Feasibility of Laparoscopic Telesurgery

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Abstract. A telesurgical system was created to allow an endoscopic specialist at a remote site to offer guidance and assistance to a surgeon during laparoscopic surgery. The remote and operative sites were connected by a single T1 link. The system provided real-time video, audio, telestration, and robotic arm control of the laparoscope. Seven patients underwent successful procedures using this system. This study demonstrates the feasibility, effectiveness, and safety of telementoring.

1 Introduction

Laparoscopy is the most familiar of the therapeutic approaches referred to as minimally invasive surgery. Laparoscopy offers advantages over open surgery including less postoperative discomfort, shorter hospitalization, reduced convalescence, and improved cosmesis [1,2]. As the popularity of laparoscopy has grown, data has emerged indicating that major complications occur more commonly during a surgeon’s initial cases (learning curve). The challenge is to avoid the complications associated with relative inexperience. Telemedicine may provide a solution for creating a uniform standard of care for laparoscopy.

A telesurgical system would allow an endoscopic specialist at a remote site to offer guidance and assistance to a surgeon during a laparoscopic procedure. The authors first tested the premise for telesurgical mentoring by establishing a remote site within the same hospital as the operating room (OR) [3]. All of the remote components were directly wired to their sources in the OR. More than 30 procedures were performed demonstrating that telesurgical consultation was effective and safe. This report represents the initial experience with telesurgical consultation between two hospitals. Packaged in a personal computer (PC), and requiring only a single high-bandwidth telecommunications link, such a system may represent a method for guiding surgeons through the final stages of the learning curve without requiring travel by the mentor or trainee.

2 Methods

The remote site was located at the Johns Hopkins Hospital. The local site was 3.5 miles away in an OR at the Johns Hopkins Bayview Medical Campus. The OR had been outfitted with a dedicated T1 line operating at 1.544 Mbps with the
associated Data Service Unit/Channel Service Unit (DSU/CSU). A 120 MHz Pentium computer with a video compression/decompression (CODEC) board and communications board comprised the core of the design. The Windows 3.x compatible software application (ICE, Inc., Reston, VA) had been custom developed for this particular purpose. The inputs to the CODEC included a balanced microphone, S-video input from the endoscope, composite video input from the external room camera, and VGA input. The outputs included an amplified speaker, RS-232 camera control, and VGA signal.

Because the current design for the telesurgical system required 30 frames-per-second of video update, the video input was coded under the H.261 coding algorithm and converted into the Quarter Common Intermediate Format (QCIF). This provided 176x144 pixels of resolution. The CODEC then compressed the picture under the H.261 standard using a Discrete Cosine Transform algorithm.

The audio input to the CODEC board was achieved via a hi-impedance microphone. The CODEC was capable of conforming to the G.711 A law and u law. The control software apportioned the T1 bandwidth and allocated a 128 Kbps high speed data channel for this function. This channel was shared by the audio, external camera control, and telestration data. The audio from the remote site was fed into powered speakers at the local site.

Data output from the CODEC was fed into a V.35 communications board (Zydacron, Inc., Manchester, NH) which processed and formatted the data for the DSU/CSU to interface to the T1 link. The T1 link utilized an extended superframe format for framing of the data, and a Binary 8 Zero Substitution signaling technique. This ensured rapid and reliable data transfer. The T1 line was connected to the DSU/CSU interfacing the V.35 board.

The remote site was equipped with a 90 MHz Pentium computer with identical CODEC and communication boards as that of the local site. A PC camera and microphone were available for routine teleconferencing. The conventional mouse was replaced with a pen/pad assembly connected to the COM port.

The custom software allowed the remote physician to control the pan, tilt, zoom, and focus capabilities of the external camera in the OR. The software could switch the video source between the external and endoscopic views. The pen/pad assembly allowed annotation over the video screen. These annotations appeared on both the local and remote monitors within one second. A software echo cancellation button enabled the audio echo cancellation feature of the CODEC board and resulted in high quality audio.

A surgical robot (AESOP 1000, Computer Motion, Inc., Goleta, CA) at the local site stabilized the endoscopic camera. For this system, the remote surgeon was capable of driving the robot via a hand controller located at the remote site. Remote control of the robot had been integrated into the system and the data was transmitted via the T1 line. The surgeon at the local site could override the remote control with a foot control.

The remote surgeon could also activate the electrocautery. A command generated at the remote site caused a normally open relay to close in a switch box (Dataprobe, Paramus, NJ) at the local site. These relays were connected in par-