

Portable Chest Radiography: Comparison of High-resolution Digital Displays with Laser Printed Digital Film

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Abstract

Computed radiology is a radiographic imaging technology that generates a conventional radiographic image in digital form. The image can be recorded on a laser sensitive film or archived to a digital storage device and displayed on a video monitor. This study was performed to evaluate the adequacy of reporting digitised images directly from the workstation. The test set consisted of portable chest images of 55 patients from the cardiothoracic intensive care unit. Normal structures and nine abnormalities were pre-selected for analysis. The radiographs and images on the video display were reviewed on two separate occasions, six months apart by two independent readers. No clinical details were supplied and the intraobserver and interobserver agreement were assessed using Kappa statistics. The overall results indicated that direct reporting from the workstation was as reliable as reporting from the laser printed copies.

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Key words: *Computed radiography, Conventional, Kappa, Storage phosphor, Workstation*

Introduction

In most institutions, about 10% to 25% of imaging examinations are recorded digitally (e.g. digital subtraction angiography, computed tomography, magnetic resonance imaging and ultrasound). Conventional-projection radiographic studies are still displayed in an analog fashion (on film). Computed radiography (CR) is an imaging technique that generates a conventional radiographic image in digital form. It has two main components: (a) a reusable laser-stimulated luminescent phosphor imaging plate and (b) a scanning and recording mechanism. The imaging plate is placed in a cassette similar to the one used in a film/screen system. Exposure to radiation will form a latent image on the plate. The plate is processed through a laser scanning mechanism to extract the image. The extracted image is then recorded on a laser-sensitive film (hard copy) or stored as a digital image. The latter can be archived to a digital storage device and displayed on a video monitor (soft copy).

The aim of the paper was to assess for any significant variation in the reporting of digitised portable chest images directly from the video monitor and from the laser printed copy. Interobserver variation in reporting can also be assessed at the same time.

Materials and Method

Study Group

The study group consisted of 55 consecutive patients admitted to the cardiothoracic intensive care unit over a one-month period. Only the initial portable chest X-ray that was taken for the whole duration of stay in the intensive care unit was utilised for the study.

Equipment

The portable radiography unit used was a Siemens Mobilett II with a focal spot size of 0.8 mm. The computed radiography system was a Fuji FCR 7000 CR system containing a helium neon laser (633 nm). Imaging phosphors were of Europium doped barium fluorohalide. Storage phosphor plate size for the portable chest X-ray were 35 x 35 cm or 35 x 43 cm. The hard copy images were laser printed on Fuji CR film type 780 (single emulsion, 26 x 36 cm) and consisted of two post processed images. One was an unenhanced, density-optimised image with characteristics that approximated those of a conventional radiograph, and the second was a high frequency, edge-enhanced image. To ensure uniformity, the post processing parameters were pre-adjusted at the beginning of the study and no alteration was made during the study. The model of the workstation installed in the

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intensive care unit was Fuji HI-C654 with 1568 pixels and 1152 lines (non-interlaced).

Reading Method

For analysis of the chest radiographs in our study, 9 abnormalities were selected. They were the presence of any atelectasis, pleural effusion, hilar/mediastinal mass, air-space consolidation, thickened septal lines, parenchymal scarring, interstitial disease, pleural disease and bone/rib destruction. Evaluation of normal structures was based on the following criteria to determine if they were optimally seen: (a) the dorsal spine should be visible behind the heart, (b) the trachea, carina and both bronchi should be seen, and (c) the lung markings should be visible on normal illumination to the distal third of the chest. Evaluation of the endotracheal tube (ETT) and central venous pressure (CVP) line would be done if they were present.

Two post-fellowship radiologists participated in the review of the radiographs. Each reader read the full set of 55 cases. No clinical information was given and there was also no access to any analogue hard copy images. The digitised soft copy images were read at the workstation situated within the cardiothoracic intensive care unit. The laser printed hard copy images were read 6 months later under normal lighting condition within our department to diminish the effects of observer recall. The images were also randomised for each observer.

No time limit was imposed for completion of any of the reading sessions. For the reporting at the workstation, each observer was permitted to seek his own ideal display setting [i.e. to change the window (contrast) and level (brightness) of the display]. The hard copy images were read on a standard view box. The findings were recorded on a standardised score sheet. A 'p' (positive) was recorded for each abnormality detected or when the normal structure was optimally seen and 'n' (negative) if they were not.

Data Analysis

The intraobserver and interobserver agreement between the 2 radiologists were assessed using the Kappa statistic.¹ A zero value of kappa indicates no agreement above that expected by chance, a value of one indicates perfect agreement and a negative value indicates agreement worse than that expected by chance (Table I). Calculation of kappa however, requires both positive (p) and negative (n) entries by both readers when evaluating the selected structures/abnormalities.

Results

The results obtained from each radiologist were given in Table II and the kappa values for analysis of the intraobserver and interobserver variation were given in Table III.

The lung fields were visualised in all cases by both radiologists. Endotracheal tubes and central venous pressure lines were also optimally assessed whenever they are present (42 and 49 cases, respectively). The air column (trachea, carina and both bronchi) and the dorsal spine were also seen in most cases in both the soft and hard copy images.

Of the 9 abnormalities selected, pleural effusion is the most common abnormality. One notable observation was bone/rib destruction which was reported by both readers but only on the hard copy images.

In general, the intraobserver agreement between the soft and hard copy images for both radiologists was good. Interobserver agreement between the 2 readers ranged from fair to moderate agreement.

Discussion

Computed radiography is a radiographic imaging technique that generates a conventional image in digital form.²

TABLE I: KAPPA RELATED TO STRENGTH OF AGREEMENT

Value of Kappa	Strength of agreement
<0.20	Poor
0.21 to 0.40	Fair
0.41 to 0.60	Moderate
0.61 to 0.80	Good
0.81 to 1.00	Excellent

TABLE II: COMPARISON OF DETECTION OF PULMONARY ABNORMALITIES AND NORMAL STRUCTURES ON LASER PRINTED RADIOGRAPHS AND IMAGES DISPLAYED ON THE WORKSTATION

	Reader A		Reader B	
	Soft copy	Hard copy	Soft copy	Hard copy
RMB	40	44	43	46
LMB	41	44	43	44
Carina	47	48	39	41
Trachea	50	52	52	54
Dorsal spine	44	50	50	55
Lung fields	55	55	55	55
ETT	42	42	42	42
CVP	49	49	49	49
Atelectasis	2	2	8	11
Pleural effusion	24	28	19	15
H/M mass				2
Consolidation		6	2	5
Septal lines		4	6	13
Scarring			4	
Pleural disease	1	1	7	6
B/R destruction	0	2	0	3
Int disease	0	0	0	0

B/R: bone/rib; CVP: central venous pressure line;
ETT: endotracheal tube; H/M: hilar / mediastinal; Int: interstitial;
LMB: left main bronchus; RMB: right main bronchus

TABLE III: KAPPA VALUES INDICATING STRENGTH OF INTRA-OBSERVER AND INTEROBSERVER AGREEMENT BETWEEN THE TWO READERS

	Intraobserver agreement for reader A	Intraobserver agreement for reader B	Intraobserver agreement between A & B (soft copy)	Intraobserver agreement between A & B (hard copy)
RMB	0.60	0.71	0.56	0.63
LMB	0.64	0.62	0.70	0.77
Carina	0.61	0.63	0.48	0.60
Trachea	0.73	0.49	0.46	0.49
Dorsal spine	0.29	NA	0.29	NA
Lung fields	NA	NA	NA	NA
ETT	1.00	1.00	1.00	1.00
CVP	1.00	1.00	1.00	1.00
Atelectasis	1.00	0.56	0.36	0.26
Pleural effusion	0.86	0.66	0.66	0.53
H/M mass	1.00	0.66	1.00	0.66
Consolidation	0.91	0.55	0.41	0.70
Septal lines	0.64	0.20	0.70	0.27
Scarring	1.00	0.30	0.38	0.23
Pleural disease	1.00	0.74	0.23	0.26
B/R destruction	NA	NA	NA	NA
Int disease	NA	NA	NA	NA

B/R: bone/rib; CVP: central venous pressure line; ETT: endotracheal tube; H/M: hilar/mediastinal; Int: interstitial; LMB: left main bronchus; RMB: right main bronchus

NA: Not applicable as calculation of kappa requires both positive (p) and negative (n) entries when evaluating the selected structures/abnormalities

This system has numerous advantages over the conventional film / screen system, which include:

- reduction in radiation dose delivered to the patient,^{3,4}
- CR has a wide dynamic range or latitude which will decrease the number of repeat examinations due to exposure error,⁵
- image processing-the ability to manipulate the window level and width of the display and to apply image enhancement allow visualisation of both soft and hard tissues from the same image, and
- digital optical storage-images can be stored in a digital optical disk library for long-term archiving.

The disadvantages of the CR system are:

- limited spatial resolution,
- risks of contrast artefacts which appear as an illusion of a radiolucent zone at high contrast steps for example between metal and bone in an examination of a joint prosthesis,
- difficulties in visual evaluation of bone density,⁶ and
- the hard copy of the CR image is smaller than the conventional film which can create problems when comparison with conventional radiographs is required.

Our study was conducted to test if there is any significant variation in the reporting of CR images directly

from the workstation as compared to the laser printed copies. The cardiothoracic intensive care unit was chosen for the following reasons:

- technical difficulties are common in portable radiography using the conventional system requiring frequent retakes,
- there is a daily requirement of about 5 to 10 X-rays from the cardiothoracic intensive care unit, and
- transmission of images to the workstation allow immediate review of the radiographs in acutely ill patients and also the placement of any chest tubes or central lines.

The intraobserver agreement obtained using the kappa statistic was good for both radiologists indicating that direct reporting from the workstation was as reliable as reporting from the hard copies. This applied not only in the visualisation of normal anatomical structures but also in the detection of a wide variety of common clinical chest abnormalities. Our study concurred with previous report that laser-printed and high resolution workstation images yielded comparable performance levels.⁷ Digitised films as compared with conventional radiographs were also found to be superior in the detection of hilar and mediastinal disease but inferior in the detection of hyperlucent lung problems like pneumothorax and interstitial disease.^{7,8} We were unable to verify this point as there was only one case of pneumothorax and hilar mass in our study and both were optimally seen by the readers from the workstation and the hard copies.

The limitation of our study was the relatively small sample of patients but they were representative of patients admitted to the intensive care unit as these were consecutive patients admitted over a one-month period. As majority were post thoracotomy patients, pleural effusion was expected to be the most common abnormality. Thickened septal lines, atelectasis and airspace consolidation occur less frequently.

A significant observation was the detection of rib destruction in the hard copy images but not on the workstation. Several factors may have contributed to this finding:

- the radiologists' unfamiliarity with the workstation (i.e. the abilities to manipulate the window level and width of the video display and to apply image enhancement),
- inferior resolution, brightness as well as image flutter and increased noise level of the workstation, and
- a hard copy permits the radiologist to view all areas simultaneously while making rapid visual comparisons across the entire radiograph. This probably enables greater diagnostic accuracy and certainly allows the radiologist to work faster.

Interobserver variation is recognised and the radiologist is an important source of possible error in any

reporting. It had been reported that experienced interpreters of plain chest radiographs were apt to miss 3% of films positive for radiological evidence of disease and to overread about 2% of those negative for disease.⁹ This variation in interpretation may depend on the experience of the observer, the clinical information available, quality of the radiograph and reporting facilities.

In our study, the interobserver agreement between the two readers for both the soft and hard copy images ranges from fair to moderate agreement. This result compared favourably with other studies done previously.^{10,11} Close agreement between the two readers was essential to ensure that the kappa values obtained for intraobserver variation assessment were valid and meaningful.

Conclusion

Manipulating digitised image on computers and direct reporting from video monitors facilitate a picture archiving and communications system (PACS) environment. Digital images also open up possibilities for teleradiology where images can be communicated within the department, within the hospital or between hospitals.

Our study had shown that direct reporting from the workstation was reliable and the potential benefits would most certainly be in emergency situations, intensive care wards and operating rooms, where CR will reduce the need for repeat examinations due to exposure errors and the presence of a video monitor will enable rapid transmission of the processed image. Adequate training for each operator using the workstation is however an important prerequisite to ensure optimum performance level.

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