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Assessment of entrance surface air kerma in patients undergoing chest X-ray from conventional diagnostic radiology in Ogun State, Nigeria

L.R. Owoade*, Isa Sambo and S.A. Tijani

National Institute of Radiation Protection and Research, University of Ibadan, Ibadan, Nigeria.

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Due to the universality and high percentage demand of chest X-rays and the importance of this examination in diagnostic radiology, there is a strong need for the assessment of its entrance surface air kerma. Entrance surface air kerma (ESAK) has been measured for a total of 60 patients undergoing posteroanterior chest x-ray from conventional diagnostic radiology in three diagnostic centers in Ogun State, Nigeria. ESAK was measured based on the x-ray equipment output obtained from a CONNY II dose rate meter. The entrance surface air kerma for the selected hospitals A, B and C are 0.20, 0.30 and 0.43 mGy, respectively with an average of 0.31 mGy. Variance analysis was performed to evaluate the significance of the difference between the entrance surface air kermas. The variation in entrance surface air kerma found among diagnostic centers in this survey showed that there is need to assess radiological techniques of x-ray examination and the personnel, among different diagnostic centers. In addition, when the ESAK average value is compared with other average values in some countries, it showed that the ESAK for Nigeria in chest PA examination is higher than other countries except Iran. This shows that optimal protection of patient against excessive radiation dose is possible by improving the influencing factors in diagnostic radiology examinations.

Key words: ESAK, posteroanterior, CONNY II, radiological techniques, optimal protection.

INTRODUCTION

Incident air kerma and entrance surface air kerma are two important quantities in x-ray diagnostic radiology (International Atomic Energy Agency, 2007). The use of x-rays as a medical diagnostic tool is increasing day by day. It is an established fact among all other artificial sources, it is the one with the largest contribution to patients and radiographers' radiation doses (UNSCEAR, 2000). In developing countries, the conventional radiography remains an important diagnostic tool compared with those of other imaging techniques, such as magnetic resonance imaging (MRI), computed tomography (CT) and digital radiography. A report of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), (UNSCEAR 2000) has concluded that unnecessary repeat of radiographic examination for the same patient is common in many countries around the world (Mettler, 2001). The report concluded that the radiation exposure of people has in-

*Corresponding author. E-mail: owoade.latifat@yahoo.com.

Table 1. X-ray equipment parameters of the studied hospitals.

Parameters	Hospitals		
	A	B	C
Name of machine	Mobile x-ray machine-520	GE medical system-500	Intermedical basic-100
Tube Output (mGy/mAs)	0.017±0.01	0.14±0.01	0.023±0.009
kV(mean)	66.55±19.99	62.80±4.70	73.45±14.38
mAs(mean)	47.10±6.77	4.52±1.38	40.60±8.65
BSF	1.35	1.35	1.35
FDD	100	100	100
FSD	180	180	180
Film speed	200	200	200

Table 2. Comparison of mean ESAK (mGy) values with values from other countries.

Examination	This study	Iran (2015)	UK (2010)	Saudi Arabia (2014)	Sudan (2010)
Chest PA	0.31	0.37	0.15	0.14	0.23

creased for medical radiations all over the world, especially in countries where the mending and maintenance of the medical devices are yet to be fully developed (Rehani, 1995).

Thus, based on the concerns resulting from increasing exposure of the general public, the assessment of patients' radiation doses who were subjected to the conventional diagnostic radiography examinations was carried out in order to reduce patients' radiation exposure as low as reasonably achievable and now with particular attention to chest examination. It is generally recognized that even 10% reduction in patient dose is a worthwhile objective for optimization. The main aim of patient dosimetry with respect to x-rays used in medical imaging is to determine dosimetric quantities for the establishment and use of guidance level (diagnostic reference level) and a comparative risk assessment (ICRP 1990; Rehani et al., 1992; Rehani et al., 1995).

This study aims to evaluate the entrance surface air kerma for standard-sized patients in chest examinations in some hospitals in Nigeria, and to carry out comparison of data with some countries (International Commission for Radiation Units and Measurements, 2005).

MATERIALS AND METHODS

This study was carried out in three hospitals in Abeokuta, Ogun State. Hospital A, using mobile x-ray apparatus 520 unit, model F100 manufactured by Siemens, hospital B using GE medical system 500 unit model number, 2185226 manufactured by GE Private LTD Bangalore, India and hospital C using intermedical Basic 100 unit . All the x-ray units had a 2.5 mm Aluminum filter and all the studies were performed with grids. Sixty adult patients were monitored for the chest postero anterior radiological examination in general. Meanwhile, twenty patients were considered for each of the hospitals, taking into consideration the x-ray exposure parameters (kVp, mAs) and geometric parameters (Focus–Film distance (FFD), Focus–Skin distance (FSD) and the field size).

The patients' average weight was considered as 70±10 kg, and the obtained parameters were used to estimate patient doses from incident air kerma measurement (ICRP 1992; Hart and Wall, 2004). All the data related to geometric parameters and exposure after implementing the corrective actions were again collected (Rehani et al., 1995; (ICRP 1992). X-ray tube output was measured using a dose and dose rate meter – CONNY II made by PTW company with model number T11007-0411 (a semi conductor detector) which was calibrated for measuring the air kerma in the range 40 -150 measured in kVp. The tube potential was set between 50 kVp and 110 kVp in steps of 10 kVp and the desired amount of mAs (depending on convenient tube load condition). The radiographic exposure was performed and the mAs dosimeter readings was recorded. This was repeated three times for each similar adjustment of mAs and kVp and the average dosimeter readings determined (Rehani, 2001).

The dosimeter was positioned in the central beam axis at a preferable x-ray tube focal spot–detector distance of 100 cm. The radiation field size of10 cm ×10 cm at focal spot–detector distance was set to cover the detector completely in the useful beam to avoid the possible influence of scatter radiation to the dosimeter. The X-ray tube output was determined as the ratio of average dosimeter reading (incident air kerma) to the tube current - time product used for the tube voltages. Entrance Surface Air Kerma (ESAK) was determined according to the relation:

$$\mathrm{ESAK} = \frac{(\mathrm{Tube\ Output}) \times \mathrm{mAs} \times \mathrm{BSF} \times (\mathrm{FDD})^2}{(\mathrm{FSD})^2} \quad (1)$$

Where FSD is x-ray tube focus-skin distance and FDD is x-ray tube focus-detector distance (Table 1).

RESULTS AND DISCUSSION

Table 2 and Figure 1 presents the comparison of dose levels to patients in Nigeria, in terms of entrance surface air kerma values with other countries like Sudan, United Kingdom, Saudi Arabia and Iran (Akbar et al., 2015;

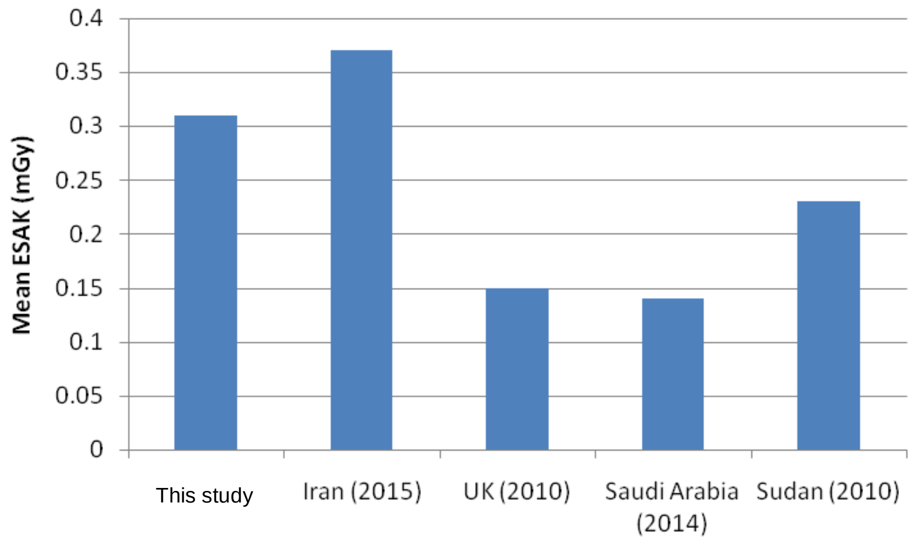

Figure 1. A bar chart showing the variation of ESAK from this study with other countries.

Table 3. Mean ESAK for the three hospitals.

Hospital	Mean ESAK (mGy)
A	0.20
B	0.30
C	0.43

Table 4. Significance P-values for each comparison between means of ESAK obtained using ANOVA in the statistical difference.

Hospital comparison	P-value	Significance
A and B	0.289	>0.05
B and C	0.132	>0.05
A and C	0.041	<0.05

Osman et al., 2010). Determination of entrance surface air kerma values are very important in assessing the doses to patients and which eventually would help in optimizing radiation doses to patients in diagnostic radiology. The mean ESAK in mGy were 0.20 in hospital A, 0.30 in hospital B and 0.43 in hospital C and this is shown in Table 4.

Table 3 shows the differences in the values of ESAK collected from hospitals A, B and C. From the ANOVA analysis, it could be seen that there is no significance difference from the data obtained for mean ESAK in hospital A and B, so also hospital B and C. But there is significance difference in the mean ESAK for hospital A and C. All the machines were not AEC and the exposure parameters were selected manually by the radiographers. The higher value of C could be a malfunction of the machine and the age of the machine.

Furthermore, in the comparison of the ESAK obtained from this study with other ESAK values from Sudan, United Kingdom, Saudi Arabia and Iran. Saudi Arabia has the lowest ESAK at 54.8% lower, followed by United Kingdom by 51.6% and Sudan with 25.8% difference. Only Iran has a higher value of 19.4% than the Nigeria's value. From the comparison, it is clear that much could still be done to reduce the EASK value as low as possible by improving this study radiological techniques, the type of machines used and the personnel involved.

Conclusion

Determination of patient doses or ESAK values and their comparison are an important part of the optimization process in diagnostic radiology. A comparison of average ESAK from a specified imaging procedure with diagnostic reference levels should identify unusually high or low doses for that particular procedure. Each hospital should establish their own ESAK levels that are appropriate to their equipment, exposure parameters and patient size in order to optimize patient protection. Results from this survey has shown that most entrance surface air kerma values in the investigated hospitals need to be improved upon by the regular assessment of their radiological techniques of x-ray examination and the personnel in charge. Furthermore, there is need to establish dose reference level in Nigeria.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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