Journal of Digital Imaging

Work Flow Redesign: The Key to Success When Using PACS

Eliot L. Siegel, M.D. and Bruce Reiner, M.D.

OBJECTIVE. Our objective is to emphasize the importance of work flow redesign, rather than filmless operation itself, to achieve cost reduction and improvement in productivity with picture archiving and communication systems (PACS). CONCLUSION. Our 8-year experience with PACS shows that the greatest benefit of the transition to a digital system has been the ability to use it as a tool to reengineer overall work flow, both in the imaging department and throughout the health care enterprise.

INTRODUCTION

FILMLESS operation has been touted as the solution to many of the challenges faced by radiology departments that use conventional film. The use of picture archiving and communication systems (PACS) can reduce many of the inefficiencies that exist in diagnostic imaging departments and free those departments of many of the constraints imposed by film. These limitations include the fact that a radiograph on conventional film can be in only one place at a time, the relatively slow retrieval times for film, and the tendency of films to get lost or stolen. PACS also offer the potential to improve departmental productivity and overall image quality.[1]

The growth rate in sales of PACS has been impressive despite the fact that less than 1% of hospitals in the United States have achieved the milestone of near (>80%) filmless operation. Surveys conducted in 1997 and 1999 by the Technology Marketing Group indicated that the percentage of imaging sites with PACS (defined as multiple modalities with a shared archive) grew from 9% to 14%.[2] However, few studies have been performed that evaluate the cost-effectiveness and operational benefits of these systems.[3,4] Without this information, it is difficult to determine the economic impact of the implementation of PACS, other than what has been learned at the few sites that have collected data both before and after transition to a digital environment.

Lack of documentation of the changes in personnel, supplies, and other parameters is reflected in the variability of the assumptions made in financial spreadsheets used by the vendors to estimate potential costs and savings associated with PACS. All of these models seem to agree that the transition to a film department will result in savings in film costs (actually even this premise has not been universally true for all sites). However, widespread disagreement exists about savings in other areas, particularly with regard to personnel costs. These different views reflect the varied experience from one site to another in personnel requirements, changes in staff productivity, and other factors.

Despite the many theoretic advantages of PACS, many departments that have made the transition to filmless operation have discovered that although they are saving money by reducing costs associated with film as well as providing improved image access for clinicians, they are not achieving overall cost savings or improvements in either radiologist or staff productivity. To a great extent, these findings probably reflect differences not only in the type of PACS purchased but also in the effectiveness

From the Departments of Radiology, VA Maryland Health Care System, and the University of Maryland, School of Medicine, Baltimore, MD and Nanticoke Memorial Hospital, Seaford, DE.

Online publication 30 April 2003
doi: 10.1007/s10278-002-6006-9

with which the PACS is used as a tool to redesign departmental work flow.

In our experience, one of the most common mistakes made by facilities with PACS has been to underestimate the critical importance of the role PACS can play in the redesign of departmental and enterprise-wide work flow. Without proper integration of this tool into the departmental work flow or reinvention of the work flow process in the department, the potential gains associated with the use of a PACS cannot be realized.

For example, some departments have set up their filmless radiology departments to almost exactly emulate their film-based departments, with relatively few changes in departmental work flow. In many of these digital departments, images are still ordered using paper requisitions that require manual reentry of patient and study information into the radiology information system. This information is printed out, and the paperwork is physically carried to the technologists, who manually retype patient identification and study information into their modality acquisition workstations (the CT scanner operator's console, for example). Images and relevant old studies are sent to a specific workstation for interpretation, via a manual or semimanual process that is not too different from hanging films on an electronic alternator. Radiologists are handed the paper imaging requests and are required to manually type in a patient identification number, name, or both, or to use a bar code to read this information from the piece of paper. Old reports are often available only on paper, if at all, and they are dictated onto tape using a conventional tape recorder. Paper reports are printed, sorted, transported, and then filed in the patient's chart. Digital images are manually "pushed" to workstations in clinical areas in anticipation of clinic appointments in a manner similar to the way that films are pulled for these clinics. In departments that operate in this way, some savings are achieved by a reduction in the number of films printed, but these savings are negated by the increased costs of the equipment and, often, by the need for additional personnel.

Improvements in productivity and cost savings can be optimized when an imaging department does a careful work flow analysis and redesigns work flow to take advantage of the PACS. In 1989, the consulting firm Booz-Allen & Hamilton conducted a process analysis at the Baltimore Veterans Affairs Medical Center. The analysis revealed that 59 steps were required in the process of requesting, obtaining, reporting, and transcribing a conventional chest radiograph (Fig. 1). Knowledge gained from this process analysis, implementation of a PACS integrated with the hospital and radiology information systems, and the transition to the use of an electronic medical record can be used to develop a streamlined, much more efficient system (Fig. 2).

The work flow for diagnostic imaging at the Baltimore Veterans Affairs Medical Center has changed dramatically since the 1989 process analysis study. Physicians currently use the electronic medical record to request imaging studies from workstations located throughout the medical center. These orders automatically generate electronic folders in the PACS database and trigger automatic retrieval of old comparison studies (those performed more than 3 months previously) from the longterm archive into a short-term archive (studies done up to 3 months previously) for rapid retrieval by the workstations. A function known as a modality work list makes it possible for these orders in the electronic medical record or hospital information system (HIS) to be pushed or pulled (depending on the imaging modality) automatically to or from the various imaging modalities where they can be accessed by the technologist. The list of studies to be interpreted becomes available to the radiologists at their PACS workstations. Each radiologist can determine the types of studies (according to modality or anatomic area or a combination of these) to be displayed on his or her work list. This capability eliminates the need to type in or barcode patient information from a piece of paper. The study is then dictated into a digital dictation system and is then transcribed directly into the hospital electronic medical record. The department has begun to use voice recognition, which will eliminate additional overall work flow steps but at the cost of additional steps for the radiologists.

The ability to have information as well as images automatically flow among the hospital

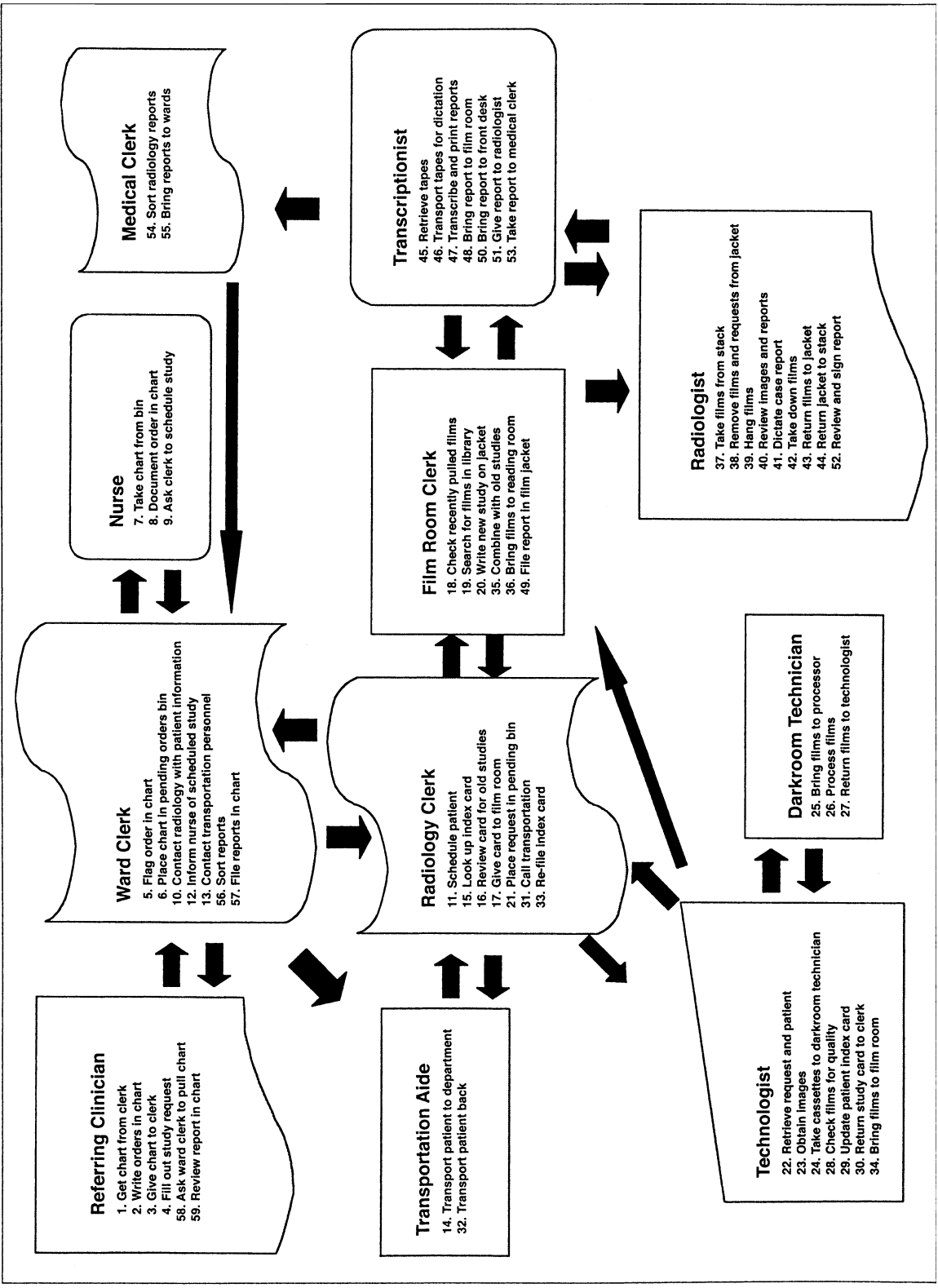

Fig 1. Flow chart for ordering, acquisition, reporting, and review of inpatient chest radiograph using conventional film-based radiography system shows 59 steps involving 11 hospital staff members.

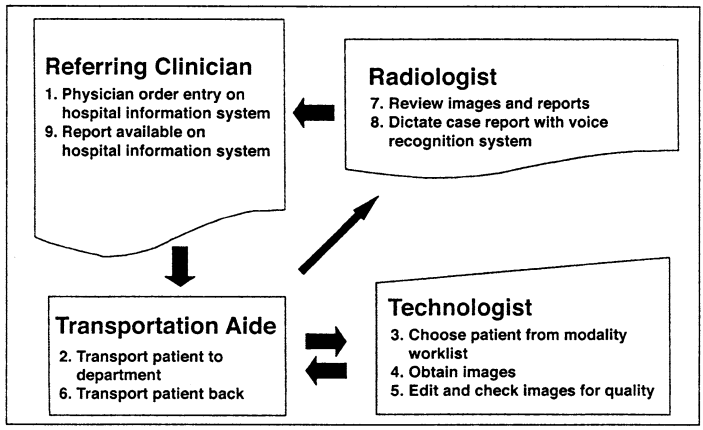

Fig 2. Redesigned flow chart for ordering, acquisition, reporting, and review of inpatient chest radiograph using picture archiving and communication system (PACS) shows 50 fewer steps by seven fewer staff members when compared with conventional film-based radiography system.

and radiology information systems, the PACS, the imaging modalities, and the transcription system has resulted in the elimination of most of the 59 manual steps that were required in the film-based system. It has also resulted in the ability to reengineer the work flow of our clinicians, clerks, radiologists, technologists, and transcriptionists in such a way as to make them substantially more efficient. We have documented that the change in work flow associated with the use of the PACS has resulted in increased efficiencies of our technologists by 20–60%,[5] of our clerical staff by more than 50%, and of our radiologists by more than 40%. Automatic image-display protocols have, for example, increased radiologists' interpreting efficiency by more than 10%. Our clinical colleagues indicate that they save more than 45 min a day, on average, as a result of changes in work flow associated with the transition to a filmless department, although we have not been able to design a study to verify this estimate. Use of the modality work list alone has reduced the error rate in transmitting CT scans to the PACS from 8% to approximately 1.5% at our facility.[6] These increases in departmental and hospital efficiency would not be possible merely with the transition to filmless operation; they require extensive work flow reengineering.

Unfortunately, integration of PACS, imaging modalities, and transcription systems with the electronic medical record or the hospital information system/radiology information system (HIS/RIS) is difficult, because it requires a level of communication between the HIS/RIS and the imaging modalities that is currently not available in most institutions. Two major problems underlie this situation: The first is the absence of information exchange functions such as the modality work list in most radiology and nuclear medicine imaging systems currently available, along with a lack of support for this level of integration by most HIS/RIS vendors. The second is the lack of agreement on the way in which existing standards are used. The standards themselves allow for a great deal of flexibility in the way in which they are implemented. This can result in a "Tower of Babel" communication mismatch among modalities, PACS, and HIS/RIS, despite the use of these standards.

The two most common standards used in this communication of patient and study information are Digital Imaging and Communications in Medicine (DICOM) and Health Level Seven (HL-7). Despite the almost universal support for DICOM in radiology and nuclear medicine modalities, many HIS and even RIS vendors have provided minimal, if any, DICOM capabilities in their systems. Consequently, only a small percentage of radiology and nuclear medicine departments or outpatient centers have been able to take advantage of the work flow savings made possible by the implementation of the DICOM modality work list function. This is also true for other desirable work flow

enhancers such as the performed procedure step that can be used to automatically communicate to an HIS/RIS that a study has been completed.

Fortunately, the Radiological Society of North America and the Health Information Management Systems Society have become partners in sponsoring what they call a "phased series of public demonstrations of increasing connectivity and systems integration," which have brought together imaging vendors with HIS/RIS vendors. This effort, known as the Integrating the Health Care Enterprise (IHE) initiative, has already resulted in the creation of a consensus among image modalities, PACS, and HIS/RIS vendors on the use of both DICOM and HL-7 to communicate information between an imaging modality, hospital, or radiology information system and a PACS. The IHE technical committee is also exploring the use of other standards, such as extensible markup language (XML). These standards will probably be necessary for further progress in the next several years. The IHE initiative may also facilitate the ability to communicate information between two PACS or two HIS/RIS, which would have a major positive impact on the ability to share patient medical records and images between facilities.

During the past few years, the importance of an understanding of work flow for RIS and PACS vendors has resulted in substantial improvements in the development of intelligent software and use of integration with other information systems. This trend will undoubtedly continue. Universal adoption of communication protocols such as the IHE initiative and standards such as DICOM and HL-7 will continue the trend toward the elimination of paper and will result in further reductions in the number of steps in the flow of information to and from the imaging department. Future versions of PACS software will observe work flow patterns by clerical, technical, radiologist, and clinical staff members and will anticipate their requirements in such as way as to continue to decrease the number of steps, time, and frustration associated with routine tasks. For radiologists, this will involve the incorporation of technologies such as voice recognition built into the PACS, the ability to have real-time televideoconferencing with clinicians and other radiologists, and the use of improved radiology reporting systems that will be an outgrowth of current research on structured reporting systems.

The benefits of digital over conventional radiology have been extensively documented and include the elimination of lost and misplaced imaging studies and easier and more reliable access to those studies by radiology and hospital staff. However, based on our 8-year experience with PACS, the greatest benefit of digital radiology, by far, has been the improvement in work flow that is made possible in a digital environment. Now that PACS has gotten past the early adopters phase, both vendors and customers have learned that success will be predicated on the ability of the vendor and the imaging department to work together to take advantage of the tremendous potential that PACS provides to reengineer the work flow process. This new understanding will serve to accelerate the development and acceptance of PACS during the next several years and will undoubtedly allow radiologists to continue to improve the quality and timeliness of care of our patients.

REFERENCES

1. Siegel EL, Diaconis JN, Pomerantz S, Allman RM, Briscoe B: Making filmless radiology work. J Digit Imaging 8:151-155, 1995

2. Goldburgh M: Medical consumers drive market for PACS. Diagnostic Imaging 22[suppl]:11-13, 2000

3. Bryan S, Buxton M, Brenna E: Estimating the impact of a diffuse technology on the running costs of a hospital: a case study of a picture archiving and communication system. Int J Technol Assess Health Care 16:787-798, 2000

4. Tucker DM, Barnes GT, Koehler RE: Picture archiving communication systems in the intensive care unit. Radiology 196:297-304, 1995

5. Reiner BI, Siegel EL, Hooper FJ, Glasser D: Effect of film-based versus filmless operation on the productivity of CT technologists. Radiology 207:481-485, 1998

6. Reiner B, Siegel E, Kuzmak P, Severance S: Transmission failure rate for computed tomography examinations in a filmless imaging department. J Digit Imaging 13:79-82, 2000