Implementation of an International Teleradiology Staffing Model1

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Abbreviation:
PACS = picture archiving and communication system

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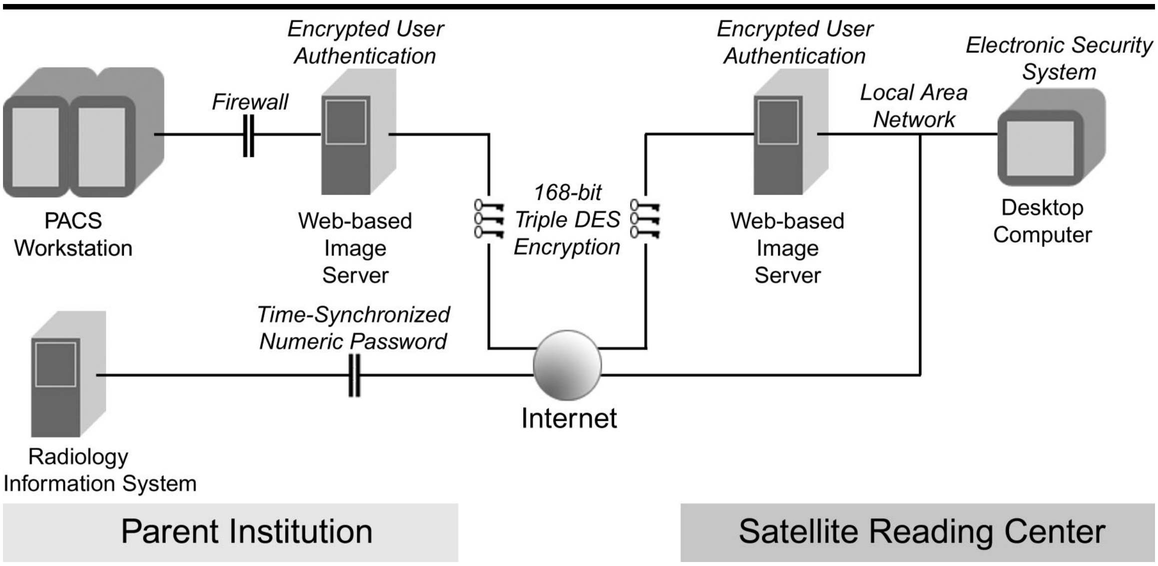
Although teleradiology is presently being used extensively in the United States—for both overseas subspecialty consultations and overnight coverage of imaging services at domestic medical centers—there has been limited investigation of its potential to help provide staffing support to U.S. medical centers from offshore locations. In this review, the authors describe an empirical assessment of the clinical feasibility and applicability of body computed tomographic (CT) image cases that originated at a U.S. university hospital being interpreted nearly contemporaneously by a staff radiologist in India. During a 3-month period, nonemergent CT cases obtained at a tertiary care institution (Yale-New Haven Hospital) were transmitted daily to a satellite reading facility in Bangalore, India. The cases were interpreted at the satellite reading facility by a faculty member radiologist who maintained hospital privileges and academic appointment at the parent institution in the United States. CT imaging reports were transcribed and uploaded directly to the parent institution's radiology information system. Technical problems temporarily prevented the transfer of image cases twice during the study period. Overall, the project results demonstrated the feasibility and reliability of an international teleradiology staffing model.

Teleradiology is the electronic transmission of radiologic image data from one location to another for the purpose of interpretation or consultation (1). By making radiologic consultations with personnel in remote and underserved areas (2–6) possible, this technology is increasingly enabling greater access to radiologic care. In addition, teleradiology has been used to provide greater coverage of imaging services when on-site reading is not possible or practical and to offer medical centers greater flexibility in staffing radiology departments (7). However, there has been limited exploration of the potential of teleradiology to address staffing issues on an international level.

The results of a study previously conducted by Kalyanpur et al (8,9) showed international teleradiology to be a means of providing night coverage of imaging services by allowing radiology personnel to take advantage of the time difference between India and the United States. With this model, a day shift of radiologic procedures can be substituted for what is considered a night shift for radiologists in the United States. In addition, staffing flexibility may be increased by allowing radiologists who are overseas to interpret the images in overflow cases from each workday. Our project was implemented to assess the clinical feasibility and applicability of such a staffing model.

Our international teleradiology pilot project represents the culmination of several years of development of a secure and reliable teleradiology operation. Beginning in 1999, we embarked on a scientific investigation to evaluate different levels of image data compression for the teleradiologic transmission of body computed tomographic (CT) image data (10). After this technical investigation, we performed a trial in which 102 consecutive emergent CT image cases that were obtained during night shifts were sent by means of teleradiology to our staff radiologist in Bangalore, who interpreted them simultaneously with the in-house night-shift emergency room radiologist at our facility in the United States. The results of this study confirmed that satisfactory diagnostic performance could be achieved with this approach (8,9).

It should be noted that another academic institution has effectively implemented similar clinical practices with the teleradiologic transmission of neuroradiologic magnetic



Schematic illustration of technical implementation of international teleradiology system. CT image cases were transmitted to the satellite reading center through Web-based image servers while dictated reports were uploaded directly to the parent institution's radiology information system. Security issues were addressed by using 168-bit triple-data-encryption-standard *(DES)* encryption, time-synchronized secure passwords, and network firewalls.

resonance images to a radiologist in London, England (11). The results of other published studies also have supported the validity of the primary interpretation of teleradiologic images (12–14).

PROJECT OVERVIEW

Between September and December of 2001, 216 body CT image cases that originated at our parent institution, Yale-New Haven Hospital, were selected for primary interpretation via international teleradiology. The cases were selected by radiologists who were working in the body CT service by using the following criteria and protocol: Nonemergent outpatient body CT scans of the chest and abdomen; abdomen and pelvis; or chest, abdomen, and pelvis for which the primary interpretation could be deferred for at least 12 hours were selected for teleradiologic transmission and remote interpretation. Most of the cases consisted of oncologic CT scans obtained for staging or follow-up; these cases represented 98% (n = 212) of the total number of cases sent. No patient age groups were excluded; however, some images were not included because the referring physicians preferred that their patients' cases not be transmitted.

The project team consisted of a clinical administrator (J.A.B.), a technical director (V.P.N.), a project data coordinator (D.T.P.), a quality assurance coordinator (S.T.S.), and a radiologist (A.K.) at the satellite reading center in Bangalore. The radiologist was a faculty member at our institution who had returned to his home country. He had completed a radiology residency and neuroradiology fellowship at our institution in 1998 and had worked as a full-time faculty staff member in our emergency radiology department for 1 year after completing his training. After moving back to India, this radiologist maintained his U.S. state licensure and his appointment on the medical staff at our institution. He returned to work in our department for short periods every few months and thereby remained up to date on our imaging protocols and practices. In addition, he had maintained a working relationship with many of our referring physicians before beginning this study.

There is an optimal difference in the day and night shifts between the satellite reading facility in Bangalore and the facility on the East Coast of the United States (10½-hour difference during daylight savings time, 9½-hour difference otherwise). In addition, Bangalore has a high degree of Internet connectivity as a result of a thriving software industry (8,9).

DATA TRANSFER PROTOCOL

Each of the selected cases comprised 21–818 CT images, and the average case consisted of 132 images; two to eight cases were transmitted each day. The CT examinations were performed by using one of two GE LightSpeed four–detector row scanners or a GE CT/i single-section scanner (GE Medical Systems, Milwaukee, Wis). The cases were selected by the in-house radiology staff and faculty in the United States, who then transmitted them from the picture archiving and communication system (PACS) workstation (Autorad; Kodak, Fremont, Calif) in the CT reading room to a local Web-based image server (Encrypted Telemedicine Raq; Medweb, San Francisco, Calif) (Figure). No compression or encryption was used for this local transfer of image data. The cases were then queued for lossless encrypted transmission to another identical server at the satellite reading center in Bangalore. When previously obtained images existed, these were also transmitted.

At the end of each day, the project data coordinator collected information on the transmitted cases and then double-checked all transmission records to ensure that the cases had been transferred. By way of an encrypted e-mail, the radiologist in Bangalore was notified of the transmission date, medical record numbers, and image count information for the scans obtained that day and any relevant previously obtained images in the cases, without the patients being identified by name. The clinical information on each patient was available in the hospital's radiology information system, which provided the same information to radiologists at both the parent hospital and the satellite reading center.

The CT image cases, once delivered to the server at the satellite reading center (Figure), were transferred over a 10 megabits per second local area network to a standard desktop personal computer (Compaq Presario, Intel Pentium III; Dell, Round Rock, Tex), and the image data were interpreted by the remote radiologist on a 19-inch personal computer monitor with 1,024 × 768 maximum spatial resolution at 32-bit color and 100-MHz refresh rate settings. This software allowed for lesion size and attenuation measurements and for postprocessing by means of edge enhancement filtering and adjustments in the display window width and level. A report for each case was then generated and transcribed by using a combination of voice recognition software (Dragon Systems; Lernout and Hauspie, Newton, Mass) and structured format reporting, the latter of which was customized by the remote radiologist (15).

After all image cases for a given day had been interpreted, the reports were uploaded to the parent institution's radiology information system directly and thus were available at the parent facility before 8:00 AM Eastern time the next day. Any urgent or clinically important findings were immediately reported to the referring physician via fax by using a feature of the radiology information system that was triggered by the remote radiologist. During the course of this pilot study, the clinically important findings that required a fax to the referring physician were noted in 54 of the 216 cases.

Quality control measures consisted primarily of daily structured communications between the project members to ensure the reliable transmission and receipt of case data. The project data coordinator doubled-checked the records of the image data delivery to the satellite facility each evening and sent e-mail notifications to the other project members, as described earlier. The following morning, the remote radiologist sent the project members at the parent institution an e-mail notification that the cases had been interpreted and reported on and of which cases had been faxed. The quality assurance coordinator double-checked with the physicians' offices to make sure the reports had been received and re-sent faxes when necessary. The project technical director performed routine maintenance and testing of the teleradiology network and was available 24 hours a day for troubleshooting in the event of a technical complication.

SECURITY

Security issues were addressed in the form of several measures that were taken to protect data from unauthorized access and to ensure patient privacy. The cases were transmitted by using 168-bit, triple-data-encryption-standard encryption (22) (Figure). Access to local and satellite Web servers was restricted by using a combination of encrypted user authentication and network-level security measures. In addition, the remote server and viewing computer at the satellite reading facility were physically protected by an electronic security system (HID, Irvine, Calif) that restricted access to the reading room. All patient identifiers were removed from e-mail correspondences; cases were referred to only as medical record numbers. While reviewing previously obtained radiologic reports or uploading new reports into the hospital's radiology information system, access through the hospital firewall could be gained only by using an electronic time-synchronized numeric password (SecurID; Security Dynamics, Bedford, Mass).

PERFORMANCE

For quantitative assessment, data processing and transmission rates were used as indicators of system performance. The timeliness of image delivery to the Web-based image server at the satellite reading center was a function of the processing time for data compression, encryption, Internet transmission, decompression, and decryption. However, the time required for compression, encryption, decompression, and decryption was minimal compared with the time required for Internet transmission. To determine the effects of network traffic on transmission rates, the project coordinator randomly sampled data transfer rates at different time points during the workday. The rate of data transfer from the PACS workstation to the local Web-based image server in the United States remained relatively constant, about 15 images per minute, whereas the average rate of transfer to Bangalore was three images per minute.

Only a few minor variations in these rates were observed during periods of peak network activity during the day. However, the transfer rate fluctuations for individual image files were nonsubstantial when they were volume averaged and included in the overall transfer rate for a given case, which consisted of 132 images on average. At this level, the average rate of transmission to Bangalore was three images per minute for each case sampled. For the average case, which consisted of 132 images, the transmission time from the PACS workstation to the local Web-based image server was 8.8 minutes, and the subsequent transfer of the case to Bangalore across the Internet took 44 minutes.

During the course of the project, Web-based image servers operating with the Linux Operating System (Linux, Ogdensburg, NY) demonstrated consistent reliability during 24-hour, 7-day operations. Technical difficulties led to transmission downtime in two instances. The first downtime resulted from the expiration of the satellite Web server license, and the second resulted from a temporary routing loop on the Internet, which prevented normal transmission and subsequently caused overloading of the queue due to multiple attempts to resend the cases. These problems were detected during the evening by the project coordinator at the parent institution and by the remote radiologist at the beginning of his workday. The technical director, who was immediately notified of these complications, then began the process of system troubleshooting and was able to establish the cause shortly thereafter.

Both problems were resolved by implementing backup measures that enabled the radiologist at the satellite facility to securely transfer and view images directly from the local Web server by using 128-bit Secure Socket Layer encryption (Netscape, Mountain View, Calif); this process required longer image-viewing times. However, the remote radiologist was able to upload his reports on the cases by the next morning. These occurrences underscore the importance of having both a redundant backup means of transmitting the data and technical support available at all times in different parts of the world.

SECURITY, CONFIDENTIALITY, AND COMPETENCE

Additional issues are associated with the shift to teleradiology-facilitated patient care. Among these issues are confidentiality and security, access to and control of information, competence, the patient–health care provider relationship, and interprofessional relationships (16). The measures taken to protect patient confidentiality included the removal of patient identifiers from project correspondences and data records. Security issues concerning the electronic transmission of patient data were addressed by using high-level encryption and systems that restricted information access physically and electronically.

Credentialing requirements, certification and state licensure, and malpractice coverage are also important concerns associated with international teleradiology. The feasibility of a clinical operation of this nature is contingent on the remote site radiologist being U.S. board certified, state licensed, and credentialed at the institution where the images originate. Our experience was ideal because the remote radiologist was a faculty member at our institution, having completed both residency and fellowship training there. Competence criteria include the requirement that the remote radiologist have a knowledge base at the level of U.S. standards; these criteria can be met by attending the appropriate conferences and using the numerous continuing medical education resources that are available online. The patient–health care provider relationship was addressed in this study by always having radiologists present at the parent site to monitor imaging procedures and answer patient-related questions.

The CT case reports were transmitted to the referring physicians who were directly involved in the patients' care. However, changes in the remote radiologist's relationships with referring physicians and with colleagues in the radiology department were matters of concern owing to the distance between the parent hospital and the satellite reading center. In this regard, constant communication between primary site personnel and remote site personnel—to the extent that the location of the remote site is rendered irrelevant—is critical for the smooth running of such an operation. With newer technologies having facilitated major reductions in the costs of intercontinental telecommunications, a simple and reliable communication system can now be set up at the outset of a teleradiology program to minimize opportunities for miscommunication.

In our case, the remote site radiologist could be contacted by e-mail, telephone, and electronic messages through the hospital's radiology information system. In addition, the quality assurance coordinator of this study was active in contacting physician offices to ensure the receipt of faxes that were sent in cases of clinically important findings and in answering any questions about the study. The majority of the referring physicians were supportive of this project and continued to have their case images read by means of teleradiology through the duration of the study period. Many referring physicians expressed concerns about security, confidentiality, and competence, which we were able to address. A few of them requested that their cases not be transmitted, and we honored these requests.

CONCLUSION

As the demand for radiologists has continued to exceed the supply of them, a personnel shortage that may exist for years to come has emerged (7,17–19). One proposed solution is to use the increased capabilities offered by teleradiology to provide more efficient off-hour coverage of imaging services (8,9,12–14,20). Our study findings indicate that in addition to facilitating subspecialty consultations and emergency coverage of imaging services, off-site radiologists may also be used in diagnostic imaging departments to address personnel requirements. Taking a cue from the globalization of other industries, those in our field can exploit the benefits of an international staffing model for radiology practice. These benefits include greater work shift flexibility, an increased candidate pool, and decreased overhead costs.

Such an international staffing model may be necessary to provide coverage of imaging services during unfilled work shifts at some medical centers in the United States. This model has already been investigated as a means of eliminating the night shift for local radiologists (8,9). Teleradiology may also be used to fill many positions with candidates from around the globe, provided they meet the necessary certification standards. In addition, other than the initial capital investment for the setup of a teleradiology program, the operating expenses for a radiology practice overseas may be substantially lower than those for radiology practices in the United States. However, at present, regulations of the Centers for Medicare and Medicaid Services stipulate, with limited exceptions, that no payment shall be made for medical services rendered to Medicare recipients who are not covered for services in the United States (21). This regulation was passed before teleradiology became feasible and was designed to prohibit payments for medical care rendered in countries other than the United States, with limited exceptions. To gain the full benefits from future applications of international teleradiology, this regulation will require modifications.

Our experiences in the current study demonstrated the technical and clinical viability of an international teleradiology staffing model in which a faculty member at a satellite facility in India read CT image cases generated from the daily workload at his parent institution in the United States. Our trial results show that an international teleradiology model can be used to reliably address staffing issues at an academic medical center. The benefits included decreased workload for local radiologists, who were consequently able to quickly address more urgent cases; shorter turnaround times for generated reports; and increased flexibility in the coverage of imaging services.

The chosen cases were consistently and securely transmitted, read, and reported before the next workday. Despite some initial skepticism, the majority of the referring physicians responded positively to the model. However, a certain level of resistance is to be expected during the initial implementation of a new technology. Increased use of teleradiology in medical centers and increased numbers of validation studies published in the literature may lead to greater acceptance of teleradiology protocols. Given the persistent shortage of radiologists, it appears that technology, in the form of international teleradiology, may be used to address the urgent staffing issues facing the field of radiology.

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