The Association Of Radiographers Of Nigeria
EYE OF MEDICINE

JOURNAL OF RADIOGRAPHY & RADIATION SCIENCES

ISSN: 1115- 7976 Vol 32, Issue 1, May 2018

The Official Journal of The Association of Radiographers of Nigeria

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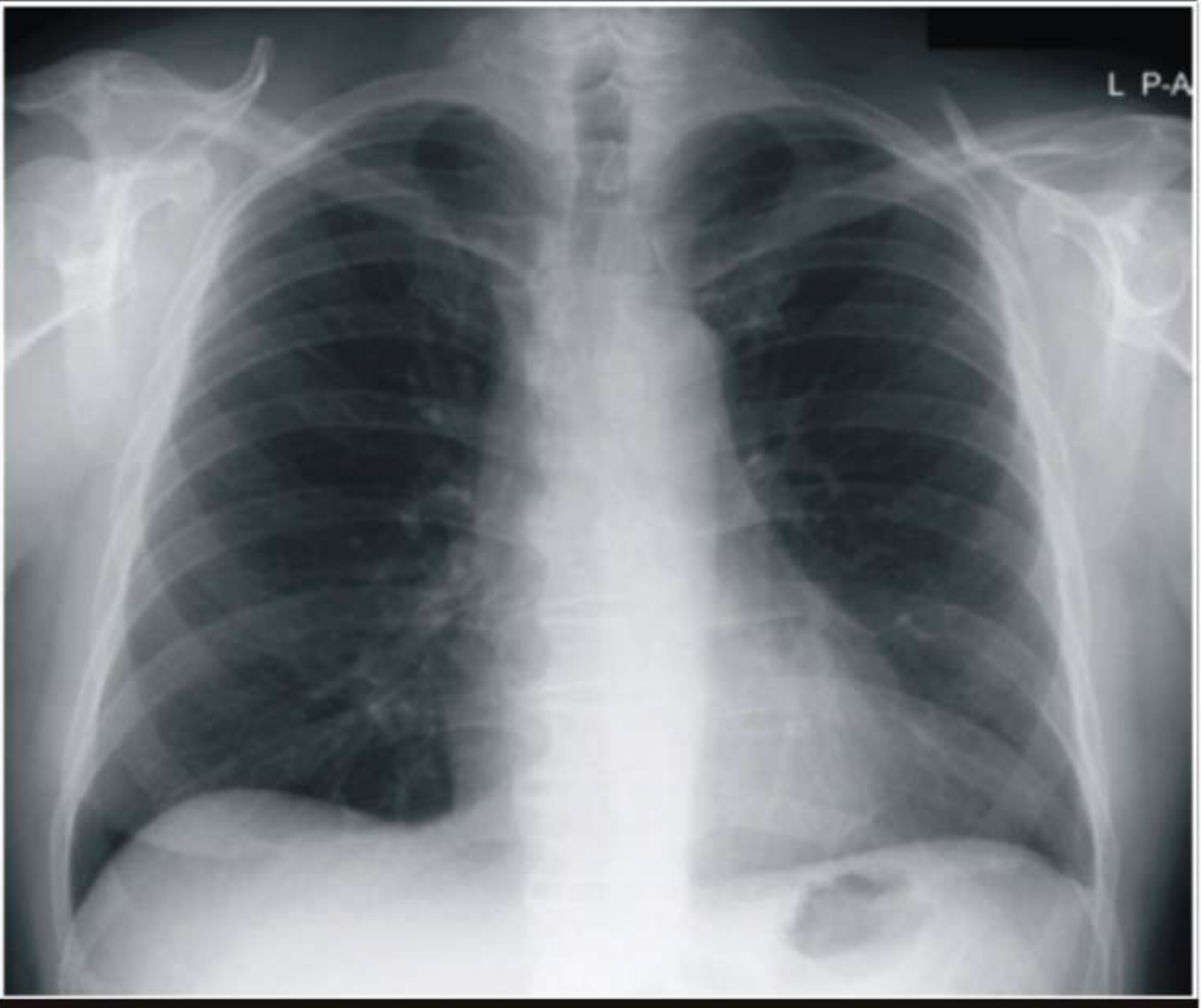

Journal homepage: www.jarnigeria.com

Accuracy of X-Ray Exposure Parameters in some Radio-diagnostic Centres in Kaduna State, Nigeria

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Received: 30 April, 2018. Received in revised form: 21 May, 2018. Accepted: 24 May, 2018

ABSTRACT

Background: Dose levels in radio-diagnostic settings depend largely on equipment status and examination techniques. It is essential to carry out quality control (QC) on the x-ray systems to ensure proper optimization and the maintenance of quality for better diagnostic outcome, and to avoid the risk of injury.

Objective: To carryout QC for the assessment of the accuracy of exposure parameters for the purpose of optimization of radiation protection.

Methodology: Quality control measurements including tube output, kVp, mA and timer accuracy, linearity and reproducibility were carried out using a multi-function quality control kit, RMI, 181B and measuring tape.

Results: The results of these measurements indicate that the tube output of the machines within the kVp range of 60 to 120 falls between 13.52 x 10^{-3} and 161.26 x 10^{-3} with a linear relationship between the kVp and tube output in all the hospitals. It also showed exposure parameters' operation to be within tolerance limits except in a single hospital with aspects of out-of-range performance.

Conclusion: All equipment under study functioned within safe limits but further investigation and corrective action is required in one of the centres.

Key words: Quality control, optimization, x-ray, tube output

Introduction

X-ray is considered to be the major man-made contributor to collective effective dose to the population [1]. Radiation from x-ray also has potential cancer risks [2]. Though x-rays are extensively used all over the world for diagnosis of diseases and injury, improper use can produce biological damage because of their ionizing nature [3]. This calls for control through various means of optimization to reduce the risks.

Diagnostic reference levels (DRLs) have become popular of recent due to its efficacy in dose reduction. The tripods on which this concept rests are specific examinations, standard size patients and equipment characteristics [4]. As a result, the starting point in DRL may be an investigation of equipment status. Quality control (QC) is crucial in defining equipment characteristics, which is crucial when DRLs is to be determined.

In Nigeria, regulatory control on x-ray installations is lacking, as less than 5% of these installations operate under license and supervision [5]. Weak national and state control on x-ray facilities has led the proliferation of x-ray diagnostic centers in Kaduna state with doubtful attention to standards.

The goal of quality control, besides dose reduction, is to reduce cost through the elimination of unproductive imaging caused by inefficiency of the devices used in the chain of operation [6].

Exposure parameters such as kVp and mAs used in day-to-day x-ray examinations in the hospitals are the major determinants of x-ray tube output and dose to the patients [7]. Studies have shown various levels of dose variability for the same x-ray examination within and between hospitals and have been attributed to suboptimal imaging equipment performance and poor technical skills of operators [8, 9, 10, 11]. Therefore, investigation into some of these variables is important for appropriateness and reduction in dose.

From anecdotal experience of the authors, most x-ray facilities in Kaduna state have no periodic institutional quality control program in order to detect actionable sources of errors. Therefore, the aim of the present study was to carry out quality control on the x-ray machines used in selected hospitals in Kaduna State as a preliminary to the estimation of DRLs in these facilities. The objectives of the study was to assess the age, x-ray tube output variation with kVp, tube potential and timer accuracies of the x-ray devices included in this study for the purpose of optimization of radiation protection.

Materials and methods

The QC measurements were carried out using the multi-function QC kit, RMI model 181B, with kV, mA and timer accuracy meters. The survey was carried out in four major referral hospitals which serve a vast majority of the population, offering both specialized and routine clinical services. These include Ahmadu Bello University Teaching Hospital, Zaria (A), Nigerian Army Reference Hospital (B1 and B2), Nigeria Air Force Aeromedical Hospital (C), and Barau Dikko Teaching Hospital (D). Specific machine information was obtained from the tubehead and technical manual of the x-ray systems. These include the model/make of the machines, manufacture and installation dates, technical parameters and quality control records. A measuring tape was used to measure distance.

Quality Control Test

The kVp meter was placed on the x-ray table. The x-ray beam with the central ray was positioned at a focus-meter distance of 100 cm, perpendicular to the centre of the meter sensor. The beam was collimated to the size of the detector. Exposure was made using set parameters of 60 kVp and 10 mAs. The meter reading was recorded. This process was repeated three times using the same set of parameters and the mean meter reading was recorded.

The procedure was conducted for kVp range of 60 to 120 used in practice at a constant tube current of 10 mAs. The values displayed were recorded. This was repeated and the accuracy, reproducibility and linearity performance were noted. The tube output test was carried out using the radiation output meter with same detector-x-ray tube arrangement as above. Repeated exposures were made with variable kVp of 60, 80, 100 and 120, at a fixed tube current of 8mAs. The exposure in milli-roentgen (mR) was multiplied by a factor of 0.00877 to convert to output in mGy/mAs [12].

The timer accuracy was determined using the timer accuracy meter. The tube voltage was set at 80kVp and tube current of 400 mA. The time was varied and set at 10, 20, 30 40 and 50 milliseconds during exposures. The mean timer reading and percentage variation between the nominal and the recorded time was computed. The summary and comparison of the QC test with AAPM recommendations [13] were done.

Results

Table 1 shows the result of the specific technical parameters of the x-ray machines that were considered in this study. The x-ray machines in hospitals A, B1 and D were static 3-phase units, while the machine in hospital B2 was a mobile x-ray system. The minimum total tube filtration in the study was 2.5mmAl. There was absence of QC records in all the hospitals.

Tube Voltage Accuracy

Table 2 presents the results of the tube voltage accuracy in respect of the nominal kVp and the actual kVp measured during exposure. The tube voltage accuracy measurements indicate that there were variations in percentage deviation among the hospitals. For the x-ray machines in hospitals A, B1, B2 and C, the mean deviation was less than 5%. The device in hospital D deviated more than the normative values.

Timer Accuracy

Table 3 presents the results of timer accuracy test. All the units had timer percentage variation measurements between 2.3% in B1 to 40.0% in D. A summary of the results of the accuracy performance of the exposure parameters is shown in Table 4.

Table 1. X-ray machines technical information

		Hospital				
S/No	**Factor**	**A**	**B1**	**B**	**C**	**D**
1	Machine model	Silhoutte VR	DRF	AMX4	Allengers	Multi Hase
2	Manufacturer	GE	GE	GE	Toshiba	Siemens
3	Manufacture date	2004	2010	2010	2010	N/A
4	Year of installation	2005	2013	2013	2013	2004
5	Total tube filtration	2.5	2.5	2.6	2.5	3.0
6	kVp maximum	150	150	125	125	125
7	mAs maximum	600	600	300	300	320
8	Last QC date	NIL	NIL	NIL	NIL	NIL
9	Last repairs	04/2016	N/A	N/A	N/A	N/A
10	Acceptance Certificate	N/A	N/A	N/A	N/A	N/A
11	Phase	S***	S***	M*	S***	S***

(N/A= Not Available, QC = Quality control, S*** = Static 3-phase unit, M* = Mobile unit)

Table 2. Tube voltage (kVp) accuracy measurements

Nominal	Hospital; kVp (% deviation)				
kVp	A	B1	B2	C	D
60	63.07 (5.0)	61.43 (2.4)	61.20(2.0)	58.80 (2.0)	51.50 (14.2)
70	71.00 (2.9)	71.02 (1.9)	69.20 (1.7)	69.00 (1.4)	64.00 (8.6)
80	81.61 (2.0)	80.50 (2.0)	80.06 (0.08)	79.07 (0.4)	73.00 (14.0)
90	92.13 (2.4)	93.13 (2.4)	92.30 (2.6)	89.90 (0.4)	81.00 (11.3)
100	102.03 (2.0)	103.60 (3.6)	105.10 (5.1)	102.50 (2.5)	89.00 (11.0)
110	113.83 (3.5)	114.63 (4.2)	114.90 (4.5)	112.27 (2.0)	101.00 (8.2)
120	124.77 (4.0)	126.33 (5.3)	126.80 (6.5)	123.17 (2.6)	111.00 (7.5)
Mean deviation	3.1 %	3.1 %	3.2 %	1.6 %	10.6 %

Table 3. Timer accuracy measurements

Nominal time	Hospital; timer accuracy (% deviation)				
(ms)	A	B1	B2	C	D
10	12.00 (20.0)	12.20 (22.0)	11.90 (19.0)	9.50 (5.0)	6.00 (20.0)
20	22.00 (10.0)	22.00 (10.0)	21.50 (7.5)	22.20 (11.0)	14.20 (24.0)
30	32.00 (6.7)	31.80 (6.0)	28.90 (3.7)	27.90 (7.0)	21.60 (28.0)
40	41.80 (4.5)	42.00 (5.0)	42.00 (5.0)	42.30 (5.8)	31.00 (23.0)
50	51.80 (4.4)	48.85 (2.4)	52.10 (4.2)	52.50 (5.0)	39.00 (22.0)
Mean deviation	9.1 %	9.1 %	7.9 %	6.8 %	23.4 %

Table 4. Summary of QC tests in the hospitals

Parameter	AAPM Standard (2002)	Hospitals A	B1	B2	C	D
kVp Accuracy	±5%	WRS	WRS	WRS	WRS	OR
kVp Consistency	±10%	WRS	WRS	WRS	WRS	WRS
kVp Reproducibility	±10%	WRS	WRS	WRS	WRS	OR
Timer Accuracy	±5% (timer >10mS)	WRS	OR	WRS	WRS	OR
	±20% (timer <10ms)	WRS	WRS	WRS	WRS	OR

WRS = Within Recommended Standards, OR = Out of Range

Tube Output

The results of the x-ray tube output tests presented in Figure1 show that the highest tube output was recorded in hospital B1, B2, and C respectively. Hospitals A and D had the least outputs. The machine at hospital B2 showed sharp increase in output at tube voltages above 100 kVp. The variation between the highest and the lowest output for kVp range of 60 – 120 was (65.23 – 161.26) x 10^{-3} for B1 and (13.53 – 20.27) x 10^{-3} for D.

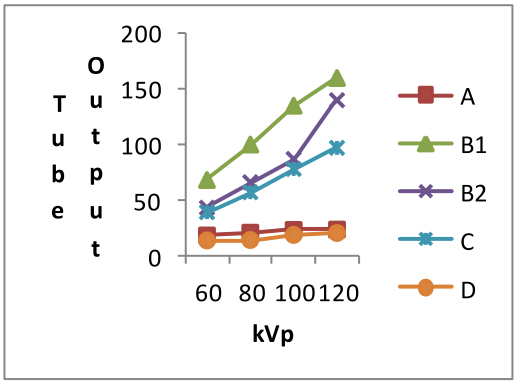

Fig. 1: Chart of x-ray tube output (x10^{-3}) mGy/mAs as a function of kVp

Discussion

The minimum total tube filtration recorded in this study (2.5) mmAl complied with recommended standards for diagnostic x-ray [13]. Tube filtration is necessary to remove low energy photons to ensure beam quality and to reduce unwarranted skin exposure. The absence of QC records in all the hospitals indicates the probability of lack of institutional QC program to check unproductive exposures. This is likely to increase dose overall as systemic malfunction can go undetected without QC.

The x-ray devices in hospitals B1, B2 and C were newer and had higher outputs of (65.23 – 161.20, 43.36 – 140.13 and 39.11 – 97.25) x 10^{-3} respectively, with good linearity and sensitivity to increase in kVp (Figure 1). Although A and B were linear, they exhibited poor response to increment in kVp.

Tube output is the single most important parameter to quantify radiation yield [14]. The sharp increase in output in B2 at kVp above 100 may be due to line voltage surge during operation. Such instability in voltage and the low outputs recorded in the devices in hospitals A (18.0 – 26.05) x 10^{-3} and D(13.52 – 20.27) x 10^{-3} may impact on image quality. Aging and workload could contribute to systems low output as a result of anode wear and tear [15]. The outlook of the curve in Figure 1 correlates with the plots in a study of the x-ray tube output in Nigeria [12] and Egypt [16].

The kVp accuracy, consistency, reproducibility and timer accuracy deviation were within the recommended AAPM limits [13]. The parameters measured at the device in hospital D were consistently out of the recommended range. Exposure time is one of the methods employed in the control of exposure. It is therefore imperative that exposure times are accurate to ensure appropriateness of dose to the patients and to maintain a balanced image quality. The inclusive range of deviation in this study was between 2.3 and 40.0 %. This is less than the 0.5 to 133.2% in an Iranian study [6].

Conclusion

The QC tests carried out to measure the stability of the x-ray machine parameters during exposure show most of the equipment performance to be sufficiently within recommended limits except hospital D where out-of-range performance was observed.

Recommendation

There is need for further investigation and remedial action on the system in hospital D. In addition, regular QC is recommended for all x-ray installations to forestall unproductive exposure of the population in the state.

Acknowledgement: My appreciation goes to all the radiographers in the centres studied for their immense assistance.

Conflict of Interest: None.

References

1 Hart D. and Wall BF (2002). Radiation Exposure of the UK Population from Medical and Dental X-ray Exposures. Didcot, UK. National Radiation Protection Board Report, NRPB-W4.

2 Linet MS, Slovis TL, Miller DL, Kleinerman R, Lee C, Rajaraman, P. and Dehorizakz, AB. (2012). Cancer Risk Associated with External Radiation from Diagnostic Imaging. Ca Career Journal, 62(2):75 – 100

3 Ajayi IR. and Akinwumiju A. (2000): Measurement of entrance surface dose to patients in four common diagnostic examinations by thermos-luminescence dosimetry in Nigeria. Radiation Protection Dosimetry. 87:217-20

4 ICRP (1996). Radiation Protection and Safety in medicine. International Commission on Radiological Protect Annals of ICRP 101.26 No. 2 1996 Pergamum Press, Oxford 1996

5 Elegba SB (2006). Radiation Safety Officer (RSO) in Diagnostic and Interventional Radiology". Keynote Address, University of Ibadan, Ibadan , Nigeria

6 Mehrdad G, Fataneh N and Vahid K (2015). The Evaluation of Conventional X-ray Exposure Parameters Including Tube Voltage and Exposure Time in Private and Governmental Hospitals of Lorestan Province, Iran. Iranian Journal of Medical Physics. 12(2):85 – 92.

7 Tran NT, Limoto T. and Ksako T. (2012). Calibration of kVp Meters Used in Quality Assurance Test of Diagnostic X-ray Units. Radiatiopn Protection Dosimetry. 148: 352 – 357.

8 Akpochofor, MA, Omojola AD, Adeneye SO, Aweda MA and Ajayi SB (2016). Determination of Reference Dose Levels Among Selected X-ray Centers in Lagos State, South West Nigeria. Journal of Chemical Science 13: 167 – 72

9 Winston JP, Karen B and Linda P (2003). Patient exposure and Dose Guide. CRCPD Publication E-03 – 22

10 Kwang-Hoong NG, Rassiah P, Wang HB, Hambat AS Muthurelu P, Lee AP. (1998) Dose to patients in routine X-Ray Examinations in Malaysia BJR (71):654-660

11 Ofori EK, Antwi WK, Scutt DN, Ward M (2013). Patient Radiation Dose Assessment in Pelvic X-ray Examination in Ghana. OMICS J Radiology 2: 151. doi: 10.4172/ 2167-7964.1000151

12 Oluwafisoye PA, Olowookere CJ, Jibiri NN, Bello TO, Alausa SK and Efunwole HO (2010)."Quality Control and Environmental Assessment of Equipment used in Diagnostic Radiology" in International Journal of Research and Reviews in Applied Science. 3(2):148 – 158

13 AAPM (2002). American Association of Physicist in Medicine: Quality Assurance in Radiology

14 Zoelief I, Van-Soldt RTM, Silimam II, Jansen JTM and Bosmans H (2006). Quality Control of Equipment used in Digital and Interventional Radiology. Radiation Protection Dosimetry 117 (1-3) 277 – 282.

15 Akaagerger NB, Agba EH and Ige TA. (2016). Diagnostic X-ray Machine Quality Control Parameter Analyses in some Major Hospitals in Benue State. International Journal of Reseach. 13 (12) 834 – 842

16 RadyAzzoz KM and ElShahat RAM (2014). Evaluation of Quality control systems for X-Ray machines at different Hospitals using patient's radiological dose assessment technology IOSR Journal of Applied Physics (IOSR-JAP). 6(5): 29-34.

How to cite: Ishiekwen AC and Aliyu AS. Accuracy of X-Ray Exposure Parameters in some Radio-diagnostic Centres in Kaduna State, Nigeria. J Rad & Radiat Sci, 2018; 32 (1): 64 - 69