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Thermoluminescence measurements of entrance surface skin dose in exams of dog's chest in veterinary radiology

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ABSTRACT

This study aims to determine the entrance surface skin doses in dogs (with suspected pulmonary metastasis) submitted to chest X-rays using the technique of thermoluminescence (TL) dosimetry. Twenty seven radiologic exams of dogs of different breed and sizes were performed. The radiation doses were assessed using thermoluminescent dosimeters of calcium sulphate doped with dysprosium ($CaSO_4$:Dy) produced at Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN). The entrance surface skin dose range evaluated in this type of procedure was between 0.43 mGy to small size dogs and 4.22 mGy to big size dogs with repeated exams. The obtained results indicate that is extremely important the assessment of radiation doses involved in veterinary diagnostic radiology procedures, to evaluate the delivered doses to the animals, to be used as a parameter in the individual monitoring of pet's owners, who assist the animal positioning, and to protect occupationally exposed workers at the Veterinary Radiology Clinics.

1. Introduction

The most common organ affected by most types of cancer is the lung. Hence the importance of getting a lung X-ray to found out if this vital organ is affected when a cancer is detected (Parisi, 2009).

The International Commission on Radiological Protection (ICRP)'s current position regarding protection of the environment is set out in its Publication 60 (ICRP-60, 1991): *'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'* (ICRP-60, 1991). The Commission intend to develop a set of reference fauna and flora, plus their relevant databases – in a manner similar to that of Reference Man – to serve as a basis for the more fundamental understanding and interpretation of the relationships between exposure and dose and between dose and certain categories of effect for a few, clearly defined types of animals and plants. 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 (ICRP-91, 2002).

The basic guidelines for radiological protection at the national level in Brazil are regulated by the Secretaria de Vigilância Sanitária (SVS), Decree 453 of June 1st, 1998 Ministry of Health (Decree 453, 1998) and the Comissão Nacional de Energia Nuclear (CNEN), Norm CNEN NN-3.01 Nacional Commission of Nuclear Energy (CNEN/NN-3.01, 2006), 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 majority of our information on the exposure and effects of radiation relates to 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. It is necessary that a system for radiological protection of non-human organisms be harmonized with the principles for the radiological protection for humans (ICRP-91, 2002).

This study aims to evaluate the entrance surface skin doses received by dogs submitted to chest X-ray, to check for pulmonary metastasis using the methods involved with the concepts of radiological protection specified for the man, applying the technique of thermoluminescence dosimetry.

2. Materials and methods

2.1. Dosimetric material

- TL dosimeters of calcium sulphate doped with dysprosium ($CaSO_4$:Dy);

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- 51 plastic badges containing three filters (plastic – 3 mm thick, lead – 1 mm thick and lead 0.8 mm with a central hole 2 mm) used to radiation dose and energy evaluation.

2.2. *Irradiation systems*

- X-ray machine SHIMADZU model EZY-RAD 125 kV with operation parameters presented at Table 1:
- X-ray machine PANTAK/SEIFERT model ISOVOLT 160HS 5–160 kV/0.5–45.0 mA with operation parameters presented at Table 2:

2.3. *Equipments*

- Cubic Water Phantom 30 × 30 × 30 cm^3 filled with distilled water;
- TL Reader Harshaw model 3500.

2.4. *Dosimeters irradiation*

The radiographic exams and exams simulations using a water phantom were performed using the X-Ray system SHIMADZU. Each procedure was carried out taking three radiographs of each animal, two latero-lateral and one ventro-dorsal.

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 distances source-surface were attentively observed, to be reproduced during calibration and exams simulation using a water phantom. The TL badges containing three $CaSO_4$:Dy dosimeters 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 as control 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

2.5. *Calibration curves*

Considering that the X-rays energies used to dogs examinations varies between 50 and 70 kV, these energies were used to obtain the dose-response curves of the $CaSO_4$:Dy dosimeters. The irradiations were carried out using the X-rays machine PANTAK/SEIFERT and a water 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 curve three badges containing three $CaSO_4$:Dy dosimeters each were irradiated with the following doses: 1.5; 2.0; 2.5; 3.5 e 4.0 mGy. 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. The beam energy (kV) as well as the irradiation time calculations to obtain the desired doses were performed using the program "*Lab VIEW 7.0*".

Table 1
Irradiation parameters of the SHIMADZU X-ray machine.

Radiation quality	Additional filtration mm Al	1st HVL mm Al	Tension kV	Current mA	Effective energy keV
RQR3	3.0	4.45	50	10	36.52
RQR5	3.0	4.75	70	10	38.86

Table 2
Irradiation parameters of PANTAK/SEIFERT X-ray machine.

Radiation quality	Inherent filtration mm Al	Additional filtration mm Al	1stHVL mm Al	Tension kV	Current mA	Effective energy keV
RQR3	0.13	2.5 mm Al	1.79	50	10	27.15
RQR5	0.13	2.5 mm Al	2.35	70	10	30.15
RQR7	0.13	2.5 mm Al	2.95	90	10	33.05

2.6. *TL readings*

The TL evaluations were performed always 24 h after irradiation. Each presented value is the average of three measures and the error bars the standard deviation of the mean.

3. Results

The dose-response curve of the $CaSO_4$:Dy dosimeters positioned under lead filter with central hole, that provides energy independent response, irradiated using a water phantom obtained to 30.15 keV X-radiation (70 kV) is presented in Fig. 1.

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 $CaSO_4$:Dy due to its atomic number (15.3), was necessary since the calibration curves were obtained at the same energies of the irradiated dogs and dosimeters.

With the help of the dose-response curves and its fitting equation was possible to estimate the entrance surface skin doses of the animals for each investigation performed.

The dogs were divided into three groups according to animal size: small (5), medium (9) and big (13) dogs. The field sizes used were 20 × 25 cm, 25 × 30 cm and 30 × 40 cm, respectively. The

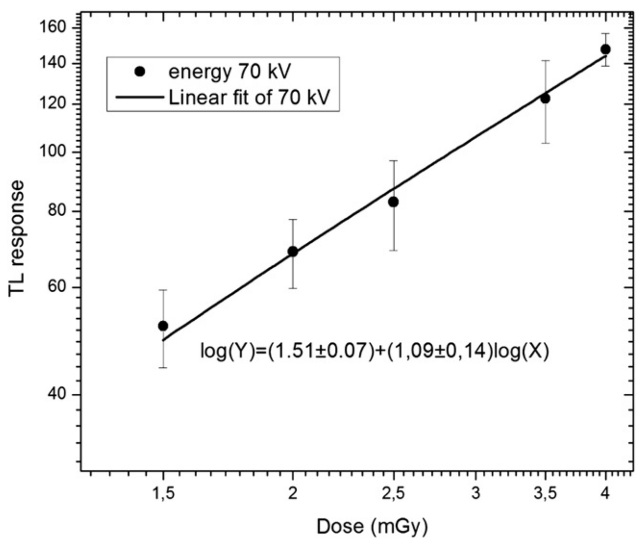

Fig. 1. Dose-response curve for the $CaSO_4$:Dy dosimeter positioned under lead filter with a central hole to X-radiation of 30.15 keV (70 kV).

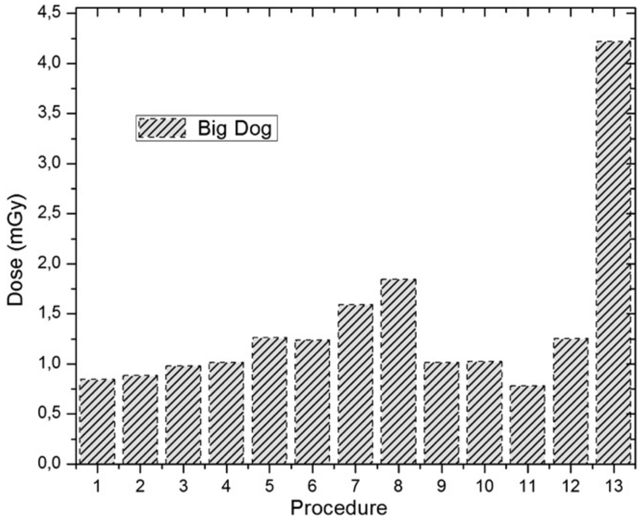

Fig. 2. Entrance surface skin dose of big size dogs.

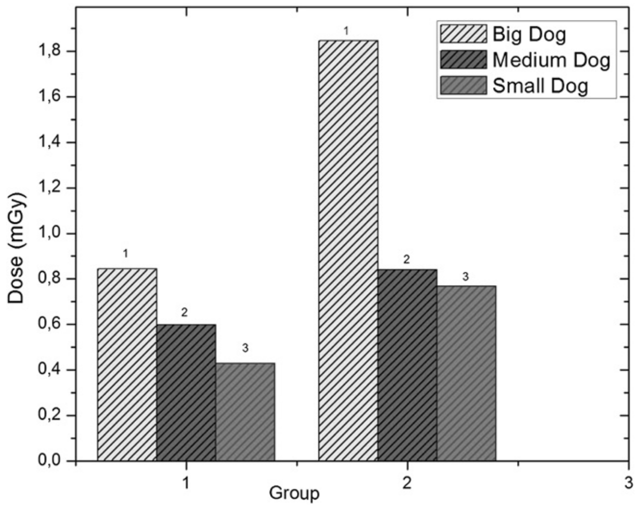

Fig. 3. Comparison between procedures performed without any repetition and the ones who needed to be repeated.

entrance surface skin doses evaluated to small size dogs were: average dose 0.53 mGy, 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. It is important to mention that there are no reference dose values in the literature showing the dose limit to animals.

The entrance surface skin doses obtained from chest X-rays of medium size dogs were: average dose 0.59 mGy, minimum dose 0.49 mGy and maximum dose 0.84 mGy. It is observed an increase in the dose compared to the small size animals.

Fig. 2 presents the entrance surface skin doses obtained from chest X-rays of big size dogs. The average dose was 1.45 mGy. 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 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.

The second step in analyzing the results is the comparison between the ideal procedures, without the necessity of repetition, and using the best possible procedures in order to obtain a diagnostic with quality following the basic principles of radiologic protection (Fig. 3).

Fig. 3 was divided into two groups: group 1 that contains 3 cases, one for each animal size which repetition was not necessary and group 2 also containing 3 cases showing investigations which needed to be repeated. The bars presented in group 1 are the ones who represent the procedures according to the basic principle of radiological protection once the entrance surface skin dose increase as a function of the animal size.

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

The third part of the work was to monitor the owner of the animals exposed to the radiation since they immobilize their dogs during the imaging procedure. According to the Brazilian regulations public individual cannot receive dose higher than 1 mSv/year. In order to monitoring the personal doses received by the pet's owners and occupationally exposed workers wristlet thermoluminescent dosimeters were used, as well as a hole body dosimeter positioned under the lead coat, which is required during the immobilization procedure.

4. 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 is extremely important the assessment of radiation doses involved in veterinary diagnostic radiology procedures, to evaluate the delivered doses to the animals, to be used as a parameter in the individual monitoring of pet's owners, who assist the animal positioning, and to protect occupationally exposed workers at the Veterinary Radiology Clinics.

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