Clinical Input Into Designing a PACS

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The purpose of this study was to evaluate clinical attitudes and expectations in the implementation of a neuroradiology picture archiving and communication system (PACS). A 1-page survey of expectations and clinical attitudes toward a neuroradiology mini-PACS was distributed to 49 full-time faculty members in the departments of neurosurgery, neurology, and otorhinolaryngology at an academic center. Interest in viewing soft-copy images was moderate to very high for over 89% of clinicians. All clinicians were comfortable with phone consultations with radiologists while viewing soft-copy images. Clinicians preferred retrieving images from personal computers over workstations and film libraries by 72.9%, 27.1%, and 0%, respectively. However, 38.5% of surgeons felt the need for hard copy in the operating room. Clinicians estimated that in 18.3% of cases, patients took their in-house films to outside institutions for consultations. Clinicians were enthusiastic about implementing PACS. Although acceptance of soft-copy viewing among clinicians is high, some provision for supplying hard-copy images appears to be necessary.

KEY WORDS: picture archiving and communication system, teleradiology, economics, medical.

MANY RADIOLOGY departments have embraced the concept of a picture archiving and communication system (PACS). However, information in the literature regarding referring physicians' attitudes toward a PACS is sparse.[1,2] When contemplating how to address problems in clinical service within a radiology department, it is important to survey these clients to assess in advance the level of acceptance and support from the physicians who will be referring cases to the facility. In any radiology department, there are numerous "customers," but in the end it is the referring physician who determines which imaging studies will be ordered.

Therefore, our referring physicians were surveyed to provide background information with respect to the potential purchase of a mini-PACS for neuroradiology. Our department has embraced a strategy of rolling out a PACS in a division-by-division fashion; the individual design of a division's mini-PACS could be tailored to fit that division's referral base.

MATERIALS AND METHODS

A 1-page survey was distributed at staff meetings of the departments of neurosurgery, neurology, and otorhinolaryngology at the Johns Hopkins Hospital between November 1998 and January 1999. An accompanying 2-page letter explained the concepts of a PACS, hard-copy versus soft-copy film reading, and Web-based versus workstation-based systems. The letter also noted the differences between workstations and personal computers and invited the clinicians to participate in the PACS creation. The departments selected to be surveyed were the 3 most frequent users of neuroradiology services. All faculty members present at these staff meetings completed the survey. Surveys were faxed to faculty members who were absent from the staff meetings. Follow-up telephone calls were made to the clinicians in January and February 1999 to ask 2 additional questions prompted by the responses from the written survey (Table 1).

The clinicians had experience with a soft-copy radiology workstation that was used to evaluate outpatient studies from 1995 to 1998. In addition, the neurosurgeons had investigated purchasing their own PACS program for importing neuroradiological studies the previous year. The neurosurgeons (through MR-guided craniotomies, pallidotomies, thalamotomies, and skull base surgery), otorhinolaryngologists (through CT-guided endoscopic sinus surgery and skull-base surgery), and neurologists (through MR-guided seizure focus ablation) were familiar with interactive image-based surgeries and computer manipulations of imaging data on workstations in their clinical practice. For the previous 5 years, the hospital's intranet electronic patient record has provided access to all office notes, inpatient and discharge summaries, operating reports, laboratory results, and radiology reports. The chairman of neurosurgery attended the RSNA the previous year and discussed PACS with his colleagues at a staff meeting.

Eleven neurosurgeons (100% compliance), 23 neurologists (85% compliance), and 15 otorhinolaryngologists (100% compliance) completed the survey.

The verbal and written survey included the questions listed in Table 1. The survey questions were developed by a physician member of the Information Technology Steering Committee of the radiology department.

RESULTS

When asked to identify 3 problems they hoped the PACS would address, the majority of clinicians identified the following: (1) delayed access to studies performed on their patients (100%), (2) lost films (75%), and (3) inadequate comparison to previous studies (62.5%) (Tables 2 and 3). The most common envisioned benefits of PACS that were cited, above and beyond ameliorating these

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Table 1. Questions From the PACS Survey

1. What is your level of interest in access to neuroradiology films on a workstation? (Circle One)
   1 = Very interested 2 = Moderately interested
   3 = Neutral 4 = Not interested
2. What locations in your department would be optimal sites for workstations to view neuroradiology cases? How many workstations would you need?
3. What is your level of interest in being able to retrieve neuroradiology cases from the worldwide web (ie, personal computer)? (Circle One)
   1 = Very interested 2 = Moderately interested
   3 = Neutral 4 = Not interested
4. Given the choice of retrieving films from (1) your personal computer, (2) workstation, or (3) a film library, which would you prefer?
5. If cases were left on a worldwide web server for 2 weeks after completion for immediate access, what percentage of the studies you ordered would you expect to look at via this server as opposed to retrieving films? _____ %
6. How would you feel about discussing a case on the telephone while looking at a workstation or personal computer rather than reviewing films in the radiology department?
   1 = Very interested 2 = Moderately interested
   3 = Neutral 4 = Not interested
7. If only selected images of a study were filmed for the patient's record, but the entire study could be retrieved electronically, how would this affect your patient's care?
8. How often do your patients take their films to outside consultations (outside of the Johns Hopkins Medical System)? _____ % of time.
9. Would you be comfortable operating on a patient with images on a workstation in the OR as opposed to having films on a viewbox (circle one if applicable) Yes No

Supplemental questions:
1. Name up to 3 problems you hope a PACS system will address.
2. Please list 3 benefits of a neuroradiology PACS.

problems, were (1) improving patient care through greater efficiency (100%), (2) allowing image analysis to be done by the referring physician (50%), and (3) reviewing images from remote locations (38.5%).

A high percentage of faculty members were moderately to very interested in being able to access neuroradiology images from a workstation (97.9%) or through the worldwide web on a personal computer (PC) (89.6%). Despite this apparent preference indicated for workstation viewing, most faculty members preferred retrieving images from PCs (72.9%) over workstations (27.1%) or film libraries (0%). This lack of enthusiasm for the film library did not necessarily reflect a desire to shun all hard copy viewing, because a number of physicians (8 of 42 responding) wanted films available even if the cases were assessable via soft copy. More than 69% of those who responded felt that not printing the entire study would have no impact on patient care, 11.9% thought it would improve patient care, and 19% believed it would worsen patient care.

Clinicians were either very interested (74.5%) or moderately interested (25.5%) in telephone consultations using PACS as opposed to reviewing films in the radiology department.

We sought to determine how often hard-copy studies would be needed even in a filmless department. Therefore, we asked about the frequency with which patients take their films to outside consultants. The mean score for this question was 18.3% of the time. Twenty-five of 35 physicians who answered this question (71.4%) stated that less than 20% of their patients take their studies to outside hospitals. In 3 of 35 cases (8.6%), physicians responded that their patients take films for outside consultations 60% to 80% of the time.

We also asked about the need for hard copy as opposed to soft copy in operating rooms. Seven of 11 neurosurgeons, 6 of 11 otorhinolaryngologists, and 3 of 4 neurologists (who are involved in surgical procedures) stated that they would feel comfortable operating with images displayed on a monitor and no hard copy, but 38.5% of operating physicians still preferred having film in the OR.

In the commentary portion of the survey, many physicians stated concerns about the time for retrieval of the studies across the worldwide web if they were to view images from their home computers outside the hospital intranet. Others were concerned that keeping images on a server for a short time would obviate the ability to compare previous studies to current ones in a timely fashion (defined as less than 10 to 15 minutes for a full MRI/MRA study). By the same token, many respondents worried about the transition period when previous hard-copy film scans were compared to soft-copy scans in a side-by-side fashion by radiologists and how that would be done by clinicians who chose to eschew the film library. The availability of postprocessed images (magnified views, cine loops, 3D volume-rendered studies, and segmented MR and

Table 2. Responses to Questions by Service [NUS (n = 11), ENT (n = 15), Neurology (n = 23), Total (n = 49)]

Question	Very	Moderate	Neutral	Not	DNA	All
Interest in viewing on workstation						
NUS	11	0	0	0	0	11
ENT	13	2	0	0	0	15
Neur	17	4	1	0	1	23
All	41	6	1	0	1	49
Interest in viewing on Internet from PC						
NUS	10	1	0	0	0	11
ENT	8	3	4	0	0	15
Neur	17	4	0	1	1	23
All	35	8	4	1	1	49
Interest in phone consultation rather than in radiology department						
NUS	10	1	0	0	0	11
ENT	10	4	0	0	1	15
Neur	15	7	0	0	1	23
All	35	12	0	0	2	49
	PC	WS	FL	DNA	All	
Favored viewing modality						
NUS	10	1	0	0	11	
ENT	9*	6*	0	1	16	
Neur	16	6	0	1	23	
All	35*	13*	0	2	50	
	Improve	No Change	Worsen	DNA	All	
Effect on patient care						
NUS	2	7	1	1	11	
ENT	3	7	3	2	15	
Neur	0	15	4	4	23	
All	5	29	8	7	49	
	Yes	No	Wait/See	DNA	All	
Comfortable with no films in OR?						
NUS	7	4	0	0	11	
ENT	6	5	2	2	15	
Neur†	3	1	0	0	4	
All	16	10	2	2	30	

Abbreviations: DNA, did not answer; PC, personal computer; OR, operating room; WS, workstation; FL, film library; NUS, neurosurgeons; ENT, otorhinolaryngologists; Neur, neurologists.

*One person had equal preference for WS and PC.

†Not all neurologists perform functions in the OR.

CT angiograms on workstations and PCs) also was desired by clinicians.

Numerical values (1 = very interested, 2 = moderately interested, 3 = neutral, 4 = not interested) were assigned to the responses provided by clinicians in order to statistically assess the replies provided. Based on this methodology no significant difference was noted in the level of interest in using workstations or PCs to view images. A one sample t test showed that (a) there was a preference for

Table 3. Summary of Responses (n = 46)

Question	Very	Moderate	Neutral	Not
Interest in viewing on workstation	85.4%	12.5%	2.1%	0%
Interest in viewing on Internet from PC	72.9%	16.7%	8.3%	2.1%
Interest in phone consultation rather than in radiology department	74.5%	25.5%	0%	0%
Favored viewing modality	PC: 72.9%	Workstation: 27.1%	0%	
Effect on patient care	Improve: 11.9%	No change: 69%	Worsen: 19%	
Comfortable with no films in OR?	Yes: 61.5%	No: 38.5%		

viewing images on a PC over a workstation ($P = .05$) and film ($P < .001$) and (b) that overall clinicians did not believe that filming selected images would affect patient care ($P < .05$).

DISCUSSION

When evaluating the implementation of a PACS for a radiology department, one must consider the "customers." Too often, a PACS is designed to address the needs of the radiologists in the department without considering the implications for the referring clinicians and/or the patients. The purpose of this survey was to examine the attitudes of the referral base to a neuroradiology PACS, to identify problems the clinicians would like addressed by a PACS, and to determine the likelihood they would embrace the implementation of a PACS.

Whereas members of a radiology department are largely focused on issues of service, staffing, film costs, film storage, access to current examinations (stolen films), cost of the PACS, and space limitations, these are not primary concerns of our referring physicians. The major issues that referring clinicians would like addressed by a PACS are those pertaining to the radiology film library, including retrieval of current and past studies and the time they expend traveling to the radiology department to view images. Many of our clinicians commented that a significant portion of their day is spent "on x-ray rounds" as they roam from one site to another in the radiology department, viewing the images of their patients in the various divisions of the department and discussing the cases with a radiologist. They believe that a PACS will reduce the time spent retrieving films and traveling through the radiology area, thereby increasing their efficiency in seeing and treating their patients.

Reiner et al recently surveyed physicians' preferences with respect to a PACS.[3] The authors found that access to images and length of time required to view images were the major concerns. Improvements in these factors were the major perceived benefits when a PACS was implemented. When an ultrasound PACS was implemented at Cattinara Hospital in Italy with workstations placed on the wards, the clinicians noted the advantages of a decreased rate of repeat and unnecessary studies, decreased hospitalization times, and faster availability of ultrasound reports.[4]

The benefit of greater availability of comparison studies with PACS has been demonstrated to increase significantly ($P < .01$) the rate at which radiologists compare old studies to current ones,[5] although this has little impact on report turnaround time. The time taken to display new studies with relevant comparisons is shorter using a PACS. In one intensive care unit setting, 75% of studies were able to be displayed with comparisons within 20 minutes of completion of the examination on a PACS, compared with 90 minutes using a film-based system.[6]

Overall, our referring physicians favored an intranet image retrieval system over installing multiple workstations throughout the hospital areas. However, a dominant concern of the clinicians is the time required for downloading the images both at the office and at home. The speed of hospital intranet retrieval is on the order of seconds to a few minutes for most studies, but the clinicians also wish to view studies in private offices off the hospital campus and at their homes. This means that the Internet and wavelet or lossy compression and/or selecting only relevant images for display remotely would have to be used. Some clinicians (19%) were concerned about a policy of not having whole studies available.

It remains difficult to predict in advance, based on this survey, how often patient studies in neuroradiology would need to be printed in order to accommodate patients who wish to take their images to an outside consultation. As another indicator of latent filming rate in a filmless environment, we found that 38.5% of the surgeons would like hard copy images in the operating room, at least until they are confident that workstation images in the OR are of similar image quality and easy to use.

Methodist Hospital in Houston and Loyola Hospital in Chicago have integrated PACS systems but continue to provide hard copies of studies for their operating rooms. At Loyola, the issues of space and cost allocation for monitors and workstations have been addressed partially by implementing flat screen displays in 2 operating rooms. In a neuroradiology division in which surgical cases are a mainstay, this is a factor to be considered. Again, one would need to know the number of operations performed per physician and their individual preferences to estimate the rate of film usage for the operating room.

The fear of some clinicians that image quality may be compromised seems to be unfounded because the full DICOM data is usually transferred

to the in-house operating room. Pomerantz et al have shown that, after 10 months of PACS use at their hospital, physicians rated quality of images as similar or superior to film for all modalities except MRI, which was graded as having "lower resolution than film" (postulated as due to an inability to optimally adjust window and level controls).[2] The authors noted that most surgeons request film when MRI images are used in the OR because of the multiple sequences that must be manipulated and scrolled with this modality. However, lost hard-copy images were enough of a problem that PACS soft-copy images were preferred because they were always available. Finally, of the 12 surgeons surveyed, 1 preferred film, 1 had no preference, and 10 preferred the PACS. Pomerantz underscores the importance of sampling surgeons' preferences, stating that "Interviews with an area's doctors and staff would be of value *prior* to implementation of a PACS."[2]

The issues concerning how long to leave cases on a rapid retrieval system and how to handle requests for soft- or hard-copy images after that period can be addressed by expanding RAID capacity. For a patient arriving unannounced with a request for his or her film jacket, the options currently employed throughout the country include (1) having a technologist retrieve and film the study (VA Hospital of Baltimore), (2) continuing to film a single set of images of all studies for just such an occasion (Presbyterian Hospital in Pittsburgh, University of Pennsylvania Medical Center in Philadelphia, Loyola Hospital in Chicago, Methodist Hospital in Houston, Mayo Clinic in Jacksonville), (3) having film librarians retrieve and print whole studies and/or selected images for certain physicians (University of Maryland, Baltimore). Providing the patient their studies on paper copies or on computer-based media (eg, CD-ROM) may be options to explore.

What biases might be introduced by surveying the faculty members of a major academic center? That university-based physicians are more savvy with computers than non–university-based clinicians is highly debatable. However, the hospital-based nature of the physicians surveyed lends itself more readily to the deployment of workstations joined by an intranet for fast viewing. An office-based setting probably would be more conducive to transfer of images via the web with its security issues, and physicians in private offices may be less demanding of hard copy film because retrieving films would be more cumbersome. One might expect that in the community, the referrers are more comfortable with phone consultations without actually viewing images themselves. There may even be a more favorable disposition toward PACS with respect to patient care (question 7, Table 1).

With respect to the types of clinicians surveyed, there was a preponderance of physicians who are used to handling images as part of their practice. Thus, images are manipulated in the operating room. Our neurosurgeons often utilize 3D data sets for surgical planning and intraoperative localization on research workstations. The neurologists compute volumes on patients with seizures, schizophrenia, and Alzheimer's disease routinely. Otorhinolaryngologists use an imaging wand during functional endoscopic sinus surgery. The comfort level of these physicians may differ from that of a more traditional office-based medical practice.

Nonetheless, the survey has provided this neuroradiology division with needed information concerning the problems the clinicians feel should be addressed with a PACS, the perceived benefits of the system to clinicians, and the likelihood that they would accept implementation of a PACS in the radiology department. Pursuing a web-based intranet-Internet PACS solution as opposed to one that is provided solely on strategically placed workstations seems prudent. If the division is to go totally filmless, it must provide alternative media for printing images because a significant number of patients and surgeons are likely to require hard-copy images for their own needs.

Limitations of this study include that it is based on a nonvalidated questionnaire. The respondents were not fully familiar with the capabilities of a modern PACS, and the surveyors have PACS experience only in ultrasonography. There is the possibility of information bias because queries may have been framed in a manner encouraging favorable responses. Some questions were open-ended and could be interpreted incorrectly. The survey was distributed before a PACS was configured. A follow-up survey after installation and start-up is planned.

Addressing the concerns of all consumers/customers of a PACS, including radiologists, patients, administrators, and nonphysician researchers is useful in providing an overall picture for the

development of an ideal PACS. As was stated in a review article by Carrino et al, success depends on the ability to integrate institutional directives, user expectations, and available technologies. A team approach is mandatory for success.[7]

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