

ECG Devices Interoperability in Hospital Environment: Clinical Experience

C Carpeggiani¹, F Conforti¹, S Dalmiani¹, M Emdin¹, A Macerata²

¹CNR Institute of Clinical Physiology, Pisa

²Department of Internal Medicine, Pisa University, Italy

Abstract

The clinical use of information systems is now widely accepted in hospital departments. Among diagnostic instrumental examinations the electrocardiogram is the most popular diagnostic procedure in hospitals and out-patient points of care and its integration in Hospital Information System (HIS) is mandatory. We report our experience in integrating ECG devices in the clinical HIS of an advanced Health Care Center for pulmonary and cardiovascular disease. In the last five years the Electronic Medical Record was daily used and automatically filled, as much as possible, by diagnostic instrumentation. Electrocardiogram was the last diagnostic procedure to be integrated; this depended both by technical problems and by functional variables. Solutions adopted are the results of technical choices for an optimal integration of ECG devices into Electronic Medical Record and the guidelines and advices suggested by doctors and nurses. One year validation takes into account the real bedside process of ECG acquisition in clinical ward or laboratories, following the instrumentation requirements as expected by the users. On the basis of our experience we conclude that the commercial ECG device integration is far to be reached and it is one of the most challenge problems in a hospital environment.

1. Introduction

The rising of health care and hospital efficiency has underlined the necessity of Clinical Information Systems. Hospital represents a complex organization that requires the control of different kinds of data for the management of patients and resources. Clinicians are daily confronted with a variety of data differently collected; an insufficient communication between different professions may generate misunderstandings and mistakes. Only an effective information aid could be able to guarantee to all the staff a coordinated and integrated activity in different parts of the system.

A network-based information system was set up five years ago interconnecting the different units and health

care services of the clinical departments of the CNR Institute of Clinical Physiology in Pisa, to achieve a transparent access to patient data, both administrative and clinical, reaching a total integration among different human and instrumental sources [1,2]. The final electronic medical record is a multimedia collection of data automatically selected from different remote databases, e.g. echo lab, cath lab, chemical lab, nurse system, administration, etc.

Electrocardiogram is the most common diagnostic tool in a cardiological department and it is the most frequently performed test. Therefore, since the beginning of the information system implementation, it was planned to integrate ECG devices, as possible including signals. Conversely, ECG-system was the last one to be installed for the difficulties met in the integration of ECG devices in the network.

Today the operation of most ECG devices is still based on proprietary software, communication protocol and file format. Even if communication and format data problems are solved, i.e. by implementing the SCP-ECG standard, the ECG device requires a further software customization to import admitted patients work-list and to avoid unnecessary data entry [3]. Only the collaboration with the manufacturer can overcome this major problem.

Object of this paper is the description of problems we had to cope in the integration and use of ECG-system in the ward of our Institute.

2. Methods

Digital ECG devices from only one manufacturer were chosen, according to manufacturer's agreement in supporting device integration.

The SCP-ECG standard allows a reliable communication between ECG devices and hospital information system [4]. Signal acquisition and patient data are quickly transferred and saved: as soon as the patient is admitted to the hospital, his name is sent to the ECG device to update the internal list of patients. The instrument keyboard and screen allow the operator to select the patient or, to enter a new patient name in case of emergency (Fig 1).



Figure 1. ECG device: the keyboard and screen allow patient name selection or, to insert a new patient name.

Each ECG device has to be continuously connected to the network to allow a time-based update of the internal list of patients. The device can be temporarily disconnected from the network for bed-side recording or emergency (Fig.2); in this case attention has to be paid by the operator in writing correctly the patient name which is the only data, together with admission date, able to identify not yet registered patients in the central database.

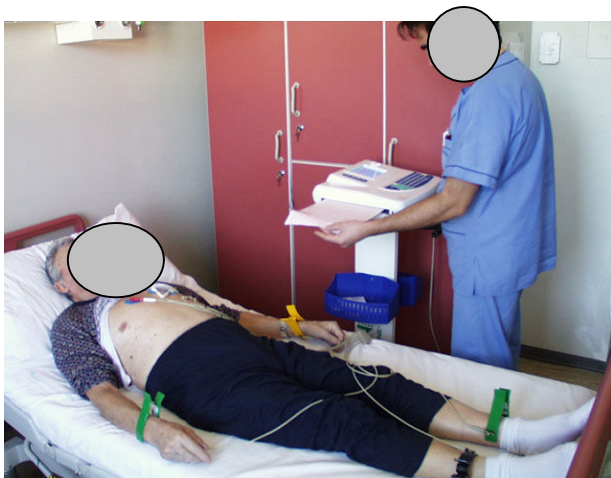


Figure 2. Bed-side ECG registration.

Moreover, the network connection of the device allows nurses to send easily the ECG recordings from the local device to the central database to archive and to update patient clinical record. As soon as the ECG data are transferred to the database they are contemporarily available for consultation to all the authorized users of the clinical department. ECG report is in charge of selected

medical personnel who can input diagnostic conclusion at all the system workstations available in the department; physician signature is saved together with ECG examination data (Fig.3).

The specifications of the system were defined according to nurses requirements and the implementation suffered of many upgrades following the user complaints and suggestions, and trying to optimize the nurse activity, taking care of the overall system ergonomics

ECG data are stored in the central database of the HIS and they gain all the privacy and security facilities of the overall system. ECG examinations, including signals, can be viewed everywhere by authorized persons through a common Web browser inside the intranet environment of the department.

3. Results

The ECG-system was daily used in these last 12 months; 12 doctors and 28 nurses were in charge of the experimental test of the system. An average of 4 ECG recordings per patient were collected during each hospitalization. Conventional paper was still produced from the device to allow traditional ECG consultation and to archive ECG strips and reports as required national legislature.



Figure 3. ECG trace viewed from Medical Record.

During this 12 month period, among the 5 ECG devices available in the clinical department two of them (ELAN Cardioline) were devoted to the experimental test; nurses were trained to the proper use of the devices and they were strongly advised to employ them in daily activity; physicians were educated to the new ECG procedure and invited to gain of the direct consultation of

ECG signals inside the Electronic Medical Record of the patient.

In this period, 4342 ECG were acquired and digitally archived. The total number of ECGs, including the ECG obtained by the other no-integrated machines, was 7741 in 1761 patients.

At the beginning the ECG system was used with many complaints. First of all a more friendly machine was required. The use of the new digital ECG system was considered by the nurses as an unuseful work load , like the necessity to insert the patient name in the device. This problem was solved by downloading into the device the list of all the patients present in the department; the list was well accepted by the operators and moreover it reduced the typing errors improving the quality of the data. Another problem was the time delay between the ECG collection at patient bed and the data transferring to the central database. The necessity to plug-in the ECG machine at the end of its use to send immediately the data to the central database created a series of troubles in the managements of clinical data. The delay of data transfer provoked a delay in the availability of data at the medical station and it forced doctors to use the paper ECG traces, inserting in the Electronic Medical Record a report which was not associated with the digital trace.

Finally ECG digital integration seemed answer to doctors requests without any advantages for nurses.

Doctors applauded the availability of ECG traces everywhere in the ward, and in their rooms too (Fig. 4). Nevertheless they found the automatic report offered by the machine not reliable; they usually erase it and rewrite a new one.

A number of facilities were added to the system in order to improve the management of ECG data as obtained by this cooperative work between nurses and physicians. For instance, new unreported ECG acquisitions are represented in different colors on the Electronic Medical Record main screen of the clinical workstation.

The time needed for the connection of the computer limits the use of digital ECG trace during emergency when paper consulting is still easier.

4. Discussion and conclusions

An ECG network integration is required to increase department operative effectiveness and to increase the service towards the patient, being electrocardiogram the most frequently performed test in cardiac patient. Integration of ECG device is still difficult, essentially for manufacturers objections to disclose ECG file format and to allow a complete integration in any network.

The physician is supported in the clinical evaluation of the patient by a great amount of data inserted almost on-

line in a network by different procedures. The ECG device allows the integration of signals with other sources of data in the network supporting a cardiological department. The use of the system underlined different criticisms from physicians and nurses. The first ones, concerning friendliness and efficacy of the new machine, were overcome forcing nurses to use it; ECG device was the only electrocardiograph left in the ward for routine ECG registration. The acceptance became gradually evident with its use. The system, which showed limited efficiency in its automatic report, demonstrated several advantages for the activity of the doctors: a quick vision of ECG in any place of the ward, the standardization of the procedures, an easy support for consultation of different tests and to catalogue them.

In conclusion, we would like to point out some final remarks following our experience in integrating an ECG device in a Hospital Information System:

Standard and interoperability: it seems incredible that, in the 2K years and when quite all the hospitals use information systems, it will be not possible to interchange ECG devices without modifying some piece of software to allow a clear and sure data transfer; and sometimes it is not possible to do it at all.

Integration and feasibility: the capability of communication between HIS and device is not enough to guarantee a real integration of the instrumentation. Efforts should be done to optimize the communication not only between machines but also with the users, offering a friendly interface and a useful support, for instance the work list filled by external queries.

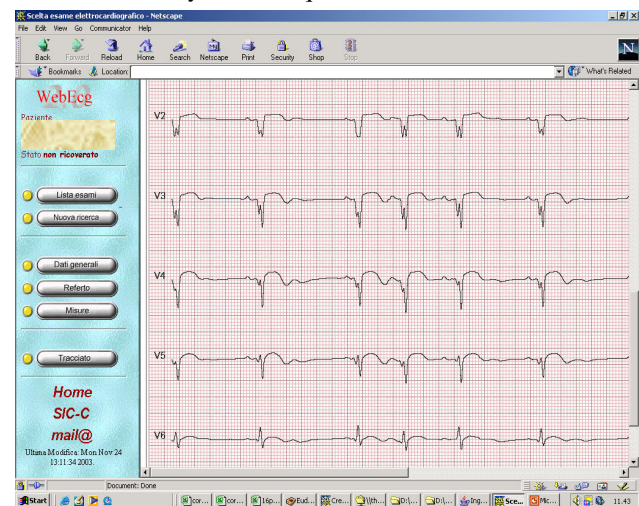


Figure 4. Web consultation of ECG signals.

Wireless: the specificity of the ECG examination procedure, acquired by the nurse at the patient bed and analyzed by the physician at the clinical workstation,

could gain by the full and instantaneous integration in the patient Medical Record. The availability of native wireless ECG device could dramatically improve the power of an ECG system, lightening the operator actions and guaranteeing an immediate availability of data for archiving and distributed visual consultation.

The efficacy of such a system is based on the effective and fruitful co-operation between any partner during its implementation. A diffuse utilization of different commercial ECG devices might consent to compare the automatic reports and ameliorate their performance, with beneficial effects for both customers and industries.

Acknowledgements

This work was supported by the Special Program of National Health Ministry (Project SPERIGEST: art 12 D:Lgs 502/92)

Thanks to the OpenECG consortium for their efforts in promoting the knowledge and use of standards in ECG clinical practice and the interoperability of medical devices. (www.openecg.net)

References

- [1] Taddei A, Carpeggiani C, Emdin M, Balocchi R, Dalmiani S, Cecchetti G, Macerata A, Pierotti D, Marchesi C. Development of an electronic medical record for patient care in Cardiology. *Computers in Cardiology*, 1997; 641-644.
- [2] Carpeggiani C, Dalmiani S, Taddei A, Franchi D, Michelassi C, Chelozzi L, Emdin M, Macerata A, Benassi A, L'Abbate A. Use of electronic medical record in a department of cardiology. *Computers in Cardiology*, 2000, 291-294.
- [3] 2nd OpenECG Workshop on "Integration of the ECG into the EHR & Interoperability of ECG device Systems". April 1-3, 2004. Berlin, Germany
- [4] CEN Health Informatics, TC251: Standard communications protocol for computer-assisted electrocardiography; www.cen251.org/TCMeet/doclist/TCdoc02/N02-015-prEN1064.pdf

Address for correspondence

Carpeggiani Clara
CNR Institute of Clinical Physiology
V Moruzzi, 1 56124 Pisa- Italy
E-mail address: clara@ifc.cnr.it