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Patient's posteroanterior chest radiographs are routinely displayed at different sizes on PACS: Cause and prevalence

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ABSTRACT

Objective: Sequential posteroanterior chest radiographs (CXRs) on any one patient are commonly displayed at different sizes on PACS monitors. The purpose of this study was to determine the cause of these differences, the percentage of radiographs affected, the relative change in magnification seen and if radiologists were aware of this display difference.

Methods: Differences in routine radiographer collimation pre-acquisition and image cropping (shuttering) post acquisition were noted. From three different hospitals, 300 posteroanterior (PA) erect CXRs with prior comparative studies were viewed side-by-side on a standard landscape display monitor. Variation in display size was calculated using the number of detector elements in the autofitted axis of the radiograph, when compared with the prior study. Correlation between patient gender and extent of magnification between images was recorded. Following this, a national survey was circulated to see if radiologists were aware of this phenomenon.

Results: Large variations in display size were noted. The mean extent of magnification between sequential PA chest radiographs was ±6.8% (range 0–21.6%). 98% of CXRs had some degree of variability in display size. There was no significant difference in the extent of variation in magnification based on age or gender. 86% of the radiologists who responded to the survey (n = 132) were unaware of any display size variability.

Conclusion: Sequential DR acquired chest radiographs are routinely displayed with varying degrees of magnification on PACS monitors due to differences in radiographer practice and auto-fit display settings. Most radiologists surveyed were unaware of these differences and their causation.

1. Introduction

The chest radiograph is the most widely acquired imaging study in radiology departments worldwide.[1,2] Comparison with prior radiographs is often key to image interpretation. All posteroanterior chest radiographs (CXRs) are acquired at standard parameters including a standard focal film distance of 180 cm to allow accurate comparison of pathology on sequential studies.[3,4] A standard focal film distance prior to the advent of digital radiography (DR) ensured that the degree of magnification of lung pathology was constant on all posteroanterior CXRs for any one patient.

It was observed that sequential posteroanterior CXRs on individual patients acquired on DR chest units are often displayed at different sizes on PACS monitors in our hospital (Fig. 1). Accordingly, normal anatomy and pathology on those patients are displayed at different degrees of magnification. The authors propose these differences result from differential collimation of the radiographic beam prior to CXR acquisition and image cropping post acquisition prior to transmission to the PACS system.

The purpose of this study was to test this hypothesis, determine the percentage of radiographs affected, assess the relative difference in magnification between sequential CXRs and to assess whether radiologists were aware of this phenomenon.

2. Materials and methods

Institutional clinical audit board approval was granted for this study. In order to test the effect of collimation and cropping on PACS display size a square 1.5 mm thickness copper filter was radiographed in the chest unit (Siemens Axiom Aristos VX plus, Siemens, Erlangen,

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Germany). First a radiograph was taken with no beam collimation and a second radiograph was taken with beam collimation close to the margins of the phantom. A third image of the phantom was taken with no beam collimation, but on this occasion the image was electronically cropped to the margins of the phantom at the console in the chest unit prior to being sent to PACS for viewing. The radiographs of the phantom acquired with either preacquisition collimation or post-acquisition cropping appeared larger on the PACS screen than the radiograph of the phantom with no collimation or cropping (Fig. 2). The DR system recognises this change in display size by adjusting the adjacent scale accordingly. As such PACS integrated calliper measurements of the phantom remain the same on all radiographs.

In order to assess the percentage of CXRs affected and the relative difference in magnification between sequential radiographs, a review of CXRs acquired as part of normal clinical practice was performed. Beginning in January 2017, one hundred consecutive posteroanterior departmental CXRs with prior comparative studies performed on the same DR chest unit (Siemens Axiom Aristos VX plus, Siemens, Erlangen, Germany) were compared side-by-side (2 × 1) on a standard landscape display monitor (Barco Coronis Fusion 6MP 30″, Barco, Kortrijk, Belgium). The study location is a university teaching hospital and national cardiothoracic centre. Our hospital has a McKesson PACS (McKesson, Irving, Texas, USA) which is part of a National Integrated Medical Imaging System (NIMIS). Anteroposterior, semi-erect and portable chest radiographs were excluded. The study population included adult inpatients and outpatients. One hundred additional sequential PA CXRs were reviewed from each of two other university teaching hospitals using the same exclusion criteria, display windows, viewing monitor and NIMIS PACS to exclude differences in radiography practice confined to our institution. The study population consisted of 162 men and 138 women. Patients were aged 18 to 91 years. Relative magnification differences for all 300 patients were analysed. Differences between gender was compared using an independent samples *t*-test and differences between hospitals was compared using one-way ANOVA on SPSS software version 26.0 (IBM, Armonk, NY, USA). Statistical significance was defined as $p < 0.05$.

The number of detector elements (Dels) in the x and y axis used to form a CXR image on PACS is recorded as a Digital Imaging and Communications in Medicine (DICOM) standard for each image on PACS. The matrix size of our digital chest detector (Trixell Pixium 4600) is 3000 by 3000 Dels. To measure variability in sequential display size of CXRs the number of Dels present in the horizontal autofit axis for each radiograph was recorded from standard DICOM PACS software. The difference in display size between sequential radiographs was calculated by comparing the number of Dels in the autofit horizontal axis for each CXR. For example, if the index radiograph is formed from 2000 Dels width and the most recent prior formed from 2200 Dels, it follows that objects in the index radiograph are displayed larger, with a relative magnification of 10% (200/2000). These values were calculated for all 300 pairs of CXRs (Fig 1.)

In order to assess the radiologist awareness of this phenomenon an electronic survey was undertaken of all radiologists in active practice nationally using SurveyMonkey (SurveyMonkey Inc., San Mateo, Cal, USA). Four questions were asked. Firstly, what PACS system is used in your institution? Secondly, are sequential posteroanterior CXRs on a patient displayed at uniform size on this PACS? Thirdly, how do you assess change in size of a lesion on sequential posteroanterior CXRs on your PACS? (a) subjective visual assessment, (b) measure a minority of time with PACS integrated callipers, (c) measure a majority of the time with PACS integrated callipers (d) always measure pathology with PACS integrated callipers. Fourthly, if multiple lesions are seen on sequential posteroanterior CXRs, do you base your assessment of size change on subjective assessment alone?

3. Results

For the 100 patients who had sequential CXRs in the authors institution differences in display size resulted in a mean relative magnification of 7.4% (range 0–21.6%). Similarly, for the 100 patients sequential CXRs in the other two hospitals the mean relative magnifications were 6.3% (0–17.4%) and 6.7% (0.2–15.4%) respectively. The differences between the 3 sites were not statistically significant ($p = 0.22$). For the entire study group of 300 patients the mean relative magnification for display of sequential CXRs on PACS was 6.8% (range 0–21.6%).

The seven patients who had no difference in display size were large patients with CXRs acquired at full FOV autofitted in the horizontal (x) axis (2500 Del width compared with 2500 Del width prior). Six of the seven patients were male, although no significant difference in display size based on gender was found in the overall study population ($p = 0.35$).

With regards to the survey assessing the radiologists awareness of the

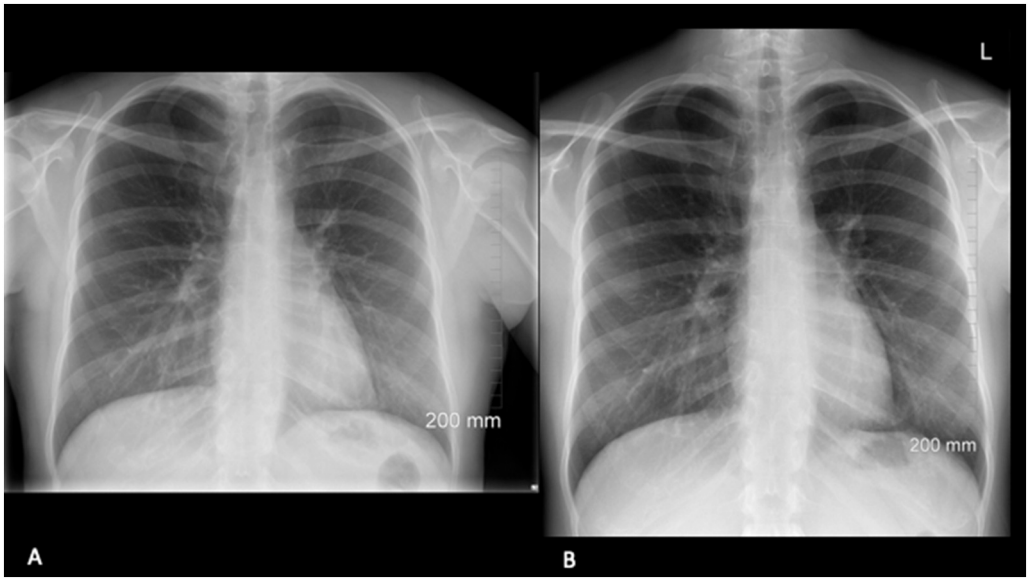

Fig. 1. Sequential CXRs of the 26 year-old female taken 4 years apart. (a) The most recent CXR is composed of 2987 horizontal Dels. (b) The prior CXR is composed of 2472 horizontal Dels. Objects in the prior radiograph are displayed larger with a relative image magnification of 515/2472 or 21%.

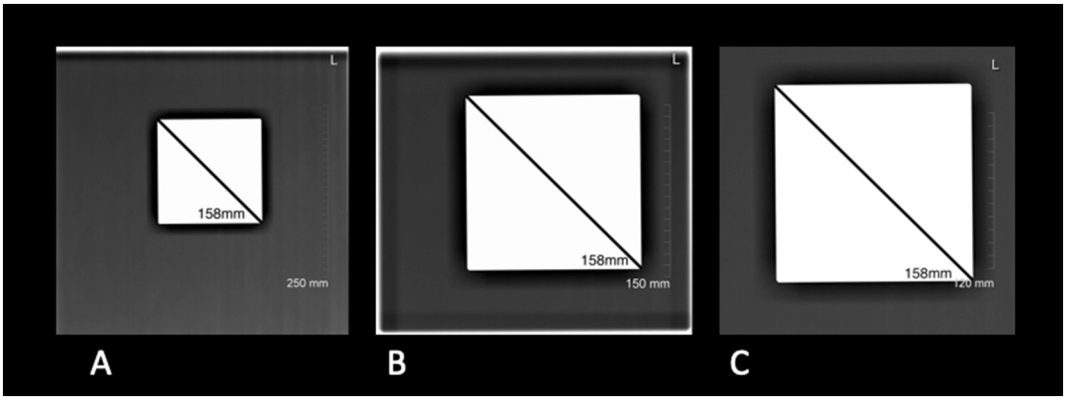

Fig. 2. Three radiographs of the same 1.5 mm thickness square copper filter plate. (a) was taken with the cones fully open and no electronic cropping. (b) was taken with collimation of the x-ray beam close to the margins of the phantom. (c) was taken with no collimation however there was post processing of the image with cropping close to the margins of the plate. The square plate appears larger on the collimated and cropped images although the scale on the right of each image acknowledges its true relative size. Calliper measurements confirm object is same size in all images at 158 mm.

phenomenon,132 of 255 radiologists in active practice nationally responded to the survey (52% response rate). Of those, 79 of 132 (60%) used NIMIS PACS in their institution. One hundred and twelve (86%) believed patients sequential CXRs are displayed at uniform parameters and were unaware that radiographic technique had an impact on image display size. When assessing for change in the size of a lesion on sequential chest radiographs, 18 (14%) make a subjective assessment alone, 25 (18%) measure with PACS integrated callipers a minority of the time, 46 (35%) measure a majority of the time and 43 (33%) measure all the time. Finally, the majority of radiologists (68 of 132; 52%) make a subjective visual assessment alone when comparing multiple lesions present on sequential CXRs.

4. Discussion

Differences in display size on PACS monitors between sequential radiographs on individual patients were noted for 98 % of DR acquired PA CXRs with no significant difference between all three hospitals. To the authors knowledge this is the first description and quantification of this phenomenon. The results of the national survey suggests that most radiologists are both unaware of this phenomenon (86%) and make subjective judgements on the interval change in size of lesions on CXR at least some of the time. This may lead to an interpretive error.

Two radiographic factors were found to contribute to CXR display size on PACS monitors. Firstly, operator dependent beam collimation, where the light beam (corresponding to the X-ray beam) is collimated to the edges of the patient's thorax, to above the clavicle and below the 12th rib in order to exclude other body regions which are not of clinical interest and reduce the patient dose. On a DR acquisition there is automatic post-processing where Dels outside the collimated region, with sub-threshold exposures, are deleted from the image before viewing. Secondly operator dependent post acquisition image cropping, also known as shuttering or electronic collimation may be performed at the acquisition console to delete further unwanted components of the image or to improve image centring. Collimation is an almost universal practice, and is important to reduce radiation dose to patient anatomy outside the area of clinical interest. It also particularly important in digital imaging as digital receptors are more sensitive to scatter beam causing a reduction in image contrast.[5] Post-acquisition image cropping is more controversial.[6] The use of image cropping masks unnecessary large preacquisition collimation and by implication higher patient dose.[7] The practice appears widespread, with a study by the American Society of Radiologic Technologists showing that half of respondents used electronic cropping >75% of the time in paediatric radiography.[8] The most recent revision of the joint ACR–AAPM–SIIM–SPR practice parameters for digital radiography acknowledge this is a contentious issue[4] and advise electronic collimation never be used to mask areas of the image having anatomical information. However, removing unintentionally bright components of the image that may result in veiling glare or air gaps is permissible.[6] Radiology departments may want to consider whether post acquisition cropping should be discouraged.

As the cause of differences in relative magnification on sequential CXRs relate to operator dependent variability in acquisition, one might expect differences in the degree of relative magnification seen between the three hospitals but this was not the case. The range of relative magnification may be greater if multiple different radiographers rotate through the chest unit, but we did not assess for this as it was rarely the same radiographer acquiring both radiographs given staff rotation in a teaching hospital department and the time interval between sequential studies. A potential weakness of this study was that it was not possible to separate the effects of operator dependent beam collimation, cropping, or a combination of both on relative magnification as we did not directly observe radiographer workflow during acquisition due to retrospective nature of study. Also, patient body mass index and height may influence degree of variability of display size on sequential CXRs, but we were unable to independently assess these parameters as they were not routinely recorded at time of CXR acquisition.

Recent innovations in medical imaging technology may be able to mitigate the degree of relative magnification seen on PACS. A number of computer aided diagnosis (CAD), and more recently machine learning algorithms have applications in chest radiograph interpretation.[10,11] Many of these systems rely on lung boundary detection to complete their diagnostic functions which could be used to standardise the size of anatomical detail between sequential PA CXRs. This would make an interesting area for further study.

In summary sequential DR acquired CXRs are routinely displayed at different sizes which results in relative differences in magnification of both normal anatomy and pathology on a PACS monitor. This results from differences in radiographer preacquisition beam collimation and post-acquisition cropping in conjunction with PACS software autofit display settings. The majority of radiologists surveyed were unaware of this phenomenon.

Declaration of competing interest

None.

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References

1. NHS England. Diagnostic imaging dataset annual statistical release. https://www.england.nhs.uk/statistics/statistical-work-areas/diagnostic-imagingdataset/.
2. United Nations. Scientific Committee on the Effects of Atomic Radiation., Sources and effects of ionizing radiation: United Nations Scientific Committee on the Effects of Atomic Radiation: UNSCEAR 2008 report to the General Assembly, with scientific annexes. New York: United Nations; 2010.
3. Whitley AS, et al. Clark's positioning in radiography thirteenth edition. In: Whitley AS, Jefferson G, Holmes K, Hoadley G, Sloane C, Anderson C, editors. Clark's Positioning in Radiography. 13th edn. London: CRC Press; 2015.
4. American College of Radiology. ACR–AAPM–SIIM–SPR, Practice Parameter for Digital Radiography, in III, C, 3 Electronic Collimation. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/rad-digital.pdf; 2017.
5. Bomer J, Wiersma-Deijl L, Holscher HC. Electronic collimation and radiation protection in paediatric digital radiography: revival of the silver lining. Insights Imaging 2013;4:723–7. https://doi.org/10.1007/s13244-013-0281-5.
6. Tsalafoutas IA. Electronic collimation of radiographic images: does it comprise an overexposure risk? Br J Radiol 2018;91(1086). 20170958-20170958.
7. Temsah MH, Al-Eyadhy A, Alsohime F, Nasser SM, AlHosen TN, Alebdi HA, Almojel F, AlBattah MA, Narayan O, Alhaboob A, Hasan GM, Abujamea A. Unintentional exposure and incidental findings during conventional chest radiography in the pediatric intensive care unit. Medicine (Baltimore) 2021;100(9): e24760. https://doi.org/10.1097/MD.0000000000024760.
8. Morrison G, John SD, Goske MJ, Charkot E, Herrmann T, Smith SN, Culbertson J, Carbonneau K. Pediatric digital radiography education for radiologic technologists: current state. Pediatr Radiol 2011;41(5):602–10.
10. Candemir S, Antani S. A review on lung boundary detection in chest X-rays. Int J Comput Assist Radiol Surg 2019;14(4):563–76.
11. Zotin A, Hamad Y, Simonov K, Kurako M. Lung boundary detection for chest X-ray images classification based on GLCM and probabilistic neural networks. Procedia ComputSci 2019;159:1439–48.