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SPECIAL ARTICLE

Displaying chest X-ray by beamer or monitor: comparison of diagnostic accuracy for subtle abnormalities

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ABSTRACT

***Background*: The advent of beamer projection of radiological images raises the issue of whether such projection compromises diagnostic accuracy. The purpose of this study was to evaluate whether beamer projection of chest X-rays is inferior to monitor display.**

***Methods*: We selected 53 chest X-rays with subtle abnormalities and 15 normal X-rays. The images were independently judged by a senior radiologist and a senior pulmonologist with a state-of-art computer monitor. We used their unanimous or consensus judgment as the reference test. Subsequently, four observers (one senior pulmonologist, one senior radiologist and one resident from each speciality) judged these X-rays on a standard clinical computer monitor and with beamer projection. We compared the number of correct results for each method.**

***Results*: Overall, the sensitivity and specificity did not differ between monitor and beamer projection. Separate analyses in senior and junior examiners suggested that senior examiners had a moderate loss of diagnostic accuracy (8% lower sensitivity, p<0.05, and 6% lower specificity, p=ns) associated with the use of beamer projection, whereas juniors showed similar performance on both imaging modalities.**

***Conclusion*: These initial data suggest that beamer projection may be associated with a small loss of diagnostic accuracy in specific subgroups of physicians. This finding illustrates the need for more extensive studies.**

KEYWORDS

Chest X-ray, projection, monitor, beamer, diagnostic accuracy

INTRODUCTION

Nowadays, computer-generated images are commonly used for displaying chest X-rays. Monitors are frequently employed, but beamer projection is also used for presentation and evaluation of X-rays during clinical rounds and conferences. There are differences in optical characteristics between beamer projection and monitors. In particular, beamers have inferior performance in terms of contrast and resolution, and sensitivity to ambient light intensity.[1-7] This may pose a problem in the interpretation of more subtle abnormalities.

We set out to investigate whether beamer projection of chest X-rays is inferior to monitor display. Our hypothesis is that beamer projection results in underdiagnosis of relatively subtle abnormalities.

MATERIALS AND METHODS

A senior pulmonologist and radiologist collected 53 chest X-rays which they judged unanimously to show subtle abnormalities. They also collected 15 normal chest X-rays. The X-rays were reviewed by both physicians independently on a state-of-the-art radiological computer monitor (NEC md213mc or similar type). They reached consensus either directly or after brief deliberation. We used this consensus judgment as the reference standard.

Four observers (one senior pulmonologist, one senior radiologist, both with over five years of clinical experience, and one junior resident of each speciality) participated in the observer study. They independently judged the set of images on a computer monitor and with beamer projection. The interval between these sessions was two weeks, the order of cases was randomised for each

projection session to prevent recognition and avoid learning bias. They were asked to record the nature and location of each abnormality they observed.

During the viewing sessions, we used standard computer monitors and beamers that are commonly used in hospitals. The monitors that were (randomly) used were: Dell 1908 WFP (brightness: 300 cd/m²; contrast: 1000:1), Dell 1708 FPT (brightness: 300 cd/m²; contrast: 800:1), Dell 1704 FPT (brightness: 300 cd/m²; contrast: 500:1) and Philips MCL 1801 (brightness: 270 cd/m²; contrast: 400:1). The beamer projectors that we used were: ASK C170 (brightness: 2000 lumen; contrast 1000:1), ASK 460 (brightness: 3500 lumen; contrast 750:1), ASK 200 (brightness: 2500 lumen; contrast 800:1) and ASK 160 (brightness: 1700 lumen; contrast 400:1). The viewing time per chest X-ray was limited to 60 seconds. If less than 60 seconds were used, the time was recorded. During the reading sessions, observers were allowed to use the image manipulation functions (brightness, contrast, magnification). Ambient light intensity in the room was standardised to around 100 lux.

Data analysis

Data were analysed overall as well as in five separate categories: 1) discrete/solid abnormalities in lung parenchyma, 2) diffuse intrapulmonary abnormalities, 3) pleural/thoracic wall, 4) mediastinum/heart/hilus and 5) remaining (*table 1*). We compared correct diagnostic classifications for each imaging modality, and used the Z-test for proportions to compare sensitivities and specificities between visualisation modalities.

RESULTS

The first two rows of *table 2* show if the observers identified identical abnormalities compared with the reference standard. The sensitivities and specificities are essentially identical (60% against 58% and 53% against 53%).

Also displayed in *table 2* is the time observers took for reviewing the X-rays, which did not differ between monitor en beamer projection (49 seconds for both).

Table 3 summarises the mean sensitivities for the diagnosis categories 1 and 2. The remaining categories were not analysed separately because the number of X-rays in these groups was too small (13, 9 and 9 respectively). The mean sensitivities are essentially identical between categories. *Table 3* also specifies sensitivities divided by specialists and residents. In terms of sensitivity, specialists performed moderately better on the monitor, and the resident did moderately better on the beamer (not significant). Overall, diagnostic sensitivity on the beamer is 53% for specialists and 71% for residents, which is a significant difference ($p<0.05$ by *Z*-test for proportions).

Table 4 summarises mean specificities for the diagnosis categories 1 and 2. As was the case for sensitivities, mean specificities are essentially identical between categories. Also in line with *table 3*, the specialists perform slightly worse on the beamer projection than on the monitor (not significant), while there is no similar difference among residents. The higher overall specificity among residents compared with specialists is not statistically significant.

Table 1. *Categories of chest X-ray abnormalities*

Category	Common abnormalities
1. Discrete/solid abnormality in lung parenchyma	Solid mass Bullae
2. Diffuse intrapulmonary abnormality	Infiltrate Diffuse consolidations Redistribution of blood flow Emphysema Bronchiectasis
3. Pleural/thoracic wall	Pleural effusion
4. Mediastinum/ heart/hilum	Expanded mediastinum Aorta abnormalities Hilar abnormalities Peribronchial cuffing Abnormal cardiac silhouette
5. Remaining	Corpus alienum Intravenous catheter Elevated diaphragm Prosthetic heart valve Clavicular fracture

Table 2. *Sensitivity and specificity (95% CI) of monitor versus beamer visualisation of subtle chest X-ray abnormalities*

	Monitor	Beamer
Sensitivity	61% (56-66%)	57% (56-62%)
Specificity	53% (41-65%)	53% (40-65%)
Time used for judging X-rays	49 seconds	49 seconds

Table 3. *Sensitivity (mean, 95% CI) per diagnosis category and per observer experience*

Category	1	2	1+2
Monitor	63%	64%	64% (57-69%)
Beamer	60%	63%	62% (55-68%)
Specialists monitor	59%	63%	61% (52-69%)
Residents monitor	68%	65%	66% (58-74%)
Specialists beamer	49%	57%	53% (44-61%)
Residents beamer	72%	70%	71% (62-78%)*

1: Discrete/solid intrapulmonary abnormalities; 2: Diffuse intrapulmonary abnormalities; *significantly ($p<0.05$) different from 'mean specialist beamer' sensitivity.

Table 4. *Specificity (mean, 95% CI) per diagnose category*

Category	1	2	1+2
Monitor	58%	58%	58% (54-62%)
Beamer	55%	55%	55% (51-59%)
Specialists monitor	58%	57%	58% (52-63%)
Residents monitor	58%	60%	59% (54-65%)
Specialists beamer	54%	51%	52% (46-58%)
Residents beamer	57%	59%	58% (52-63%)

1: Discrete/solid intrapulmonary abnormalities; 2: Diffuse intrapulmonary abnormalities.

DISCUSSION

This study shows no convincing difference in diagnostic accuracy between beamer projection and computer monitors. The time needed for assessing the X-rays does not differ on beamer projection and computer monitor. Separate analyses in senior and junior examiners suggested that senior examiners had a moderate loss of diagnostic accuracy associated with use of beamer projection, particularly in terms of sensitivity. Whether or not this could be related to a higher degree of educational exposure to beamer projection in juniors cannot be concluded from this study, but clearly is a possible explanation.
This is the first study to address this issue. Furthermore, an important feature of our design is that we exclusively used X-rays with a subtle abnormality or normal X-rays. This explains the limited overall diagnostic accuracy, but we feel a similar study using images with very clearly identifiable abnormalities is not likely to reveal a difference between treatment modalities, and would thus be irrelevant from a practical perspective.

Our study has a few limitations. Although the total number of observations is substantial, only 68 X-rays were used. We divided these X-rays into five different categories, three of which were too small for separate analysis. If indeed the diagnostic accuracy were to be lower for a particular type of abnormality, much larger sets of X-rays would be needed. Also, future studies should include more observers. Our preliminary data provide useful information on the basis of which the required numbers of images and observers for similar future studies can be estimated.

In conclusion, the use of beamer projection does not appear to be associated with a marked loss of diagnostic accuracy. Senior examiners, however, who may have had little exposure to beamer projection during their early professional training, are at risk for missing subtle abnormalities during beamer projection.

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