

# Evaluation of dog's doses submitted to pulmonary radiographic exams and correlation with individual doses of the owners and clinic staff

Veneziani, G. R.<sup>a</sup>; Matsushima, L. C.<sup>b</sup>; Fernandez, R. M.<sup>a</sup>; Campos, L. L.<sup>b</sup>

<sup>a</sup>Instituto de Biociências (IBB-UNESP), Distrito de Rubião Junior, Botucatu, SP, Brazil

<sup>b</sup>Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN), Avenida Professor Lineu Prestes 2242, São Paulo, SP, Brazil

**Abstract:** Aiming to evaluate the dose range that animals submitted to pulmonary radiographic exams are exposed and the relationship with the individual doses of owners and clinical staff, the entrance surface skin dose of dogs of different breed and sizes with cancer and with suspected pulmonary metastasis were evaluated. Thermoluminescent dosimeters of  $\text{CaSO}_4:\text{Dy}$  applied to individual, area and environmental monitoring were used to entrance surface skin dose evaluation of 27 dogs. Simulations of dog's irradiation were also carried out using a water phantom.

## Introduction

With the development of advanced technologies applied in the veterinary field also increased also the applications of ionizing radiation in diagnosis and treatment of various types of diseases that affect animals, but there are not still national or international dose limits applied to animals.

The main problem in veterinary radiology is the animal immobilization, which cannot be anesthetized due to the high costs involved, considering the simplicity of procedures which are rapid and painless. Thus, in many cases it is necessary to repeat the image acquisition several times, increasing the dose to the animal and the owner and clinic staff who help to keep the animal in place.

Unlike the clinical staffs, who are classified as occupationally exposed workers, the owners are considered individuals of the public, and can receive higher doses than those described for individuals from the public.

Seifert et al.<sup>(1,2)</sup> published studies on the evaluation of radiation exposure to owners and clinical staff during the radiographs in small animals, concluding that the dose values measured were all below the limits set within the standards adopted in Germany, and that is not appropriate to the owners receive doses above the limits for individuals from the public.

In Brazil there are no published studies evaluating the doses received by the owners of the animals. The most affected organs are hands, crystalline and thyroid, since the owner must use a lead apron.

The basic guidelines for radiological protection at the national level in Brazil are regulated by the Comissão Nacional de Energia Nuclear (CNEN), Norm CNEN NN-3.01<sup>(3)</sup> and the Secretaria de Vigilância Sanitária (SVS), Decree 453 of June 1<sup>st</sup> 1998<sup>(4)</sup>, in view of the risks of using ionizing radiation and the need of to establish a national policy for radiological protection in the field of radiology.

The standard exposure of the individuals should be restricted in a manner that neither the effective dose nor the equivalent doses in organs or tissues of interest, caused by eventual combination of the exposures originated by authorized methods, exceed the dose limit determined by Norm NN-3.01, except in specific circumstances, authorized by CNEN. These dose limits are not applicable to medical exposures<sup>(3)</sup>.

The annual dose limits for workers and individuals from the public given by Norm NN-3.01 are presented in Table 1.

**Table 1.** Annual dose limits given by Norm CNEN NN-3.01

Annual dose limits (a)			
Quantity	Organ	Occupationally exposed workers (mSv)	Individuals from the public (mSv)
Effective Dose	Whole body	20 (b)	1 (c)
Equivalent dose	Crystalinne	150	15
	Skin (d)	500	50
	Hands and feet	500	_____

[a] For purposes of administrative control performed by CNEN, the term annual dose should be considered as a dose in the calendar year, i.e. in the period from January to December each year.

[b] Weighted average of 5 consecutive years, not exceeding 50 mSv in any year.

[c] In special circumstances, the CNEN may allow a value of effective dose of up to 5 mSv in a year, since the average effective dose over a period of 5 consecutive years does not exceed 1 mSv per year.

[d] Average of 1 cm<sup>2</sup> area, in the most irradiated.

Considering these factors, it is necessary to establish a system of radiological protection for non human that is harmonized with the principles of radiological protection adopted for the human-beings<sup>(5)</sup>.

Aiming to evaluate the dose range that animals submitted to radiographic exams are exposed and the relationship with the individual doses of owners and clinical staff, the technique of thermoluminescence dosimetry - TLD was used to evaluate the entrance surface skin dose in dogs with cancer undergoing x-rays to confirm pulmonary metastasis.

## Materials and Methods

### Dosimetric material

- 153 TL dosimeters of calcium sulphate doped with dysprosium ( $\text{CaSO}_4$ : Dy);
- 51 plastic badges containing three filters (plastic – 3 mm thick, which provides electronic balance to gamma radiation from  $^{60}\text{Co}$ ; lead - 1mm thick, cut-off radiation of low energy and lead - 0.8 mm thick with a central hole 2 mm in diameter, which provides response independent of energy) used to radiation dose and energy evaluation.

### Irradiation Systems

- X-ray machine SHIMADZU model EZY-RAD 125kV of the Veterinary Radiology Department of the Faculdade de Medicina Veterinária e Zootecnia da Universidade Estadual Paulista de Botucatu (FMVZ-UNESP) with the following operation parameters (Table 2).
- X-ray machine PANTAK/SEIFERT model ISOVOLT 160HS 5 - 160kV/0.5–45.0mA of the Instruments Calibration Laboratory of Instituto de Pesquisas Energéticas e Nucleares (LCI/IPEN) with the following operation parameters (Table 3).

**Table 2.** Irradiation parameters of the SHIMADZU X-ray machine model EZY-RAD 125 kV.

<b>Radiation Quality</b>	<b>Additional filtration (mmAl)</b>	<b>1<sup>st</sup> HVL* (mmAl)</b>	<b>Tension (kV)</b>	<b>Current (mA)</b>	<b>Effective Energy (keV)</b>
RQR3	3.0	4.45	50	10	36.52
RQR5	3.0	4.75	70	10	38.86

\*HVL = Half Value Layer

**Table 3.** Irradiation parameters of PANTAK/SEIFERT X-ray machine model ISOVOLT 160HS.

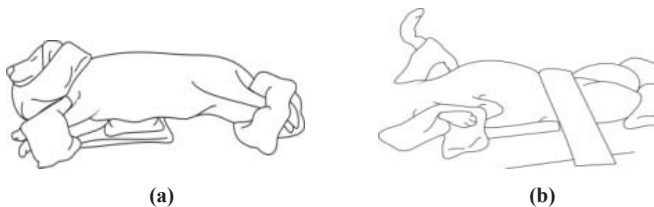
Radiation Quality	Inherent filtration (mmAl)	Additional filtration (mmAl)	1 <sup>st</sup> HVL (mmAl)	Tension (kV)	Current (mA)	Effective Energy (keV)
RQR3	0.13	2.5	1.79	50	10	27.15
RQR5	0.13	2.5	2.35	70	10	30.15
RQR7	0.13	2.5	2.95	90	10	33.05

## Equipments

- Cubic PMMA Phantom 30 x 30 x 30 cm<sup>3</sup> and walls 0.5cm thick filled with distilled water;
- Microwave heated Furnace CEM model PHOENIX-HT;
- TL Reader Harshaw model 3500.

## Dosimeters irradiation

The radiographic exams and exams simulations using a water phantom were performed at Veterinary Radiology Department (FMVZ-UNESP) using the X-Ray system SHIMADZU. Each procedure was carried out taking three radiographs of each animal, two latero-lateral and one ventro-dorsal. Figure 1 illustrates the correct positioning of the animals in latero-lateral (a) and ventro-dorsal (b) projections for chest radiography.



**Fig 1.** Latero-lateral (a) and ventro-dorsal (b) animal positioning for chest radiography.

The field sizes used were 20 x 25 cm<sup>2</sup>, 25 x 30 cm<sup>2</sup> and 30 x 40 cm<sup>2</sup>, for small, medium and big size dogs respectively and source-surface distance of 100 cm.

Twenty seven chest radiological examinations of dogs of different breed and sizes were evaluated. During each examination parameters such as thicknesses of the two

projections (latero-lateral and ventro-dorsal), field size, kV and mAs values and source-surface distance were carefully observed, to be reproduced during calibration and exams simulation using a water phantom.

The TL badges containing three  $\text{CaSO}_4:\text{Dy}$  dosimeters (one under each filter) were positioned on the dog's chest and on the phantom surface. Before and after irradiation the dosimeters were maintained inside a lead shield (two dosimeters were used for the assessment of natural background radiation during the period between the preparation and evaluation of the dosimeters) to guarantee accuracy and precision of the measures.

After the radiographic examinations the irradiations simulations using the water phantom were performed using the same X-Ray machine and same irradiation parameters. The phantom was positioned in the center of the table aiming to adjust the luminous field and the dosimeter badges.

### **Calibration Curve**

Considering that the X rays energies used to dogs examinations and simulations varies between 50 and 70 kV, these energies were used to obtain the dose-response curves of the  $\text{CaSO}_4:\text{Dy}$  dosimeters. The irradiations were carried out at the LCI – IPEN using the X-rays machine PANTAK/SEIFERT, with the dosimeters placed on the surface of a cubic phantom filled with distilled water, similar to that used to simulate dog's examinations. The water phantom was correctly positioned and the field size was adjusted according to the dosimeter badge size in a way to guarantee the reproducibility of the radiographic images acquisition.

In order to obtain the dose-response curves the dosimeters were irradiated with doses between 1.5 and 4.0 mGy, with applied voltages of 50, 70 and 90 kV and field size of 298.5 cm<sup>2</sup>. The determination of the irradiation time to obtain the desired doses and the effective energy was performed using the program “*Lab VIEW 7.0*”.

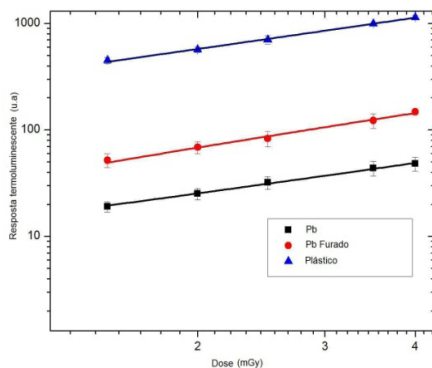
### **TL readings**

The TL evaluations were performed always 24 hours after irradiation using a thermoluminescent reader *Harshaw* model 3500 from the Dosimetric Materials Laboratory (LMD-IPEN).

Calibration curves were obtained for the dosimeters positioned under each filter and to the effective energies of 27.15, 31.15 and 33.05 keV. Each presented value is the average of three measures and the error bars the standard deviation of the mean.

## Results

The dose-response curves of the  $\text{CaSO}_4:\text{Dy}$  dosimeters positioned under plastic, lead and lead with hole filters, irradiated using the water phantom, obtained to 30.15 keV X-radiation (70 kV) is presented in figure 2.

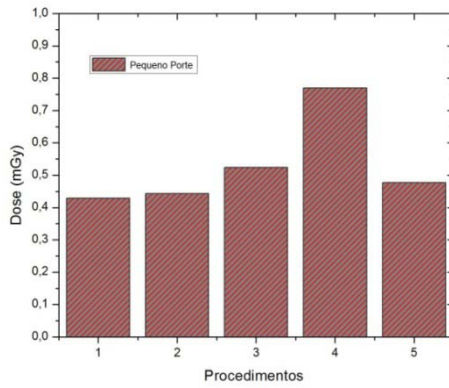


**Fig. 2.** Dose-response curves for the  $\text{CaSO}_4:\text{Dy}$  dosimeters positioned under three filters: plastic filter (a), lead filter with a central hole (b) and lead (c) to X radiation of 30.15 keV (70 kV).

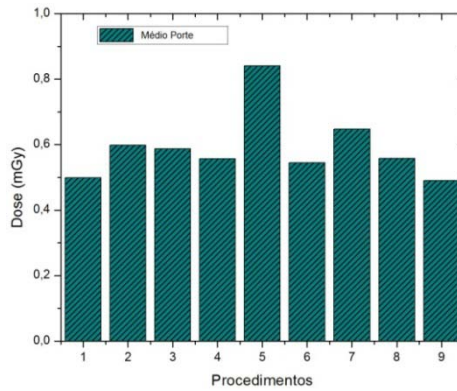
The TL response presents linear behavior in the studied dose range to the three different filters and effective energies. No correction to energy dependence TL response that is high to  $\text{CaSO}_4:\text{Dy}$  due to its atomic number (15.3) was necessary since the calibration curves were obtained at the same energies of the dog's irradiations.

To better evaluation the dogs were divided into three groups according to animal size: small (5), medium (9) and big (13) dogs. Figure 3 (a) presents the entrance surface skin doses evaluated to small size dogs. The average dose was 0.53 mGy, the minimum dose 0.43 mGy and the maximum dose 0.77 mGy. This difference comes from the necessity, in some cases, of repetition of the imaging procedure since it is difficult to control the animals' movements. Figure 3 (b) presents the entrance surface skin doses obtained from chest X-rays of medium size dogs. The average dose was 0.59 mGy, the minimum dose 0.49 mGy and the maximum dose 0.84 mGy. Finally figure 3 (c) presents the entrance surface skin doses obtained from chest X-rays of big size dogs. The analysis of the results shows that the average dose was 1.45 mGy, the minimum dose reported 0.84 mGy and the maximum 1.85 mGy. It is important to point out that the average was calculated only for the first 12 investigations because the procedure 13<sup>th</sup> 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.

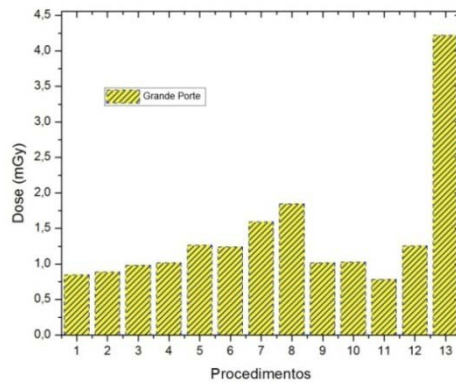
It may be observed that there is an increase of the average doses depending on the size of the animal (the field size used). It can be noticed that the doses in some procedures are close to the values for a standard human, which according to Decree 453 is 2.3 mGy (considering three radiographic projections for a standard human: 2 postero-anterior and 1 lateral).



(a)



(b)



(c)

Fig. 3. Entrance surface skin dose evaluated to: (a) small size dogs, (b) medium size dogs and (c) big size dogs.

## Conclusions

The entrance surface skin dose range evaluated in this type of procedure was between 0.43 to small size dogs and 4.22 mGy to big size dogs with repeated exams.

The obtained results indicate that it is extremely important to evaluate the doses involved in veterinary diagnostic radiology, both for the knowledge of the doses applied to the animals, but to be used as a parameter in the assessment of individual doses for workers of Veterinary Clinics, which can perform several procedures daily and owners, because the doses may exceed the annual dose limits in force in Brazil.

The values found confirm the need for optimization of veterinary diagnostic procedures aiming to reduce doses as low as reasonably achievable (ALARA).

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