A Revolution In Radiology: PACS* 101 (Part 2)

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**Picture Archiving and Communication System*

In Part 1 of this series, we reviewed the demise of film-based imaging, and the development of Picture Archiving and Communication Systems, or PACS, a revolution which has occurred over the past decade, and which continues to evolve and to change the way we care for patients. In Part 2, we will look at some of the newer features and add-ons to the basic PACS system, and also mention the darker side of PACS, for some things have been lost in the move to computer-based imaging.

SPECIALTY PACS

Every modality in the imaging armamentarium has its own unique requirements for optimal display and interpretation. Most PACS systems handle the common modalities very well, whether CT, MRI, or plain films of the bones and chest. A few specialty areas, however, put extra demands on the PACS, specific to that modality, and additional software (at additional cost!) is required to do the job properly. This software may be purchased either from the PACS vendor or from a third party with special expertise in that modality.

MAMMOGRAPHY

Nowhere is this issue more evident than in digital mammography because the images must have very high resolution in order to display the microcalcifications that are often the only marker of a developing cancer. Each image file is therefore large, and must be displayed on extremely high-resolution monitors. In addition, women typically have mammograms every year or two, and it is vital to be able to compare multiple old exams with the newest. A change over 12 months may be too subtle to detect, but may become very apparent when the images from 5, 4, 3, 2, and 1 years ago are all displayed side-by-side, allowing perception of small alterations in architecture or density in a region of the breast. All this must be done extremely quickly, as mammography is the radiologist's perfect storm: high volume (our practice sees 150-200/day), high liability (missed breast cancer is in the top 3 reasons why radiologists get sued), and low reimbursement per case. The imaging physician must be able to move very quickly through a large number of cases, the vast majority of which do not harbor a cancer, but be able to stop and hone in on a case with suspicious findings without wasting time. Computer-aided detection (CAD), which can help focus the radiologist's attention on important abnormalities must also be integrated into the PACS, to increase cancer detection without increasing false positives. Finally, in addition to the usual radiology report, every patient must receive a letter with the results of their mammogram and recommendations for follow-up. Systems that do all of these tasks are now becoming available and allow mammographers to do a better and more efficient job.

NUCLEAR MEDICINE

Unlike virtually every other part of diagnostic imaging, nuclear medicine looks at physiology rather than anatomy. This difference is most apparent in oncologic imaging, where PET/CT scanning allows the fusion of anatomic information from a CT scanner with the physiologic information derived from a PET scan. PET scanning uses an injected analogue of glucose to look for areas of increased metabolism that are the hallmark of cancer. Again, the data files generated by a PET/CT machine are enormous, with more than 1000 images per study. These images may need additional post-processing by the radiologist, and must be reviewed with prior studies, often multiple prior studies, to determine if a cancer has spread, or is being effectively treated by chemotherapy or radiation. Critical prognostic and therapeutic information can be derived from these exams, and some specialty vendors provide very powerful tools to work with these images within PACS.

3-D IMAGING

The development of multislice CT, especially scanners that generate 16 slices per revolution or more, has allowed the creation of images with essentially the

same resolution in any plane, not just the transverse plane in which the scanner originally acquired the images. These scans can thus be reconstructed in any orientation; sagittal, coronal, oblique, or even curved, to emphasize important anatomical relationships, and to allow simplified views of complex anatomy. This in turn can permit quantification of vessel stenosis, calculation of tumor volumes (not just diameter), and a variety of other tasks. Implanted devices like aortic endografts can be fitted accurately to the patient's anatomy prior to surgery, cerebral aneurysms can be mapped for surgical or endovascular treatment, and orthopedic hardware can be sized for a specific patient. While the basic tools for these tasks are imbedded in most current PACS systems, the advanced visualization techniques described above are the province of a number of third-party vendors, whose products rely on integrating with the PACS system to provide all of these tools and more. The new technique of virtual colonoscopy is an example of how data stored in PACS can be processed with appropriate software to create a "fly through" of the colon, simulating what the endoscopist sees without the scope.

QUALITY IMPROVEMENT

There are numerous agencies, including the Joint Commission and state licensing boards, that have created policies and procedures designed to improve the quality of the work we do and avoid medical errors. The advent of PACS has allowed the development of tools that are added to or included in PACS to help with a number of these tasks.

PEER REVIEW

As in every other specialty, radiologists are required to undergo review of their work by others in the field, to assure accurate and timely interpretation. Until very recently, this required a process that was very labor and paper intensive, and permitted sampling only a small amount of work. Now, since every radiologist in any institution sits at a workstation that is linked to the same imaging archive, it is easy to automate the review process in PACS. The system can be programmed to select a certain number or percentage of cases done in the department each day, sort them by modality, and randomly assign them to other radiologists in the practice with specialty expertise in that area. These cases can be reviewed and scored for accuracy as part of the regular workflow. All of these data can be collected, tabulated, anonymized if needed, and used for recredentialling and additional training.

PEER-TO-PEER COMMUNICATION

Radiologists frequently seek the opinions of their colleagues as they review challenging or unusual cases. In the film era, this required "shopping" the films around the department for other input. Even with PACS, a phone call was required to locate a helpful colleague, who then needed to enter the patient's name or medical record number in their own workstation to begin viewing the images and providing their assessment. New software allows radiologists to "instant message" (IM) a coworker directly from their workstation, without regard to where either of them is sitting in the network, and insert an automatic link to the case within the message. The consulting radiologist can click on the message and immediately begin reviewing the study and forming an opinion. The consultant can take over the dictation, call to further discuss the case, or IM their partner back with their thoughts. Obviously, these systems could also aid in discussions among imaging physicians and their clinical counterparts, an application which is currently under development.

CRITICAL RESULTS

The Joint Commission requires a process for handling critical results; findings on radiographic studies that must be relayed to the treating provider for immediate action. Each institution can specify its own list, but conditions such as intracranial hemorrhage, tension pneumothorax, or active bleeding are among those on which everyone agrees. Again, this process can be very laborious and fraught with error. Typically the interpreting radiologist or department staff tries to get the ordering provider on the phone to initiate the communication, but this is often not as simple as it might seem. Sometimes the name of the ordering physician is incorrect, and if correct, a phone call to their office takes one through an automated telephone tree that puts the caller on hold behind patients trying to refill their prescriptions. New systems allow the reading radiologist to activate an automated process that attempts to track down the appropriate person, get them to the phone, relay the critical information, which can be read back and verified for accuracy, and document this whole transaction in the medical record. These systems can make sure that every loop is closed, so that vital information arrives in time to help the patient and no one "falls through the cracks." Such programs increasingly rely on the use of smartphones and other mobile computing devices to keep

the radiologist and the treating physician in contact. Such approaches are still in their infancy, but their use is rapidly expanding.

THE DOWNSIDE OF PACS

None of us would willingly go back to hauling around heavy jackets stuffed with films, dealing with lost X-rays on the day of surgery, and similar issues that were the norm in the pre-digital era. However, there are some difficulties with our brave new world of imaging.

Protecting patients' privacy when all of their personal health information is sitting on the computer in their doctor's office, vulnerable to hackers and curious office staff, has created an entire industry for computer security, and the news tells us that such security can be and has been breeched with distressing frequency. While films can be misplaced and become unavailable, computers, monitors, and entire networks can fail, requiring very robust strategies for backup and redundancy in case of such breakdowns. Teams of information technology experts must be on call 24/7 to support the work. One of my colleagues has half-joked that fifty years from now, someone will walk into a radiology department and announce, "Look, here's this cool new portable way to store images," and hold up a sheet of X-ray film.

The digital era has also done much to isolate the radiologist from the clinical team caring for the patient. Many of us are old enough to remember "X-ray Rounds" in the hospital, when teams of physicians traipsed down to the dungeons of the radiology department and went over the findings on their patients with the attending radiologist. Many a family physician would stop in the department after rounds to go over a particularly perplexing case and get advice on what to do next. While such communication can certainly still occur, it rarely does. Even though the interested parties can discuss the findings over the phone while both look at the images on their own computer screens, providers have become much more likely to just view the images themselves in their office (and soon at home or on their tablet computer), perhaps read the report, and move on. The opportunity to consult, to discuss alternate or additional imaging strategies, to establish a professional relationship, even a friendship, has been lost.

Concurrent with this has been a trend toward commoditization of imaging. Since the image is just a bunch of bits and bytes, it can be transmitted at lightening speed to the lowest bidder. This individual may be halfway around the world and may interpret the study without any access to prior images or relevant clinical data, yet will generate a report for the record. Much of the value added by the radiologist is lost in this scenario, but with the explosion of imaging and the desire to lower costs, we have only begun to see the ramifications of this approach to medical imaging. As in so many other facets of life, technology has the potential to vastly improve what we do, but it must be used with discretion, lest it become the master rather than the servant.

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