medicinska revija
medical review

UDK: 61:004
ID = 176483852

Mitrović Z. et al . Med Data Rev 2010;2(2): 123-126 *MEDICAL DATA / Vol. 2. No 2 / Jun 2010.*

Opšti pregledi/
General reviews

INTRODUCTION IN PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS) IN MEDICINE: DICOM (DIGITAL IMAGING AND COMMUNICATIONS IN MEDICINE)

UVOD U KOMUNIKACIONI SISTEM ZA ARHIVIRANJE SLIKE U MEDICINI (PACS): DIGITALNI IMIDŽING I KOMUNIKACIJE U MEDICINI (DICOM)

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Ključne reči
priroda ateroskleroze, klinički značaj

Key words
nature of atherosclerosis,
clinical significance

Abstract

Rapid development of new Internet/Intranet technologies enabled development of telemedical applications and systems. The possibility of creating low-cost, highly standardised, accessible and open systems, based of new technologies, provides linkage and exchange of information between medical institutions and departments and among the very participants in the provision and use of medical services. DICOM (Digital Imaging and Communications in Medicine) became widely accepted PACS (Picture Archiving and Communication System) that includes standardized picture format along with the database and a network communication protocol and enables data exchange between equipment of different manufacturers. Sophisticated new medical equipment is already prepared for remote use for the purpose of bridging the space and time barrier.

1. INTRODUCTION

1.1. Hospital Information System

Information technologies do not solve problems alone, they are only the tools that enables efficient problem solving.

Hospital Information System generally consists of the following subsystems:

- Clinical Information System (CIS)
- Financial Information System (FIS)
- Laboratory Information System (LIS)
- Nursing Information Systems (NIS)
- Pharmacy Information System (PIS)
- Picture Archiving Communication System (PACS)
- Radiology Information System (RIS)
- Telemedicine

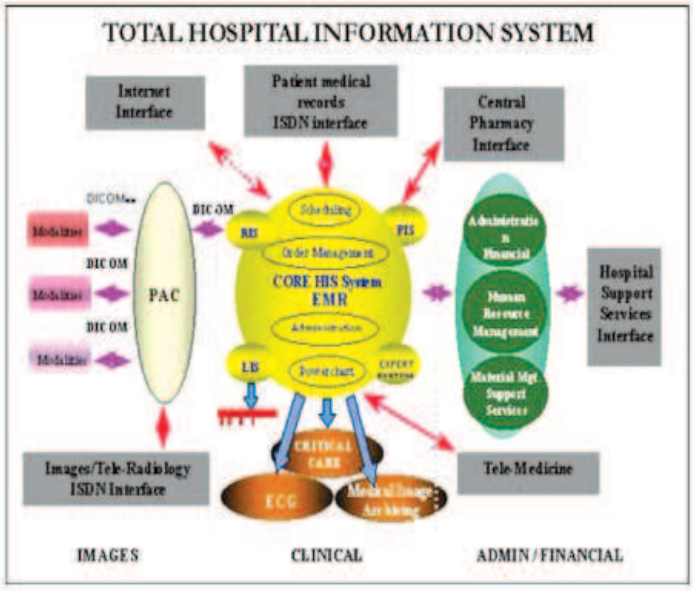

Figure 1. Total hospital information system

1.2. PACS

A Picture Archiving and Communication System (PACS) is an information system that stores, distributes and presents medical imaging data.

For many years, film has been nearly the exclusive medium for capturing, storing, and displaying radiographic and other medical images. During more than 100 years of use the film evolved as a relatively fixed medium, with the drawback that there is usually only one set of images available, that either patient takes home with the risk of mishandling, damaging or losing, or the hospital keeps it in archive, making it hardly available to doctors from other hospitals.

Rapid development of computer technologies, along with the implementation of computers and digital technology in medical devices and systems, provided that digital image and database handling could be introduced. PACS technology allows for a near film-less process, with all of the flexibility of digital systems: viewing the images on computer screens, removing all the costs associated with film processing and releasing valuable space currently used for film storage. Also, there are significant benefits to patients from the changes brought about by PACS: new digital PACS images will be available instantly; by storing them on computer storage, these images will be clearer and easier to manipulate, it will be easy to have simultaneous access from several locations to the same data, or even make several copies of the medical image, and medical images, using various digital processing algorithms, could be sharpened and filtered to emphasize particular parts or properties. This usually leads to improved diagnosis and, consequently, better care.

Digital images are generated instantly and do not have to be transported by hand for reporting. In such a way, they will not be lost and can be examined at the same time by clinicians in different places, so the "second opinion" or consultation can be made by MDs from even different continents at the same time. Small hospitals can provide better patient care, because they can obtain opinion from associate specialists from other hospitals in a very short time.

PACS means an end to lost x-rays, elimination of unneeded radiation of patient due to repeated x-ray due to lost or damaged films, improved diagnosis, better care and an improvement in both the quality and speed of patient treatment.

Most radiologists are familiar primarily with film images, and film can be viewed anywhere there is a light source. It is the transition from film images to digital images and the need to communicate, display, and store these images that has made standardization of the PACS necessary. With film, slight differences in exposure, processing, and viewing will have little effect in these areas. In digital imaging, however, the difference of a few bytes can make it impossible to transfer an image from one system to another.

2. PACS system

A Picture Archiving and Communication System provides for storing and retrieving, viewing, communication and managing of medical digital images and related information, such as patient demographic information, diagnostic reports or clinical history. Nature of the data requires special care that access to a patient's digital images and other data must be strictly controlled. Anyone wanting to look at a patient's digital x-ray or scan must be involved in their care. What they will be able to see depends on their role. Patient digital images are stored in a secure database with the strongest security measures available for handling patient records. These measures make sure that patient information is stored safely and stays private whilst being transferred.

A PACS system consists typically of an archive device that automatically makes backup copies, sometimes on several locations, servers that distribute images and other data via a public network with the required database and extensive workflow management software, and diagnostic viewing stations for radiologists and physicians.

Shifting from using film to viewing images on a computer screen requires many changes on the part of an user; some of the work functions concerning film development, managing and storing disappear, while some new, such as system administrators, application specialists and trainers for use of the new devices are created. The work in a radiological department must be re-engineered.

A significant barrier to using PACS is the cost of a system. However, computer equipment prices are lowering and processing power and storage capacities are increasing, more and more new medical devices such as MR and CT are equipped with digital output compatible with PACS system, so PACS is slowly entering every hospital. The question for each institution is not whether to use or not the PACS system, but rather when to do it.

3. HISTORY

The first working PACS installation was at the University of Kansas in 1982. This system was pioneer attempt to make working system with slow computer network, small storage capacities, low processing power of computers, low resolution of computer monitors etc. Yet, this system was a good base for further development. With network standardization that followed in 80's and 90's, along with communication standard (OSI standard) a special standard for medical images and data, DICOM (Digital Imaging and Communications in Medicine) evolved also. As of today, PACS and DICOM go hand-in-hand having an inter-dependent relationship.

The focus for PACS evolved through time. It began as a way to eliminate film archiving, so at the first time the focus was on the "A" (archiving) in PACS. Development of teleradiology, telepathology and telemedicine shifted focus to "C" (communication) and enabled that images can be sent to remote hospital or even to a doctor's home. With time, more and more the "S" (system) has become critical, with initiatives to Integrated Healthcare Environment (IHE) or Hospital Information System (HIS). Today, typical Hospital Information System consists of Clinical Information System (CIS), Financial Information System (FIS), Laboratory

Information System (LIS), Nursing Information Systems (NIS), Pharmacy Information System (PIS), Picture Archiving Communication System (PACS), Radiology Information System (RIS) and Telemedicine. All parts of a Hospital Information System communicate and exchange data in a standardized way in order to avoid as much as possible human-introduced errors and to provide data consistency and benefits, such as extensive reports.

During past more than twenty years PACS has been in use to facilitate the exchange and integration of medical imaging into healthcare, based on extensive use of computers. However, there is still a long way to go. Still many hospitals in the world still use films and do not have a PACS. Given its many benefits, constant increase in power and reduction of prices, it is only a matter of time when a hospital will decide to switch to partial or full implementation of PACS.

Up to now the PACS has been well standardized. Early development showed that patient demographic data consistency, image and other data management, image quality and standardization, archive media volatility and availability for a long time even when technology changes and migration to hardware independent solutions are critical for widely adopting the PACS. A PACS system requires a dedicated support staff, such as IT professionals, biomedical engineers and PACS administrators. A PACS is still rather complex and requires hand-holding, checking and several dedicated maintenance tasks.

4. DICOM

The Digital Imaging and Communications in Medicine (DICOM) standard is widely adopted standard for medical image and data handling. It is designed to ensure the interoperability of systems used to produce, store, display, process, send, retrieve, query and/or print the medical images and derived structured documents in a standardized way, independent from the equipment manufacturer, as well as to manage related workflow.

The initial goal in developing a standard for the transmission of digital images was to enable users to retrieve images and associated information from digital imaging equipment in a standard format that would be the same across multiple manufacturers. Since this is a multidisciplinary field, the American College of Radiology (ACR) and National Electrical Manufacturers' Association (NEMA) made joint effort to produce a standard, which specified a point-to-point connection, to transfer data between two devices. The rapid evolution of computer networking and of picture archiving and communication systems meant that this point-to-point standard would be of limited use and needed to be expanded. Consequently, a major effort was undertaken to redesign the ACR-NEMA standard by taking into account existing standards for networks and current concepts in the handling of information on such networks. The Digital Imaging and Communications in Medicine (DICOM) standard was the result of this effort. The DICOM covers the most image format used in medicine and gives specifications for messaging and communication between image machines.

The actual DICOM standard (dated 2009) is maintained by the National Electrical Manufacturers Association (NEMA). It consists of 18 parts:

PS 3.1 Introduction and Overview
PS 3.2 Conformance
PS 3.3 Information Object Definitions
PS 3.4 Service Class Specifications
PS 3.5 Data Structures and Encoding
PS 3.6 Data Dictionary
PS 3.7 Message Exchange
PS 3.8 Network Communication Support for Message Exchange
PS 3.10 Media Storage and File Format for Data Interchange
PS 3.11 Media Storage Application Profiles
PS 3.12 Media Formats and Physical Media for Data Interchange
PS 3.14 Grayscale Standard Display Function
PS 3.15 Security Profiles
PS 3.16 Content Mapping Resource
PS 3.17 Explanatory Information
PS 3.18 Web Access to DICOM Persistent Objects (WADO)

The standard can be retrieved free of charge from the NEMA website (http://medical.nema.org/).

According to part 10 of the standard, a single DICOM file contains both a header (which stores information about the patient's name, the type of scan, image dimensions, etc), as well as all of the image data (which can contain information in three dimensions). This is different from some other formats in use, which store the image data in one file (*.img) and the header data in another file (*.hdr). Another difference between DICOM and other popular formats is that the DICOM image data can be compressed (encapsulated) to reduce the image size. Files can be compressed using lossy or lossless variants of the JPEG format, as well as a lossless Run-Length Encoding format (which is identical to the packed-bits compression found in some TIFF format images).

The DICOM Standard facilitates interoperability of devices claiming conformance. In particular, it:

- Addresses the semantics of Commands and associated data. For devices to interact, there must be standards on how devices are expected to react to Commands and associated data, not just the information which is to be moved between devices;
- Addresses the semantics of file services, file formats and information directories necessary for off-line communication;
- Is explicit in defining the conformance requirements of implementations of the Standard. In particular, a conformance statement must specify enough information to determine the functions for which interoperability can be expected with another device claiming conformance.
- Facilitates operation in a networked environment.
- Is structured to accommodate the introduction of new services, thus facilitating support for future medical imaging applications.

5. CONCLUSION

As it is shortly showed, PACS required standardized way of handling medical images and associated data. As a result, a DICOM standard has been developed. Due to various fields of medical image applications, DICOM is, of necessity, a complex standard. As other standards, it is written in the dry language required of standards and with a minimum of explanatory (called ”informative” in the DICOM documents) information. Nonetheless, the standard has proved to be practical and widely acceptable, with still evolving parts as more medical image fields and applications are included, maintaining backward compatibility. The main purpose of this introductory article has been to give a hint of complexity of switching to a digital world in data handling, demystify DICOM to some extent. Fortunately, most users of DICOM system and devices compatible with DICOM do not have to be experts in DICOM standard (leave it to equipment manufacturers), yet they have to know some assumptions and basic limitations of a digital image system. Having that knowledge, all users can only benefit from extended use of digital image handling procedures and enhancements that were not possible in the analog (film) world.

Apstrakt:

Brzi razvoj novih Internet/Intranet tehnologija omogućio je razvoj telemedicinskih aplikacija i sistema. Mogućnost kreiranja jeftinih, standardizovanih i otvorenih sistema sa lakim pristupom, baziran na novim tehnologijama, obezbeđuje povezivanje i razmenu informacija između medicinskih institucija i odeljenja kao i među učesnicima u primeni medicinskih usluga. DICOM (Digitalni imidžing i komunikacije u medicini) je postao široko prihvaćen PACS (sistem za arhiviranje slike i komunikaciju) koji sadrži standardizovane formate slike, kao i baze podataka i protokola za umrežavanje i omogućava komunikaciju opreme različitih proizvođača. Složena nova medicinska oprema je već projektovana za daljinsk primenu i premošćavanje prostornih i vremenskih barijera.

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The paper was accepted 18.05.2010.