CHALLENGES IN SETTING UP QUALITY CONTROL IN DIAGNOSTIC RADIOLOGY FACILITIES IN NIGERIA

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ABSTRACT

BACKGROUND
The Nigerian Nuclear Regulatory Authority (NNRA) was established to regulate and control the use of radioactive and radiation emitting sources in Nigeria. Quality control (QC) on diagnostic radiology equipment form part of the fundamental requirements for the authorization of diagnostic radiology facilities in the Country.

METHOD
Some quality control tests (output, exposure linearity and reproducibility) were measured on the x-ray machines in the facilities that took part in the study. Questionnaire was developed to evaluate the frequencies at which QC tests were conducted in the facilities and the challenges in setting up QC.

RESULTS
Results show great variation in the values of the QC parameters measured. Inadequate cooperation by facilities management, lack of QC equipment and insufficient staff form the major challenges in setting up QC in the facilities under study. The responses on the frequencies at which QC tests should be conducted did not correspond to the recommended standards; indicating that personnel were not familiar with QC implementation and may require further training on QC.

KEY WORDS: Quality control, challenges, exposure reproducibility, regulation, diagnostic radiology

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INTRODUCTION

In 1995, the Nigerian Nuclear and Radiation Safety Act 19 was enacted in Nigeria to establish the Nigerian Nuclear Regulatory Authority (NNRA) which started actual operation in 2004. The NNRA is empowered by this Act to regulate the use of nuclear materials and ionizing radiation sources. The NNRA publishes regulations guiding each practice conducted within its mandate. Diagnostic radiology uses among other methods, ionizing radiation (X-ray) for investigation of internal structure and pathologies which requires licensing from the regulatory authority for the facility to operate legitimately. Regulatory control over diagnostic radiology facility is to ensure that ionizing radiation is used in a manner that, the protection of life, property and environment from the harmful effect of ionizing radiation is ensured.

The regulations covering diagnostic radiology practice[1,2] require that the use of ionizing radiation in diagnostic radiology must be justified and optimized to ensure personnel, patient and public protection[3,4]. To achieve the required level of protection, the regulations stipulate principal requirements for the operation of diagnostic radiology facility. Among these requirements are quality assurance and quality control, organization and responsibilities, staffing, education and training, radiation safety and protection[1,2].

Quality assurance (QA) according to the World Health Organization (WHO) is an organized effort by the staff operating a facility to ensure that the diagnostic images produced are of sufficiently high quality so that they consistently provide adequate diagnostic information at the lowest possible cost and with the least possible exposure of the patient to radiation[5]. Quality assurance therefore encompasses quality control and the administrative procedures required to ensure quality in a diagnostic radiology facility. Quality control (QC) deals with all the techniques used in monitoring and maintenance of radiology equipment.

In view of the WHO definition of quality assurance in diagnostic radiology, it is important to note that quality assurance which is meant to assure the workers and

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public of their safety and optimal performance of equipment is a basic parameter in the list of principal requirements by the regulatory body[2, 6, 7]. In a previous study[6], Inyang et al examined the baseline implementation of quality control in diagnostic radiology facilities in some parts of Nigeria following the introduction of the Nigerian Radiation Safety in Diagnostic and Interventional Radiology Regulations[2] and the Nigerian Basic Ionizing Radiation Regulations[1]. In the study, it was observed that the level of implementation of quality control was low notwithstanding the fact that practitioners in diagnostic radiology facilities within the study area appreciated quality control implementation and its importance in their practice.

The study[6] by Inyang et al did not examine the challenges of setting up a quality control program in Nigerian diagnostic radiology facilities. The present study was therefore set up to acquire more data on diagnostic radiology QC in Nigeria. The study was conducted by measuring some quality control parameters and through the use of questionnaire.

METHOD

The x-ray equipments under study were subjected to some QC tests using a ratemeter-timer (model 3036) ionization chamber dosimeter that was factory calibrated. These tests which included exposure reproducibility, radiation output and linearity were conducted using methods described by Papp[8] and Lloyd[5], and the results of exposure reproducibility, radiation output and linearity were analysed using Equations 1, 2, and 3 respectively.

$$\text{exposure reproducibility} = \frac{(mGy_{max} - mGy_{min})}{(mGy_{av} + mGy_{min})} \quad 1$$

$$output = \frac{mGy}{mAs} \quad 2$$

$$linearity = \frac{\left[\left(\frac{mGy}{mAs}\right)_{max} - \left(\frac{mGy}{mAs}\right)_{min}\right] \div 2}{\left(\frac{mGy}{mAs}\right)_{average}} \quad 3$$

where $\left(\frac{mGy}{mAs}\right)_{max}$, $\left(\frac{mGy}{mAs}\right)_{min}$ and $\left(\frac{mGy}{mAs}\right)_{average}$ are maximum, minimum and average values of the ratio of exposure to the product of current and time (milliampere-second) of x-ray tube current and time. All measurements were taken at 100 cm source to detector distance (SDD), 80 kVp and 10 mAs except for linearity where the mAs values were varied.

A 23 item questionnaire was also designed to evaluate the challenges experienced by diagnostic x-ray facilities in setting up quality control and the frequencies at which QC tests were carried out. Part of the questionnaire that sought to evaluate the frequencies at which QC tests were conducted is presented in Table 1. The questionnaire used for this study was pre administered on five experienced radiographers and two radiologists to ascertain its reliability. Suggestions made by the radiologists and radiographers were incorporated into the questionnaire before its use as an instrument for this study.

35 facilities were selected for the study in the six States within the South-South geopolitical zone and the Federal Capital Territory (FCT) of Nigeria. Selection was based on accessibility of the facility, the willingness of the staff to participate in the study and the availability of three-phase x-ray machine in the facility. Personnel in some facilities visited were unwilling to participate in the study for fear of the data being used for regulatory assessment, the assurances to the contrary offered by the researchers notwithstanding. In each facility visited, the questionnaire was administered on the most senior radiology personnel found in the facility.

RESULT

Output values observed varied from 12.6 µGy / mAs to 226.4 µGy / mAs. The percentage deviations in output linearity and exposure reproducibility ranged from 2.1% to 8.7% and 0.8% to 29% respectively in the 35 diagnostic radiography facilities visited. 9 facilities had other x-ray machines that were not three phase, hence were not considered in this study. Data obtained from the questionnaire show that 40.0% of the facilities had the support of their management in setting up quality assurance program, 20 facilities, about 57%, had an established QC program while about 86% or 30 facilities were aware of regulatory requirements on QC in diagnostic radiology and all the facilities (100%) indicated that lack of QC equipment, high workload, lack of QC personnel, and low staff strength were the major challenges in setting up QC program.

Table 1 shows the frequencies at which different facilities conduct the different QC tests listed in the questionnaire. Tube warming was conducted daily in the facilities under study. Most of the facilities did not conduct kVp, mAs, apron cracking, exposure survey and shielding efficacy measurements and did not keep or use log books.

Table 1: Frequency of conduct of QC test

QC test	Daily	Weekly	Monthly	Annually	Not at all
kVp	0	0	0	5	30
mAs	0	0	0	5	30
beam alignment	8	7	9	6	5
white light leakage in darkroom	5	2	7	12	9
safelight in darkroom	3	5	10	14	3
grid alignment	10	9	0	5	11
tube warming	35	0	0	0	0
aprons cracking	0	0	0	5	29
electrical checks	3	7	12	6	7
viewing box cleaning	2	8	16	9	0
film storage	8	13	7	4	3
densitometry	0	3	17	8	2
recording of QC results	3	3	1	0	28
exposure survey	0	0	5	7	23
shielding efficacy	0	0	0	2	33
reject film analysis	0	0	18	5	12

DISCUSSION

The availability and use of radiology equipment is undoubtedly on the increase. The need to implement QC in diagnostic radiology cannot be over emphasized due to the sophistications involved in equipment design and manufacture, rapidly changing technologies, equipment wear and tear, and the desire for quality health services delivery. A good QC program is known to be useful in the early detection of defects and changes in the imaging process before the deterioration in the system becomes irretrievable. The radiation output values observed in this study varied greatly similar to those observed by Oluwafisoye et al[9] in their assessment of equipment used in diagnostic radiology. The output results obtained in this study could not be compared with existing values in any of the facilities visited as no facility had any record of previous measurements of radiation output. The lack of records on output results deprived the facilities of the benefits of using such results in the preparation of manual technique charts and calculation of patients'doses[10].

The deviations in output linearity and reproducibility of some equipment were greater than the maximum deviations of 5% and 20% respectively, recommended by AAPM[10] and IPEM[11] for x-ray equipment with optimal performance. In essence, most of the equipment considered in this study did not have proper tube current calibration since constancy in reproducibility is an indication of good calibration of tube current. The situation observed in this study may be attributed to the fact that most of the facilities did not have any history of QC implementation.

100% of the respondents identified lack of QC equipment, lack of QC personnel, low staff strength and high work load as the major challenges in setting up QC program. About 86% of the respondents maintained that they had knowledge of regulatory requirement concerning QC as one of the fundamental requirements for the licensing of a diagnostic radiology facility. This knowledge could not be reflected in the setting up of QC program due to lack of equipment. Though 40% of respondents claimed that the management of their facilities supported them in setting up QC program, this support did not translate into procurement of QC equipment, employment of sufficient QC personnel and reduction in workload to enable the personnel concentrate more in QC program. About 57% of the respondents accepted that QC program was established in their facilities. However, the lack of sufficient staff and equipment observed in this study may not yield significant impact in the facilities to bring about the benefits of QC implementation.

Most of the responses on the frequency of conducting QC tests were inconsistent with the standards proposed by AAPM[10]. All the respondents accepted that tube warming should be conducted daily. The observed inconsistency in the frequency of performing QC tests could be due to the level of staff training on QC. Non establishment of QC program in about 43% of

the facilities that participated in the study indicates that personnel in these facilities may not have adequate knowledge of experience on QC.

CONCLUSION

Most of the facility that took part in the study did not have any QC test performed on their equipment. The measured output values, exposure linearity and reproducibility varied greatly, with most of the deviations in these parameters higher than the maximum recommended by AAPM[10], IPEM[11] and Palmer and Walker[12]. The major challenges in setting up QC are non-adequate management support, lack of equipment and insufficient personnel. The personnel that took part in the study did not have adequate knowledge of the frequency at which QC test tests should be performed and may require further training to improve such knowledge.

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