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An Regional Network Initiation for Surgical Telemedicine Education

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Abstract

Telemedicine is influencing surgical training, allows mentoring, proctoring and teleconferencing. In addition, telemedicine is increasingly being applied to carry out remote surgical procedures. It is anticipated that teleconsultation will bring significant value to health care delivery by increasing professional collaboration, education, and information sharing around individual patient care issues while decreasing the need for patient travel and diminishing professional isolation. This paper presents an initiation of a regional network for a surgical telemedicine education, and two examples are briefly introduced.

Keywords: *Surgical telemedicine education, regional network*

1. Introduction

Telemedicine usually refers to the use of information-based technologies, such as computer and communications systems, to provide healthcare across geographic distances [1]. It is becoming an important component in the provision of healthcare by improving access, quality of services, and reducing cost. Even though the cost of the equipments and technologies is getting lower, today's use of telemedicine is still cost-dependent; however, the fast growth of the Internet and telecommunication makes its globalization more feasible and effective. Surgical telementoring represents an advanced form of telemedicine, whereby an experienced surgeon can guide and teach practicing surgeons new operative techniques utilizing current enabling video, robotics, and telecommunications technology Surgical telementoring is very significant because it can offer a technological solution to surgically underserved areas by potentially increasing the availability of expert consultation to surgeons serving a rural community during their actual operative procedures. It can also potentially enhance surgeons' education, increase patients' access to experienced surgeons, and decrease the complications due to inexperience with new procedures. In the recent decade, efforts to implement the concept of surgical telementoring have greatly increased. Telemedicine is influencing surgical training, allows mentoring, proctoring and teleconferencing. In addition, telemedicine is increasingly being applied to carry out remote surgical procedures. It is anticipated that teleconsultation will bring significant value to health care delivery by increasing professional collaboration, education, and information sharing around individual patient care issues while decreasing the need for patient travel and diminishing professional isolation. This paper

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presents an initiation of a regional network for a surgical telemedicine education. Two examples are briefly introduced and discussed.

2. Related works

IT-assisted surgical telementoring is becoming a new field of surgical telementoring supported by the advanced technology. It may be defined as an experienced surgeon's active involvement (assistance) in a operative-site operation. One example of such active involvement is that an experienced surgeon assists an operation in a operative area by manipulating instruments through the use of remotely controlled robots for handling the laparocopic view. With the increasing accessibility of telecommunication, telementoring has been demonstrated that it improves medical decision making, patient outcomes and medical training [2]. Rosser *et al.* [3] gave an overview of telementoring and teleprotoctoring, and Eadie *et al.* [4] reviewed the current effects on telementoring in surgery. Hoznek *et al.* [5] also reviewed the use of telementoring and it especially focused on the advantages and limitations of all available training modalities in minimally invasive surgery. Marescaux *et al.* [6] provided an overview of the most important advances and issues developing from the use of computer and robotic technologies in surgery as well. Initial reports of surgical telementoring introducing robotics technology were published in 1994 by Kavoussi *et al.* [7]. They used a purpose-built AESOP®, the robotic arm to manipulate a laparoscopic camera during cholecystectomy, bladder suspension and a varix ligation procedure. Moore et al. [8] performed in-house telementoring in 23 urologic laparoscopic procedures. 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 with robotic arm control of the laparoscope. Seven patients underwent successful procedures using the system without complications, demonstrating the feasibility, effectiveness, and safety of robot-assisted surgical telementoring [9,10]. There are also a variety of intercontinental operations introducing surgical telementoring based on robotics technology [11-14]. In most cases, the surgeon remotely operate one or two robots, assisting the surgical team at the site. The surgeon controls only the laparoscope held by the robot to obtain an internal view of the surgical anatomy field. He/she also uses a telestrator to illustrate incision lines, anatomical structures or critical areas visually to the local team. The lag times for transmission of data have all been reported to be less than 200 milliseconds, which is hardly noticed during the procedure [15]. Jannson *et al.* [16] used teleparamedic and telementoring communication platforms and robotic systems to offer full-duplex 2D/3D wireless communication based interactive telepresence, as well as telementoring. Lee *et al.* [17] used a PC-based system utilizing public telephone lines to telementor 27 laparoscopic surgeries between Johns Hopkins Bayview Medical Center and Johns Hopkins Hospital. They also performed three successful international surgical telementoring operations, one in Innsbruck (Austria), and two in Bangkok (Thailand) (which was more than 11,000 miles away). They extended the work to determine the clinical utility of delivering remote subspecialty surgical care using a novel telesurgical mentoring system, and a remote robotic manipulation designed for Percutaneons Access of the Kidney (PAKY) [18]. In the work of Rodrigues *et al.* [19], two procedures between Baltimore (USA) and Sao Paulo and Recife (Brazil) were carried out to assess the safety and feasibility of transcontinental telementored and telepresence surgery. AESOP® was attached to a laparoscope, and the remote surgeon drove the robot via a controller on the remote computer. In the second case, another robot (PAKY) was used

for percutaneous needle placement into the renal collecting system. Bove *et al.* [20] reported 17 procedures telementored between two sites 9230km apart: a primary operating room at the Policlinico Casilino "Tor Vergata" University of Rome (Italy) and a remote site at the Johns Hopkins Medical Institutions in Baltimore (USA) from September 1998 to July 2000. All procedures were performed with the help of two robots: the first robot, AESOP®, for the orientation of the laparoscope, and the second one, PAKY, to perform the percutaneous renal access as well as the remote control of the electrocautery and the telestrator. Figure 1 shows the overview of the proposed telemedicine network initiation for a surgical telemedicine education.

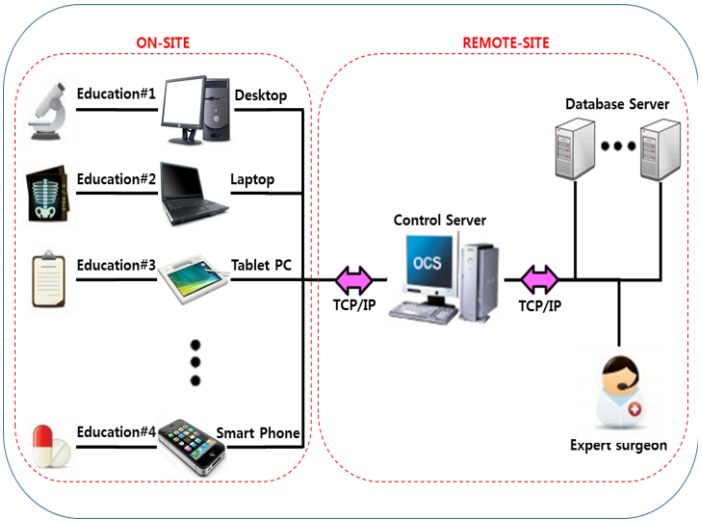


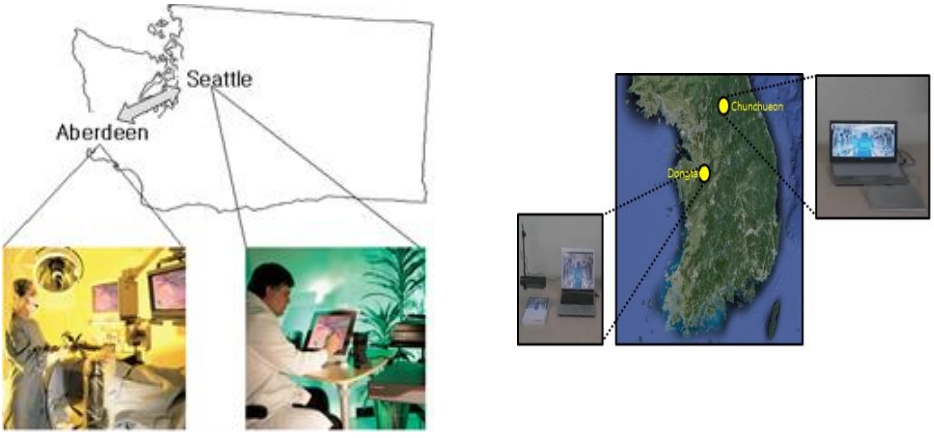
Figure 1. Overview of the proposed telemedicine network initiation for a surgical telemedicine education

3. Examples

The first example as the results is the system based on real-time interactive video-endoscopic telementoring support and robotic assistance. The remote site is located at University of Washington Medical Center (UWMC) in Seattle, Washington (USA). The system as telemedicine link is installed between Grays Harbor Community Hospital in Aberdeen which is the regional Seattle: the operative site is about 115 mile across the state in the operating room (OR) at Grays' Harbor Community Hospital in Aberdeen, Washington (USA). A surgically dedicated industrial system, the SOCRATES™, has been provided to the both sites. The both sites are enhanced with experienced surgeon's active involvement in a operation by using the system. Three surgical telementoring cases between Seattle and Aberdeen took place as the preliminary clinic trials: a case of bowel obstruction, a laparoscopic cholecystectomy, and an umbilical hernia repair. The SOCRATES™ links the both sites with a PolyCom FX: PolyCom FX has four ISDN lines with 512 kilo-bits per second (Kbps). The PolyCom FX was chosen because it independently bridges up to four sites, and has the capability to utilize H.320 (*i.e.*, ISDN or T-1 lines) or H.323 (*i.e.*, internet) protocols. This helps each site provide video teleconferencing over the internet, which would be of great value if any of these sites decide to implement an intranet-based video teleconferencing system within their institutions. It is also supported for mobile use and PolyCom Viewstations. The SOCRATES™ at the remote site is equipped with Pentium

933EB PC, a video Coder/DECoder (CODEC) which provides real-time audio/video interaction, and annotation system which can telestrate (telementor) [21]. An additional 200 giga-byte hard drive was added to the current system to record the procedures in real time up to 61 hours (with LP video mode, Mpeg type, 352x240 frame size, and 30fps frame rate). The operative site has two cameras for internal view and external view. The camera for internal view is provided by the shared control of an endoscopic camera implemented with the AESOP® robotic camera control system. A overhead lights (PrismAlix® Lighting Systems [22]) in the OR at the operative site is installed in order to enable the surgeons at the remote site to properly view procedures and activities taking place in the OR. It supports zoom-in/out functionality for the external view, but controlled by the surgeon in the OR by the request from the surgeon at the remote site. Through the surgical telementoring at both sites, expert surgeons at the remote site can mentor the surgeons at the operative site while they are actually performing open and endoscopic general surgical procedures, and have the ability to view a procedure both from the operative surgeon's perspective (by the external camera) and from the endoscopic view (by the internal camera). Moreover, the surgeons at the remote site can communicate with the surgeons at the operative site via interactive video teleconference, with an added telestration capability for instructional precision.

The second example is the system based on real-time interactive video telestration support. The remote site is located at Hallym Medical Center in Chuncheon, South Korea. The operative site is about 200 mile across the nation in the operating room (OR) at Community Hospital in Dongtan, South Korea. Instead of the SOCRATES^{TM} used in the first example, we developed and built inter-hospital system for ourselves, a part of the entire system, as shown in Figure 1. Both sites are enhanced with experienced surgeon's active involvement in a operation by using the system. Surgeons at both locations were able to see the tissues accurately enough to discriminate the color and texture quite well. The zoom capability of the overhead camera for external view allowed excellent closeup views with adequate lighting, and the telestrator, that allows annotation and drawing on the screen, also worked satisfactorily. Planned procedures will take place approximately 4 to 5 times per month initially, with an anticipated increase in utilization over the period to 8 to 10 times per month. Figure 2 shows the two examples based on the proposed surgical telemedicine education network.



(a) (b)

Figure 2. Examples of the proposed surgical telemedicine education network: (a) telemedicine link between Seattle and Aberdeen, USA (b) telemedicine link between Chuncheon and Dongtan, South Korea

3.2. Preliminary Clinic Trials

The first was a case of bowel obstruction, the second a laparoscopic cholecystectomy, and the third an umbilical hernia repair. Surgeons at both locations were able to see the tissues accurately enough to discriminate the color and texture quite well. The zoom capability of the overhead camera for external view allowed excellent closeup views with adequate lighting, and the telestrator, a software and hardware system that allows annotation and drawing on the screen, also worked satisfactorily. Overall the internal camera (laparoscopic) camera connection was satisfactory, showing details regarding anatomy, relationships, tissue properties, color, and texture clear; this allowed effective consultation between the two sites. Both the external and internal camera functions, light, and at least at baseline, resolution effectiveness have been demonstrated. The lag times for transmission of data were hardly perceptible during the procedures. The clinical focus of surgical telementoring is general surgery for chronic and acute conditions, including advanced gastrointestinal endoscopic procedures (such as Nissen fundoplication for gastroesophageal reflux), procedures involving the gallbladder and biliary tract, pancreas, liver, colon, and rectum for oncology patients, ventral hernia repair, surgical treatment for acute inflammatory or infectious disorders. Planned procedures will take place approximately 4 to 5 times per month initially, with an anticipated increase in utilization over the period to 8 to 10 times per month.

Clinical questionnaires: the easeness of contacting the consultant by phone; the time interval of the operative equipment (between the consultation decision to its transmission); the length of time required to make a surgical telementoring connection satisfactorily; the worthiness of the extra effort to set up a surgical telementoring consultation; the degree of the mentor/mentee's satisfaction with the video resolution to the consultation questions, with the color fidelity, and with the telestration capabilities; effective comparison with a MedCon telephone audio connection on the same answered; significant differences made by surgical telementoring consultation; significant contributions to the patient care by surgical telementoring consultation; educational value to the consultation, independent of any effect on this patient's care.

Engineering questionnaries: equipment setup time at operative site; need of any steps beyond the protocol to establish connection; the degree of audio/video latency; the degree of lag interference with the consultation; any technical problems with connection including inability to achieve audio/video connection; the degree of poor video resolution and poor color fidelity perceived; failure of telestration.

The above research questionnaires are collected by handout form, and will be electronic form which allows on-line data collection and analysis through. The following issues in both procedural issues and etiquette, and engineering issues were considered to develop the above questionnaires to evaluate feasibility, utility, and economic viability of such system and incorporated in the framework of one year clinical trial:

Procedural issues and etiquette: confidentiality; consent; security and safety; cost for services; set-up; maintenance; electronic protocol for medical documents; responsibility; liability; patients' preference (teleservices vs in-person services),

Engineering issues: communication/networking: latency due to time delay, bandwidth, traffic prioritization; efficiently shared surgery environment for cooperation and telecollaboration; bandwidth; fidelity; movement scale.

4. Discussions

4.1. Secondary Activities and Benefits

Additional activities and benefits resulted from the program are also significant, and they have included or will include:

4.1.1. Enhancing connectivity for its rural hospital flexibility program: The proposed program has begun to work closely with Health Services, a consortium of hospitals with a telehealth network throughout state (case for USA) or nation (case for South Korea), in order to link critical access hospitals, as well as to provide educational programs. This surgical telementoring initiation will bring more powerful impact on clinical consultations as well as educational training to the well-established regional networks.

4.1.2. Community and patient outreach: for disease specific support groups and educational offerings that require the assets of an academic medical center.

4.1.3. Promoting local connectivity within areas/communities/populations: This includes access to and among academic, community, and regional medical centers and research facilities in the two examples. T1 network connectivity within State as well as Nation provides toll-free connectivity for rural members and any institution.

4.2. Sustaining Issues

From the experience with the telemedicine examples, it is learned that several key factors influence the long-term sustainability of such programs. Accordingly, the sustainability plan for the advanced IT-based telementoring beyond grant funding is based on the following efforts:

4.2.1. Robust utilization and integration: A single site program does not provide cost-effective use of expensive equipment and telecommunications costs. Rather, robust utilization of equipment and transmission modes must be realized in order to justify the costs. As mentioned in the section 2, the ultimate goal is to integrate and expand the proven program's activity into the standard healthcare delivery system, as well as the standard educational programs of the regions.

4.2.2. Reimbursement: Teleradiology is currently reimbursable nationwide. This fact will be used as a foundation for the sustainability of the UW Medicine Telehealth Network (USA case). Reimbursement for clinical consultation via real-time interactive video teleconferencing is available in a limited manner from Medicare nationwide, and from several payers in the State of Alaska. Network members will continue negotiating with commercial payers and Medicaid and collaborating with legislative authorities to obtain reimbursement on a broad scale for clinical telemedicine. Such negotiation and collaboration are already underway. It is anticipated that reimbursement will be available within Washington State for clinical consultation (by surgical telementoring) via real-time interactive video teleconferencing within two to three years.

4.2.3. Contractual relationships: In some cases, contractual relationships with rural (operative) sites will include service charges for providing regularized healthcare services - even when such services may be reimbursable - to support infrastructure costs at Medicine.

One example is a contractual arrangement to provide evening and weekend coverage for clinical services including surgical telementoring when local coverage is not adequate.

4.2.4. Other income potential: Sites that provide educational program over telemedicine networks have the opportunity to charge fees for such services, both to support the content as well as the technology and coordination.

4.2.5. Tehnology cost reduction: Most of the problems with sustainability of telemedicine (including telementoring) have been related to technology costs (equipment and line). In this case, rural (operative) sites will have obtained connectivity to the regional telemedicine network through the state(or nation)-wide educational T1 network. Membership in the network provides state(or nation)-wide connectivity for these rural (operative) sites at a significantly reduced monthly maintenance cost – about one-quarter of a standard T1 line cost – and all calls within the state-wide network are toll-free. This allows the operative sites to have great potential to maintain telecommunication lines beyond grant funding, and removes the per-call disincentive of toll charges so that sites will be financially better off in fully utilizing and sustaining their participation beyond initial grant funding.

4.2.6. Supporting local health care providers: Keeping the patient in local hospital can also bring additional revenues to the hospital, increasing the incentive for rural sites to maintain the program.

5. Conclusions

This paper reported on a surgical telementoring initiation of a regional telemedicine network with its two preliminary results linked between Seattle and Aberdeen, WA, USA, and between Dongtan and Chuncheon, South Korea. They has attempted to combine the well-established telemedicine networks with a surgically-dedicated industrial system for improving patients' healthcare and enhancing surgical educations in the operative sites. Those programs have potential to bring enormous benefits to patients who will, in effect, be obtaining consultation and supportive care from highly experienced surgical specialists, while remaining within the care of their local surgeons and institutions. Healthcare providers and their institutions will also gain access to valuable education and experience in new procedures, while keeping their patients together with their families in their home communities.

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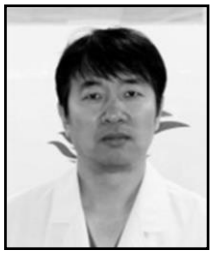

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