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Real-Time Radiologist Review of Remote Ultrasound Using Low-Cost Video and Voice

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RATIONALE AND OBJECTIVES. **A radiologist practicing remote ultrasound occasionally needs to review a case in real time before releasing the patient. The authors conducted a pilot study to evaluate one solution in which the radiologist views real-time images on a video monitor while conversing with the technologist via a headset telephone.**

METHODS. **Two experienced ultrasonographers and five technologists participated in a 5-week pilot study in adjacent rooms.**

RESULTS. **Subjective assessment indicated that the system could function well enough for use at a remote site.**

CONCLUSIONS. **Although this technology appears effective, an ongoing training environment is recommended.**

KEY WORDS. **Remote ultrasound; remote radiology; teleradiology.**

DIRECT HANDS-ON MANIPULATION of the ultrasound transducer by the radiologist—what we refer to as "direct review"—before releasing the patient, is time-consuming for the radiologist, technologist, and patient. In the past, occasional hands-on radiologist review was logistically straightforward, because the ultrasound reading room was proximate to the examination room. However, radiologists, like other physicians, are now asked to spread their expertise across buildings, complexes, campuses, and towns. Ultrasound radiologists need a low-cost technical solution that allows real-time direct review of remote cases.

As a case in point, we are opening an ambulatory care clinic (ACC) 1.5 kilometers from our main hospital. Most of the ultrasound work at the remote site includes a case mix ranging from pelvic and obstetric ultrasound to gynecologic oncology imaging. The case volume justifies stationing technologists and ultrasound machines at this remote location; however, because of cost containment and the shortage of radiologists specializing in ultrasound interpretation, often only one ultrasound radiologist is available to cover both sites. This radiologist will be stationed at the main hospital most of the time, but will be at the ACC several afternoons per week (during the obstetric clinics). The round trip between sites can take more than 30 minutes, so several trips per day could completely disrupt ultrasound operations.

An ultrasound picture archive and communication system (PACS) can be used to carry still ultrasound images from the remote site to the radiologist.[1–5] However digital systems can be expensive and acquisition may take quite some time.[6] Further, while real-time video signals—which are very advantageous for review because they allow non-predefined visualizations to be requested in real time—can be digitized and transmitted using digital computer networks, this digitization and transmission can be accomplished only at considerable expense. The need for real-time viewing and interaction also precludes transmitting delayed video loops.

We believe that for many institutions, a more cost-effective alternative that provides direct hands-on radiologist review can be implemented using conventional television and telephone technology. Real-time analog ultrasound images, which are actually conventional television signals (using the National Television Standards Committee [NTSC] protocol in the United States), can be carried on baseband and broadband coaxial cable, fiber optics, air-

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waves broadcast via television transmitters, and narrowcast via satellite or microwave receivers. Scrambling can be used to insure confidentiality.

The cost of such a real-time video system will vary considerably depending on the existing cable plant. If the ultrasound sites are physically adjacent or if transmission facilities already exist between the sites, then a low-cost ultrasound video system can be developed. However, if a cable plant must be installed to connect distant buildings, the costs of the ultrasound television system may be prohibitive.

Video technology has been used to manage various remote modalities.[7–9] However, real-time video images are insufficient without voice feedback, for the radiologists need to be able to direct the technologist to image the anatomy in a non-predefined manner. By providing a headset telephone to the technologist in the examination room and a conventional phone for the radiologist (possibly with a speaker-phone option if fellows or residents are present), the radiologist, in real time, can verbally direct the technologist to image various anatomy. The headset insures that the radiologist and the technologist can consult each other without the patient overhearing the radiologist's comments. The headset also allows the technologist to converse with both hands available for imaging.

Materials and Methods

We conducted a 5-week pilot study in the ultrasound clinic to determine whether the radiologists and technologists would be willing to use this real-time video/voice technology instead of direct hands-on review.

An examination room and the ultrasound reading room were modified for the study. These rooms are separated by approximately 10 meters. A headset connected by a cord to a telephone was installed in the examination room to allow the technologist hands-free conversation with the radiologist in the reading room. The phone in the reading room already had a speaker-phone option. The conventional television (NTSC) output connection on the Acuson ultrasound machine (Acuson, Mountain View, CA) was attached by a coaxial cable to a 10″ monitor in the reading room (Fig. 1) positioned next to the film viewbox.[10–12] The examination room and reading room were in closeproximity, so with any case the radiologist could reject the video/voice system and go back to direct hands-on review. This allowed the technology to be evaluated in a "clinically safe" manner.

Two experienced ultrasound radiologists and five experienced technologists participated in the study. (An additional three radiologists each read less than five cases because of scheduling. Because of the limited data, their results are not included.) The majority of cases were pelvic and obstetric endovaginal examinations, but renal and abdomen procedures also were performed. These cases were chosen because of their relative difficulty and the need for direct review.

If a case required review, the radiologist could either view the monitor connected to the ultrasound machine while conversing with the technologist over the phone, or could walk to the examination room and conduct the examination. A number of interviews and focus groups were conducted with the participating radiologists and technologists after the study to determine whether they believed this technology would provide effective visual review in remote sites.

Results

A total of 69 cases were reviewed during the study (Table 1). Radiologist 2 did not interpret cases during week one. No quality problems were detected in the reviews of these

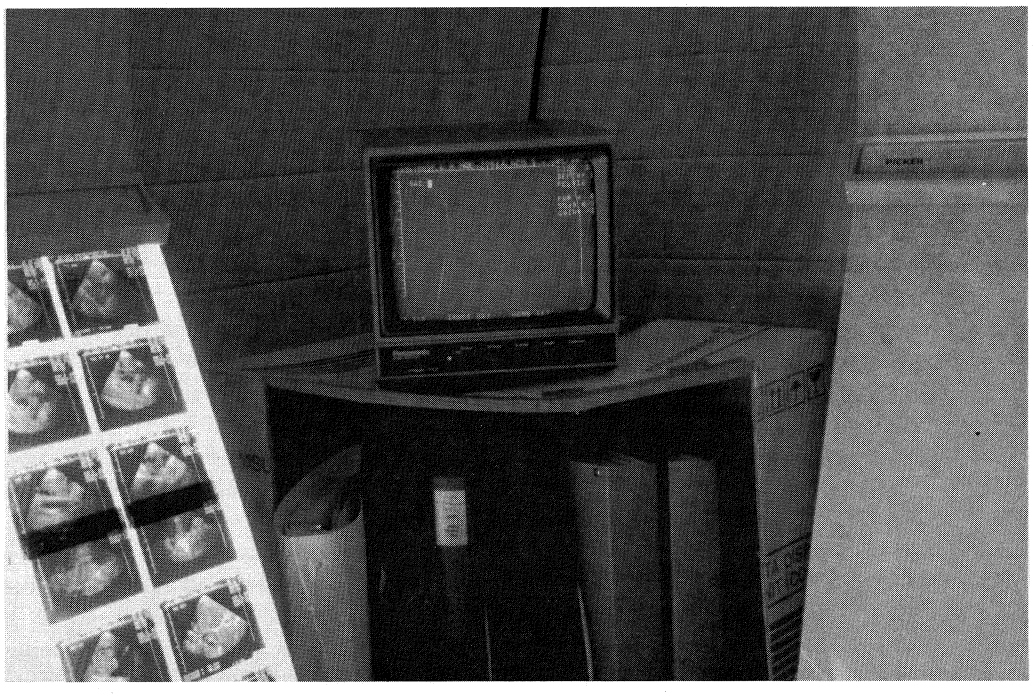

Fig. 1. Monitor for remote ultrasound video.

TABLE 1. Direct Reviews Radiologists Believed Were Clinically Necessary—by Radiologist and by Weeks (Direct/Totals)

	R no. 1	R no. 2	Totals
Weeks 1, 2	5/12	6/22	11/34 (32%)
Weeks 3, 4, 5	0/18	0/17	0/35 (0%)
Totals	5/30	6/39	11/69 (16%)

R: radiologist.

radiologists. A learning effect seems evident with no direct review occurring during the last 3 weeks of the study. By the third week, both radiologists believed that video/voice review would allow remote ultrasound review to be effective (i.e., direct review could be eliminated) for noninterventional examinations. Based on this experience, the participating radiologists and technologists were enthusiastic about using the video/voice review system in the ambulatory care center.

The radiologists often used the phone to instruct the technologist to image different portions of the anatomy, allowing fuller coverage than the standard protocol. Thus, the real-time feedback provided by the phone appeared to make the video/voice review environment superior to simple video-monitoring systems without the verbal feedback connection. The headset was essential because the technologists often needed two hands to image the patient. A cordless headset would have been superior to the corded one we provided the technologists as the cord occasionally became tangled with the transducer cord or became twisted around the technologist.

Using the video/voice system, radiologists were able to teach residents, fellows, and technologists from the monitor in the reading room, though a larger monitor might have been advantageous. The remote system was especially useful for teaching, because the radiologists were able to provide detailed analysis of the patient's history and condition as it related to the ultrasound findings, without distress to the patient. Residents and others still had hands-on experience with both routine and especially interesting cases during examinations not conducted as part of the remote consultation pilot study. The speaker-phone option in the reading room was essential for teaching.

Discussion

The results of our pilot suggest that careful selection of procedures to be performed at the remote site combined with careful training of both technologists and radiologists will allow a remote ultrasound operation to function with video/voice review being used remotely in lieu of direct hands-on review. Video/voice review also will allow resident and fellow teaching, which otherwise might be curtailed in a remote operation. Only experienced technologists participated in this pilot study. Less experienced technologists may require considerably more training.

Given the learning effect that appeared in the data, we believe that training and assimilation are essential. Therefore, we strongly recommend that consideration of a remote video environment include the initiation of a training environment operating between an examination room and a nearby reading room similar to what we used in the pilot. This training system will provide an environment for radiologists and technologists to become familiar with remote video ultrasound, while still having hands-on direct intervention only a few steps away. This training operation should be in place several months before opening the remote facility and should be continued indefinitely to provide a training environment for new personnel. Discussions, interviews, and group sessions with the radiologists and technologists during and after the training sessions can be used to help alleviate concerns and insure that the remote operational environment is accepted.

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