# Teleconferencing Bridges Two Oceans and Shrinks the Surgical World

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Endoscopic surgery has led to changes in surgical practice which may rival the introduction of anesthesia and antibiotics in significance. As a result, an exciting synergy has rapidly emerged between technology and clinical practice. However, questions of training, credentialing, and patient safety have been raised as traditional procedures have been adapted to the minimally invasive approach and new ones are described. Many surgeons have been reluctant to venture beyond laparoscopic cholecystectomy. Halting first efforts at advanced procedures may prolong operative times, increase risk, and raise costs. Older methods of surgical education are not adequate to meet the current need (Fig. 1).

Equally exciting advances in telecommunication may provide the means to address these concerns. Although currently in its infancy, teleconferencing may soon become as common in the workplace as copiers and FAX machines are today. The adaptation of advanced telecommunication systems to the dissemination of surgical innovation is a logical next step (Fig. 2). In its fully realized form, "Telementoring and Teleproctoring," an experienced surgeon can use real-time, two-way audio-video systems to guide another surgeon through his early cases (Fig. 3). As it employs televised images, endoscopic surgery is ideally suited for this approach. Such linkages between proctor and student will be significantly more cost-effective and less disruptive to the proctor's practice than the current approach.

Phase I trials of this concept were carried out by one of us (JCR) in Detroit, Michigan, earlier this year.[1] Two-way audio-video communication was enhanced by CD-ROM, "instant-replay" video tape, and "Surgistrator" technology connecting a control truck on the grounds of a hospital to an operating room (Fig. 4). Phase II trials were recently completed (JCR & JHP) in Hawaii where this technology was used within and between two hospitals for the performance of laparoscopic Nissen fundoplications.[2]

To gain experience with long distance teleconferencing and as a prelude to full-capability international telementoring and proctoring, the following demonstration was arranged.

## TELECONFERENCING DEMONSTRATION

The goal of the demonstration was to test the possibility of surgical teleconferencing through commercially available systems. Contact was established between Maastricht, The Netherlands, and Honolulu, Hawaii, using established telephone and satellite links. Sixteen thousand kilometers and two oceans were shrunk to the dimension of a television monitor, as a laparoscopic cholecystectomy performed in Maastricht (PG & RMS) was monitored in Hawaii (JHP & JCR). This relatively "routine" operation was chosen to test the system while providing an extra margin of safety for the patient. Fully informed consent was obtained for this patient as it was for all those in the other trials. Special attention was focused on the resolution and synchronization of the "real-time" audio and video images exchanged.

In the operating room in Maastricht, two cameras were used to capture the operation. One camera recorded the surgical team and the operative field. The other camera was a three-chip CCD (Stryker, Uden, The Netherlands) connected to the laparoscope. These cameras transmitted the same images to the two surgeons, half a world apart. The transmission began as the audio and video signals were fed to a coder/decoder (CODEC) device (PictureTel International Corp, Danvers, Mass.). The CODEC then converted the images into digitized data and compressed them at a ratio of approximately 800:1. The compression algorithm refreshed the images of moving people and surgical instruments more frequently than those of the static background elements. The synchronization of voice and picture was another goal of the algorithm. The CODEC can translate PAL and NTSC signals to digitized data in both directions. This eliminates conversion problems between the television formats standard in the two countries. PTT Telecom, the Dutch national telecommunication service, transmitted the compressed, digitized data through the Integrated Services Digital Network (ISDN). ISDN transmission is circuit-coupled in a more rapid version of regular telephone lines. ISDN-2 lines permit simultaneous 2 x 64 Kbit/sec data transfer. It can be transmitted via ground lines or communication satellites. For this demonstration, two numbers in Hawaii were dialed (ISDN-2) and another compatible CODEC decompressed the data to images with a resolution of 352 x 288 pixels. Each transformation of image to compressed data by the CODEC takes 350 msec. Satellite transmission adds an additional 250 msec per connection. Consequently, a delay of 750 msec was noted in each direction. The interlaced image was built at a relatively low resolution of 352 x 288 pixels. The images were refreshed at approximately 15 frames/sec, depending on the content. Static objects, such as background features, were in sharp focus, but rapid movement produced blurred images.

## EVALUATION

The laparoscopic cholecystectomy in Maastricht was uneventful and quite successful. The surgeons were quite pleased with the experience. Numerous observers in both sites were also impressed with the technology and the potential of the concept. The patient was discharged in excellent condition on the second postoperative day. This is the typical hospital stay for laparoscopic cholecystectomy in The Netherlands.

During the operative procedure, a vivid interaction was possible. There was a rapid adaptation to the 1.5 sec time delay. The slight lag between sound and video was easily overcome in normal conversation. Each surgeon quickly learned to wait for a response to his remarks. This was especially apparent when a humorous comment resulted in a delayed laugh from the other side.

For teleconferencing, this delay was tolerable. However, for more complex telementoring, proctoring, robotics, or actual telesurgery, this delay may prove to be a real issue. With robotics in particular, any time delay could result in inaccurate control of a device which could possibly endanger the patient. As the speed of data transfer and related software improve, this delay should be reduced.

Image quality is determined by the number of pixels and lines, image refreshment rate, and the number of gray/color levels. Therefore, high image quality requires a broad transmission band. One ISDN line can

Figure 1. The old ways of learning are rapidly being replaced.

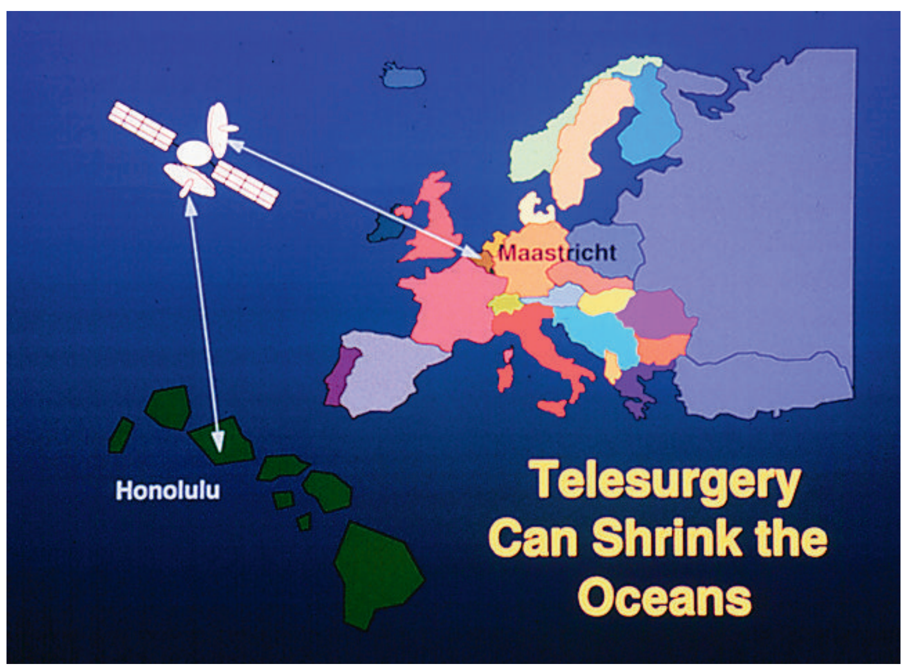


Figure 2. Evolving technology will continue to erode international barriers and enhance the sharing of new skills and procedures.

transmit 64 Kbit/sec. The ISDN-2 line used in our demonstration provided twice this rate of data transfer. It was adequate for two experts to discuss the operation. In the actual telementoring and proctoring setting, faster data transfer and higher resolution are manditory. This was the case for the Phase I and II trials cited above. ISDN-32 lines will permit data transfer at 32 x 64 Kbits or 2 Megabit/sec. Newer satellite systems permitting 1 Gbit/sec are about to come on-line. Faster data transfer may increase the cost of telementoring in the short term.

The major expense of establishing teleconferencing systems is in providing compatible CODECs and establishing the telephone and satellite linkages. Many of these lines are already in place for computer data transmission. For this demonstration, the ISDN-2 line from Maastricht to Honolulu cost $150/hr/line. This is certainly less than the cost of transportation if on-site proctoring were undertaken.

## CONCLUSIONS

This demonstration has shown that international surgical teleconferencing is both possible and safe. The improved resolution required for true telementoring and proctoring is becoming available. The legal and ethical issues involved are the subject of intense study as the project proceeds.

Through cooperative efforts such as this and the other projects described, advanced telecommunication systems may provide the next great breakthrough in surgical training (Fig. 5). It will bridge continents and shrink oceans in ways limited only by our imagination. The very real concerns raised with the introduction of any new technology (Fig. 6) are the subject of continued study.

## REFERENCES

1. Rosser JC. Phase I Telementoring and Teleproctoring Feasibility Study 1994. In press.
2. Rosser JC, Payne JH. Phase II Telementoring and Teleproctoring Feasibility Study 1994. In press.


Figure 3. These elements are critical to smooth interaction and a safe operation for the patient. The surgeons must clearly understand the procedure and communicate within a standardized format.

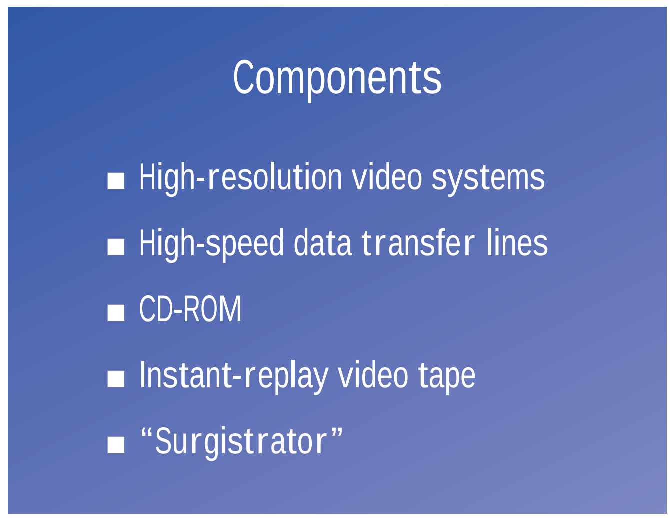


Figure 4. The image which the Teleproctor sees must be equivalent to that of the operating surgeon. Access to CD-ROM and instant replay permits review of critical steps. Using the "Surgistrator" allows the Teleproctor to highlight anatomical landmarks and danger points as the case progresses.


Figure 5. The applications are limited only by our imagination. Every area of medicine will benefit.


Figure 6. These concerns are being addressed by demonstration projects around the world. We must keep the safety of the patient as our primary concern.