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Does PACS improve diagnostic accuracy in chest radiograph interpretations in clinical practice?

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ABSTRACT

Objectives: To assess the impact of a Picture Archiving and Communication System (PACS) on the diagnostic accuracy of the interpretation of chest radiology examinations in a "real life" radiology setting.
Materials and methods: During a period before PACS was introduced to radiologists, when images were still interpreted on film and reported on paper, images and reports were also digitally stored in an image database. The same database was used after the PACS introduction. This provided a unique opportunity to conduct a blinded retrospective study, comparing sensitivity (the main outcome parameter) in the pre and post-PACS periods.

We selected 56 digitally stored chest radiograph examinations that were originally read and reported on film, and 66 examinations that were read and reported on screen 2 years after the PACS introduction. Each examination was assigned a random number, and both reports and images were scored independently for pathological findings. The blinded retrospective score for the original reports were then compared with the score for the images (the gold standard).
Results: Sensitivity was improved after the PACS introduction. When both certain and uncertain findings were included, this improvement was statistically significant. There were no other statistically significant changes.
Conclusion: The result is consistent with prospective studies concluding that diagnostic accuracy is at least not reduced after PACS introduction. The sensitivity may even be improved.

1. Introduction

Conventional film and paper based information systems are currently being replaced by Picture Archiving and Communication Systems (PACS) in many hospitals and imaging centres. The potential of these systems has been well documented, and economic benefits have been demonstrated [1–11]. Less is known about the actual impact on diagnostic quality and accuracy in clinical practice.

When monitors are used to view radiographs, the radiographs are displayed with less resolution and contrast than film. Thus, there is a potential for missing pathological findings that might have been identified if the images were viewed on film. On the other hand, the information technology is getting increasingly sophisticated, and offers manipulation tools to adjust window/level, magnification, edge enhancement, etc., and provides easy access to previous examinations that could facilitate the detection of lesions. Several prospective studies have indicated that, under optimal conditions, diagnostic accuracy can be maintained when images are viewed on monitors rather than on film. Linhardt, e.g., concluded that all images can be read on 2K monitors (high resolution) without any loss of clinically important information [12]. Others have drawn similar conclusions [13–16].

To our knowledge, no blinded retrospective study has addressed whether diagnostic accuracy can be maintained also in a "real life" clinical setting, with time constraints, limited training, unpredictable interruptions, variable viewing conditions, etc. We selected chest radiographs for this study, as chest radiography is a common examination where small details can be of great importance. A method good enough for chest radiograph interpretation is likely to be acceptable for most areas of general radiology.

The purpose of this study was to assess the impact of the introduction of PACS on the diagnostic accuracy of the interpretation of chest radiology examinations in a "real life" clinical setting in a department of radiology.

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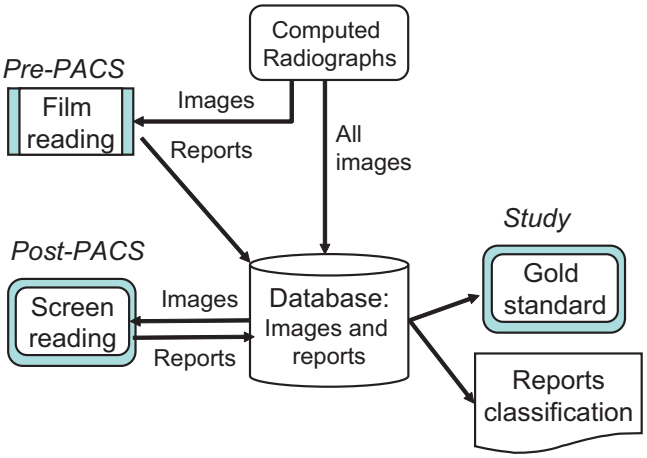

Fig. 1. Basic study outline. Computed radiography images and reports from both periods were stored in the database. Originally, the images from the pre-PACS period were examined on film, from the post-PACS period on screen. Images and reports from both periods were retrieved from the data base to establish the gold standard and classify the original reports.

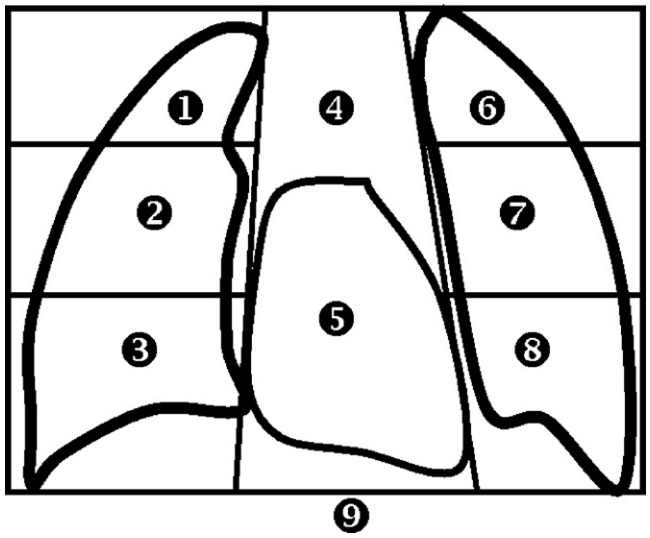

Fig. 2. A simplified drawing of eight specific and one general zone for the localisation of pathological findings.

2. Materials and methods

Approval for the conduct of this study was obtained from the Norwegian Social Science Data Service (NSD) and the Regional Ethics Committee, and was exempted from review by the Duke University Medical Center Institutional Review Board. The study was performed at a 500-bed teaching hospital in the capital region of Norway.

The basic design of this study was to compare retrospectively the diagnostic accuracy of chest radiograph reporting before and 2 years after the introduction of a Picture Archiving and Communication System (PACS). Diagnostic accuracy was measured by comparing a classification of pathological findings in the reports with an independent classification of pathological findings in the corresponding images (the gold standard).

2.1. Background and data collection

Before PACS was introduced in the hospital in May 2005, Computed Radiology (CR) images were printed on film and viewed by radiologists on light boxes. In preparation for the PACS introduction (Siemens MagicView®, Erlangen, Germany), the imaging modalities were gradually connected to the PACS database, and images were copied to this databases in parallel with the manual routines. Consequently, the database stores some CR images from the spring of 2005 that were originally printed on film and viewed by radiologists on light boxes. After the PACS introduction, reading of all images were performed on 2K (high resolution) PACS monitors.

The preliminary storage of images in the database provided an opportunity to conduct a blinded retrospective study. The gold standard established from the images was based on a consensus in the literature that, under optimal conditions, chest lesions that are detected on film would also be detected on screen [12–16]. The study is outlined in Fig. 1.

In 2005, nine specialists in radiology (all with more than 5 years of experience) and nine junior radiologists were reporting chest radiographs in the Department of Radiology. In 2007, the number of specialists had increased to ten; the number of juniors remained the same. The increase in the number of radiologists (5.6%) corresponded to a 5.6% increase in clinical volume; the Department performed 9349 examinations in April 2005 and 9876 in April 2007. All reporting done by junior radiologists was reviewed and signed by a specialist in radiology in both periods. The conditions did not differ significantly between the two periods. Eleven of the radiologists worked in the department during both periods.

Initially, 200 examinations were selected for this study. However, to reduce the impact of differences between observers, it was decided only to include examinations reported by radiologist that worked in the department in both the pre- and post-PACS periods. The final data set consequently consisted of 122 examinations. The first 56 were consecutive studies from the spring of 2005 (pre-PACS), starting from the first image stored in the database. These were originally reported by radiologists after viewing them on film. From equivalent dates in 2007 (post-PACS), 66 consecutive images were selected. During the latter period, images were viewed on monitors. All images originated from the same CR modalities. The images as well as the radiology referrals and reports for these examinations were retrieved from the database. We included only patients without previous examinations (performed in this hospital), and with one anterior (PA) and one lateral erect chest radiograph. Each examination was assigned a random number, and all attributes that could identify the patient or the examination period was removed. The images were separated from the reports and referrals.

2.2. Scoring

A scoring sheet was developed to record findings in images and reports. Each examination was divided into nine zones (Fig. 2). Eight zones represented specific findings in the upper, middle and lower part of the right and left hemi thorax, the cardiac region and the mediastinum beside the heart. One zone represented non-specific findings.

This approach was chosen as the main focus of the study was the identification of pathological findings. We had no reason to believe that the viewing method influenced the wording or classification of findings in the reports. To facilitate the evaluation of false negative cases, findings in the hemi thorax zones were also classified according to type (nodule/tumour; infiltration/consolidation; atelectasis; pneumothorax; congestion; emphysema; effusion; pleura/chest wall; other).

Each finding could be categorized as either certain or uncertain. Radiological assessments are not always binary decisions, and in prospective studies, the observers are frequently given the option to report several degrees of certainty [14,16–18]. We chose to distinguish only between certain and uncertain, as there was no