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AWireless Telecardiological System

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Heart-related diseases and disorders are abundant in the western world. Around 500,000 cases of sudden cardiac death, over three million patients with atrial fibrillation and about 600,000 heart attacks are a significant factor in the cost structure of the European healthcare system every year.

Effective therapy in this area is usually no longer the problem. Defibrillators and sufficient medication have had revolutionary success in saving the lives of patients with heart disorders. Crucially, the biggest issue is the lack of diagnosis. So far, the standard is that even high-risk patients only visit their physician every six months for a check-up. If the health situation worsens between visits, problems will not be identified until the symptoms become acute. Due to a prevalent fear of hospitals, many patients wait until their health condition develops into an unbearable situation. It is at this point that they would call the emergency service and be brought to the hospital, normally needing to remain there for days before becoming healthy enough to return home, thus costing the healthcare system a great deal.

Different programs to circumvent these problems have been carried out with patients for the first symptoms of heartrelated diseases. These programs have proved to be successful. However, for more effective prevention, the best solution would be a continuous monitoring of the relevant vital parameters, especially the electrocardiogram (ECG). The monitoring in hospitals is very effective but also very expensive. Furthermore, most patients prefer to remain at home in their place of comfort, where they have the support of their family and friends. In contrast to the often very sterile atmosphere in hospitals, from a physiological point of view, the home is a much better surrounding for treating patients. Obviously, it is also much more cost effective if patients do not have to stay in a hospital or can leave the hospital as early as possible. To give the necessary medical security at home, a monitoring system for the homecare area must be the goal.

There have been many attempts to find a practical and efficient way to monitor patients with heart-related problems at home. Recent approaches rely on the interaction of the patient. In the event that symptoms arise, the patient has to apply an ECG recorder or, as a minimum precaution, has to activate a recorder that he is wearing. Afterwards, the ECG is transmitted via the telephone line or a mobile phone. Some downsides are that often this procedure is not possible because the patient either does not feel any symptoms or it is an acute situation where he is unconscious within seconds and therefore unable to activate the device.

The Proposed System

An innovative system has been developed which overcomes these disadvantages. The central part of this monitoring system is a mobile sensor, an ECG chest strap1,2, which is worn by the patient and analyses the patient's ECG. When an event is detected, an automatic wireless connection is activated to a relay station, which receives the message from the ECG chest strap and sends it via the mobile telephone network to a central internet- based Electronic Health Record (EHR). This EHR automatically informs a care giver via fax. The care giver logs in the EHR, checks what happened and initiates the appropriate help.

In this scenario, the patient is monitored with a small and light ECG chest strap, which is worn in a way similar to the pulse watches familiar from the sport area. This sporty connotation, together with a high level of comfort, reduces the patient’s inhibition to wear the device over a long period of time.

The chest strap contains an integrated ECG sensor, which continuously analyses the patient's ECG readings. A one-lead ECG is picked up with dry stainless steel electrodes, further adding to the comfort. The ECG is filtered to a bandwidth of 0.5 to 60 Hz and sampled with a rate of 200 Hz. If the analysis identifies a tachycardia including ventricular fibrillation3, a bradycardia including an asystole, or an arrhythmia absoluta, a message is automatically sent to the relay station via a wireless data transmission. The message includes an indicator for the detected event and two minutes of ECG. The transmitted ECG starts one minute before the detected event and ends one minute afterwards. To enable this, the ECG chest strap always has the last minute of ECG stored in its memory. Testing has shown that the settings for the detection need to be adapted to the individual patient, and is now possible via the EHR.

Once the ECG reading has been transmitted, the relay station switches the wireless nearfield communication from the ECG chest strap to the wireless far-field communication and then to the EHR4. For near and far-field communications, bluetooth and General Packet Radio Service (GPRS), respectively, are applied. The relay station is a mobile phone with an integrated application for data handling. Once the data is in the EHR, it is stored in a database and, depending on the prior setting, a message is sent to a care provider. This can be via FAX, SMS, email or voice call. The EHR is especially adapted to the needs of a telemonitoring system. To ensure data security, the EHR complies with high security standards for EHRs such as tripple DES incryption and XPath compatible access rights managed. The care provider has to log in via a secure internet connection and can then access the ECG and any additional data from the medical history of the patient. On this basis, he can make a qualified decision as to what actions should be taken. In less acute cases, it is sufficient to make an appointment with the family physician. In acute cases the emergency medical service is sent to the patient to guarantee prompt assistance.

sensor	parameter
scales	body weight
blood pressure meter	blood pressure
pulse oxymeter	oxygen saturation of blood
peakflow meter	lung function (PEF, FEV1)

Results of the System Implementation

The described system and its parts were tested in detail and were proven to be reliable. Although dry electrodes were used, the ECG signal in this long-term application showed no significant differences to standard Holter ECGs. The system was tested with a dozen patients suffering from persistent atrial fibrillation, tachycardia and bradycardia. All the pathologies were identified correctly. The patients were questioned about the application and the benefit of the system and the overall impression was a remarkable 1.6 average score (1 best; 6 worst), with comfort, simple application and handling especially being mentioned. The algorithm tests with different databases showed both a sensitivity and a specificity of over 88%. Further extensive tests are currently being conducted.

Scenarios of Application

There are different circumstances in which the system can be applied. The most important may be for hospitals to save costs in diagnostic related group (DRG) surroundings. With such a system, patients can leave the hospital much earlier without the risk of unnoticed medical complications. At home they profit from a more comfortable atmosphere. Furthermore, patients hooked up to an expensive monitoring unit can be moved to a normal ward when they are equipped with this system.

Other scenarios would be the temporary monitoring of pre-operative patients who could stay at home instead of waiting for the operation in the hospital.

Another interesting area is the preventative monitoring of high-risk patients, e.g. in disease management programs, where the option to extend the ECG system by other relevant sensors (see Table 1) is an advantage. This allows an adaptation of the system to the specific needs of the patient.

Final Analysis

This monitoring system meets current and future demands of the healthcare sector, which is more and more aiming at the ambulatory area. This system provides the necessary security for patients and their relatives to live without the threat of an unnoticed cardiac event. The ECG chest strap is the first device that can summon help to the patient’s home automatically without the necessity that the patient himself has to be active, and is an available CE certified medical product. This system, which can be combined with other vital sensors, provides an ideal platform for hospitals, diseasemanagement programs and many other homecare applications.

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