Original article
UDC: 61:681.324:621.398:621.316

The Institute of Oncology Sremska Kamenica in the New Era of High Technology-Telemedicine and Multimedia Interactive Communication in the Internet Environment

Dubravka STRIBER DEVAJA
Svetozar ZDRAVKOVIĆ
Vladimir Vit. BALTIĆ

INSTITUTE OF ONCOLOGY SREMSKA KAMENICA,
SREMSKA KAMENICA, YUGOSLAVIA

Telemedicine experiences at the Institute of oncology Sremska Kamenica are presented in this paper. Our experiencies in telemedicine included: video-conferencing related to teleeducation and telediagnostics, teleducation by using of internet on-line journal and our plans for futher development of teleradiology.

This paper was awarded with the annual prize Discobolos 2000 of Yugoslav Association of Informatics.

KEY WORDS: *Telemedicine; Videoconferencing; Internet*

For more than thirty years, the clinicians and medical personnel in general, have been researching the usefulness of telecommunication systems and computers, and they have also been testing their most useful mutual connection in the improvement of health protection. The main characteristics of modern telecommunications are: the massive number (the great number of nodes), the variability (exchanging messages from different sources and with different types of traffic) and the interactivity (in a direct or indirect way). Multimedia communications comprise different services, which enable simultaneous transfer of different continuous signals (music, speech, image...) and discrete data through the same link between users connected via the local or global network. One of the most attractive multimedia services is Telemedicine - a relatively new branch, a combination of everyday life, medicine and the latest informational technologies. One of the acceptable definitions of Telemedicine can be: Telemedicine represents the usage of electronic information and communicational technologies in providing and giving help in health protection when the participants are physically separated, this actually says that Telemedicine represents the application of modern telecommunications in medical practice. Telemedicine represents the means of giving health protection to patients regardless of their geographical location, combining communication technologies with the knowledge of medical experts. The consultations of medical experts are necessary in establishing the right diagnosis, and according to this, the therapy that is to be administered to the patient.

The services in Telemedicine include:

* Synchronous, cooperative work of both sides
* Videoconference between central and remote health facilities
* Video-consultations which allow the examination, consultations in establishing the diagnosis and the therapy for a remote patient
* Digitizing of medical pictures
* Processing, preserving and printing of medical data
* Teleradiology
* Telepathology
* The electronic medical file of a patient
* The local and distant approach to medical databases, etc.

At one end of the range of Telemedicine usage, there is a telephone for the consultations between patients and clinicians, as well as for the emergency calls for doctors in medical facilities. At the other end of this range, is the usage of satellite technology for the transmission of international consultations. Between these two ends of the range, there is an area of transmission of many video, audio and textual data about the patient himself.

We can roughly define two main kinds of technologies, which are accepted in Telemedicine today. The first type of technology is a two-way interactive television (ITV), which means the equipment for videoconferences in both locations. Videoconferences allow the clinicians to see, hear, "examine", ask questions and give

Address correspondence to:
Dubravka Striber Devaja, Institute of Oncology Sremska Kamenica, Computer Center, Institutski put 4, 21204 Sremska Kamenica, Yugoslavia
E-mail: dubravka@uns.ns.ac.yu

Accepted for publication: 20. 04. 2001.

some advice to patients in real time; to reach the diagnosis based on mutual consulting, and thanks to that, to suggest or execute some changes in therapy, depending on the established diagnosis. The other form of Telemedicine usage based on the principle of "store and forward" technology, which is of client-server type, is the sending of medical pictures in a digital format, which are a constituent part of the electronic medical file, to other health facilities, where, after their examination and interpretation, the answer will be formed and transferred to the facility which has made the original request. The important characteristic of the Telemedicine is a big quantity of information, which has to be transferred with additional requirements like reliability, authenticity, confidentiality and security of data transfer. Of course, it must not be forgotten, how big 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 field 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 procedures to clinicians, doctors during their specialization, medical students and all other medical staff.

The role of the Internet becomes more and more significant concerning the patient - doctor relationship. World Wide Web (WWW), electronic addresses (E-mail) and discussion groups drastically increase the number, as well as the size of medical and health data, which are, on one side useful to doctors, and on the other to patients. Also, the Internet becomes a very important medium for the circulation (expansion) of medical pictures by FTP (File Transfer Protocol) or by The World Wide Web. This is the way of helping clinical doctors in exchanging experiences and in making the most favorable decisions concerning patients, through their teamwork and consultations. One must consider which type of ontological information can be exchanged through the Web, as well as the educational level of the patient who is one of the potential Web searchers. On its Web presentation, the Institute of Oncology has the base of the Archive of Oncology journal, where, all the papers dealing with the clinical oncology, published in this journal, are available on-line, and where one can easily find all the information concerning the required data, by one's own search, following the principle of key words. The user of this database is in constant contact with the editorial board of the journal through E-mail. The electronic version of the journal has been made on the base of the ASP (Active Server Page) technology, which is supported by IIS (Internet Information Server 4.0) as Web server. It is important that this is the only scientific journal in the field of oncology, which has an electronic version. Also, at the Web presentation of the Institute, the relevant data from the hospital register are available: the information about the ways of treatment and the therapies applied at the Institute of Oncology, with the marking of successfulness of those therapies, as the data from the population register of malignant neoplasms. As an attempt to promote the oncological health prevention, especially for the breast cancer, which has the significant incidence in Vojvodina, the Institute of Oncology in its Web presentation offers one of the telemedical services: "Self-examination of the breast". This service can enable the potential users to carry out a self-examination of the breast based on the instructions which consist of pictures and textual instructions, as well as inform the potential users about other important questions concerning breast cancer: which is the risk group of women, when is it necessary to consult a doctor, the importance of the self-examination of breast, the way to reduce the risk of breast cancer, the sign of warning for a malignant disease. The Institute of Oncology is planning further development of the telemedical services, such as these in the field of teleradiology and telepathology, and also the services specific to the field of oncology like: telephysiotherapy for oncology patients, teletherapy of pain and telepsychotherapy.

It is necessary to provide the infrastructure in medical and telecommunication environment for the use and application of Telemedicine. In the Telemedicine development the important steps are the development of strong PACS-a (Picture Archiving and Communications Systems) system, the introduction of DICOM 3.0 standard into practice and the training of medical-engineers personnel for the work on the new computer oriented equipment. It seems clear from this that the logical outcome is the development and existence of an electronic patient record.

We have opted for a phase development of the informational system. So far, two phases of development of the informational system have been completed:

* Phase I - passive network components
* Phase II - with several sub phases - active network equipment switch - 22+1:
* Sub phase I - central switch + 3 segments
* Sub phase II - 2 segments
* Phase III - projecting, realization and implementation of IS, provision of DBMS I tools for development of applications
* Phase IV - provision of computers (WS, servers)

The characteristics of the active network equipment are: scalability of the appliances, redundant charge of the appliances, and support for VLAN, SNMP for steering, backplane min 2Gbps.

The advantages of the usage of the local computer network are:

* Approach and elaboration of the common data (electronic file of a patient,)
* Resource division
* Usage of the knowledge base on the Internet (Medline, OncoDisc,)
* E - mail
* Approach to the common archive of medical pictures (MRI, CT,

US,)
* Videoconference
The active components, the most up-to-date technologies are placed in the following segments:
1. Computer center - central switch
2. Center for imaging diagnostics
3. Part of the Clinic for Operative Oncology - Operating room and the consulting room
4. Part of the Department for Radiology - the part for treatment planning
5. Polyclinic
The main principle of Telemedicine is the acquisition of the input data from different medical appliances and transfer of this information to other centers for adoption and diagnoses with different requirements such as processing, transferring, acquisitioning and searching of the enormous quantity of files, like medical pictures. These have been focused on the areas as Center for imaging, Department for Radiology, Department for Pathology, and Clinic for Operative Oncology and Clinic for Internal Oncology. At the Institute of Oncology, in the field of pathology and imunobiology there are two ways of getting digital pictures:
1. The older, which has an analogue video camera and where the signal is preprocessed and digitized in A/D converter, also known as frame-grabber;
2. Digital video camera, which uses CCD sensors for direct transformation of the signal of optical image into an electronic, so that the output signal is digital.
Consequently, after having provided the digitalization of the pictures, by means of direct telephone lines or Internet on the principle of a questionnaire with a "glued" picture, the sending of histopathological preparations to other centers for consultation and diagnosis has been made possible. Of course, this ensures the communication from the other side so that we have also been sent pictures of preparations for consultation on more than one occasion. Besides these pictures we use the pictures from Ultra Sonography (US), Computer Tomography (CT), Magnetic Resonance Image (MRI) and Gamma Cameras. Required resolution depends on the type of the analysis as well as on the specialist's experience. The Center for Imaging is the source of medical pictures, which have been taken with the use of Magnetic Resonance Imaging (MRI), Computerized Tomography (CT) and Ultra Sonography (US). All of these medical pictures can be found in DICOM 3.0 format (Digital Imaging and Communications in Medicine), which is the accepted standard for the acquisition and exchange of medical pictures and video materials by the ACR-NEMA (American College of Radiology - National Electrical Manufacturers Association). The medical pictures have also been transferred to the PC platform where their cataloguing is done. Standard DICOM 3.0 provides the basic network characteristics: transfer and processing of pictures, printing on the network cameras and support of the interface for Radiology Information System or Hospital Information System (RIS/HIS). As we talk about a large amount of data contained in medical images the signals need compression. It has been proved that diagnostic pictures - still pictures compressed by the technique named JPEG (Joint Photographic Experts Group) or "wavelet" with a compression factor of 10:1 can not give the wrong diagnosis. The standard DICOM 3.0 have incorporated option of JPEG compression up to 100:1, which can be adjusted. The compression reduces the amount of data, increases the processing time and the transferring of pictures with small delays in propagation. Of course, the compression decreases the memory space requirements for backup and for archiving pictures. Pictures (from archive or online) can, with a specific interpreter, (for CT it is DICOM browser on PC NT server side, and for MRI special program installed on PC side because the MRI equipment is an older generation) be browsed on the PC platform. This is the way for enabling these medical pictures to become a part of the electronic medical file, so that they can be used in Telemedicine, or that they can be available in the field of medical education. It is clear that with the 100MB computer network of the Institute, the pictures can be found and used in any of the segments of the Institute. At this stage of development of the informational system of the Institute, they can be used in the Clinic for Operative Oncology - the operation room and the consultation room; and at the Department for Radiology. The resolution of pictures from CT is 512x512 pixels with 12 bits/pixel, from MRI is 512x512 pixels with 8 bits/pixel. We accept that 8 bit-palette (256 gray scale) is quite enough. For one session in Telemedicine a row of 60-100 snapshots with 8-12 bits/pixel is used. In nuclear medicine a sequence of snapshots, 30-50MB per patient, is used. It means that the scope of a file per patient from CT is about 12MB (approximately 70 snapshots) and from MRI about 16MB (approximately 80 snapshots). We store patients' snapshots on optical discs. Weekly two CD-ROM-s (650MB) are used for CT archive and three for MRI archive. If we accept that the maximum transfer delay is 10 sec, then minimum transfer rate should be around 25 Mbits/sec. The special problem is the searching of this sort of database. Still, now, in the Center for imaging the first step of realization of the project PACS (Picture Archiving and Communications Systems) is in progress - SQL database in the Intranet environment, which will offer easier accessibility and searh of the image database for all the patients' snapshots in this center. A stage introduction of teleradiology is being planned at the Institute of Oncology:
1. Videoconferences and presentation of digital pictures necessary for the system of planning of irradiation doses, within the Institute;
2. Taking out the same pictures from the base of digital pictures

and the process of planning of irradiation doses;
3. Teleconsultations with the other centers within the system of planning

Prerequisite for the introduction of such a system is the existence of digital archive of images, which has already been done at the Institute of Oncology. By this, we can decrease the needs for films that are the source for the planning system in radiology because the digital images can be available in the Department for radiology. So, the most frequent type is based on the "store and forward" technology, the rate is not of primary interest, but protecting, secure transfer and exact transfer are very important.

Besides the problem of database searching, here is the problem of image processing. An engineer point of view often differs from that of a medical specialist. Usually, it is often required to simultaneously display more than one image on the screen, at least with worse particular image quality, the zooming and cropping the part of the picture, control of brightness and contrast. The procedure of false coloring is being introduced so that the adjacent levels of grey could be in contrast colors which contributes to the visual effect for diagnostic purposes.

For the interuniversity video conferences the Institute of oncology uses the standard H.320 designed for the ISDN application, with rates from 64 kb/s (i.e. B channel) up to 144 kb/s (i.e. basic ISDN supporting two B and one D channel) The connection between the users is realized on point-to-point base (teleconsultation), point-to-multipoint base (teleeducation) or by star topology (teleconference). For compression of audio and video signals we use MPEG-x (Moving Picture Experts Group) standards.

Here is a chronological review of some of the activities in the field of Telemedicine done at the Institute of Oncology. In December 1997, with the help of VMA (Vojno Medicinska Akademija - Military Medical Academy), Belgrade, a system for telepathology was tested, where the Institute of Oncology was a distant working station, which was sending the inquiries for pathological examination of suspect slide samples. In May 1998, there was a television transmission of the laparoscopic resection of colon carcinoma, performed by Prof.dr Durocq Bordo, from the operating room into the Congress hall of the Institute of Oncology. For the first time, a videoconference was established on 16th December 1998, between the Center for Imaging Diagnostics and the Clinic for Operative Oncology. Actually; it was a live transmission of pictures from the operating room -gynecological operation, into the Congress hall of the Institute. A software package Microsoft Netmeeting was used. During the operation, some consultations were necessary with the Center for Imaging Diagnostics about the interpretations of the MRI shots of the patient. Both, the audio and the visual consultation were established with satisfying quality. It has already been said that the Center for Imaging Diagnostics is connected with the Department for Radiology, where the pictures in DICOM 3.0 format, done at CT, are directly introduced into the system for planning a teletherapy.

During the year 1999 and 2000, a videoconference was held several times for educational purposes. Namely, instead of the traditional method of students entering the operating room, the picture was transmitted from the operating room - the operation itself, into the consulting room, thus enabling an easier way of educating medical students in Surgery. A satisfying audio and video communication was established here as well. Of course, there was a questionnaire given to the students, which confirmed that they accepted this way of education well, and that they would gladly participate in it again some other time if possible. Also, a real-time transmission of compressed video pictures was performed where the connection was to the gastroscope at gastroenterology or to the colonoscope.

Testing the transmission of data through analogue commuted telephone lines, analogue transversal connections (a rented telephone line), digital lines (ISDN) and World Wide Web we have opted for the transmission of data through ISDN (Integrated Services Digital Network) line. For the time being, the Institute possesses one base ISDN connector, which is used for dial-up approach to the Eunet provider in Novi Sad. The velocity of the transmission of data through the base ISDN connector is not enough for videoconference of good quality, but it can be used as the first and the testing step in the introduction of this service of Telemedicine in everyday practice in medicine. It is evident that a possible usage of a special programme for compression of medical pictures could enlarge the effective bit velocity and lessen the delay, which would enable video transmission of higher quality. Also, adequate network equipment with ISDN interface is necessary. It would enable the exit from several network positions along the local computer network of the Institute of Oncology. As it has been stated before it is not possible to restore videoconference of high quality through the base ISDN connector. We have chosen the principle of a questionnaire with a "glued" picture. The picture, which was obtained at the MRI, was in that way sent to the hospital in Kaposvari, Hungary, for the consultation. The size of the picture to be sent from CT was 512 KB and from MRI was 100KB. During the testing stage we concluded that special attention should be paid to the programme for picture compression. The problem of compression of medical pictures should be worked upon very hard, concerning the level and the type of compression, which is clinically accepted (either for diagnostic or cataloguing purposes). After the consultation in Kaposvari hospital, the picture was returned with the answers given in textual format. The same thing was repeated with the Clinic of Neurology, Clinical Center Novi Sad, where the pictures were sent from both MRI and CT. Of course, after the sending of the pictures, the consultation

was established and a mutual diagnosis was reached.

So far, in the year 2000, during the laparoscopic oncology operation at the Institute of Oncology a teleconsultation was done with the Clinical Center in Subotica - Operation block. ISDN interface cards made a connection between two personal computers; so one PC was 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 were using Microsoft Windows 98 as operating system and Microsoft NetMeeting 2.11 for video communication. The audio and video communication was satisfactory. 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 - the Institute of Oncology. The video quality in some sessions was dissatisfactory; there a very mosaic effect and a delay effect like in cartoon movies were observed. Because of "only" 128Kbps transfer velocity we expected these effects.

The testing of transmission of histopathological pictures, for the needs of oncology multidisciplinary meetings is being carried out at the moment.

The introduction of telemedical services in expert meeting, under the name of "Oncological Forum" (for connecting the segments: MRI-radiotherapy-Oncological surgery), which are regularly held at the Institute of Oncology for clinicians and nurses, at the moment, is in its full realization.

During the year 2001, this system should be realized at the Department for Radiology.

The main role of the project Telemedicine is to connect all oncology scientific centers and hospitals to establish on-line exchange of information (using video conferences) and off-line exchange (using distributed medical database).

The Institute of Oncology possesses the communicational and informational infrastructure, skilled medical experts and information technologists, who, all together, working as a team, can make the usage and the application of Telemedicine possible - in the field of clinical oncology and in giving the everyday health protection to patients. However, only a small number of health facilities and oncology dispensaries, as well as the individual patients living in Vojvodina, which is covered by the Institute of Oncology, own computers and communicational equipment which is necessary for the usage of all telemedical services. All of this, of course, makes the spreading of Telemedicine in practice more difficult and narrows the number of the participants. For a complete implementation of Telemedicine in our case, which also must cover the area of clinical oncology, it is necessary to form the informational technological groups which will, with the help of oncology center for Telemedicine, ensure the necessary technical and informational technological support and start the process of planning the introduction of this high technology at all levels of health protection. Of course, the financial aspect of the introduction of telemedicine must not be forgotten because it requires considerable investments in the network and the communicational infrastructure. A pilot project would be the first step in presenting the cost-effectiveness and benefits of the introduction of Telemedicine, because, even though there are some potential advantages and uses from the introduction of Telemedicine, the analysis should be conducted under our conditions and at our level of development of infrastructure, presumably a basis for the introduction of telemedicine into the routine health protection.

REFERENCES

1. Telemedicina: A Guide to Assessing Telecommunications for Health Care. Field MJ, ed. Committee on Evaluating Clinical Applications of Telemedicine, Institute of Medicine,1996.
2 van Bemmel JH, Musen MA, eds. Handbook of Medical Informatics. Bohn: Springer, 1997.
3. Kayser K, Szymas J, Weinstein R.Telepathology. Berlin: Springer,1999.
4. Spasić P, Milosavljević I, Jančić Zguricas M, eds. Telemedicina. Beograd: Akademija medicinskih nauka SLD, 2000.
5. Wright D. The sustainability of Telemedicina projects. J Telemed Telecare 1999;5(Suppl.1):S107-11.
6. Devaja Striber D, Zdravković S, Baltić VV. Transmission of live oncological surgery (Local Area Network, Wide Area Network-first experiences). Archive of Oncology 2000; 8(3):105-8.
7. Gersak B, Gorjup V, Jazbec A. The telemedicine and second medical opinion. Stud Health Technol Inform 1999;68:245-6.
8. Doolittle GC, Allen A. Practicing oncology via telemedicine. J Telemed Telecare 1997;3:63-70.
9. Buckner F. Telemedicine: the state of the art and current issues. J Med Pract Manage 1998;14:145-9.
10. Lowe HJ. Transforming the cancer centre in the 21st century. MD Comput 1999;16:40-2.