

## PRACTICE

**Telemedicine in urgent neurosurgery**

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The transportation of patients, the speed of stating the diagnosis and fast commencement of adequate treatment are the most problematic moments. We see the solution to this problem in the shortening of time between accident and admission of the patient at the neurosurgical center. We would like to underline that no matter how important is the connection between the hospitals, it represents only one technical aspect of communication. The software module for fast, comfortable and safe transmission of data was developed by experts of f. West Trend Encore Inc. in cooperation with the medical expert group and in our region it is referred to as ER-Slovakia, with the access to Internet.

Our experience has proved definitely that the time between the accident and the admission of the patient at the neurosurgical center can be shortened. According to our experiences the time of 6–8 hours, could be possibly reduced into 2–2.5 hours. The process of mailing the request for consultation with picture documentation to and receiving a qualified evaluation from a distant center takes about 10–15 minutes. From September 1, 1999 to December 31, 2000 we have 244 consultations among the hospitals and the neurocenter.

We have focused our consultations on acceleration of the correct diagnosis statement, early commencement of sufficient treatment and at last but not at least, on providing of qualified evaluation of treatment by the specialized center. On the basis of consultations, a conservative way of treatment was used in 100 patients, further diagnostic evaluation was necessary in 32 patients, and 77 patients were hospitalized in the neurosurgical center. 47 patients of the given number (19 % of total number), needed an urgent transportation to different hospitals were they were subdued to operations. (Tab. 2, Fig. 1, Ref. 6.)

**Key words:** telemedicine, neurosurgery.

Head injuries are the most common causes of death in our technological society. The death rate of severe head injuries has not changed considerably, and reaches 60–70 % of injury cases. During the last analysis of our system of neurotraumatological care in the southwestern part of Slovakia, we made an important conclusion. Regardless of the type of injury we deal with, we have identified the most problematic moments for helping the injured summarised as follows: 1. transportation of patients, 2. the speed of stating the diagnosis and 3. how quickly we begin the adequate treatment. It is clear that the acceleration of the diagnosis statement in patients with severe head injuries would be one of the possibilities how to improve the results of their treatment. In the Southwestern region of Slovakia there are approximately 1 million inhabitants within the radius of 80 kilometers from the Nove Zamky neurocenter. Patients with head injuries are transported to the site of CT and after the diagnoses are made, patients are transferred to the Department of Anesthesiology and Intensive Care at the nearest health center, or to the neurosurgical department in Nove Zamky. Our experience has shown that the time between the

accident and admission of the patient at the neurosurgical center is excessive and represents the point of particular potential improvement. This fact seems relevant with our statement that the time of commencing the treatment is vitally important for the survival of the patient. One possibility of how to reduce this interval is to improve communication between hospitals within the region, especially with those equipped with CT scan.

Initially, when we sought the solution of this problem, we thought about the use of Internet for the transfer of case history information among hospitals, but now we are sure that this way is more complicated than we had expected. The patient's data and picture

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documentation might get coded during the transmission and would require some time to decode them, thus shortening the saved time to minimum. As far as the security and the speed of data transfer are concerned, the implementation of private computer network is the next solution to be considered. Implementation and maintenance of such a private network proved to be too high, considering insufficient financial resources of health services in Slovakia.

The connection between the hospitals via ISDN (Integrated Services Digital Network) lines with the capacity of 64 or 128 kb/s seemed to represent the solution. Establishment and running costs are effective and all conditions for safe and fast data transmission are satisfactory.

### Description of the consultation system

No matter how important is the connection between the hospitals, we consider it to be only one of important technical aspects of such communication. We are sure that the development of the software module for fast, efficient and safe transmission of data would be the most important step. This type of software module was developed by experts of West Trend Encore, Inc., in cooperation with the medical expert group, and it is used in our region. It is referred to as ER-Slovakia, and provides a secure connection for patient's data transfer via access to the Internet. Information on ER-Slovakia can be found Internet at <http://www.er-slovakia.net>.

ER Slovakia is the modular Internet application based on client-server architecture. It is used especially for the needs of both urgent and non-urgent medical consultations. The use of this system can be widely and easily expanded for use into other geographic areas, and its original core can serve several hundreds of users simultaneously. It can be applied as a secondary console of diagnostic devices (e.g. magnetic resonance, computer tomography, subtract angiography, ultrasonography, etc.). Their highly efficient database system provides safe data storage as well as extremely good organization of the data. A part of this complex system is composed of various types of programs for displaying picture supplements which are the part of patient's records.

The most important part of the system is the second generation consulting module, put into action using the standard data center model. The data centre is responsible for maintaining the physical environment needed for reliable maintenance of servers, using the operating system Windows 2000 Server, Windows 2000 Advanced Server and Windows NT 4.0-SP6. The system platform uses a so-called "farm" of primary servers and a number of assisting subsystems.

The consulting module relies upon three basic services: web, database, and distribution services. Servers are available through the help of 2 independent synchronized steady lines and ISDN lines. The data centre maintaining discreet information is protected by a central "firewall" for added security of the stored data. The centre is responsible for providing secure communication and for application of the latest technology in the field of data storing and security. All active elements are continuously monitored. The monitoring system is able to detect any attempts of unauthorized access immediately. Round-the-clock service for technical consultations concerning the system, or for solving unplanned events, is also available. While the team in the centre monitors internal

processes, it also monitors, upon agreed time limits, individual types of consultations, as well as the general functioning of the system.

The high level of security is guaranteed by industrial and governmental standards (CPRI-ISO 7498-2). Client-server communication runs in 3DES coding (168 bit encryption). The center is protected by a sophisticated design consisting of combinations of NT firewall and Cisco PIX firewall. Internal interaction of individual subsystems uses extended modifications of the safety model "Kerberos". Proprietary G&G cascading security was especially developed for the use with the consultation module. It reliably prevents unauthorized modifications of the data by users themselves, once the opinions are submitted by the consultants, providing necessary accountability.

Most, but not all of connected workplaces can scan CT pictures in 2D format when needed for consultations and then are sent to the consulting specialist. The apparent disadvantage is an informational loss for the consulting doctor. The problem of information reduction has been solved at the State Hospital Levice by connecting the CT apparatus to the network directly. The ability to send dynamic CT data brings information of distinctly better quality. The freeware program from the Information Center of the University Hospital in Geneva is used for CT data processing. In spite of the shortcomings of the older data, ER-Slovakia can work with older data formats (ACR-NEMA 2.0) which are still produced by CT devices. The data are processed in POPYRUS format, which is DICOM 3.0 compatible format.

At the end of August 1999, after several months of preparation, we started the experimental work with the ER-Slovakia communication system. The first connection was established between the Nitra and Nove Zamky hospitals. Recently other hospitals — Hospital Levice, Hospital Dunajska Streda, and Slovak Railways Hospital Bratislava — have been connected to the system.

### Results

After several months of experience of using ER-Slovakia telemedicine system, it is possible to state that this system provides highly qualified assistance in the treatment of patients. The transmission of patients' data can be carried out in several few minutes, honoring complete discretion and it is a significant element of quality in neurotraumatological care we are now able to provide.

Our experience with ER-Slovakia communication system has definitely proven that the time between the accident and admission of the patient at the neurosurgical center can be reduced. The time of 6 to 8 hours can be shortened to 2 to 2.5 hours. If the system is used all over the region in order to assist in severe injuries, we can expect real improvement in clinical results of treatment.

In most cases the process of mailing the request for consultation together with picture documentation, and receiving qualified evaluation from a distant centre takes only about 10—15 minutes. In the period of 16 months (from September 1, 1999 to December 31, 2000) 244 consultations were performed between the hospitals Nitra, Levice, Dunajska Streda, Bratislava and the Neurocenter in the Nove Zamky Hospital. The number of consultations was influenced especially by the working hours of computer tomography in particular hospitals. Quite often, in this given period, only

2 out of 5 CTs in the region were functional. If all of them had been in use, the number of consultations would have been considerably greater.

The highest number of consultations were carried out in coincidence with patients with head injuries (24 %) and patients with spontaneous intracranial bleeding. It is an important point that we have gradually performed more consultations on patients with the diagnosis stated by the consulting physician, especially for those patients whose states could be worsened due to unnecessary transportation (Tab. 1). Consultations were carried out in most cases from 6 a.m. to 6 p.m. At midday they reached their maximum of occurrence (Fig. 1).

The goals of consultations via this computer system are acceleration of the correct diagnosis, fast commencement of proper treatment, and at last but not at least, the provision of qualified evaluation of treatment by specialized center. On the basis of consultations per 100 patients, 40 % needed conservative treatment, 32 % of patients required further diagnostic evaluation, and 77 % of the total of patients were hospitalized in the neurocentre of the Nove Zamky Hospital. 19 % of the total of patients needed urgent transportation to different facilities where they were subdued to operations (Tab. 2).

The consultation system among medical centres connected to the network is not limited to urgent consultations. In fact, 25 to 30 % of all cases are non-urgent consultations, in cases of distinctly algic patients who cannot be transported, and also in cases where transport could threaten the life of the patient. Quite often, these consultations mean mere confirmation of the diagnosis by the more specialized centre without transportation and hospitalization of the patient at the specialized center. Consultation without seeing a patient may seem incomplete, but in most cases it is sufficient for making a decision about the necessary diagnostic and treatment procedure. In addition to its standing as an important professional contribution, this method of consultation has economical benefits as well. Such consultation lead to decreased transport expenses and excludes useless transportation of patients or slow transportation of case history information. The possibility of consulting and stating the procedure of treatment in a few minutes gives the patient a greater chance to get sufficient treatment at the specialized centre as soon as possible. Therefore, greater possibilities of successful treatment can be carried out at the very beginning of treatment.

## Discussion

Telemedicine can be defined as the use of electronic signals for transmission of medical information (X-ray images, photographs, audio records, etc.) from one centre to another, with the aid of information and communication technologies. The aim of telemedicine is to raise the quality of provided health care.

Though the use of communication and information technologies in health care is becoming more and more common, telemedicine still represents only a small segment, though expanding rapidly. More than 80 % of federal telemedicine projects in the U.S.A. have started in the last 2–3 years. According to the opinion of specialists, the future of medicine looks for safe models of “information storing and forwarding”, in spite of wide use of interactive methods of communication such as videoconferencing. We expect

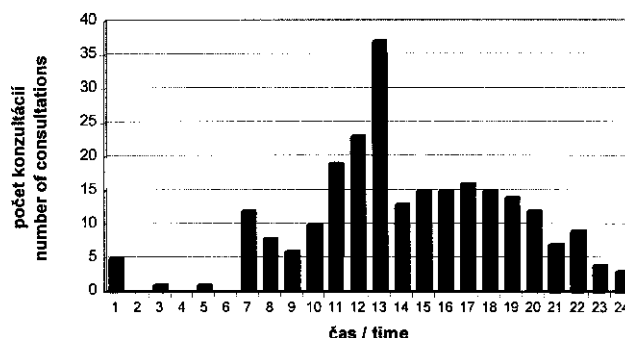


Fig. 1. Review of the number of consultations during a day.

that the contribution of telemedicine projects will improve health care, especially the effectiveness of diagnosis and treatment, and higher efficiency of services provided. Using the latest communication technologies will lead to an increased level of education by

Tab. 1. Review of the consulted patients according to the diagnosis.

Diagnosis	Number of patients
Contusions	30
Acute subdural hematoma	15
Chronic subdural hematoma	13
Missible injuries	1
Acute epidural hematoma	9
Cerebral oedema	1
Hydrocephalus	5
Spontaneous intracerebral hemorrhage	44
Subarachnoid hemorrhage	17
Brainstem hemorrhage	3
Cerebral ischemia	1
Tumors of the spine	13
Metastatic brain tumors	13
Posterior fossa tumors	5
Gliomas	9
Meningiomas	3
Subdural empyema, abscess	5
Arachnoid cysts	5
Intervertebral disc herniation	19
Lumbar spinal stenosis	2
Cervical myelopathy	2
Spondylolisthesis	1
Spine injuries	1
Different	18
Postoperative examination	6

Tab. 2. Review of the recommendations for consulted patients.

Guidelines	Number of patients	%
Conservative procedure	100	40.9
Urgent transportation	47	19.2
Planned admit to hospital	30	12.3
Diagnostic procedure	32	13.1
Out-patients examination	16	6.5
Different	19	7.8

users, since the system leads them to continuous study. The users will become more precise in particular diagnostic steps and information processing, and the technology will improve their way of thinking in the process of asking questions and providing responses in the consultation process. We believe that if more hospitals were using this system, specialists from specialities other than neurosurgery and neurology would be able to make use of this effective consultation measure.

Another important benefit of the project connecting all 15 hospitals in the region into the ER-Slovakia information system, is the possibility of exchanging the information on patients, including picture documentation, without communication problems. Smaller hospitals without CT and without the possibility of getting such equipment in the near future will have the ability to view the results of all examinations even their picture forms, not just in the form of text information, and descriptions. This is very important from the point of view of further post gradual education of doctors and the possibility to be able to compare their clinical experience.

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