

Telemonitoring in Cardiology - ECG Transmission by Mobile Phone

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The paper describes the new way of ECG telemonitoring. By using the electronic and telecommunications equipment of the newest generation it is possible to build a portable ECG machine embedded in the mobile phone. A new ECG recorder has sealed metal contacts being thus very comfortable for everyday and permanent use. With the new mobile telemedical device patients can be under permanent medical supervision. In case of emergency the nearest medical center can be contacted and by GPS capability the patient can be found and saved.

KEY WORDS: Telemedicine; Telemonitoring; Electrocardiography

INTRODUCTION

With the development of electronics and its application in medicine it is possible to transmit and process many vital parameters of the human body. The most important, and in this moment the most interesting signal for monitoring and analyzing is the electrocardiography (ECG) signal. For the patient suffering from the cardiac disease it is very important to perform accurate and quick diagnosis. For this purpose a continuous monitoring of the ECG signal and the patient's current heart activity are necessary. In this medical field, a big progress has been achieved in last few years, especially by applying the latest generation of mobile phones. This paper gives a survey of today's solutions for ECG telemonitoring, from an engineer's point of view.

Nowadays the ECG signal recording is usually performed in two main ways: by using the ECG machine in short time intervals during the examination by physician, or by using permanent 24 hours ECG recording and a later analysis (the so-called the Holter monitoring). The disadvantage of the first method is that it is not possible to have the complete diagnosis, and the shortcoming of the second method is that it is not possible to intervene immediately, which sometimes can be fatal.

The new methods are direct transmissions of ECG in real time for few minutes or few hours, the so-called telemetric ECG. An electronic equipment (including sensors and transmitter) is mounted on the patient's body permitting continuous monitoring of the heart activity and sending the ECG signal to the receiver located in the remote center. The signal is monitored on a central monitor in real time. The transmission can be made either by wire or wireless [1].

The standard telephone lines are used for a wired transmission of

ECG signal. The patient and the central unit are connected through appropriate modems on both sides. The disadvantage of this system is the limited radius of the patient's motions.

For a wireless transmission it is necessary to have a system of antennas with amplifiers placed on some points on the corridors between the patient and the medical center. This is a very limited way, depending on antennas, the land/corridor configurations, and obstructions on the transmitted way. Due to these reasons it is used mainly in the hospital area. For monitoring and transmitting the ECG signals of stationary patients walking in the building or around it a system of antennas are installed on the interior and exterior walls covering all hospital area. The disadvantage of this system is a very limited area of the covered signal. On the other side, this limiting factor enables a very rapid intervention, because the patient moves in the area where medical staff is always present.

A common point of all above-mentioned methods of recording and monitoring of the ECG signals is that the signal is picked by ECG electrodes and cables connected to the body of a patient. Only a skilled person can find the exact position and connection of electrodes. The second point is that some consumables must be spent, 3-5 electrodes and batteries per each patient.

NEW METHODS OF REMOTE ECG MONITORING

The modern electronic and telecommunications equipment permit us to reach one step further in transmission and recording of ECG signals. The new, miniature ECG machines having many possibilities and advantages are offered to physicians and patients. They are much smaller and lighter than standard ECG machines used in telemetry. It is not necessary to connect cumbersome ECG cables and to apply ECG electrodes, because a new recorder has sealed metal contacts. It is interesting that such recorders are made as a common daily used small things, like wallet for credit cards, bills, etc. (Figure 1).

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Figure 1. Wallet-like ECG recorder

The education of the patient is very simple. By simply placing the contacts against the chest the user can record a real-time ECG signal. The users can carry such ECG devices not only in their homes, but also while working, traveling or driving a car. Thus, no matter where the user is located, when he feels heart irregularities, he has the ability to record and to transmit the ECG signal by only pressing a button. The recorded data on some models can be completely viewed on a built-in small LCD monitor (Figure 2).



Figure 2. Small Tele-ECG monitoring device with metal contacts (Company IFE, Germany)

The signal strings observed during few minutes (till 2 hours) are stored in memory blocks. By expanding the system to include PC software the data can be stored for the user to access at any time for further interpretation and analysis. The stored data enable also to continuously monitor the treatment of the patient and to compare new data with previous ones. Software contains functions

for various measurements, calculations, analyses and printing of the ECG characteristic parameters.

For transmitting the ECG signal the communication path used might be a standard telephone line. The signal can be transmitted in real-time, or later, in the case when there is no access to a telephone line. Within just a few seconds the ECG signal is transmitted to a monitoring center and downloaded to the patient's personal home page. For less than 20 seconds it is possible to transmit the 12-channel ECG signal. Thus the physician is provided with continuous access to essential information about the patient's state of health. Trained medical staff at a remote monitor center can interpret the ECG signal, receive the patient's symptoms over the phone and provide real-time diagnosis, immediate consultation and clinical advice. In this way it is possible to drastically shorten the time preceding the treatment and reduce morbidity and mortality rates. The schematic representation of the remote ECG monitoring is depicted in Figure 3.

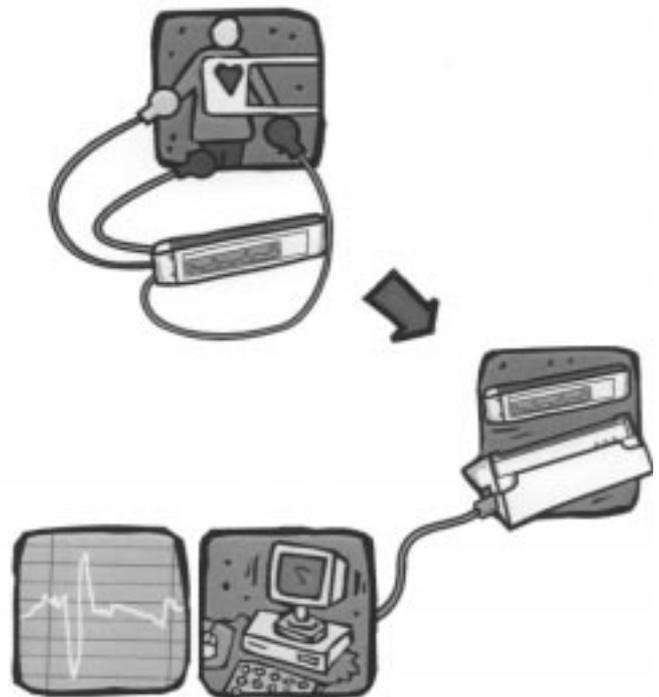


Figure 3. Schematic representation of ECG recording using a small ECG recorder (with ECG cables) and transmitted by standard telephone line to a monitor center

The use of the standard telephone line limits the patient's movement. The newest, the so-called the third generation wireless networks, as the Universal Mobile Telecommunications System (UMTS), will extend the services provided by current second-generation systems (GSM, PHS, IS-95, etc.) from simple circuit-switched voice telephony to complex data services ranging from e-mail and web-browsing to voice over packets, media on demand, and video conferencing [2]. Mobile network is spread all

over the world and it is accessible to many people. The logical question is how to use this network to transmit medical signals, especially the ECG ones. The greatest advantage of this system is practically unlimited movement of the patients and unlimited covered area. The newest mobile phones offer the revolution in the telemedicine concept [3]-[5]. This concept includes the popularity and the convenience of a mobile phone and provides results which are in no way inferior to those obtained from standard ECG machines. Several (usually three to four) metal electrodes on the back of the standard cellular phone record the heart event and the data are stored and transmitted to cardiac monitor center (Figure 4). Now it is possible to record and transmit ECGs at the onset of symptoms in everyday situations. They are particularly important for the diagnosis and the resulting therapy. This technology allows the attending physician much better observation and evaluation of the therapeutic effects of a treatment. Mobile connection allows the physician to monitor the patient all the time irrespective of the location of the patient. By using the GPS (Global Positioning System) built in mobile phone it is possible to determine the exact location of the patient.

A large number of patients, especially with paroxysmal tachycardia, unstable angina pectoris, ischemia, etc., are afraid to leave their house. Something could happen to them beyond the house and nobody would be around to help them. With the new mobile telemedical device they can be now permanently under the medical supervision. In the case of emergency the nearest medical

center can be contacted and by GPS the patient can be found and saved.

The next step is to organize a remote cardiac center, where ECG signals are received. The center is a backbone of the whole system, designed for a wide range of patients (Figure 5).

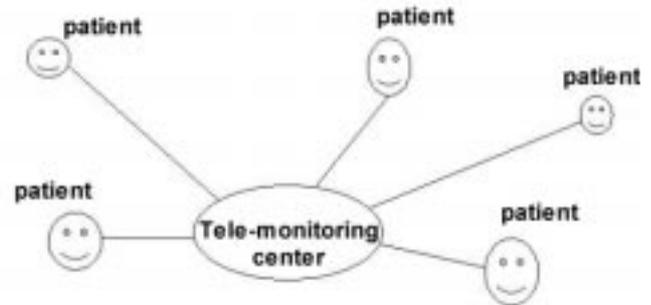


Figure 5. The structure of the Tele-ECG network

Twenty-four hours a day, all the year round, the center receives ECGs from many patients in a real-time, and the patients have a direct access to a cardiologist. Detailed real-time ECG waveforms are displayed on the center monitors (Figure 6). The trained medical experts retrieve the patient's medical history, receive his symptoms over the phone (standard or mobile), compare a transmitted ECG with a previously recorded ECG and interpret ECG. A quick initial analysis can be undertaken and instructions for the treatment and clinical advices can be given. If it is necessary, the position of the patient can be determined using GPS and emergency medical service can be contacted. Not negligible is a psychological factor. The consultation with the cardiologist provides the patient with the reassurance that he is not alone and that he can expect help whenever he needs it. Both medical and emo-



Figure 4. New generation cellular phone with ECG recorder embedded (Company Vitaphone, Germany)



Figure 6. SHL Tele-Care Center, Tel Aviv, Israel

tional supports are provided by the cardiac center, and the patients are encouraged to call for help.

The services of the cardiac monitor center are profit-based. The patients pay monthly a certain amount for the service and benefits they get. For instance, the HomeMed service in the USA provides the equipment and nursing staff starting at \$13/day. Certainly, with a greater number of users the costs become lower [4].

The use of telemonitoring of ECG signals has many advantages compared to a classical examination of ECG patients, such as: covering many patients at the same time, covering a large area, real-time information, faster diagnosis, faster therapy and prevention. The logical conclusion is that with the new millennium a new method of monitoring actual and potential heart patients is developing.

In Yugoslavia, successful attempts in development and application of this method in one hospital were made. The future development depends on new investments. Our experts follow the newest world research, and our belief is that with the support of a health institution the ECG transmission by mobile phone will be a reality in our country very soon.

CONCLUSION

There are several methods of recording and transmitting ECG signals. A classical recording in health centers, then ambulatory ECG recordings and telemetry monitoring the patient in and round medical center.

With the use of mobile phone in medical purposes, monitoring and recording of the ECG signal offer many advantages. It is possible to monitor a heart patient in a real time, immediately to give an advice and therapy, the covered area of movement of the patient is practically unlimited (depends on the covered area of a mobile phone). The control monitor center with trained medical staff enables 24 hour monitoring of few thousands patients. With pre-paid service we get more economical and efficient way of monitoring heart patients than with classical recording of the ECG signal.

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