The Greek E-Journal of Perioperative Medicine 2003; 1: 14-9 (ISSN 1109-6888) www.anesthesia.gr/ejournal
Ελληνικό Περιοδικό Περιεγχειρητικής Ιατρικής 2003; 1, 14-9 (ISSN 1109-6888) www.anesthesia.gr/ejournal

Experience from the Clinical Information System of the Cardiac Surgery Division in Thrace. Implications for the anesthesiologist.

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Abstract

Patients are almost unlimited data generators. Nowadays, handling data can be easily and accurately supported by technology. In this brief note, we present the Clinical Information System (CIS) of the Cardiac Surgery Division in the University Hospital of Alexandroupolis, which is in use for the past three years, focusing on its clinical applications and merits in the operating room, intensive and intermediate care. The implications for the anesthesiologist as well as further expansion and planning are also discussed.

Introduction

In modern medicine, the ability to generate data from the patients exceeds the ability to absorb it and this situation is rapidly worsening. For the anesthesiologist, information concerning the patient is generated not only in the operating room but in other areas also (imaging, lab, ward, intensive care etc) in a widely scattered manner. The anesthesia record comes to bring this information together. Traditionally, the anesthesia record functions as a preanesthetic summary, an aid in postanesthesia care and to the next anesthesiologist, a tool for teaching or research and, sometimes, it may have medico-legal or financial use. Its routine use serves as a reminder of information to record, actually nagging one to fill it. Strangely, it is noticed that, in recent years and despite the significant increase in monitored parameters, the number of average manual entries per anesthetic record was kept almost unchanged [1]. Nevertheless, a number of anesthesia records, held in a dark dusty room, forms an insidious database.

Technology has the ability to handle enormous amount of data. Patient information management systems (PIMS) are already in use. This term (PIMS) encloses a wide variety of applications in different inhospital functional or geographical areas, integrated fully or in part. For the anesthesiologist, the ideal way to handle the information would be to more automatically and less manually, enter all the data, display it comprehensively to the user, process it and store it in an easy

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retrievable manner. The tools for performing these tasks are already available. It is almost impossible to locate nowadays a commercially available device, which is intended for anesthetic use and is not capable of digital communication with a computer. It is easy, therefore, to connect all these in an isolated system and, as a next step, to cable it with the patient management system. Performing the first step results in an ***automated anesthesia record*** and a limited, isolated database [2,3]. Integrating through the next step not only increases the potency of anesthesia record keeping but creates a more complete PIMS database as well [4,5,6].

The evolution and proliferation of intra-operative measuring and data collecting techniques expanded the need of monitoring from not only the patient but to the equipment itself as well. The need for systems to handle information which is independently delivered (from different monitoring devices) but simultaneously generated from the same integrated source (from the patient) was strongly suggested, improving the standard of providing anesthesia. This approach led to the development of ***computerized monitoring*** [5]. The incidence of artifact was rapidly decreased. Smart alarms were implemented. The concern about "big brother" watching was soon replaced by a sense of "black box" weapon against lawyers. Furthermore, it was challenging enough to produce an automated anesthesia record with a meaningful format, capable of the finer resolution that might be desired. Towards this direction, various attempts appeared in the literature, grown in the informatics lab, and were applied in the operating room. However, this institutional research presented homemade characteristics, which were escorted by a number of limitations. Soon, the primary concern was translocated from the need of automation of anesthesia recording to the need of setting standards for functional specifications, quality, reliability and uniformity of presentation. Lack of such standardization leads to development of different types of automated record systems and, possibly, depending on codes or protocols or software characteristics and restrictions, to sometimes difficult or even impossible "communication" of databases. Nevertheless, industry addressed these issues aggressively. A new market was created and investments were made. In the nineties, many different systems of automation, designed for individual or departmental use by anesthetists, were commercially available. Furthermore, the similarities to the intensive care environment led through an analogous path in a more or less same frame of development and applications [7,8]. In the late nineties, the role of these systems was recognized, their performance was validated in some degree [9,10] and in many hospitals they were already functioning at the disposal of the personnel.

Obviously, the application of these systems is strongly affected by the conditions in which the medical "product" is been produced. Not all the Countries or Health Systems can afford them. In Greece, as in most of the western European Countries, law describes the availability of anesthesia monitoring and budgets are tending to comply. Presently, it is difficult for the clinicians to persuade the administration boards about the benefits of upgraded systems, such as automated anesthesia record and computerized monitoring, without using the not so familiar language of managers or financial advisors.

The Clinical Information System of the Cardiac Surgery Division, University Hospital of Alexandroupolis

In Greece, as far as we know, the only existing Clinical Information System (CIS) lies in the Cardiac Surgery Division in University Hospital of Alexandroupolis, in Thrace. The system is under operation for almost three years in its original form, although it has undergone minor hardware upgrading and several software improvements. Many people, clinicians, informatics scientists and technicians worked together for months for the development of the system and the users or the patients are, in a way, indebted to them. It is not our intention to discuss its technical or economical aspects.* Actually, this sort note is focused on a brief description of the system, the implications for the anesthesiologist and the research or the developments that are currently under way. The system can be distinguished in its two independently functioning and yet inter-connected parts (RTN and CILN), as it will be discussed in the following paragraphs. Furthermore, a local network serving the personal computers with their peripherals is at the disposal of the staff of the Cardiac Surgery Division.

The Real Time Network (RTN)

The first component of the system is an independent real-time patient data network (RTN). It includes a minimum set of monitoring functions for haemodynamics and respiration from the patients in the operating room, in the intensive care unit (6 beds), in the intermediate care (4 beds) and from the patients carrying cordless portable monitoring devices, electrocardioscopes and pulse oximeters (8 telemetry positions). Medical equipments are connected to a high communication capability network and automatically entered clinical data, after being processed, analyzed and exchanged, are finally stored and/or displayed, using comprehensive graphical visualization techniques. Network independency and architecture guarantee vital clinical data security and safety, avoiding pollution or inappropriate delay, while, on the other hand, its open design permits unrestricted further expansion. For example, the four "intermediate care" beds can be mounted in different positions in the ward, simply by plugging in the monitor to the wall, because the network exists everywhere.

Real-time data acquisition is shown in the lower part of Figure 1. Up to this configuration, the user can divide a monitor's screen and "follow" not only the connected patient, but every other patient who is "plugged in" the RTN. It is easy, for example, in the operating room, to watch waveforms generated in the ICU or even in the hospital's little store, if the telemetry followed patient is drinking a beverage there. Nevertheless, the capabilities up to this level are limited to the almost primitive processing and the characteristics of the monitor's screens.

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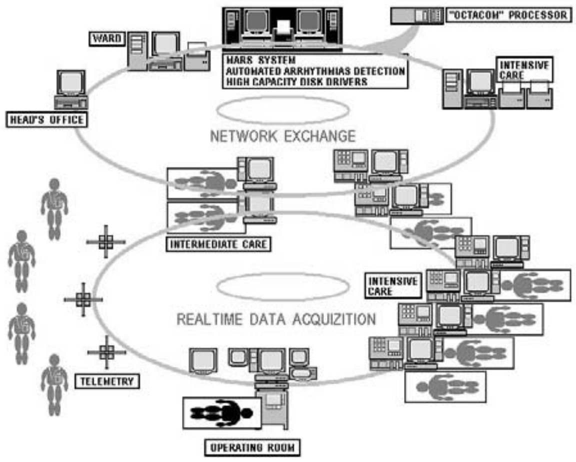

Figure 1. The real-time, patient-data network (RTN)

In the upper part of Figure 1, network exchange with server and computer promotes further processing, analysis and visualization of the material generated from medical instruments. In this way, the RTN becomes a very powerful tool, providing two independent workstations, located in the nursing stations of the ICU and the ward, while a display unit ("slave monitor") is also available at the head's office. In the workstation, one can see not only real-time data, simultaneously or not, from all the patients in the RTN, but almost limitless waveforms, in a beat-to-beat basis from preceding time periods. It's easy, for example, to understand the haemodynamic significance of an arrhythmia that occurred during the previous night, by examining not only the ECG but also the systemic arterial, pulmonary arterial, central venous and pulse oximetry waveforms. It is easy to trace similar clinical events as the system provides a catalog of alarms listed in a timely fashion. Furthermore, numerous report and trend forms can be displayed and printed.

As it is shown in the upper part of Figure 1, a semi-independent unit for automated detection, analysis and diagnosis of arrhythmias (the MARS system) is continuously gathering information from the RTN. Unfortunately, the very sophisticated software of this sub-system works independently and is not shared to the two main workstations of the RTN. The user has to go to the MARS computer if he/she wishes to work on it. Finally, as it is also shown in the figure, a special processing unit (OCTACOME) digitizes the biosignals in an epoch fashion form, generating thus numerical data for every waveform (beats/min for heart rate, numerical value for systolic/mean/diastolic arterial pressure, numerical value for end-tidal capnometry, etc). Its function will be discussed later.

The Clinical Information Local Network (CILN)

The second component of the system is practically a database. This system is spread throughout the areas where the cardiac/ thoracic patients are served. There are three stable workstations (outpatients clinic, ICU and ward) and one mobile cordless (a laptop that is usually used during the rounds in the ward). The system uses the network facilities of the hospital, while hubs and communication protocols ensure security and safety of the data. Although it functions independently, this configuration provides easy access and interchange to future developments of other in-hospital activities. The system is connected to the RTN through the OCTACOME processor. In this way, the patient's record is automatically informed about his/her vital signs, in a numerical / trend form, at least for the period that he or she was connected to the RTN, or, in other words, was monitored in the operating room, in the ICU, in the intermediate care, or by telemetry. All other entries are presently manual. Doctors, nurses and perfusionists have to pass information concerning the patients by specially designed keyboards.

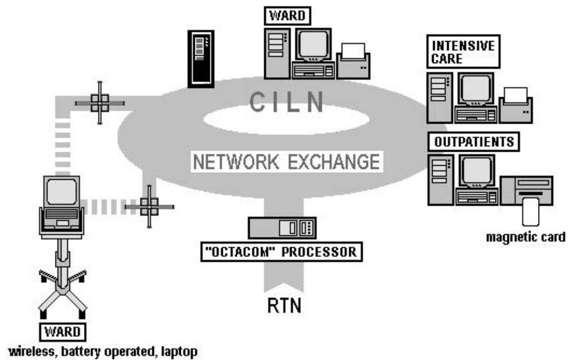

Figure 2. The Clinical Information Local Network (CILN)

Generally, a file is opened for every patient who visits the Cardiothoracic Division either as an outpatient or as an elective or emergency admission. At this moment the patient takes an ID number and, in a step-by-step fashion, the file is filled with all kinds of medical information, irrespectively of patient's location. The software provides simplicity and friendliness to the user. From admission to discharge of a patient, an enormous amount of data is gathered concerning his/her demographics, somatometrics, history, physical status, clinical signs, medical treatment, laboratory and imaging findings, intraoperative findings, kind of operation, anesthesia, times of cardiopulmonary bypass and aortic clamping, fluid balance, blood gas analysis, details about the course in the ICU or in the ward and, finally, information about outcome. Furthermore, the Cardiothoracic Division's secretariat has the facility to load clinical information to common magnetic cards. When the patient leaves the hospital, he receives the card along with the relevant documents, in order to facilitate future readmission. The advantages of CILN are enlightened if someone considers a banking system. Furthermore, the integration through laboratory access, which is presently under way, will make the maintenance less time consuming and diminish human error during data entry. Figure 2 is a schematic representation of the Clinical Information Local Network.

Implications for the anesthesiologist and future developments

Generally, monitoring can be defined as the maintenance of constant surveillance by the anesthesiologist over the patient and equipment. The term expands to the analysis and interpretation of the obtained information and to the use of assisting instruments. Nowadays, the role of instrumental monitors in the operating room includes the protection of the solitary anesthesiologist from task overload, particularly during certain phases of anesthesia, protecting thus the patient. A consequence of the increase in data production is the difficulty in record keeping. A solution of this problem comes with the use of computers and with the development of patient data management systems, as the already discussed CIS of the *Cardiac Surgery Division* in the *Hospital of Alexandroupolis*. Nevertheless, using the system in daily basis revealed deficiencies and shortcomings. Experience with the system in practice showed that users (surgeons, anaesthesiologists, perfusionists, nurses), everyone from his point of view, have to demonstrate unsatisfied performance, if any, and design improvements, based on the easy of upgrade and the network capabilities. Presently, our primary concern is to construct a sub-system, as a part of the anesthesia workstation, connecting all monitoring devices in the operating room to a semi-independent computer under a standard hardware platform for anesthesia record keeping and intra-operative anesthetic use of the already existing database. Data from the anesthesia ventilator, including information about inspiratory and expiratory anesthetic gas concentrations and lung mechanics, data from BIS monitoring, data from transoesophageal echocardiography and data from bronchoscopy could be added to the information generated from the haemodynamic monitoring that is already gathered by the system. Our computer scientists are working towards this direction. The final step would be integration in a record specially designed for cardiac anesthesia. We also work on its functional specifications, quality, reliability and presentation characteristics, taking under consideration the experience and the proposals of other centers. Preferably, this system could be expanding to the perfusionists, avoiding a second similar sub-system in the theater.

In conclusion, the merits of the CIS are many. Quick adaptability and easy of upgrade are promising factors for our ambitious objectives. Software to fully utilize the capabilities of our system is not a restricting factor as it is already available in the area of Medical monitoring. We believe that the system provides a convenient platform for high quality of care for our patients and for various research activities.

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Key words :

anesthesia, intensive medicine, cardiac surgery, computers, medical informatics, network, computerized monitoring, record