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Transmission of live oncological surgery (Local Area Network, Wide Area Network - first experiences)

ABSTRACT

Background: *Video broadcasting of surgical procedures is an important tool for education, training and consultation. Real-time video through ISDN line is known for its medium quality, but for the country with medium developed telecommunication infrastructure such as Yugoslavia, it has the basic role for video broadcasting and video-conferencing. The aim of this article was to point out the possibility of transmission of live video signal via ISDN line for WAN and to give a suggestion to the doctors for its usage this in their every day practice. On the other hand, every institution which has LAN must not hesitate to use it for broadcasting of various video signals.*

Materials and methods: *Transmission of live video oncological surgery is done by using computer technology and Local Area Network with the following basic characteristics: Fast Ethernet technology (IEEE 802.3μ) switch as active network equipment and TCP/IP as network communication protocol. The personal computers have standard business configuration for video-conferencing and Microsoft Windows 98 as operating system. Transmission of live video oncological surgery from a distant place using WAN technology is done by ISDN interface cards using both B channels of Base ISDN connector.*

Results: *On December 16, 1998 a live picture of a gynecological operation was transmitted from the operating room into the Congress Hall of the Institute. During the operation, some consultations were necessary with the Center for Imaging Diagnostic. In the second live transmission - the laparoscopic surgery using WAN, two operations were transmitted: a laparoscopic cholecystectomy and an operation of a colorectal carcinoma.*

Conclusion: *Telemedicine, used in surgical training, can become a powerful tool for teaching and monitoring complex surgical procedures at distant medical facilities. Institute of Oncology is interested in established telemedicine in the following areas: surgery, pathology, gynecology and internal medicine.*

Key words: *Oncology; Telemedicine; Telesurgery; Live video broadcast; LAN/WAN*

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INTRODUCTION

For more than thirty years, the clinicians and health workers in general, have been researching the usefulness of telecommunication systems and computers, and their role in improvement of health protection. Telemedicine is there as well, at the crossroads of these high technologies, the combination of everyday life, medicine and the newest informational technologies. The application of telemedicine started in late 50's. It was noted in medical literature that in 1948, a transmission of radiological pictures was brought through telephone lines between West Chester and Philadelphia, Pennsylvania, USA, which are 24 miles distant form each other (1). Having in mind and based there work on this, in 1950, the Canadian radiologists created a teleradiological system. During the 80´s, telemedicine expanded to the areas of orthopedics, and today it covers all fields of medicine, especially in the field of transmission of live surgery procedures. Since 1986, the International Academic teleconferences have been held in the field of surgery. For the first time in the history of communications, in the Department of Surgery, North Oakland Medical Center, Pontiac, USA on August 29th, and September 3rd, 1996, the conducted live interactive broadcasts through the Internet were done. The successful transmissions live oncology surgery were performed from Pontiac, Michigan, to Laguna Hills, California, and Buenos Aires, Argentina (2). On September 16th, 1998 in the Department of Gastrointestinal surgery, CHU Saint - Pierre, Brussels, Belgium, laparoscopic gastric banding procedure was performed by a surgeon while he was actually sitting at a distance from his patient, and he manipulated handles that were connected to a computer in command with robotic arms mounted on the operating table near the patient (3). The final result was a transmission of live oncology surgery over the Internet2, a new high-speed large bandwidth data network (up to 2,048 Mbps). One of the first experiences

Abbrevations used in text: ISDN - Integrated Services Digital Network; LAN - Local Area Network; WAN - Wide Area Network; TCP/IP - Transfer Control Protocol/Internet Protocol; WWW - World Wide Web; UTP - Unshielded Twisted Pair; FO - Fiber Optic; MRI - Magnetic Resonance Imaging; PC - Personal Computer

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dated on September 28 and 29, 1998 in the Department of Surgery, Ohio State University, Columbus, USA (4).

As a definition of telemedicine, the following can be accepted: Telemedicine represents the usage of electronic information and communicational technologies in providing and giving help in health protection when the participants are physically separated (1). This actually means that telemedicine represents the application of modern telecommunication in medical practice. Telemedicine represents the means of giving health protection to patients regardless of their geographic location, costs, or travel limitations, combining communication technologies with the knowledge of medical experts. According to this definition of telemedicine, all services (phone consultations, video-conference, video-consultations, telemonitoring, teleradiology, telepathology, telesurgery, distance learning, remote approach to medical databases,...) can be seen as a wide range of common activities on one side of the range such as telephone for consultations among patients and clinicians, as well as for the emergency calls for doctors in medical facilities, and complex activities on the other side, such as telesurgery in which a surgeon receives visual and tactile information to guide robotic instruments to perform surgery at distant site. Between these two ends of the range, there is an area of transmission of many video, audio and textual data about the patient himself. In the field of surgery, telemedicine is used for teaching, diagnostic or therapeutic assistance, and even consultation of remote patients. Video-conferences allow clinicians to see, hear, "examine", ask questions and give some advice to patients in real time; to reach the diagnosis based on mutual consulting, and thanks to that, to suggest or carry out some changes in therapy, depending on the established diagnosis. Of course, it must not be forgotten, how huge the role of telemedicine is in scientific area, concerning the search through literature: current and archival, from all over the world, the news and new discoveries in the filed of clinical oncology. Telemedicine also plays a great role in the educational area, where it can be used for presenting some new methods of treatment and some new surgical practices to clinicians, doctors during their specialization, students and all other health workers. Internet sites, relevant to surgery are appearing rapidly. Multimedia capabilities of WWW expand the depth of information transmission, enabling education emanating from remote sites with narration and video depiction of procedures.

MATERIALS AND METHODS

Understanding telemedicine as it is described above, means also that the complexity of the telemedicine service determines the level of telecommunication infrastructure, i.e. the transfer velocity of the data as shown in Figure 1.

Analyzing this picture, the minimum velocity transfer for transmission of video signal is 64K. By testing transfer the video signal through LAN we can say that there are no problems at all considering that the Fast Ethernet (IEEE 802.3μ) technology is used. For long distance transfer of video signal, i.e. Wide Area Network (WAN), the following telecommunication channels are tested: analogue commuted telephone lines, analogue transversal connections (a rented telephone line), ISDN and WWW. The ISDN is chosen because of its best cost benefit-transfer velocity rate.

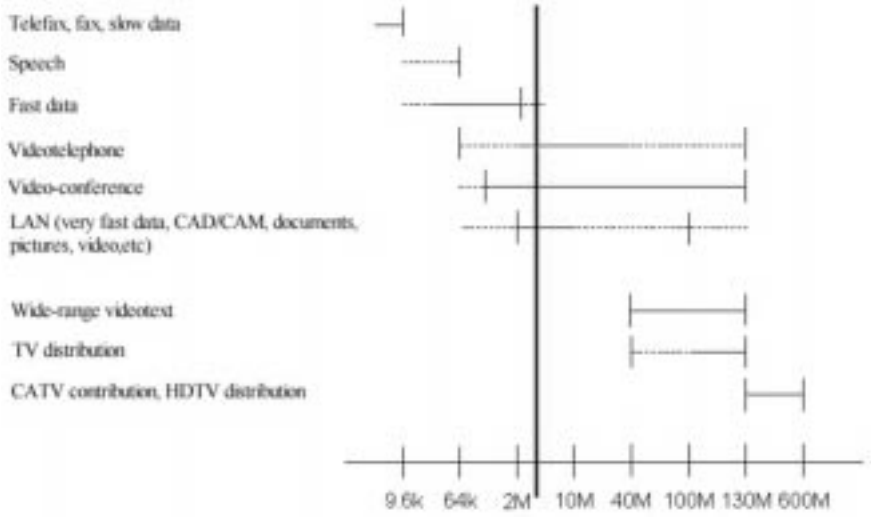

Figure 1. Velocity of the information flow

Transmission of live video oncology surgery is performed on December 16th, 1998 in the Institute of Oncology Sremska Kamenica, Novi Sad for the first time using computer technology and LAN. During the transmission, a video conference was established between the Clinic for Operative Oncology and Center for Imaging Diagnostic. The LAN is based on Fast Ethernet technology with following characteristics:

- Physical topology-star; Logical topology - bus;
- Technology - Fast Ethernet (IEEE 802.3μ)
- Active network equipment - Switch technology
- Number of segments - 22; Number of connections: UTP - 371, FO - 40
- Cabling of primary star-62,5μ FO 4 (≈3 km); Cabling of secondary star - UTP cat5 (≈8 km)
- Network communication protocol - TCP/IP

For transmission of live oncology surgery, the switches placed in the following segments are used:

1. Computer center - central switch
2. Part of the Clinic for Operative Oncology - segment L
3. Cinema Hall - segment W
4. Center for Imaging Diagnostic - segment V

The personal computers (PC) connected to the LAN (one in the operating room, and the other in the Cinema hall where the oncology surgery was presented) have the following configuration:

- Pentium II processor
- Random Access Memory (RAM) 64Mb
- Graphic card ATI All-in-Wonder with 4Mb of memory with connector for analog video camera
- Fast Ethernet network card
- Sound blaster card (full duplex) with speakers
- Analog VHS video camera
- Other hardware is standard business configuration
- Microsoft Windows 98 as the operating system
- Microsoft NetMeeting 2.11 as software for

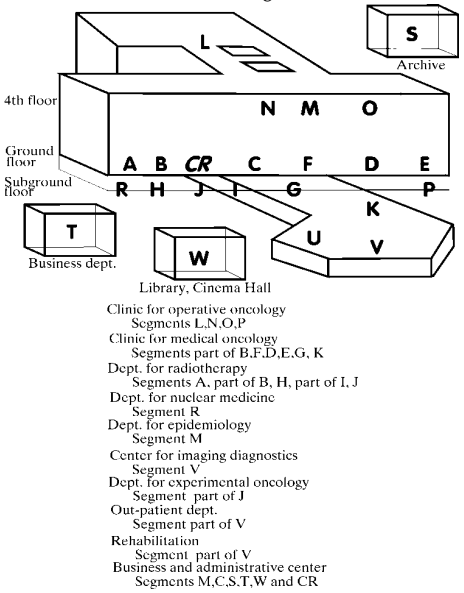

Figure 2. Review of the local computer network at the Institute of Oncology Sremska Kamenica, Novi Sad

presenting live video signal from surgery room

The review of the LAN is shown in Figure 2.

Connection between VHS analog video camera and graphic card of PC is done by CATV connector of graphic card via coaxial cable. To establish communication between two users (two PCs) by NetMeeting, calling is done by using Internet Protocol (IP) address.

The transmission of live oncological surgery using WAN was done on June 14th, 2000, from Subotica Health Center, Surgery Department to Institute of Oncology Sremska Kamenica, Novi Sad in Sremska Kamenica. The connection between two personal computers was done by ISDN interface cards Diva 2.0 manufactured by Eicon, Canada using both B channels of Base ISDN connector (2 x 64 Kb transfer velocity). Because of the technical nature of ISDN interface card, one PC is configured as dial-up server (PC at the Institute of Oncology in Sremska Kamenica) and the other one as dial-up client (PC at Health Center in Subotica). Both PCs are using Microsoft Windows 98 as operating system and Microsoft NetMeeting 2.11 for video communication. The calling between two PCs is done by IP address generated by dial-up server (private class of IP addresses - 192.168.55.1 and 192.162.55.2). The PCs have the following configuration:

PC at Subotica Heath Center in Subotica:

- Pentium II processor
- Random Access Memory (RAM) 64Mb
- Graphic card ATI All-in-Wonder with 8Mb of memory with connector for analog video camera
- Eicon Diva 2.0 ISDN interface card
- USB PC Camera manufactured by Samsung, South Korea
- Sound blaster card (full duplex) with speakers
- Other hardware is standard business configuration
- Connection to the oncology equipment via coaxial cable.

PC at Institute of Oncology Sremska Kamenica, Novi Sad in Sremska Kamenica:

- Dual Pentium II processors
- Random Access Memory (RAM) 128Mb
- Standard graphic card with 8Mb of memory
- Eicon Diva 2.0 ISDN interface card
- Sound blaster card (full duplex) with speakers
- USB PC Camera manufactured by Samsung, South Korea
- Other hardware is standard business configuration

Testing communication through ISDN base connector by configuring ISDN interface card and adjusting parameters of dial-up server wass done in cooperation with an engineer from NIS Naftagas in Novi Sad.

In the Health Center Subotica, video output of laparoscopic camera (the S connector of image generator of laparoscopic equipment) was connecting to CATV connector of the graphic card in the computer via coaxial cable. The receiving site participated in two-way, real time video and audio communications and graded the quality of the signal they received. At the same time, the USB PC camera is connected to the USB connector of PC. During the surgery procedure, switching between video inputs (USB camera and laparoscopic camera) was done by using the software NetMeeting and its option "My video properties".

The scheme of connection between two peers of WAN is shown in Figure 3.

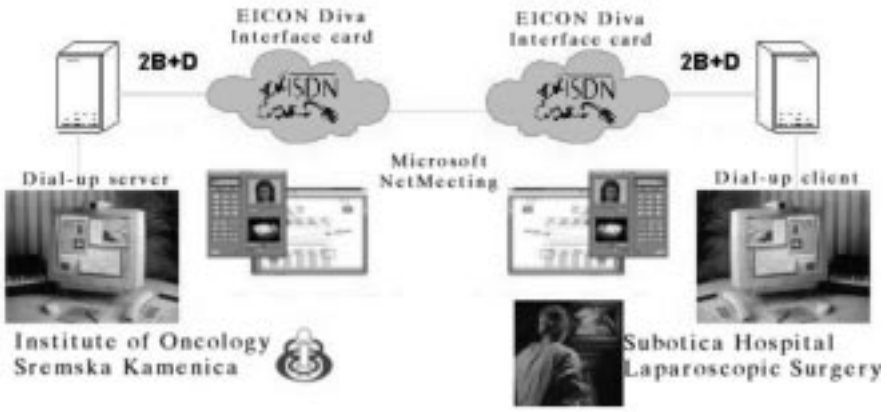

Figure 3. Scheme of connection for the transmission of live video signal between two peers of WAN

RESULTS

A live transmission of a picture of a gynecological operation from operating room (segment L) into the Congress Hall of the Institute - segment W, was done on December 16th, 1998. During the operation, some consultations were necessary with Center for Imaging Diagnostic - segment V on the interpretation of the MRI shots of the patient. All the time, the procedure of the operation was commented by the surgeon. The recording of the procedure was done by the professionals using the external VHS camera in the Congress Hall. Also, the video output from the PC computer in the Congress Hall was connect to the video-beam whose resolution was 800x600 pixels. There was no time delay like in the cartoon movie and no noises, the quality of the picture was very good and there were no mosaic effects. Also, the quality of audio signal was very good. The overall performance of this LAN technology was very satisfactory.

In the second live transmission - the laparoscopic surgery using WAN - two operations were transmitted: the laparoscopic cholecystectomy and the operation of colorectal carcinoma. The entire procedure lasted 90 minutes. Video images were transmitted at a rate of 12-15 frames per second from Subotica and displayed in a 320x240 window at the remote site - Institute of Oncology. The audio quality was very good. The video quality in some sessions was dissatisfactory, there was a mosaic effect present (the digitalization of the images was not finished) and also there was the delay effect like in cartoon movies. The broadcasting computer station was able to receive real-time video and audio from distant computer, allowing complete interaction between both parties over the duration of each transmission session. Because of "only" 128Kbps transfer velocity we expected these effects.

DISCUSSION

Telemedicine industry must develop minimum standards so that all units correspond at the same speed and speak the same language. Measured in kilobits, the quality of the transmission improves with higher kilobit settings. Improving picture quality also increases the number of phone lines in use, and thereby raises the cost of the connection.

Time delay does effect surgical performance during telesurgical manipulation. There is an acceptable delay of less than 700 ms in which surgeons can compensate for this phenomenon. Clinical studies will be needed to evaluate the impact of time delay.

Remote diagnosis in pathology requires high-resolution images transmitted via 64Kbps ISDN connection. Video conferencing proved to be effective and popular with the doctors, although there was some dissatisfaction with the visual quality of the ISDN video conferencing at 128 Kbps. Today, in the field of transmissions from operating room is used special telecommunication lines for installing a polycom videoconferencing system in a conference room which works with ISDN teleconferencing at 384 Kbps. With this innovation we are able to ensure live transmission of surgical procedures with high-quality images. The Inernet2 (a new technology using PC-based implementation of H.320 video conferencing over a TCP/IP network) is currently able to

provide the bandwidth needed for a turn-key video conferencing system with high-resolution, real time transmission.

CONCLUSION

Surgeons are interested in using telemedicine in the operating room in order to present laparoscopic procedures being performed at distant locations and to demonstrate to others procedures they are performing themselves. Telemedicine, used in surgical training, can become a powerful tool for teaching and monitoring complex surgical procedures at distant medical facilities. The vision of telesurgery comprises a multitude of new communicative elements influencing the way surgeons will treat their patients in the future. The first prerequisite is to digitize surgical data. If Three-dimensional image reconstruction is available, and if such data can be useful during surgery, different image sources must be combined into some virtual, multiparametric body model and matched to an intraoperatively distorted organ contour (5). In the very near future, computer-aided navigation and robotic assistance, based on the same surgical data sets, will be available in all fields of surgery. The key to acceptance of telemedicine is proving its clinical, academic, and economic benefits to the medical community. Telemedicine will improve both quality and efficiency of care at the Institute of Oncology Sremska Kamenica.

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