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Radiological kVp accuracy, reproducibility and consistence assessment of some hospitals in Zaria environs of Kaduna state, Nigeria

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ABSTRACT

The X-ray machines used for radio-diagnostics are required to meet certain quality assurance (QA) measure. For the exposure of patient in diagnostics radiology, individual dose limit does not apply, but justification and optimization of radiological protection do. This paper reports radiological checks carried out in five hospitals in Zaria, Kaduna State, Nigeria. The radiological kVp accuracy, reproducibility and consistence checks on the X-ray machines were assessed. The Quality Control (QC) parameters were evaluated using quality control kitto check the optimal exposure conditions at the five hospitals. The assessment showed that, some of the X-ray machines are over aged and others need adjustment corrections for good radiographs so as not to have rejects that may lead to unnecessary and unwanted exposure. The reported methods can easily be implemented in any clinical situations where kVp accuracy, reproducibility and consistence optimisation check assessment in radiography is necessary. From the study, varying levels of adherence to guidelines were evident with no hospitals demonstrating complete compliance to(NNRA) standard guidelines that is needed to check possible over exposure of patients.

Keywords: *kVp accuracy, Reproducibility, Consistency, Optimization, Radiological.*

INTRODUCTION

The radiation protection of patient undergoing medical X-ray examinations isgoverned by principle of justification and optimisation. [1]. It is concerned with the control of the manner in which source of ionizing radiation is used so that in the use of the radiation source, members of the public are not exposed above acceptable levels. [2].Good radiographic technique is necessary to reduce level of exposure and risk from diagnostics procedure. For this reason, in the last twenty to thirty years most of the developed countries did the atmost to establish programs which could warrant the quality of the radiographic image. Optimization in X-ray imaging in order to reduce patient dose during diagnostics X-ray examination is a complex process given the high level of image quality required [3].

One of the main reasons of rejected radiological films is the lack of applying QC programmes at the radiology Centres. In this study, the radiographic techniquesemployed in the five (5) hospitals' radiology unit in Zaria were examined. Variations in output consistency/accuracy of the machines were recorded and compliances to standard were also examined.
A survey of the number and causes of spoiled X-ray films which were carried out under the aegis of the radiation protective committee of BIR (British Instituted Radiology) revealed that exposure fault at all cases were the major

reasons for retake particularly in films taken with portable radiographic equipment and also mal-positioning of patient was shown to be the causes of about 25% [4].A study of a number of general radiography facility by the DalewareUSA(DU) cited in IAEA TECDOC 1423 of 2004 revealed that an average of 9% of the radiographs taken had to be repeated. An analysis of the reason for rejection and hence repeat led to the conclusion that poor equipment performance made a significant contribution to the prevalence of the poor image quality.

Similarly, in optimization of radiation protection checks on diagnostics radiology equipment in some Nigerian hospital, it was found that equipment malfunctioning and human factor contribute to reject or retake of radiographs.

MATERIALS AND METHODS

This study was conducted in five hospitals, in Zaria, Kaduna State, Nigeria. The room dimensions of the five (5)hospitals were measured to ensure conformity to NNRA minimum standard. kVp output consistency and reproducibility were measured using RMI multifunction meter Model 240. This equipment is capable of measuring kVp, and exposure time it is barred on the differential absorption of X-ray through filters used for ionizing chambers for radiographic assessment.

MEASUREMENTS AND RESULTS
ROOM DIMENSION

Generally radiographic rooms should according to NNRA recommendation and requirement be a minimum of $16m^2$. This is to provide for sufficient space and a shielded protective cubicle. Others are that the access doors should be sliding Lead (Pb) lined type giving better radiation protection with a clearing of 1.5m as a recommendation by NCRP. [5]

TABLE 1: Showing Room Dimension of The Selected Hospitals

Hospital	RD	PC	Shielding
A	$16m^2$	Available	No lead lining
B	12/14m	No space	No lead lining
C	$14m^2$	Available	Available
D	12/10m	No space	Ion sheet lining
E	13/16m	Available	Available

RD = room dimension
PC = protective cubicle

PHYSICAL OPERATION OF X-RAY EQUIPMENT OF THE SELECTED HOSPITAL

From our findings, it was obvious that some of the machine parameters were unacceptable for the acceptable operational point of view, considering the hospitals utilities we tried to eliminate the problems.

TABLE 2: Showing Physical Operation of X-ray Equipment

Parameter		Hospitals				
		A	B	C	D	E
1	The tube is for the table surface	✓	X	✓	X	✓
2	Regulating lamp of X-ray	✓	X	✓	X	✓
3	X-ray/light space coincident	✓	X	x	X	✓
4	The padlock are operating	✓	✓	✓	✓	
	The axis of X-ray is perpendicular to the table surface	✓	X	✓	X	✓
6	The grid groove/X-ray are same dimension	✓	X	✓	X	✓
7	Movement of diaphragm	✓	✓	✓	✓	✓
8	Localising light	✓	✓	✓	✓	✓
9	Accuracy of focus to table top	✓	✓	✓	✓	✓
10	Room Dimension	✓	x	✓	X	X

X= not available
V = Available

KVP OUTPUT CONSISTENCY FFD = 100CM

This test measure the kilovotage across the X-ray tube, kVp set affect the intensity of the X-ray output as well as contrast of the image. The test ascertains, if KV set of the control panel produces the same amount of voltage across the tubes within acceptable limits, Kvp accuracy can be calculated using the formular:-

$$Accuracy = \frac{kVp_{max} - kVp_{\min}}{kVpmin} x\ 100\%$$

$$while\ reproducibility = \frac{kVp_{max} - kVp_{\min}}{kVpmin\ +\ Kvp_{min}} x\ 100\%$$

$$kVp\ consistence = \frac{(kVp_{max} - kVp_{min})}{kVp_{min}}\ x\ 100\%$$

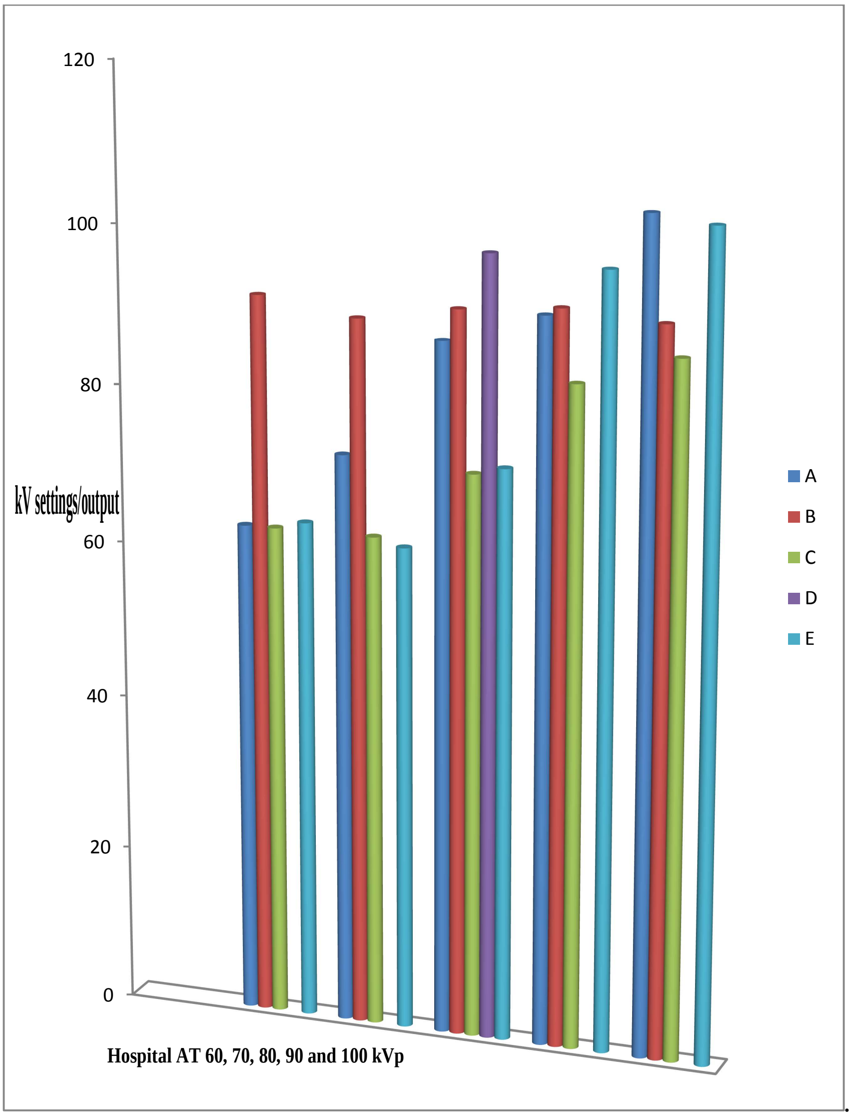

Figure 1: showing kVpsetting for 5 hospitals

Table 3: Showing kVp Settings and Measurements obtained for the 5 Hospitals

kV_{Sets}	Hospital				
	A	B	C	D	E
60	6.2.8	90.9	60.9	-	61.9
70	71.8	90.7	62.9	-	61.3
80	88.5	91.1	70.7	98.6	73.8
90	93.5	91.1	80.5	-	99.5
100	105.1	91.	88.0	-	101.5

kVp accuracy should not exceed = 5 kVp

Table 4: Showing kVp setting and Percentage Consistency obtained for the 5 Hospitals

kVpSets	A	B	C	D	E
60	4.7	51.5	1.5	-	3.1
70	4	29.6	-10.1	-	-12.4
80	-10.6	-13.9	-11.6	23.3	-7.8
90	3.9	1.2	-10,6	-	10.6
100	5.1	-8.9	-12	-	1.5

kVp consistency should not exceed ±10%

The International Committee of Radiation Protection[ICRP] and other international organization are emphasizing the importance of appropriate quality assurance (QC) programme in diagnostics radiology in order to optimise the dose given to patient during X-ray diagnostics examinations. Good radiographs were obtained where instructive guidelines are provided in the radiology units, it also will promote the optimization principle of producing images of good diagnostics efficacy at the lowest radiation dose. Previous studies here showed that adherence to guide lines have led to the reduction of rejects and hence, retake and unwanted and unnecessary exposure [6].

In this study QA/QC techniques employed in room dimension, mechanical checks on X-ray machine, kVp the tube potential, allows varying levels of conformity to standard by international and national bodies.

In Table 1, the room dimension of some of the hospitals do not meet to the minimum required of NNRA as seen in Table 2, the physical operation of the X-ray equipment of the selected hospital, shows varying levels of noncompliance to the acceptable standard. In Hospital B and Dthere were improper maintenance of the equipment.

In the kVp settings and measurements obtained for the 5 hospitals is presented. The X-ray tube voltage has a significance effects on the image contrast the optical density and the patient dose.It is therefore expected that the kVp stated on the control panel should produce an X-ray beam of the stated voltage withacceptable variation limit within ±5% from the results for Hospitals A at 80kVpthe result obtained showed over exposure hospitals B showed noncompliance to the standard,showing both over exposure and under exposure at different kVp settings. Both young and old, fat and slim receive the same dose of radiation which is very dangerous to human Health [7].

The kVp reproducibility at allkVp settings in the hospital showed variance in percentage. For hospital B at 60kVp and 70kVp, the reproducibility are 20.5 and 12.9 percentage respectively while for hospital D at 80kVpreproducibility is 10.4%. Theseshows that the ability for the machine to produce the same kVp is out of allowed or accepted range. This implies that, the voltage of the generator type is fluctuating. It is evident therefore that areas that require little or low radiation exposure were over exposed while areas that required high radiation receives low exposure or under exposed [8].

CONCLUSION

In Conclusion,from radiological point of view any radio-diagnostic equipment in radiology unit especially X-ray machine should have kVplimits within ±5% which is thestandard acceptable limits. While the kVp reproducibility allowed is within the limit of ±10%. If kVp is outside range or limits,it's bring about either over exposure or under exposure which inturn increase the level of rejects, retake or unwanted exposure to radiation [9].

There should be workable maintenance programme after QC programme if outside allowed range on agreement with a reputable well trained engineer to ensure that X-ray machines are routinely checked. A radiation protection programme which will include routine QA/QC of the equipment and appropriate format should be set for hospitals that do not maintained consistencyin which unnecessary and unwanted exposure are checked and corrected.

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