Data Integration in Cardiac Surgery and Resource Management

A Taddei [1,2], S Dalmiani [1,2], G Piccini [2], A Vellani [2], T Carducci [2],
M Buffa [2], L Scebba [2], M Glauber [2], B Murzi [2], A Biagini [1,2], A Macerata [1]

[1]CNR Institute of Clinical Physiology, Pisa, Italy
[2]G Pasquinucci Hospital, Massa, Italy

Abstract

At "G. Pasquinucci" Hospital in Massa, a section of CNR Institute of Clinical Physiology, an information system for cardiac surgery has been in use during the last years. This system was integrated with the Hospital Information System, already set up at the head of our institute in Pisa. Anesthesia data are recorded in the Operating Room (OR) as well as materials used during cardiac surgery operations. From the OR, data are transferred into the central clinical database, creating surgery reports in the medical record and filling in standardized clinical registers. Since 2000 a total of 2185 adult and 956 pediatric cardiac surgery operations were recorded.

1. Introduction

The "G. Pasquinucci" Hospital in Massa (GPH), specialized in Cardiac Surgery (both adult and pediatric), is a section of the CNR Institute of Clinical Physiology (IFC), located 60 kilometers from Pisa. The extension at GPH of the Hospital Information System, previously set up at IFC by the SPERIGEST project (supported by Italian National Health Ministry, 1995-98) (http://ifc.cnr.it/sperigest) [1] for the integration of resources in Cardiology, required both the adaptation of existing systems and the development of new ones, typically related to the management of cardiac surgery and pediatric cardiology. The HIS architecture is based on three levels of data archiving (administration, clinical system and functional units, such as diagnostic laboratories, care units, OR) and on two modalities for data exchange (middleware data integration into the central clinical database ARCA and Web distribution of health care information over the HIS network). The computer-network infrastructure, interconnecting GPH with the IFC head in Pisa, allows achieving full access to patient information from any workstation within the HIS.

Network connection between GPH and IFC was fast enough (2 Mb/s) to guarantee effective access to patient data, archived in the central clinical database located in Pisa (ARCA, SQL IBM DB2/2). Supplementary connection (128Kb/s) is available to guarantee continuity of patient data access in case of failure of main line (Figure 1). Development of HIS at GPH started with the implementation of the anesthesia information

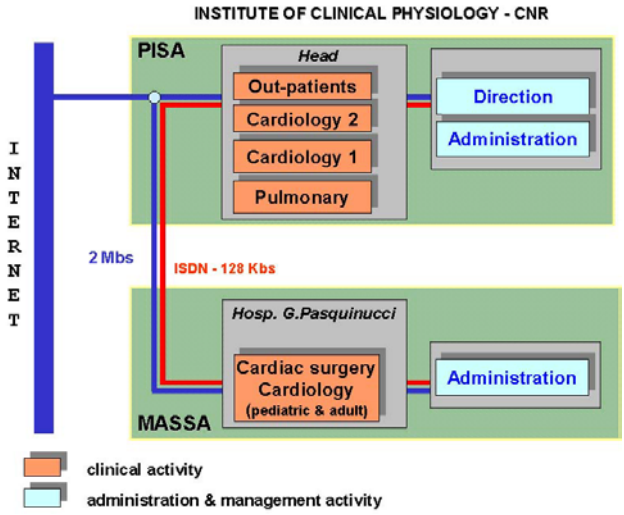

Figure 1. Structure of the computer-network of HIS

management system [2] for documentation of anesthesia procedure during cardiac surgery operations. Commercial software (OTIS by Dedalus S.p.A.), designed for anesthesia data entry with on-line acquisition from OR equipment, was integrated in HIS.

Given, today, the increasing need of hospital administration to get cost-effective patient care it is important to document the use of available resources. Particularly cardiac surgery activity is cost-intensive in the hospital. A major parameter in resource management is OR utilization [3], which can be derived from anesthesia records. Expenses for surgery mainly derive from use of materials and from employment of staff and equipment. The hospital LOS (length of stay) should be also taken into account for evaluating efficiency of health care delivery.

Building clinical information systems provides the capability of collecting and archiving patient data useful for health care delivery and for developing clinical

registers. Adoption of standard dataset for the characterization of patients undergoing cardiac surgery interventions, such as the coding systems promoted by Society of Thoracic Surgery (STS) [4], is crucial to achieve a comprehensive register allowing individual surgeons to improve quality and benchmark their practice by making prospective prediction of patient outcome according to multicenter risk stratification models.

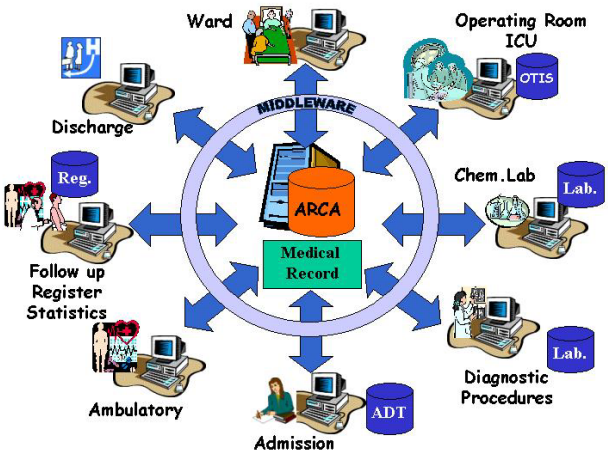

Figure 2. Work-flow in cardiac surgery and middleware data integration into the central database.

2. Data integration in cardiac surgery

The project of the information system is aimed at collecting, archiving and integrating all data related to patient care, from the visit in ambulatory to hospital admission, diagnostic procedures, cardiac surgery intervention and finally discharge and follow-up (Figure 2). Different sources of information are integrated by middleware into the central database ARCA that is the repository of patient data. Completion of patient data integration will allow use of Electronic Medical Record (EMR) in the ward in place of paper documents.

2.1. The operating room

The anesthesia record keeping system, currently installed at GPH [2], consists of one MS-W2k server (OTIS SERVER) with the anesthesia database (MS-SQL Server 2000), interconnected within a local area network with MS-W2k workstations, each installed in the three ORs with on-line data acquisition, and in both the adult and pediatric ICUs and one at anesthesia secretary. ODBC access to the ARCA database is provided, allowing integration of the anesthesia "functional island" with the patient medical record (Figure 3). Panel PCs, electrically insulated, were installed in each OR, close to patient and connected to monitoring and blood analysis equipment (Figure 3).

Figure 3. Anesthesia information system in the OR.

The following phases are distinguished:

- Pre-operative patient identification and importing personal and clinical data from the medical record. In case of patient not yet admitted in HIS, a temporary patient identifier is created and later aligned with the medical record.
- Intra-operative data capture and archiving. Monitor and blood parameters are automatically recorded and plotted at OR workstation. Staff enters any data for documentation of anesthesia, such as events, shot (i.e. sternothomy) or duration (e.g. anesthesia, surgery, extra corporeal circulation), drugs. Post-operative orders are transferred to the ICU workstation.
- Post-operative printing of anesthesia record and data exporting to the clinical database ARCA. The programmable middleware interface allows to set up, as needed, the set of data (currently a total of 112 parameters) exchanged between anesthesia and ARCA databases, thus enabling full integration with HIS.

Remote on-line control of OR activity is allowed from HIS workstations by graphical Visual Basic application. Service remote connections are also used for on-line technical support, even out of the OR.

Nursing personnel is charged of recording for each operation all materials used for both surgery and extra corporeal circulation (EC) procedures. A graphical form, including 212 surgery and 193 EC items, was provided for detailed manual annotation during operation and later computer data entry into the anesthesia database.

In order to facilitate the surgeon reporting operations the report is automatically created in medical record, by means of a trigger, at the end of operation on anesthesia data export to ARCA. Dates of operation and times of surgery, already recorded in OR, are also included.

3. Reporting cardiac surgery operations

EMR, already developed and used in cardiovascular departments of IFC in Pisa [5], is currently under extension for use at GPH for the management of cardiac surgery patients. Graphical user interfaces (developed in Java) were designed and embedded in the EMR for reporting both adult and pediatric operations. Text descriptions of findings and procedures were provided to secretary for inclusion into the discharge letter. Standard STS-derived [4] datasets were adopted to characterize surgical patients and to develop registers aimed at both clinical research and outcome evaluation. These registers were partially filled in automatically by data retrieved from the medical record or exported from anesthesia system.

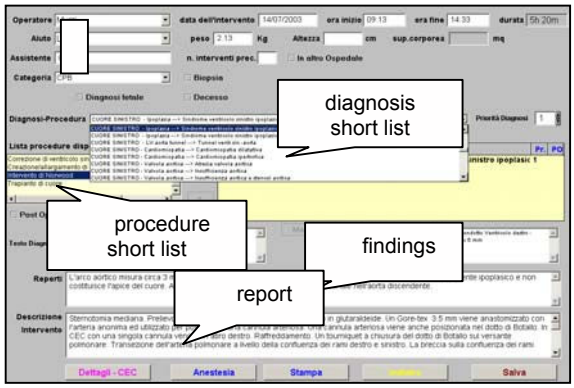

Figure 4. User interface for structured reporting pediatric cardiac surgery interventions.

3.1. Pediatric cardiac surgery

The nomenclature of EACTS congenital heart surgery database was adopted as reference for pediatric patients [6]. The dataset consists of 28 parameters for each patient, including short lists of diagnoses, procedures, pre-operative risk factors and complications or operative death. Structured data entry is made by the user interface used for reporting operations. The operation complexity was also estimated from the type of procedure according to a 3-level model, developed in a multicenter study.

3.2. Adult cardiac surgery

The dataset of National Society of Cardiac Surgery (derived from STS) [4] was adopted as reference for the characterization of adult patients undergoing cardiac surgery. A total of 448 parameters were defined concerning demographic data, history, risk factors, clinical conditions, therapy, surgery procedures, EC, complications and follow-up. Register data collection was achieved by the use of "Matrix" system, the system

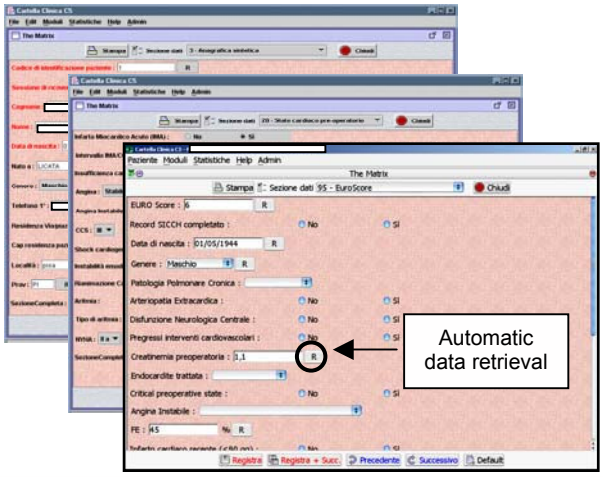

Figure 5. User interface of adult cardiac surgery register, with automated data retrieval capability.

recently developed at our institute for easy customization of datasets and automatically built graphical dynamic interfaces [7]. The register database shares data with the database ARCA (repository of medical record) or other registers. Automatic data inheriting capability allowed retrieving a part of data from both medical and anesthesia records (up to 93 parameters), thus saving time of surgeons. On-line field guide and user defined default value facilitate manual data entry. Standard risk scores are derived (Parsonnet, Euroscore). Follow-up of patient was essential for outcome analysis: while in pediatric patients hospital mortality was initially considered, status 30 days after intervention was also assessed in adults.

The "Matrix" system was also applied to filling in records for national register of Anesthesia in Cardiac Surgery, retrieving data from ARCA and surgical register. Data collected in registers were periodically validated and submitted to multicenter collection centers.

4. Web consultation of clinical data

Distribution of health care information over HIS network was achieved by the use of Web technology. HTTPS server was installed for secure Web access to clinical data recorded in the central database ARCA. A Web clinical site, containing dynamic HTML modules, was developed for allowing each authorized user to browse into patient clinical data from any workstation over the HIS or even from outside by modem connection. While initially CGI applications in C language were realized, recently Java servlets have been developed. Typically Web access has been provided to: medical records of in- and outpatients, diagnostic reports, cardiac surgery and anesthesia data. Views in tabular form were developed, such as list of operations including location of surgery, times of anesthesia or surgery, operators,

diagnosis, procedures and mortality. Data, represented on the browser, can be downloaded into files for further processing by common packages (e.g. MS-Excel, S-Plus).

5. Results

Information archived in the clinical database and in standardized registers allowed to achieve comprehensive reports of cardiac surgery activity, useful for health care management. A total of 2185 adult major operations were characterized and archived. Detailed clinical audits were made possible by easy data retrieval from databases. The computed standard risk scores were compared to patient mortality for outcome evaluation. Selected data of patients undergoing aortic coronary bypass were contributed for a national study on outcome.

Pediatric cardiac surgery operations, recorded since 2000, were 956, of which 748 CPB, 141 non-CPB and 67 minor ones. Time analysis of LOS (Length Of Stay) of surgical patients allowed assessing the level of efficiency of pediatric cardiac surgery department. LOS values, before and after the major operation, were distinguished.

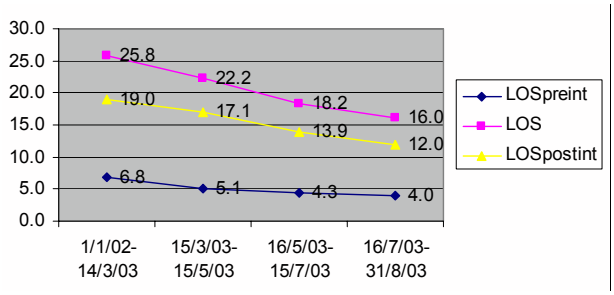

Figure 6. Time analysis of average LOS

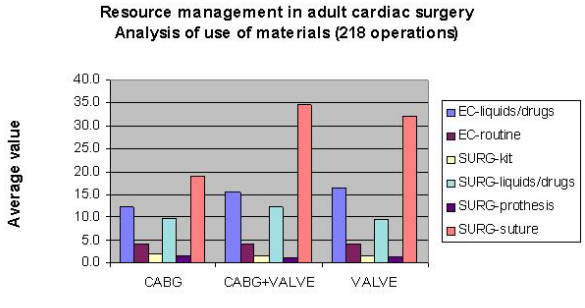

Figure 7. Materials used in different procedures

Time durations of anesthesia and surgery procedures were analyzed to assess the OR utilization. From comparison of average values in two consecutive periods reduction of OR utilization (4.6%) was assessed. Analysis of data recorded during operations allowed estimating the amount of materials used for different types of procedures (Figure 7).

6. Conclusions

The developed system allowed collecting, archiving and integrating patient information in cardiac surgery. Secure Web technology facilitated distribution and consultation of health care information within the HIS. Adoption of standard nomenclatures was crucial for comprehensive patient characterization and outcome evaluation. Actually EMR implementation in cardiac surgery departments is still challenging: first, integration of data-intensive functional units (e.g. chemical laboratory) has to be completed and secondly health care personnel should become acquainted with the new system.

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Address for correspondence:
Alessandro Taddei
CNR Institute of Clinical Physiology
Hospital G.Pasquinucci - 54100 Massa, Italy
E-mail: taddei @ ifc.cnr.it