IMAGE COMMUNICATION BY TELEPHONE

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A simple, inexpensive, reliable system for transmitting organ imaging examinations to remote locations would have many useful applications in nuclear medicine. In this paper we will review our experience with a method of transmitting radionuclide images to a distant location using slow scan television and ordinary telephone lines.

EQUIPMENT

Ordinary (real-time) television is suited to motion picture-type visualization of the happenings at a distant location. Nuclear images, including radioisotope scans and gamma scintigram pictures, generally are static; therefore it is not necessary that the capability of real-time television be present. It is possible to send images one frame at a time by a facsimile. However, facsimile does not lend itself easily to the format of the radioisotope scan. Generally facsimile is used with opaque material and is limited to a fixed size. Certain television techniques, however, are adaptable to transparencies such as are used in nuclear medicine and can also be used with various sizes and shapes of original material, whether transparent or opaque.

The method used in this study involved a slow-scan video system adapted for transmission over existing telephone lines. At the transmitting terminal, the equipment consisted of a television camera, television monitor, video converter (Colorado Video, Inc.), standard x-ray view box, and telephone data set (Bell 602C Data Set). The receiving terminal was equipped with a video converter and magnetic rotating disc storage device (Colorado Video, Inc.), television monitor, and an identical data set. The receiving video converter contained a video disc memory feature which allowed the transmitted image to be retained on the television monitor until the next transmission. The equipment was compact and could be housed in a small cabinet or desk top (Fig. 1). No special wiring except for the telephone was required. Simple telephone pickups and amplifiers were helpful for conference use. A zoom lens accessory for the television camera was used and was felt to aid in rapid adjustment for the various film sizes, reducing times of setup for transmission.

STUDY PROTOCOL

Ninety scintillation scan examinations were transmitted. The type of examination and the display material used are shown in Table 1. Before each transmission, a brief clinical history was given. The image was interpreted by the receiving physician with the interpretation being recorded. At a later time, the films were viewed directly with the same clinical information and another interpretation was recorded. The results of the telephone and direct interpretations were then compared and tabulated as positive for pathology, negative, or equivocal. Organ imaging examinations were recorded as "positive" when an abnormal cold or hot area could be identified on at least two views with anatomic correlation and the official interpretation recorded an abnormal finding. Renograms were interpreted as abnormal when one or both analog curves depicted a delayed peak (over 5 min) or a delayed excretory phase (over half the peak value at 15 min) and when serial scintiphotographs confirmed the sequence of events shown in the curves. "Equivocal" interpretations included organ imaging examinations in which variations in size and shape might be attributed to anatomical variation (usually liver and perfusion

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FIG. 1. Receiving terminal for nuclear medicine image communication system.

TABLE 1. TYPE OF EXAMINATION AND DISPLAY MATERIAL TRANSMITTED

Type of examination	No. of cases	Type of material transmitted	No.
Brain scan	57	X-ray film, 10 × 14	251
Liver scan	15	X-ray film, 14 × 17	70
Lung scan	8	Polaroid format	9
Renogram	6	Renogram graphs	5
Thyroid scan	2	Radiographs	2
Bone scan	2	Data sheet	1
Totals	90		338

lung scans) and probable artifacts or abnormalities seen in only one view. The official interpretation recorded the type of abnormality and usually suggested additional or repeat studies. "Negative" interpretations consisted of those examinations in which no abnormality was noted and the official interpretation was recorded as normal. The two interpretations of each scan were then compared. Observations were also made regarding the reliability of the system, resolution, photographic factors in the gamma images which made for best transmission, and cost.

The general routine was as follows: The initial telephone contact was made. A single view was transmitted (equipment takes 100 sec), after which verbal discussion took place using the talk mode of the data set while the image was retained on the receiving monitor. In practice, four or five patient examinations were transmitted and discussed in a period of approximately 1 hr. Much of the discussion involved the technique of scan performance and the diagnostic question posed by the particular examination.

The transmitted material included primarily radiographic films upon which scan images had been made (Table 1). It also included Polaroid displays, renogram graphs, some radiographs, and printed material. The use of a zoom lens permitted quick changes of film size between transmission. The television camera was used with a standard view box. No special masking was required.

In the course of this study, four 10 × 14 or two 14 × 17 transparency scans were generally grouped and transmitted at one time, which made it possible to transmit four views of a brain scan at once.

RESULTS

The comparison between the telephone interpretation and direct interpretation is shown in Table 2. In 68 of the 90 examinations, the two interpretations were the same. When both interpretations were positive, the abnormal features were identical; i.e., the positive interpretations were consistent. There were no instances in which a positive direct interpretation had been preceded by a negative telephonic interpretation. In four cases a telephonic interpretation of "equivocal" was followed by a positive reading. Since, however, an interpretation of "equivocal" would be an indication for either direct viewing of the films or further examination, it was concluded that no significant abnormalities were missed during the interpretation of the transmitted images.

Seven examinations might be considered as "false positive" transmissions. One was read as abnormal by telephone and normal directly. Four were read as positive by phone and equivocal by direct interpretation. Seven were interpreted as equivocal by phone and negative when viewed directly.

EVALUATION

Comparison of the two methods of interpreting organ image examinations reinforced the authors' overall impression of the transmission technique, namely, that examinations transmitted in this manner can be interpreted promptly and with a degree of accuracy sufficient for clinical use. The resolution of the imaging instruments displayed on the actual films did not appear to be degraded in transmission since the abnormalities on all positive examinations were identical and no significant "false-negative" transmitted interpretations were rendered. Further experience in transmission technique and improved equipment should decrease the incidence of "false-positive" interpretations. The system was sufficiently flexible to permit transmission of material of varied composition and size.

Except for films of low contrast, all organ image examinations recorded on radiographic film were

TABLE 2. COMPARISON OF TELEPHONIC AND DIRECT INTERPRETATIONS

Interpretation			Phone	Direct
identical	68	Positive	32	32
Phone positive, direct negative	1	Negative	36	48
Phone negative, direct positive	0	Equivocal	19	10
Phone positive, direct equivocal	4	Technically inadequate	3	0
Phone negative, direct equivocal	0	Total	90	90
Phone equivocal, direct positive	5			
Phone equivocal, direct negative	9			
Phone technically inadequate:				
Direct positive	1			
Direct negative	2			
Total	90			

transmitted without difficulty. With proper magnification, 35-mm negatives could be transmitted. Scintiphotographs displayed on Polaroid film were successfully transmitted as were analog curves recorded during renograms. Gross features of selected radiographs could be transmitted, such as cardiac size on chest x-ray and isolated findings in contrast studies. The system was simple to operate at both the sending and receiving terminal. Nuclear medicine technologists were able to operate the transmitting terminal after approximately 1 hr of instruction. Setup time was minimal and the combination of zoom lens and television monitor eliminated the need for special masking. No transmission was cancelled because of equipment failure except for a period when telephone service at the receiving station was interrupted due to an earthquake. No maintenance was required during 4 months of regular use. Although cost figures were kept during the study, the special design of the experiment and recent changes in equipment rendered this information meaningless. Replacement of the data set with a standard voice coupler will reduce the fixed cost substantially, and toll call time undoubtedly would be shortened in a working situation. Even with the system as it was used, it was concluded that the cost was reasonable and within the budget of a moderately active department.

LIMITATIONS

Slow-scan television is suitable for static images only. However, serial images from dynamic studies can be transmitted in groups of six or eight frames. Cerebral flow studies and serial scintiphotographs taken during renograms were transmitted in this manner. The system was unable to detect and transmit small changes in image density at the white end of the gray scale, in spite of the contrast enhancement effect of minification. As a result some underexposed films or films of low contrast *could* be interpreted directly but could not be transmitted successfully, even though the minified image on the receiving monitor could be adjusted to a degree for contrast and brightness. Resolution was grossly inadequate for routine radiograph transmission. Accurate interpretation of printed material was limited to block lettering of 1 in. or larger. Further refinement in the equipment will probably enhance the capability to transmit printed material since the manufacturer proposes its use mainly for this purpose.

Distortion of the image and noise artifacts were occasionally bothersome but rarely prevented interpretation of the image. The type of artifact that was most distressing was an image of lesser intensity or of reversed gray scale which was occasionally seen displaced downward from the main image. The appearance was not unlike "ghost" images which are occasionally seen in real-time television where more than one path for the radiofrequency picture signal exists. The artifacts could be eliminated on many occasions by breaking the circuit and reestablishing the connection.

FUTURE APPLICATIONS

The participants in this study have been encouraged by the technical capability of the system and intrigued by the teaching potential of a similar system. It is our hope that future studies of this sort will facilitate further the application of the university teaching center's special knowledge and experience in a community hospital setting. Additional formally structured teaching projects will be undertaken to explore this potential more fully. Improvements in equipment can be expected to result in improved resolution, faster transmission, and reduced costs. Improvement in the quality of the images should make it possible to transmit radiographs, photographs, and written or printed material. Improved storage devices may make it possible to store a series of examinations at the receiving end of the terminal to be interpreted at a later time. Smaller hospitals, especially those in remote locations, might wish to perform routine organ imaging examinations and arrange for immediate interpretation at a distant center. Several hospitals might be linked to a single center with the necessary trained physicians to provide expert interpretation, thus providing an important category of diagnostic service to a population of patients who otherwise might not receive this service, or who might have to be transferred to a point where the service is physically available.

SUMMARY

The investigators evaluated a slow-scan video system capable of transmitting static nuclear medicine scan images over the telephone line. The system was found to have potential for future applications in bringing nuclear medicine services to small, remote hospitals. The results of this study indicate that no positive examinations were misread. However, there was a tendency for television interpretation to be equivocal or positive when direct interpretation was negative. It was felt that the difficulties which were encountered in this initial use of the system could be overcome.

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