PICTURE ARCHIVING AND COMMUNICATION SYSTEM: THE IMPACT OF FILMLESS AND DISTANCE RADIOLOGY

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The progressive spread of Picture Archiving and Communication System (PACS) in medical imaging constitutes some of the major changes in the radiology and hospital environment during the past decade. The major benefit of PACS resides in its ability to communicate images and reports to referring physicians in a timely and reliable fashion. Filmless radiology offers the opportunity to redesign departmental and enterprise-wide workflow with increase in efficiencies of technologists, clerical staff and radiologists. PACS may improve patient care by providing real-time radiology and by enabling teleradiology. These technologies and the changing environment in radiology may force the radiologists to become more directly involved in the triage and management decisions for the patient. Occasional consultations, regularly scheduled consultation services, and multidisciplinary clinical discussions including a radiologist may help directing physicians to the best sequence of examinations to resolve a clinical problem.

Key-words: Picture archiving and communication system (PACS) - Economics, medical.

Information technology is becoming a vital component of all healthcare enterprises, from managed care services to large hospital networks, and provides the basis of electronic patient records and hospital-wide information. The rationale behind such systems is deceptively simple: physicians want to sit at a single workstation and call up all information, both clinical data and medical images, concerning a given patient. PACS, a computerised means of replacing the roles of conventional radiological film, is responsible for solving the problem of acquiring, transmitting, and displaying radiologic images. The major benefit of PACS resides in its ability to communicate images and reports to referring physicians in a timely and reliable fashion. Furthermore, the teleradiology component of PACS allows remote coverage of multiple sites by the same radiologists and allows remote consultations and expert opinion (1).

Today, a growing number of institutions have adopted and implemented PACS. PACS data integration with the radiology and hospital information systems (RIS and HIS, respectively) provides medical care more efficiently. Data integration of PACS with the RIS and HIS facilitates more informed and presumably more accurate interpretations, decreases waiting time for radiology reports, which has the potential to determine the length of stay, increases clinicians’ efficiency and accuracy in patient care, patient satisfaction and decreases medical-legal risks (2, 3). PACS may play a beneficial role in situations in which the radiology department is one of the greatest bottlenecks to the effective diagnosis and management of patients, especially emergencies. All institutions that have undertaken the deployment of PACS clearly recognize that the traditional paradigms and procedures for delivering of imaging services, from the acquisition of the image to the delivery of the final image product to the customer, evolve after implementing PACS. A proper integration with redesign of departmental and enterprise-wide workflow will be necessary to realise the potential gains associated with the use of PACS (4).

Furthermore, the change in economics and medical practice with managed care and capitated costs have introduced a higher degree of complexity and a shift of emphasis to the benefits of PACS. Whereas PACS was envisioned as a productivity tool for the radiology department, it is now being pursued as a means for faster and more efficient communication of data to the medical community outside the department to provide more efficient and cost-effective service and care delivery (1).

Impact on workflow

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 with which PACS is used as a tool to redesign departmental workflow (4).

PACS implementation offers the opportunity to redesign departmental and enterprise-wide workflow. Without proper integration of this tool into the departmental workflow or re-intervention of the flow process in the department, the potential gains associated with the use of PACS cannot be realized (4).

Developing filmless radiology departments with relatively few changes in departmental work flow will have some saving 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 (4). Therefore, it is important to perform a careful workflow analysis and to redesign workflow to optimise productivity and cost savings and to take advantage of PACS. Implementation of PACS integrated with the HIS and RIS and transition to the use of an electronic medical record has proven its value to develop a streamlined efficient system. This integration has been shown to

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eliminate most of the manual steps required in a film-based system and resulted in extensive work flow reengineering of clinicians, clerks, radiologists, technologists and transcriptionists to make them substantially more efficient (4). The work flow changes associated with the use of PACS has been reported to increase efficiencies of technologists by 20-60%, clerical staff by more than 40% and radiologists by more than 40% (4, 5). Automatic image-display protocols have, for example, increased radiologists’ interpreting efficiency by more than 10%. Despite more preparation work, the easy access to images and the voice-recognition software that often accompanies PACS result in less time needed to generate reports. However, the literature concerning turnaround time and load - and not productivity – the number of examinations that may be completed in a fixed-length workday. Furthermore, most research reports on a single modality, not a full department, and “publication bias” - that is the tendency to report successes and not failures - is probably strong.

Integration of PACS with the HIS and RIS facilitates more informed and presumably more accurate interpretations (6). When interpreting radiological examinations, access to previous reports without HIS/RIS integration requires logging in to the HIS on a separate computer and navigating through the menu structure to view the report. This process may be avoided by radiologists during the film interpretation portion of the study because it is relatively time-consuming and disrupts work flow. In an integrated PACS environment, when using either automated display or work list display, previous reports may be available for every image on display by clicking a single icon. Unfortunately, integration of PACS, imaging modalities, and transcription systems with the electronic medical record or the 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 (4). The two most common standards used in this communication of patient and study information are Digital Imaging and Communication in Medicine (DICOM) and Health Level Seven (HL-7) (7, 8). Despite the almost universal support for DICOM in radiology, many HIS and even RIS vendors have provided minimal, if any, DICOM capabilities in their systems (4). Consequently, only a minority of radiology departments or outpatient centers have been able to take advantage of the workflow savings made possible by the implementation of the DICOM modality work list function. This is also true for other desirable workflow enhancers such as the performed procedure step that may be used to automatically communicate to an HIS/RIS that a study has been completed. However, initiatives, known as the Integrating the Health Care Enterprise (IHE) initiative, has 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, HIS/RIS, and PACS. 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, further improving the development of intelligent software and the use of integration with other information systems, with respect to work flow patterns by clerical, technical, radiologist, and clinical staff members, will result in further decreasing the number of steps and time to perform routine tasks. Finally, IHE initiative offers a future opportunity to communicate information between two PACS or two HIS/RIS, which would have a major positive impact on the ability to share medical records and images between facilities (4).

Changes in the world of radiology

Radiology is “going digital” and will increasingly be the key triage event in a patient’s encounter with health care. More and more, computed tomography (CT) and magnetic resonance imaging (MRI) are being used for screening such as in the evaluation for coronary artery calcification, colon and lung cancer. Two- and three-dimensional reformatting techniques have long been considered by most of us as a luxury or, at most, as a good marketing tool towards clinicians, especially surgeons. HIS or RIS and PACS cannot be expected to take advantage of the workflow associated with PACS because it cannot be lost, stolen, or misfiled. Thus, images are always available within a few seconds throughout all areas of the hospital, obviating travel to the radiology department as was often required for image review in a film-based system. This enhanced image and report accessibility may result in significant clinician time savings. A comprehensive patient record database, where PACS data are integrated with the RIS and HIS may potentially link several health care centres into a “virtual” radiology department, or even a “virtual” hospital. As a consequence, images may become available simultaneously in many places. In this network of databases, Web technology is becoming the tool of choice for efficient database query and data retrieval (10).

Real time radiology

PACS will have a tremendous impact on the radiological profession as a whole. As soon as an examination is acquired onto PACS, immediate reporting, and thus real-time radiology, may become possible (11). Real-time radiology is possible by improving the efficiency of the radiology office to allow for the immediate release of an image has been acquired onto PACS it cannot be lost, stolen, or misfiled. Thus, images are always available after PACS has been installed, so no
patient appointment is cancelled, no clinical decision deferred, no images are repeated because they are missing, and no time is wasted by doctors or other healthcare workers looking for missing films. All images are available day and night for viewing anywhere in the hospital (and outside the hospital if there is a teleradiology facility). All images may be accessed rapidly anywhere within the PACS institution, and no film transport is necessary. Worklists of unread images may be prioritised according to their urgency, for example, emergency examinations on sick patients may be reported before outpatient clinic images on relatively well patients. This will prevent errors in clinical management due to misinterpretation of images not yet reviewed by the radiologist. Ideally, images and the report should be directly linked to form one single document (11). Radiologists may choose to work out-of-hours shift work (e.g. choosing to report in the early morning, in the late evening or on weekends). This is possible since no ancillary staff is necessary to sort, file and transport the images. Physicians in separate hospitals may function as a single virtual hospital unit, with a shared database allowing auto-routing of examinations between the various institutions, according to the workload, so that the reporting worklists are evenly distributed, thus optimising the use of radiologists’ time. In this condition, physicians never know where the study is read, as long as the information goes back to them in a timely fashion. Real-time radiology requires sufficient radiologists employed in the PACS institution to allow continuous reporting, including night and weekend cover. However, imaging departments that once had downtime overnight may become to work around the clock. Radiologists may become driven to higher levels of productivity by administrators armed with reams of data. This is not necessarily a good thing because it may result in ‘killing’ radiologists when increasing their productivity. PACS cannot compensate for under-staffing.

Teleradiology

Teleradiology or ‘radiology at a distance’ may improve radiologists’ competence by the provision of a routine diagnostic service and by the opportunity to carry out specialist referrals (11). The provision of a diagnostic teleradiology service is usually aimed at providing a rapid reporting service at a remote location, thereby saving the expense and inconvenience of either sending a radiologist to the distant location, or of physically sending the films between the two institutions. Providing diagnostic teleradiology service of sufficient high quality may be costly with the implementation of computed radiography or digital radiography. However, with the cost of data transmission decreasing as fast as the cost of computing power, practical opportunities for global teleradiology are rapidly opening. Teleradiology has distinct advantages. It may provide subspecialty expertise in the form of second readings as well as 24-hour radiology presence through networks at an affordable cost (12). This makes it possible to allow referring doctors to demand that a specialist radiologist should report on, for example, an abdominal MRI, and will force radiologists to move more rapidly into providing subspecialist radiological opinions for all clinical specialists. The district general hospital without an experienced abdominal radiologist will be able to send all abdominal radiology images to another center for expert opinion, but may have to buy such a service (13). Changes in workflow in large hospitals may require broader radiologic coverage for “off-hours” and night periods (1). Traditional coverage by “on-call” residents on-site is often insufficient, and direct access to more senior radiologists and sub-specialists is constantly required. “Home teleradiology” systems may allow convenient access to specialists who may supervise and interpret radiologic studies from home. Teleradiology also provides a more cost-effective solution than having to rely on specialists on-call to come physically from home to the hospital when called upon for a given procedure. However, with teleradiology, there is loss of direct patient contact, and thus, no possibility of seeing the patient to ask for more history details or to perform a physical examination (12). Another drawback is the inability for face-to-face contact with referring physicians. These encounters generally provide invaluable information about patients. Telephone contact is possible, but often between the two institutions, and rather less informative and often time-consuming. Exchanges of information with referring physicians in the reading room are also valuable for teaching.

Challenges for the radiologists

The general availability of radiological images almost instantaneous throughout the hospital opens up new perspectives and potential changes in the way radiology services are being provided. The introduction of a pure PACS teleradiology system has been reported to result in a decline in face-to-face interaction between radiologists and their physician colleagues (14). A well-defined, comprehensive analysis at the Baltimore Veterans Affairs Medical Centre has shown an 82% reduction (from 13% to 2.4%) in the general radiography consultation rate, between 9 a.m. and 5 p.m. on weekdays, in face-to-face interaction between radiologists and their physician colleagues during the study period when compared with a similar interval before the introduction of PACS. This decrease in the consultation rate was considerably less in the body imaging section, where the consultation rate dropped from 32% to 18% (decrease of 44%) (14). Furthermore, the availability of digitised images in the emergency care unit has been shown to reduce consultation with the radiologist (15).

The explanation for this decrease in clinical consultations is multifactorial (17). Part of the decline may have been the result of structural rearrangement of the flow of information. The convenience of obtaining a radiology consultation while already in the radiology department to retrieve or return films likely plays a major role in the number of consultations. For example, in many emergency department radiology suites the reading area is near the film processing area. Therefore, the referring physician is apt to consult with the radiologist, sometimes only because of the incident opportunity afforded by propinquity, even for cases in which the diagnosis is clear. The transfer of the locus of image viewing to a monitor in the emergency department instead of a panel of view-boxes near the radiologist should tend to reduce face-to-face encounters, although the imaging physician and trauma surgeon remain next door to each other (16). The lesser reduction in the consultation rate for cross-sectional imaging may be related to the lower level of clinician confidence in their ability to read these imaging techniques, or may be related to the more complex case histories and findings in patients undergoing cross-sectional
imaging compared to general radiography. Clinicians are more likely to consult with radiologists before or after they order a study in a patient with more complex imaging needs.

Another factor is the report turnaround time, which has been shown to reduce substantially with PACS introduction. The resulting time saving implies that reports were available for clinical review more rapidly. Some people have demanded that with PACS, no image should leave the radiological department without a final report. Especially in areas like intensive care, such a general rule is neither practical nor wise and defeats the purpose of an image network. One just has to imagine a chest radiograph showing a high-tension pneumothorax being held back in the radiology department because the radiologist-on-call is currently unavailable. However, it remains the responsibility of the radiologist to assure that the referring physician be made aware of important findings as soon as possible. Thus, immediate “wet” reading of intensive care and emergency cases will become even more important with PACS to prevent errors in clinical management due to misinterpretation of radiographic images not yet properly reviewed (17, 18). Ideally, image and radiological report should be directly linked forming one single multimedia report (1, 19).

Furthermore, radiologists may communicate findings electronically by annotating images using PACS. A nodule can be circled, a pneumothorax delineated, and a fracture pointed out using drawing tools available at the workstation.

Teleradiology and the tendency of decrease in the total number of direct consultations in radiology may have significant implications for the practice of radiology in a filmless environment. The lack of direct consultation may have the undesired effect of depersonalizing the practice of radiology, putting the radiologist in the basement. With PACS, images are readily available and it is often fairly easy for a knowledgeable clinician specialist to read his or her clinical diagnosis into the images and very often the diagnosis will be correct. It is, therefore, easy to foresee that clinician specialists may come to believe that radiologists do not consult sufficiently in the care of patients to justify their presence (8). Out of sight, radiologists might be considered as disembodied functionaries, more akin to servicing technicians than professional colleagues. To prove their clinical value, radiologists in specialized situations should be organ system oriented and knowledgeable in all the aspects of physiology, pathology, and up-to-date therapies applicable to the respective organ system, as well as being experts in the multiple imaging modalities applicable to the clinical problem addressed. A multi-centre study assessed the contributions of a second reading by radiology sub-specialists of cross-sectional images in patients with cancer of the abdomen; the results indicated a substantial number of findings affecting therapy decisions not detected by the primary readers (20). In large clinics, these organ system oriented radiologists may become sitters, for hours glued to a diagnostic viewing station reporting films transmitted from remote clinics and hospitals in great volume with a variable amount of attached clinical information and little opportunity for clinical discussion. This may not be an attractive career style. Nevertheless, it may be preferable to have a superb radiological opinion of an abdominal study by such remote method rather than the opinion of the on-site neuroradiologist or the general radiologist, doing their half-day a week reporting the stack of abdominal CT cases (13).

Currently, the primary care physician often manages the patient through the complex diagnostic workup as well as decides when and with whom to consult for the care of the patient. With the expanding role that imaging plays in the diagnostic workup and therapeutic pathway for patients, the radiologist could become much more directly involved in managing the patient through the health care system and, in the process, replace a fundamental role of the primary care physician (8). Regular conferences and occasional consultations must be seen as part of the regular routine and are regarded as highly valuable for decision-making and clinical patient management. However, radiologists have always performed consultations on an everyday basis, but unlike other specialists, this has been done informally, without codifying participation with a prescribed (fee schedule). Several reports have documented that the institution with a regularly scheduled consultation service has engendered close collaborations with referring physicians (21, 22). In light of radiologists’ special knowledge of the appropriateness of the various imaging examinations, some have proposed that they should serve as the gatekeepers for many clinical presentations. Radiologists should direct physicians to the best sequence of examinations to resolve a clinical problem (8, 23). However, the radiologist will need to be trained and prepared to manage the decision process for the patient.

Multidisciplinary clinical discussions should always include a radiologist. Yet these sessions tend to occur too infrequently to affect immediate clinical decision-making. For daily consultations, radiologists need to locate themselves close to or within medical, surgical, orthopaedic, and neurology wards. They should also station themselves centrally in an outpatient facility and must occupy a place as close to the emergency department as possible (16). However, through electronic teleconferencing it is now possible to perform these conferences remotely, thereby saving the valuable time of referring physicians from coming to the radiology department to review their patient studies with the attending radiologist. Remote consultations and interactive video conferencing capabilities clearly will change the way radiologists’ work is being organized. In the new generation of diagnostic workstations used in radiology, such capabilities are being imbedded in the same system used to read the radiologic studies. This allows the radiologist to provide remote expertise and consultations on the same workstation being used for routine diagnostic tasks (1).

Conclusion

PACS provides a tool that may result in substantial savings in efficiency, and this tool, if used properly, may improve communications between radiologists and their clinician colleagues. Finally, to improve patient care, radiologists should become, in a PACS environment, more directly involved in the triage and management decisions for the patient.

References


