

METHODOLOGY FOR THE EVALUATION OF POST-OPERATORY MOBILE CONTROL IN AMBULATORY SURGERY

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Abstract: An m-health system for the support of home post operational control of patients in ambulatory surgery is presented in this paper. The system allows the sending of objective information (photos and pulsioximeter data) by the patient to the hospital in order to increase the quality of this control, usually done by means of telephone control calls.

Our system of evaluation consists of five aspects: whether or not this modifies the evolution of post-operation, the number and duration of calls, degree of satisfaction, if the system avoids visits to the emergency unit, and economical aspects.

The evaluation of the system must indicate the utility and feasibility. Finally we observed that the main utility of the system of control with mobile phones and pulsioximeters is an improvement of the communication with a reasonable cost.

Introduction

The latest enhancements in medical areas like anaesthesia, surgery and hospital management have made possible the assimilation of patients and more complex processes in the ambulatory surgery field [1][2]. These patients are not hospitalized after the operation, and post-operational control is done by a nurse, by means of a protocol of call phones. [3]

In the case of the Ambulatory Surgery Unit (ASU) of the Hospital Universitario Doctor Peset in Valencia (Spain) the quality of the post operational state is quantified by means of a scale that can indicate, using a phone questionnaire, whether evolution of the patient at home is normal. This scale includes seven parameters: general state, pain, oral tolerance, blood, grade of treatment realized, fever and state of operated limb. In addition, the quality of others parameters is taken into account, such as the calls made by the patients at ASU, the visits to the Emergency Unit or the post discharge re-admission.

A nurse calls the patient once or twice a day, normally during a 3-day period, and asks the questions included in the questionnaire. Each question and answer has a score, and the total score gives an indication of the grade of evolution of the patient. Based on this total score the nurse can make recommendations to the

patient and, if necessary, recommend that he goes to the emergency unit as soon as possible. However, sometimes the answers are subjective, so several calls the same day or several visits to the emergency units to ensure the well-being of the patient are necessary. This situation can lead to patient distrust of the control process that is so vital for his treatment.

For this reason, the supervisor of the ASU Unit in the hospital realised the necessity of implanting a Telemedicine System [4] that provides a communication channel between the patient and the medical staff in order to make the interchange of three types of data possible:

- Oral (phone call): questionnaire used up to this point.
- Image: by means of the sent of photos and video.
- Pulsio-ximeter telemetry.

This way, objective data (photos, video and pulsioximetry data) would be added to the information given by the questionnaire.

In order to achieve this objective the Group of Bioengineering, Electronic and Telemedicine Group is developing a system based on the possibilities that offer the transmission of data through the new data mobile networks (GPRS and UMTS) [5][6] using multimedia mobile phones.

We need to evaluate this mobile system control to compare two groups of patients; one with mobile systems, and one without.

Materials and method

The test pilots of the system have been carried out in ASU of the Hospital Universitario Dr. Peset for a year. During this period a total of 121 patients have taken part, and pathologies of similar surgical aggression are evaluated. In 61 cases the mobile system is used and for the other 60 only the standardized telephone call in the ASU is used.

Our system of evaluation consists of five aspects: whether or not this modifies the evolution of post-operation, number and duration of calls, degree of satisfaction, if visits to the emergency unit are avoided, and economical aspects.

The system mentioned above is divided into the following parts:

- **Mobile ASU Application:** this forms part of a mobile phone and allows the user to take a photo or video and to send it to the server. A custom application for Symbian version 6 has been developed using the C++ programming language, the Microsoft Visual Studio development environment, and the Symbian Series 60 SDK which provide the necessary tools to create the application package to be downloaded to the mobile telephone. The initial implementation works with a Nokia 7650, but it can be used with any mobile phone that provides the same operating system and version. The Nokia 7650 phone is GPRS data network capable and it has a built-in camera to take photos with a 640x480 pixel resolution. The Symbian OS [7] is a real time operating system used in most smartphones. It controls all mobile device functionality, provides some user application and is able to install and run 3rd party applications developed with the development kits. The mobile software development targets devices with limited memory or processing power resources and in which power consumption is critical. This restrictive environment demands special designs in the application development. [8][9][10]
- **ASU Data Base:** this data base stores the images, questionnaire answers and pulsioximetry data, relating them with the corresponding information of the patient. In the first phase, the MS Access Data Base existant in the hospital was extended with questionnaire and patient information. In the second phase, the data base will be migrated to SQL Server thereby enhancing its security and functionalities, and making possible the access with different devices (PC, PDAs, mobile phones,...)
- **ASU Control Application:** PC application that allows the user to access and add information to the AMS Data Base. In the first phase this information is integrated with the AMS Data Access, adding to the possibility of filing and access to the existing questionnaires, the visualisation of images, introduction of data and management of the devices (mobile phones and pulsioximeters). In the second phase the application will be migrated to .NET or Java technologies.
- **Communication between Mobile AMS Application and ASU Data Base:** an ASU Remote Server has been developed supported by Microsoft Operating Systems in order to receive all the communication opened by ASU Mobile applications that establish a socket connection over TCP/IP using a GPRS or UMTS connection, which permits access to the Hospital network via Internet. The remote server is based in a webservice model [11][12], developed in C# using Microsoft Visual Studio and is

designed as multithreading server to attend several requests at the same time. The AMS Mobile Application sends, in a XML format, the mobile identification IMEI and the date and time joined to the image captured by the mobile device, that is encoded in a 64base string, to the AMS Remote Server, which stores this data in the data base.

- **Pulsioximeter:** external compact device that is used to acquire the oxygen level in blood, pulse and plethysgram wave by a patient.

In the Figure 1 the ASU Mobile and Control Applications can be observed.

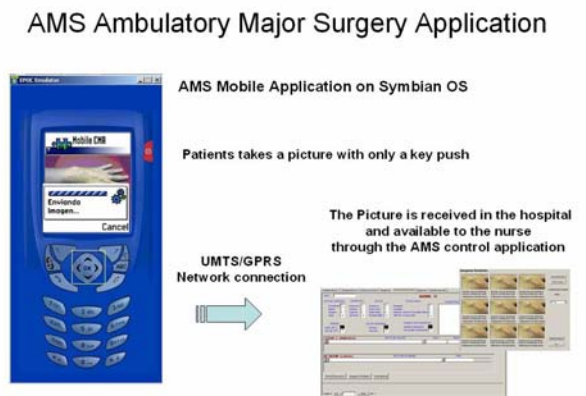


Figure 1: Overview of the software applications

Results

The system developed, which is currently being implanted in the Hospital Universitario Dr. Peset, makes possible the realization of the post operational control for patients of AMS as is described below.

After an operation in the ASU, a mobile phone and a pulsioximeter device are lent to the patient by the nurse, keeping a control of all the devices by means of the ASU Control Application and Data Base.

The post home operational control usually lasts three days. The nurse calls periodically (twice the first day, and once or twice the following two), and follows the questionnaire introducing the patient's answers in the data base using the ASU Control Application. According to the total score calculated by the application, the nurse knows the evolution of the patient and, in case of any problem, can request that the patient visit an emergency health unit as soon as possible.

Should the total score of the test not be conclusive, the nurse can ask the patient to send a photo or measure the pulsioximetry parameters himself.

In order to send a photo, the patient uses the simple application that runs over the mobile

phone; this displays a visor with the current camera capturing images and with one simple button clickstarts a session that captures an image, connects to the GPRS network, contacts with the ASU Remote Server via internet and sends an XML document with the mobile IMEI identification code, the date and time of the photo and the image captured. The application can be operated either by the patient or their carer, without any need for knowledge of technological devices. For this reason, the user interface has been designed in order to be user-friendly. The images and additional information sent is automatically stored in the data base, allowing its visualisation by the nurse almost in real time.

The acquisition of the oxygen saturation level and pulse is made easy by means of a user-friendly measurement device that allows the patient, with or without help, to easily extract this information. The patient can measure the levels whenever the nurse requests and transmit the results through the call phone. The nurse can introduce this information in the data base and compare with other previous checks made.

With the help of this objective data, the nurse can take decisions about the state of the patient with more security.

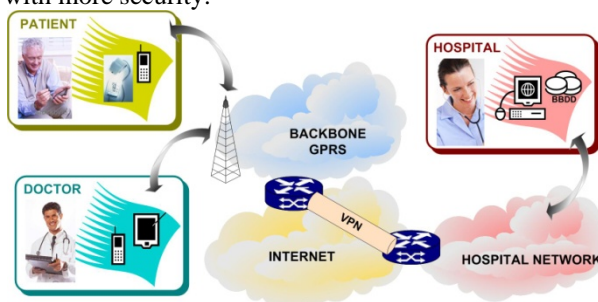


Figure 2: ASU control system architecture.

Additionally, the nurse can forward photos which arrive to the system to a mobile phone (by means of a MMS multimedia message) or e-mail address belonging to a doctor, or the system can automatically send photos transmitted by patients in a situation where they are not in a controlled phone call with a nurse.

After the implantation of the system in the hospital, a four-month pilot phase is going to be carried out, testing it with 120 patients and comparing the results with those obtained by 120 patients that don't use the system.

The system modifies the evolution of those cases of dressings and drainages mainly in orthopaedic surgery. Less in other operations.

The number of calls was higher in the mobile group than the no mobile group (140 / 121).

The average duration of the calls was greater in the mobile group than in that without mobile (average 18 min / 8 min).

The degree of satisfaction in use of mobile phone service was 98%.

The number of visits to the emergency unit was greater in the group without mobile (4 versus 11), 68% less than in the mobile group.

Economically, the cost of the group using the mobile phone is greater than that without the mobile in all aspects: time spent learning how to use it, the duration and number of calls, the cost of the mobile phone, cost of calls, the cost of time spent learning to control the phone in the mobile group comes to 11,87 euros/patient while in the no mobile group it comes to 2,72 euros/patient, supposing 9,15 euros difference. But if we take into account the cost of us of the emergency unit is 90 euros per patient in our hospital, the difference between both groups shows less cost for those using the mobile phone (1,07 euros/patient).

Discussion

The success of the telemedicine system described in this paper has repercussions in the increase of the post operational control quality that would make the following possible:

- An increase in the perception of quality of the care of patients during post operational control.
- An increase in the number of processes that can be included in ASU.
- A decrease of unnecessary visits to emergency wards by patients.
- An increase of time spent on phone control without increasing the total cost of the post-operational care process.

There are three factors that will make success of the system possible.

- A system free of both technical errors and security problems.
- The simplicity in the use of the system ie it must be as user-friendly as possible.
- The sending of photos and SPO2 data must hold enough significant information to enhance the information provided by the questionnaires.

As regards the technical question, the system has been designed, developed and tested in the laboratory in order to reduce possible problems when sending photos through GPRS, in order that only network errors may occur. Technical security has been covered with the use of security transmission protocols, the necessity of authentication of the users (transparent for the patients) and the inclusion of log files in the data base in order to control all access to it.

On the other hand, in the development of the system, special attention has been paid to the details of the system usability, particularly in the

application included in the mobile phone in order to achieve a user-friendly application for the patients. Another advantage of this system is the lack of necessity of any installation at the patient's home, since both mobile phone and pulsioximeter are very portable devices and the GPRS or UMTS mobile network is used for the transmission of data. A problem was found due to the technical impossibility of carrying out a real phone call and data transmission in the current GPRS mobile phones, meaning that the phone call must be established using the patient's landline and the mobile phone is used only for transmitting data. The new characteristics of UMTS mobile phone will allow this problem to be solved, since this type of device has the capacity of transmitting voice and data at the same time.

Finally, the last critical factor is the information that gives the photos, video and pulsioximetry data.

Photos and video are going to be used in order to control the rate of bleeding by means of the visualisation of dressings, drainages, colour of the bandages, oedemas in operated areas and surgical injuries. There are several factors that can void the information given, since taking photos is not always simple depending on environmental conditions such as light, distance of the photo subject, or excessive movement of the mobile phone. In order to avoid this problem the inclusion of extra elements such as marks around the dressings can be a great help. In any case, the nurse always has the possibility of requesting that the patient send through a new photo, instructing him beforehand to increase the light or modify any other necessary factor.

Regarding the pulsioximetry data; this will be used for the detection of abnormal situations that require special vigilance, the indication of a justified visit to an emergency unit, acquiring the oxygen saturation level and pulse of the patient. In addition, it allows the detection of ischaemias in limbs, comparing the pulsioximetry of the operated limb and the healthy one.

Regarding future functionalities that can be added, further enhancements can be included to different parts. In the mobile client application the arrival of the faster 3G network could make the use of streaming video to send images on real time to the ASU server possible. In this scenario the patient would take the images of the affected area guided by the vocal instruction of the personnel unit. Also the advanced features of the new mobile devices due to appear during the coming months: more computing resources, bigger screens, better resolution cameras, full connectivity, etc. must be used to improve the mobile application. For instance, it could be possible to collect the data through a Bluetooth communication channel from external devices, such as a pulsioximeter,

connected to the patient and send it to the ASU server. On the server side the ASU control application could be improved with utilities and forms for better management of the images received.

Conclusions

The use of mobile devices together with compact external pulsioximeter and other control mobile devices is the first step in allowing the acquisition and sending of objective information through mobile communication networks to hospital units, almost in real time, in order to increase the quality of the control of a patient outside the hospital, providing concrete information about the state of a patient, wherever he may be.

In the case of the ASU unit, this procures objective information about a patient located at his home and provides better support and information in order to take decisions about post operational treatments, allowing the introduction of new processes and avoiding unnecessary visits to the emergency unit, making the patient feel as confident as if he were in a hospital room, but with the comfort of being in their own normal living environment.

The evaluation of the system must indicate the utility and feasibility by means of the analysis of the following parameters: usability and the satisfaction of use as much of the patient as of the sanitary personnel. The economical aspects can be defined. In spite of the fact that the system uses more resources than that of normal post-operational control, economically it does not increase the price of the process because it allows avoidance of visits to the emergency ward. Our final observation is that the use of the system of control with mobile phones and pulsioximeters results in the improvement of communication at a reasonable cost.

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