Reduction in Retake Rates and Radiation Dosage Through Computed Radiography

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Abstract

The availability of computed radiography has opened the possibility of using reduced dosage for radiographs in clinical settings and reducing the retake rate. A prospective controlled study was carried out over a period of four months comparing conventional X-rays and computed radiography. The aim was to assess if computed radiography at 50% normal dosage would result in films of adequate quality and a reduced retake rate compared to conventional radiography. The number and reason for retakes in each group were recorded. Film quality comparison using only chest X-rays (CXR) in one of three positions; erect posterior-anterior (PA), anterior-posterior (AP) sitting and supine was done by a panel of radiologists.

A total of 6373 conventional and 4127 digital films were analysed. The overall retake rate was lower in the computed radiography group (4.6 vs 8.2% P ***<0.001) as was the retake rate due to exposure factors (0.6% vs 3.2%*** P ***<0.01). There was a higher proportion of optimal films in the computed radiography group for erect PA and sitting AP CXR (71% vs 61%*** P ***= 0.0015 and 64% vs 9%*** P ***= 0.0009 respectively) but no difference for supine films.***

Computed radiography resulted in a reduced retake rate due to exposure factors leading to a reduction in the overall retake rate. Despite 50% dosage reduction, films were of better or equal quality when compared to conventional radiography.

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Introduction

New computed radiography imaging systems are slowly gaining a foothold in radiological departments worldwide. By computed radiography we mean a digital imaging system which exposes a photostimulable phosphor image receptor plate to obtain a latent image using existing radiographic equipment. The image is read by a laser and converted from analogue to digital data by a computer. The digital image can then be processed and viewed on a video display terminal or film.

The computed radiography system has many advantages over conventional radiography. The photostimulable phosphor plate is reusable, unlike film. User controlled post processing is automatically performed to generate the display features desired for the anatomic part selected. There are interactive capabilities which allow the image to be modified. With a computed radiography system more efficient image archiving, retrieval and transmission is possible. One of the most important advantages of computed radiography is that the image plate has a wide dynamic range or latitude. This means that a wide range of exposures would give acceptable images unlike conventional film where the range is narrow.[1] Therefore exposure errors may be less likely to necessitate a retake in computed radiography. The advantages of computed radiography could be nullified by disadvantages of the system which include higher noise and poorer spatial resolution. Our hypothesis for this study was that in a clinical setting, the use of computed radiography would result in a lower retake rate and allow for reduced exposure dose.

Materials and Methods

The conventional radiography equipment used was a Philips SM 80, focal spot size 0.6 mm and Siemens polymat 50 vertix U, focal spot size 0.6 mm using exposures at 120 kV and 125 kV, respectively. The conventional screen-film system comprised of Kodak Lanex medium screen with Fuji HRC film (speed 300) spatial resolution of 8.5 mm / lp (measured by line pair phantom). Film sizes were 35 x 35 cm and 35 x 43 cm. The computed radiography system used was a Fuji computed radiography 7000 system containing a helium

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neon laser (633 nm). Imaging phosphors were of Europium doped barium flourohalide. The computed radiography films were exposed with the same radiographic equipment. Storage phosphor plate size for chest radiographs was 35 x 35 cm or 35 x 43 cm. Pixel size was 0.2 mm (effectively 0.1 mm for half size computed radiography image).[2] Spatial resolution for computed radiography was 3.5 lp / mm / (4.2 lp / mm for half size image). Hard copies were made on Fuji computed radiography film type 780 (single emulsion). Film size was 26 x 36 cm (pixel size 0.1 mm).

A series of reduced dosage (25%, 50% and 75% of conventional dose) X-rays were done on skull and pelvic phantoms by recalibrating the auto timer to reduce the MAS. After evaluation of the films by a panel of radiologists the maximum dosage reduction that did not give a appreciable degradation of image was found to be 50%. This level was selected as the dosage for computed radiography. Manual exposure setting was used for supine chest X-ray and orthopaedic films of extremities.

Film retake data collection from two general rooms was conducted over a 4-month period during which half of all X-rays were done using conventional imaging and half using computed radiography. General films such as orthopaedic, skull, chest and abdominal films were included. The decision on film retake was made by the radiographer taking the film. The reason for retaking a film was recorded as due to exposure, technique, patient movement, equipment, processing or other factors e.g. film fogging. Prior to the study a one week practice period took place to allow staff to familiarise themselves with the computed radiography technique.

Film quality comparison was done over a study period of four months using only adult chest radiographs. All general (excluding emergency and portable) chest radiographs in the department were included in the study over a period of four months. For the first two months conventional radiography was done while computed radiography was done for the last two months. For computed radiography, besides the near analogue image which was assessed in the study, applying standard processing parameters prescribed by the manufacturer, an edge enhanced image was taken for clinical reporting purposes but not used in the study. Computed radiography images were half life size. Chest radiographs were taken in one of three positions; erect posterior-anterior (PA), anterior-posterior (AP) sitting and supine. Only two radiographers were involved in taking the films for consistency of results.

Prospective evaluation of quality of all the chest films was done by a panel of 13 radiologists during routine daily immediate reporting. Each film was assessed for adequacy based on a series of guidelines. These were:

1) the dorsal spine should be just visible behind the heart
2) the carina should be clearly visible
3) lung parenchyma should be of satisfactory density with vessels seen at the outer third of the lung on normal illumination.

If all the above were satisfied, the film was judged to be optimal; otherwise, it was suboptimal.

Statistical Analysis

Chi-square test was employed to test for statistical significance between the rates achieved with computed radiography and conventional radiography.

Results

Film Retake Analysis

A total of 6373 conventional and 4127 digital films were analysed. For conventional, the overall retake rate was 8.2%; whereas for computed radiography, the overall retake rate was 4.6% (P <0.001). When subgroup analysis was done, the retake rate for conventional films due to exposure factors was 3.2% and only 0.6% for computed radiography (P <0.01). Exposure factors in conventional group made up 39.1% of the total retakes and 13.3% in the computed radiography group. Technique problems were important causes of retakes for computed radiography resulting in 52% of retakes as compared to 38% for conventional films (Table I).

Film Quality Analysis

For erect PA and sitting AP chest X-rays, the rate of optimal films was higher in computed radiography compared to conventional radiography. There was no difference for supine films (Table II).

TABLE I: CAUSES AND FREQUENCIES (%) OF RETAKES

	Tech	Mov	Exp	Eqp	Proc	Others
Conventional	37.6	4	39.1	1.3	2.1	15.8
CR	52.1	4.8	13.3	1.1	0	28.7

Frequencies (%) of retakes in Conventional vs CR (computed radiography). Causes of retakes are Tech: technique; Mov: Patient movement; Exp: faulty exposure; Eqp: equipment failure; Proc: processor problems

TABLE II: QUALITY OF CONVENTIONAL VERSUS COMPUTED RADIOGRAPHY

	Conventional		CR		
Position	Number	% optimal	Number	% optimal	
Erect PA	479	61.3	467	71.3	P = 0.0015
Sitting AP	32	9	11	64	P = 0.0009
Supine	138	22	119	17.6	ns

CR: computed radiography; PA: posterior-anterior; AP: anterior-posterior; ns: not significant

Discussion

The overall retake rate in computed radiography was about half that of conventional radiography (4.6% vs 8.2%). For computed radiography, subgroup analysis showed technique problems to be the main cause for retakes (52%). Faulty exposure was responsible for only 13% of the retakes. In conventional radiography however, exposure was the main cause for retakes (39%). Technique problems were responsible for 38% of the retakes. It is evident that exposure factors were less of a problem in computed radiography compared to conventional radiography. This is because exposure errors were less likely to require a retake due to the wide latitude of the medium allowing for less than exact exposure. We were thus able to reduce the overall retake rate using computed radiography. The technical problems with computed radiography were in part due to inexperience and we expect this to reduce with time resulting in an even lower retake rates in future.

Despite a 50% dose reduction in computed radiography we were able to obtain significantly more optimal chest radiographs taken in erect PA and sitting AP films compared to conventional radiography. This is similar to a previous study[3] of paediatric patients where a 33% dose reduction gave adequate films. The number of sitting AP films were however small and will require further evaluation. There was no significant difference for supine films. A study[4] on portable films with low dose portable films showed improved control of image optical density compared to conventional films. This led us to expect that there would be more optimal films in the supine computed radiography group as supine films are similarly taken without an auto timer in relatively more ill patients. This was not the case however. This could be that despite less dependence on exposure factors, computed radiography did not overcome the other inherent problems in obtaining optimal supine films such as problems in positioning which may have led to more suboptimal results by our criteria.

Achieving an equal rate of optimal films between reduced dose computed radiography and conventional radiography would have been a good result as patient exposure is reduced without compromising the adequacy of the film. However in this study low dose computed radiography actually resulted in a higher rate of optimal films in normal and sitting AP chest radiographs. Two other studies[4,5] of portable chest radiographs using film density measurements showed that the computed radiography system produced films of more consistent film density resulting in more films of optimal density. Image processing and the lower K-edge of the computed radiography system phosphor may lead to the higher lung contrast of the computed radiography system. Optimising window level and width on the monitor prior to printing may also have contribute to improving the image. Our ability to get a good rate of optimal computed radiography films with at least a 0.2 mm pixel size is in keeping with the findings of Fraser et al[1] on the minimum pixel size required.

Conclusion

Computed radiography resulted in a reduced retake rate due to exposure factors leading to a reduction in the overall retake rate. We were able to achieve the same or greater percentages of optimal chest radiographs despite a 50% reduction in exposure dose. Patient dosage was therefore reduced both directly by decreasing exposure dose and indirectly by reducing the number of repeated exposures.

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