How to Satisfy Both Clinical and Information Technology Goals in Designing a Successful Picture Archiving and Communication System

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Designing and operating a PACS system requires an integrated focus to maintain peak performance of the system from an information technology (IT) perspective and to ensure that all clinical and financial requirements are met. An IT-based picture archiving and communication system (PACS) manager is in the best position to satisfy these sometime conflicting audiences. This report will describe how an institution moving towards PACS can unite radiologists, hospital administrators, and information systems (IS)/IT specialists into one cohesive team to ensure the highest levels of success with their future PACS. There are several keys to success: (1) Designing and selecting PACS requires a dedicated team, with representatives from radiology, as well as IS/IT and administration. (2) Each group needs to thoroughly outline their specific needs, so that the final PACS solution is relevant from all perspectives. This needs assessment needs to be made before issuing a request for proposal (RFP) and interviewing vendors. (3) The team needs to be small to be effective. Each group should have one or at most two representatives that collect input from, and report to, a group of his or her peers. (4) Plans need to be made to determine how to integrate current and future hospital information systems (HIS), in order to ensure a smooth pathway to the electronic medical record. (5) All team members should agree on the overall objectives for PACS and participate in its design and installation. (6) Each team member is charged with motivating, and helping to educate, his or her peers. (7) Training should be tailored to the needs of each audience. Explain how each staff member benefits from the PACS. Training should be ongoing to accommodate the addition of new system features and new users. This report will describe the importance of recognizing PACS as being an IT system with a clinical focus. The importance of designing goals of the PACS system from various perspectives, including clinical, technical, and financial, will be addressed. More importantly, this presentation will highlight the benefits a medical institution will receive if the various groups can work together, while at the same time outlining some pitfalls they can expect to encounter if the groups take an adversarial approach.

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EACH FACILITY must establish a set of parameters for a picture archiving and communication system (PACS) to ensure that all clinical and financial performance objectives are met, and that the system performs well from an information technology (IT) perspective.

The Veterans Affairs Ann Arbor Healthcare System in Ann Arbor, MI, recently completed a multiyear implementation of a PACS that integrates all modalities. The PACS is now located in a new \$70 million clinical addition, which was completed in 1998. As a result of PACS, our facility has completely converted to the reading and viewing of digital images.

CLINICAL BENEFITS

From the clinical perspective, our streamlined workflow saves time for both radiologists and referral physicians, while at the same time eliminating lost or missing films. Our radiologists also report that soft-copy reading, and the special features offered by our digital workstations, have dramatically improved the diagnostic process. If a radiologist sees a suspicious area, he or she can immediately review other studies for comparative analysis. Previous studies of the same or multiple modalities are automatically prefetched by the system and supplied with the current study. Any study is also available at any time, from any workstation, on an ad hoc basis.

The diagnostic workstations offer easy-to-use tools that adjust contrast and enlarge selected areas to check subtleties in an image. On-screen measuring tools allow precise recording. Each radiologist can also create individualized hanging protocols that direct the order and location for the placement of each study and image.

FINANCIAL BENEFITS

The primary cost justification for PACS is the reduction in film and related expenses and the increased productivity for staff and clinicians. At our facility, we reduced the cost for film and chemicals from \$110,600 in fiscal year 1997 to \$20,400 in fiscal year 1999. Labor costs have been

trimmed by \$26,300 a year. Because we are a teaching hospital, our percentage of missing films is high—between 15% and 20%. Therefore digital imaging has also eliminated the cost of labor and consumables for retakes and film searches.

Departmental workflow is greatly improved. Imaging studies are now available in just minutes to referring physicians on any floor of the hospital. With the film-based system, it takes an average of 2 to 6 hours for a referring physician to obtain a film study. Productivity has also improved, and we are able to handle growing volumes with the same or slightly reduced full-time employees (FTEs).

IT PERSPECTIVE

From the IT perspective, we have designed a system that supports the highest level of REV-STATUS="revised" performance with minimal administrative overhead. Two newly acquired images from a computed radiology (CR) device are available at a diagnostic workstation in just 4 to 5 seconds. A 50-image computed tomography or magnetic resonance image study is available in less than 25 seconds.

The archive provides short-, intermediate-, and long-term storage, and supplies an object-oriented database where the patient is the object. Records are accessed by patient name, patient ID, or study case number.

The network supports multiple active path and active redundant linking between hubs, as well as other backup processes and fault tolerant procedures to provide continuous service in the event of scheduled system downtime, one or more system failures, or a natural disaster. The PACS is open architecture, uses industry standards (including Digital Imaging and Communications in Medicine [DICOM], Health Level 7 [HL7], and Common Object Request Broker Architecture [CORBA]), and supports expansion both within the radiology department and at remote sites.

Based on our experience at the Veterans Affairs Ann Arbor Healthcare System, we make the following suggestions to other institutions that are currently designing or implementing a PACS.

1. *Establish a small and dedicated PACS team, with representatives from radiology, information systems (IS)/IT, and administration.* Because a PACS must serve the needs of all of these departments, it is important that representatives are carefully selected. Our PACS

team consisted of myself as the PACS systems administrator, the chief of radiology, the radiology administrator, the chief technologist, and a referring clinician. Each representative communicated the requirements of that department to the team, and reported feedback from peers regarding proposed system design and performance. We also invited the chairman of surgery, chairman of internal medicine, and representatives from ambulatory care and other areas to outline their needs and to provide feedback during the design phase, as well as during on-site demonstrations and testing. By working together, we were able to achieve consensus in areas of potential conflict. For example, we were adding modalities at the same time we were designing the PACS, so the PACS team played a crucial role in determining which specific systems were selected. In many cases, the system that offered the most attractive clinical features was not always DICOM-compatible or easily integrated into the PACS environment. Addressing these issues initially facilitated our ability to design a smoothly functioning PACS.

2. *Conduct a needs assessment before interviewing any vendors.* After a thorough needs assessment, we developed a list of requirements that drove the selection and implementation of PACS. We began by examining workflow charts for the film-based system and drawing up charts that represented proposed digital workflow. We reviewed current service levels, and the possibility for improvements with inpatient, emergency room, intensive care unit, and outpatient clinics.

We estimated growth levels for the next 5 years for each modality and factored the hospital's plans for expansion of its outpatient facilities into this plan. We established the length of time we would store studies online and used our workload estimates to determine the size of our archive. Based on this planning, our system currently features a 17-terabyte long-term DLT archive, a 140-GByte intermediate redundant array of inexpensive disks (RAID), and a 600-GByte fiber-channel RAID that provides on-line access.

We also elected to implement storage area network (SAN) technology with fiber chan-

nel. The SAN/fiber-channel combination forms a dedicated server-to-storage communications link that operates on the backend of a server, independent of the local area network. In our on-site benchmark testing, the SAN/fiber-channel solution achieved a 600% average improvement in retrieval speeds over fast Ethernet. The other major benefit of SAN/fiber-channel technology is its capability to provide universal access to all imaging modalities from all workstations. Increased access is due in part to the increased server-to-client ratio in a SAN/fiber-channel switch environment. SANs have the ability to support 30 workstations on a single server, whereas fast Ethernet can only support up to eight workstations per server.

3. *Incorporate specific requirements outlined by the PACS team in the RFP.* Based on input from the PACS team, a 25-page RFP was prepared that included technical and performance requirements for the following: diagnostic and referral workstations; the PACS interface with imaging modalities and with the HIS; archive storage and database functions and technology; the network; and fault tolerance and quality control. A standard image set was defined for four image types so that performance specifications and objectives could be evaluated.
4. *The PACS team must consider and plan to integrate PACS with current and future HIS.* Our PACS incorporates a bidirectional interface between its workstations and the HIS and radiology information system (RIS). The RIS link equips us to supply radiology reports with imaging studies, while the HIS link allows us to import patient demographics to CR studies to eliminate the potential for data entry errors. The HIS link also ensures a smooth pathway to the electronic medical record.
5. *All PACS team members should agree to participate in the implementation of PACS by*

helping to facilitate the process changes caused by digital imaging. In any major system conversion, human factors must be considered. Each member of the PACS team assumed responsibility for communicating personal enthusiasm for the new system with his or her peers. We took the time to describe how each staff member would benefit from the PACS. We explained to physicians and nurses in CR and the intensive care unit, for example, that the new PACS would provide faster access to images and eliminate lost or missing films. We emphasized to all audiences that the primary purpose of our PACS is to achieve improved convenience for medical staff and improved care for patients.

6. *We implemented an ongoing training system so that all users would feel comfortable with the system and be able to use it to its greatest capacity.* The vendor conducted periodic training sessions, usually in conjunction with hardware or software upgrades. We adopted a "train the trainer" approach in which a small group attends the vendor training sessions and then trains other users. We have a group of computer-savvy physicians, for example, that answers questions from their peers on an informal basis. I answer any questions that arise from users, as a whole. Since we are a teaching hospital affiliated with the University of Michigan, I conduct refresher training for incoming staff.

CONCLUSION

We have designed and installed a PACS that incorporates all modalities into a completely digital imaging environment. Our PACS offers streamlined workflow, enhanced productivity, and better patient care. We believe that our up-front commitment to serving clinical, financial, and IT requirements, through our multidisciplinary PACS team, played a critical role in the successful implementation of PACS at our facility.