

Laparoscopic Telesurgery Between the United States and Singapore

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Abstract

Introduction: *Telemedicine is the use of electronic digital signals to transfer information from one site to another. With the advent of a telepresence operative system and development of remote robotic arms to hold and manoeuvre the laparoscope, telemedicine is finding its role in surgery, especially laparoscopic surgery. Clinical Features and Treatment:* *We report two successful cases of laparoscopic surgery—radical nephrectomy and varicocelectomy for a 3-cm renal tumour and for bilateral varicoceles causing pain, where a less experienced laparoscopic surgeon in Singapore was telementored by an experienced laparoscopic surgeon located remotely in the United States. Both patients recovered uneventfully and returned home on postoperative day 4 and on the day of surgery, respectively. Outcome:* *This study demonstrates that telementored laparoscopic systems are feasible and safe, between countries halfway across the world. Conclusions:* *As the Internet expands in utility and the cost of higher bandwidth telecommunication lines decreases, even to remote countries, telementoring systems will become more affordable and may potentially pave the way for advanced surgical and laparoscopic applications and training for the future.*

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Introduction

Telemedicine is the use of telecommunication technologies to provide medical information and healthcare services. Early applications include medical use of the telephone and facsimile. Presently, telemedicine use had increased to facilitate remote clinical consultation. Interest in the field has increased dramatically in the 1990s. There is tremendous potential application to the future practice of medicine. Possible applications range from simple radiographic consultation to complex telerobotic surgery.

Telemedicine is composed of a diverse integration of technologies and clinical applications. The defining aspect of telemedicine is the use of electronic digital signals to transfer information from one site to another. These techniques have been under development for nearly 35 years. Wittson and colleagues were the first to employ

IATV (interactive television) for medical purposes in 1959 when they used a microwave link for telepsychiatry consultation.¹

The adaptation of this telecommunication technology to a dissemination of surgical innovation is seen as the next logical step. With the advent of a telepresence operative system, telemedicine is finding its role in surgery and gaining recognition, especially in the field of laparoscopic surgery.² Because laparoscopic surgery already utilises video images, the integration of a telecommunications interface to transmit digital signals to a remote location was achievable and formed the foundation of the first clinically utilised telesurgical system. In addition, robotic arms have been constructed to hold and remotely manoeuvre the laparoscope.³ As was demonstrated by Janetschek et al,⁴ it is feasible to remotely position the robot across 2 continents

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to control the video camera and subsequent image (Table I).

One application for telesurgery is postgraduate surgical training in two forms—telementoring and teleproctoring. Telementoring is when an experienced laparoscopic surgeon can use real-time, two-way audio-video systems to guide another surgeon through a surgical procedure. In teleproctoring, the experienced surgeon would observe from a remote site and document the performance for privileging purposes.^{5,6}

We would like to report 2 cases of laparoscopic surgery—nephrectomy and varicocelectomy—where a less experienced laparoscopic surgeon in Singapore was telementored by an experienced laparoscopic surgeon located remotely in the United States.

Method

The objective of the project was to evaluate the telepresence operative system for telementoring between two continents, Asia and North America. Ethics committee / Institutional Review Board for Human Subjects Research approval from both institutions and patient informed consent were obtained. Medical indemnity insurance was available to insure the project, the telementor, surgeons and all parties involved.

On the 8 December 1998, transcontinental interactive laparoscopic teleoperation was performed between Singapore and the United States. Two cases of laparoscopic surgery were carried out in National University Hospital, Singapore, while the telementor (LRK) assisted in the surgery from the remote operating room at the Johns Hopkins Medical Institutions, Baltimore, Maryland, USA.

Two video cameras were used to capture the operation. The laparoscope camera displayed the operative field of

view and an external view camera recorded the surgical team and the operative field. The laparoscope was attached to the AESOP (Automated Endoscope System for Optimal Positioning, Computer Motion, Goleta, CA) robotic arm via a magnetic coupling device. Microphones were used at both sites to provide real-time full duplex audio communication, giving the mentor and surgeon continuous interactive information. Telestration also allowed the telementor to draw on the monitor of the screen and demonstrate significant anatomic structures and points of interest to the operating surgeon. The telementor also had control over the robotic arm as well as an activation switch of the electrocautery machine. However, as a safety measure, a control switch located in the primary operating room could override these devices. A total of 6 ISDN lines were used to establish the link between Singapore and the United States in order to provide sufficient bandwidth for data transmission.

Software was written by ICE Communications (Reston, VA, USA) and an image transfer routine allowed digitised X-ray images to be transmitted to the remote surgeon to review the patient's films prior to the procedure.

Results

The first case was a needlescopic-assisted varicocelectomy performed on a 20-year-old male with bilateral varicoceles causing testicular pain. A 5-mm 30° laparoscope was used, remotely controlled by the telementor. The operation was uncomplicated and the patient was discharged the same day. The second case was a 41-year-old man with end stage renal failure. He had an incidental 3-cm solid mass at the right lower pole kidney detected on ultrasound examination. Laparoscopic nephrectomy was carried out with assistance of the telementor. The procedure was approximately two hours

TABLE I: TABLE SHOWING TELESURGICAL PROCEDURES BETWEEN JOHN HOPKINS, BALTIMORE AND VARIOUS OVERSEAS CENTRES

	Bangkok, Thailand	Innsbruck, Austria	Bangkok, Thailand	Rome, Italy	Singapore
Procedure	Laparoscopic (Lap) varicocelectomy	Lap adrenalectomy	Lap nephrectomy	Lap varicocelectomy	Lap nephrectomy, Lap varicocele
Distance	10,880 miles	5,083 miles	10,880 miles	4,461 miles	9,641 miles
Bandwidth	3 ISDN lines (384 kbps)	3 ISDN lines (384 kbps)	3 ISDN lines (384 kbps)	3 ISDN lines (384 kbps)	4 ISDN lines (512 kbps)
Remote functions	AESOP robot, telestration	AESOP robot, telestration	AESOP robot, telestration cautery	AESOP robot, telestration	AESOP robot, telestration, image transfer, cautery
Delay	<1 s	<1 s	<1 s	<1 s	<1 s
OR time	45 min	2 h	1 h 25 min	1 h 45 min	2 h, 1 h
EBL	minimal	minimal	minimal	minimal	minimal

EBL: estimated blood loss; OR: Operating

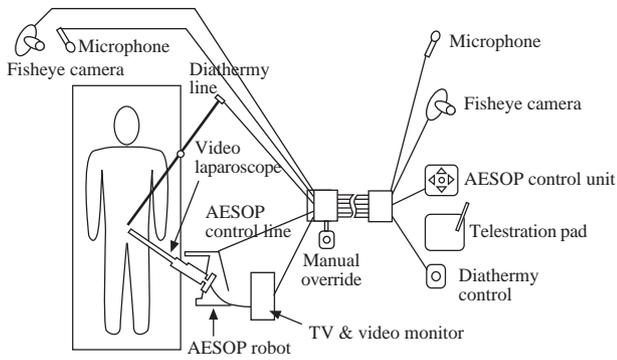


Fig. 1. Schematic diagram of telesurgery between National University Hospital, Singapore and Johns Hopkins Medical Center, USA.

with minimal blood loss. The patient recovered uneventfully with minimal postoperative pain and went home on postoperative day 4.

Continuous discussion between the remote surgeon and operating surgeon was performed throughout both operations and allowed vivid interaction and exchange of views during the surgery. Remote movement of the robotic arm, activation of the electrocautery switch and transmission of X-ray images were accomplished. A less than 1 s time delay for transmission of sound, video, robotic control and electrocautery activation existed, but both telementor and the operating surgeon quickly adapted within a few movements. Control of both the robotic arm and electrocautery machine were maintained and enabled the telementor to participate actively in the surgery (Fig. 1).

Discussion

Surgery has always been an apprenticeship. One learns from the experience and guidance of others. Telementoring, although in its infancy and technology dependent, is a tool that puts the surgical trainee and the mentor in the same room although physically miles and hours apart.⁷ As newer minimally invasive procedures gain in popularity and complexity and communication means such as the Internet make the world a much smaller place, training and credentialing for surgeons in such techniques allow a radical shift from traditional training methods.

Telementoring, together with telestration, is a system that allows apprentice-type training to occur despite being physically on opposite sides of the world. This system would allow surgeons who have basic skills in laparoscopy through the learning curve. Optimal use of this system would not be to mentor novice surgeons in a novel technique, but more to assist or advise surgeons with basic laparoscopic skills perform a procedure they have familiarity with in an open surgical procedure perform the procedure in a laparoscopic fashion. The recipient surgeon must be qualified to handle any complications that may arise. This

series of telesurgical procedures carried out between two institutions, National University of Singapore and the Johns Hopkins Medical Institutions, USA, clearly proves the feasibility of telementoring halfway across the world. It is also the first time a series of telesurgical procedures was achieved between the United States of America and Singapore. An additional series of general surgical procedures, two laparoscopic cholecystectomies were also performed (unpublished data). During these subsequent two laparoscopic procedures, the roles were reversed. The patient was physically located in the United States, and the remote telementoring surgeon was located in Singapore. Both procedures were completed safely and achieved, for the first time, an inter-continental telesurgical collaboration that demonstrated teaching in both directions.

Such a system would also be beneficial given that medical and surgical training is conducted in different methods in countries in the West. The cost of sending just one trainee to the West incurs considerable financial costs, given the strength of the US dollar compared to most Asian currencies. Such a technology would allow a larger number of trainees to be trained at a time and be more cost efficient, especially for more advanced procedures where patients may not be as easy to come by. A telementoring system, apart from the capital costs, can be switched on and off when an appropriate case comes along. Furthermore, training or even workshops can be conducted from remote locations between countries. Trainees, meanwhile, can provide service to their home countries and get advanced training at the same time.

Telementoring is feasible but has a number of limitations, including initial capital costs, reliability of equipment and availability of stable and reliable communication lines. The failure of a single component can prevent interaction between the mentor and student. The issue of social and legal responsibility needs to be addressed in such situations. In our demonstration, international assurance and legal review throughout this project has provided a precedent and possible foundation for further international surgical procedures. Time differences are also becoming less of an issue as more societies move toward a 24-hour day and flexible working hours. The ability to remotely control the laparoscope and the electrocautery, as well as transmit radiographic images, also demonstrates the feasibility of telepresence surgery across continents.

In conclusion, our study demonstrates that telementored laparoscopic systems are feasible and safe, between countries halfway across the world. As the Internet expands in utility and the cost of higher bandwidth telecommunication line decreases, even to remote countries, telementoring systems will become more affordable and may potentially pave the way for advanced surgical and laparoscopic training for the future.

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