Teleradiology: Technology and Practice

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Teleradiology increases the ability of radiologists to provide service to remote and underserved locations as well as coverage at times when direct reading of images is not possible. Good practices for teleradiology are described in the American College of Radiology (ACR) teleradiology standard. Teleradiology equipment is converging with picture archiving and communications systems (PACS) equipment so that diagnostic interpretation from remote locations is possible. Image capture can be directly from digital modalities or by film scanner. Transmission speed is still an issue. High transmission speeds were difficult to achieve but recent improvements may increase speeds and decrease costs.

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THE GREEK PREFIX *tele* means distance or at a distance. Consequently, teleradiography in the broadest sense encompasses all of radiology practiced over a significant distance. For purposes of our presentation, two basic forms of teleradiography will be recognized: (1) hospital to hospital or to clinic site, and (2) hospital or clinic to call coverage site (home, boat, car, hammock, . . .).

How can teleradiography contribute to your practice? For many years radiologists have been utilizing teleradiography to more conveniently cover demands for service while they are away from the hospital. With the advent of picture archiving and communications systems (PACS) and completely digital radiology departments, teleradiography displays have become full featured and can nearly match those utilized in the hospital. Consequently, state-of-the-art teleradiography systems do more than just assist the radiologist in providing diagnoses from a comfortable home setting. First, a teleradiography display connected to a PACS archive has the ability to allow the radiologist on call to look at the current study, as well as previous studies and appropriate comparison studies. This important feature is always available. Second, modern teleradiography systems allow a radiology practice to extend full diagnostic quality coverage

24 hours a day and for most groups this allows for comparable levels of back up or subspecialty consultations as are available during normal hours; yet, the burden on other group members is minimal. Third, teleradiography systems using internet or browser applications can facilitate the practice of your radiology group's referring physicians. Rapid delivery of images and reports to them improves their level of service. This is an obvious marketing advantage and can be expected to increase your radiology practice, or at least hold competitors at bay. Most importantly, it has a positive impact on the quality of care extended to patients in the off-hours and on weekends.

Hospital to hospital teleradiography provides at least five significant benefits. First, these systems facilitate taking radiology services out to where the patients are, which, in our modern competitive medical environment, aids the radiology practice and equally important assists the patient in obtaining quality care. Second, as a correlative to number one above, teleradiography improves the timeliness of care delivered both by moving it into the community where the patients are, and by providing diagnoses faster than the standard film systems will. Third, teleradiography allows subspecialty consultations and requests for double reads to occur during the usual short time interval when patients' studies are actually interpreted. No waiting, no compromises and no hedging. Fourth, teleradiography improves the efficiency of radiology groups who are trying to staff multiple practice sites. Less of the radiologist's time is wasted in transit, and there are no delays as staff look for studies which have not been delivered or have been lost in transit between sites. Finally, the modern teleradiography system interfaced into a PACS archive facilitates construction of a database common to all of the multiple sites covered by a radiology group. Hence, all previous studies and comparison scans are always available for correlative interpretation. This in turn speeds up the diagnosis and insures that study interpretations are delivered in a timely manner, thereby decreasing reimbursement denials.

Good practices for teleradiology are described in the American College of Radiology (ACR) teleradiology standard. While this standard applies primarily to teleradiology, it has implications for PACS

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since the ACR standard would apply anytime images are transmitted from one location to another. The standard defines teleradiology as the electronic transmission of radiological images from one location to another for purposes of interpretation and/or consultation. The ACR standard requires minimum levels of equipment performance and a quality control program. The standard is divided into eight parts and includes references and a useful glossary. The ACR standard includes certain equipment specifications, which for purposes of the standard, are divided into small matrix and large matrix. Small matrix are 512×512 images from computed tomography, magnetic resonance, ultrasound, nuclear medicine, and digital fluoroscopy. Large matrix images are computed radiography and digitized film. The standard requires minimum values for bit depth and resolution, as well as display matrix, and also addresses the brightness of the monitor. In discussing the display capabilities, the standard describes a minimum set of controls that should be available at the display station. These include window level, magnification, inverting, flipping and rotating, and linear measurements. The standard mandates weekly quality control procedures and a quality improvement program to assess the accuracy and appropriateness of studies and a review of problems encountered and a review of the quality of transmitted data.

The equipment for teleradiology from hospital or clinic to call coverage site (home) can be divided into source capture, transmission, and display devices. While archiving can be, and frequently is, an issue, this form of teleradiology in and of itself does not imply that the images are archived in a digital fashion. Archiving and image (database) management is covered in depth in other presentations. Image capture from the inherent digital modalities is easiest if they have Digital Imaging

and Communications in Medicine (DICOM) transmission as part of the device itself. If DICOM output is not available, frame capture from a medical gateway is necessary. Projection radiographs enter the system either via computed radiography or by film scanners. Film scanning can be done by a variety of techniques and it is important to assure that the images are captured with appropriate fidelity.

Transmission of images for intramural teleradiology is accomplished over conventional networks (Ethernet, asynchronous transfer mode [ATM], etc), via copper or fiber optic cables. Occasionally direct microwave links or satellite transmission is used. Extramural transmission of images utilize telecommunications providers via plain old telephone service (POTS), integrated services digital network (ISDN), or T-1 lines. Broad band cable systems affording bi-directional 1.5 mb/s bandwidth are just now being introduced as cost-effective competitors.

Teleradiology displays must have sufficient brightness, contrast and resolution to support accurate rendering of the images. The brightness of the display interacts very strongly with the ambient lighting conditions and display brightness and ambient light levels should be checked at installation and periodically thereafter. Conventional computer monitors can be used if good control of ambient light is available, but high brightness, gray scale monitors are often more appropriate for diagnostic teleradiology. Routine quality assurance on the system should be obtained by transmitting test images. It is important to realize that all parts of the system, digitizers, transmission links and displays must be tested. The ACR standard requires weekly testing of the system, but simple tests that are done at power up are highly recommended.