SESSION I

Large-Scale PACS Implementation

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The transition to filmless radiology is a much more formidable task than making the request for proposal to purchase a (Picture Archiving and Communications System) PACS. The Department of Defense and the Veterans Administration have been pioneers in the transformation of medical diagnostic imaging to the electronic environment. Many civilian sites are expected to implement large-scale PACS in the next five to ten years. This presentation will relate the empirical insights gleaned at our institution from a large-scale PACS implementation. Our PACS integration was introduced into a fully operational department (not a new hospital) in which work flow had to continue with minimal impact. Impediments to user acceptance will be addressed. The critical components of this enormous task will be discussed. The topics covered during this session will include issues such as phased implementation, DICOM (digital imaging and communications in medicine) standard-based interaction of devices, hospital information system (HIS)/radiology information system (RIS) interface, user approval, networking, workstation deployment and backup procedures. The presentation will make specific suggestions regarding the implementation team, operating instructions, quality control (QC), training and education. The concept of identifying key functional areas is relevant to transitioning the facility to be entirely on line. Special attention must be paid to specific functional areas such as the operating rooms and trauma rooms where the clinical requirements may not match the PACS capabilities. The printing of films may be necessary for certain circumstances. The integration of teleradiology and remote clinics into a PACS is a salient topic with respect to the overall role of the radiologists providing rapid consultation. A Web-based server allows a clinician to review images and reports on a desk-top (personal) computer and thus reduce the number of dedicated PACS review workstations. This session will focus on effective strategies for a seamless transition. Critical issues involve maintaining a good working relationship with the vendor, cultivating personnel readiness and instituting well-defined support systems. Success depends on the ability to integrate the institutional directives, user expectations and available technologies. A team approach is mandatory for success.

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THE GOAL OF THIS PRESENTATION is to provide a framework for a seamless transition from a traditional radiology department and file-room to a PACS for a large institution without

substantially diminishing services during this period. This opinion is derived from experience implementing one of the largest PACS in the world. Analogous to a HIS and a RIS, a PACS is a hospital system and should be viewed as such by the hospital administration, medical information systems (MIS) personnel, referring health care providers (HCP), nurses, technologists and radiologists.

The methodology for transition to a PACS will be considered in a strategic and tactical framework. The strategic plan is the broad blueprint for overall success. The tactical plan addresses the immediate objectives. The focus of this presentation is the tactical plan for implementation. However, the implementation plan derives its success from a sound strategic plan.

The strategic plan includes evaluating the present clinical scenarios while attempting to anticipate future growth or changes in the institution. Therefore, some flexibility is required by the vendor and the customer during implementation. At our institution, the strategic plan and clinical scenarios were developed well before to actual purchase and implementation. In the interim, the clinical scenarios changed due to the migration of healthcare to outpatient services and the downsizing of the military. Also, during this period dramatic technical advances occurred including: the DICOM standard, dry laser printers, changes in computer architecture, the development of the internet and web-based servers.

A PACS team approach should be employed. The overall team should consist of 12-15 people.

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0897-1889/98/1103-1003\$8.00/0*

This is separated into two sub-teams: the program team and the consulting team. The program team would consist of approximately 6 people coordinating the PACS. The consulting team would set the program objectives and have a representative from each of the departments or functional areas to approve of decisions that affect their respective clinical areas. A member of the administrative staff should be included on the consulting team to address financial concerns.

The on site program team composition is as follows: radiologist, physicist, technologists (1-3 from different modalities), system administrator (SA), and project manager. These will reflect and complement the vendor-provided team. The team leader is usually a radiologist or physicist. This person delegates responsibility as appropriate, follows important issues and tracks overall progress. The team leader also acts as a single point of contact for consistent interaction with the vendor and other users. One of the technologists should be groomed as a computed radiography expert. The system administrator may be part of MIS but needs to develop an intimate knowledge of the PACS database and the associated HIS/RIS gateway. This person would also schedule the user training. The project manager is the "details" person and keeps on top of schedules (eg, construction), delivery orders, modifications to the contract and interacts with the appropriate institutional agencies such as facilities management, logistics, biomedical engineering, equipment maintenance, administration, and so on. In our case an intermediary from the Joint Imaging Technology Project Office (JITPO) was also available to facilitate the process, especially with respect to contractual issues.

The vendor provides a program team which typically consists of a project manager, field engineers, SA, network specialists and any necessary subcontractors. The institution should provide a suitably large enough staging area within the facility for workstation construction as well as a permanent storage space for extra parts and equipment. Sufficient office space should be allocated for the vendor team since they will be on-site quite a while. If field engineers and a SA are retained for support and maintenance then the office space can serve as the PACS center of operations.

Installation Plan: The installation plan should be

finalized and completed by the PACS vendor. The program team works with the PACS vendor to complete a formal installation plan. This binding document formalizes and clearly defines the roles and responsibilities (terms and conditions) for the participants over the next several years. It will be used as a guideline for interactions between the institution and the vendor.

Our concept of a phased implementation included the following steps: promotion; education, conversion; connectivity; acceptance testing (AT); and hardcopy reduction. This proposed scheme was meant to progress along a continuum with anticipated overlap of the phases. Construction and equipment deployment should progress concurrently. Each functional area was converted based on the strategic plan. Our major functional areas consisted of outpatient radiology, inpatient radiology, intensive care units (medical, surgical, pediatric and neonatal), operating rooms (OR), emergency department (ED), inpatient wards, subspecialty clinics with heavy imaging focus (urology, orthopedics, cardiology, obstetrics-gynecology), other subspecialty clinics and the primary care clinic. The purpose of defining functional areas is to segment user requirements based on the clinical scenario encountered. Equipment was selected so that the PACS functionality matched the specific demand.

PROMOTION

This consisted of a marketing campaign to garner support and broadcast realistic expectations. The enthusiasm for and anticipation of a PACS should be a sentiment shared by the referring departments as well as the imaging departments. Proponents should be recruited from within each of the major functional areas to serve on the consulting team to represent the specific concerns of that area. An emphasis on realistic expectations was important. People tend to support a project that they helped to create. This promotes a sentiment of common shared goals rather than radiology imposing its will on others. Serious consideration should be given to incorporating other image generating sections (eg, cardiology, gastroenterology, urology, obstetrics-gynecology) into the PACS to legitimize the concept that it is an entire hospital system.

EDUCATION

All hospital personnel that will interact with the PACS system at some level will require training. Planning to train such a large hospital population (especially since many will be health care providers) can be difficult to coordinate. The timing of training should be based on the schedule for phasing the functional areas into a film-less environment. Also effective, is scheduling training at pre-determined times when sections, divisions or departments routinely meet. Providing training during morning report, grand rounds or at scheduled routine in-servicing times greatly facilitates capturing as many users as possible. Training should be tailored depending on the user segment, thus only pertinent functions are covered. A training room is essential and should include representation (whether actual or simulation) of all the user interfaces employed. Training modalities include didactic sessions (live or videotape), interactive hands on sessions with a trainer; computer assisted instruction (CAI). The vendor must sign up to both phased training and additional follow-up training.

Operating Instructions (OI) represent formal, comprehensive, day-to-day guides for performing all duties related to the PACS. These need to be specific to the electronic environment because the business practice of the imaging department will be different than before, should be encyclopedic, and standardize all procedures from image acquisition to final display. Routine policies and backup procedures should be included. All radiology personnel need a firm understanding of these OIs and they should be readily available and well indexed so that they may be easily referenced.

CONVERSION

Converting to digital acquisition devices with hardcopy output may antedate PACS by a substantial amount of time if necessary. Some institutions implement CR, digital fluoroscopy and mini-PACS years in advance of the main PACS. Because CR usually replaces an existing film screen operation, alternate workflow patterns during construction will have to be carefully planned.

Mini-PACs are solutions for modalities that have special functions or requirements not supported by a general purpose PACS. Ultrasound and nuclear medicine lend themselves to this scenario because these modalities generate data that may require

color display and/or time versus intensity (or flow) curves. These modalities are also more tolerant to going filmless without a wide dissemination availability of the images because HCPs typically rely on the report rather than primary viewing. Mini-PACS may precede, parallel or follow the main PACS implementation. Communication between the systems is via DICOM gateways.

CONNECTIVITY

Images need to be available in a reliable, timely and useful fashion. Attention must be paid to the technologist interfaces with the system, the use and location of the acquisition workstation (AW) or a quality control (QC) workstation. AWs need to be co-located with all modalities so that the technologist can verify that patient data has made it into the PACS and that the appropriate study is matched with that patient. In order to achieve the greatest workflow enhancement for radiologists, a study must be QCed, information integrity verified, and a robust HIS/RIS gateway operating to replace the paper trail. Worklists are created such that images find the user. Likewise, for clinicians, viewing of patients either grouped by location (eg, coronary care unit) or by referring service (eg, rheumatology clinic) is tremendously useful.

ACCEPTANCE TESTING

Once the system is installed and ready for clinical use, the PACS will require testing to validate the functionality of the system. When you begin working with the vendors, one must ensure that the system will not be accepted or paid until it passes the acceptance testing (which should consist of functionality testing and component-level testing). The institution should have an acceptance testing protocol planned prior to signing a contract to install a PACS. This protocol should be agreeable to both the hospital and PACS vendor. The intent should be to test the functionality of system at the extremes including the network, user interface, and worklist management prior to full implementation. The system needs to be tested in all aspects, from image acquisition to report generation, in order to certify its robustness.

HARDCOPY REDUCTION

The program team should plan for a period of time when images are available as hardcopy and

softcopy (approximately 3-6 months). The phasing out of hardcopies should be scheduled at a point when the films are superfluous. The advantages of soft copy display and the ease of accessibility to the images usually become readily apparent and can hasten the transition for certain functional areas (eg, ICU, ED). As an operator's comfort level with the system increases, a trend will be generated from the bottom up, that is from the user to the provider. A concurrent draw down of file room services also facilitates this process. The issue of prior comparisons is addressed by having the fileroom digitize the prior exam and transfer the study into the PACS which is available for soft copy review with the original report. For some modalities such as CT and MR, the image data from the modality archive can be pulled back into the short term memory of the acquisition device and then pushed through the DICOM gateway to populate a historical folder created in the RIS portion of the PACS.

The ideal goal of having an entirely filmless imaging department is not realized at present for several practical reasons. At our institution, we do not have digital acquisition for mammography nor long cassettes (eg, for scoliosis films). In other settings, the capabilities of the PACS in its present form is not beneficial. Evaluation of the OR clinical scenario deserves special merit. Pre-operative images are predominantly used in the OR as a road map. The utility of a 1 or 2 screen workstation with an interface primarily designed for diagnostic purposes is dubious in this setting. Therefore, as part of the pre-operative planning, the surgeon requests selected images to be printed for the case. There is an advantage of soft copy display for intra-operative portable examinations which can be manipulated to show the area of interest without repeating the examination. Not all of our surgical suites are designed to fit a workstation and keep the monitors within view.

WEB SERVER

Web-based viewers provide compressed images and the radiologist's interpretation report. The quality of these images is not considered suitable for primary diagnostic interpretation but rather for review by the referring HCP. The main utility is to expand access to the images. Ideally, a provider need only have a single terminal to access patient related data (ie, HIS, RIS, PACS) which may be considered the precursor to the electronic medical record. The software demands that a pentium-level

(or better) computer be used. At present, there is only access to exams performed in the last 2-4 weeks which are on the short term storage with no fetching capability from the archive. The Web server hangs off of the main PACS and is a redundant database of the short term storage. The server is accessed by way of the institution's local area network (LAN). It is presently implemented as an intranet within the hospital. Provisions are being made to access the web server as an extranet. Patient demographics must be scrambled in order to comply with federal regulations. Both the PACS and the web server are password protected.

MAINTENANCE AND FAULT TOLERANCE

A plan for quality control, preventive maintenance, and unscheduled maintenance is paramount. Quality control is typically performed by the users or a hospital representative periodically. Preventive maintenance is performed by the vendor on a scheduled basis. Unscheduled maintenance is the procedure to be followed in the event of a system or a component failure. The term *Fail Over* refers to the mode of operation when the network portion of the PACS is down. At some point, all mechanical and electronic devices will fail (especially if maintenance schedules are not adhered to). Computer software introduces another potential point of failure.

During Fail Over a specified course of action should be outlined as part of the OI. One option is the local review of images at the AW. However, this is less than ideal for any prolonged time period. Our solution is to have a completely redundant printer network so that any modality can output to a hardcopy during Fail Over. The plan during Fail Over is to start printing newly acquired examinations and save the images on a magneto-optical (MO) disk. Dry laser printers are preferred because they avoid chemicals and are suitable for intermittent use. However, these devices should have multiple connections available and serve as network printers during uptime and as local printers during Fail Over. A core minimum of devices need to be directly connected to maintain operation when the network is down (e.g. several CRs, CT, MR, US). The availability of a completely redundant printer network is probably the single most important factor for increasing fault tolerance.

Fail Over training is paramount and should be comprehensive. A Fail Over plan should be in place

with all pertinent personnel briefed on their specific roles. Since this is not a routine event, these procedures should be written down and incorporated into the OI. In addition, step-by-step Fail-Over procedures can be posted on the acquisition devices. The plan needs to include recovery of images from the temporary storage (MO) into the PACS when the network connection resumes.

CONCLUSION

We have described a planned methodology for transforming a large medical treatment facility from a film-based operation to an electronic environment. The emphasis has been on techniques to maintain workflow while the PACS is being implemented. A smooth transition can be accomplished if the concepts described are successfully employed.