Remote Clinical Assessment of Gastrointestinal Endoscopy (Tele-endoscopy): An Initial Experience

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ABSTRACT

Background: *Gastrointestinal (GI) endoscopy is an effective tool to screen for cancers of the digestive tract. However, access to endoscopy is limited in many parts of South Carolina. This trial is a part of a prospective multi-part study for remote cancer screening in coastal South Carolina. This pilot study was to evaluate the quality of tele-endoscopy for cancer screening.* ***Methods:*** *10 patients scheduled for endoscopic procedures were observed simultaneously by the endoscopist and a remote observer connected over a 512kbps ISDN line. Findings by both were compared for concordance on malignant or premalignant lesions.* ***Results:*** *The image quality was adequate to support remote diagnosis of GI cancer and abnormal lesions by an experienced observer. However, assessment of the esophagogastric junction for Barrett's esophagus was equivocal.* ***Conclusions:*** *Overall, our tele-endoscopy setup shows great promise for remote supervision or observation of endoscopic procedures done by nurse endoscopists. Tele-endoscopy is both adequate and feasible for diagnosis of most gastrointestinal lesions. Subtle lesions still may be missed in our current setup. However, improvements are being made in our setup to address the problem with resolution prior to further evaluation.*

INTRODUCTION

Telemedicine was first marketed as a tool to mitigate perceived inequality of heath care delivery caused by distance and other issues of accessibility. While telemedicine pilot projects began in the late 1960's, very little interest in sustainable programs was generated outside of the military until the late 1980's and early 1990's when such diverse projects as the Kansas University Medical Center link to the Hays Medical Center, the MedNet Project of Texas Tech University, and the Medical College of Georgia telemedicine program were developed.[1,2]

Accessibility to quality health care is still a major driving force behind the proliferation of telemedicine projects, but other factors are now supporting the growth in use of telemedicine to deliver care. First, technology and telecommunications have improved to a point in which image quality and speed of transmission make feasible the use of telemedicine for diagnosis and management of remote patients. Second, patients are becoming more active participants in their own health care and may defect to another provider if a specialist referral involves inconvenient travel. Third, while telemedicine consultation, for the most part, is still not reimbursable under Medicare, Medicaid, or by major third-party payers, managed care is making its use more cost-effective.[1,2]

Coastal Cancer Control Program (S. Carolina)
Medically underserved populations exhibit the highest cancer incidence and mortality rates. The need for cancer control and prevention is acute in the South Carolina coastal counties, which have a high level of poverty in both urban and rural populations. For example, Coastal South Carolina's incidence rate for squamous cell carcinoma of the esophagus is one of the highest in the world, and the state leads the nation in mortality from this disease.

The Coastal Cancer Control Program was inaugurated in 1996. Its principal thrust is to demonstrate ability to provide subspecialty medical care at remote sites. The extension of specialty expertise will be accomplished by using telemedicine technology and physician extenders to provide screening, early diagnosis, and treatment to a population whose members have inadequate access to medical specialist care, and thus typically present with late-stage thoracic cancers, including esophageal cancer.

Supervision of Endoscopy by Non-Physicians
An economical means of screening a remote population would be to have physician extenders, such as nurse practitioners or physician's assistants, perform the screen. For esophageal cancer and premalignant lesions (Barrett's esophagus), a direct visualization with an endoscope is the most effective diagnostic tool.

Physician extenders are being trained and are able to perform both upper and lower GI endoscopy. However, regardless of the degree of competence after training, a required level of supervision is set by the particular state board of nursing.[3] In South Carolina, the State Board of Nursing requires a nurse endoscopist to be an advanced practice nurse. In addition, the collaborating physician must be within a 45-mile radius. Extent of practice is dictated by protocols agreed upon between the collaborating physician and the advanced practice nurse.

Endoscopy
Flexible endoscopes have dramatically improved the diagnosis and therapy for certain disorders of the digestive tract. Fiberoptic instruments were developed in the late 1960's. In the 1990's, the fiberoptic bundles of these instruments have been for the most part supplanted by a CCD (charged coupled device) or "video" chip. The video endoscope enables the transmission of the image to a television monitor, which enhances color definition and field of vision. In addition, multiple observers besides the endoscopist can view the image, which enhances teaching and patient care.[4]

In the past, observers of the endoscopic procedure were limited to being in the same room of the procedure. Now with advances in telemedicine the procedure can be transmitted to observers outside the room and even outside of the institution where the endoscopy is being performed. This has spawned the birth of "tele-endoscopy."[1]

The instrumentation involved in performing a routine endoscopic procedure is identical to that needed for tele-endoscopy. Therefore, there is no learning curve on the part of either the endoscopist (whether a gastroenterologist or a physician extender) or the remote observing gastroenterologist. The technology needed to transmit the images has been widely used and evaluated. The majority of these have been in the field of radiology and greyscale images rather than the color images used in gastrointestinal endoscopy. In fact, there has been only one reference in the literature through 2000 about the use of tele-endoscopy as a viable component of telemedicine supporting gastroenterology.[1]

We are completing training of a nurse practitioner (TFG) in performing an unsedated screening upper endoscopy for esophageal cancer and Barrett's esophagus. Our goal is to enable her to perform screening upper endoscopies at a remote location with a collaborating physician observing from a tertiary medical center. Therefore, a small feasibility study was undertaken to observe the quality of remote endoscopic procedures.

METHODS

In a recent article describing a staged approach to the evaluation of telemedicine, DeChant, et al. suggested that accuracy and reliability must first be assured before other forms of evaluation can take place. The second stage of the evaluation should include access, quality and cost.[5]

This study was the first evaluation of the accuracy and reliability of a tele-endoscopy system. This evaluation falls under the category of an early "proof of concept" study that tests the basic feasibility and logic of tele-endoscopy in gastroenterology.[6]

Image quality
For this evaluation, the image quality was evaluated based on a review by two experienced endoscopists at the Medical University of South Carolina concurrently observing the endoscopic procedure performed at the Ralph H. Johnson VA Medical Center. Both medical centers are located in Charleston, SC. For tele-endoscopy to be effective, the image appearing to the observing gastroenterologist through video transmission must replicate the image actually seen by the endoscopist performing the procedure.

The observing gastroenterologist was given the indication for the procedure. No identifying information about the patient was given with the video transmission or to the observing gastroenterologist. Then both the endoscopist (or nurse endoscopist) and the observing gastroenterologist were asked to record their findings (positive or negative), and these were compared for concordance. In addition, the observing gastroenterologist was asked to comment on the quality of the received video transmission.

Because the focus of this project was on cancer, the significant findings to be evaluated were colon cancer or polyps on the lower endoscopy (colonoscopy or flexible sigmoidoscopy) and esophageal/stomach cancer, ulcers, and Barrett's esophagus.

Technology

All endoscopic procedures at the Ralph H Johnson VA Medical Center were performed using an Olympus GIF-140 (upper digestive tract) or a CF-140 (lower digestive tract) video-endoscope attached to CV-140 video processor and a CLV-U40 light source. The images were displayed on a 19" Olympus OEV202 monitor (a Sony Trinitron monitor). Through control of the Polycom 512 Viewstation, the endoscopist could transmit either the endoscopic video transmission or the external video camera image on the Polycom unit showing the endoscopy room, patient, or endoscopist. However, both views could not be sent simultaneously.

The core telemedicine system is based on the use of four Integrated Services Digital Network (ISDN) lines that will transmit two-way audio and video at a combined rate of 512kbps. Our project required the use of existing communication technology that could be used in remote locations in the Southeastern United States. ISDN lines are fully developed technology that has been around for many years and is available worldwide. Similar to telephone lines, ISDN lines require only one pair of twisted wire per line, effectively transmitting 128 kbps, the equivalent of two 56k modems per wire pair.

Recently Polycom, Inc (http://www.polycom.com) developed a four-channel ISDN system that could easily be transported in a handheld carrying case and connected to virtually any standard television set. At the VA Medical Center, the Polycom 512 system has been installed, is easy to operate and pre-configure, and can be connected in less than a minute. The combination of ease of operation and quality of images enables the nurse endoscopist to concentrate on the care of the patient. This device has a built-in camera that produces an excellent image and may be used by the remote physician to evaluate the patient or to observe the nurse endoscopist's technique. The system also allows the user to take high quality still images that can be transmitted on the system using Microsoft's NetMeeting program or another third-party collaboration software.

At the Medical University of South Carolina, the remote signal is received by a Primary Rate Interface Gateway developed by First Virtual Corporation, Inc. (http://www.fvc.com) that connects via Asynchronous Tranfer Mode protocol to a 25 Mbyte network switch made by FVC. The host computer uses a FSA 1000 ISA network interface card (NIC) also by FVC. The host computer is a Dell Optiplex Gx1 with a Pentium II 400-MHz processor and 128 megabytes of ECC RAM (greater reliability in high-energy areas close to radiological equipment). The videoconference Z240 codec was developed by Zydacron, Inc. (http://www.zydacron.com) and is directly integrated with the NIC card by use of a mother-daughter card and a 40-pin flat ribbon connector. The Z240 codec does only include an S-video connection and not an NTSC connection. The monitor used by the observing gastroenterologist was also a 19" Sony Trinitron monitor.

FINDINGS

Ten (10) patients were evaluated over a 9-workday period. There were 5 upper endoscopies and 5 lower endoscopies (4 colonoscopies and 1 flexible sigmoidoscopy). In every case, there was significant pixellation (visible squares of solid color as a result of the JPEG/MPEG compression) noted in the video transmission, but for the most part did not affect noting the final diagnoses or significant lesions (except one specific instance).

Lower endoscopies

For these procedures, polyps (potentially malignant lesions) and cancers were considered significant findings. Of the 5 lower endoscopies (4 colonoscopies and 1 flexible sigmoidoscopy), two showed neither polyps nor cancer. One had just one polyp; the remaining two cases had multiple polyps, which were all easily noted on the observing side. In addition, one of the colonoscopies with multiple polyps also had a colon cancer, which also was easily noted.

Overall, the 5 lower endoscopies showed 100% concordance for significant lesions. The only real difficulty for the observation end was determining the location of the colonoscope, especially when polyps were seen, because the length of the endoscope inserted into the patient was not available unless requested.

Upper endoscopies

For these procedures, cancers and ulcers were considered significant findings. In addition, the ability to observe clearly the esophagogastric (EG) junction was important because of the increased risk of developing esophageal cancer in the presence of Barrett's esophagus (seen as a projection of salmon-colored/red mucosa from the stomach into the mucosal lining of the esophagus). Of the 5 upper endoscopies, one had an esophageal cancer, and another had a benign ulcer, both of which were seen by the observer. The ulcer, because of its red color, was not seen on the initial pass by the observer but was seen on the second pass.

However, when evaluating the EG junction, the observer had difficulty in seeing the boundary clearly in 2 of the 5 cases. In these difficult cases, the color difference between the esophagus and stomach were subtler. Although there were no cases of Barrett's esophagus in these patients, the inability to see this boundary clearly in almost half the cases limits its usefulness, especially when screening for this condition as a premalignant condition.

Overall, the 5 upper endoscopies had 100% concordance for cancer and ulcers as well as for minor lesions, such as vascular ectasias and gastritis/duodenitis. However, when assessing the EG junction, the difficulty in seeing the border between the stomach and the esophagus in 2/5 cases may limit the effectiveness of screening for early esophageal cancer.

The resolution of the video transmission for lesions that could be viewed was excellent. The observer could easily see 1mm (~1cm large on monitor) vascular ectasias or scope trauma without any comments from the endoscopists in one case.

Unlike colonoscopy, upper endoscopy allows for easy determination of location because of the different appearance of the esophagus, stomach, and small bowel. Again, inability to see the markings on the endoscope makes it impossible to tell if a lesion (such as tumor) is located in the upper, middle, or lower esophagus unless another landmark is present. In this case, it would be reasonable for the observer to ask the endoscopist for the length of insertion of the endoscope.

Other notes

For both upper and lower endoscopies, when the bright xenon light source is reflected off the gut wall an intense red color is displayed if the endoscope is too close to the wall. As noted above, a significant amount of pixellation was obvious. The best visibility occurred when the endoscopist did not move too quickly and avoided being too close to the gut wall. Although this observation could result in a change in the endoscopist's manner of performing the procedure, an improvement in video transmission resolution will likely make such an adjustment unnecessary.

At the speed of 512kbps on the ISDN line, there was no evidence of jerkiness in the motion of the endoscope in the gut.

During this period, two service breaks (one at the VA, and one at MUSC) in the ISDN line resulted in the connection not being available for 2 of the 9 workdays.

DISCUSSION

Overall, it appears our tele-endoscopy setup shows great promise for remote supervision/observation of endoscopic procedures done by nurse endoscopists. With the small sample size, it is too early to make any conclusions except that the tele-endoscopy setup is definitely feasible. In comparison with the only other previous study for tele-endoscopy done in Vermont,[1] our results appear similar and support that tele-endoscopy is viable. Our study is smaller (10 vs. 30) and is still preliminary, and we do not yet have adequate information for cost analysis.

However, our studies do differ in that the Vermont study focuses on using tele-endoscopy to assure rural primary care providers that their flexible sigmoidoscopy exams were adequate (although the study itself used rural gastroenterologists as the ones observed). Our study is focused 1) on upper endoscopies to screen for esophageal cancer rather than colorectal cancer; and 2) provide required supervision of a nurse endoscopist without the physical presence of the collaborating (supervising) physician.

There are two major issues that need to be addressed still in this feasibility evaluation stage. Obviously, the blockiness (pixellation) is a serious problem that needs to be addressed before any further evaluation can be done. In discussion with Polycom and Zydacron companies, it appears that the problem lies in the Zydacron Z240 codec setup. In our setup, the Zydacron Z240 codec integrates with the monitor. The VGA output goes into the Zydacron codec, and the output of the codec goes to the monitor. Zydacron acknowledged a problem with this setup and in the current generation videoconferencing board, the Z360 (~$3000), they have included an NTSC output that bypasses all of this and sends the H.320 output directly out the back of the card, thereby eliminating the pixellation. If this is the case, then we eagerly await re-evaluation of the tele-endoscopy setup with a larger study.

A second problem appears to be the downtime of the ISDN due to circumstances beyond the control of the VA endoscopy suite or the MUSC observation center. In a larger study with more cases over a longer period of time, a better assessment of reliability can be determined. Obviously, this link is *sine qua non*.

After a larger feasibility study is performed focusing on the upper endoscopy and the EG junction to screen for Barrett's esophagus, then the next stage of evaluation will have to address issues, such as access, quality and cost. The access will involve a study in sending the nurse endoscopist to a remote center in a small town and establishing an ISDN connection from there with the same videoconferencing equipment.

Also in the future, we plan to test a second monitor in the form of a digital palette (Wacom PL-400, 13.3" LCD screen), which will allow the physician to annotate the images and send notated images back to the nurse endoscopist. The tablet's light weight (6.4 lbs) boosts portability, and its interactivity would enable communication between the nurse endoscopist and the collaborating gastroenterologist even if the audio link were weak (not a problem in this small trial).

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REFERENCES

[1] Moses PL, McGowan JJ, Ricci MA. Efficacy of Tele-Endoscopy in a Rural Capitated Market. Proc AMIA Annu Fall Symp 1997:398-402.

[2] Crump WJ, Pfeil T. A telemedicine primer: An introduction to the technology and an overview of the literature. Arch Fam Med 1995;4:796-803.

[3] American Society for Gastrointestinal Endoscopy (ASGE) Guidelines for Clinical Application. Endoscopy by Non-Physicians. Gastrointest Endosc 1999;49:826-828.

[4] Cotton PB, Williams CB. Practical Gastrointestinal Endoscopy. Fourth Edition. Oxford: Blackwell Science Ltd, 1996.

[5] DeChant HK, Tohme WG, Mun SK, Hayes WS, Schulman KA. Health systems evaluation of telemedicine: A staged approach. Telemed J 1996;2:303-312.

[6] Field MJ (ed.). Telemedicine: A Guide to Assessing Telecommunications in Health Care. Washington DC: National Academy Press (Institute of Medicine), 1996.