

Application of Telemedicine in Surgery

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Introduction

Telemedicine is being practiced for over 30 years¹. Recent technological advances, however, have expanded the scope of medical interaction that may be achieved. Whereas consultative services, examination of still documents (photos, x-rays, slides, or ECGs), and interactive voice sessions previously defined the state of the art, the telemedical event may now involve “live” manipulations of patients and/or tissues “at a distance”. In fact, there are now many levels of health care-related interaction that may take place in the telecommunications medium: physician-to-physician consultation, physician-to student (physician, nurse, other care giver) teaching, physician-to-patient examination and consultation, and physician-to-patient treatment²⁻⁹.

Telemedicine in surgery, or ‘telesurgery’, has been defined as: ‘Surgery, procedure or technique performed on an inanimate trainer, animate model, or patient in which the surgeon is not at the immediate site of the model or patient being operated on. Visualization and manipulation of the tissues and equipment is performed using electronic devices’¹⁰. ‘Telesurgery’ is an umbrella term covering

educational and professional assessment techniques, surgical discussion among remote participants, and surgery using telemanipulation (the expansion of a person’s movements to a remote location) and telepresence (telemanipulation with added sensory information to make the operator feel that they are physically present at the remote site)¹¹. Besides telesurgery the other applications of Telemedicine in surgery is in the same line as in any other medical disciplines such as teleconsultation, telefollow up, distance education, and teleconference.

Application of Telemedicine in Surgery:

Various applications of Telemedicine technology in surgical practice can be grouped into following categories.

1. Telesurgery
 - Telepresence Surgery
 - Telerobotics
 - Telementoring / Teleproctoring
2. Tele healthcare for surgical patients
 - Teleconsultation
 - Pre referral screening

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- Tele follow up
 - Remote treatment planning
3. Distant surgical education
- Teleconferencing of surgical conferences, CMEs and Workshops
 - Web casting
 - Surgical education portals
 - Interactive virtual class room

Telesurgery (remote surgery)

Surgery, procedure or intervention performed on an inanimate trainer, animate model, or patient, in which the surgeon or operator is not at the immediate site of the model or patient being operated upon. Direct real-time visualization and manipulation of the tissues and equipment is performed using tele-electronic devices.

It may be categorized as follows:

- **Telepresence surgery:** Uses a computerized interface to transmit the surgeon's actions at a surgical workstation to the operative site at the remote surgical unit, with haptic (forced feedback) input to transmit to the surgeon the tactile environment of the operative field.
- **Telerobotics:** Remote control with a robotic arm, usually in conjunction with a laparoscope, without haptic feedback.
- **Telementoring:** An experienced surgeon acts as a preceptor for a remote inexperienced surgeon by observing the

surgeon via interactive video. Teleproctoring is an extension of telementoring, referring to documentation of performance for privileging purposes.

Telesurgery systems currently in practice¹².

Many telesurgery systems are under development but only two are currently available for clinical use.

The first telesurgery system was developed by Green and colleagues at Stanford Research Institute (SRI International, California, USA) in 1992¹³. It consisted of a surgeon's workstation with a high-resolution colour three-dimensional image with adjustable magnification. The system included conventional surgical instrument handles for the surgeon to use placed underneath the viewing screen, so maintaining the eye-hand axis normally present in surgery. There was also stereo audio input and forced feedback grasping, whereby motors in the surgeon's console instruments re-created the amount of resistance being encountered at the remote surgical site. This system was then developed commercially as the MONA telesurgery system (Intuitive Surgical, California, USA), and was later improved and renamed the da VinciTM telesurgery system¹⁴. This is a master-slave telemanipulator, with three modular robotic arms mounted on mobile trolleys

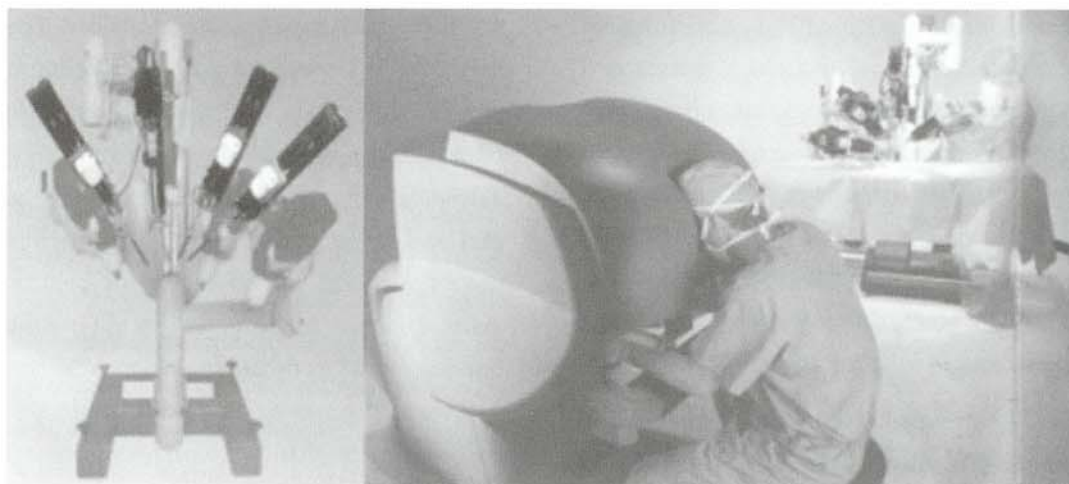


Fig. 1 The da VinciTM robotic system showing master and slave components

that can be wheeled into the operating theatre (Fig. 1) The first operation using the MONA system on humans was performed in Belgium in 1997¹³ and within a year over 150 cardiac procedures had been performed in France using this system¹³. The da Vinci system now uses EndoWristTM technology, giving the arm seven degrees of freedom in its articulated movement, and has two cameras to allow three-dimensional views to be presented through a specialized binocular arrangement^{15,16}.

The ZEUS[®] system (computer Motion, California, USA) is similar in design to the da Vinci system. It has robotic arms on the patient side that attach directly to the operating table, and the surgical site is viewed on a screen by theatre staff. Until the recent inclusion of MicroWristTM technology, giving the instruments a wider range of motion inside the body, standard straight adapted laparoscopic instruments were used (Fig. 2). The ZEUS[®] system uses a voice-controlled automated endoscopic system for optimal

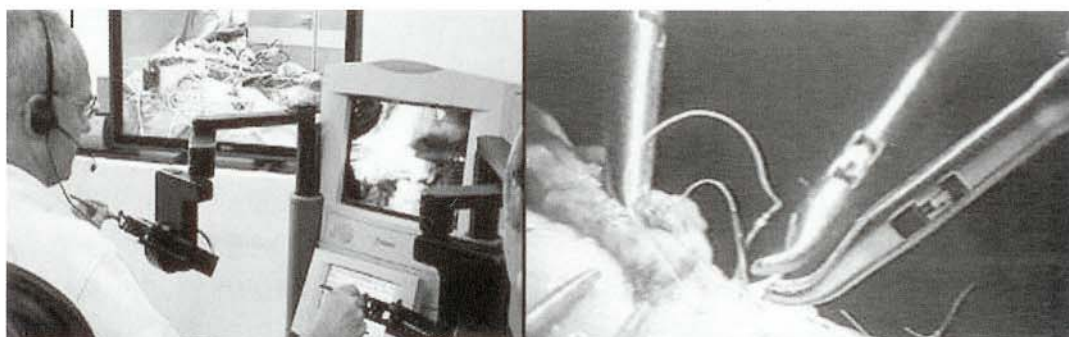


Fig. 2 The ZEUS[®] robotic system used in telemanipulation of laparoscopic instruments

positioning (AESOP®) robotic arm (Computer Motion) to hold a camera and has a range of laparoscopic instruments that attach to the other two arms. The system was first demonstrated in 1996 for remote suturing and performing anastomoses on cadaveric hearts¹⁵, and then in 1999 for coronary artery bypass grafting (CABG) operations in humans¹⁷.

Both systems produced technically successful outcomes, but the da Vinci system had significantly shorter operating times¹⁸.

Telepresence surgery:

Telepresence surgery uses a computerized interface to transmit the surgeons actions at a surgical workstation to the operative site at the remote surgical unit, with haptic (force feedback) input to transmit to the surgeon the tactile environment of the operative field.

In 2001 the first international telesurgery was performed on a patient in France while the operating surgeon was 6500 km away in New York^{19,20}. A remote laparoscopic cholecystectomy procedure was completed successfully using the ZEUS system connected to the remote site by a dedicated high-bandwidth fiber-optic ATM service (10 megabits/s).

Benefits of telesurgery¹²

The potential benefits relate to cost, convenience and enhanced performance. Money might be saved through reduced

travel costs of patients and specialists. The expertise is brought to the patient, with national and international specialists available to advise or treat the patient remotely. Telesurgery may also enhance and extend the skill and range of the surgeon through its use of a robotic interface. In the robotic assisted surgery, the surgeon gets to view the operative field in three dimensional fashion and the camera position can be controlled automatically through voice command. Further, the surgical error is minimized and performance of surgeon is enhanced by reducing fatigue. Many of the precise movements which can not be performed by surgeon has been achieved through robotic assistance.

Concerns about telesurgery:¹²

While the technical benefits to the patients and surgeon are widely accepted the concern about the cost of installing and maintaining a robotic system in an operation theatre is financially not viable at present. Equally important are factors like safety of the procedure, medico-legal, licensing and regulation of its use since telesurgery may involve a number of specialists, hospitals, states or countries. In the event of a complication it may be difficult to establish whether it was due to telesurgeon's mistake or a technical failure of the system. Conversely, it might be considered negligent to withhold access to telesurgery if it is

available. Guidelines have been produced by the Society of American Gastrointestinal Endoscopic Surgeons, who recommends that hospitals defer clinical implementation until the technology has been validated¹⁰. SAGES guidelines concludes - remote surgery remains investigational and should be performed with IRB approval and only by surgeons familiar with the technology. The introduction of telerobotic surgery, coupled with improvements in bandwidth and reduction in time has allowed for the remote safe completion of common surgical procedures²¹⁻²³.

Tele-mentoring:

Tele-mentoring – real-time interactive teaching of techniques by an expert surgeon to a student not at the same site¹⁰ - was first reported in 1965 by Dr DeBakey, who transmitted guidance on open heart surgery from the USA over broadband satellite to surgeons in Europe²⁴. Since then several telementoring trials have been conducted around the world. In March 2004 the first telementoring trial was carried out in India between SGPGIMS, Lucknow and AIMS, Kochi. Surgeons in SGPGIMS assisted surgeons in AIMS Kochi to successfully operate a patient of primary hyperparathyroidism who had two unsuccessful operations in the past. Broadband satellite communication was provided by Indian Space Research

Organisation. Besides broadband telecommunication, excellent picture of the surgical field needs to be grabbed and exchanged in real time with interactive discussion.

Tele-proctoring:¹²

It is mentoring and evaluation of surgical trainees from distance with the involvement of broadband connectivity, power cams, and sophisticated videoconferencing equipment. A real time and live interactive teaching of techniques or procedures by a teleproctor to a student. The teleproctor is in one location and the student is in another. The teleproctor must have the ability to see the performance of the procedure or technique being executed by the student in real time. The teleproctor and the student must have the ability to verbally communicate during the session. Implicit in the definition of teleproctoring is that the teleproctor does not have the ability to physically intervene on-site and can therefore not assume primary patient care responsibility.

Appropriate Use:

- Demonstration and/or teaching technique or procedures using inanimate trainers.
- Demonstration and/or teaching techniques or procedures using animate ex vivo models.

- Demonstration and teaching techniques or procedures on patients as an adjunct teacher when a qualified preceptor is on-site with the student.

Teleconsultation (remote patient evaluation & consultation)

Evaluation of patient(s), and/or patient data, and consultation regarding patient management, from a distant site, using a telecommunications interface. The teleconsultant, by definition, does not have the ability to physically interact with the patient, except through the telecommunications interface.



Fig. 3 Teleconsultation session through ISRO satellite between SGPGIMS, Lucknow and S.C.B. Medical College, Cuttack

Appropriate Use:

- Initial urgent evaluation of patients, triage decisions, and pretransfer arrangements for patients in an urgent/emergency situation
- Intra-operative consultations
- Supervision and consultation for primary

care encounters in sites where an equivalently qualified physician/surgeon is not available

- Routine consultations and second opinions based on history, physical findings, and available test data
- Public health, preventive medicine, and patient education

Teleconsultation and follow up for surgical patients is the commonest application of Telemedicine in surgery currently practised in India. At SGPGI, Lucknow the department of Endocrine Surgery had provided 39 teleconsultations on complex surgical problems to S.C.B. Medical College, Cuttack between March 2003 to January 2005

Teleconferencing¹⁰

Teleconferencing is the discussion and interaction between surgeons during surgical conferences, about surgical cases in a virtual class room environment and live surgery demonstration workshop transmitted through videoconference. One of the widely used technology it has now changed the concept of physical presence in any of the above events. Different kinds of teleconferencing modalities are now in use such as Interactive two way, one way broadcast, web cast etc (Fig.4).

Once the cost of broadband telecommunication comes down and internet technology is advanced more and more



Fig. 4 Shows distant medical education teleconference session through ISRO satellite between SGPGIMS, Lucknow and S.C.B. Medical College, Cuttack

people would like to stay afoot at their place of work and participate in events remotely. SGPGIMS has organised 1st, 2nd, 3rd, telesurgical conferences in the years 1999, 2001, 2003 respectively. In 1st Telesurgical workshop, live surgery performed at SGPGIMS was transmitted online using high bandwidth (384 kbps) ISDN telecommunication link to hospitals located as far as Cochin and to a city hospital for surgeons to view and interact live with the experts while in 2nd and 3rd Telesurgical Workshop Endocrine Surgical procedures was telecasted live to S.C.B. medical college Cuttack, Bangalore via ISDN and VSAT at 384 kbps with interactive question answer sessions. While image quality and operative steps were good enough for observing surgeons to identify pertinent anatomic structures. Also, the interactivity enabled exchange of comments and advice.

References

1. DeBakey ME. Telemedicine has now come of age. *Telemedicine Journal* 1995; 1(1): 3-4.
2. Allen A, Cox R, Thomas C. Telemedicine in Kansas. *Kans Med*, 1992; 93(12): 3235.
3. Satava RM, Simon IB. Teleoperation, telerobotics, and telepresence in surgery. *Endosc Surg Allied Technol* 1993; 1(3): 151-3.
4. Eide T J, Nordrum I. Current status of telepathology. *APMIS* 1994; 102(12): 881-90.
5. Belmont JM, Mattioli LF, Goertz KK, et. al. Evaluation of remote stethoscopy for pediatric telecardiology. *Telemedicine Journal* 1995; 1 (1): 133-150.
6. Mexrich RS, DeMarco JK, Negin S, et. al. Radiology on the information superhighway. *Radiology* 1995; 195(1): 73-81.
7. Sweet HA, Holaday BA, Leffell O, et. al. Telemedicine: delivering medical expertise across the state and around the world. *Connecticut Medicine* 1995 October; 59(10): 593-602.
8. Nakamura K, Takano T, Akao C. Assessment of the value of videophones in community model networks for developing a comprehensive home health care system employing multimedia. Paper presented at the Second International Conference on the Medical Aspects of Telemedicine and Second Mayo Telemedicine Symposium, *Telemedicine Journal* 1995; 1(2): 174.

9. Darkins A, Gough O, Opett L, et. al. Inner city Telemedicine—management of patients with minor injuries by low cost videoconferencing. Paper presented at the Second International Conference on the Medical Aspects of Telemedicine and Second Mayo Telemedicine Symposium, *Telemedicine Journal* 1995; 1(2): 177.
10. Society of American Gastrointestinal Endoscopic Surgeons. Guidelines for the surgical practice of Telemedicine. *Surg Endosc* 2000; 14: 975-979.
11. Simon IB. Surgery 2001, Concepts of telepresence surgery. *Surg Endosc* 1993; 7:462-463.
12. Eadie LH, Seifalian AM, Davidson BR. Telemedicine in Surgery. *Br. J. Surg* 2003;90:647-658.
13. Satava RM. Emerging technologies for surgery in the 21st century. *Arch Surg* 1999;134:1197-1202.
14. Cadieere GB, Himpens J, Germaey O *et al.* Feasibility of robotic laparoscopic surgery: 146 cases. *World J Surg* 2001; 25: 1467-1477.
15. Rassweiler J, Fred T, Seemann O *et al.* Telesurgical laparoscopic radical prostatectomy, Initial experience. *Eur Urol* 2001; 40: 75-83
16. Marescaux J, Smith MK, Folscher D *et al.* Telerobotic laparoscopic cholecystectomy: initial clinical experience with 25 patients. *Ann Surg* 2001; 234: 1-7.
17. Reichenspurner H, Damiano RJ, Mack M *et al.* Use of voice-controlled and computer-assisted surgical system ZEUS for endoscopic coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 1999; 118: 11-16.
18. Sung GT, Gill IS. Robotic laparoscopic surgery: a comparison of the da Vinci and ZEUS systems. *Urology* 2001; 58: 893-898.
19. Marescaux J, Leroy J, Rubino F *et al.* Transcontinental robot-assisted remote telesurgery: feasibility and potential applications. *Ann Surg* 2002; 235: 487-492.
20. Marescaux J, Leroy J, Gagner M *et al.* Transatlantic robot-assisted telesurgery. *Nature* 2001; 413: 379-380.
21. Cheah, W.K., Lee, B., Lenzi, J.E, Goh Pmy. Telesurgical laparoscopic cholecystectomy between two countries. *Surg Endosc* 2000; 14:1085.
22. Link, R.E., Schulam, P.G. and Kavoussi, LR Telesurgery. Remote monitoring and assistance during laparoscopy. *Urologic Clinics of North America* 2001; 28(1) 177-88.
23. Ballantyne, G.H. Robotic surgery, telerobotic surgery, telepresence and telerobotics. Review of early clinical results. *Surg. Endosc* 200; 216: 1389-1402.
24. Allen D, Bowersox J, Jones GG. Current status of telesurgery. *Telemedicine Today* 1997. <http://www.telemedtoday.com/articles/telesurgery.html>.