Evaluation of Radiologist Performance Using Telemedicine Services

Elizabeth Krupinski, Kris Maloney, Lisa Hopper, and Ronald Weinstein

Observer performance of radiologists using a telemedicine service was evaluated. Diagnoses between the rural and consulting radiologists agreed 84% of the time. The main reason for disagreement was extent of lesion rather than type or absence/presence. Consulting times and image quality were considered adequate.

Copyright © 1997 by W.B. Saunders Company

KEY WORDS: teleradiology, observer performance, diagnostic accuracy.

THE UNIVERSITY OF ARIZONA is currently in the process of establishing a state-wide telemedicine system. The Department of Radiology is a key component of the system as an expert referral site. There are a number of ways this system should be evaluated.¹ On the one hand, the hardware and software aspects of the system can be evaluated—how fast can images be transmitted, at what resolution should they be displayed and so on. Much of this work is done “behind the scenes” before systems are even installed. Evaluation can also occur at the users’ level, and in general, must be done not only in pilot or demonstration projects to show that the system works, but must also be done while the system is up and running. At this level two aspects can be considered. The first aspect is whether the users are satisfied with the image quality, resolution etc.² The second evaluation aspect is whether the users are making correct diagnostic decisions and are they confident in those decisions.^{3,4} In a practical sense, this aspect is of primary concern if telemedicine/teleradiology services are to be of any significant value to patients and hospitals. If telemedicine services cannot provide the same level of diagnostic accuracy as current practices do, then they will not be of benefit to the patient and thus will not be accepted. The final level of concern, especially for cost-benefit analyses, is what patient population is receiving services and what are the benefits derived from these services (eg, cost savings, travel time savings etc).⁵ This issue is a very difficult one at this point in time to address fully and effectively, although efforts are being made to address it.

METHODS AND MATERIALS

Cobre Valley Community Hospital (CVCH) in Globe, AZ, was chosen for the first teleradiology connection in May, 1996 after a preliminary requirements analysis was performed. Cobre Valley Hospital has a full service radiology department that provides service to a large surrounding community. The hospital itself has 40 to 60 beds with a large outpatient base (90% v 10% inpatient). The radiology department has one full-time physician and 10 technologists cross-trained in modalities. Full services include: general diagnostic, computed tomography (CT), ultrasound, nuclear medicine, mammography, fluoroscopy, angiography, and one-day-a-week magnetic resonance imaging (MRI) service. Approximately 28,000 exams are performed each year.

For teleradiology sessions, plain films are digitized before transmission with a 50 micron spot size digitizer. Video capture is used for the digital modalities. An IBM compatible capture and send workstation is the image server. For the first 8 months of service, a 28.8 Kbps modem was used for transmitting all images. A T1 link has recently been installed. At the University of Arizona (U of A), an IBM compatible high-resolution (2K × 2K) workstation is used to receive and display the images for review. Images are sent from Cobre Valley to the University on a need basis—ie, they can arrive at any time. Software for the telemedicine workstations was originally provided by Magnetic Research Inc (Provo, UT) and is currently provided by CompuRad (Tucson, AZ).

For each case diagnosed via the telemedicine network, the University radiologist had to complete a short questionnaire, (1) reporting their diagnostic decisions and (2) evaluating various aspects of image quality and the consulting session.

RESULTS

Patient characteristics and demographics. Patients ranged in age from 13 to 95, (mean, 53.27, standard deviation = 21.68). Fifty-six percent of the patients served were women and 44% were men. Seventy-three percent of the patients served were White, 24% were Hispanic, and 3% were African American. Fifty-nine percent of the patients served were married, 27% were single, 12% were widowed, and 2% were divorced. Twenty-two percent of the patients were unemployed at the time of their exam, 32% were retired with only Social Security income, 10% were students (no individual

From the Departments of Radiology and Pathology, University of Arizona, Tucson, AZ; and Arizona Telemedicine Program, Tucson, AZ.

Address reprint requests to Elizabeth Krupinski, PhD, Department of Radiology, University of Arizona, Tucson, AZ 85724.

*Copyright © 1997 by W.B. Saunders Company
0897-1889/97/1003-1031\$3.00/0*

income), 2% made less than \$10,000 a year, 2% made less than \$20,000 a year, and 32% made less than \$30,000 a year household income. Thirty-four percent of the patients were insured by a major insurance company (eg, Aetna), 44% were on Medicare, 5% were students (insurance source not listed), 5% were on Access (state subsidized), and 12% had no insurance coverage. Forty-nine percent of the patients were from Globe, the town where Cobre Valley Hospital is located, 46% were from the surrounding area, and 5% were from out of state.

Performance Evaluation

Technical aspects. In 83% of the cases, the consulting radiologists felt that the number of images sent by CVCH was adequate to reach a diagnostic decision. In 17% of the cases, the images were inadequate and more images had to be requested. Sixty-seven percent of the cases that required more images to be sent were inadequate because more views (eg, coned down images) were needed. On average, 4.5 more images (standard deviation = 1.4) were required to complete the diagnosis (range, 3 to 7 images). In 22% of the cases, poor display was the reason for inadequacy—the images were technically poor or were presented poorly on the monitor. The other 11% of the cases were inadequate due to technical problems (eg, images sent at 50% reduction resulting in considerable loss of data).

The U of A radiologists were asked to judge image quality and various aspects of the consultation process. Eighty-five percent of the cases were deemed to have adequate image quality and 15% were inadequate (due to the reasons listed above). Ninety-five percent of the consultations were judged to take place in a timely manner. The 5% that were judged not to take place in a timely manner were those in which more cases had to be transmitted. Sixty-one percent of the cases were diagnosed in less than 5 minutes. Another 22% were diagnosed in less than 10 minutes, another 12% in less than 15 minutes. Five percent of the cases took about 30 minutes to reach a final decision. The average consultation/decision time was 7.73 minutes (sd = 6.28), with a range of 2 to 30 minutes. Ninety-five percent of the sessions were judged to be a success and 5% were not. The cases that were judged not to be a success were a case that was

transmitted at 50% reduction and a case that required many more images to be sent.

Diagnostic confidence/accuracy. The radiologists were very confident in their diagnostic decisions 61% of the time, somewhat confident 27% of the time, and not very confident 12% of the time. When they were not very confident, there was either no patient history available or there was a technical problem (eg, images sent at 50% reduction). In 84% of the cases, the initial impression of the referring physician corresponded to the decision rendered by the consulting "expert" radiologist. The other 17% either had no initial diagnosis (ie, a radiologist was not available at the remote site and the teleradiology session provided an initial diagnosis or there was a difference in the degree of severity or type/classification of the abnormality noted. In no case was there a missed lesion by either the referring or consulting physician. For example, on a particular mammographic case, both physicians noted the presence of microcalcifications, but the referring physician called them benign and the consulting called them negative. In this type of case, the patient was affected by the consultation, as she was subsequently sent to biopsy (which proved positive).

DISCUSSION

Overall, the initial period of teleradiology use between CVCH and the U of A has been a partial success. The expert radiologists were in general quite satisfied with the system and were confident in their diagnostic decisions 88% of the time. When they were not very confident, it was generally due to reasons outside the realm of the teleradiology situation (eg, patient history not available). Overall image quality was judged to be adequate. For the majority of cases, the consultations seemed to take place to confirm suspicions held by the referring physician and that is precisely what the consulting radiologist did (ie, most decisions did not differ). When differences did exist, they were mostly decision/classification errors rather than detection errors. Decision/classification errors are easily resolved via consultation, especially when follow-up confirmatory tests are ordered. The physicians at the remote site found the teleradiology system particularly useful when the on-site radiologist was out of town. In the past they had to rely on their own skills for immediate interpretation and then

wait for the radiologist to return or to wait for a FedEx consultation to be sent and returned. The savings in time to diagnosis for those times when a radiologist was not available can be measured in days in some circumstances. A more detailed analysis of the savings in time is being performed presently.

The main area that seems to need improvement is in the number of required images sent from CVCH. In all cases where the consulting radiolo-

gist expressed some amount of dissatisfaction, it was due to inadequate numbers or types (eg, coned down view) of images being sent. It is, of course, impossible to predict in every case exactly what images need to be sent to reach a confident diagnostic decision. However, as the teleradiology system is used more often in the future and the clinicians and radiologists interact more and get to know what each expects, this sort of problem will certainly decrease substantially.

REFERENCES

1. Bashshur RL: On the definition and evaluation of telemedicine. *Telemedicine J* 1:19-30, 1995
2. Grigsby J, Schlenker RE, Kaehny MM, et al: Analytic framework for evaluation of telemedicine. *Telemedicine J* 1:31-39, 1995
3. Forsberg DA: Quality assurance in teleradiology. *Telemedicine J* 1:107-114, 1995
4. Krupinski EA, Weinstein RS, Rozek LS: Experience-related differences in diagnosis from medical images displayed on monitors. *Telemedicine J* 2:101-108, 1996
5. Welz R, Ligier Y, Ratib O: Design of a cooperative teleradiology system. *Telemedicine J* 1:195-201, 1995