Study of entrance surface skin dose in veterinary radiology

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Abstract — **This study aims the evaluation of the radiation dose levels involved in veterinary radiology and to contribute to review the procedures for performing radiographic exams in animals in the Department of Veterinary Radiology of Faculdade de Medicina Veterinária e Zootecnia of Universidade Estadual Paulista (FMVZ-UNESP/Brazil). The obtained results has shown to be extremely important the assessment of doses involved in veterinary diagnostic radiology procedures both to protect the occupationally exposed workers and to optimize the delivered doses to the animals.**
Keywords— **absorbed dose, thermoluminescence dosimetry, veterinary radiology.**

I. INTRODUCTION

The human radioprotection is a very recent issue, which came almost with the discovery of X-rays by Roentgen in 1885. This concern relates a series of measures to protect the human being and their descendants against possible unwanted effects caused by ionizing radiation (1).

The International Commission on Radiological Protection (ICRP)'s current position regarding protection of the environment is set out in its Publication 60 (ICRP 1991) (2). "*The Commission believes that the standards of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk*" (2). This concept of deriving such data sets for reference fauna and flora is therefore similar to that of the reference individual (Reference Man) used for human radiological protection, in that it is intended to act as a basis for many calculations and decisions (3).

The basic guidelines for radiological protection in Brazil are regulated by Secretaria de Vigilância Sanitária - SVS by the Decree 453 of June 1st, 1998 (4) and for Comissão Nacional de Energia Nuclear - CNEN Norm NN-3.01 (1) in view the risks of use of ionizing radiation and the need to establish a national policy for radiological protection in the field of radiology. The basic principles governing the rules above are three: the justification of the practice, the optimization of radiological protection and the limitation of individual doses.

The principle of justification is the basic principle of Radiological Protection which states that any practice or source should be permitted unless it produces sufficient benefit to the exposed individuals or to society in order to offset the hazard that may be caused (1,4). The principle of optimization requires that the facilities and practices involving the use of ionizing radiation should be planned, implemented and enforced so that the magnitude of individual doses, the number of people exposed and the likelihood of accidental exposures are as low as reasonably achievable ALARA ("*as low as reasonable achievable"*) (1,4). Finally the principle of limitation provides that the limits for individual doses are values of effective dose or dose equivalent, set for occupational exposure and exposure from the public practice audited, whose magnitude should not be exceeded (1,4).

The majority of our information on the exposure and effects of radiation relates to, and has been obtained to serve the needs of, the radiological protection of human beings. Similarly, much of our information on the behavior, effects, and distribution of man-made radionuclides in the environment has also been derived to meet the needs of human radiological protection (3).

It is necessary that a system for radiological protection of non-human organisms be harmonized with the principles for the radiological protection for humans (3). This work used the rules and regulations involved with the concepts of radiological protection specified for the man together the techniques of termoluminescence dosimetry to evaluate the risks incurred by the animals subjected to X-rays exams to check for pulmonary metastasis.

II - MATERIALS AND METHODS

The procedures were divided into three steps:

TL dosimeters irradiation: All the radiographic investigations were performed in the Faculdade de Medicina Veterinária e Zootecnia da Universidade Estadual Paulista (FMVZ-UNESP) in the city of Botucatu/Sao Paulo state. Each procedure was carried out by the acquisition of three chest radiographic images, two latero-lateral and one ventro-dorsal of dogs with suspect of pulmonary metastasis. Figure 1 illustrates the correct positioning of the animals in the two projections mentioned above.

(a) (b)

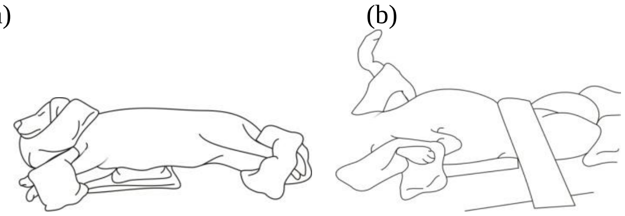

Figure 1- Latero-lateral (a) and ventro-dorsal positioning (b) used to obtain the radiographic image.

Twenty seven chest images of different dogs' breeds were monitored. During the procedures the values of the thicknesses of the two projections (latero-lateral and ventro-dorsal) were measured and was possible to measure the source-skin surface distance of the animal. According to the animal size different irradiation field sizes were necessary to acquire the chest image. Values of the kV and mAs were also taken for each image, which were used for the simulation of the dogs' irradiation of each investigation procedure. It is important to point out that the dosimeters were stored into a lead shield before and after the radiation exposure (two plastic badges were used as control group), thus providing more accurate measurements.

After all data acquisition, the simulations of dogs' irradiations were performed with the same X-rays device (SHIMADZU model EZY-RAD 125 kV of FMVZ-UNESP) and a cubic water phantom filled with distilled water, assuring the reproducibility of all parameters mentioned before. The water phantom was positioned in the center of the table allowing the correct adjustment of the light field with the area of the plastic badges. Afterwards, the dosimeters were sent to the Instituto de Pesquisas Energéticas e Nucleares (IPEN/CNEN-SP) in order to evaluate the doses and further analysis of the results.

Dosimeters calibration: The irradiation of the dosimeters for the calibration curve obtaining was performed in the Instruments Calibration Laboratory of IPEN (LCI – IPEN) with the X-rays device used for radiodiagnostic and a water phantom filled with distilled water. In order to obtain the dose-response curves it was used 9 dosimeters of $CaSO_4$:Dy (positioned in their plastic badges containing three filters: lead filter- 1 mm tick, lead 0.8 mm with a central hole 2 mm and plastic- 3 mm tick) for each of the following dose values: 1.5; 2.0; 2.5; 3.5 e 4.0 mGy. The irradiation control, beam energy (kV), as well as the irradiation time to obtain the desired doses was done by the program "*Lab VIEW 7.0*". As the energy value of the beam energy used to chest examinations varied between 50 and 70 kV, these kV values were used to obtain the dose-response curves of the dosimeters. The water phantom was correctly positioned and the field size was adjusted with the $CaSO_4$:Dy dosimeters in a way to guarantee the reproducibility of the radiographic images acquisition.

TL Reading: After the X ray exposure the thermoluminescent response was evaluated using a thermoluminescent reader *Harshaw* model 3500. All measures were carried out 24 h after irradiation.

III - RESULTS AND DISCUSSION

The dose-response curves obtained to the plastic filter, with beam energies of 50 kV and 70 kV are shown in Figure 2. Using the dose-response curve and its linear fitting equation shown in Figure 2, it was possible to estimate the entrance surface skin doses of the animals for each radiographic investigation performed. The results show the skin dogs entrance doses using the simulation discussed in item II.

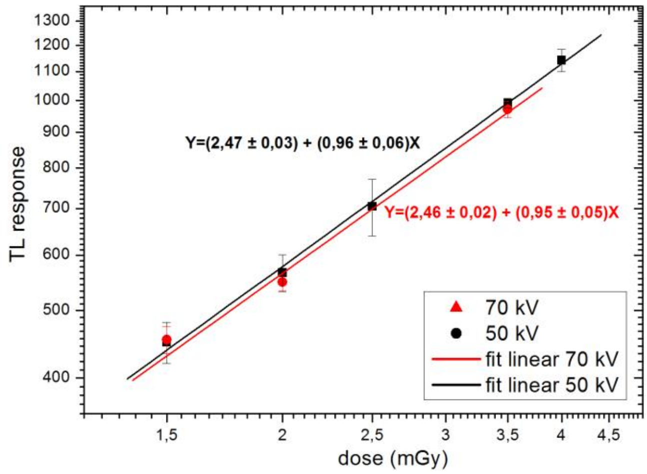

Figure 2- Dose-response curves of plastic filter for X rays beam with energies of 50 kV and 70 kV.

To evaluate the results the animals were divided into three groups: small, medium and big size dogs. The number of monitored exams was 5, 9 and 13 with average field size of 20 x 25 cm, 25 x 30 cm and 30 x 40 cm, respectively.

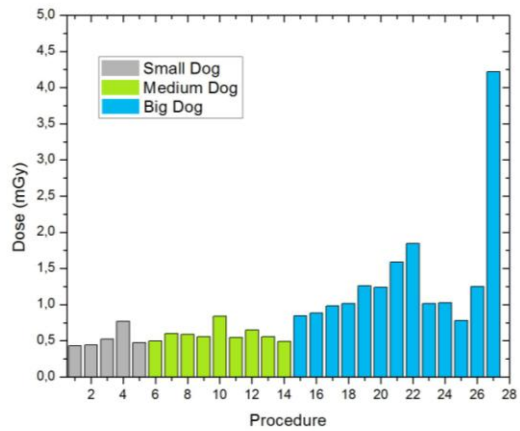

Figure 3- Entrance surface skin doses received for small, medium and big size dogs submitted to chest X-rays to check pulmonary metastasis.

Figure 3 presents the entrance surface skin doses of the animals according to each procedure monitored. The 5 first procedures (grey bars) referring to the small size dogs, the following 9 procedures (green bars) referring to the medium size dogs and the 13 remaining procedures (blue bars) referencing to the big size dogs.

The average dose received by the small size dogs was 0.53 mGy, where the minimum dose was 0.43 mGy and the maximum dose was 0.77 mGy. This difference comes from the necessity of repetition of the imaging procedure since it is difficult to control the animals' movements.

The average dose for the medium size dogs was 0.59 mGy, where the minimum dose was 0.49 mGy and the maximum dose was 0.84 mGy. It can be noticed an increase in the dose values compared to the small size animals. The analysis of the results shows that the average dose value for the big size dogs was 1.45 mGy, which is a value higher than to the smaller-sized animals. It is important to point out that the average was calculated only for the first 12 investigations because the procedure 13th corresponds to an isolated case where the animal was extremely obese and for which many repetitions of the imaging procedures were performed. The dose received by this dog was 4.22 mGy, in other words, a relatively high dose in the veterinary radiology routine. The minimum dose registered was 0.84 mGy and the maximum was 1.85 mGy.

It is important to mention that there are no reference dose values in the literature showing the dose limit in animals, however for a standard human in a similar procedure the reference dose is 2.3 mGy (summing the three projections), described in Decree 453 of SVS [(4)].

The biggest problem of the veterinary radiology is the immobilization of the animal, which cannot be anesthetized due to the high costs and simplicity of the procedures which is fast and painless. Therefore, most of the time it is necessary to repeat the imaging procedures, increasing the dose received by the animals.

The obtained results indicate that the doses received by occupationally exposed workers and the animal owners that participate of the procedures helping in the immobilization and positioning can exceed the regulatory limits and it is necessary to optimize the delivered doses to the animals.

IV – CONCLUSIONS

The obtained results has shown to be extremely important the assessment of the doses involved in veterinary diagnostic radiology procedures both to protect the occupationally exposed workers and animals´ owners and to optimize the delivered doses to the animals. New procedures can be developed aiming to reach a good exam image and safe radiological protection conditions.

ACKNOWLEDGMENTS

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