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Evaluation of half value layer (HVL) and homogeneity factor (HF) of some hospitals in Zaria environs Kaduna State Nigeria

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ABSTRACT

In radiography low-energy x-ray do not contribute to the quality formation of an x-ray image; but instead exposes the body to unwanted radiation. The process of removing this low-energy x-ray from the x-ray beam is known as filtration. Filtrations also increase the average energy (quality) of the x-ray beam. Evaluation of total filtration of x-ray tube is one of the radiological tests that determine the adequacy of filtration and it also reflects the penetration power of the beam. This research evaluate the Half Value Layer (HVL) of the X-ray in the radiology unit of some Hospitals in Zaria, Kaduna State and determined their homogeneity factor (HF)(whether it is polychromatic or monoenergetic in nature). Series of Aluminum sheets of different thickness in conjunction with ion chambser used to detect and indicate the integrate exposure to be read directly on the internal calibrated scale were used. It was found that some of the hospitals beam homogeneity factors is one (1) while some showed less than one (1). The HVL Aluminum sheet, homogeneity factor for all the hospitals showed little or no variance from the standard recommendations. The calculated first HVL of the hospitals A-E were found to be 0.032, 0.0119, 0.0045, 0.016 and 0.024 respectively. And, the HF 1, 0.98, 1.05, 0.53 and 1 respectively.

Keywords: Homogeneity Factor, Half Value Layer, Monoenergetic, Polychromatic.

INTRODUCTION

A quality revolution is brewing in Nigeria in the field of radiodiagnostic equipment, along with globalization. For hospitals in Nigeria to compete with modern world, quality service must take precedence. If one asks about the need of quality, all senior radiologist would agree in profession that it is very much needed [1]. An objective assessment of quality control practices in radiology include monitoring and grading of radiograph, identification of causes of poor quality films, equipment quality control (QC) checks, film processing controls etc. Precisely, equipment/instrument quality control comprises of the qualitative or quantitative measurement or performance test of the instrument and the determination of adequacy and acceptability of its performance [1].

In radiodiagnosis many factors affect the quality of film image, and these factors are largely interdependent, and fault in any single factor has effect on the quality of the final image produced [2].

The evaluation of total filtration of x-ray tube is one of the radiological tests in which adequacy is determined it also reflect the penetration power of the beam. Too low filters will allow low energy X-ray to fall on patient and hence increase the patient-dose with no improvement on the needed diagnostics information: Also too hard x-ray reduces the contrast leading to loss of details [3].The filtration of radiation beam produced by X-ray tube reduces the patient's radiation exposure since it removes low energy photons that are unnecessary for the formation of diagnostics image of interest. ICRP's minimum value for the total filtration thickness to be adopted for diagnostic X-ray beam is not lower than 2.5mmAl. X-ray equipment manufacturers are required to ensure that the ICRP minimum filtration requirements are met.

This work checked the HVL of some hospitals in Zaria and its environs and using their homogeneity factor (HF) to describe whether the x-ray penetrating beam are polychromatic or monoenergnetic in nature. By definition, Oxford Advance Learner's Dictionary 8th Edition states that a material's half value layer is the thickness of the material at which the intensity of radiation is reduced by one-half. It HVL is therefore the thickness of specified material that attenuate the beam of radiation to an extent that the AKR is reduced to one- half of its original value. [4].

The homogeneity factor determines whether the polychromatic nature of the beam agree with the standard [5] which is given.

$$HF = \frac{1^{st}HVL}{2^{nd}HVL} \dots \dots .1$$

HF always should be less than or equal to one, it is only (equal to 1 in the case of monochromatic beam and for polychromatic beam, less than one because of beam hardening).

By definition polychromatic beam is a variety or a change of colours, having multiple colours or wave lengths. The physics of electromagnetic radiation is composed of more than one wavelength. This implies that a polychromatic beam have different wavelength which when exposed are not be attenuated at the same time, and thus may increase the skin dose of a patient, while monochromatic energetic beam is a single beam or of one wavelength. So hospitals whose machines emit polychromatic beams of X-ray radiation may constitute a risk to the life of patients. [6].

MATERIALS AND METHODS

This work was carried using five hospitals in Zaria, Kaduna State, Nigeria. Aluminum sheets of thickness 0.1, 0.5, 1 and 2mm were used for each X-ray unit. An ion chamber was used for detecting and indicating integrated exposure.

The exposure monitoring meter was placed on a couch at 100cm distance from the x-ray target and the radiation field collimated to the sensitive chamber size. The first exposure was made at frequently used kVp at 20mAs to determine the penetrating level of the radiation i.e the half value layer of the machine. The filters were placed approximately mid-way between the detector and the tube target. The thickness of the Aluminum filters was increased in steps and measurement taken. The initial half value layer of the hospitals A-E was obtained to be 0.032, 0.0119, 0.0045, 0.016 and 0.024 respectively.

RESULTS

Table 1indicating Reduction in Intensity for Various Thickness Obtained at kVp 80, 10mAs, and 100cm for the Five Hospitals

AlXmm	Hospitals				
	A	B	C	D	E
0.5	.056	0.212	0.0057	0.224	0.045
1.0	0.051	0.175	0.0043	0.0267	0.039
1.5	0.038	0.0163		0.036	0.030
2.0	0.036	0.151		0.046	0.029
2.5	0.034	0.149		0.038	0.029
3.0	0.032	0.138		0.028	0.024
3.5		0.134		0.029	
4.0		0.121		0.030	
4.5				0.030	
5.0				0.030	
5.5				0.030	

Table 2indicatingcalculatedHF at 80kVp 10mAs and 100cm Settings for the Five Hospitals

Hospitals	1st HVL	2ndHVl	HF
A	0.032	0.032	1
B	0.119	0.121	0.98
C	0.0045	0.0043	1.05
D	0.016	0.030	0.53
E	0.024	0.024	1

Table 3 indicating HF for aluminumThickness (mm) at 80kVp 10mAsand 100cm for the Five Hospitals

Hospitals	Aluminum thickness (mm)	HF
A	3.0	0.76
B	4.0	0.58
C	1.0	2.30
D	5.5	0.42
E	3.2	0.72

RESULTS AND DISCUSSION

Filtration is necessary to remove the unwanted low energy photons that would unnecessary contribute to patient dose. If these photons are not removed, it may increase patient dose by up to 90% [2]. HVL value therefore used to estimate the thickness of shielding required to reduce the radiation intensity to permissible dose rate. Table I shows the fractional reduction in radiation intensity at various thickness of shielding materials that could be used.

Table 2 describes the beam homogeneity factor that is whether it is polychromatic or monoenergetic. It is polychromatic if the HF is less than one while in the case of monoenergetic HF is equal to 1. Hospitals A, C and E showed that HF is one, this implies that the beam attenuated is monoenergtic (beam of one wave length) while hospitals B and D showed HF to be polychromatic emitting beam of different wave lengths, and hence possibly exposing patients to more ionizing radiation

At hospitals B and D, the machine were old (over age) and also the over usage made the target surface pits to be rough and hence increased filtration of the tube. Table 3 shows, the homogeneity of the various hospitals. For a good machine, the HVL should be within 0.5-0.75 HF, any machine outside this limit are not acceptable and hence requires change or replacement of the HVL kit. The hospitals showed little or no variance, this implies that the shielding uses for attenuation are within acceptable range.

CONCLUSION

HVL value of the X-ray beam is used to judge the adequacy of filtration and reflects the penetration power of the beam. Filters in the beam should be within tolerance limits. Knowing that too low filters will allow low energy X-ray to fall on the patient which will increase the patient dose without adding to the quality of the diagnostic information, while too hard X-rays reduce the contrast leading to loss of required details and could lead to rejects and retake.

The, HVL is also a function of X-ray tube age use, and kVp. With constant and long usage, the target surface pits can become rough leading to increased filtration of the tube. It is therefore required that HVL should be measured at least annually and after replacement of the X-ray tube assembly. [6].

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