CHAPTER 4 AT A GLANCE: TELECOLLABORATION

Overview

Telecollaboration as practiced in the operating room (OR) uses telecommunications technology to connect surgeons and other medical professionals to another OR and its personnel. Telecollaboration can enable remote consultation, evaluation, mentoring/proctoring, monitoring, and performance of surgical procedures. It is a very new area of service delivery and its limitations as discussed by this Working Group are indicative of a developing field that lacks a terminology, established expertise, and accepted delivery protocols.

Clinical Needs

Defining terminology for telecollaboration was one identified need. Disseminating knowledge of telecollaboration's applications is also important for those who are new to this field, so that they can better plan interactions and determine telecollaboration's potential usefulness for particular cases. A lack of standardized practice, available equipment, and limited training were the main limitations identified as currently preventing greater use of telecollaboration. Advantages of using telecollaboration that were identified included accessing remote experts to mentor at a distance and reduce the learning curve time for young surgeons who are unfamiliar with particular procedures.

Technical Requirements

Technical problems in telecollaboration relate to adapting the technology specifically to surgeons' needs in the OR, and included the following:

1. Need for decreased latency in video data compression.
2. Lack of a standardized telecommunications network for the OR.
3. Lack of standardized data, resulting in too many variables among data that are delivered to surgeons in the OR.

Research Priorities

Research priorities must focus on developing technical standards for telecollaboration to promote interoperability. Challenges for the development of the field include involving industry and political-arena representatives for improving a nation-wide communications network and addressing licensure and privacy issues so as to enable wider adoption of telecollaboration and its effective use.

The full report of this Working Group appears below.

CHAPTER 4:
TELECOLLABORATION

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4.1 Introduction: A Historical View of Collaboration in the Surgical Theater and Potential Uses for Telecollaboration Today

Telecollaboration in surgery is an innovative approach to sharing experience and expertise and is enabled by today's advanced communications technology. The operating room (OR) of the nineteenth century was surprisingly collaborative, however. Surgeons, nurses, consultants, and other members of the healthcare team, as well as medical students, nurses-in-training, and other learners were, in many cases, free to come and go to the OR as patient care and learning needs required. With a name that is now a misnomer in the countries that still use it today, the operating "theater" was just that: a theater where people gathered around the process of surgery to contribute and learn. However, the advent of aseptic technique changed everything.

The OR of the twentieth century can best be described as "anti-collaborative." To even get to an OR today, individuals must change clothes—donning scrubs, booties, bonnets, and masks; enter physically isolated "suites" guarded by nurse managers whose principle objective (in the opinion of many would-be students at least)—is to block the entry of all but the most essential parties; timidly cross a brightly-colored line on the floor indicating the point of no return; and then finally enter further partitioned rooms. And all of this is just to get in the room! Should someone be so bold as to actually want to see the operative field, much less have physical contact with the patient, they must first cleanse themselves of integumental impurities and don yet another layer of sterile clothing. Thus the process of "collaborating" with someone in the OR has become, not surprisingly, very intimidating, resulting in a drastically reduced dialogue between surgeons and consultants, surgeons and nurses, surgeons and students, and surgeons themselves.

The OR of the twenty-first century can and must be different. Throughout the twentieth century, the introduction of local intercoms and telephones into hospitals began to reconnect the OR with the outside world. In the mid-1990s, the first telementoring in the OR using real time audio-video teleconferencing equipment furthered this connection, as did surgeons' use of telecommunication networks to remotely control a laparoscopic camera. On Sept 9, 2001, Jacques Marescaux ushered in the new millennium for OR telecollaboration when he controlled a Zeus telesurgical robot in Strasbourg, France from an office in New York City to perform the first transatlantic telerobotic laparoscopic cholecystectomy. The stage had thus been set for the advent of routine telecollaboration.

There is a range of current uses of telecollaboration, which in the OR, can enable surgeons and other medical professionals and robots to communicate with each other regardless of location. Telecommunication between experts or between experts and less experienced professionals, students, or robots has multiple functions. It can be used for remote consultation, evaluation, mentoring/proctoring, monitoring, and manipulation, and for actually performing surgical procedures.

Telecollaboration is particularly valuable in isolated areas where access to major centers and/or experts is difficult to achieve. It is particularly needed in rural settings as well as in remote areas such as on the battlefield, at sea, and in outer space. The field is still very new, however, and there are relatively few practitioners today. Nonetheless, technological advances in the past 25 years in video and computer communications have established the capabilities to enhance, compress, and transmit video signals and other information over long distances. More than ever, telecollaboration in today's OR is possible.

This Working Group identified some key issues for improving the delivery of telecollaborated services for the OR. Among these was the absence of both clinical and technical standards, a problem that poses significant limitations to the development of this nascent field. Among the other major drawbacks are limited tools for educating students and practitioners about this field and its effective applications, and limited communications technology that has been specifically adapted to surgeons' needs in the OR.

4.2 Clinical Needs: Defining a Frontier Field

At the outset of discussion, this Working Group identified a need to define terminology for surgery-related telecollaboration. This need is particularly important for telesurgeons obtaining licensing privileges and specifying what activities will be performed during a tele-intervention (and for which they will subsequently submit payment requests). Terminology is also needed for health care planners who are assessing options and examining the potential usefulness of tele-interventions for particular cases.

According to this Working Group, there is a great deal of misunderstanding about the meaning of "telecollaboration" in the OR. As a result, ill-defined and ambiguous terminology has surfaced. The following terms and definitions were discussed:

Teleconsultation. Communication at a distance between two or more health professionals to "discuss" the diagnosis, prognosis, and treatment of a particular patient's case. This includes, but is not limited to, the use of email, telephone, and audio-video teleconferencing to exchange information between an operating surgeon and one or more other providers.

Tele-evaluation. The appraisal, typically including some type of physical examination, of a patient distant from the health care professional. The most common media type used for this process is audio-video teleconferencing.

Telementoring/Teleproctoring. The teaching and supervision of a less experienced surgeon by a remotely located expert surgeon. Telementoring includes giving real-time advice about the various mechanical steps of a particular operation. Audio-video teleconferencing is fundamental to this activity. Oftentimes, telementoring is enhanced with the use of telestration devices.

Telemonitoring. The observation of another surgeon's or surgeon-in-training's performance during a surgical procedure. This practice can be thought of as "telegrading" that is typically done in real time, but can be accomplished via store-and-forward technology. Telemonitoring usually includes some assessment of the operating surgeon by the expert, but without the real-time expression of that assessment.

Telemanipulation. The remote operation of a device (e.g., camera, needle, instrument, etc.) for a specific purpose (e.g., visualization, biopsy, etc.). This activity necessitates that control signals be sent across telecommunications lines in order to move the device. Telemanipulation is a limited subset of telesurgery (defined next).

Telesurgery/Telepresence Surgery. The performance of surgery (including all tasks typically assigned to a surgeon) at a distance using remote control of surgical robots over telecommunications networks. Telesurgery is bimanual remote manipulation of the tissue being operated upon with complete real-time visual access to the operative field. When using telesurgery to operate in conjunction with a local surgeon, telesurgery allows the remotely

located expert or consultant surgeon to "take over" as necessary to demonstrate the "next move," or to actually perform the surgery.

The sharing of expertise is key to all of these defined tele-activities. To date, surgical areas that have primarily been focused on telecollaborative efforts include neurosurgery, orthopedic surgery, and vascular surgery as well as telepathology. This terminology must be established to avoid confusion about the use of telecommunications-ready technology in the OR as well as to help people to better understand what the approaches are and how valuable they can be in teaching and mentoring.

An overwhelming goal of telemedicine has been to replicate on-site activity from a distance. Much of what is measured in telemedicine and judged successful focuses on how closely (and without incident) these replicated activities have taken place. For this reason, four other terms that also affect the use of telecollaboration were defined by this Working Group. These are:

Control Latency. The delay between when a remote surgeon moves a controller and when the surgical tool actually moves inside the patient. This time is a sum of the delays inherent to digitization of the controller movement, transmission of these digital signals to the patient's location, and electro-mechanical translation of these signals.

Visual Discrepancy. The delay between when something moves in the operative field and when the surgeon visually appreciates such movement at the remote location. This time is a sum of the delays inherent to digitalization and compression of the video signal(s) by the CODEC(s), transmission of the signal(s) across telecommunication networks, and decompression of the signal(s) by the remote CODEC(s).

Round-Trip Delay. The sum of control latency and visual discrepancy—i.e., the time between when a remote surgeon moves a controller and when such translated movement is visually appreciated at the remote location.

Jitter. Real-time variations in the amount of delay introduced by variable traffic in telecommunication networks.

Limitations of the clinical uses of telecollaboration in the OR were identified by the Working Group, and included:

- uncertain and nonstandardized reimbursement mechanisms and amounts for telemonitoring (at least in the U.S.)
- high set-up costs of equipment and systems
- uncertainties about licensure, credentialing, and other legal-related issues (which can vary from state to state)
- extensive set-up tasks and time required for readying both the robotic components of the surgery and the telecommunications infrastructure, thus increasing the amount of needed OR time
- time consuming tasks for coordinating participants in teleconsultations (e.g., between teams or between just two surgeons, matching their capabilities, pinpointing schedule availability times, and so forth)
- uncertainties about telemedicine's use and HIPAA (health insurance portability and accountability act) compliance and privacy issues
- varying amounts of skills among mentors and collaborators (making it difficult to estimate amounts of time needed for teleconsultations)
- language issues and time zone coordination issues, especially affecting international consults
- limited knowledge about telecollaboration among user or potential users—what is available, how easy it is to use, and identification of appropriate applications
- variations in quality of video resolution at different institutions (depending on network capabilities) and as are needed for different procedures. For instance, for a 352 by 240 VHS quality video, approximately 1 Mbps per second (a relatively large amount of bandwidth) is required to send compressed images for telesurgery and telementoring. Lesser bandwidth may be acceptable for other teleinteractions.

Many of these issues are clearly related to an emerging and evolving technical field.

Particular advantages of using the technology were also identified (these, apart from telecollaboration providing access to specialty care and knowledge by remote providers). These advantages include:

- reduced need for on-site pathologists whose work can be done electronically on an as-needed basis (i.e., getting telepathology analyses immediately in the OR from surgical biopsies using a telerobotic microscope).
- shortening of the usual learning curve time for young surgeons and surgeons unfamiliar with particular procedures, as a result of telementoring/teleproctoring.
- real-time verbal, video, and imaging communications from which surgeons can assess the impact of what they are doing, rather than simply reviewing their work after the surgery has been completed.

Issues making telecollaboration less successful were identified as follows:

- Varying amounts of bandwidth availability at different institutions, and the potential for loss of signals that can affect quality of service (particularly in regard to unpredictable latency issues).
- Absence of network standards for reliability and security ensured during telecollaborative interventions.
- Lack of standardized communication skills between mentors and telesurgeons. Improving these skills is needed so that teleconsultations and other tele-interactions will be understood and successfully accomplished.

Figure 4: Laproscopic telesurgery case from Center for Minimal Access Surgery, Hamilton, Ontario, Canada
(courtesy of Mehran Anvari, MD)

4.3 Technical Requirements: Standardizing Services Specifically for the Operating Room

Limited standards in technical matters such as data compression and synchronized transmissions greatly affect the quality of telecollaboration services in today's OR. As this Working Group noted, the quality of service is dependent on packaging and aligning different data types: audio, video, and commands. Losing quality of one of these data types (say, losing audio for 5% of the time during a teleinteraction) may or may not be an issue; however, losing control of commands for as little as 5% of the time can result in serious problems.

Four key technical problems related to telecollaboration in the OR are as follows:

1. Data compression and latency issues. There is a need to develop a low latency data compression algorithm for low bandwidth synchronized transmission of data to the OR if disparate data types are used. To date, emphasis on a compression algorithm has focused on decreasing packet loss rather than on decreasing latency. However, although latency is less of a problem for certain aspects of telecollaboration, such as tele-evaluating or telemonitoring, it is a significant problem when telesurgery is practiced.

2. Telecommunications network development. There is an urgent need for good and reliable telecommunications networks. Networking issues are currently directed by commercial vendors and have varying capabilities. This Working Group suggested the need for development of a new (or improvements on existing) national/international telecommunications network that should be designed from the perspective of telesurgeons. This network should address some of the issues that are unique to telecollaboration in the medical community.

3. Absence of standardized data. The need for standardized data transmission was recognized by this Working Group. However, given the many disparate data streams that become available during telecollaboration activities, it is not yet clear which of these data need to be synchronized or standardized in one presentation format and be of a certain quality. Standardization of various data that are transmitted to the OR is a topic that requires future research.

4. Human factors interaction issues. It is still not well understood how humans respond to telecommunications and accept its use. Several early studies have noted that some OR personnel disliked being audiotaped, videotaped, or otherwise "watched," and sabotaged the tele-interactions (by covering up the cameras, for instance). More study is required to understand the extent of this problem and develop strategies for handling it.

4.4 Research Priorities

Telecollaboration is still very much in frontier territory, and many research needs and priorities were suggested by this Working Group. This group's members agreed that routine telesurgery is still a distant goal, but that telementoring and teleconsulting are feasible at this early stage of telecollaboration's development.

For growth of the field, research ought to:

1. Identify practitioners of telecollaboration, and identify the kinds of cases and payers involved in their practices. Compiling this information may help to justify the case for making telecollaboration become a priority item for research.

2. Study and document telecollaboration's efficacy. A study of clinical efforts may note a reduction in morbidity, for instance.

3. Undertake cost analyses and demonstrate cost effectiveness of telecollaboration efforts.

4. Study intangible issues like patients' preferences for not having to have to travel for surgery.

5. Develop practice standards, especially for troubleshooting. For example, standard procedures to follow when systems inadvertently shut down or a complication occurs are needed. Standards will have to define a certain expectation of care in telecollaboration. The need for using back-up systems should be indicated. There should also be a standard plan for interventions by other personnel in the OR or at remote sites to try to correct problems that are encountered during the telecollaborated episodes of care.

Several members of this Working Group also noted the need for developing technical standards for OR data devices. The overarching priority is to establish routine telecollaboration in a well-developed, dedicated medical network. Critical to the operation of this network are the following needs:

- Develop better codecs to reduce latency in the OR. The lack of cost-effective devices for compressing/decompressing video signals at a rapid rate is limiting surgeons' telecollaborative ability.

- Develop a compression algorithm that is ideally suited to the needs of telecollaboration. This algorithm would place a greater emphasis on low latency rather than low packet loss, picture quality, and related components of telecommunications.

One challenge for developing this network is to convene an industry-grounded meeting to discus the surgical needs of telecollaboration and telecollaborators. The telecommunications industry must be involved in this discussion.

A second challenge calls for managing a political agenda, one that addresses issues such as licensure, privacy, and consent. There is a need to send a clear message to political decision makers that this agenda must be addressed for work in telecollaboration to advance in the medical community.