Information Systems for the Management of Clinical, Administrative and Government Data of Clinical Imaging Laboratories

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Abstract

From its first implementation, the integrated clinical and healthcare information system, developed at the CNR Clinical Physiology Institute, undergoes to updated and upgraded procedures and protocols, by solving problems of: harmonization of instrumentation of different brands; management of multimedial data provided by different medical imaging labs; satisfaction of both clinical and research needs as well as legal and economical requirements; user-friendship of the provided tools. Peculiar attention has been paid to the management of the laboratories devoted to biomedical imaging: medical and healthcare operators have coworked with engineers, to get a system able to guarantee coordinated activity, higher efficiency, simplified procedures, major concentration onto the medical decision-making issues, by supporting conventional techniques as well as new hybrid imaging technologies.

1. Introduction

The effective and efficient overcoming of fragmented diagnostic and therapeutic procedures is today a challenging target. Projects of integrated network-based medical information systems involve complex technologic, legal and healthcare solutions. Generally, the aim is to achieve a three dimensional integration: in the space, in the time and among the component levels of the health services.

Spatial integration means overcoming and optimizing the appropriate addressing and access of the patient to the required clinical and health care services, providing medical operators with every necessary tools and data under their hands in real time, to yield the best service for the patient. Time integration means to offer an important help to the decision process at all levels by providing access, via appropriate authorization, to the entire clinical history of patients. The integration into the Health Systems, with reference to the various levels (prevention, home or hospital care, general or specialized medicine,…), implies the overcoming of the differences between the various health professional figures, as well as the harmonization of software and hardware varieties available in the clinical environment. A combination of scientific competences in the fields of health care, informatics and telemedicine, together with industrial research units able to assure both view on market evolution and support for implementation of the model at a suitable scale, is helpful to have available functionalities to improve patient care and administration, clinical decision making, and to get an optimal use of the health care resources.

The healthcare structure of the CNR Institute of Clinical Physiology (IFC) gets a full integration of clinic, technologic, epidemiological, administrative activities, including hospital planning and management. In particular, aside a centric view, as required by data integration needs, the different laboratory tipologies or healthcare environments have shown the need to conjugate flexibility and modularity [1]-[6]. Local information systems, devoted to the management of each single laboratory activity, have been realized, supporting their link to the central system by means of a suitable network to exchange information both inside and outside the hospital [7]-[9].

2. Methods

The model "central integration/local autonomy" has been applied, among the others, also to the laboratories involved with the production of medical images. Actually IFC provides many important image data providers. In facts there are two gamma cameras serving the cardiology, pneumology, endocrinology and hypertension groups; a Positron Emission Tomography (PET) laboratory, enabled for the cardiologic, neurologic and oncologic studies, also enforced by a PET/CT hardware; a digital radiology unit, that serves both the inpatient as well as the outpatient departments; the Magnetic Resonance Imaging laboratory, with its 1.5T and 3T equipments, mainly serving cardiologic and neurologic activities. Around these sources, subsystems oriented to

personnel/instrumental organization and diagnostic examination planning and execution inside a specific laboratory, were created: each of these subsystems has generally been named "functional islands", to identify its main specificity given by its function [7]-[9]. These subsystems are linked to the central database through a middleware channel, to allow continuous communication and exchange of data to and from the central database and the external applications. Web applications for consultation of all the collected patient data are available on all the workstations of the intranet hospital network, to get updated infos about each patient in real time.

3. Functional islands

Modularity is the keyword to correctly approach a project, to take into account similarities and differences. In facts, in a typical hospital environment, different clinical, administrative and management functions refer to different data sources or hospital information subsystems. By focusing onto medical imaging laboratories, a functional island, identified by a specific imaging modality, can serve different medical branches, characterized by their own peculiar clinical protocols and procedures. The model reorganizes the laboratory in a set of activities, which are related to the instrumental equipment and the peculiar clinical employments. "Functional island" is more a logical than a physical concept, larger than that of a simple local Information System dedicated to peculiar clinical specialization. By means of a secure telecommunication infrastructure, each functional island deals with clinical, administrative and management functions, locally reproducing the main components of the overall hospital information system. The functional island gathers lab equipments, human resources, management and clinical protocols and procedures, networking, to characterize and to provide a specific, self-referenced and autonomous activity and outcomes. Autonomy is got by restraining to the local environment everything is not performing or useless for the rest of the Hospital Information System, so improving efficiency. Different models have been studied and applied for the integration and the operative protocols, by harmonizing different clinical practices, instrumental resources and human expertise. The personnel operating in a typical medical imaging laboratory has to manage a wide variety of data generated, processed, transferred and used for diagnosis, therapy suggestion, research and education, administration and planning. Therefore, while facing the project of a functional island, part of the problem is the identification of common procedures and protocols, which do not relate to a peculiar clinical need. From a functional island to another, with respect to an assessed model of procedural steps from the admission up to the patient's check-out, only inner differences of the procedures strictly related to the clinical activities are subjected to a formal re-design. This is true also when updating or upgrading the equipments inside each island. In this framework the set of protocols has been defined, as much as possible, adopting current standards or their extensions, also taking into account their flexibility in consideration of the continuously evolution of the health domain.

The lab staff includes physicians, nurses, technicians: all of them are functional to the correct, synergic activity around the patient, with no redundancy, and with optimization of costs and time consumption for the clinical examination. The personnel operating in a typical medical imaging laboratory has to manage a wide variety of data generated, processed, transferred and used for diagnosis, therapy suggestion, research and education, administration and planning. Efficiency of the functional island is not only the organization of protocols but also of the personnel, by creating an operating diagram which takes into account the organic integration of clinical, paramedical and administrative activities. The knowledge of the clinical needs is a fundamental step for defining actual protocols, procedures, and resources before outlining the project and translating it into final product design. The personnel involvement in the design phase, allows to overcome subsequent conflicts or resistance in applying new work procedures. This preliminary approach allows to discover redundancies or weakness in the lab resource availability and use, and to change or to adapt the workflow of the procedures. Consequences of a bad organization or a misuse of the available resources can increase real healthcare costs, with a not corresponding enhancement of quality of the service offered to the patient. Personnel operating in a lab tailored on the real needs, and contributing to any improvement, is also motivated to further enhance the lab performance. They receive also a continuous training which results in growth of clinical expertise and technical culture.

4. Results

The adoption of a three dimensional integration model has given many important consequences, both at the level of the individual functional islands and of the global hospital information system. Spatial domain integration yields optimized appropriate addressing and access to the required clinical and health care services as well as real time availability of every necessary equipment, tool and data. Time domain integration allows real time sharing of laboratory results, access to clinical history of the patient, epidemiological comparison, therefore enhancing the decision process. The integration into the Health System domain facilitates the exchange of informations, and

meets the needs for prevention, home or hospital care, follow-up controls, therapeutical effectiveness.
An important challenge was to organize each lab so to reduce costs, to shorten the patient's permanence, to provide quick, professional and exhaustive reports. In order to reach these targets patient's admission has been simplified and speeded up, with multiple local and centralized retrieval sources, which can be updated or upgraded. Patient's identification data, to be associated to images and other clinical outputs, travel inside the functional island by means of suitable worklists, fed at the admission to the laboratory. Acquired images subdue real time storage into digital archives (based on DICOM standard and protocols), so to be immediately available for processing, editing and report integration on the specialized workstations. Tools for the creation of clinical reports, customized for the affering medical specialties, are available on the workstations set up at each of the functional islands. Report drawing is speeded up, without affecting the diagnostic clinical and technical requirements, by an efficient use of software tools for editing, correcting and management of multimedial data. The complete report, although structured in contents, is compacted into a multimedial layout, including identification, protocol and anamnestic data, as well as images, response and quantitative data; if printing is required, high quality, color, not expensive printout can be provided. Report storage is in real time, both for the local and the central Information System, making the results of the specialistic examination common property to the other clinical investigators; information is stored in structured format as well as in print-ready "pdf" format. Local central servers store both the administrative and report data produced by the studies into separated databases, always on-line for subsequent consultation. Local image storage includes the complete instrumental output, while shared image servers allow comparisons between modalities to get an overall idea as well to get integrate info about the pathologic status of the patient.

Tools for querying the Intranet accessible databases have been set on each workstation, to get ubiquitous real time recovery and browsing of patient clinical and laboratory history, on line information about the daily clinical activity of each laboratory or to access reports produced by other functional islands, so ensuring continuity of care.

5. Discussion and conclusions

A carefully engineered management system, based on an efficient local Information System and supported by adequate technology, can improve the level of efficiency of the imaging department, with benefits for both medical, paramedical, administrative components, and the user (the patient). This goal has been achieved at the IFC, by means of: modularity, protocol efficiency, resource harmonization, shortening of total examination duration, standardization and safe share of the information. The development process of the functional islands has been a sequence of coordinated activities, between clinical operators and technical personnel. The information regarding clinical needs has been a fundamental step to know what was really necessary to the definitions of protocols, procedures, and resources, before outlining the project and translating it into the final product design. This phase of the development has shown its peculiar importance, due to the acknowledgment of redundant or, on the other side, missing or usually considered less important steps of the adopted procedures. As a result, it has been possible to attain a standardization of the clinical procedures, keeping the necessary differences due to the variety of diagnostic approaches and of medical instrumentation [1]-[5]. Long development times have been avoided: in facts, once defined the common procedures which remain unaltered, any change towards new protocols is deserved to peculiar clinical activities subject to the update or upgrade. Reduced development times, therefore, imply no rejection by the operators because such changes are not either outdated, or unfeasible in terms of operative capability. The final effect is that any improvement yields benefits for the medical, paramedical, administrative components as well as for the patient, while the clinical routine is not affected.

Another important result of the project is that it is possible to second any technological improvement in response to the increase of demand of new health services with no dramatic revolutions, thanks to the capability of transparent harmonization of custom and commercial software and hardware.

From the operative point of view, among the more evident results of the realized project, the shortening of both administrative and clinical procedures of the examination has been hailed as an important improvement from both the personnel and the patients. Shorter permanence at the lab, together with quick, professional and exhaustive clinical output, implies, from the patient's point of view, the committment to respond as soon as possible to his clinical need [5]-[7]. From the healthcare management, paperless reporting, time shortening of acquisition, processing, integration, reporting and storage phases, proper coworking of individual professionalisms, rational use of laboratory equipments are welcome to get reduced health care expenditure, with no loss of the quality of the service, provide a dramatic reduction of costs.

The use of digital archives for images and reports allows to reduce costs, both in terms of money and in terms of time, by allowing fast data recovery and

processing for extracting knowledge and for supporting the diagnostic/treatment process, as well as the management of the laboratories. Structured information allows the treatment of the report not only as a whole, but also as a collection of data separately useful for tracking each clinical parameter, as well as for data mining in research and epidemiological studies [10]-[11], while providing the necessary inputs to the healthcare management. This approach has allowed the participation to task forces involved in the development of standardized clinical document architectures [12].

The adoption of all digital laboratories allows also to overcome the maintenance and the management of paper reports archives. Many positive consequences and benefits have been experienced inside and outside the laboratories. In facts, the standardized storage of all data outputs by the laboratories, allows access to and comparison of images provided by different modalities and equipments, not homogeneous by brand, in real time, so improving clinical and research protocols. Long time storage, entrusted to optical disks (i.e. CD-ROMs and DVDs) keep, in a reduced space, a large quantity of unaltered data, for a very long time, dramatically collapsing logistic and maintenance costs. Short time storage, entrusted by suitable high capacity servers, allows immediate sharing of a large amount of pictorial information suitable during the clinical process not only inside IFC, but, by means of safety and security tools, also towards external healthcare coworkers [8]-[9]. In other terms, IFC image laboratories can provide full clinical imaging services also for external care units, which can receive, safely and securely, in real time, reports and images to provide the most suitable care to their patients.

Staff continuous training is essential to reach the best results. Unavoidable initial cautious distrust shown by each professional of the laboratory has been quickly overcome by the involvement into the project design, which has taken into account the individual expertise to get the optimized result [1], [6]. Actually, the laboratory personnel finds a strong motivation by perceiving the growth of skillness about the technology in terms of professional improvement.

Next future challenges are the multidisciplinary development of systems able to further exploit stored image and report information for learning, teaching, more complex tools supporting clinical decision making. More, a standard clinical document architecture could be hailed as the solution to allow any potential patient able to receive everywhere the same care as at home [12].

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