

Integration of Healthcare Information: from Enterprise PACS to Patient Centered Multimedia Health Record

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Abstract

Every single piece of healthcare information should be fully integrated and transparent within the electronic health record. The Italian Hospital of Buenos Aires initiated the project Multimedia Health Record with the goal to achieve this integration while maintaining a holistic view of current structure of the systems of the Hospital, where the axis remains are the patient and longitudinal history, commencing with section Computed Tomography. Was implemented DICOM standard for communication and image storage and bought a PACS. It was necessary adapt our generic reporting system for live up to the commercial RIS. The Computerized Tomography (CT) Scanners of our hospital were easily integrated into the DICOM network and all the CT Scans generated by our radiology service were stored in the PACS, reported using the Structured Reporting System (we installed diagnostic terminals equipped with 3 monitors) and displayed in the EHR at any point of HIBA's healthcare network.

Keywords:

Electronic medical records, PACS, Radiology information systems.

Introduction

In medical literature there are several definitions of medical records. The Institute of Medicine (IOM) defines it as the repository of information about a single patient, generated by health care professionals as a direct result of interaction with a patient or with individuals who have personal knowledge of the patient (or with both) [1]. According to Von Bommel a medical record is "composed of findings, considerations, results of examinations and information about treatments followed in relation to the morbid process" [2]. Electronic Health Records (EHR) aren't outside these definitions. However, this last concept is more difficult to define. A large number of health organizations have information systems with different levels of development and integration, storing the information of clinical patients in different ways. The IOM defines EHR as a record that resides in a system specifically designed to support users by providing accessibility to complete and accurate

data, alerts, reminders, clinical decision support systems, links to medical knowledge, and other aids [1].

On the other hand, images management and PACS (Picture Archiving and Communication Systems) development were conceived with the aim of achieving significant benefits for radiology departments, in terms of reducing film storage space needed and the staff's time, and ensure immediate access to the images. It is recognized that several of the major benefits of PACS is providing processed images and reports to physicians in a timely fashion. This improves care, facilitates clinical management and expands the capacity to conduct remote consultations [3]. The complete implementation of a PACS system has been often been an evolving process within a clinical institution with the concurrent evolution of hospital information systems with multimedia applications, facilitating images distribution [4]. And it also has been taking a growing interest in other areas which use diagnostic imaging, different to radiology, (e.g., cardiology, pathology, nuclear medicine).

Most centers that have implemented Healthcare Information Systems (HIS) and PACS, the latter was implemented in exclusively in radiology departments or in fewer cases in an integrated manner [5-7]. This way, most healthcare centers with HIS leave outside their clinical data repository (CDR) the multimedia elements, having them managed by stand alone applications, in an isolated way.

Ideally, the integration of this multimedia information must be fully and transparently with other CDR information. Thus, maintaining this integral approach, not looking forward to a separate repository for each service, but the professional been able to access multimedia information in the context of the patient's medical record, without changing application [8].

Then emerge the need for a Multimedia Health Record, in which the PACS in no longer a departmental component and becomes part of the storage system in which the CDR relies, and its information can be access in the context of the entire patient's information in the electronic medical record.

Objectives

Incorporate into our EHR the different studies that generate the various ancillary services in its original formats (images,

movies, audios, signals, etc.) beyond the text in the report.

Materials and Methods

Setting

The Hospital Italiano de Buenos Aires (HIBA) is a non-profit health care academic center founded in 1853, with over 1,500 physicians and 4000 employees. HIBA has a network of two hospitals with 750 beds (200 for intensive care), 500 home care patients under care, and 23 clinics. It has an insurance plan that covers approximately 150,000 people and also coordinates insurance for another 1,500,000 people who are covered by affiliated insurers. Each year over 38,000 inpatients (pediatric and adult) are admitted to its hospitals that are located in Buenos Aires and its suburban area. HIBA has more than 2,200,000 outpatient visits annually from patients from across the country and Latin America.

Since 1998, HIBA began to implement a Healthcare Information System (HIS) by coordinating clinical information with the administrative applications that were already in use [9-10]. It is an in-house project that currently handles all the information related to health care both clinical and administrative from capture to analysis.

All of our systems are web based, and among the most important components are:

- Electronic Health Record (EHR): is the access point to every piece of health information recorded in our healthcare network, as different GUI's for each level (ER, Inpatient, Ambulatory, Home Care, Day Hospital). It is problem-oriented and patient centered EHR system that includes a computerized provider order entry (CPOE) is available throughout the HIBA network.
- RPTGen: Generic Reporting System, transversal to the whole network. Is the Information System for each Ancillary Service, and also enables free text reporting. Its output is a CDA Document [11].
- Terminology Services: an interface vocabulary of our own, allowed us mapping of local vocabulary (thesaurus) to reference vocabulary SNOMED CT, and is in use by each of our applications [12].
- Master Patient Index, Scheduling System, Admissions, ADT, Intranet, among others

HIBA has used HL7 standards since 1999 [10]. Framed by the process of integrating the information systems for the EHR, Ancillary Services and Patient Services, the Department of Medical Informatics developed a document repository for clinical documents (consultation notes, discharge reports, etc.) and final reports from ancillary services, using HL7 and CDA documents to achieve full system interoperability.

Along with these developments it was necessary to incorporate desktops computers, not only in the development area and servers, but also through our entire healthcare network. Currently every point of care has a computer connected to the

network, which can access de EHR and the rest of our applications; and there is more than 3000 point of care in our network.

The Radiology Department is a complex department, in many different locations inside the hospital because of its massive growing. It has over one hundred physicians (including residents) and other hundred and twenty healthcare professionals including technicians and nurses. Each month near 60.000 diagnostic procedures are performed, including MRI, CT scan, PET, US, X-Ray, Mammography, Angiography and Interventional Radiology.

Preliminary Stages

To ensure the success of this project, we developed a staged project management process. Each phase was well defined, resourced, and had the advantage of benefitting from strong administrative support.

Feasibility Study

In order to sustain support we elicited and defined institutional expectations with our planned objectives. During this feasibility period three major objectives redefined scope and project.

To achieve a complete and transparently integration of multimedia information it was necessary to maintain a holistic view of current systems in the hospital and specifically the electronic medical record and its interaction with the rest of systems. I.e., the multimedia component would be incorporated as any other piece of health information. But the main focus would remain the patient and his longitudinal record. We sought to avoid (as a concept) service independent repositories that would have increased physician workload.

In summary, we sought to provide professionals with seamless access to patient information within the context of clinical history without requiring a change of application.

Scope

It was necessary to define whether a service is in the scope of the project. This involved defining the departments that generates multimedia information whose inclusion into the EHR has clinical relevance. Taking into account national and international experiences, how they managed digital imaging and subsequent storage, and available standards.

It was also necessary to take into account the volume of each individual study and the organizational logistics that would present as a result of the change. We needed to explore workflow, equipment requirements –technical, physical, and ergonomic issues-. And, of course, our impact study dealt with the financial parameters.

Risks

As an extended project, it was necessary to take into account corporate and technological risk areas, scope redefinition, and changes, which would impact on the project from project inception to its implementation.

Equipment

It was necessary to make an inventory of equipment that generates clinical information in the form of images, audio, video, their ability to generate that information in an electronic manner to store it on the clinical record.

For each ancillary department we generated document detailing the inventory by hierarchical sub-area. This inventory was provided by the sector and completed by our team. In each group of teams was detail the possibility of issuing or receiving messages DICOM and its potential compatibility with the various types of messages [13].

Definitions

During 2006 our project team carried out surveys in each ancillary department. We decided to take the Radiology Department as our starting point, including the following sections: Computed Tomography, Radiology, Interventional Radiology, Digital Angiography, Positron Emission Tomography and Magnetic Resonance.

Ultrasound and mammography services were partially included in the project, because all administrative processes, technical and medical, including the report would change as the others, but without incorporating the images.

We decided to use the DICOM standard for communication and image storage, HL7 messaging which was already an institutional standard, and for administrative information a CDA standard (Clinical Documents Architecture) for reports [14-16].

All studies will be stored for an indefinite period of time, with lossless compression (without loss of information). Based on the analysis of the images generated by each section, we estimated that the storage needs for all Radiology Department would be 12 Terabytes per year. Is left out of the calculation the area of mammography, because the storage required only for this section is equivalent to all the rest of the project, the high cost of digital mammography devices and high definition monitor, besides its application is still somehow discussed among radiologists [17].

At last, some changes took place the radiological process to achieve the main objectives:

- Film less Service
- Reduce primary information in modalities, optimizing technology use and standards application.
- Change the reporting method, from traditional dictation to structured reporting.

With these definitions, we sought to reduce report turnaround time, which will allows faster access to the image by the referring physician.

Results

RIS

In spite of the fact that HIBA does not have a standalone Radiology Information System (RIS) its administrative functions are integrated within HIBA's HIS. Because of this, it was necessary to adapt our system of generic reports (RPTGen) to match the RIS commercial standards. Amendments were made in RPTGen for all involved. This included administration, technical, nursing, physician and systems professionals. This was done to reflect new or suggested post implementation processes for the Radiology Service.

At the same time we designed and developed a new structured reporting system, which output are CDA documents with coded entries and was integrated into the RPTGen.

PACS

Hardware

HIBA acquired an IBM System I server 570 (5 microprocessors Power 6), with a storage capacity of 40 Terabytes.

Software

We acquired a Picture Archive and Communication System (PACS) developed by the Spanish company UDIAT Center Diagnosis: RAIM. It enables a full integration with our systems and works with all required international standards.

Modalities

Through the different sections of the department we integrated DICOM (Digital Imaging and Communications in Medicine) modalities with our PACS network. Our aim was to make a full bidirectional integration including DICOM send, storage, print, modality work list (MWL), MPPS (modality performed procedure step):

- CT: we have five CT Scanners; three were able to make a seamless integration with the mentioned standards. An older device, just accepted DICOM storage and query & retrieve. And the oldest needed a "dicomizer" in order to perform DICOM SC (Secondary Capture).
- Radiology: we acquire a CR Solution with phosphorus chassis, seven single scanners and one multi scanner, with remote operation panels distributed near the most common image acquisition places (ICU, ER, Operating Rooms).
- Interventional and Dynamic Radiology and Digital Angiography were integrated using dicomizers.
- MRI: we have three scanners, all of them had a seamless integration with the mentioned standards.
- PET: one single Position Emission Tomography scanner fully integrated

Besides we were also able to successfully integrate most workstations. Following literature recommendations we decided to

install high resolution diagnostic terminals equipped with 3 monitors:

- Reporting Monitors: 17-inch LCD screen with standard resolution for using the reporting system.
- Diagnostic Monitors: 2 monitors between 19 and 22 inches, four of them are three megapixels monochrome screens.

Communication

A network dedicated to the project, independent of the existing bi-LAN, with a category 6 cabling (1 gigabit per second) and category 7 inter-nodes. This DICOM network communicates PACS server with each DICOM node installed (modalities, workstations, terminals diagnostic, printers).

Integration

This is the key issue of the development of this project and the main purpose of it. The EHR is a gateway to all patient clinical information. Now, it includes the images and other multimedia information, accompanied by a report complying with the rules of the CDA standard, viewed from the EHR as all results of the studies generated by the Hospital, with the difference that includes a link to the corresponding images (Figure 1).

The installation of a PACS for managing digital images, the use of standards and modern systems used in the HIBA, helped seamlessly integrating systems described above. In this way, any image digitally generated by any of the mentioned modalities is automatically stored in our PACS and immedi-

ately creates an empty report in CDA (until the radiologist makes de definitive report) linking to the images. This web viewer is a Java application that requires minimal resources and runs on PC's with Windows OS from 98 to Vista.

Point of Departure and Current Status

At the conclusion of the stages of development and testing, it was decided to begin a pilot test in the Computed Tomography Section of our Radiology Department. After two months, we began wide spreading our implantation to the rest of the department, with a two months interval between sections. In year 2010 we will begin implementing other ancillary services: Pathology and Hemodynamic.

Discussion

There are recognized challenges of integrating the various modalities beyond DICOM Conformance Statement (especially those modalities of the past century); but this technical issues in most cases have a solution [18, 19].

A project of this magnitude implies a great deal of technological challenges (adequacy of internal networks, acquisition of the diagnostic stations to replace the negatoscopes, high availability systems, modernization of modalities, development and acquisition of software). It is also important to note some organizational challenges that have a high impact on the daily workflow of physicians in our institution. These include changes in the way of reporting for specialists (report dictation vs. direct reporting with structured systems).

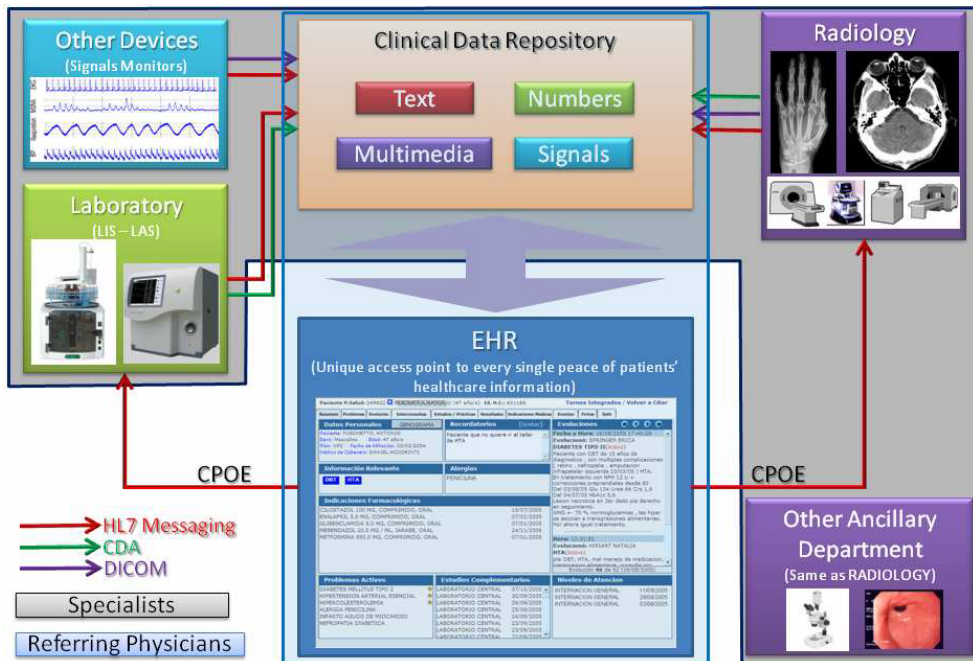


Figure 1 – Schema showing the EHR as the universal Access point to the clinical information for referring physicians

Despite the clear clinical and operational benefits of the project, clearly need to raise its economic justification. The savings would be generated by replacing image printing consumables and the improvement in the radiological process that will allow us to relocate 60 employees (typist).

Our filmless policy is not possible in all cases, depending which patient (outpatient, inpatient, etc.), the social security or medical program, type of study (radiography, ultrasound, mammography, ECG, etc.) and referring clinicians (HIBA, external, etc.).

Another economic aspect to investigate was the time in which, by legal or regulatory reasons, was necessary to store multimedia objects. In this aspect, technology improvements make storage costs dwindling, but it was necessary to define the cost per storage unit, to ensure feasibility over a period of time.

Conclusion

Taking into account our goals and the points outlined above, it is clear that, in our approach, a PACS is not a mere repository of images, but a documentary repository of multimedia elements in a Healthcare Information Systems setting, which provides data to the EHR. This is why the project is called "Multimedia Health Record" and not "PACS Project". And while making the Radiology Department as our starting point, the goal is to integrate all the ancillary services within this single repository, making a multidepartmental PACS.

References

- [1] Institute of Medicine (U.S.). Committee on Improving the Patient Record., Dick RS, Steen EB, Detmer DE. The computer based patient record : an essential technology for health care. Rev. ed. Washington, D.C.: National Academy Press 1997.
- [2] Bommel AJH, Musen MA, Helder JC. Handbook of Medical Informatics 2002.
- [3] Schuster S. MARKET UPDATE - PACS: Cost-Benefits. Medical Imaging. 2003.
- [4] Siegel EL, Reiner BI, Siddiqui KM. Ten filmless years and ten lessons: a 10th-anniversary retrospective from the Baltimore VA Medical Center. J Am Coll Radiol. 2004 Nov;1(11):824-33.
- [5] Digital Imaging Unit UHoGS. Design and implementation of Geneva PACS. [cited; Available from: http://www.sim.hcuge.ch/pacs/01_Pacs_Presentation_EN.htm
- [6] Nardi MD. Estrategias para el diseño sistemico de un PACS Institucional. SIS 2000.
- [7] Wong STC, Jr KSH, Knowlton RC, Laxer KD, Cao X, Hawkins RA, et al. Design and Applications of a Multimodality Image Data Warehouse Framework. Journal of the American Medical Informatics Association. 2002;9(3):239?54-?54.
- [8] Cohen S. PACS and Electronic Health Records. IBM Haifa Labs.
- [9] Luna D, Otero P, Gomez A, Martinez M, García Martí S, Schpilberg M, et al. Implementación de una Historia Clínica Electrónica Ambulatoria: "Proyecto ITALICA". In: Ceitlin M-R, M., editor. 6to Simposio de Informática en Salud - 32 JAIIO; 2003 2-5 Septiembre 2003; Buenos Aires, Argentina: SADIO; 2003.
- [10] Gomez A, Bernaldo de Quiros FG, Garfi L, Luna D, Sarrandria G, Figar A, et al. Implementación de un sistema de mensajería electrónica -HL7- para la integración de un sistema multiplataforma. In: Luna D-O, P., editor. 4to Simposio de Informática en Salud - 30 JAIIO; 2001; Buenos Aires, Argentina: SADIO; 2001. p. 300-6.
- [11] Sosa G, Navas H, Cancio A, Plazzotta F, Otero P, Luna D, et al. Integration of Specialist and Ancillary Services System into HIS: Development and Implementation of a Generic Report System. In: Kuhn KA, Warren JR, Leong T-Y, editors. Medinfo 2007: Proceedings of the 12th World Congress on Health (Medical) Informatics; 2007: Amsterdam: IOS Press; 2007. p. [2067]-[9].
- [12] Gambarte ML, Osornio AL, Martinez M, Reynoso G, Luna D, de Quiros FG. A practical approach to advanced terminology services in health information systems. Stud Health Technol Inform. 2007;129(Pt 1):621-5.
- [13] Passadore D. Experiencia en el desarrollo y puesta en funcionamiento de un servidor DICOM en un entorno PACS altamente heterog. neo. SIS 2004.
- [14] Mildenerger P. Real Use of DICOM in the Domains.
- [15] Oosterwijk HJ. DICOM: your guarantee to interoperability? Proceedings of SPIE; 1997: SPIE; 1997. p. 165-.
- [16] Publication NS. Digital Imaging and Communications in Medicine (DICOM) Digital Signatures. 2001.
- [17] Nagy P, Farmer J. Demystifying data storage: Archiving options for PACS. APPLIED RADIOLOGY. 2004;33(5):18-22.
- [18] Levine BA, Cleary KR, Norton GS, Cramer TJ, Mun SK. Challenges encountered while implementing a multivendor teleradiology network using DICOM 3.0. Proceedings of SPIE; 1997: SPIE; 1997. p. 237-.
- [19] Wong AWK, Huang HK. Integration of multi-vendor imaging equipment with DICOM into PACS [3339-33]. PROCEEDINGS-SPIE THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING; 1998: SPIE INTERNATIONAL SOCIETY FOR OPTICAL; 1998. p. 294

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