Data Integration in Cardiac Surgery Health Care Institution: Experience at G. Pasquinucci Heart Hospital

A Taddei[1,4], S Dalmiani[3], A Vellani[4], E Rocca[4], G Piccini[4], T Carducci[4], A Gori[4], R Borghini[4], P Marcheschi[3], A Mazzarisi[2,3], C Salvatori[3], A Macerata[5,2]

[1]National Research Council, Institute of Clinical Physiology, Massa, Italy
[2]National Research Council, Institute of Clinical Physiology, Pisa, Italy
[3]Gabriele Monasterio Foundation, Pisa, Italy
[4]Gabriele Monasterio Foundation, G Pasquinucci Heart Hospital, Massa, Italy
[5]University of Pisa, Human Physiology Department, Pisa, Italy

Abstract

During the last ten years the Hospital Information System (HIS) was developed at the Institute of Clinical Physiology of National Research Council (IFC-CNR), recently reorganized on clinical side into the "Gabriele Monasterio Foundation" (FGM) by joint efforts of CNR, Tuscany Region and Universities. At G.Pasquinucci Heart Hospital (GPH), currently FGM's section in Massa, the HIS was adapted and extended to Cardiac Surgery and Pediatric Cardiology. Data archiving and middleware integration through HIS network, connecting GPH with head institution in Pisa, allowed to achieve full secure access to patient information from any workstation within hospital or outside. PACS was developed using Open Source DICOM utilities. Electronic Medical Record is daily used since 2005 on both inpatients and outpatients. Recently telediagnosis was set up between Balkan countries and GPH in Massa.

1. Introduction

The Hospital Information System (HIS) was first developed at IFC-CNR in Pisa 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. Later extension of HIS at G.Pasquinucci Hospital, IFC-CNR's section in Massa, 60 kilometers far away from Pisa, specialised in Cardiology and Cardiac Surgery (adult and pediatric), required both adaptation and development. Last year IFC-CNR health-care activities converged into the new "G.Monasterio Foundation" (FGM) by the joint effort of CNR, Tuscany Region and Universities. HIS architecture is based on three levels of data archiving (administration, clinical system and functional units, i.e. diagnostic laboratories, care units, Operating Rooms) 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). PACS for imaging modalities was developed using Open Source DICOM utilities. The computer-network infrastructure, interconnecting GPH with the head institution in Pisa, allows achieving full access to patient information from any workstation. Secure Web technology was applied for distribution of health care information within hospital Intranet and also outside by Extranet.

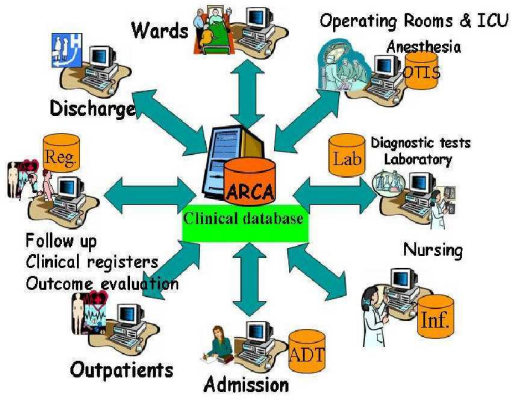

Figure 1. Workflow and middleware data integration

2. Methods

The project of the information system was 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 1). The different sources of patient information were

integrated by middleware into the central hospital database (ARCA) which represents the clinical repository. Network connection between GPH and IFC is currently fast enough (8 Mb/s, BMG 4Mb/s) to guarantee effective access to patient data, archived in the ARCA repository located in Pisa (SQL IBM DB2/2).

EMR development. Transition from conventional paper-based towards electronic medical record (EMR) required, first, to set up regular and comprehensive patient information flow from health care units into ARCA repository [2]. Each diagnostic or care unit (ECG, echocardiography, cath lab, chemical lab, nursing system) as well as the Operating Room Theatre and the Intensive Care Unit were provided with computer-based systems for recording patient data and transferring reports into EMR. Structured data entry was generally implemented in addition to free text. Standard IDC9-CM codes of diagnoses and procedures were applied for filling in DRG forms.

Data integration in Operating Rooms. Development of HIS at GPH started with the set up of the Anesthesia Information Management system [3] for documentation of anesthesia procedure during cardiac surgery operations. Commercial software (OTIS by Dedalus Inc.) for anesthesia data entry with on-line acquisition from OR equipment was adapted and integrated with HIS (Figure 2). Three phases were distinguished: pre-operative patient identification and characterization, importing data from ARCA repository; intra-operative data entry (drugs, events, notes) and automatic data capture from OR equipment; post-operative ICU ordering, anesthesia record printing and data exporting to ARCA repository. Material data entry system was developed for resource management during operations.

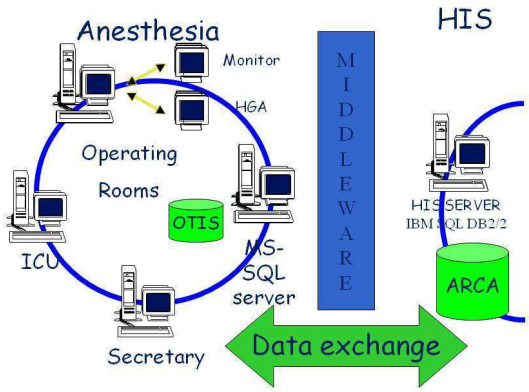

Figure 2. Operating Room information system

Laboratory data integration. Laboratory Information System (LIS) was integrated with HIS to automate the testing process from clinical departments to laboratory and back into EMR [4]. Laboratory workflow consists of three parts: (a) test ordering by clinical staff, printing bar-coded ID labels and transmitting orders by network to laboratory; (b) processing test requests and controlling identified specimens by laboratory staff, providing work orders to analytical instruments and validation of results authorizing delivery into the hospital clinical repository; (c) consulting test results in clinical departments by referring physicians through the EMR.

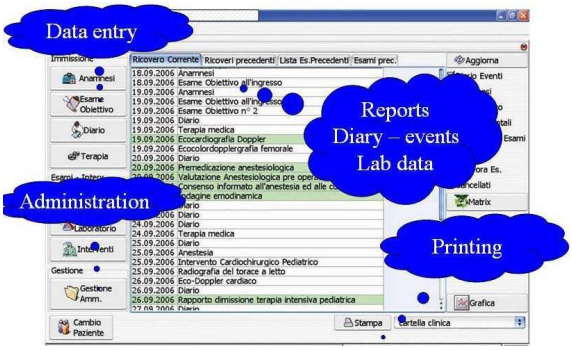

Figure 3. EMR main panel

EMR user interface (Figure 3) was set up extending the model already used in Cardiology departments of IFC-CNR in Pisa [5]. Use of Java language allowed to deploy EMR on different platforms (MS-Windows, Mac, Linux). Safe wireless networks were installed in the wards of both adult and pediatric cardiac departments to allow use of mobile EMR workstations at patient bed (Figure 4).

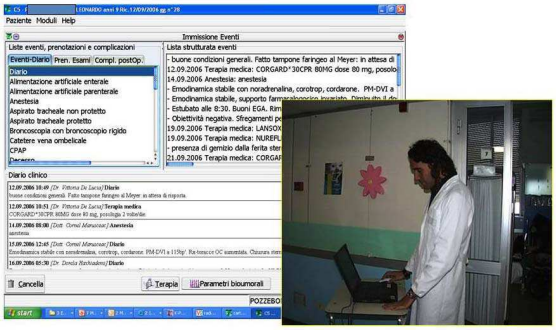

Figure 4. Using EMR in the ward for diary data entry

Cardiac surgery registers. International nomenclatures were adopted to characterize cardiac patients developing registers, aimed at both clinical research and outcome evaluation. An information model was created for structured data management to build clinical registers [6]. Registers were partially filled in automatically by data retrieved from EMR or from anesthesia record. EACTS congenital heart surgery dataset was adopted as reference for pediatric patients [7], while National Society of Cardiac Surgery dataset for adults undergoing

cardiac surgery [8]. Standard risk scores were derived from datasets (Euroscore for adult and Aristotle for pediatric cardiac surgery).

Web data distribution. Distribution of health care information over HIS network was achieved by the use of Web technology. HTTPS Web server was installed for secure access to clinical data recorded in ARCA repository. Web clinical site was developed for allowing authorized users, through password control, to browse into patient clinical data from any workstation over HIS network or even from Internet by VPN connection. First CGI applications in C language and in NetData script (IBM) were realized and later Java servlets and PHP4 applications were developed. Tabular or graphic views were implemented for reporting medical records of in- and outpatients, discharge letters, lists of patients and diagnostic reports, cardiac surgery and anesthesia data. Data, downloaded from the web site, were further processed by statistical packages.

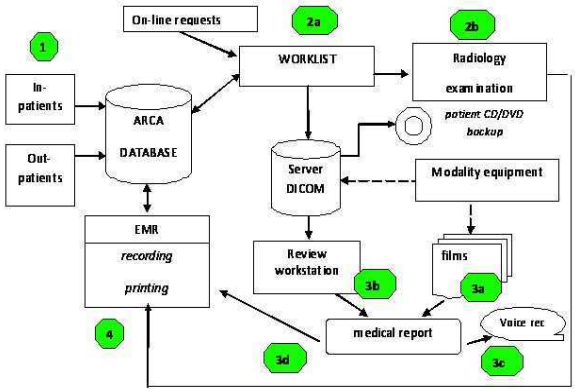

Figure 5. RIS-PACS workflow

RIS-PACS. Using Open-Source utililities [9], the PACS for different DICOM modalities (CR, CT, XA, US) was set up, while viewer/processing workstations (OSIRIX) were installed for both reporting and consultation [10] (Figure 5,6). According to conformance statement of DICOM server (DCM4CHEE) and modality equipment Work-List service was implemented was applied to get patient lists from HIS, thus allowing to identify examinations. Radiology workflow (Figure 5) include the following steps: examination reservations (1) (in- or out-patients); execution of examinations, identified by worklist and recorded on DICOM server (2a,b); examination reporting on review workstation (3b) or on conventional films (3a); report data entry and printing by EMR (4). Data security was maintained by RAID architecture and using CD/DVD automated DICOM backup systems. Better performance will be achieved implementing short-term and long-term memory servers.

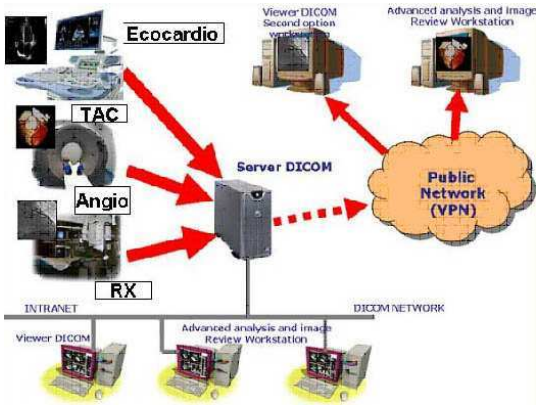

Figure 6. Open-Source PACS

Telemedicine. Recently telemedicine applications were implemented by on-line secure transmission over Internet of echocardiography and angiography images over public network (project for tele-diagnosis between Balkan countries and GPH – Massa) (Figure 7). Videoconference commercial equipment (Aethra Vega X5) was used to transmit images during diagnostic examination in addition to audio/video signals. Real-time capability is crucial for allowing specialists to drive remotely proper echo scanning of cardiac structures in patient or foetus with suspected congenital heart disease. Upload 512 kbits/s transmission bandwidth, divided into 64 kbps for audio and 448 kbits/s for video channels, allowed real-time reproduction of echocardiography images received from Banja Luka (Bosnia) maintaining diagnostic quality according to the cardiologist's evaluation.

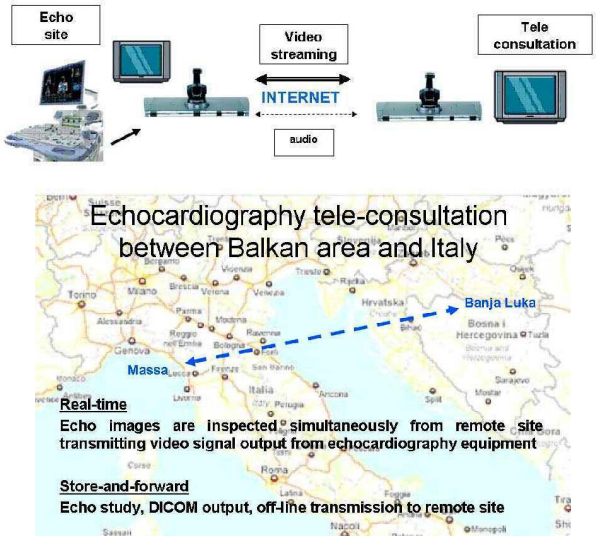

Figure 7. Real-time tele-diagnosis system

3. Results

While information systems for reporting diagnostic, clinical and cardiac surgery activities have been in use at GPH for more than ten years, since 2005, EMR is daily used on all the patients admitted in the clinical departments (Cardiology, Cardiac Surgery and ICU). A standard protocol was set up by health director for the management of the patient medical record since hospital admission to discharge: roles and duties of health care personnel (medical, nursing, secretary) were carefully defined. In order to assure confidentiality, EMR access is allowed only to authorized health care personnel using a personal password to login. So far at GPH in Massa more than 24000 inpatient and 150000 outpatient records were processed and archived, including up to 10000 cardiac surgery reports (adult and pediatric).

4. Discussion and conclusions

The hospital information system, developed by the efforts of interdisciplinary teams working in IFC-CNR and GPH during the last ten years, despite initial difficulties, mainly due to adoption of new technology, was finally effective for both clinical and administrative management [11]. Data integration and archiving allowed hospital personnel (physicians, nurses, secretary and administration officers, director) to access clinical records easily and reliably with benefits to overall health-care process. Particularly EMR in the ward promoted staff inter-communication and comprehensive documentation of patient care during hospitalisation. Actually a series of technical measures, continuously updated, were needed for assuring data security, confidentiality and integrity, given the continuous exposure to intrusion risks on networks. Technical services were organized to monitor HIS for maintaining it 24-hours operational.

Currently medical records need to be printed out after patient discharge and signed by the responsible of department, just achieving a legal value. Application of both electronic signature and official clinical data storage systems, according to current regulatory laws, will allow soon to authenticate electronic documents achieving a real paperless medical record. Policies for data access, backup and storage will be revised and updated.

Adoption of standard dataset for the characterization of cardiac patients was crucial to achieve comprehensive registers allowing to benchmark surgeons' practice by making prospective prediction of patient outcome according to multicenter risk stratification models. Uploading pediatric cardiac surgery records on international EACTS database it was possible to qualify the GPH centre as one of the best ones in terms of outcome during the last years.

Actually revision of both database architectures and clinical applications according to recent data exchange standard (HL7 v3) [12] is currently under development aimed at improving performance of information systems, safeguarding their security and also to assure multicenter interoperability.

Acknowledgements

We gratefully acknowledge advice of physicians, nurses and secretary personnel at GPH in Massa and of colleagues at IFC-CNR in Pisa. Particularly we mention Sergio Berti, Sandra Giusti, Vittoria De Lucia, Bruno Murzi and Clara Carpeggiani for their suggestions and help in developing and implementing the EMR at GPH.

References

[1] Macerata A, Landucci L et al. Networking for health care administration and delivery: the information system at the CNR Institute of Clinical Physiology. In: Proceedings of Health Telematics '95. Pisa: CNR, 1995, 113-18.

[2] Taddei A, Dalmiani S., Piccini G et al. Data integration in cardiac surgery and resource management. Computers in Cardiology 2003, 30:279-282. IEEE

[3] Taddei A, Fiaschi A et al. Integrated system for anesthesia records in cardiac surgery. Computers in Cardiology 2000; 27:789-792. IEEE.

[4] Taddei A, Pisani P, Vellani A et al. Laboratory Data Integration into Medical Record. Computers in Cardiology 2005, 32:909-912. IEEE

[5] Carpeggiani C, Dalmiani S, Taddei A et al. Use of an electronic medical record in a department of Cardiology. Computers in Cardiology 2000; 27: 291-294. IEEE.

[6] Dalmiani S, Taddei A, Glauber M et al. An informative system for structured data mbacksanagement to build a cardiological multidimensional database. In: Computers in Cardiology 2002; 29: 369-372. IEEE.

[7] http://www.eactscongenitaldb.org/ EACTS congenital heart database.

[8] http://www.sicch.org/sections/Database_Nazionale/index.html SICCH Italian National Database.

[9] http://www.dcm4che.org/

[10] http://www.osirix-viewer.com/

[11] Carpeggiani C, Macerata A, Taddei A et al. G Ital Cardiol 2008; 9:558-565.

[12] http://www.hl7.org/

Address for correspondence

Alessandro Taddei
CNR Institute of Clinical Physiology
G.Pasquinucci Heart Hospital
Via Aurelia Sud
54100 Massa, Italy
taddei@ifc.cnr.it