Sophisticated Hospital Information System/Radiology Information System/Picture Archiving and Communications System (PACS) Integration in a Large-Scale Traumatology PACS

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Picture archiving and communications system (PACS) in the context of an outpatient trauma care center asks for a high level of interaction between information systems to guarantee rapid image acquisition and distribution to the surgeon. During installation of the Innsbruck PACS, special aspects of traumatology had to be realized, such as imaging of unconscious patients without identification, and transferred to the electronic environment. Even with up-to-date PACS hardware and software, special solutions had to be developed in-house to tailor the PACS/hospital information system (HIS)/radiology information system (RIS) interface to the needs of radiologic and clinical users. An ongoing workflow evaluation is needed to realize the needs of radiologists and clinicians. These needs have to be realized within a commercially available PACS, whereby full integration of information systems may sometimes only be achieved by special in-house solutions.

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RADIOLOGY IN THE CONTEXT of an outpatient trauma care center demands high technical as well as logistical expertise. Rapid image acquisition and immediate distribution of all necessary patient images, as well as reports to the clinician, is the foremost aim. In the context of a picture archiving and communications system (PACS), this task can only be reached with in-depth analysis of the workflow within the joined departments and transfer of the desired workflow onto the digital environment by sophisticated integration of all involved electronical information systems.

SYSTEM DESCRIPTION

The traumatology PACS in Innsbruck is based on a fast asynchronous transfer mode (ATM) network in star topology, shown in detail in Fig 1. Included are three Agfa ADC70 digital phosphor storage radiography units (Agfa Gevaert, Morthel, Belgium), a GE helical computed tomography (CT) scanner (GE Medical Systems, Milwaukee, WI), an ATL HDI 5000 ultrasound scanner (ATL Ultrasound, Bothell, US), and a Lumisys x-ray film scanner (Lumisys, Sunnysvale, CA), as well as 28 workstations. The traumatology PACS is closely linked to the general radiology PACS, with direct

access to data derived from digital fluoroscopy, angiography, etc. Image viewplaces at the intensive care department are integrated in the PACS as well. As a general rule, all images in both the short-term and long-term archives are available to every user on every workstation within the network at any time.

To supply the need of traumatology, as well as radiology users, a high level of automation had to be reached, especially for scheduling of procedures (prefetching of images for clinical visits, with or without follow-up images, etc), but also to avoid multiple entry of patient data and misregistrations. The radiology information system (RIS) is the main controlling instance in the radiology environment. Connections exist with the hospital information system (HIS) and traumatology information system (TIS). As the HIS in its present form is a rather old system that does only allow for registration and transfer of demographic data, as well as radiology reports but not for scheduling procedures, the latter functions have been attributed to the TIS (concerning the traumatological imaging procedures), which means that the PACS is somewhat serving two masters (the RIS is concerned with all of the nontraumatologic imaging procedures). The exact workflow for handling of the trauma patient is shown in Fig 2.

The patient is normally registered or scheduled via the TIS (which also directs the prefetching in this case) where patient data are cross-checked with the HIS via a health level 7 (HL7) interface. Patient data and the information about the requested radiology examination are then handed over to the PACS server via HL7 and sent to a laser printer in the

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Fig 1. Schematic overview of the Innsbruck traumatology PACS with connections to general radiology and intensive care unit.

radiology department (to inform the radiology technician and to read the data into the RIS via a barcodelaser) and then distributed to the Agfa identification terminals via a proprietary protocol (Agfa NFS) or to the CT console via a Digital Imaging and Communications in Medicine (DICOM) worklist function. Acquired images are sent to the PACS archive immediately (and thus accessible for every user at the same time) and a study content notification is sent to the RIS (via DICOM) and TIS (via HL7) simultaneously. Changes in the patient status or in demographic data are transferred to the TIS and RIS from the HIS via HL7.

RESULTS

Many of today's PACS installations face the problem of the unavoidable need for integration with old HIS, allowing only for integration of basic workflow features—mainly cross-checking of demographic patient data and distribution of medical reports. Workflow analysis performed before the installation of the Innsbruck traumatology PACS showed that more sophisticated methods of digital

Fig 2. Schematic presentation of digital workflow between HIS (MEDAS, proprietary system), RIS (MEDORA; Innomed, Dornstadt, Germany), TIS (MEDDOC, proprietary system), modalities, and PACS (IBM/TIANI, Vienna, Austria).

workflow management were needed to cope with the heavy workload of a large trauma care department with more than 70,000 outpatients per year. The decision to use the TIS as a second master to the PACS turned out to be an effective solution for this aim; nevertheless, the implementation was troublesome (while the RIS interfaces adhere to the DICOM 3 standard, the TIS interface is based on HL7). Identical organizational structures had to be constructed in both departmental information systems (both were preexisting systems supplied by different vendors) to guarantee for unequivocal image identification data and steering commands within the PACS scenario. This kind of implementation enables the system to cross-check examination or prefetching requests; if there is a request for the same examination from both systems, only one entry into the PACS database is performed.

Patient and thus image identification in PACS is normally via the patient ID number (supplied via a cross-check of patient data with the HIS), which is a lifelong identification number of a single patient within the scope of our hospital without any possibility for multiple entry. At our trauma department, patients are identified by the trauma ID, which is a yearly rising cardinal number for every trauma case in the hospital. Patients are often taken to the emergency room unconscious and without identification; nevertheless, examinations have to be taken and assigned to the single trauma patient. The trauma ID serves this purpose, giving an unmistakable identification number to the patient, as long as his personal data are not known, and therefore is the master case identification means in the TIS. It also allows to separate different trauma cases in the same patient. The trauma ID was thus introduced into the organizational structure of our PACS as well. So, the PACS uses the patient ID to organize image data and in second-line provides the trauma ID for the TIS by assigning different image files within a patient folder to different trauma cases.

In the existing realization of the PACS, input of patient data is kept to a minimum—normally only once in the HIS—and via the departmental information systems transferred to all imaging modalities directly with exception of ultrasound (no worklist function available). Image requests are performed electronically by choosing the required examination from an anatomically oriented selection in the

TIS and also transferred via the aforementioned worklist function. In scheduled examinations for outpatient controls, the TIS allows for efficient prefetching during the night before the day of examination (the same is true for patients scheduled by the RIS), which avoids the need for immediate image retrieval and thus reduces network traffic during normal working hours.

An analysis of procedure times in the PACS-equipped trauma radiology section and the conventionally equipped general radiology section of our radiology department showed direct benefits of the attempts in system integration. Patient waiting times and the time used for the acquisition of x-rays were compared. While in the conventional department the time between the arrival of the patient at the radiology department and the end of image acquisition is about 26 minutes, in the PACS environment it is only about 21 minutes.

To perform a cost analysis for PACS installations is not an easy task, as many factors have to be taken into account. Reduced costs for archiving, films, chemicals, etc are counterbalanced by costs for system hardware, maintenance, and expenses for highly educated and specialized system technicians. Besides the well-known benefits of a PACS, such as reduced amounts of unavailable images, simultaneous availability of images on multiple workplaces, and immediate availability of images for radiologists and clinicians at the same time, which are difficult to express in bare numbers, some benefits may well be measured. We were able to lower costs for films and chemicals, for example, from 2,000,000 to 1,500,000 Austrian Schilling within 1 year since the traumatology outpatient department is in filmless operation. This will be even lower as soon as the traumatology wards are equipped with viewing stations as well, which is not the case right now.

CONCLUSIONS

In a large-scale PACS, we are faced with different needs of various radiologic, as well as clinical users. To realize the demands of all users may only be accomplished with in-depth analysis of the departmental workflow by a team of medical and technical specialists. This workflow analysis serves as the basis for the process of tailoring a commercially available PACS to the local needs of the

hospital. Many hospitals and clinical departments are equipped with previously instituted hospital- or department-wide information systems, which sometimes cannot be integrated into a modern PACS

easily. If you aim for implementation of all of the possible benefits of PACS in such a situation, special solutions have to be developed, to allow complete functionality.

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