Telemedicine in Anesthesiology and Reanimatology

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1. INTRODUCTION

Although it can be said that telemedicine began with the invention of the telephone or wireless telegraphy, serious development of telemedicine is recorded in the early 60s of the last century when NASA within space exploration began Apollo project by sending human crews into space (1,2,3). Then began the development of telemedicine for the purpose of biomedical and health monitoring of astronauts. After the Space Shuttle project NASA continues to develop and improve telemedicine applications during the cooperation of American astronauts or the United States with Russian astronauts at the Russian space station Mir.

At the same time NASA has continued to apply its experience in telemedicine in different areas of the world affected by natural and other disasters. In addition it establish a telecommunications infrastructure that should support further cooperation in areas including preventive medicine, public health, medical education, space biology, life sciences, microgravity science, space and aviation medicine, and medical informatics. Initially set up a satellite link (768 kbps) for communication via the Internet, with a plan to get over a hundred Russian universities connected with U.S. centers and involved in teleeducation (4,5).

Another important factor in the development of telemedicine is the army. Looking historically, the development of the international telemedicine significantly influenced the U.S. Department of Defense. For example, Project Akamai, a project of the military medical center for electronic diagnosis and consultation at Hickam Air Force Base in Hawaii, has as its goal to realize a long-term telecommunications system for medical information, including PACS (Picture Archiving and Communication System), telemedicine, teleradiology, digital patient records and new telesurgery and telepathology as it becomes available. Systems support the diagnosis based on medical images was developed by Loral-Siemens. This system is teleradiology digital system without film for radiology and transfer digital images via satellite to the (U.S.) military hospitals around the world.

1.1. Basic concepts of telemedicine

The word “telemedicine” is a compound in which the first part (from the Greek ‘tele’) denotes the distance, the distance or relation to the distance. One can therefore say that the telemedicine is “remote” medicine or medicine at a distance “. Telemedicine itself is not the medical profession, but the way the medical profession realize their work. So we talk about teleototorinolaringology, telecardiology, telepathology, etc (6,7,8).

Essence in descriptions of telemedicine is the spatial distance between the parties involved in the health care system, whether the one of them is patient and the other doctor–telediagnosis,
telemetry—whether both parties, or more of them, are doctors and medical teams are used—teleconsultation, teleeducation. Potential applications of telemedicine include (Coles 1995):

- Remote diagnostics using videophone or telemetry based on medical equipment that includes, for example, monitoring of heart rate and computerized tomography;
- Remote physician consultations among themselves about the problems of interpretation of X-ray image, the transfer of EEG and other biomedical signals in real time or a rapid transfer of files;
- Telesurgery, which includes an interactive video link between the operating theater and the remote expert who advises the surgeon during the operation;
- Telerobotics, which includes computer supported surgery and clinical applications of virtual reality;
- Tele-education, as an additional option of adding to the medical knowledge;
- Interactive use of electronic medical records;
- Medical monitoring and alarm that connect patients to home care and emergency medical service;
- The possibility of obtaining the text information, detailed pictures, video or moving images from a source which is organized and interconnected via the Internet;
- Data generated during the development of new drugs and research

1.2. Telemedicine branches

Just like the medicine has its specialties, so the telemedicine adjusts special needs of each. For this purpose, in its framework is using two basic methods of transmission of relevant data—the so-called store-and-forward and data transfer in real time, “live.” Store-and-forward technology is used to transfer digital images from one location to another, in situations where the level of emergency medical cases is relatively low. Static image (or several) of organs, tissues or cell structure is obtained from a patient with a diagnostic device (X-ray, magnetic resonance imaging, computed tomography, electron microscope or other), recorded and then stored in a medium (“store”). Thus acquired image is then forwarded (forward) to an expert in the particular field, which on the basis of it makes diagnosis or give an opinion regarding the medical condition for which the patient is subjected to imaging.

Practically, this means that using telecommunication technologies (Internet, first of all) save huge funds and other resources, because the diagnostic procedure is done where it is most advantageous, and its results are forwarded to wherever needed, without having to transfer them on physical media (which above all have a real risk that during the transport medium is lost or damaged). The archiving is achieved in other ways: by the data recorded in electronic form, saving on disposable media (X-ray films, documents ...); electronic record ensures transparency of data about the patient and his status to authorized persons, thus preventing unnecessary repetition of diagnostic procedures, which are costly and harmful to human health; Finally—an easy transfer of telemedical diagnostic relevant records to the top experts, to whom would be difficult by conventional ways (or impossible) to reach, drastically increases the chances of setting the correct diagnosis, starting treatment as soon as possible and finally-successful recovery of the patient.

Because of these benefits, store-and-forward technology is widely applied in fields of medicine, which usually are used for efficient and accurate diagnosis of disease—radiology and pathology. How are images obtained with the imaging devices are often the most powerful diagnostic tool, their importance in telemedicine is huge. Teleradiology allows increasing levels of medical care quality through the provision of radiological diagnosis in areas where there is no appropriate specialist support 24 hours a day via centralized radiological emergency cases, by enabling high-quality and reliable diagnosis in complex cases through obtaining a “second opinion” services by reference centers in the world and in other ways.

Telepathology provides high-quality pathological diagnosis at any medical center. Where there is a pathologist, it can provide “second opinion” consultation with experts in reference centers, to a reliable diagnosis in complicated cases. In centers where the pathologist does not exist, it is possible to establish virtual pathology laboratory where, with the help of modern technology and trained staff can perform all the necessary diagnostics by pathologists at the remote location. Telepathology is now a routine reality in many developed countries, and its introduction is justified primarily by a lack of specialist pathologists and huge savings made in terms of eliminating the expensive cost, and inadequate therapy as a result of inadequate diagnosis of malignant disease.

Real-time (ex tempore) technology is used in special cases, when considering their nature is necessary to provide communication between multiple entities in real time (“live”). Very often it is a case of teleconsultations with experts who are located in different geographic locations, but these cases can apply to medical procedures that are in progress. A typical example relates to the complex surgery, at which the diagnosis of diseases of the remote expert pathologist-performed while the patient is under anesthesia, on an operating table, and which therefore must be done in the shortest possible time.

1.3. Goals of telemedicine in anesthesiology and reanimatology

Governments of developed
countries face today major problems related to increasing overall health care costs, particularly costs related to treatment and care of critically ill patients who are under the domain of reanimatologist at the intensive therapy units. Also demographic changes are radically changing health care market. The health care systems around the world experienced a radical re-evaluation and reform. Goals are usually multiple. For example, in the United States pursued the realization of the three-fold objectives:

- Ensure universal access to health care;
- Restrict the growth of costs;
- Maintain the quality.

Introduction of telecommunications technology enables data transmission about all, especially the severely ill patients (instead of sending patients) to large, virtually unlimited distances. The data are sent to experts who can help solve the health problems of patients in a much shorter time than would be possible if instead of the data patient would be send.

Escalating health care costs increase is mainly attributed to technological progress. While from the telemedicine is expected to reduce these costs. One American study led by Arthur D. Little found that the introduction of electronic medical records, electronic patient record, electronic findings, and videoconferences can annually save more than 36 billion dollars.

2. TELEMEDICINE STANDARDS

Telemedicine, as a set of procedures to ensure, simplifies and improves health care, cannot be viewed separately from the technologies that support it. These, modern information and communication technologies are constantly developing and shaping the way that people will in future take care of their health. Standardized forms and procedures for the acquisition, storage, transfer results of relevant diagnostic images and other medical information, standardized quality of equipment and systems for tele-diagnosis, and the level of quality computer and telecommunications equipment that may be used in hospitals and its individual departments and others are necessary because at least, is a prerequisite for link with other telemedicine centers in the world, in order to obtain and provide telemedicine services, as well as engaging in other telemedicine networks, systems and associations.

In addition, they provide high efficiency in work; remove the possibility of errors and increase reliability and performance of the system as a whole, with a minimum investment and its high profitability. Medical information systems in the (western) world have already been developed for a few decades. Since ten years ago there are standards (now called DICOM—Digital Imaging and Communication in Medicine), which defines in detail all aspects of computer applications in medicine and the ways to download information from a medical equipment through the transfer and protection, storage, and presentation to users. DICOM compatible device (computer) for storing and retrieving files can be directly connected to the DICOM port of for example ultrasound device.

Standardized is the transfer of images and related data between different systems without any loss or adverse changes in diagnostic and clinically relevant information. Any kind of improvisation is not permitted, because those in such complex systems, regularly lead to expensive and/or fatal mistakes. Largest piece of data that should be stored somewhere and organize are images, followed, of course by other service information. In order to shorten the time of data transmission over the network, compression must be made, but such that it does not lose any information that to the diagnostician can be significant. Archiving this is not easy because the annual data on examinations easily exceed terabytes and must be kept for years (1,2).

2.1. PACS

PACS (Picture Archiving and Communication System) is not a precisely defined standard, but there are recommendations which each PACS viewer must contain of user tools, in addition it have to search DICOM database and display DICOM images and their associated additional information such as annotations. It is a client-server application. Initially, PACS systems have very limited possibilities and were consisted of the computer device that downloads relevant information on the review and place them in your local database. The systems are designed for storage of images for several sections, from the multiple devices from with which the information will be transferred into the central database, called multi-modal and represent a major step forward in usability.

With them, previous examination information for several departments (x-ray, ultrasound, laboratory ...) is no longer a problem. The prices of medical equipment are extremely high, and such systems cost several hundred thousand dollars. It is known that each specialty (radiology, pathology, cardiology ...) has special needs and requirements. To meet the requirements of such, the current world trend is the complete abandonment of the idea of universal PACS Viewer designed for all users and creating a special module with tools adapted to various specialists. It is significant that, thanks to strong increase in use of Web technologies, any modern PACS system should be Web-oriented, or at least have the ability to transfer data through an appropriate Web server into a format that can be seen in the Web browser. This detail is of great importance, because allows the use of uniformity regardless of the location from which data is obtained, in a familiar environment that are now used to.

2.2. Hardware issue

The standards clearly define the minimal technical character-
istics of computers used for diagnostics, depending on the type of diagnosis (primary, secondary or tertiary) and the types of images where it is. It is the transfer of data to any location one of the fundamentals “Web centric” of PACS. Implementation of Web Technology in the core of the system facilitates the use of all paths of transmission of information—local area network, dial-up, virtual private networks and more. These systems receive the full meaning in telemedicine and teleconsultations, and may include a person who is physically perhaps on another continent. Larger importance of “overseas” consultation is with emergency cases, when there is no problem that the images obtained in the emergency room the radiologist view at home, without the need for coming to the clinic.

This saves valuable time that may decide the future of the injured. Significant use is when there are not enough specialists where necessary. The main gains of using PACS is reflected in an increase in the quality of diagnosis, a significant acceleration of (clinicians in the United States report that they save an hour a day just due to the fact that their data is always close at hand, i.e., computers), the exclusion of loss of recordings, the ability to see the same information in several places simultaneously, then a lower cost compared to examinations that use film ... PACS was first formed precisely for the radiological departments, because of the huge funds that are spent on films, chemicals and archiving that are with us are often not even implemented.

3. BASIC PRINCIPLES OF TELMEDEICINE IN ANESTHESIOLOGY AND REANIMATOLOGY

Telemedicine in anesthesiology and reanimatology provides a wide range of applications. Although not yet sufficiently developed for us, given the high specificity of access to the patient and the constant need to literally be immediately accessed, or treatment of critically ill patients under general anesthesia, telemedicine allows you to immediately share the information about the patient, the diagnosis with multiple centers and application of adequate therapy, all without loss of precious time. Unfortunately, there are still many people who are often doctors themselves, anesthesiologists and reanimatologist, which under the term “telemedicine” perceive the video conference, where experts discuss, inform or train.

These applications, though quite feasible and useful, are marginal in telemedicine services. Telemedicine is a way that, using modern information and communication technologies facilitates the transfer of medical data from one place to another, which can provide medical services regardless of the physical location of doctors, patients and patient information. It is, in fact, “the icing on the cake” in relation to medical information systems a part of its infrastructure. It allows you to trace the course of general anesthesia during surgery from one center which does not have available anesthesiologist to a larger center that can immediately send a valid advice to any treatment applied.

In doing so drastically reduces the redundancy, maximum automate various work processes and reduces the possibility of errors, diagnostic and therapeutic quality increases, improved is early diagnosis of critically ill patients in remote small medical centers, and early detection of adverse effects of therapy and more. Also are important economic factors, which are reflected in lower costs for materials with which to work (such as film), increasing the degree of utilization of resources, less staff time lost to administrative tasks, improved monitoring of the consumption of materials and procurement planning ...

3.2. Examples of telecommunication application in anesthesiology and reanimatology treatment of critically ill

In many developed countries...
nursing staff makes a majority of staff before patient’s hospitalization (3). Since the initial treatment of critically ill patients requiring highly professional treatment, there is a need for training of people who are in first contact with these patients. In such cases, basic information about the cause of illness and patient’s vital parameters (ECG, SpO2, etc.) are automatically collected in the dispatching center and forwarded to the doctors in the outpatient clinic. The data are instantly analyzed by anesthesiologists and decision on the initial treatment is sent back about triage of such patients, etc. to the staff who is on the spot and accompanied the patient. Thus, with the help of telecommunications, the patient on the spot receives the necessary specialist treatment.

The potential that allows telecommunications in the case of trauma and other emergency medical conditions requiring anesthesiology-reanimatology treatment is enormous. For example, in the University of Maryland (6), which has a highly developed anesthesiology research laboratory, has developed a system that uses cellular phones to multiplex transmission of low-speed video of information from the patient during transport to the University Clinic. Transportation time thus becomes a time for which there is a possibility for rapid diagnosis and intervention that has not previously been available. In the case of a suspected stroke it reduces the incoming time of patients on CT of the head by 30 min. Specifically, in collaboration with neurologists is transmitted over the phone completes the NIH stroke scale. When a stroke is suspected, those patients receiving emergency treatment at center and immediately are referred to CT, where, on the basis of the findings is made a decision on the emergency surgical treatment or in the case of ischemic stroke, the use of thrombolytic therapy significantly improves survival rate and possibility of complete recovery. This can substantially reduce the costs which these patients may cause to the health systems if they we not react in time.

These or similar wireless technology can be applied to the traumatized patients. During transport by ambulance or helicopter, accompanied by a doctor sends a description of the physical status through video footage and vital parameters to anesthesiologist and surgeon, who immediately decide about initial treatment, possible need to secure airway through endotracheal intubation, a specific type of treatment etc., which can significantly reduce mortality and morbidity of these patients.

4. SIMULATION TECHNOLOGIES IN ANESTHESIOLOGY

Conducted are several studies that aimed to show increased efficiency in anesthesia crisis, after the anesthesiologists had a chance to practice on simulators such situations. One of the commonly used simulators in order to improve efficiency of endotracheal intubation in patient with problematic anatomy of respiratory pathways. In such situations are used a computer-controlled patient simulators. The results indicate a great advantage in terms of reducing the number of hours needed for mastering the basic skills, and greater safety in the work on a real patient in the operating room (1,5,6).

Similar simulation technologies are used in a study recently done at the University of Toronto, where 24 of 117 specialists attended the simulation of a crisis situation that may come into practice over the video tape (6). The results showed that students who attended the simulation, reacted more quickly to the actual practical situation and in the actual situation, compared to students who have not participated this simulation.

5. COMPUTERIZED MEDICAL CHART AND CLINICAL-HOSPITAL INFORMATION SYSTEM

When you store somewhere the information on the examination of patients, it is clear that we should make a step forward and create the appropriate database in which we can locate a particular patient data with all his/her examinations and findings, which we call the computerized medical record (CMR). CMR is based on a PACS system for archiving and handling of images and Documentation Information System (DIS), which handles all other information. In this way, combined with other computer-communications technologies which include Internet and Web, information about the patient can be seen as they were needed elsewhere. So, if someone gets sick on vacation in place B, and the data in the hometown at place A, a doctor can easily find them and thus significantly expand the basis for diagnosis.

In the case of global connectivity, there must be a mechanism for automatically relocation of data into the archive of the home institution (which usually carried out the largest number of reviews), which should be done automatically. In this way, the data of the survey which was conducted at a remote location will be placed in the CMR and will be available for later analysis. These databases, in addition to giving a qualitative jump in the speed for medical staff, are supporting research that is often used in statistical terms. Instead of great search, often over incomplete data in a cardboard folder, it is sufficient to make the function of the corresponding query and to wait for the answer.

Computerized medical record (CMR) is a cornerstone of modern patient-hospital clinical information system (CHIS) that will allow all the data to be placed in manner that allows their easy search and transfer where necessary, with monitoring of relevant information on business of facilities (procurement, stores, publishing materials, various types of expenses ...). To make that possible, the CMR data should come from department (clinical) information system (DIS), which are created
5.1. Anesthesia record

In everyday practice of anesthesia it is necessary to conduct a detailed intraoperative record on the course of surgery, anesthesia techniques that are applied to the patient, doses of medications, vital parameters of patients and so on. Computerization of anesthesia record would have more advantages. Among them, for example, that with telecommunication technologies person who is with the patient in the operating room may be online to consult with experienced colleagues. Then to allow access to specific patient anesthesia record from previous operations, where such could be the time to find any problems in a patient with regard to the guided anesthesia, which may be of great importance for the new operation. The computerization of anesthesia records would also help in training of staff, because it would allow access to specific ways of keeping the previous anesthesia for various pathological conditions which they can encounter in practice (5,6,7,8).

5.2. Patient record at the ICU

Given the specific pathology and complexity of illnesses of patients in the intensive therapy, a physician anesthesiologist often has a problem with a large number of consultancies from specialist who almost daily are involved in treating the patient; the findings of various diagnostic procedures also included a large number of drugs, etc. In our country we are storing such data is the old way, while in the world long ago is introduced data stored in the computer and thus become easy to review and available at any time. In addition to the 24h monitoring that is connected to every patient in the ICU it automatically connects to a central computer at the department and patient record, and thus there is a permanent archive of data on vital parameters of patients with its other findings.

6. DISTANCE LEARNING

The rapid development of Internet and computer technologies in the last few years has influenced to change traditional ways of learning (1,2,9,10). Whereas before the students attended classes in the way that they came to the lectures and were in direct contact with a professor, now used are virtual classrooms and virtual training (1). With the advancement of the Internet and falling price of computers has resulted in changes, where students have the opportunity to attend classes via the Internet without leaving their home. They do not have to be any more physically present in classes due to new information and new knowledge. Lectures and examinations are increasingly conducted online. In medical facilities, videoconferencing is increasingly used for distance learning. For example, a lecture from anesthesiology (e.g. endotracheal intubation, emergency conicotomy etc.), which is held on the premises for videoconferencing at one university, can be followed by students from other universities or if they have equipment from home. This way of teaching also applies to the United States, Asia and some Western European countries (Sweden, United Kingdom). An interesting example is the interactive teaching at a distance achieved between the University of Michigan and Daewoo in Korea, and Cathay Pacific in Hong Kong. This program enables students to study in the countries of Asia, as well as attend special courses, University of Michigan, without unnecessary travel costs and stay in the United States. Distribution of all required textbooks and other materials is in electronic form to further reduce costs. University of Michigan in this manner significantly increases the number of students, reduces costs, and provides far better quality of interactive lectures.

7. INTERNET TELECONFERENCE IN ANESTHESIA

Using the Internet for professional medical purposes is an elegant way of solving the problems of access to medical information and provides the potential for improvement of existing medical practices of all physicians, including the anesthesiologist. On the Internet is a great number of data from anesthesiology, papers, etc., which can be of great help in educating both residents and physician specialists, anesthesiologists. However, a recent study conduct-
ed in Croatia revealed that the pattern of Internet use in professional purposes among doctors is more for “general information” rather than “evidence-based” oriented. Specifically, the main information required on the Internet are the news and information on medicines, while the search for information on diseases, clinical guidelines or reading papers is in the background. Second could be interpreted by infrastructure issues (Dial-up, the cost of access), lack of time for a more detailed search, not knowing English, or poor understanding of the principle of evidence based medicine, which will be necessary to check in the further researches.

In the world is a different situation, so they used the Internet in various ways for improving medical practice of anesthesiologists. Internet teleconference software, among other things, is used for “virtual” meetings during which the participants from around the world also can share their ideas and opinions (9). A group of anesthesiologists who are members of the society SATA (Society for Advanced Telecommunications in Anaesthesia) held regular meetings, so called „Virtual roundtables”. This system uses two teleconference systems: White Pine Software CU-Seema and Microsoft NetMeeting. While both systems provide acceptable results, each has its specific advantages and disadvantages. CU-Seema is easier to use when conference meeting includes more than two participants. NetMeeting provides higher quality of audio and video signals in circumstances where the Internet network is overloaded, but it is better for a conference involving only two participants. Although both systems have disadvantages in relation to the so-called point-to-point teleconference systems, SATA society used them due to wider availability and low price, usually for regular meetings of the anesthesiologist, the members of that society (3,12,13).

8. CONCLUSION

Today, all experts agree that the telemedicine systems in healthcare are inevitable. This particularly applies to anaesthesiology and reanimatology, because there is a lack of this specialist everywhere, and is expensive even in developed countries, so the networking of small and large medical centers provides access to highly specialized personnel to all patients. At first glance it all looks simple, but because of the apparent complexity of the implementation will be difficult to implement it easily, and the big issue is the allocation of funds, planning and superior knowledge of the matter. The complexity and multidisciplinary of these systems require special staff, called clinical engineers, trained in special courses at the faculty of electrical and computer science. Emphasis is placed on these systems need to be in a function of doctors, and not vice versa. You may need to engineers who design them and develop an understanding and lead exclusively to the needs of doctors, not vice versa, they impose technology and engineering solutions that are convenient for implementation.

During application of telemedicine in anaesthesiology we should take into account how these disciplines covering different pathology, and therefore there is necessary multidisciplinary approach. This means that it is necessary to plan networking of more specialized branches of medicine, so that the anesthesiologist could have consultancy based opinions of doctors received by the telecommunications technology make the final decision on the patient.

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