must put this requisition in that stack by the dictation station.”
6. “Once the requisition is in that stack by the dictation station, then it must have been dictated.”
7. “If I lose or misplace the requisition form, I may forget to dictate the case. And transcription may not transcribe the case. And I (or another radiologist) may be required at a later date to redictate the case.”
8. “Once I have finished with the films and requisitions at my reading station, my work is done. Since all the other requisitions in the department today are being routed to other radiologists, those other cases are not mine to read. Alternatively, I must physically move to another site in the department to look for more requisitions to read.”

In order to replace the radiologists’ reliance on paperwork, the PACS itself must be consistent in telling all the radiologists what cases have been dictated, what cases have not been dictated, and what cases are in the process of being

dictated. Beyond that, the PACS system needs to be able to accurately group undictated cases into logical specialties or subsets so that the most appropriate radiologists will be directed to the batch of cases that they are “assigned to” or are most qualified to interpret.

If all of the above works correctly, then the individual radiologists can gain confidence that the PACS “knows” what has been dictated and what needs to be dictated. Beyond that, the individual radiologist can easily “pitch in” to help other areas, when his or her assigned work is done or during gaps in the workday. All of the above likely seems logical, desirable, and achievable. However, it is our observation that many core PACS installations do not inherently achieve the level of sophistication, integration, or functionality necessary to allow the paperless transition. The precise details of what needs to be customized or optimized within the PACS, RIS, and dictation/transcription systems are beyond the scope of this article and are heavily dependent on local factors. It may be useful, however, to highlight a few of the items we believe were instrumental for us at MMC:

1. **Tight integration of the digital dictation stations to the PACS workstations.** This eliminates keying errors on the part of the radiologists when logging in to read a particular case. Beyond that, the interface results in a high degree of concordance between what has actually been dictated and what the PACS “thinks” has been dictated.
2. **Careful attention to specialty mapping, both in the RIS and in the PACS.** In order that logical “wizards” or macros could be developed for radiologists to identify appropriate batches of cases to be dictated, we found it helpful to modify the entire list of radiology examinations in our RIS. For each RIS examination name, we added a two-letter suffix indicating the body part or specialty for that examination. In this manner, we can assure that the PACS wizards find all of the cases of a particular type, and also that appropriate prefetching rules have a high likelihood of identifying and retrieving the most appropriate comparison studies. For example, the suffix [BD] indicates a body

case, [NE] indicates a neuro case, [SP] indicates a spine case, and so forth.

3. **Careful attention to mapping of RIS (HL-7) messages from the RIS to the PACS broker.** There is a natural tendency, when installing a new PACS, to do just enough mapping of information to get the PACS functioning at some level. That is a pitfall to be avoided, in our opinion. We spent over a month setting up the broker and mapped all the RIS information that we could to the broker, even if we did not understand whether or how we might need that information in the future. On several occasions since the startup of our PACS, we have been glad that we spent that time, since it has helped facilitate the paperless transition.
4. For example, in the pre-PACS workflow, the radiologist needed the printed requisition form in order to know the order number (generated by the RIS) for the particular exam being dictated. To replace this dependency on paper, we have successfully mapped the order number from the RIS to the broker. There is an “interface” application that utilizes the context server on each workstation to query the broker for the order number and then forwards this identifier number to the digital dictation system when the radiologist clicks the “Dictate” icon in PACS.

In this example the paperwork has been replaced by a more reliable workflow that eliminates the dependency on paperwork. As a side benefit, transcription always receives the correct order number, and the transcriptionists spend less of their workday “fixing” bad information flow. The secondary benefit of software linkage of the PACS and dictation transcription systems is increased concordance between the PACS list of what needs to be dictated and that subset of cases that is actually waiting to be dictated. The tertiary benefit of all this integration and accurate specialty mapping is that our radiologists have developed a high level of confidence in the PACS information and the PACS wizards. If the PACS indicates that a case has been dictated, we believe it. Conversely, if the PACS says that a case needs to be dictated, we believe that. As a consequence of

the radiologists' confidence in the system, the radiologists were finally comfortable "letting go" of the paper requisition within 12 months of PACS startup.

Overall Results and Observations

While some parts of our radiology workflow were already inherently paperless in the pre-PACS environment, there were 5 potential areas identified for potential improvement: (1) Paperless for the Film Librarians, (2) Paperless for the Radiologists, (3) Paperless for the Technologists, (4) Paperless for Transcription, and (5) Paperless for the Referring Clinicians.

Paperless for the Film Librarians. One of the unifying goals of the process was to identify and eliminate the paperwork that was traditionally stored in the radiology film folder. By definition, going filmless meant no more film jackets. For the most part, we have been successful. There remain, however, two pieces of paper that we have not yet conquered. First is the patient consent form for contrast administration and invasive procedures. For the present, we are still utilizing paper consent forms, which are stored manually. The second is the ultrasound sonographers' worksheets. For the most part, the sonographers and radiologists have migrated away from detailed worksheets. This is a change from their pre-PACS workflow, but the sonographers and radiologists have adapted by making more liberal use of on-screen notations during the ultrasound exams. In addition, the sonographer may make a few notes on the paper requisition form. A radiologist always reviews the case and discusses it with the sonographer before the patient leaves the department. The radiologist dictates the pertinent information into the report and the requisition is discarded. (Alternatively, for on-call cases, the resident will enter the pertinent findings in the Comments section of the PACS information page. Thus, the ultrasound radiologist the next day does not need the requisition form.) For a small subset of ultrasound exams, however, worksheets are still utilized. These forms are manually filed by the film librarians in case the forms need to be retrieved in the future. For both the consent forms and the few remaining

sonographers' worksheets that are generated, we are considering digital means of replacing this storage functionality. The film librarians note that the forms are virtually never requested again, and they do not currently find the storage duties onerous. We have thus far avoided resorting to paper document scanners/digitizers as a means of inputting paperwork into the PACS images. While we understand that many centers have had success with such paper scanners, this alternative is not without its drawbacks in efficiency and accuracy, in our opinion. Thus, other than signed patient consent forms and a small proportion of ultrasound sonographer worksheets, the film librarians have been freed from dealing with the paperwork that previously resided in the film folder.

Paperless for the Radiologists. In general, radiologists have traditionally had two major uses for paper requisitions or printed schedules during their routine workday. First, certain cases need to be customized, prescribed, or "protocolled" before they are performed. In our practice, this includes most MRI and CT exams. The radiologist needs all the available clinical information, demographics, indication, list of old studies and exams, etc, that might be available in order to prescribe the optimal exam. This information traditionally was passed along to the radiologist in the form of a paper requisition slip. The radiologist would write down the protocol and pass the form on to the technologist who would be performing the exam (more on this later). The second major function of the paper requisition is to "flag" that a case is ready to be dictated. On this front, we have achieved a virtually paper-free environment for the radiologists reading the daily workload. Other than ultrasound, mammography, and certain angiography exams, virtually any exam performed anywhere in our system can be interpreted from any workstation, without need for paper requisition or printed schedules. This is achieved largely through tight integration of the PACS with the Radiology Information System (RIS) and with the dictation/transcription system. This has created a benefit for the radiologists in increasing productivity, balancing the workload, and decreasing stress levels.

In order to achieve these goals, key personnel in the radiology department met on a weekly basis during the year leading up to PACS implementation to identify and discuss the paper forms that needed to be eliminated. And, more importantly, we discussed and strategized how to replicate (or improve upon) information flow in the digital environment.

In focusing on the twin goals of paperless for the film librarians (ie, elimination of the film folder and its contents) along with the desire for the reading radiologists to be paperless, we identified eight pieces of paper-based information that needed to be eliminated or replaced:

1. The requisition form for the current examination, generated from RIS
2. Additional clinical information gathered by the technologist at the time of the exam. (In the paper-based process, such notes were commonly handwritten on the paper requisition form.)
3. The reports of prior exams, which previously had to be manually printed out by the film librarians
4. The fax form to be further described below
5. For on-call cases, the resident's preliminary reading, additional clinical information, etc
6. For on-call cases, a QC (quality control) form was filled out, allowing for "grading" or over-reading (double-reading) of on-call cases. In the pre-PACS era, this QC form was combined with the paper-based form used by the residents to capture their on-call readings.
7. The traditional catch-all functionality of the paper requisition as a repository for notes from technologists to radiologists, from residents to staff, from radiologists to technologists, and from radiologists to the film librarians.
8. A paper-based logbook or interesting case book at several reading sites in the department for capturing interesting cases for followup, research, or case conferences.

In order to achieve the paperless goal for reading radiologists, several pieces of information need to be routed to the radiologist in a seamless, paperless way, and that data need to appear on the PACS information page when a study is accessed to be dictated. The means for

achieving these goals are specific to the limitations and capabilities of our various support systems but include tight integration of the RIS to the PACS broker, integration of the digital dictation system to the PACS system, and routing information from the modality consoles to the PACS information page for each patient exam. In addition, extensive use was made of the PACS' inherent capability of capturing and storing notes or "comments," which may be shared among radiologists, technologists, and film librarians who have access to the PACS. For example, we have evolved a novel, paperless means for notifying the film librarians that a current exam cannot be interpreted until the prior exam has been retrieved. This is accomplished largely through communications (notes) shared via the comments section of PACS. Also, the radiologist can selectively change the status of such a waiting-for-priors examination to something other than "New," so that other radiologists will not "see" the case in question and will not read it until the prior study has been made available. This "Other" status is one that only the film librarians query for, and they check this queue several times a day. Once the film librarian has the comparison films, the films are either digitized into the PACS system or placed in a particular spot or "cart" in the main reading room. The film librarian then puts a note in the comments field to indicate that the old films are available. Finally, the film librarian changes the status of the exam back to "New," and the exam would now be available for reading.

In addition, a novel, customized process was developed to replace the paper-based QC (peer review) process utilized in the pre-PACS era, to be described later in this article. The success of this QC process is also heavily dependent on the PACS' inherent capability of capturing and communicating comments as well as keywords (to be described below).

Cases for teaching conferences and collected for research are no longer being manually tabulated into logbooks. This functionality has been supplanted by the keyword function of our PACS. Each PACS user can define his or her individualized list of keywords into a dropdown "pick list." Also, a certain few "system" keywords are made available to all users. By

tagging individual cases with selected keywords, we are able to put cases in individual “bins” for easy future retrieval for teaching conferences, research, and other purposes.

One of the paper forms that plagued our radiologists in the pre-PACS era was a Fax form that was manually filled out by the reading radiologist for each outpatient examination. This was unfortunately necessitated by chronically prolonged report turnaround time in the pre-PACS era. Prior to PACS, the radiologists found it necessary to resort to faxed wet reading forms in order to assure that results reached referring clinicians in a timely manner. This manual process was time-consuming, error prone, and a drag for all involved in the process. In the current environment, however, transcription turnaround time is typically under two hours, eliminating the need for paper-based fax forms.

Paperless for the Technologists. The technologists have been freed from paperwork to the degree that it makes sense. That is, there is still a printed requisition form as a placeholder and a notepad for writing protocols and handling inter-technologist and radiologist-to-technologist messages and imaging protocols. But the paperwork is discarded as soon as the exam is completed and all “tracking” and billing of examinations is achieved through the RIS.

The end-of-shift QC process is also substantially paperless. A novel process utilizing the webserver allows the technologist to compare the daily study log with the studies that successfully arrived at the webserver, assuring that all cases were successfully archived. In our architecture, an exam will not appear on the webserver unless it has been successfully archived in the PACS.

A substantial amount of redundant manual data entry has been eliminated by virtue of implementation of DICOM worklist management at all modalities. This has saved the technologists considerable amounts of time and has successfully limited the possibility that the technologists can enter erroneous data. This is a benefit for both the technologists and the PACS support personnel and has substantial downstream benefit to Transcription, as the transcriptionists are consistently dealing with

“clean” data and do not have to waste time fixing errors.

We can envision one or more new work processes that might eliminate the need for paper for technologists. At present, however, the process is comfortable and effective, and it is currently felt that full elimination of printed paper from the technologists’ workflow might create as many problems as it might solve. If our technologists conclude otherwise and would like to go paperless, we have a concrete plan that should allow us to achieve that goal.

Paperless for Transcription. As a side benefit of achieving the paperless transition for the radiologists, the throughput of radiology transcription has improved remarkably. In the pre-PACS environment, the radiology transcriptionists would begin transcribing a particular report only after being provided with the hardcopy requisition form. That form had to travel through several hands, including the radiologist’s, prior to arriving at the transcription office. This process itself was time-consuming and prone to a number of snags, including the possibility that the requisition might be lost or set aside along the way. While the weekly departmental quality control (QC) process would eventually reveal the undictated cases, there would typically be a delay of days or weeks before the problem was discovered and the case belatedly transcribed.

In the current environment the radiologist is no longer waiting for paperwork to begin dictating a case. Within a few seconds of the completion of a new exam, it is available on the PACS, with all the needed clinical and RIS information attached to the images. The PACS system has been integrated with the digital dictation system such that when a radiologist clicks on the “Dictate” icon to begin dictating, the appropriate order number is automatically routed to dictation system, accurately and without possibility of keying errors. Once the dictation is completed, the radiologist clicks the “Dictate” icon a second time. This sequence of events in our integrated PACS/transcription environment has three important consequences:

1. The exam status is changed globally, throughout the PACS, as the radiologist

progresses from “New” status, to “Dictation started,” and finally to “Dictated” status. Thus, all users in all locations have accurate information as to which cases remain to be dictated and which cases are in progress or have been completed. This is a critical function and prevents duplicate readings on cases. Beyond that, the radiologists have developed a great trust and confidence in the system—what the PACS indicates for status is always correct. This degree of consistency and confidence could not have been achieved without the tight integration between the PACS and the digital transcription system.

2. Because the order number is linked directly to the exam in question, the radiologist can no longer make the mistake of dictating under the wrong order number, for example, on a patient who has several exams in a short period of time.
3. The order number is always correct. The transcriptionists use that order number to find the order in RIS and can thereby autopopulate the demographics on their transcription form. The transcriptionists have immediate access to the digital voice file and can begin transcribing as soon as the radiologist clicks on the “Dictate” icon for the second time.

The departmental transcription QC process for assuring that all cases have been dictated/transcribed is also greatly simplified in the integrated PACS environment. As a result, it is rare for a case to go undictated for more than a few hours.

Paperless for Referring Clinicians. Transcribed radiology reports are immediately routed to the PACS broker, which causes them to be available to the clinicians via the webserver (along with the images). As noted, these reports are transcribed fairly quickly and, as a result of the all of the above workflow enhancements, both inpatient and outpatient results are commonly available in two hours. Reports are also routed to the Hospital Information System (HIS) for inpatients and are available in a timely fashion on the hospital’s electronic medical record. Printed reports are also autofaxed to referring clinicians as soon as

approved or digitally “signed” by the radiologist.

Further Elaboration on Improvements in Report Turnaround Times

There are many possible ways to document and measure radiology report turnaround times. For the purposes of the following discussion, we will focus on the time between when the radiologist dictates an exam and when the typed report is available for the referring physician to read. In the process of transitioning from the film-based world to PACS, and the subsequent process of transitioning to paperless PACS, MMC was able to take advantage of stepwise improvement in work processes, with resulting cumulative improvements in report turnaround time.

1. In the pre-PACS environment, report turnaround time averaged 50–100 h. No reports were available to clinicians within 2 h.
2. The process of changing over to PACS, by itself, resulted in two fundamental changes. First, the process of ordering, naming, and coding individual examinations became more rigorous and consistent, resulting in “cleaner” data coming into the transcription office. This change, by itself, dropped the average turnaround time to 30–50 h, with no change in the size of the transcription pool.
3. The second fundamental change with the startup of PACS was the change in the way that clinicians could access reports. Reports were now available on the PACS webserver, on virtually any PC in the hospital. This was a major improvement over the paper-based process that preceded PACS. In addition, the radiology department made the strategic judgment that clinicians would be allowed to see “preliminary” or unverified reports before they were signed off by radiology attendings. These innovations allowed approximately 50% of reports to be viewed within 4 h of the time they were dictated.
4. The next step in the chain of improvement came when both transcription and radiology felt comfortable moving forward without the paper requisition form. In this paperless era, typical turnaround time during routine day-

time work hours is less than 2 h. Overall, including nights and weekends, average report turnaround time has decreased to 15–20 h, with 50% of all exams available within 1 h of the time they were dictated. The proportion of reports that lag to beyond 24 h is typically less than 5%.

5. The resulting improvements in the clinical timeliness and relevance of the radiology reports have been a gratifying enhancement to the way our radiology department is perceived within our medical community.
6. Admittedly, our reliance on traditional transcription does make our turnaround time dependent on a healthy and fully staffed transcription pool, and it is likely that report turnaround time could be further decreased by instituting speech recognition technology. The MMC radiologists are thus far leery, however, of the potential for speech recognition to slow them down and take their attention away from the images.

Replacing and Improving QC Peer Review Process for On-Call Cases

As noted above, there are dual reasons for collecting on-call readings in a systematic manner. First, it allows the final reader of subspecialty cases to know what the resident (and on-call staff) saw and communicated during the night. Second, knowing how the on-call cases were read allows for the possibility of providing teaching and feedback to the on-call radiologists, so their mistakes can be identified, and so they can receive beneficial feedback and learn from their mistakes. As important, the on-call staff and resident receive positive feedback on the vast majority of the cases they handle. The coauthors of this article, with guidance from staff and residents, developed a PACS-based process to replace the paper-based process that existed prior to PACS, briefly outlined below:

1. The on-call radiologist captures the on-call reading in the “comments” section of the PACS information page. Additional clinical information that the resident obtains from the patient, tech, or emergency department physician is also entered during this data-collection step.

2. The on-call resident (and staff radiologist) are identified in PACS by keywords selected from a drop-down menu.
3. The final reader of the exam uses the same drop-down menu to identify himself or herself and enters a score (scale 1–4) on the exam.
4. The final reader may also add “comments” to clarify the error or teaching point.
5. The data are offloaded to a non-PACS server on a daily basis.
6. This QC data are “scrubbed” from the PACS on a daily basis.
7. An automated email reporting system has been developed that provides explicit feedback to the individual on-call radiologists, in a timely manner.
8. The data are sequestered and protected.
9. By departmental policy, no one in the department can view the data on individual residents or staff radiologists. That is, the feedback is supplied to the original reader only, with no possibility of punitive or administrative use of the data by individual radiologists.
10. The system does, however, output global data to give some overall indication of error rates. This can be tracked by the department chairman and reported to the radiologists on a monthly basis.

The above system of capturing data is based upon the inherent capabilities and built-in functionality of our PACS. However, some of the functionality is novel and not truly part of PACS. This part of the on-call QC software was authored by an individual on our PACS team (D.B.) who understands and can manipulate the Oracle database that underlies the core PACS functionality. As noted above, they on-call data are mined and collected for selected purposes, primarily to get good feedback to the on-call radiologists in a timely and consistent manner. That is, it is not used for formal inter-radiologist peer review, credentialing, or disciplinary purposes. We are, however, developing a parallel process, using much of the same technology, to institute a formal peer review process within our department. There will be some key differences and a different overall focus, but there will be much similarity in the technical underpinning.

Some Paper Is Okay

It is important to note that there remains some paper in our day-to-day work and that paper itself is not inherently evil or counter-productive. In some circumstances, the paper-based process is preferable to any digital replacement we have thus far conceived. As noted above, technologists are still very much accustomed and wedded to the concept of having a paper requisition form for each exam they perform. The paper form that was developed prior to PACS is actually a highly customized output of the RIS and contains information that is not available on a single PC "screen," as our RIS is currently deployed. Thus, it is faster, easier, and more functional to have the paper form in hand rather than having to go to a PC for various pieces of information.

The technologist workflow still depends on the printed requisition forms as reminders of what needs to be completed. Technologists, radiologists, and receptionists can write notes on these pieces of paper. The key difference in the PACS environment is that the requisition form does not need to be forwarded to the reading radiologist. The technologist will enter into the RIS the information that needs to be tracked or recorded at the "completion" step and then discard the requisition.

Another area where paper seems to work better than the paperless alternatives is in the "protocoling" of CT and MRI cases at the beginning of the radiologists' work day. We still work from printed schedules and order forms when setting up the day's work in CT and MRI. Once the protocols have been communicated to the technologist and the exams have been performed, however, the paper is discarded. That is, the final reader of the exam does not need the paperwork. In fact, the resulting exam can be read from anywhere in the system, without paperwork.

We have actually conceptualized a PACS-based process to replace the paper-based process of protocoling such cases. However, it has not been implemented primarily because of our belief that it may be less efficient in operation than the current paper-based system that we utilize. We will continue to work on this concept, however, and we may yet transition to paperless protocoling of CT and MRI cases

utilizing the PACS as the data repository, but outputting protocol data in an automated fashion to the RIS, the RIS being the realm that the technologists are most accustomed to retrieving their information.

Additional Lessons Learned

1. For the radiologists' transition to paperless reading, we believe that it is important to have all the pertinent information presented to the radiologist from the PACS ("in your face"), rather than asking or expecting the radiologist to turn to an additional PC for the needed information.
2. We have considered paper scanners as a way of getting paper-based data into the PACS. For several reasons, we believe that it is preferable to avoid this workaround. Routing and mapping the primary digital information to the information page of PACS is always preferable.
3. Although a high-quality PACS is essential to the paperless transition, it is not in itself sufficient.
4. Our PACS utilizes a broker; we have no experience with a brokerless PACS. It is difficult for us to envision the type of integration we have achieved without a broker. But that may simply be a limitation in our imaginative abilities. It certainly seems possible that creative individuals could achieve most or all of the paperless transition without a broker.
5. It is erroneous to believe that the PACS vendor (or the PACS consultant) will help you achieve the paperless transition. Their focus, understandably, is to get the PACS running and to make it work for the radiologists in a filmless environment. The paperless effort lies more on the RIS side (and with integration) and requires creative cooperation among all factions of the radiology department.
6. As a result, it is incorrect to ask, "Can my PACS accomplish the paperless transition?" It is perhaps more accurate and pertinent to ask, "Can my departmental personnel accomplish this?"
7. Be alert to the possible need to "customize" or modify RIS functionality in order to

optimize PACS functionality. The main change we made to our RIS was the addition of "specialty suffixes," two-letter codes appended to the end of every examination title in the RIS. These specialties were agreed upon by the radiologists, chief technologist, and RIS/PACS personnel as the best means for assuring that the PACS wizards and the automated PACS prefetch functionality were optimized.

8. Since the functionality of the RIS is so important to the paperless transition, it is essential that the RIS be in the control of the radiology department.
9. The PACS vendor and field service engineer need to be willing and able to work cooperatively to "map" appropriate data elements from the RIS, through the broker, into the database, with appropriate data flowing through to the information page of PACS. This takes time, effort, and creativity but is key to success.
10. Speech recognition software is not the only means for improving report turnaround time. We learned, by accident, what the transcriptionists have been telling us for years. It's not the actual transcription of the radiologists' words that eats up their workday. A significant portion of the previous transcription lag resulted from the inefficient dependency on paperwork. Beyond that, a significant part of the transcriptionist's workday in the pre-PACS era was spent finding and fixing errors generated by radiologists, technologists, receptionists, and scheduling personnel. Many of these potential areas for error generation have been eliminated through integration. As noted, we are currently quite satisfied with our transcription operations and are not actively considering implementation of speech recognition software.
11. Finally, we believe that it is important to have consistent input and oversight by the end users of the system, the radiologists, to assure that the best functionality is being gained from the system. One or more

attentive radiologists can act as the "canary in the coal mine," sniffing out small problems before they become large problems and helping to direct the PACS team away from fruitless efforts.

DISCUSSION

The effort involved in going paperless has proved worthwhile at MMC, resulting in faster throughput by technologists, radiologists, and transcriptionists. Because the radiologists have been freed of the distractions of finding and moving paper documents, they are allowed to concentrate more fully on the clinical images and information and thereby may potentially render better interpretations. Likewise, because transcription has been freed from paperwork (and freed from errors introduced by radiologists and others), transcription turnaround time has improved remarkably. While the quality and power of the installed PACS system is a necessary underpinning of the paperless effort, it is not sufficient by itself. Multiple individuals in the radiology department must be willing to work with their RIS and PACS support resources.

CONCLUSION

At Maine Medical Center, we have achieved a substantial degree of freedom from paperwork, with a resulting increase in efficiency for the radiologists, clinicians, transcriptionists, film librarians, and radiologic technologists. We acknowledge that there are some pieces of paper that we have not yet conquered, and there are some papers and forms that remain useful during the workday, but virtually all of these pieces of paper are discarded at the end of each shift. None of this is possible without a knowledgeable and dedicated PACS support team, working closely with the PACS vendor, the RIS support personnel, radiologists, transcription, technologists, and film librarians.