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Full Length Research

Evaluation of radiation doses delivered to patients during conventional pelvis radiographic imaging in selected Nigerian hospitals

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ABSTRACT: Diagnostic X-ray procedures remain the largest contributor to the population dose from man-made radiation sources; therefore, there is need for evaluation of the health risks connected with the use of ionizing radiation in X-ray examinations. The aim of this study is to investigate radiation dose in pelvis imaging procedures in some diagnostic centers in Southern part of Nigeria. Entrance Surface Air Kerma (ESAK) was calculated using exposure parameters obtained during examinations. A total of 160 adult patients undergoing pelvis AP radiography in nine (9) hospitals having ten X-ray centers were considered in the study. The mean ESAK calculated ranged from 1.08 to 16.16 mGy for pelvis AP and ranged from 1.15 to 10.06 mGy for pelvis LAT. Wide variations were found in the dose values obtained from various X-ray units even within the same center. The doses estimated in this study were found to be lower, when compared with the NRPB-HPA 2010 review for UK.

Keywords: Dose optimization, Entrance Surface Air Kerma, radiation dose, X- ray procedures.

INTRODUCTION

Radiation dose measurements serve as sources information to the medical practitioners on the levels and the risks associated with the diagnostic procedures. The need to keep doses as low as reasonably achievable (ALARA) has been advocated for over the years (ICRP,1990) due to increase in the risk of stochastic radiation detriment to the patient by small radiation doses. The potential of reducing dose is to focus on the establishment of local reference levels (DRLs), continuous optimization of examination protocols and successive downward revising of national dose reference levels (NDRLs). These had been shown in United Kingdom by the National Radiological Protection Board (NRPB) through dose survey (NRPB, 2012).

In Nigeria, the diagnostic reference levels (DRLs) which is one of essential mechanism for controlling patient dose to enable it fulfilled the medical purpose of x-ray examinations have not been published (Jibiri and Olowookere, 2016; Akpochafor et al., 2016). This is due to the lack of efficient and dynamic regulatory control of X-ray facilities in Nigeria. There is therefore the need for regular monitoring of the facilities to assess radiation risk to an average patient undergoing X – ray examination. Also, monitoring pelvic X-ray examination is important in that the reproductive organs of patients are either in the primary beam of the X-ray; or in close proximity to it. This means that the radiation risk to the patient and future generations are much higher in pelvic examination than other part of the body in which gonads are farther from the X-ray examination. Hence, it is imperative to investigate radiation dose obtained during pelvic X-ray examination to ascertain the possibility of dose reduction.

Therefore, this study aimed at examining the radiation dose to patients during pelvic X-ray examinations in ten selected X-ray centers in Southern part of Nigeria; and to compare the results with the reference doses in the

Table 1. Patient information and exposure parameters for pelvis AP in all centers.

Hospitals	No of Patients	Patient mean Age (years)	Patient mean weight (kg)	Mean FFD (range) (cm)	Mean kVp (range)	Mean mAs (range)	Mean field size (cm x cm)
OAUTHC	30	42 (19-70)	69(68-84)	118 (105-122)	75(55-81)	40(25-63)	40 X 50
UTH	12	46(36-63)	70(68-75)	109(97-124)	77(70-85)	29(20-40)	30 X 40
CH	10	42(18-60)	70(70-75)	90(90-92)	96(90-110)	170(80-250)	30 X 40
FMC	14	37(19-74)	67(60-71)	100(81-124)	84(75-85)	31(25-32)	40 X 50
LTH1	20	35(28-50)	72(65-80)	92(80-114)	95(70-100)	42(40-50)	40 X 50
LTH2	10	34(26-39)	67(60-73)	111(100-128)	75(73-76)	38(36-40)	40 X 50
OAMH	13	67(60-70)	67(65-72)	114(110-120)	82(81-87)	30(25-40)	40 X50
ADC	20	35(27-50)	70(65-80)	92(82-114)	96(70-100)	41(40-50)	40 X 50
UBTH	16	54(25-76	73(60-85)	118(110-130)	82(81-87)	30(25-40)	45 X 50
TTPC	15	40(18-60)	73(70-75)	91(90-92)	95(90-110)	160(80-250)	35 X 40
UK Guidelines	NA	57(16-100)	71(41-130)	NA	77(68-90)	30(25-32)	NA

literature.

MATERIALS AND METHODS

This study was carried out in ten selected X – ray centers in nine (9) hospitals in Southern Nigeria using guidelines published in European Commission Guidelines (EC, 1999). The hospitals investigated include University of Benin Teaching Hospital (UBTH), Benin City; University Teaching Hospital (UTH), Ado Ekiti; Oba Adenle Memorial Hospital (OAMH), Ilesa; Two Tees Diagnostic Centre (TTPC), Ibadan; Obafemi Awolowo University Teaching Hospital Complex (OAUTHC); Wesley Guild Hospital Ilesa; Ayinke Diagnostic Center (ADC), Ilesa; Federal Medical Center (FMC), Ido Ekiti; Central Hospital (CH) Benin City; Two X-ray centers were considered in Ladoke Akintola University Teaching Hospital (LTH1 &LTH2), Osogbo. The survey was carried out between May 2014 and August 2019.

The following exposure parameters: tube potential (kVp), focus to film distance (FSD), tube load (mAs), filtration (inherent and added), thickness of the irradiated region of each patient, exposure projections (AP, PA) were recorded during the examinations. Patient anthropometrical data such as height, weight, sex and age were obtained and recorded at the time of examination.

A total of 160 adult patients undergoing pelvis diagnostic examinations were included in the investigation and their mean weight were within 70 ± 3 kg which is the representative of an average adult patient recommended by Commission of European Communities as standard weight (EC, 1996).

All the X-ray machines are three-phase (6 or 12 pulse) models or high frequency generators. Partial quality control (QC) of the machines were carried out using calibrated QC kit (NERO^{TM} 6000M, manufactured by Victoreen, INC, Cleveland, Ohio, USA). The outputs of the machine were measured at a tube potential setting of 80 Kv; and tube load of 10 mAs at a distance of 1 metre. The output of the machines (mGy/mAs) were measured using calibrated QC kit.

The patient dose was evaluated through the assessment of Entrance Surface Air Kerma (ESAK) from the X-ray exposure factors (kVp, mAs, FFD) using the semi empirical formula as recommended by IAEA protocol and code of practice (IAEA, 2007). The value of ESAK was calculated using the empirical formula:

$$ESAK = Y(d)\ x\ mAs\ x\ \left(\frac{d}{FFD - t_p}\right)^2 x\ BSF$$

Where Y(d) is the X-ray tube output at distance 100 cm normalized by 10 m As, FFD is the focus-film-distance, where, t_p is the patient thickness and BSF is the backscatter factor, which depends on tube potential, device filtration and the size of radiation field (ICRU, 2005; IAEA, 2007).

RESULTS AND DISCUSSION

Patient information and exposure parameters in all X-ray centers are presented in Table 1. Patients' age ranged from 19 to 72 years and the mean weight ranged 67.0 to 73.0 kg. It can be seen from the Table 1 that the focus – to – film distance (FFD) employed were generally within the value recommended by European Commission (EU, 1997) for best practices except in CH and OAMH where FFD as low as 80.0 and 90.0 cm were used instead of the FFD of 100.0 to 150.0 cm with mean value of 115.0 cm suggested by European Commission. The mean kVp in most centers were higher than the mean kVp in UK-2010 review.

Table 2 shows the distribution of ESAK values for individual patient for pelvis AP in all the centers. The ESAK values ranged from 0.18 mGy in OAUTHC to 22.45 mGy in CH, which shows a wide variation of dose values for the same type of examination. Also, the range factor (RF)

Table 2. Distribution of Entrance Surface Air Kerma (ESAK) values (mGy) for pelvis AP.

Hospitals	Number	Min	1st quartile	Median	Mean	3rd quartile	Max	Max/Min
OAUTHC	30	0.18	1.91	2.11	2.26	2.86	4.74	26.33
UTH	12	0.90	0.92	1.01	1.08	1.20	1.42	1.58
CH	10	6.80	15.68	15.70	16.17	20.21	22.45	3.30
FMC	14	0.99	1.06	1.06	1.52	1.07	2.49	2.52
LTH1	20	0.97	1.33	1.38	1.34	1.47	1.49	1.54
LTH2	10	0.87	1.25	1.46	1.34	1.56	1.61	1.83
OAMH	13	2.77	2.81	2.99	3.29	3.04	5.15	1.86
ADC	20	1.38	1.76	2.14	1.97	2.27	2.39	1.73
UBTH	16	1.13	1.23	1.65	1.93	2.18	3.18	2.74
TTPC	15	0.98	1.05	1.06	1.08	2.01	2.36	2.41

Table 3. Comparisons of ESAK from this study with other studies.

Hospitals/Organizations/ DRLs	Pelvis AP (ESKAs mGy)
OAUTHC	2.26
UTH	1.08
CH	16.17
FMC	1.52
LTH1	1.34
LTH2	1.34
OAMH	3.29
ADC	1.97
UBTH	1.93
TTPC	1.08
EC (1999)	10.0
[a]UK (2005)	4.0
[b]Canada (2012)	2.5
IAEA (2004)	10.0
[c]Iran (2014)	2.7
[d]IAEA (2008)	3.8
[e]UK (2012)	3.90
[F]Nigeria (2016)	6.60

[a]Hart et al. (2009); [b]Tonkopi et al. (2012); [c]Minaei et al. (2014); [d]Muhogora et al. (2008); [e]Hart et al. (2012); [f]Jibiri and Olowookere (2016).

which is defined as the maximum/minimum ratio is 26 in OAUTHC shows a wide variation of dose values within the same hospital. There were differences in the dose values obtained within the same hospital and different hospitals. The wide variation in dose values for the same type of examination is an indication that the operational conditions were not fully optimized. The differences in dose values may be due to the differences in patient body mass index, the choice of exposure factor, differences in technique by individual operators and machines performance.

Comparison of mean ESAK values in this study with other studies is shown in Table 3. Results have shown that the mean ESAK values were lower than the values from other studies and also were well below the internationally recommended DRLs by the IAEA and European commission (IAEA, 2004; EC, 1999) except in CH where the value ESAKis 16.17 mGy.

Conclusion

Evaluation of doses to patient or determination of entrance surface air kerma values and their comparison with diagnostic reference levels are an important aspect of the optimization process in diagnostic radiology. In this study, the Entrance Surface Air Kerma (ESAK) were estimated using exposure factors in nine hospitals consisting ten units in Southern part of Nigeria. The results were compared with other studies and with the recommended DRLs. Generally, the patient doses obtained were lower than the recommended levels but there are wide variations in dose values in the same centre. The observed dose variations could mean unjustified risk to patients undergoing similar types of radiographic examinations and that dose reduction is possible without affecting radiographic image quality. However, the spread of dose values for the same type of examination is similar to what obtained in other studies in Nigeria and other African nations. This shows that it is very important to monitor and control doses to patients during imaging procedures in the diagnostic radiology departments and that the doses delivered to patients in any imaging procedures should be fully optimized.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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