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Compliance to radiography practice of high-kilovoltage technique for chest radiography in South South Nigeria

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Abstract

Background: The production of a good quality chest radiograph depends on the selection of appropriate kilovoltage and current–time product while keeping the radiation dose to patients as low as possible. This study assessed radiographers' level of compliance to the use of high kV as standard for postero-anterior (PA) chest X-ray in the South South region of Nigeria.

Results: Seventy-seven of the 82 questionnaires administered were completely filled and returned giving a response rate of 94%. Of these 77 respondents, only 74% ($n = 57$) were aware of high-kV technique as the recommended procedure for PA chest X-ray. Departmental protocols (technique chart with exposure factors) were also non-existent in all hospitals/diagnostic centres used in this study. Thirty-one respondents were males (40%); 44% ($n = 34$) working in public hospitals only and 32% ($n = 25$) with less than five years of working experience were aware of this technique. On the benefits, more than 50% of the respondents were familiar with the benefits of using high-kV technique as the recommended standard for PA chest X-rays. Responses on the benefits of the technique varied from 77% ($n = 59$) for patient dose reduction to 51% ($n = 39$) for better imaging of the airways. The use of high-kV technique for PA chest X-rays showed only 13% compliance. Factors influencing compliance included imaging system (film screen /digital), X-ray tube rating and X-ray unit with preset/manual exposure factors ($p < 0.05$).

Conclusions: The present study revealed low compliance to high-kV technique in this region, suggesting a potential increase in ionizing radiation dose to patients during chest radiography, hence the need to improve adherence to the recommended standard.

Keywords: Imaging system, High-kV technique, Radiography, Chest X-ray, Optimization

Background

Image quality and ionizing radiation dose to the patient are two important factors to consider during X-ray examinations. Optimized chest radiography is that which achieves good image quality at a significantly low radiation dose (Lorusso *et al.* 2015). Chest X-ray remains the mainstay of chest imaging despite the availability and diagnostic superiority of cross-sectional techniques

(Setiawan *et al.* 2017). The production of a good quality chest radiograph depends on the selection of appropriate kilovoltage (kV) and current–time product (mAs) while taking into account the patient's habitus and pathology (Whitley *et al.* 2015). These exposure factors are under the direct control of the radiographer.

The use of low kV (60–70 kV) is less effective in demonstrating the part of the lungs behind the heart, retro-cardiac areas, retro-diaphragmatic areas and areas hidden by the ribs (WHO 2011; Delrue *et al.* 2011). The World Health Organization (WHO) (WHO 2011) therefore recommended high-kV technique (120–140 kV) as the standard procedure for postero-anterior (PA) chest X-ray

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examination. This recommendation is necessary for optimized chest radiography (Bontrager and Lampignano 2014; Kahn and Santos 2015; Slavtchev and Manolov 2016). Radiographic dose optimization measures for dose reduction are based on increasing kV and decreasing current–time product (high-kVp technique) (Knight 2014). It has been reported that high-kV technique for PA chest X-ray reduces the effective dose equivalent to the patient by 20% (Bamidele and Nworgu 2011) and low kV on the other hand results in entrance surface doses (ESD) above the 0.3 mGy recommended as the diagnostic reference level by the International Commission on Radiological Protection (ICRP) (ICRP 2017). Studies were done to determine the compliance level to the European guidelines on good radiographic techniques (Bamidele and Nworgu 2011); the frequency of chest X-rays performed (Akinola et al. 2014) and dose audit of patients for radiography examinations (Akpochafor et al. 2016; Zira et al. 2017; Lateef and David 2019) in Southwest and North-east regions of Nigeria showed that PA chest X-rays were acquired using less than 120 kV. As a follow-up, this study aimed to assess the radiographers' level of compliance to the use of high kV as the standard procedure for PA chest X-rays in the South South region of Nigeria.

Method

Study design

This study adopted the cross-sectional descriptive survey design. Eight public and seven private hospitals/diagnostic X-ray centres in the South South cities of Calabar (5), Uyo (5) and Port-Harcourt (5) cities were involved in this study. These hospitals/diagnostic centres were selected based on their high patient throughput, a higher number of respondents, access to respondents and X-ray rooms.

Materials

A total of 82 respondents were involved in this survey. The respondents were radiographers involved in clinical practice. The materials were open and close-ended questionnaires. Before its use, a pilot study was carried out among 10 radiographers in both the academic and clinical settings to validate the questions, respond alternatives and rule out ambiguities. These questionnaires were personally administered to the respondents. Ethical approval for this study was obtained from the ethical research committee of the Department of Radiography and Radiological science, faculty of Allied Medical Sciences of the University of Calabar with reference number UC/ECRA/19/010.

Procedure

The questionnaire comprised of two parts. Part A focused on gender, department (type of hospital/centre), years of

experience, type of image receptor [film-screen or digital radiography (DR)], performance characteristics of X-ray unit (preset or manually set and X-ray tube ratings) and departmental protocols for chest radiography examinations. Part B focused on the respondents' awareness of high-kV technique as standard procedure for PA chest X-ray, knowledge of the benefits of the use of high-kV technique, source(s) of the knowledge of the benefits, the level of compliance to high-kV technique and the possible factors affecting compliance. Awareness of high kV as a technique recommendation from WHO was assessed by asking respondents to give a Yes or No response and the respondent's source of awareness. Compliance level was assessed by requesting the respondents to mention the kV applied routinely for PA chest X-rays in their centres, the reasons for the selection of a particular kV and whether the kV selection was a departmental or individual protocol.

Data analysis

Data analysis was done using Statistical Package for Social Sciences (SPSS) version 22.0. Data were subjected to descriptive statistics and analysed using Chi-square test. The probability value of $p < 0.05$ was considered statistically significant.

Results

Of the 82 questionnaires administered, only 77 were completely filled and returned giving a response rate of 94%. Out of the 77 respondents, only 74% ($n = 57$) were aware of high-kV technique as the recommended procedure for PA chest X-ray and departmental protocols (technique chart with exposure factors) were also non-existent in all hospitals/diagnostic centres used in this study. Results also showed that 40% ($n = 31$) of the respondents were males; 44% ($n = 34$) working in public hospitals only and 32% ($n = 25$) with less than five years of working experience were aware of this high-kV technique as the recommended procedure for PA chest X-ray examinations. Response on the benefits of the use of high-kV technique for PA chest X-rays (Fig. 1) showed that more than 50% of the respondents knew the benefits of using high-kV technique as the recommended standard projection for PA chest X-rays. Responses ranged from 77% ($n = 59$) for patient dose reduction to 51% ($n = 39$) for better imaging of the airways. Fifty-two percent ($n = 40$) of the respondents acknowledged that high-kV technique results in better imaging of the mediastinum, while 58% ($n = 45$) and 61% ($n = 47$) of the respondents agreed that the reduction of patient involuntary movement and reduction of ribs' obscuring effect on the lungs, respectively, were also benefits of the use of high-kV technique for PA chest X-ray. Compliance to the use of high-kV technique for PA chest

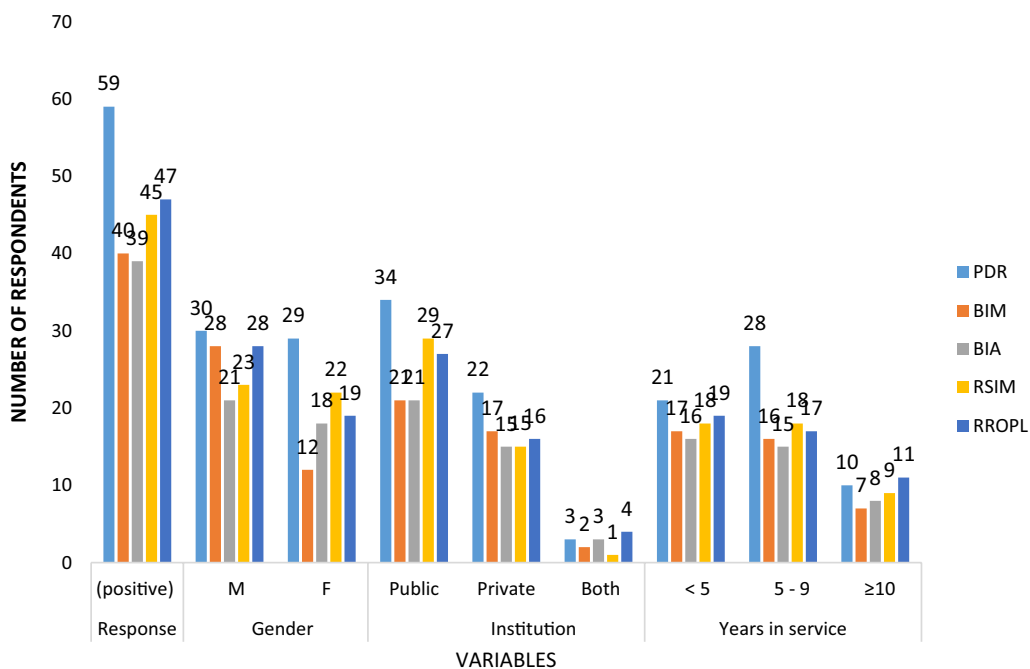


Fig. 1 Response on the reasons behind the use of high-kV technique for PA chest X-ray ($n = 77$). *PDR* Patient dose reduction; *BIM* Better imaging of the mediastinum; *BIA* Better imaging of the airways; *RSIM* Reduction in subject involuntary movement; and *RROPL* Reduction in rib's obscuring effects on underlying pulmonary lesion

X-rays (Fig. 2) showed that only 13% of the respondents ($n = 10$) complied with the use of high-kV technique for PA chest X-rays of average-sized adult patients. Factors influencing compliance to the use of high-kV technique

for PA chest X-rays (Table 1) showed that three out of the six variables affected the compliance of respondents to the use of high-kV technique as the standard technique for PA chest X-ray. These variables including imaging

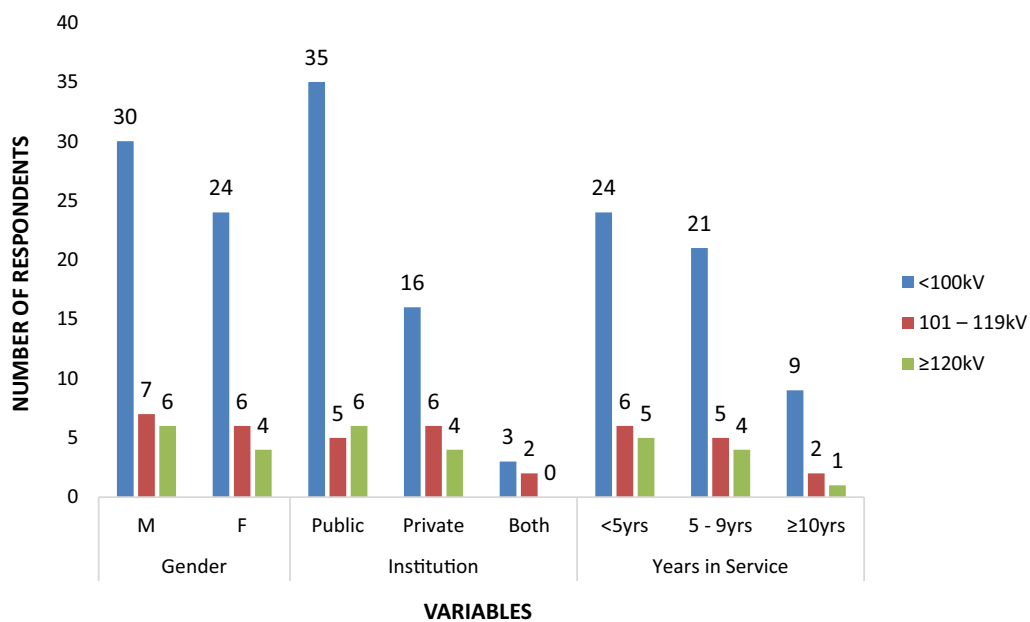


Fig. 2 Level of compliance with the use of high-kV technique for PA chest X-ray: $n = 77$

Table 1 Possible factors influencing compliance to the use of high-kV technique for PA chest X-ray: $n = 77$

Factors	Compliance		Total	Degree of freedom	chi value	p-value	
	Yes	No					
<i>Awareness</i>							
Yes	57	10 (13%)	47 (61%)	57 (74%)	1	6.0039	0.0642
No	20	0	20 (26%)	20 (26%)			
Total	77	10 (13%)	67 (87%)	77 (100%)			
<i>Years in service</i>							
<5	33	5 (7%)	28 (36%)	33 (43%)	2	4.7929	0.0910
5–9	30	4 (5%)	26 (34%)	30 (39%)			
≥ 10	14	1 (1%)	13 (17%)	14 (18%)			
Total	77	10 (13%)	67 (87%)	77 (100%)			
<i>Imaging system</i>							
Film/screen		0	18 (23%)	18 (123%)	1	4.8670	0.0273
Digital		10 (13%)	49 (64%)	59 (77%)			
Total		10 (13%)	67 (87%)	77 (100%)			
<i>X-ray tube rating</i>							
High		10 (16%)	52 (68%)	62 (81%)	1	4.1398	0.0419
Low		0	15 (19%)	15 (19%)			
Total		10 (13%)	67 (87%)	77 (100%)			
<i>Unit with preset exposure factors</i>							
Yes		8 (10%)	35 (46%)	43 (56%)			
No		2 (3%)	32 (41%)	34 (44%)	1	5.2403	0.0221
Total		10 (13%)	67 (87%)	77 (100%)			
<i>Type of hospital/diagnostic centre</i>							
Public		6 (8%)	40 (52%)	46 (60%)	1	1.4531	0.2280
Private		4 (5%)	27 (35%)	31 (40%)			
Total		10 (13%)	67 (87%)	77 (100%)			

system (film screen /digital), X-ray tube rating, X-ray unit with preset/manual exposure factors were statistically significant ($p < 0.05$), while awareness, years in service and type of institution were not significant ($p > 0.05$).

Discussion

The World Health Organization (WHO) has recommended the use of high-kV technique to ensure optimized practice for PA chest radiography. Evidences have highlighted remarkable successes using this technique, with good image quality obtained at significantly reduced doses to the patients (Lorusso et al. 2015; Masoud et al. 2015). Adherence to this recommendation, however, remains an issue in many settings (Ofori et al. 2014; Aliasgharzadeh et al. 2015).

The current study investigated the awareness and compliance to the practice of recommended high-kV technique for PA chest radiography among radiographers in South South Nigeria. Our study yielded an appreciable level of awareness, as a greater proportion of radiographers (74%) in this region had knowledge of the recommended high-kV technique for optimized chest

radiography. This trend was consistent among radiographers in private and public practice, and across the different years in service and the gender subgroup (Fig. 3). Observed high awareness was given from the survey to be due to the knowledge gained from attending the continuing professional development programmes (CPD) to update one's knowledge on new trends in the profession. From our survey, radiographers with years in service less than 5 years (40%) were as much aware of this high-kV recommendation as those who have been in practice for at least 10 years (32%) (Fig. 3). This suggests that the number of years in service did not influence the level of awareness of the practice of high-kV technique in this region. The present study showed that compliance to the use of this technique was low, meaning knowledge gained did not translate into adherence to this recommended optimized practice in this region over the years. Poor knowledge based on radiation protection measures has also been reported as being responsible for poor compliance to evidence-based practices in some facilities in Nigeria (Ekpo et al. 2014). We expected that this high awareness would mean a considerably good level

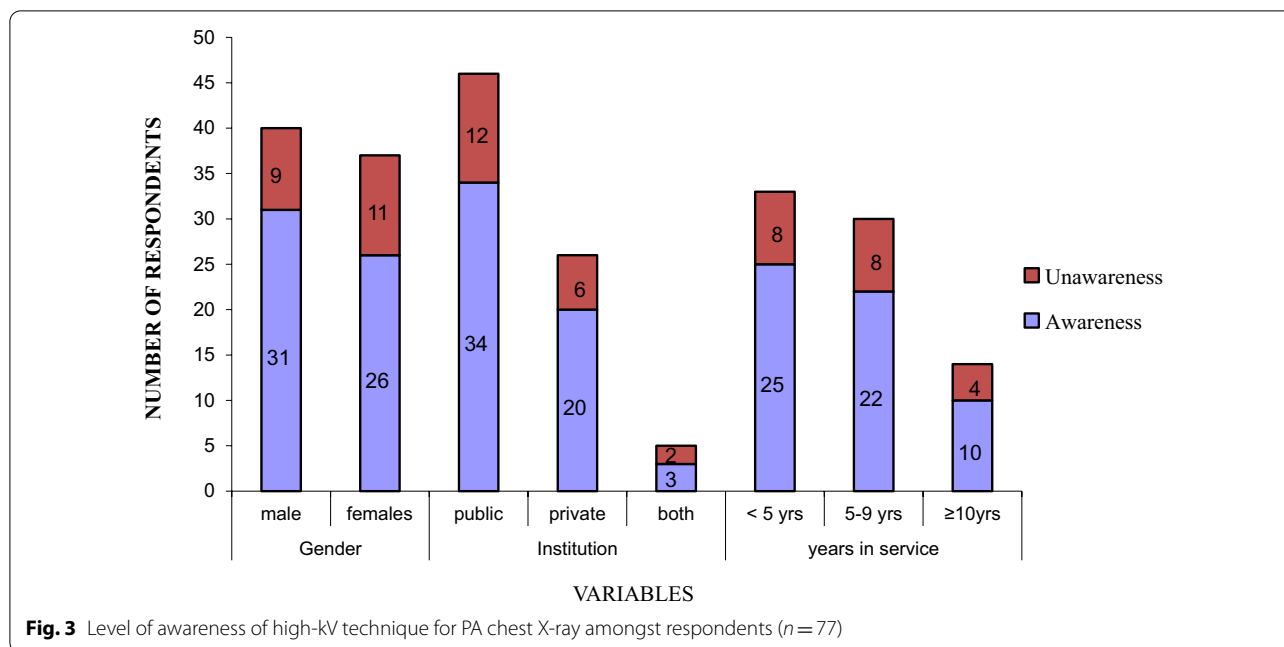


Fig. 3 Level of awareness of high-kV technique for PA chest X-ray amongst respondents (n = 77)

of compliance, but surprisingly this was not substantiated in this region. Only 13% of respondents accepted to have routinely incorporated this technique into PA chest X-ray for average-sized patients. The implication of this poor compliance is unnecessary radiation doses to patients during chest X-ray investigations. In this survey and related studies, facilities consistently used lower than recommended standard for chest X-ray, however, varied (Bamidele and Nworgu 2011; Ofori et al, 2014; Masoud et al. 2015; Aliasgharzadeh et al, 2015). The practice was similar in both private and public centres, as levels of compliance were comparable (Table 1). The survey revealed that the absence of departmental protocols for PA chest X-ray, imaging systems, X-ray tube rating and X-ray units with preset or manually set exposure factors, post-processing properties of digital radiography systems and performance characteristics of the X-ray unit underpinned observed low compliance (Masoud et al. 2015). Years in service did not change the trend in exposure settings. Low kV (< 100 kV) consistently ranked the highest tube potential settings in this region, followed by 100–119 kV, which was similar in public and private facilities. These low-kV settings were compared with the results of Bamidele et al. (2011), Zira et al. (2017) and Masoud et al. (2015). In a related study, Lorusso et al. (2015) noted that many facilities have not fully adopted the recommended optimized practice of high-kV technique as a departmental protocol. This low compliance to high-kV technique in this study, nonetheless, shows an improvement from an earlier study in Southwest Nigeria, which reported zero compliance (Bamidele and Nworgu 2011) (Table 1).

This and the outcome of our research raise concerns knowing the high number of prescriptions for PA chest X-ray examinations and the implication of poor compliance to recommended practice on patient care. These results emphasize the need for radiographers’ regulatory bodies and relevant stakeholders to organize training and implementation programmes for optimized practices and dose reduction strategies such as high-kV technique in radiography. According to Fauber et al. (2011), high-kV technique has the potential to substantially reduce patient dose during X-ray examination, regardless of the image receptor type. We expected knowledge of the benefits of high-kV technique to improve compliance with the said technique among radiographers in this region. While more than half of the respondents knew the benefits of using high-kV technique for PA chest X-rays, compliance was, however, low and did not improve even with the number of years in service. Our survey revealed patient dose reduction (PDR) as the number one reason for recommending high-kV technique for chest radiography, while the reduction in ribs obscuring effects on underlying pulmonary lesion followed after. Patient dose reduction was foremost among male and female respondents, radiographers practising in private and public health facilities and those with 5 to 9 years in service in this region. For those with at least 10 years in practice, reduction in rib’s obscuring effects on underlying pulmonary lesions ranked the highest. However, all reasons provided by the study for recommending this technique which included patient dose reduction (PDR), better imaging of the mediastinum (BIM), better imaging of the

airways (BIA), reduction in subject involuntary movement (RSIM) and reduction in rib's obscuring effects on the underlying pulmonary lesion (RROPL) were fairly represented in our survey. Besides the reduction of radiation dose to patients, penetration of dense mediastinum, lung tissue behind the heart, diaphragm and lung bases strengthened reasons for high-kV technique in chest radiography patients (Bontrager and Lampignano 2014; Kahn and Santos 2015; Slavtchev and Manolov 2016). The concept of high-kV/low-mAs technique is a radiation dose reduction measure which produces more penetrating X-ray photons with less radiation dose to patients and has been shown to reduce entrance skin dose (ESD) by 20% while maintaining acceptable image quality (Lorusso et al. 2015). The survey underpins the performance characteristics of the X-ray unit (X-ray tube rating, preset and manually set X-ray unit) and the type of imaging system as factors influencing compliance to the recommended high-kV technique for PA chest X-ray. Fauber et al. (2011) noted that the transition from film-screen to digital imaging was responsible for the practice of low-kV technique in most non-adherent settings and that radiographers tend to apply low-kV settings leveraging the wide dynamic range in digital imaging systems. The tendency to use low kV and post-process is high, since digital imaging system allows the detection of both low and high intensities (Fauber et al. 2011).

The overall implication of this low level of compliance indicates a potential increase in ionizing radiation dose to the patients and poor image quality. This survey is not without limitations as only a few facilities in South South Nigeria were included. However, the three included cities have the highest concentration of hospitals and diagnostic centres in South South Nigeria. In addition, the survey did not explore possible disadvantages of the use of high-kV technique.

Conclusions

In this study, the level of compliance to the use of high-kV technique as standard for optimized PA chest was low (13%) despite the awareness (74%) of this and its attendant benefits. The absence of departmental protocol for PA chest X-rays, performance characteristics of the X-ray unit and type of imaging system are some reasons for the low compliance to the high-kV technique in this region. There is a dire need to improve adherence to this recommended technique through deliberate professional measures, which include training, workshop, implantation and monitoring.

Abbreviations

PA: Postero-anterior; kV: Kilovoltage; mAs: Milliampere seconds.

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Not applicable.

Author contributions

EE and ME conceived the idea of assessing the level of compliance of radiographers in South South Nigeria to the recommended high-kV technique in chest radiography. AE, EE and ME wrote the first draft. EE, NC and NE designed the study, generation, processing and analysis of the data. EE, AE NC and NE wrote the final draft. All the authors read and approved the final manuscript.

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Availability of data and materials

Data for this study are available any time from the corresponding author, Dr. Emmanuel O. Esien-umo.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the ethical research committee of the department of Radiography and Radiological science, faculty of Allied Medical sciences of the University of Calabar with reference number UC/ECRA/19/010. The consent to participate was not applicable in this study.

Consent for publication

Not applicable.

Competing interests

Authors have declared that no competing interests exist.

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