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ASSESSMENT OF ENTRANCE SURFACE DOSE (ESD) IN SOME ROUTINE X-RAYS EXAMINATIONS AT THE FACULTY OF VETERINARY MEDICINE AHMADU BELLO UNIVERSITY, ZARIA

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ABSTRACT
Radiography is an important part of diagnostic imaging in veterinary medicine. It relies on X-rays to diagnose diseases in form of images. The research aims to estimate the ESD for animals undergoing X-ray diagnostic examinations at the Digital Imaging Centre (DIC), Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria. The concepts of radiological protection specified for human beings was observed and an indirect measurement of ESD was applied (mathematical formula). The result showed that the entrance surface dose (ESD) ranges for different examinations carried out on the animals were 0.97 - 39.89 mGy, 1.68 - 7.22 mGy, 5.04 - 10.61 mGy, 17.65 - 58.11 mGy and 12.78 - 38.41 mGy respectively for chest (AP), skull (AP), cervical spine (AP), lumbar spine and pelvis. The mean ESD values are slightly higher than the mean ESD from the related study specified for human beings. This indicates that there is a need for a periodic quality control program at the DIC, to reduce the animal doses to as low as reasonably achievable (ALARA).
Keywords: Entrance Surface Dose, Veterinary, Radiology, Diagnostic, Quality Control

INTRODUCTION

Animal radiology is used extensively for the diagnosing of various kinds of diseases in animals. Radiography is an important part of diagnostic imaging in veterinary medicine. It relies on X-rays to diagnose disease in the chest, abdomen and musculoskeletal system in form of images. The principles of radiography are essentially the same for small and large animals, although they vary in size and posture. The size and posture of animals require special consideration in patient preparation, equipment, animal restraint, positioning devices and radiation safety during exposure. The mounted X-ray machines are majorly used for large animals, while the portable or mobile unit is preferable for small pets.

In the medical field, the use of ionizing radiation contributes significantly to the source of exposure of the population (Maria et. al., 2009, Taha et. al., 2014). The ESD can be determined by measuring the amount of radiation dose absorbed by the skin during exposure. The need for radiation dose assessment of patients during diagnostic X-ray examination has been highlighted by increasing knowledge of hazards from ionizing radiation (Taha et. al., 2014).

The majority of information on ionizing radiation exposure and effect documented were done to meet the needs of human radiological protection (Venezahi et al., 2009). In Nigeria and other developing countries, some works were done to determine radiation dose to patients in diagnostic radiology: Atalabi et. al. (2013) determined the entrance surface dose from pediatric diagnostic X-ray examination. A survey of radiological techniques in three (3) hospitals in Nigeria was determined by Ogundare et. al. (2004). Many authors had also contributed to the assessment of ESD in humans using X-ray machines worldwide (Akhdar, 2007, Olowookere et al., 2009 & Osman, 2013). Few or no attention on the assessment of radiation dose in animals using diagnostics equipment in developing countries were carried out. A system of radiological protection of nonhuman organisms must be harmonized with the principles for the radiological protection in humans (ICRP-19, 2002). Therefore, the research seeks to estimate the ESD for animals exposed to diagnostic X-rays at the Digital Imaging Centre (DIC), Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria, with the concepts of radiological protection specified for human beings by applying mathematical methods.

MATERIALS AND METHODS

The research was performed to estimate the ESD received by animals at the Digital Imaging Centre (DIC), Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria. ESD can be determined mainly by two methods (direct method and indirect method). The direct method involves using Thermoluminescent Dosimeters (TLD) stacked on the patient skin, while the indirect method via mathematical model calculation based on the X-rays machine output (Alghoul et. al., 2017). The latter method was adopted for this study.

The ESD values of about 41 patients (animals) were estimated using mathematical model calculations (indirect method), based on the X-rays machine output. The five routine medical examinations used for the ESD evaluation include: Skull (AP), Chest (AP), Cervical Spine (AP), Lumbar Spine and Pelvis.

The X-rays machine used for the medical diagnostic examination has a specification of minimum inherent filtration Aluminum of 2 mmAl/75, X-rays rating up to 150 kVp. The animals examined during this study were mainly large animals such as cows, horses and goats. The animals' age and weight were put into consideration at the beginning of the procedure, to adjust the exposure factors of the X-rays machine to achieve an optimal image. The X-rays machine parameters recorded during the examinations include: focus to surface distance (FSD), peak tube voltage (kVp) and exposure current and time product (mAs). This information was recorded for each animal undergoing a medical procedure.

The ESDs were calculated using the Tung and Tsai (1999) formula, as expressed below and Microsoft-Excel spreadsheet was used for the estimation and statistical analysis:

$$ESD\ (mGy) = c\left(\frac{kV_p}{FSD}\right)^2\left(\frac{mAs}{mm.Al}\right) \ldots \quad 1$$

where: FSD: Focus to Skin Distance**,** kVp: X-rays peak tube voltage**,** mAs: Tube current time exposure time**,** Al: minimum inherent filtration Aluminum equivalent and C: constant value 0.2775.

RESULTS AND DISCUSSION

The result obtained were recorded in the tables shown below (Table 1-7). The result includes medical procedures at a different position, gender, animal age, kVp, mAs, FSD and ESD for all the different diagnostic X-rays procedures carried out during the period of this study at the DIC, Faculty of Veterinary Medicine, Ahmadu Bello University Zaria, Nigeria. The exposure factors were slightly different for the same procedures, due to the size of the animals.

Table 1: ESDs for Chest AP

Number	Age (months)	Gender	kV_P	mAs	FSD (cm)	ESD (mGy)
1	12	Female	75	66	100	4.12
2	8	Female	86	30	33	22.62
3	24	Male	80	60	33	39.14
4	12	Female	70	66	100	3.59
5	36	Male	50	35	100	0.97
6	12	Male	90	79	100	7.10
7	6	Female	77	66	33	39.89
8	24	Female	60	55	33	20.18
9	18	Female	68	52	100	2.67
10	18	Male	78	40	100	2.70
Range			50-90	30-79	33-100	0.97 – 39.89
Mean			73.4	54.9	73.2	14.30

Table 1 indicates the exposure factors and obtained ESDs for animals that have undergone chest (AP) examination, the ESDs ranged from 0.97 – 39.89 mGy with the average value of 14.30 mGy.

Table 2: ESD Estimation for Skull AP

Number	Age (months)	Gender	kV_p	mAs	FSD (cm)	ESD (mGy)
1	8	Female	80	45	100	3.19
2	36	Female	55	50	100	1.68
3	24	Female	70	66	80	5.61
4	12	Male	80	65	80	7.21
5	12	Female	75	66	100	4.12
Range			55-80	45-66	80-100	1.68 – 7.22
Mean			72	58.4	92	4.36

Table 2 shows exposure factors and estimated ESDs for animals undergoing a skull (AP) examination, the ESDs ranged from 1.68 – 7.22 mGy with a mean value of 4.36 mGy.

Table 3: ESD for Cervical Spine AP

Number	Age (months)	Gender	kVP	mAs	FSD (cm)	ESD(mGy)
1	12	Female	85	79	100	6.34
2	12	Male	70	66	100	3.59
3	24	Male	72	66	100	3.79
4	36	Female	80	66	100	4.69
5	12	Female	80	66	128	2.86
6	8	Male	88	75	118	4.63
7	6	Female	75	66	100	4.12
8	18	Male	75	66	100	4.12
9	30	Male	70	66	80	5.61
10	24	Male	88	79	80	10.61
Range			70 – 88	66 – 79	80 – 128	5.04 – 10.61
Mean			78.3	69.5	100.6	2.86

Table 3 shows the exposure factors and estimated ESDs for the cervical spine, the ESDs ranged from 5.04 – 10.61 mGy with an average value of 2.86 mGy.

Table 4: ESD for lumbar Spine

Number	Age (months)	Gender	kVP	mAs	FSD (cm)	ESD(mGy)
1	24	Female	110	80	43	58.11
2	18`	Female	90	70	43	34.03
3	6	Male	80	66	43	25.36
4	12	Male	88	75	43	34.87
5	12	Male	75	66	43	22.29
6	24	Female	70	60	43	17.65
7	12	Male	90	80	43	38.90
8	8	Female	90	80	43	38.90
Range			70 – 110	66 – 80	43	17.65-58.11
Mean			86.63	72.13	43	33.76

Table 4 presented the exposure factors and estimated ESDs for the lumbar spine (AP), the ESDs ranged from 17.65 – 58.11 mGy with an average value of 33.76 mGy.

Table 5: ESD for Pelvis

Number	Age (months)	Gender	kVP	mAs	FSD (cm)	ESD (mGy)
1	8	Female	80	66	53	16.69
2	12	Male	88	78	43	36.26
3	12	Male	70	66	53	12.78
4	18	Male	75	66	53	14.67
5	24	Female	77	60	53	14.06
6	36	Male	90	79	43	38.41
7	12	Female	95	66	43	35.76
8	24	Female	80	60	43	23.05
Range			75 – 95	66 – 79	43 – 53	12.78-38.41
Mean			81.88	67.63	48	23.96

Table 5 present the exposure factor and the estimates ESDs for the pelvis, the ESDs ranged from 12.78 – 38.41 mGy with an average value of 23.96 mGy.

Table 6: Mean values and range of the exposure factors used f

Diagnostic type	kVp	mAs	FSD (cm)	ESD (mGy)
Chest (AP)	73.4	54.9	73.2	14.30
	50-90	30-79	33-100	0.97 – 39.89
Skull (AP)	72	58.4	92	4.36
	55-80	45-66	80-100	1.68 – 7.22
Cervical Spine (AP)	78.3	69.5	100.6	2.86
	70 – 88	66 – 79	80 – 128	5.04 – 10.61
Lumbar Spine (AP)	86.63	72.13	43	33.76
	70 – 110	66 – 80	43	17.65-58.11
Pelvis (AP)	81.88	67.63	48	23.96
	75 – 95	66 – 79	43 – 53	12.78-38.41

Table 6 indicates the ranges and mean values of the exposure factors used for medical procedures in all the body positions.

Table 7: Comparison between the present study and the literature

Diagnostic type	This study ESD (mGy)	Yacoob *et al.,* 2017 ESD (mGy)	Korir *et al.,* 2007 ESD (mGy)	Seo *et al.,* 2014 ESD (mGy)	Algboul *et al.,* 2017 ESD (mGy)	Yousif, 2016 ESD (mGy)
Chest (AP)	14.30	1.43	1.85	0.37	7.43	-
Skull (AP)	4.36	4.14	14.16	2.08	11.24	-
Cervical (AP)	2.86	1.45	3.89	1.21	7.25	2.40
Lumbar Spine (AP)	33.76	-	-	-	103.7	22.61
Pelvis	23.96	4.71	9.02	2.34	41.73	-

Table 7 presented the comparison between the results obtained during this study, previous related studies and the established international references levels of ESDs (EC, 1996; Tamboul et al., 2014). The mean ESD values were slightly higher than the mean ESD from the related study specified for human beings.

An important parameter that has featured a lot from the above tables is the kVp. This parameter always affects the procedure of a medical X-ray machine. Its increase supports image quality and as well increasing radiation dose to the animals (Dendy & Heaton, 2011; Tungjai, Phathakanon, Ketnuam, Tinlapat, & Kothan, 2018). Thus, the quest for quality image with good contrast could be attributed to the slight increase in the ESDs for this study as well as some positions in the previous related studies. More so, from equation 1 the linear relation shows that kVp is twice the ESD, this could also be attributable to the slight increment in the estimated ESDs.

CONCLUSION

The entrance surface skin dose range evaluated in this study and the procedures observed were between 2.86 and 33.76 mGy for all animals with different sizes and ages. The ESD values were slightly higher than the mean ESD from the related studies specified for human beings. This indicates that there is a need to implement a quality control program at the DIC, to ensure reduction in the animal doses and to conform with the acceptable limits. The results presented in this study will serve as a baseline data needed for deriving a reference dose level for animal radiography. Finally, despite the notable significant increase in the ESD, there is no cause for alarm, further studies such as the use of multiple indirect methods and the use of TLDs is recommended to ensure that the principles of radiation protection are observed on nonhuman subjects.

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