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Portable chest x-rays for hospital patients: Implication, justification and image quality

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SHORT COMMUNICATION

ABSTRACT

Background and aim: Portable Chest X-ray (PCXR) is service provided to patients who are unable to travel to radiology department. However, the unjustified PCXR leads to unnecessary radiation exposure to radiographer and other patients on ward. Currently, there are no guidelines to justify PCXR requests in UK. Therefore, it was aimed to use the evidence-based guidelines with addition of National Early Warning Score (NEWS) for justifying PCXR requests and to determine the image quality and scatter radiation dose for patient positionings.

Patients and Methods: Guidelines and NEWS ≥5 were used as a trial for 3 months (July to September 2023). Scatter radiation dose of each patient was calculated. ANOVA test was used to find the relation between patient positionings (AP erect, AP semi-erect and supine) and scatter radiation. The dose area product (DAP) of patients was collected from Computerised Radiology Information System (CRIS) and images were assessed using Picture Archiving and Communication System (PACS). All the portables were done on Samsung and Agfa DR machines.

Results: The guidelines were successful in justifying the portable CXR requests for 96 patients out of 102. The 24 PCXR images (25%) were rotated and of sub-optimal exposure. AP semi-erect position (mean scatter radiation = 1.21 μGy) was found to be related with high scatter radiation dose ($Q = 6.97$, $P = <0.01$).

Conclusion: Radiology departments may consider using published criteria with NEWS ≥5 as a method for justifying PCXR. AP semi-erect position leads to higher scatter dose and 25% of radiographs were of less diagnostic value.

KEYWORDS

portable chest x-ray, National early warning score, scatter radiation dose

Introduction

PCXR accounts for most in-patient radiographs and it is obtained of acutely ill patients who may have urgent findings that require rapid diagnosis and treatment and cannot be transported to radiology department [1]. However, performing PCXR can be tough, labour intensive for radiographers and require extra caution [2].

PCXR could be useful for patients and staff compared to transporting patients to the medical imaging department, however, patients receive a high dose as compared to departmental exams [3]. Responding to PCXR requests, the imaging staff is less available to respond quickly to emergencies requiring urgent examination [4].

The unwanted PCXR has a negative impact in terms of unnecessary radiation exposure to other patients and staff [5]. The dose limits for radiographers should not exceed 20 mSv/year. Similarly, for other healthcare staff such as nurses the limit is 1 mSv/year and for other people such as patients it is 5 mSv in any period of 5 consecutive years [6]. There are currently no guidelines in the UK that classify the PCXR requests as appropriate. A study [7] has developed multidisciplinary PCXR guidelines to reduce the number of inappropriate

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requests. They were able to reduce the number of unnecessary PCXR examinations in their 21 different hospitals. Similarly, another study [5] developed guidelines for PCXR to screen the urgent requests for an efficient delivery of the service who need portable examination. Moreover, one more article [8] highlighted the need for PCXRs for only those who are with medical conditions where nursing care and treatment could be compromised if transported to the radiology department. They also emphasise the shortage of ward staff to accompany patient to radiology is not a justified reason for performing PCXR.

Therefore, a quality improvement study was undertaken at a hospital in Southeast England with the aim of 1) to assess published guidelines with addition of NEWS to justify the PCXR 2) report on the amount of scatter radiation of portable examination in relation to patient positioning 3) to examine their image quality.

Patients & methods

The guidelines from study [7] with addition to NEWS were used as a trial for 3 months (July to September 2023) in our department to evaluate the PCXR requests after the departmental approval. The NEWS was considered crucial as it is used for the detection and response to clinical deterioration of a patient and medium overall score of 5–6 is considered as red score [9]. The NEWS ≥5 was selected as a threshold as it reflects an urgent clinical review and this reflects that a patient is at moderate to high risk of clinical deterioration, sever illness or death [9]. However, patients with NEWS <5 are of low to medium risk and less frequent monitoring required [10]. These patients are safe for transferring to radiology department for x-ray.

Therefore, the overall NEWS of ≥5 was considered appropriate.

The data of 102 adult patients requested for PCXR was collected to determine whether the requests are in accordance with guidelines. The radiographers were asked to assign against each criterion from the PCXR requests. If the request does not meet the justifying criteria, then the request is deemed inappropriate.

The amount of scatter radiation and patient positioning for PCXR was also found. The scatter dose of patients at 1 m distance was found by using the following formula [11]:

$$\text{Scatter dose} = [(0.031 \times \text{kV}) + 2.5]\ \mu\text{Gy}\ (\text{Gy cm2}) - 1$$

The individual scatter dose was then found by multiplying with patient dose area product (DAP). The ANOVA was used to find the relation between patient positioning and scatter radiation. The DAP of patients was collected from CRIS and images were assessed using PACS. All the portables were done on Samsung and Agfa DR machines.

Results

The guidelines were successful in justifying the PCXR requests for 96 patients. Only 6 requests did not meet the criteria for the following reasons:

NEWS of 0, 2 and 3, nasogastric tube placement (with no other indication), patient on oxygen and a bariatric patient.

The mean age of all 96 patients was 66 years (SD = 21) with a range from 19 to 93 and a median of 71. Mean scatter radiation of patients with PCXR was 0.79 μGy (SD = 0.46) with a range from 0.11 to 4.11 μGy. All the patients were adults.

A statistically significant relationship between patient positioning and the scatter radiation was found. The Tukey's HSD showed that the significant difference was between the AP semi-erect position (mean scatter radiation = 1.21 μGy) and AP erect position (mean scatter radiation = 0.67 μGy); $Q = 6.97$ ($P = <0.01$) with AP semi-erect positioning is related to higher scatter radiation dose (Tables 1–3).

Relationship between positioning and scatter radiation

Table 1. Descriptive statistics of kk = 3 independent treatments

Treatment→	A	B	C	Pooled total
observations N	29	5	62	96
sum ∑xi∑xi	35.4500	3.9300	41.4600	80.8400
mean ¯xx¯	1.2224	0.7860	0.6687	0.8421
sum of squares ∑x2i∑xi2	58.5809	3.6437	35.0610	97.2856
sample variance s2s2	0.5445	0.1387	0.1203	0.3075
sample std. dev. ss	0.7379	0.3724	0.3468	0.5545
std. dev. of mean SE¯xSEx¯	0.1370	0.1665	0.0440	0.0566

Table 2. One-way ANOVA of kk = 3 independent treatments

source	sum of squares SS	degrees of freedom νν	mean square MS	*F* statistic	*P*-value
treatment	6.0742	2	3.0371	12.2076	1.9601e−05
error	23.1373	93	0.2488		
total	29.2116	95			

The *p*-value corresponding to the *F*-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more treatments are significantly different. The ANOVA was followed by Tukey HSD test. This post-hoc test would likely identify which of the pairs of treatments are significantly different from each other.

Table 3. Tukey HSD results

treatments pair	Tukey HSD *Q* statistic	Tukey HSD *P*-value	Tukey HSD inference
A vs B	2.5553	0.1731563	Insignificant
A vs C	6.9783	0.0010053	$P < 0.01$
B vs C	0.7153	0.8548874	Insignificant

A = AP semi erect, B= Supine and C = AP erect.
The above table shows the significant difference between the AP semi-erect position (mean scatter radiation = 1.21 μGy) and AP erect position (mean scatter radiation = 0.67 μGy); $Q = 6.97$ (P=<0.01) with AP semi-erect positioning being connected to higher scatter radiation dose.

25% of PCXR images ($n = 24$) appeared to be rotated ($n = 22$) and with sub-optimal exposure ($n = 2$).

Discussion

The use of a portable X-ray machine is a possible method of acquiring X-ray images away from department [12]. However, there is a need to reduce the burden on radiographers and the availability of quick and effective PCXR service for those in need. Therefore, the published guidelines and NEWS ≥5 cover almost all conditions and can be implemented in practice for PCXR to justify the PCXR request. All 96 patients had an overall NEWS ≥5 and the rest of 6 patients were safely transported to radiology after discussion with the ward and referring doctor. However, the patient with NEWS ≥5 (with 2 score for oxygen) can be transferred to radiology depending upon patient overall condition. Therefore, patient assessment plays an important role in requesting PCXR. Moreover, the patient travelling to department on a chair has many chances of having CXR in PA position which is better than AP position in terms of dose and image quality [13]. Moreover, as per UK Ionising Radiation (Medical Exposure) Regulations 2017 (IR(ME)R), it is referrer's responsibility to provide sufficient information to practitioner to justify the examination, ensuring the benefits outweigh the risk. Therefore, it is important for doctors to put adequate information on the PCXR request to justify the examination. This study also found that there is enough scatter dose associated with AP semi-erect position ($Q = 6.97$, $P = <0.01$) as compared to AP erect position at 1 m distance. In many situations, radiographers must remain close to the patient during PCXR and therefore, it is advised to do the x-ray in AP erect position, if possible, to reduce the scatter dose. Optimum exposure is needed to reduce the risk of over and under exposure of the patient as per patient size or BMI and for appropriate image quality [14]. The radiographers face problems doing PCXR. Firstly, patients are usually unable to cooperate due to their condition and required physical strength for accurate positioning and there is usually only one radiographer. Secondly, the room conditions are less appropriate such as source-to-image distance and exposure factors. Thirdly, the patient's condition often requires monitoring and access lines and tubes that interfere with image quality and positioning accuracy. Fourth, the radiology departments cannot assign one radiographer on PCXR which results in variation of image quality due to different level of expertise [15]. In this study, 25% of PCXR were not of adequate diagnostic value which could affect the patient management. Following are some examples of these images (Fig. 1a–c)

Scatter radiation is the major source of occupational dose for radiographers and poses a risk to nearby patients in the ward during portable X-ray [16]. The highest mean scatter dose of 1.21 μGy in AP semi-erect position at 1m was found in this study which is nearly equal to a published study [17] regarding the scatter radiation dose during PCXR. In a year, with 5 PCXRs in a day the radiographer could receive 2.21 mSv per year of scatter dose which is less than occupational dose limit. It is also nearly impossible for the same radiographer, adjacent patient, and other healthcare professionals to be present each time during the x-ray. Moreover, standing at distance more than 1m (inverse square law) and lead aprons further reduce the scatter dose. However, it should be noted that PCXR gives scatter dose which is not confined and unjustified PCXR could lead to unnecessary dose to radiographers, other staff, and nearby patients on ward [18]. Therefore, there is need of awareness among doctors, especially junior doctors about difficulty in obtaining PCXR which could affect the image quality, associated scatter radiation dose on ward and higher dose as compared to departmental x-ray.

This study also has some limitations. It includes PCXR requests for admitted adult patients only. However, the study does not include patients in ITU (intensive care unit). The scatter dose found may not represent the actual amount of dose received by radiographers or nearby patients as measured by dosimeter. The study is limited to one hospital and taken from two types of portable machines. There could be other reasons medical or non-medical for PCXR not covered in criteria. PCXR are among the highest imaging examinations ordered for admitted patients, however, there is lack of literature available for justification and implication for it. There is need for further research into effective use of service and for patient and staff safety.

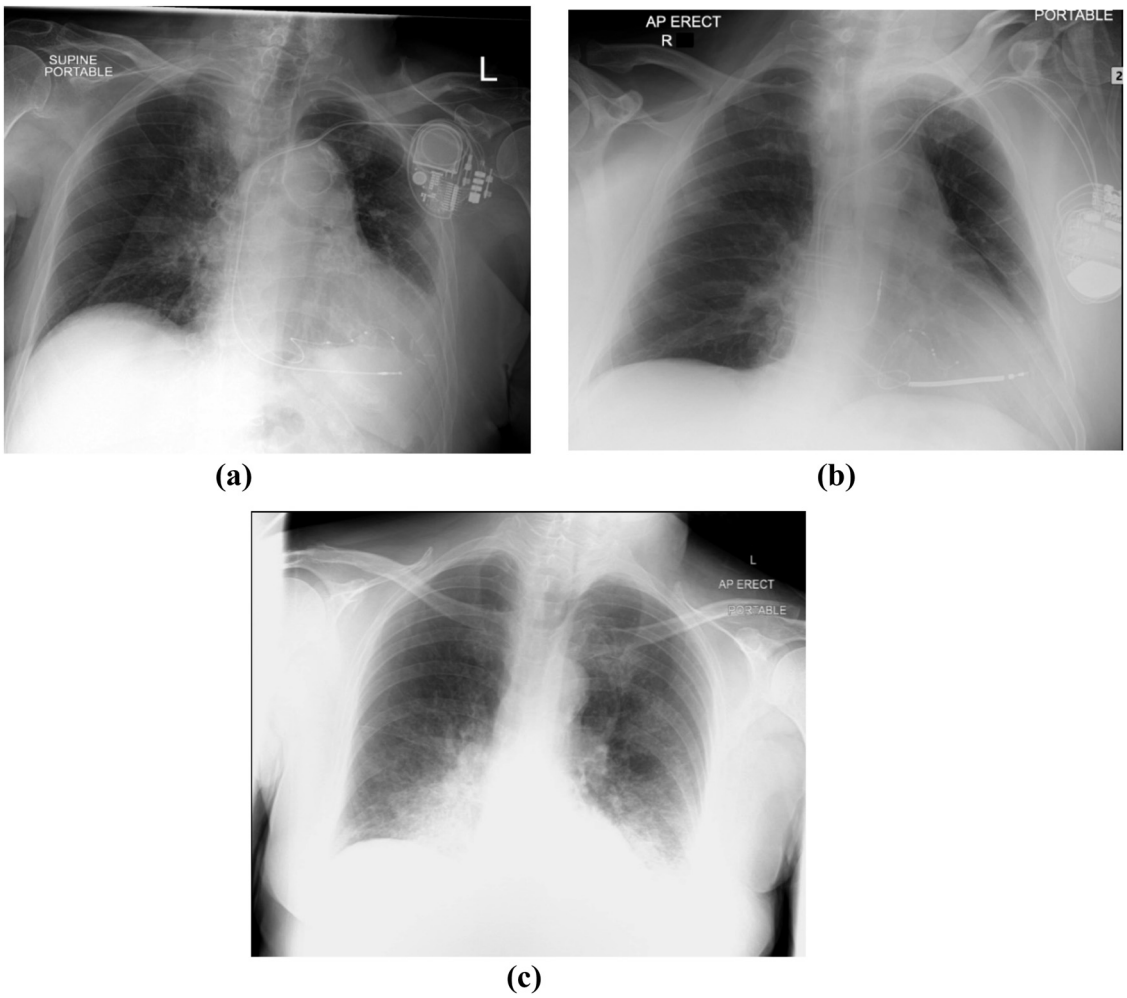

Fig. 1(a–c). The above PCXR Images are representation from the data for rotated (Fig. 1a and b) and of sub-optimal exposure (Fig. 1c)

Conclusion

The published guidelines with NEWS can be used to justify the PCXR requests. The patient assessment by doctors play an important role in deciding for PCXR. AP semi erect position is associated with higher scatter radiation dose and 25% of radiographs were not of adequate quality. The radiographers should always try to do PCXR in AP erect position which gives less scatter dose.

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