THE NEED OF THE FOLLOW-UP IN PATIENTS: A USEFUL APPROACH USING WEB SERVICES.

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Abstract—**In the last years it has been observed a rising of applications of Home-Monitoring, finalized to the tele-monitoring of medical parameters. The diffusion of new systems for telecommunications and the development of new technology user-friendly, even wearable, allows to pick biological signal in the home of the patient during daily activity.**
With this article, starting from the analysis of the main guidelines on the care and follow-up of patient suffering of Heart Failure, we propose a model for the Follow up that include the use of a Web Service. Such service is finalized to the acquisition, transmition, storing and particularly processing of clinical data to provide a useful instrument for the support of the decision and the data mining with the aim to precociously individuate marker of instabilization that, if not recognized, could bring to a new hospitalization.

I. INTRODUCTION

In the last years we have observed, all over Europe, to the progressive request to create a Net for the integration of social and health services for chronic patients and aged people with the aim to prevent and delay pathological conditions that if not treated could require complex and expansive care.
Besides the Hospital is changing and is becoming a place reserved only to acute care. Moreover the need of new models of care is grooving after the adoption in many states of the health financing system based on Diagnosis Related Group (DRG) that push the hospital to discharge patients in less time possible[1]. To face this changing many Health Systems, as USA, Canada, UK, are trying new application of Telemedicine, and particularly of Home-Monitoring particularly for the care or chronic diseases[2] and for the reduction of the re-hospitalizations.
In any case Telemedicine provides the opportunity to manage the care of chronic patient, particularly for patients that need long follow-up. Particularly for such Profile of Care that are by them self distribute and need the integration of the work of different Health Actors such as specialist physicians, Family Doctors, Nurse and social operators.
It is the case of patients suffering of Chronic Hearth Failure (CHF), that after a period of hospitalization need a long follow-up that requires periodical controls from physicians with different specialization under the continues control of a GPs.
In this article, starting from the study of different Guide Line[3,4,5] for the care and the follow-up of CHF, we investigate the possibility to integrate follow-up and management of CHF patients by using a Web Services.
We present a Service via Web for the Continuity of Care of patient suffering of CHR that has the aim to collect all the data acquired in different environment (Hospital, Ambulatory and Home). A specific tool has been developed for the automatic evaluation of such parameters acquired in the home of the patient: particularly it has been implemented a Services via Web for the processing of the ECG and the analysis via web of the Heart Rate Variability (HRV) that is a powerful instrument for the control of the degree of instabilization of the CHF.

II. METHODOLOGY

A. Medical and Clinical aspects.

The proposed service has the aim to offer an Home Monitoring to support medical activity in follow-up of patients suffering of CHF, mainly in the periods just after dehospitalization. This service needs high computational capability to recognize and evidence precociously the markers of instabilization of the pathology so that it became possible to face any new acute phase. This phases, if not threaded, could bring to new hospitalization.
From the integration of previous study[6,7,8,9] with different Guide Line[3,4,5] on CHF it has been defined a data set of parameters to control during any examination and also the frequency of this control related to the severity of CHF.
All the parameters can be organized as following in four categories, so that we will speech about:

1. subjective parameters;
2. objective parameters detached at home;
3. objective parameters detectable by physician;
4. instrumental analysis parameters.

Besides a series of clinical exams could be picked and transmitted from home of the patient, between user-friendly devices, with the support of a relative or a nurse or a Social and Health Operator (in Italy Operatore Socio Sanitario, OSS) trained *ad hoc*. Such exams can be piked with often and can be: ECG, PO2, AP, Spirometery, body temperature.
All the data can be organized in two group: the α-numeric parameters and biomedical signals.

TABLE I
PARAMITERS TO BE MONITORED

Subjective parameters	• dyspnea • abdominal pain • asthenia
Objective detached at home	• dyspnea • body wait • artery pressure • temperature • diuresis • abdominal volume variation • pallor • mental confusion
Objective detectable by physician:	• dyspnea • jugular turgor • pulmonary noise • pleuric effusion
Instrumental	• ECG (any per control) • Rx thorax (one per year) • Hematologist examination (as required from phisician)

The frequency of the controls depend on the severity of the HF classified with the NYHA scale. Actually the Guide Lines suggest some frequency as reported in the following table. In any case those are just suggested and the physician should determine the effective protocol of the follow up according also with the Family Doctor.

TABLE II
Frequency of controls

NYHA I	ambulatory controls every 3 months
NYHA II	ambulatory controls every 3 months
NYHA III	ambulatory controls monthly
NYHA IV	ambulatory controls weekly for the first 3-4 weeks then monthly for 1-2 months and then if the condition of stability are confirmed the management of the follow-up is granted to the GP.

As seen the follow up is characterized by the fact to be distribute in time and location. A series of ambulatory control and GP visit are recommended.
This process presents some difficulties: the data are not detected in one place from the same operator. That means that some data would have been lost or not standardized. Also it happens that when the specialist observes the patient during an ambulatory control he has not all the information about the period between two examinations. All this problems can be solved by using a Web Service to collect all the data.

B. The Web Service

Actually the frequency of some control can be increased by using the proposed Web Services in a Home Monitoring application. Mainly our proposal is to increase the frequency of control of all the parameters that the patient can pick by him self or with the help of a relative.
All the follow-up is organized in three phases: the Red, the Orange, the Green. Practically the patient, with the help of a relative or of a specific operator, pick all the α-numeric parameters that can pick alone and sent them to the Service. Besides a home ECG recorder is provided to the patient that record and send his ECG to the Service. The frequency of recording change in the three phases as shown in Figure 1.

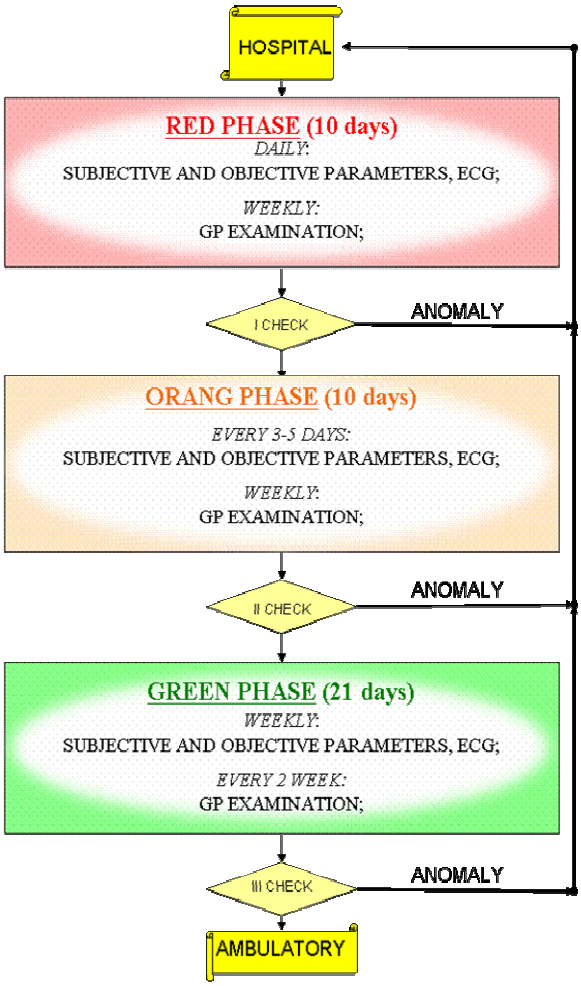

Figure 1: protocol for follow-up using Web Services.

To aim of the Services is now double. First of all the acquired data will be centralized and recorded, so that when the patient will have the next ambulatory control the physician will observe all the data recorded during the previous period. This innovation provide also a clear data standardization.
Furthermore all the acquired information will be processed from the Service so that in case of sever anomalies the physician will be advise in time and will have the opportunity to call back the patient in any moment for a control.
It have to be clear that the proposed protocol is designed to be added to follow up defined by guideline with the aim to provide more data to the specialist, to insure a platform for the cooperation of all the operators, eventually to prevent critical event that as

explained later in this article, are characterized by some clear marchers of instabilization.
The logic of the Service is explained in the following figure.

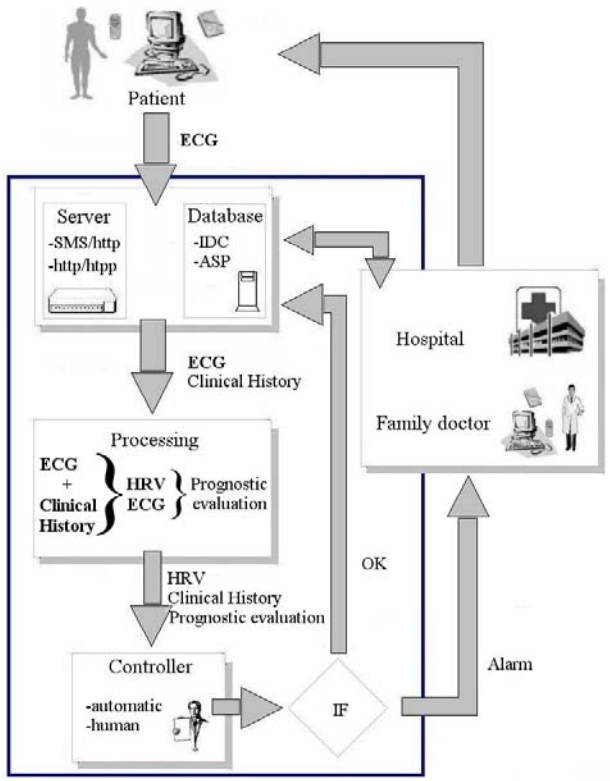

Figure 2: logic of the services. the Data are sent to the services that provide to record it in a remote Data Base. Some information and the ECG are processed by a specific control that provide to extract relevant marker of instabilization and compare it with normal value[10,11]. In case there are no anomaly, the extracted marker are recorded into the DB and the clinical history of the patient is enriched. In case of anomaly the system provide to generate a warning to the operator. The warning become a critical Alarm (via SMS) in case of patients that need particular attention or that live in remote area from where it is not easy to reach the Structure of control (Hospital or Ambulatory).

Data acquisition. All that parameters can be centralized and accessed simultaneously from different actors of Health Services (GP, Specialist, nurse) between Word Wide Web (WWW) by a Web Portal[12] realized *ad hoc*. We create a Graphical User Interface (GUI) that is practically the same for any device it is accessed. This is a relevant point specially for the physician, that have not to be trained to use different environments. To guarantee access to the system from different care points we use different technological solutions as it can be seen from the Figure 3.
Different solution are available and have been tried for the connection to WWW, from DSL to GPRS.
As seen we distinguish the parameters we observe in α-numeric parameters and biomedical signals. The first can be acquired via the Portal. The second need different channel depending on the peculiar infrastructure and the culture of the users.

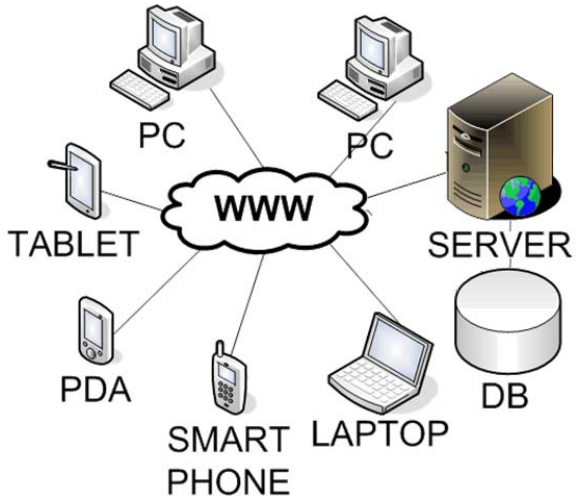

Figure 3: technological solution to access the services. The users can access the Services from any places by using different devices.

The Signals can be sent to the Services between three channels: via analogical telephonic line (in asynchronous), via specific software under remote control (in synchronous), uploading as a normal file (in asynchronous).

TABLE III
Channels to send signals to the Server

Channel	**devices**	**Software in loco**
Channel I	Telephonic ECG	Not required
Channel II	Multiparametric Monitor	Specific software that send data to the DB
Channel III	PC or PDA to upload a file	Browser

The first solution is the most easy to perform and is adapt also to aged patients and particularly for ECG. It require specific devices that modulate the acquired signal providing a shift to the acoustic frequency. The main problem of this solution is that the patient has no feedback during recording. If any problem are observed on the acquired signal, an operator have to call the patient and ask to perform again the ECG acquisition.

Figure 4: devices for the acquisition and the transmission of the ECG via analogical telephonic line.

The second solution, acquisition with a specific software and devices, is the preferable one for several reason. Mainly because it allows to acquire under

video-conference with a specialist that lead the patient during all the operation.
This channel is designed so that that the software can be used on any kind of smart devices (PDA, telephone) and not only with a PC or laptop, it means from any place and not only at home. Moreover this solution do not require any installation (usually required to control devices) because, using technology ActiveX, practically the installation is performed automatically by remote at the first connection. At least with this solution it is possible to use different kind of devices even multi-parametric monitor that allow to monitor several parameters in the same time.

Figure 5: domiciliary multiparametric monitor.

The third channel has been implemented to face the possibility of a local ambulatory would like to be linked with a specialist centre. In this case is probable that the user is already provided of devices for the acquisition of ECG and is not interested to change it with the ones compatible with the developed software. For this situation it is easier to export the file on a PC and unload it that provide another solution.

C. Remote processing.

The innovative contribute of this work has been to implement a Service for the elaboration via web of all the parameters collected and mainly the biomedical signals. This adding allows an effective data mining. As first application to test vertically all the services we chose the HRV analysis. HRV is an important marker for the state of instabilization of CHF. This state is characterized by a prevalence of Sympathetic System activity that is responsible of the speed up of cardiac activity[12] that in normal condition is well balanced from the action of the Parasympathetic System that provide slowing down of hearth frequency. The frequency analysis of HRV provide parameters that seem to be good predictor of variation in patient's state of compensation: different studies have shown that the power ot high frequency (HF) is correlated to Parasympathetic action while power to low frequency reflect the sympathetic action. From that it is clear that the ratio of HF powers on LF powers reflect the so called vagal balance and in normal condition is almost one.

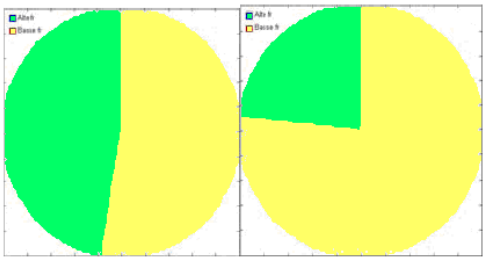

Figure 6: images generated from the system[13] The cake diagram of HF-LH power ratio. On the left the case of a normal patient to right a patient with prevalence of Parasympathetic. With these images the doctor has a fast vision of one of the indices of instabilization of the compensation degree.

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IV. CONCLUSIONS

The problems related to the follow-up, and generally to the management of chronic patients, are different. The first is centralization and standardization of the information related both to the patient and to the health operators that give the care. In many case in fact the follow up take place in different structures: Hospital, local clinic, ambulatory, home of the patient. In this conditions it is possible to lose data but more it is not possible to have data standardization. A solution to this problem is the adoption of a Web Portal as interface to input and manage all the clinical data, storing into a remote Data Base.
Another problem is that there are in any case periods in which the patient cannot be monitored. In this period the Home Monitoring can provide good solution to cover this gap. The motored parameter can be presented to the physician during next examination and can be monitored even daily.
The use of Web Services provide a new opportunity. An effective data mining can be performed on the acquired data. From that useful information can be extracted to prevent critical events that if not recognized can bring to new re-hospitalizations of the patients.

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