Application of Telemedicine in Surgery

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Introduction
Telemedicine is being practiced for over 30 years. 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 treatment.

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'. '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). 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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  e-mail: skmishra@sgpgi.ac.in
• Tele follow up
• Remote treatment planning

3. Distant surgical education
• Teleconferencing of surgical conferences, CMEs and Workshops
• Web casting
• Surgical education portals
• Interactive virtual classroom

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 practice**

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 1992. 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 Vinci telesurgery system. This is a master-slave telemanipulator, with three modular robotic arms mounted on mobile trolleys.
that can be wheeled into the operating theatre (Fig. 1) The first operation using the MONA system on humans was performed in Belgium in 1997 and within a year over 150 cardiac procedures had been performed in France using this system. The da Vinci system now uses EndoWrist™ 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. 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 MicroWrist™ 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
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 hearts\textsuperscript{15}, and then in 1999 for coronary artery bypass grafting (CABG) operations in humans\textsuperscript{17}.

Both systems produced technically successful outcomes, but the da Vinci system had significantly shorter operating times\textsuperscript{18}.

**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\textsuperscript{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 telesurgery\textsuperscript{12}**
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\textsuperscript{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 validated\(^\text{10}\). 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 procedures\(^\text{21,22}\).

**Tele-mentoring:**

Tele-mentoring — real-time interactive teaching of techniques by an expert surgeon to a student not at the same site\(^\text{10}\) — was first reported in 1965 by Dr DeBakey, who transmitted guidance on open heart surgery from the USA over broadband satellite to surgeons in Europe\(^\text{24}\). 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:**\(^\text{12}\)

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.

![Teleconsultation session through ISRO satellite between SGPGIMS, Lucknow and S.C.B. Medical College, Cuttack](image)

**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.

**Teleconferencing**

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
people would like to stay afoot at their place of work and participate in events remotely. SGPGIMS has organised 1st, 2nd, and 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


