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Short Commentary Open Access

Enhancing Quality Management through Effective Quality Assurance in Jamaican Radiology Centres

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Abstract

Objectives: To conduct a quality control assessment among Jamaican radiology facilities in a bid to create a consistent platform that can be employed as a standard for baseline radiation measurements and evaluation.

Methodology: A quad control kit was employed to conduct the reproducibility and accuracy test on 6 general radiography machines. 6 consecutive exposures were made for each of the following technical factors; 52 kVp at 6.30 mAs (mili-amperes per second) and 96 kVp at 25 mAs.

Results: The mean kVp value returned at facility 1, using high kVp technique was 96.4, facility 2 returned a mean value of 97.2 while facility 3 generated a mean of 97.1 kVp. This disparity was also identified among the other centres; facility 4 had a mean kVp reading of 96.7, facility 5 averaged 97.2 and facility 6, 95.2.

Conclusion: There is a need for national baseline standards to be coined outlining the frequency with which quality control checks are to be conducted coupled with suitable tolerance limits. It is also important that radiation workers be abreast of the tenets of the Jamaican Nuclear Safety and Radiation Protection Act.

Keywords: Quality assurance; Quality control; Kilo-voltage peak; Mili-ampere per second

Introduction

Quality assurance coins the basis for proficient operational assessment at facilities that utilize machinery and or human resource to provide a service. A quality assurance program is upheld by robust quality control procedures employed to evaluate operational practices with stipulated baseline tenets, developed to ensure quality standards are maintained. The use of radiation for medical purposes necessitates the need for a quality assurance program, which should be designed to ensure radiological equipment function optimally and provide the desired outcome. Therefore, the program must provide operational procedures or management actions stipulated to ensure all quality control procedures are accomplished accurately and in accordance with a predetermined time frame. Medical procedures such as diagnostic radiology, nuclear medicine and radiotherapy constitute the largest source of man-made exposure to ionising radiation. This highlights the importance of quality assurance where radiation is used in the diagnostic process. Quality assurance ensures that radiation exposure to patients, staff and the general public is kept as low as reasonably achievable (ALARA). To ensure the integrity of quality assurance programs checks of all the main components of the imaging system should be done. This, however, will be closely linked to some parameters such as the type of diagnostic tests performed, the type of equipment employed to conduct the tests and the patient load of the department [1].

Since the advent of x-rays, there has been an increase in its use for treatment and to a greater extent diagnosis of disease conditions. The use of x-rays is a very technical process that requires accurate dose measurements, calibration of the machines and radiation protection. To ensure that these parameters are maintained it is important that the machines operate within the confines of the factors selected to guarantee the safety of the patient, radiation worker and the general public. This paper seeks to highlight findings of a quality control assessment among Jamaican radiology facilities and offer recommendations where necessary. This in a bid to create a consistent platform that can be employed as a standard for baseline radiation measurements and evaluation. Tests conducted include; Reproducibility and Accuracy and light field/x-ray field alignment. A broad-spectrum observation was conducted and checklists were completed regarding the general aesthetics of the departments with regards to radiation safety.

Methodology and Measurements

To conduct quality control testing, an inventory of all Jamaican diagnostic facilities was undertaken. This inventory was employed to ascertain the various radiation-generating equipment operated at each facility, the approximate patient load and available staff compliment. Preceding this inventory a log was created of all imaging centres in the island and grouped according to the source of funding (private or public) and according to the size of the department based on the services offered (small: 1-2 modalities, medium: 3-4 modalities, large: more than 4 modalities). Public hospitals were grouped based on the

classification used by the Jamaican Ministry of Health and its regional health authorities.

Reproducibility and Accuracy

A Quad Control Kit was employed to conduct the Reproducibility and Accuracy test on 6 general radiography machines. Tests were conducted in 2 type A and one type C public centre along with 3 large private facilities. 3 parameters were evaluated using high and low kVp techniques. An ion chamber and the kilo-voltage meter (range: 40-160 volts) were exposed to 2 sets of exposures using high and low kVp (kilo-voltage peak) techniques with the coverage area being collimated to dimension necessary just to accommodate the measuring apparatus, with a 5% tolerance limit. 6 consecutive exposures were made for each of the following technical factors; 52 kVp at 6.30 mAs (mili-amperes per second) and 96 kVp at 25 mAs, and the resultant dose, kVp and exposure times were recorded.

Light field/X-ray Field Alignment

X-ray field/ light field alignment tests were conducted on 10 general radiography units. All exposures were made at a source to image distance (SID) of 40 inches (101.6 cm) with a light field size of 6 inches x 8 inches. Based on IAEA specifications, with these parameters, the tolerance for deviation is 0.8 inches or less for combined longitudinal and crosswise measurements [2]. Image receptor was exposed to radiation in the tabletop setting and the collimator light was adjusted to create a rectangular field with opaque markers placed at the corners of the field. Due care was exercised to ensure the outside edge of the marker was on the outside edge of the light field with the body of the marker within the light field. Measurements were made between the distance of the marker and the edge of the radiation field.

Results

The mean kVp value returned at facility one, using high kVp technique was 96.7, facility two returned a mean value of 97.2 while facility three generated a mean of 95.2 kVp. This disparity was also identified among the other centres; facility four had a mean kVp reading of 96.4, facility five averaged 97.2 and facility six 97.1. Measurements at low kVp exposures returned readings that were not consistent with the kVp value selected at the operators' console. Average readings of 53.7 kVp, 52.6 kVp and 54.5 kVp were measured for facility one through three respectively. Readings of 57.7 kVp, 52.7 kVp and 52.8 kVp were measured at facilities 4 through 6 respectively. It was noted that facilities three and four failed the reproducibility and accuracy test. Facility three returned 3 readings of 54.8 kVp which were outside the 5% tolerance limit at low kVp setting. Facility four returned 5 readings which exceeded the 5% tolerance limit at low kVp setting and 1 reading that surpassed the tolerance at high kVp setting as shown in Figures 1 and 2 respectively. No specific trend was identified with regards to exposure times across the facilities. The lowest exposure time recorded was 9.75 mSec (mili-seconds), while the highest was 147 mSec. Both exposure times were recorded at low and high kVp selections respectively. At low kVp setting private facilities on average returned longer exposure times than those of their public counterparts. The average exposure time among private facilities was 24.7 mSec, while the units in the public centres returned an average exposure time 17.9 mSec. However, this was not the case at the high kVp setting, where the average exposure time among the public centres was slightly higher than the private centres. Exposure times of 85.2 mSec and 87.8 mSec were recorded in private and public centres respectively.

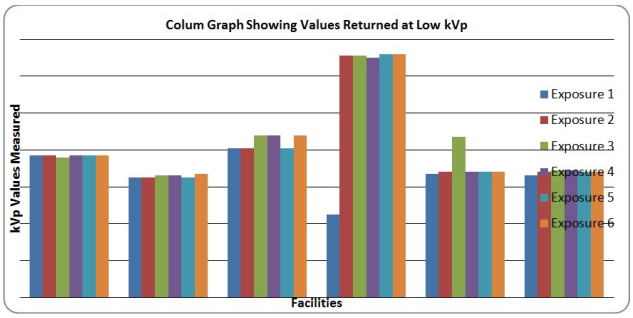

Figure 1: Illustrating kVp readings measured at facilities using low kVp technique.

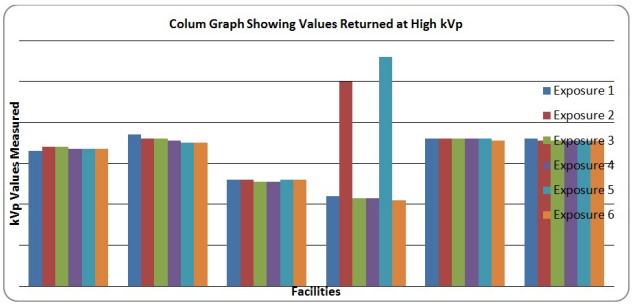

Figure 2: Illustrating kVp readings mesured at facilities using high kVp techniques.

A 2 tail t-test was conducted at the 0.05 alpha level, to determine if there was a significant statistical difference in dose readings among public and private facilities when exposures were made using high and low kVp techniques. The degree of freedom was 3 with no hypothesized mean difference. At high kVp selection, a P value of 0.862 was obtained exceeding the zα value of 0.05 obtained providing evidence of a significant statistical difference in mean dose readings. At low kVp selection, a P value of 0.872 was obtained which also exceeded the zα value of 0.05, proving that there was a significant statistical difference between the mean dose readings obtained at public and private centres. This is represented in Tables 1 and 2 respectively.

The average longitudinal deviation among all facilities for the x-ray field/light field alignment was 0.35 inches, while the average crosswise deviation was 0.48 inches. Both longitudinal and crosswise deviations were within the stipulated tolerance limits. However, it was noted that one facility failed the alignment test, as both longitudinal and crosswise deviations exceeded the tolerance limit. The total longitudinal deviation measured 1 inch, while the total crosswise deviation measured 1.3 inches.

High Dose (mGy)Test		
t-Test: Two-Sample Assuming Unequal Variances		
Parameters	**Private Facilities**	**Public Facilities**
Mean	1.733333333	1.7
Variance	0.023333333	0.07
Observations	3	3
Hypothesized Mean Difference	0	
Df	3	
t Stat	0.188982237	
P(T<=t) one-tail	0.431084525	
t Critical one-tail	2.353363435	
P(T<=t) two-tail	0.86216905	
t Critical two-tail	3.182446305	

Table 1: Illustrating t-test results at high kVp setting.

Low Dose (µGy)Test		
t-Test: Two-Sample Assuming Unequal Variances		
Parameters	**Private Facilities**	**Public Facilities**
Mean	84.36666667	91.56666667
Variance	3641.523333	1496.123333
Observations	3	3
Hypothesized Mean Difference	0	
Df	3	
t Stat	-0.173984679	
P(T<=t) one-tail	0.43647778	
t Critical one-tail	2.353363435	
P(T<=t) two-tail	0.87295556	
t Critical two-tail	3.182446305	

Table 2: Illustrating t-test results at low kVp setting.

A radiation survey was conducted using an Atomtex Dosimeter to ascertain radiation dose at different sections of a fluoroscopic suite. When screening was done for 30 seconds at 80 kVp with a mili-ampere value of 1.8, the following readings were recorded:

- Foot of table: 0.5 µSv (micro-Sieverts) yielding a dose rate of 55 µSv/hr
- Head of table: 0.7 µSv yielding a dose rate of 80 µSv/hr
- Behind lead drapes: 0.08 µSv yielding a dose rate of 2.5 µSv/hr
- Behind operators' console: 0.08 µSv/hr

A radiation survey was also conducted in a Computed Tomography (CT) suite to determine the accuracy of exposure factor selection. Technical factors for the brain and abdomen protocols were evaluated using the axial and spiral scanning methods respectively. Similar technical factors were selected for both protocols (120 kVp at 10 mili-amperes). The following readings were generated with the dosimeter:

- Brain: 77.1 KVP, 19.6 µGy (radiation dose) with an exposure time of 432 mSec.
- Abdomen: 78.1 KVP 50.4 µGy (radiation dose) with an exposure time of 439 mSec.
- No radiation was detected in adjacent rooms adjoining the CT suite.

Discussion

The Quad Control Kit was employed to conduct the Reproducibility and Accuracy test on 6 general radiography machines, namely;

- Toshiba MRX E7242X
- Phillips Optimus 50
- GE Proteus
- Phillips Eleva Diagnostic (ED) Elva (RK)
- GE Legacy LR 40921 C
- Siemens X 1953

Other radiation-generating equipment that were evaluated includes:

- Siemens Axiom Fluoroscopic unit
- Siemens E-Cam Signature Series (nuclear medicine gamma camera)
- GE Optima Multi-Detector CT scanner
- GE Bright Speed Multi-Detector CT scanner

Mechanical inspections were conducted on equipment in centres under investigation. 67% of the facilities had high tension cables that were free from kinks, break and knots. 33% of the facilities had cables that were damaged, some had exposed wires and in some cases, cables were under heavy implements. 50% of the centres had equipment with fully functional interlocks and brakes especially with regards to the general radiographic and fluoroscopic units. There were defective and non-functional locks, detents and braking mechanisms in 50% of the centres. This can be detrimental to the safety of the staff and general public. 33% of the facilities had defects in the smooth motion of the X-ray tube, table and Bucky device. All the facilities had fully functional control panels with switches, indicator lights and meters. Contrarily only 17% of the facilities had technique charts displayed indicating proper exposure factors and radiographic positioning techniques. The clinical images on the reporting workstations had the correct time, date and facility identification in the image annotation.

Defective gonad shields and other personal protection gears were identified in 17% of the facilities, while 50% had defects with tube centring and source to image distance (SID) detents. This reduces the accuracy of the distance scale of the tube mount and Bucky centring. The view from the radiographic operating console was adequate in all facilities; however 50% had no visible warning signs, radiation warning lights or alarms.

All the facilities had lead-lined doors leading to the radiation areas and 67% of these facilities had lead-lined secondary doors to changing rooms and restrooms within the radiation areas. There was a higher incidence of lead-lined wooded working cubicles as this accounted for 67% of the total cohort under observation. In some instances, the cubicle spaces were too small and were cluttered with equipment. This phenomenon was identified in 33% of the centres. It was a notable observation that none of the facilities had a door interlock system to radiation areas. It was also observed in 50% of the centres the doors did not close automatically and in some cases were left half opened during radiation exposures. No qualified radiation safety officers (RSO) or personnel in charge of radiation safety or quality control were identified in the facilities.

Conclusion and Recommendations

It can be concluded that most facilities lack a robust quality assurance program outlining the frequency and tolerance of quality control checks. It was also revealed that centers had no documentation of checks done during acceptance testing and commission of the equipment or of quality control checks that should be conducted on a regular basis.

It is recommended that all facilities be supplied with certificates of acceptance testing and commissioning conducted by a registered medical physicist. Facilities should also develop and maintain a dynamic quality assurance program by training radiation workers how to conduct and document basic quality control checks which seeks to streamline radiation protection and management, with the tenets of the Jamaican Nuclear Safety and Radiation Protection Act. It is also important that a certified medical physicist conduct more technical quality control checks when stipulated and provide oversight for the quality assurance program.

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Authors Contribution

Barrington Brevitt envisaged paper, conducted data collection and analysis, prepared manuscript and approved the final version for submission. Andre Gordon conducted data collection and analysis and Professor Mitko Voutchkov and Lisa Burnett participated in data analysis and interpretation, study design and revision of manuscript and approval of final version. The authors declare that there is no conflict of interest.

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