BENEFITS OF IMPLEMENTING PACS IN MRI CENTER

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INTRODUCTION

The wide acceptance of digital imaging today is due to the general perception of many benefits that follow the transfer from traditional film imaging to filmless digital images. The benefits are usually grouped into several categories:

- cost-effectiveness (1, 2),
- benefits to patients,
- benefits to radiologists, physicians and other radiology staff (3, 4).

Benefits to patients, physicians and radiologists, though significant, are difficult for quantitative representation, time consuming and expensive. Several research papers present in literature, show clear benefits in efficiency, diagnostics, storing, timeliness and availability of images and reports, follow-up appointments and many other fields of interest.

The benefits in diagnostic quality are of the biggest importance for both the patient and the radiologists. It comes from the possibility of direct manipulation of image attributes during the viewing of images, which was impossible for film-based operation, where image attributes had to be determined before printing out the hardcopy (5).

Other important benefit is in timeliness and availability of images and reports (6), since there is no need to wait for hardcopies to be printed out, taken to the radiologist who then types down his findings and sends the hardcopy to a referring physician. Images and reports are available over computer network, and no time is lost on printing and managing hardcopies. If needed, the images can be stored on a cheap removable media like recordable CD, and given to the patient or referring physician.

Storing digital images is relatively cheap and secure process that requires little space and investments, and brings many benefits (7, 8). If necessary, it enables eventual reprints of hardcopies, and ensures availability of images for reviews, consultations and follow-up comparisons (9).

Usually considered as easiest to represent is the issue of cost-effectiveness. It is not as easy to calculate if you try to include all the benefits that do not have direct and quantifiable effect on cost-effectiveness. These benefits have been very problematic to be accepted by non-medi-
cal and non-technological staff that is usually responsible for the economic side of running the imaging site inside a hospital or clinic (5, 10, 11). This economic issue is especially important in the situation in which Serbia is now, where clinics and hospitals lack funding for even basic needs and all investments in new technologies are likely to be regarded as waste of funding. That is why this paper is concentrating on purely material benefits of switching from the traditional film based operation to the digital filmless imaging.

Several issues should be addressed in order to clearly specify the digital imaging.

The first thing that needs pointing out is that every new imaging equipment produces digital images in concordance with DICOM standard. In our imaging centers, these digital images are then printed out on films for viewing purposes. Films are associated with patient records, and even given to the patient upon his or her release from hospital. It means that there is no storing of images, and images from the previous appointments are often lost or unavailable. Existing digital images are erased due to low storage capabilities of imaging modality itself, and the lack of networked storage.

The DICOM standard is the starting point of every work in digital imaging. DICOM is a standard, not an imaging format like JPEG, or GIF. It means that DICOM represents a set of rules and proposed regulations on variety of image and imaging related issues. It determines necessary data that should accompany images, the quality of images for each modality, even the necessary attributes of equipment and software used for acquisition, storing, transferring and viewing medical digital images. DICOM gives the list of accepted image file formats and acceptable compression of image files for use in medicine.

The size of image files used in medicine is quite considerable (12). Even the modalities that use relatively small images (i.e. CT, MRI and other) require a lot of storage space since they feature cases with large numbers of smaller images. One might argue that technical development of storage equipment put file and case size out of focus, but necessity for transferring cases and images through computer networks in reasonable time kept the focus on the issue. It is due to these two reasons that compression of images needs to take place. Compression is a summary name for all techniques implemented to reduce the size of image files. The process consists of two parts: compression during which techniques are applied to reduce the size of image files, and decompression as a process of restoring the image from the data kept in a compressed file. Roughly, compression techniques might be separated into two major groups: lossless and lossy. Lossless are all techniques that enable compression and restoring of image without any loss in image data or quality. The main problem with these techniques is relatively low compression ratio of less than 2.5:1. Better compression ratio could be provided by lossy compression, but these techniques assume that some of the data and image quality will be irreversibly lost. Still, these techniques are used, since medical practice shows that compression ratios of 20:1 are possible without a significant loss in the diagnostic quality of images. This represents the imperfection of human sight, and assumes that there is none of perceptible changes in image quality. DICOM standard recognizes several image formats that feature different compression techniques. The most familiar is JPEG standard that is used widely in other digital imaging areas as well.

Implementing a PACS system is more than just buying and connecting the necessary equipment. As noted by Pare and Trudel (13), „In order to maximize the likelihood of success, it would appear to be crucial to adopt a proactive implementation strategy, one that takes into consideration all the technical, economic, organizational, and human factors, and does so from the first phase of the adoption process。“

The goal of the paper is the retrospective study of use of digital images at the Department of Magnetic resonance in the period of 10 months, averaged on 1000 patients.

The main objective of the paper is to show the benefits of the practical use of digital imaging compared to the use of hardcopy films. Emphasis is on cost savings that are due to this transition. This choice is especially interesting because of specific local economic situation.

The results of similar researches, conducted mostly in USA and EU, lead to the expectation of extreme cost-effectiveness of digital image site. The basic savings in material alone should prove to be sufficient reason for transition to digital imaging.

The implemented system must satisfy all the present needs of a working imaging center, but it should also provide the potential to meet future needs for upgrades and improvements.

MATERIAL AND METHODS

The typical magnetic resonance (MR) imaging site that utilizes film-based operation, such as at the clinic observed in this paper has logical and physical scheme given in Figure 1.

Figure 1. MRI site.

The imaging site is the Imaging center of „Magnetic Resonance“ in Kragujevac. The imaging modality on site is SIEMENS OPEN-VIVA 0.2T. The radiologist’s workstation, and the workstation for admittance and scheduling are PC computers with propriatery OS and propriatery IS software that already had support for DICOM and digital imaging, which presented excellent base for mini PACS.

All the images taken, were printed on a film by on-site RT, and taken to a radiologist who would view them and write a report on a workstation. The report and patient information were stored in an information system (IS) without images. Hardcopies of images and report were given to the patient or sent to the referring physician.
Digital images were periodically erased from temporary storage of the modality due to the lack of space. There was no archiving of images. The IS was used mostly for scheduling appointments and periodical checkups.

The transition to full use of digital images brought a simple solution given in Figure 2. Introduction of mini PACS server removed all manual steps in handling the images. Connecting PACS server to the MR modality introduced new possibilities for storing digital images and forming an archive of all relevant patient data (demographic, images and reports). The setup also introduced a new role for clinic workstations. Their original role of a little more than a nice typewriter upgraded to the role of fully functioning diagnostic workstation that was being used for viewing images and comparisons with results from the previous appointments, as well as writing reports. With little upgrading old IS got a new purpose as an essential part of PACS system. Film printer has been kept since it was already present on site, and its purpose is just for backup in the case of an emergency, or for providing hardcopies for referring physicians that still do not use digital images (13). Since the main aspect viewed in this paper is the cost-effectiveness, the price of the equipment installed in a digital imaging site is of considerable importance. The equipment used in the digital imaging site, that did not exist on site during the film-based operation, consisted of a single computer that was run by PACS server and archiving software. One of the computers existing on site could have been used for no additional cost but it was decided that desired level of reliability demanded dedicated server with RAID 5 based storage, and the highest quality of other components. This PC based machine with all of the appropriate software did not exceed the price limit of 1500€. The study was conducted over the period of 10 months, averaged on 1000 patients.

RESULTS

The main result from IT point of view is that the system presented in figure 2 worked in real set up. The laser film printer was already installed on site and was kept after the transfer to the use of digital images. For potential set-ups of new digital imaging sites, this piece of equipment would be unnecessary. Its price is approximately 15000€, and it could be considered a major saving for setting up a new site.

The biggest cost-effectiveness related benefit comes from savings in material. Average patient appointment in a film-based operation requires at least 4 films with images. With each film costing about 2.5€, it took 10€ worth of film to conduct MRI examination. The transfer to digital imaging presented images saved on a CD for a patient, or referring clinician. The price of a writable CD is approximately 0.25€. These savings are somewhat reduced by the fact that not all the clinicians and patients are ready to accept filmless imaging and require a film hardcopy. The ability of the radiologist to view digital images reduced the need for filmed pictures, since after the exam he would print out just the relevant pictures, and a complete set of examination pictures would be given on a CD. This resulted in only one film being printed out per examination. The price of material used for examination becomes 2.75€, instead of 10€. Averaged on 1000 patients the savings reach 7250€ over a period of 10 months. This figure alone fully pays off the initial investment in additional equipment and labour with less than 300 patients, or about 3 months.

One of the benefits to the patients is in permanent record of examination on a CD. The recording medium is more robust than film, the images have better diagnostic potential, and in case the images are lost, relatively cheap copies can be made without a new examination.

The most important achieved benefits to radiologist are:
- archive,
- possibility of teleconsultations,
- shorter time from admitting the patient to the moment report is available.

The created archive was based around the existing IS, that contained demographic patients’ data and a report from the exam. Introduction of digital images enabled expanding the archive and now it contains images from examinations, demographic patients’ data, anamnesis and radiologist’s reports.

Table 1. The performance indicators.

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<th>With consultations</th>
<th>Without consultations</th>
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<td>Film-based operation</td>
<td>3 days</td>
<td>4h</td>
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<tr>
<td>Digital imaging based operation</td>
<td>3h</td>
<td>1h</td>
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Existence of images in digital format enables teleconsultations. This further improves the quality of an examination, and affects the time needed for the radiologist to finish the report. The time in which the report is available with the use of digital imaging and with the film based operation is given in table 1.

DISCUSSION

The most important benefit in implementation of any medical solution is the benefit to the patient. Transition to digital imaging in the observed MR imaging clinic brought several important improvements that were of
benefit to the patient. Time required from admittance to receiving the radiologist’s report was significantly cut down, which means that timeliness of this report has been also improved. The quality of the viewed images is significantly better, due to ability of the radiologist to zoom and adjust window and level parameters of digital images, during the viewing of images, instead of having to rely on images printed out on film with all parameters preset by RT. This improves readability of images and their diagnostic potential. It is a clear benefit to both the radiologist and the patient.

Transition to digital imaging created opportunity for making of a cheap and effective image archive. Creation of the archive results in several major benefits. Images are not lost once they have been sent to the referring clinician, or given to the patient. Instead, they are kept in their original form for potential reviews, comparisons in case of follow-up appointments, academic use, or making copies for the patients or clinicians who loose the first copy.

Full implementation of digital imaging should lead to a complete abandoning of film hardcopies. Since many referring clinicians, as well as patients, still require a film copy as well as the CD with digital images, film printer has not been completely removed. It was already installed on the site, so it showed no additional expense. In the case of forming up an imaging site from scratch, additional significant savings could be made just leaving the film printer out. Also, savings are made even with the patients and referring clinicians who ask for film hardcopies. Since it is the radiologist who determines which images are relevant for printing, he has no need to print out all the images. This leads to a lot less film being used, and improving the cost-effectiveness. Full use of digital imaging would further increase the reported savings.

Figure 3. PACS system improvements.

Special benefit, from IT point of view, of an imaging site organized like in this paper is its potential for scalability and its modularity. This mini PACS system can easily be improved to a full PACS just by adding simple broker software (Figure 3). In the example given in this paper it was left out, since there was no necessity for it. The presented system is extremely easy to scale up, just by connecting modalities, and additional workstations to it. Its modularity (Figure 4) means that the system might be included in a larger PACS system (within a hospital network, or connected to other affiliate clinics) with almost no change, just by adding a protective firewall and a network connection. The system might become a part of a teleradiology system, or even its base, just by adding protective firewall and a web server (7, 8, 9, 12).

Figure 4. PACS system upgrading.

Better diagnostic potential, as the most important benefit to the patient, the archiving feature of mini PACS server, the better timeliness of the reports, improved possibilities for subspecialistic consultations, and upgradeability should be reason enough for transition to filmless digital imaging. When gaining better quality of service proves to be cost-effective as well, motivation for further upgrades and improvement is unavoidable. The setup given in this paper represents the base of a bigger and better system that should include full teleradiology possibilities.

REFERENCES