ECG Management in Pre Hospital Emergency Care

[1]D Vourvahakis, [1]N Giannakoudakis, [1]M Zeaki, [1]M Zervopoulos, [1]H Malliotakis, [1]J Loukos, [2]D Trypakis, [2]F Chiarugi, [2]CE Chronaki

[1]EKAB, National Centre for Emergency Care of Crete, [2]Institute of Computer Science, FORTH

Heraklion, Crete, Greece

Keywords: ECG, defibrillators, vital sign monitors, emergency care, prehospital care, SCP-ECG, standards, data formats, data acquisition and presentation

1.   Introduction

HYGEIAnet [1], the health telematics network of Crete, has been in operation since the second half of the 90s.

Its main purpose is the creation of a communication infrastructure aimed to constitute the basic layer for the establishment of the citizen's electronic health record (EHR) and the creation of information systems able to cover all the different levels of care and all levels of hierarchy [2].

Crete has a population of about 600000 inhabitants, but this number is more than doubled during the summer period. A rough estimation of the tourist flow is around 2500000 people per year. The health care structure must be arranged to be able to effectively serve this people flow. In the whole island there are 16 primary health care centres and 7 hospitals and a large number of isolated communities in remote locations due to the particular morphology of the island very rich of mountains.

According to the statistics, accidents are more than tripled during the summer period and 42% of accidents involve tourists. Thus, all the aspects related to emergency and pre-hospital care are of primary importance in the regional health service.

EKAB (Hellenic National Centre for Emergency Care) is the sole public provider of Emergency Pre-Hospital Care in Greece. EKAB in Crete is composed by 6 mobile intensive care units, 8 medical doctors, 120 paramedics, 38 ambulances and 16 centre coordinators. It manages about 25000 emergency episodes per year, of which 40% are due to trauma and 20% are due to cardiac problems, and 200 air medical evacuations per year.

An integrated Pre-Hospital Emergency Information System has been operational in the EKAB Coordination Centre of Crete (HECC) since 1998[3-4].

All emergency calls are registered online resulting in a volume of 25000 episodes per year. The integrated system includes modules for ambulance tracking, resource management, and medical device communication. The ambulance-tracking module uses a geographic information system to track in real-time available resources on an area map (see figure 1) [5]:
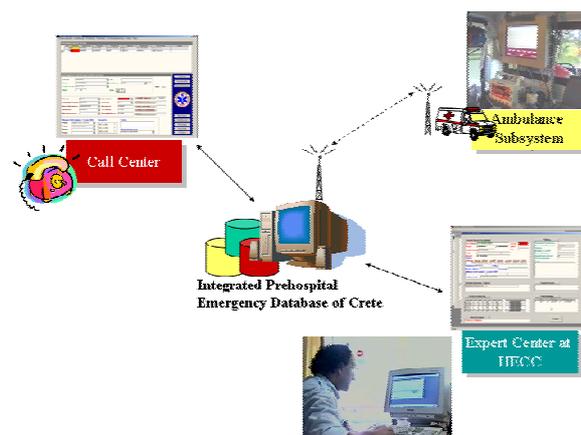

Figure 1. The overall Emergency Care Information System.

2.   The solution

Medical device communication modules have been developed to enable the transfer of objective patient information from the ambulance to the coordination centre facilitating telediagnosis and effective treatment on-site. For example, such a module is able to acquire vital signs from a portable vital sign monitor installed on the ambulance and transmit them to the Coordination Centre where a specialized doctor can provide instructions to

the paramedics. A 12-lead cardiograph has been included in the system for the real-time transmission of ECG snapshots to the coordination centre in view of setting the necessary infrastructure for the support of early thrombolysis treatment and of providing better support in case of suspected cardiac cases.

Thus, different medical devices are usually installed on-board of an ambulance such as vital sign monitors, defibrillators and 12-lead ECG. The devices (vital sign monitor and 12-lead cardiograph) are connected to the on-board panel PC where there is a local copy of the episode of care database to allow a continuous acquisition also in situations where the communication link is lost (due to the Cretan topography). A replicator agent takes transparently care of maintaining the two databases aligned.

The workflow implemented by the Information System is the following: the operator receives an emergency call and creates a new episode (with a new episode ID), assigning it to a specific ambulance that will set off on route to reach the emergency site. At the same time the on-board panel PC is powered on and through the GSM link the new episode ID is automatically received by the on-board database. Once the emergency site is reached, the patient is loaded into the ambulance, the sensors for the vital sign acquisition are connected and the acquisition of the vital signs starts automatically. Figure 2 shows the internal setting of an ambulance with the panel PC and the vital sign monitoring. The ECG module is closer to the patient so that it can be easily connected to the patient only in case of real or suspected cardiac episodes.

Figure 2. The internal setting of the ambulance with the panel PC and the vital sign monitoring.

If the ambulance personnel decide that the specific episode requires the acquisition of the ECG, the electrodes are put on the patient and the 12-lead ECG acquisition module is switched on. At this point the appearance of the user interface is enriched by the real-time 12-lead ECG display, so that the on-board personnel can have the basic information for a first evaluation. In figure 3 the user interface with the 12-lead real-time ECG is shown.
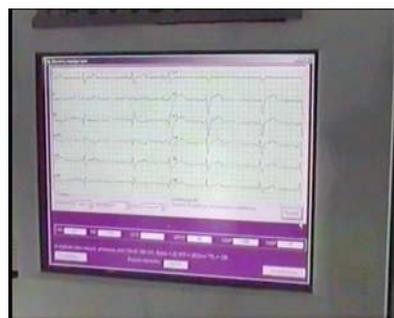

Figure 3. The user interface of the on-board PC during real-time ECG acquisition.

Clicking on the "Start" button (using the touch screen monitor) automatically enables the storage and the remote transmission of the acquired ECG.

Figure 4 shows the interior of the ambulance with a patient and all the sensors connected to him.

Figure 4. The interior of an ambulance during patient transportation and monitoring.

Due to the limited bandwidth available with the GSM link (9.6 kbps is the theoretical maximum), the uninterrupted transmission of the ECG signal is not possible. A logical and useful solution was the continuous transmission of ECG snapshots, so a snapshot interval was set up in the system with the possibility to be tuned during installation. Every 1, 2, …, 5 minutes the ambulance subsystem is able to automatically acquire 10 s of 12-lead ECG and to store it in the local database. The replicator automatically takes care of the remote transmission of the acquired ECG to the coordination centre database. During the first tests we verified that a snapshot interval of 2 minutes would be enough for providing valuable information to the coordination centre. This value was applied to the system that is now in daily use.

The 12-lead ECGs are received by the central database and listed in the expert station together with the vital signs. The expert can simply click on any ECG of the list to display the ECG signal with an appropriate ECG viewer (see figure 5). The episode of care is then integrated in the patient's EHR.

Figure 5. The ICS-FORTH multi-vendor ECG viewer.

3.   Conclusion

The integration of the emergency episode in the citizen's EHR requires the storage of the medical examinations including waveforms in well-established standards format to allow uniform display and printing from the integrated EHR. Currently, all the collected ECG snapshots are stored in the SCP-ECG standard format [6]. Similar standards are currently under investigation for the vital sign monitor, while defibrillators can still be treated (for the ECG part) using the SCP-ECG standard.

SCP-ECG standard is not very suitable for ECG real-time transmission, but it is very flexible and suitable for the storage of ECG snapshots. By using ECG devices implementing SCP-ECG or by disclosing their communication protocol and storage format, it is possible to set up an EHR for the citizen where all the ECGs stored during his clinical history are in SCP-ECG format and can be displayed and compared with a single specific SCP-ECG viewer minimizing the efforts for the system integrators and increasing the clinical effectiveness of the whole solution.

Furthermore, the OpenECG project [7] is doing a valuable effort in disseminating the SCP-ECG standard, helping manufacturers and integrators in the correct implementation of the standard and providing a certification service and other useful tools for testing the SCP-ECG format. Correct implementation of the standard by an ECG device is a valuable warranty that an ECG record produced by that device will be easily opened and displayed by the ICS-FORTH viewer as it is.

In pre-hospital and emergency care as well as in any other care delivery information system, the seamless integration of medical devices or their plug-n-play integration could be a lot easier if the communication

protocol and the storage format of such devices were compliant with a well-established interoperability standard. The communication protocol should be at least fully disclosed by the manufacturer to allow their easy and correct implementation in a generic ad-hoc designed information system and the final storage format should be compliant with approved interoperability standards.

In the long run, the wide adoption of communication and storage standards will allow the flexible integration of medical devices such as defibrillators, resulting in flourishing true multi-vendor solutions. In this spirit, HECC promotes the development of national and European guidelines and directives for procuring medical equipment that allows communication of examinations in a well-established open standard.

References

[1] http://www.hygeianet.gr/.
[2] Katehakis DG, Kostomanolakis S, Tsiknakis M, Orphanoudakis SC. "An Open, Component-based Infrastructure to Support Integrated Regional Healthcare Networks". Int J Med Inf. 2002 Dec 18;68(1-3):3-26.
[3] Leisch E, Orphanoudakis SC. "HECTOR Solutions". 1st International Conference on Health Emergency Telematics. Seville, Spain, 1999.
[4] Leisch E, Orphanoudakis SC. "The HECTOR Pilot System of Crete as Part of a Regional Health Telematics Network". 1st International Conference on Health Emergency Telematics, Seville, Spain, 1999.
[5] Chiarugi F, Trypakis D, Kontogiannis V, Lees PJ, Chronaki CE, Zeaki M, Giannakoudakis N, Vourvahakis D, Tsiknakis M, Orphanoudakis SC. "Continuous ECG Monitoring in the Management of Pre-Hospital Health Emergencies". Computers in Cardiology 2003;30:205-208.
[6] CEN TC 251/N02-015, prEN 1064:2002 Health Informatics – Standard Communication Protocol – Computer-Assisted Electrocardiography.
[7] http://www.openecg.net/.

Address for correspondence:

Dimitris Vourvahakis
National Centre for Emergency Care of Crete,
GR 711 10 Heraklion, Crete,
Greece
email: dvourvahis@hygeianet.gr