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ROUTINE TRANSMISSION OF ELECTRO-ENCEPHALOGRAMS BY TELEPHONE FROM A DISTANT COMMUNITY[1]

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INTRODUCTION

Approximately 2.2 million people live within the boundaries served by the Intermountain Regional Medical Program. The availability of medical care and health facilities for optimal evaluation and treatment of patients with neurological disease is limited. Major factors are a sparse population spread over a vast area and the fact that physicians knowledgeable in this field are concentrated in the Salt Lake Valley of Utah (Salt Lake City, Ogden and Provo) and Reno, Nevada. These two areas contain thirteen of the fifteen electroencephalographic laboratories. Consequently patients are often required to travel long distances for diagnostic procedures such as electroencephalograms. The problems of distance, the expense of travel and the delays in obtaining reports frequently influence the physician not to obtain an EEG in patients in whom it may be indicated. The major drawback in the establishment of independent laboratories in outlying communities is the lack of professional personnel experienced in EEG interpretation. One such region is the Magic Valley area of Idaho with a population of approximately one hundred thousand. The major city is Twin Falls, located approximately 240 miles from Salt Lake City.

In an endeavor to provide better diagnostic facilities for distant communities, the Intermountain Regional Medical Program supported this research project. Its major objective is the evaluation of the technical and financial feasibility of the routine transmission of electroencephalograms by telephone from a remote area, in this case the Magic Valley region of Idaho. Although electroencephalograms have been transmitted over telephone lines before on a limited basis, (3, 4, 5) this has never been accomplished routinely. It is the purpose of this paper to discuss the technique and the results of this project which have already been reported. (1).

1This research was supported in part by the Intermountain Regional Medical Program, University of Utah College of Medicine, Salt Lake City, Utah.

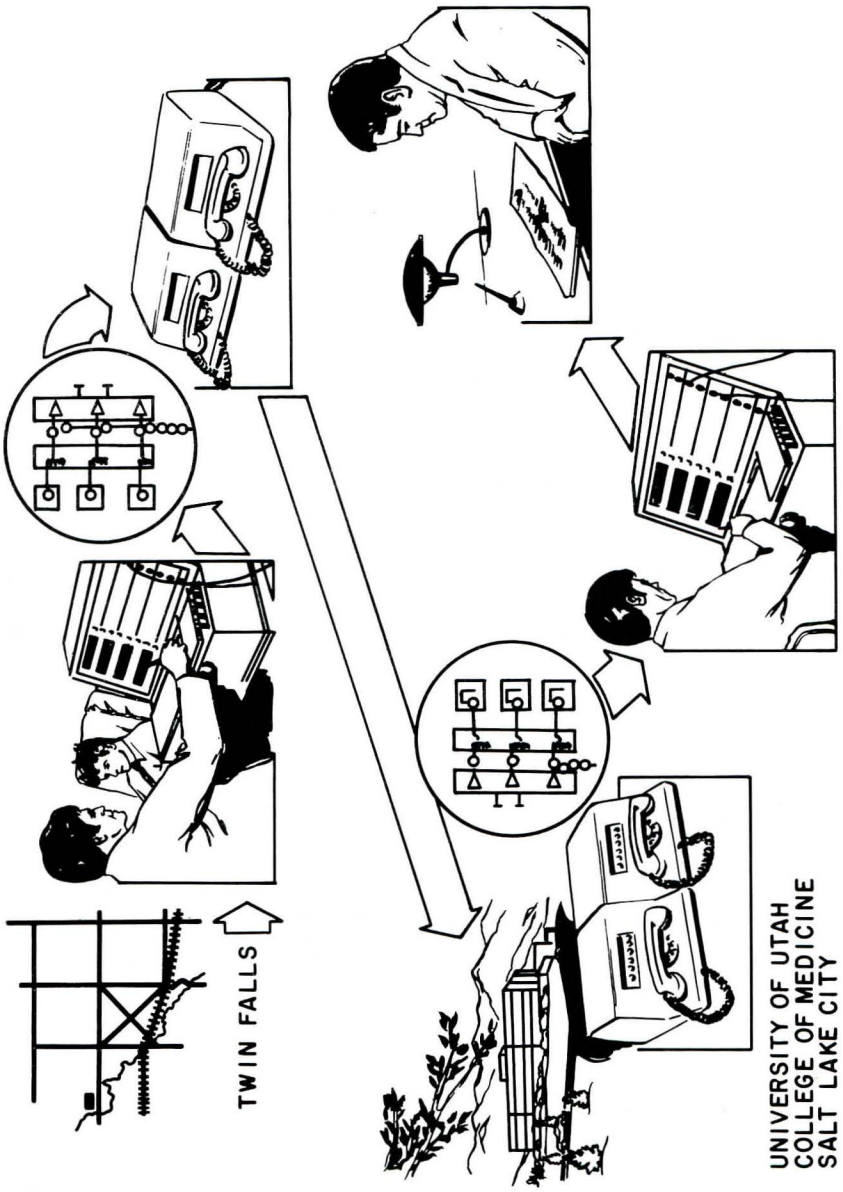

Figure 1
Schematic diagram of EEG transmission linkage.

EQUIPMENT AND TECHNIQUE

The instrumentation and transmission scheme used to accomplish EEG transmission is shown in Figure 1. The patient at the remote site is connected in a conventional manner to a standard Model 6 Grass EEG instrument. The outputs are then conditioned through an interface conversion resistive network from the standard high-level output of the Grass machine, typically ± 8 volts full scale, to a level compatible with the Bell System X604A-M10 data sets or $\pm 2\frac{1}{2}$ volts full scale. The American Telephone and Telegraph Company's X604A-M10 experimental data set provides for transmission of three channels of medical or other analog data over one telephone line. The X604B-M10 is the receiving unit. The X604A-M10 set frequency modulates and in turn multiplexes the signal onto the telephone line for transmission. In the receiving unit it is demodulated. In this project two transmitter and receiving data sets were used to send six channels of EEG over two parallel conventional telephone lines (three channels per line). The records at the remote site were compared initially with the transmitted records; however, when the fidelity was found to be excellent and sources of artifact identified, this practice was discontinued. However, it is mandatory to also obtain an ink write out EEG at the remote site so that the technician can monitor the patient, identify and correct artifact, etc.

Procedures were established for transmitting both routine and emergency tracings. The EEG reports of routine (within 24 hours) and emergency records are given by phone over the same voice and data link to the technician at the remote site. The reports are then typed and distributed to the physician.

RESULTS

Technical — Since the project was initiated in November 1968, 581 six channel EEGs have been transmitted. These included scheduled as well as emergency records and EEGs from the intensive care unit. The total time for each record transmission including phone report averaged approximately 35 minutes. The longest record transmitted was of one hour's duration and as many as five EEGs per day have been relayed. The original data sets have now been involved in approximately 340 hours of transmission and not one interruption or termination from data set malfunction or interference in line transmission has occurred. The signal transmission is of high fidelity as shown in Figures 2 and 3 in which the original record is compared with the transmitted record. Extraneous artifact usually secondary to line noise was minimal and easily identifiable. EEGs were transmitted from Twin Falls to San Diego, California, a distance of approximately 1000 miles, during the 7th International Congress of EEG and Clinical Neurophysiology (2). This showed that the absolute propagation time did not cause a time distortion of the signal.

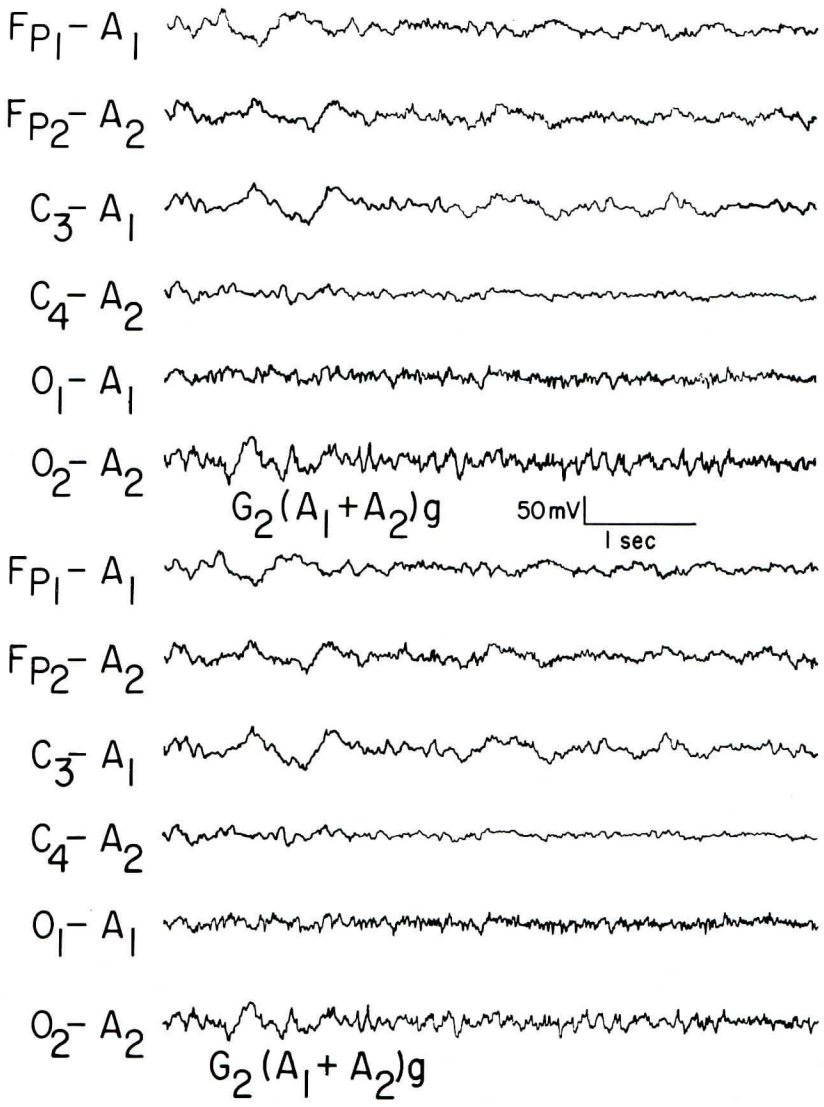

Figure 2
Comparison of an original (the first 6 channels) with transmitted record. A glioblastoma multiforme was diagnosed at operation.

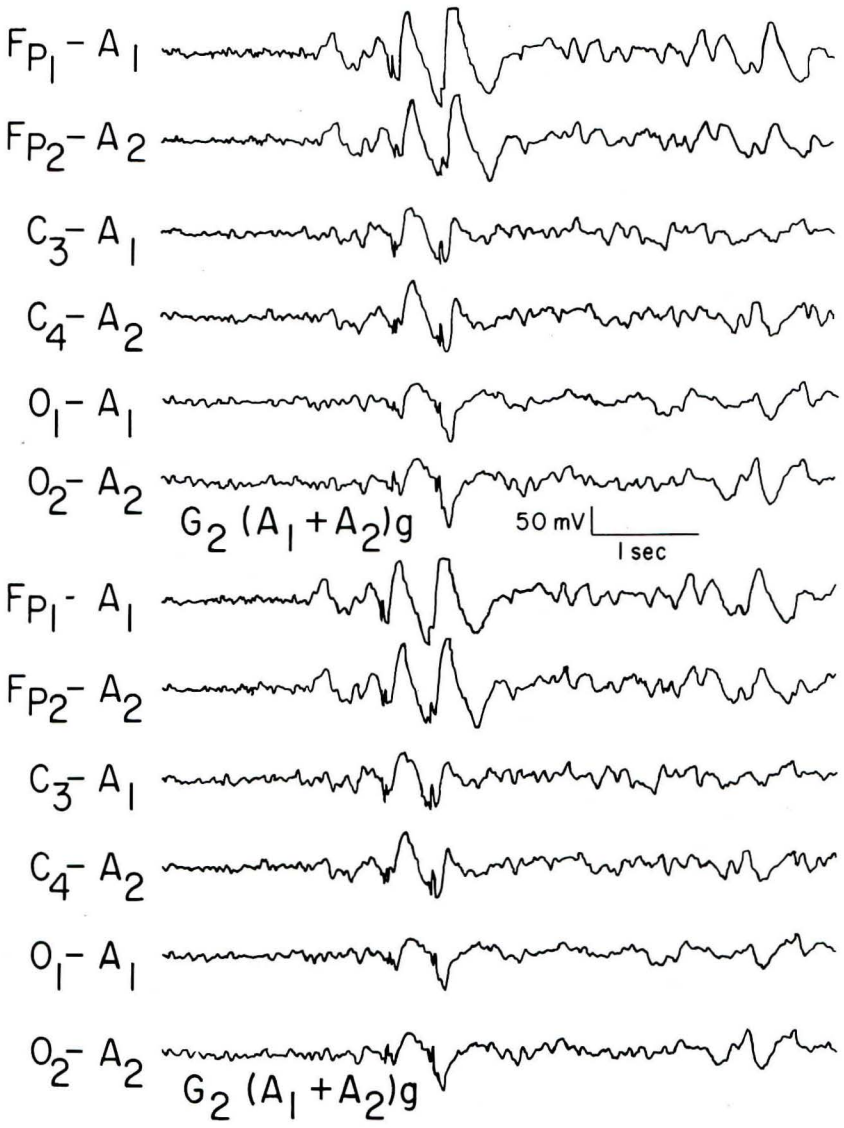

Figure 3
Original record compared with transmitted EEG on a young adult with grand mal seizures. Original is upper 6, transmitted is lower 6 Channels.

FINANCIAL ASPECTS

Tables 1A and B summarize the financial aspects of this project prior to October 1, 1970. Since then the Mountain States Division of Bell Telephone Company has reduced the monthly data set rental charge to $50 for the 604A and $85 for the 604B. The monthly charge now for the four data sets is $270 as compared to $390, a further savings for the patient. Since only 3 channels can be transmitted over one line, the cost of a station-to-station long distance connection is doubled. This amounted to approximately $17.50 for a 35 minute 6 channel record. Although additional channels can be transmitted, this requires further data sets and telephone lines, making it financially impractical at least in this project.

The initial part of this study was supported by a grant; however, since May 1, 1970 the patients have had to pay for their EEG examinations.

TABLE 1A

Major Expenses of Telephone Transmission

Rental of 2 AT&T X604A-M10 transmitter data sets	$130/month ($65 each)
Rental of 2 AT&T X604B-M10 receiving data sets	$260/month ($130 each)
Rental of 4 AT&T business phones	$66/month ($17.50 each)
Cost of station-to-station line transmission (weekday, daytime) for a 35 min. record from Twin Falls, Idaho to Salt Lake City (2 lines required for 6 channels)	$17.50 record ($8.75/line)

TABLE 1B

Patient cost based on transmission of approximately 30 records per month. Professional fee for interpretation not included.

Data set rental	$13.00
Business phone rental	2.20
Cost of transmission (2 lines)	17.50
Paper and miscellaneous expenses	5.00
Technician's salary	
Half-time technician, Twin Falls (80 hours/month)	7.33
Salt Lake City technician (20 hours/month)	1.82
	$46.85

DISCUSSION

The obvious disadvantage of this communication system is the use of two data sets and two telephone lines in order to transmit 6 channels of EEG which many would feel is an incomplete examination. However, two recent developments may help to solve this problem. Prior to two years ago, only Bell data sets could be used on the telephone network. However, a recent ruling by the United States Federal Communication Commission now allows direct access to the telephone network. The second has been the development of integrated circuit "phase-lock-loop" technology which may allow the transmission of 6 or even 8 channels of EEG over one telephone line. The authors are currently working on this technique. If this proves successful, then it would be both technically and financially possible to transmit a complete 8 channel EEG over one telephone line not only from remote communities but also within metropolitan areas. A telephone linkage of several hospitals with a central EEG laboratory would then certainly be feasible.

There are several benefits to the technician from this type of communication system. In large metropolitan areas technicians not infrequently divide their time between several hospitals either obtaining EEGs on a hospital-owned machine or transporting a machine to the installation. This not only is time consuming but proper supervision is often lacking. In addition, particularly in rural areas where records are mailed to a center for interpretation, the technician is alone and only rarely has the opportunity to converse with other technicians or electroencephalographers. Proper supervision is again lacking. With telephone communication the transmitted record is being continually monitored by a senior technician at the receiving site. By interrupting the tracing, he can talk to the technician at the sending laboratory over the same line, make suggestions about correction of artifact, localization runs, etc.

The immediate availability of reports, particularly in emergency cases, is a definite advantage over mailing records to a center for interpretation.

SUMMARY

Five hundred and eighty-one six channel EEG's have been successfully transmitted over telephone lines from a remote community. The technique, financial aspects, newer developments and advantages for the technician were discussed.

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