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CALIBRATION METHODOLOGY AND SELECTION OF TLD - 100

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ABSTRACT

In Brazil, it is estimated that for the biennium 2018-2019, that occurred 600 thousand of new cases of cancer for each year and lung cancer is the most common of all malignant tumors. Radiotherapy acts as a form of treatment from which come two basic modalities for the treatment of cancer: teletherapy and brachytherapy. In teletherapy is used a linear accelerator to make the application and before starting the treatment is carried out a planning that makes the acquisition of all anatomical information of the patient and then the classification of areas of interest in the patient. All planning prior to initiation undergoes a quality control dosimetry, which ensures that the dose prescribed in the planning will be delivered accurately in the treatment of the patient. In radiotherapy the dosimetry is applied as an independent measurement and this work has the objective of comparing the dosimetric plan of lung cancer in adjacent organs - in this case the organ of risk is the heart - with dose values calculated in the planning system (TPS) using an anthropomorphic phanton. All dosimetry was performed with thermo luminescent dosimeters (Lif: Mg,Ti-TLD-100). We selected 50 TLDs that underwent a calibration process with thermal treatment, irradiation and reading. All the dosimeters passed through the reader in order to quantify its reading. The TLDs chosen were those that obtained coefficients of variation of less than 5% for three cycles of irradiation, in order to prove the methodology used for the thermal treatment, reading and calibration of dosimeters.

1. INTRODUCTION

1.1 Cancer

Cancer is a set of more than 100 diseases that have in common the disordered growth of cells that involve tissues and organs, and may or may not spread to other parts of the body (metastasis) [1]. It occurs sporadically or hereditarily, since it begins with DNA damage. Any normal cell can be the site of origin of a neoplastic process that can develop in many ways over many years [2].

Currently, diagnoses made in advance can detect the disease in the initial stages, allowing the use of less invasive treatments and with results equal or superior to the classic treatments, such as chemotherapy, radiotherapy and surgery. In Brazil, the occurrence of 600 thousand new cases of cancer is estimated for the 2018-2019 biennium, for each year. Excluding non-melanoma skin cancer (about 170,000 new cases), 420,000 new cases of cancer will occur. The global calculation corrected for under-registration, according to MATHERS et al., Indicates the occurrence of 640 thousand new cases. [3] These estimates reflect the profile of a country that has prostate, lung, breast, and colon and rectal cancer among the most incidental but still presents high rates of cervical, stomach and esophageal cancer as shown in figure 1. [4]

Localização Primária	Casos	%			Localização Primária	Casos	%
Próstata	2.700	28,8%	Homens	Mulheres	Colo do Útero	2.300	24,8%
Estômago	1.150	12,2%			Mama Feminina	1.730	18,6%
Traqueia, Brônquio e Pulmão	820	8,7%			Cólon e Reto	660	7,1%
Cólon e Reto	450	4,8%			Traqueia, Brônquio e Pulmão	520	5,6%
Leucemias	390	4,2%			Estômago	480	5,2%
Cavidade Oral	330	3,5%			Leucemias	310	3,3%
Linfoma não Hodgkin	270	2,9%			Ovário	270	2,9%
Sistema Nervoso Central	270	2,9%			Glândula Tireoide	270	2,9%
Laringe	240	2,6%			Sistema Nervoso Central	270	2,9%
Esôfago	240	2,6%			Corpo do Útero	200	2,2%

*Números arredondados para múltiplos de 10.

Figure 1: Proportionate distribution of the 10 most common types of cancer by sex, estimated for the biennium 2018-2019, except non-melanoma skin cancer.

1.2 Radiotherapy

Radiotherapy is a technique that employs ionizing radiation beam to destroy tumor cells. A pre-calculated dose of radiation is applied at a given time to a volume of tissue encompassing the tumor, seeking to eradicate all tumor cells, causing as little damage as possible to the surrounding normal cells. [4] [5]

It is a treatment method that can be indicated exclusively or concomitantly with other therapeutic methods (surgery or chemotherapy). [6] [7]

1.3 Thermoluminescent Dosimeter (TLD)

Since the beginning of the use of ionizing radiation in medicine, dosimeters were present to determine or relate measurable physical quantities with the dose corresponding to the medium analyzed.

Thermoluminescence is the phenomenon that occurs in certain materials, which characterizes the light emission of the previously excited material. With the irradiation of the thermoluminescent material (TL), metastable states are created in the material structure, such states return to fundamental levels with increasing material temperature, and consequently the release or emission of energy from the metastable states takes place in the form of light (relaxation), as shown in figure 2.

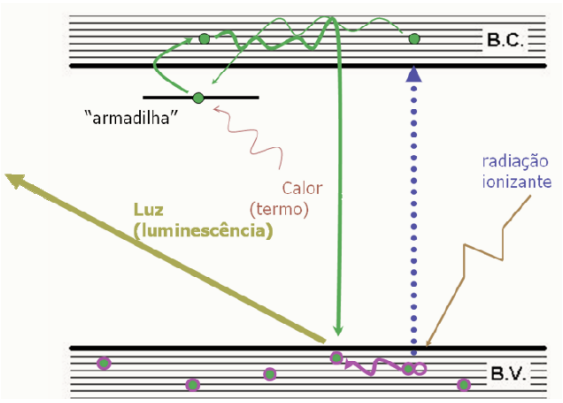

Figure 2: Schematic diagram of the energy bands of the thermoluminescent material.

The light emitted by the material TL is proportional to the energy absorbed by it, so the application of the thermoluminescent technique in dosimetry of the ionizing radiation is justified. One of the most widely used materials investigated in the literature is Lithium Fluoride doped with Magnesium and Titanium (LiF: Mg, Ti or TLD-100). [8] [9]

The thermoluminescence measurement equipment consists of a device for heating the dosimeter and an electronic system (photomultiplier) to capture the light emitted. Generally, two heating methods are used for a TL dosimeter. [10] The first is to place the material on a metal drawing board and carry out the heating through the passage of electric current. In the other method, the raising of the temperature is done by means of a flow of heated inert gas. Figure 3 shows the schematic of a TL reader system. [11]

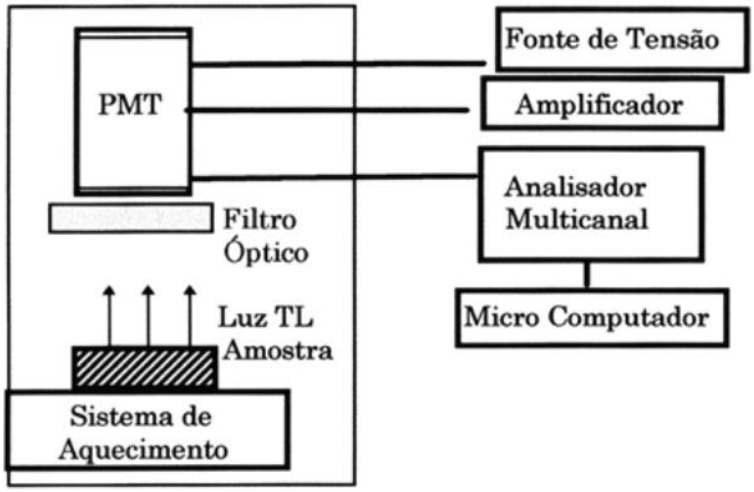

Figure 3: Schematic of a thermoluminescent dosimeter reader system.

2. OBJECTIVE

2.1. General

- Heat treatment of TLDs 100;
- Irradiate the TLD 100;
- Read one by one in the reader;
- Analyze the linearity of the response of the TLDs as a function of the dose;
- Make the selection of thermoluminescent dosimeters:

3. METHODOLOGY

The dosimeters used in this project are Lithium Fluorides, Magnesium and Titanium doped (LiF: Mg, Ti), better known in the literature as micro TLD-100, with dimensions of 1 mm x 1 mm x 1 mm. Its properties are listed below:

- Density: 2.64 g / cm3;
- Effective atomic number for photoelectric absorption: 8.2;
- Photoluminescent emission spectrum 3500 to 6000 A (max. At 4000 A);

- Dosimetric peak temperature 195 ° C;
- Energy response (30 KeV / Co-60): 1.25;
- Kerma-air range: 10 μGy - 10 Gy;
- Fade optimized at 20 ° C: 5% per year.

Thirty micro TLD-100 crystals that were irradiated in a gamma radiation source, Cobalt-60 source 15.74 TBq (425.40 Ci), were selected. Then the crystals were read individually on the Model Harshaw 3500 Reader TLD Reader with WinREMS ™. This sequence of irradiations and measurements were repeated 3 times.

The heat treatment for this TLD-100 micro dosimeter model consists of the following steps: 400 oC for 1 hour, cooled to 100 °C, where they are maintained for 2 more hours then the oven returns to room temperature (~ 22 oC) for 30 -35 minutes. The minimum interval between the irradiations and the heat treatment was 24 hours, which allowed full stabilization of the energy levels of the crystalline structure for future irradiation. The same time interval was used to perform the readings, in which case the low temperature peaks are allowed to return to the ground state.

All dosimeters passed the reader again to quantify their reading. This reader enabled the pre-loading dosimeters one by one, the positioning of the TLD in the reading compartment was done manually.

The TLDs chosen were those that obtained coefficients of variation of less than 5% for three cycles of irradiation.

3.1. Equipments

- Source of gamma radiation, activity of Cobalt-60 source 15,74 TBq (425,40 Ci) belonging to CTR-IPEN / CENEN-SP.
- Manufactured Grion oven.
- Harshaw Model 4500 TL reader belonging to IPEN-CENEN / SP, acquires the TL responses of the dosimeters reading only one dosimeter per positioning (manually operated) and has an interconnection with software called WINREMS (Windows®-based Radiation Evaluation and Management System).

4. ANALYSIS AND DISCUSSION OF RESULTS

4.1 Preparation for dosimeter selection in Cobalt 60

The batch with 30 dosimeters was irradiated in this first stage to verify its reproducibility.

As the lower the standard deviation, the greater the accuracy, thus having a greater reproducibility. Dosimeters with less than 5% and with relatively close sensitivities were considered suitable for use in dosimetry of clinical photon bundles; 25 dosimeters were selected as shown in Table 2 below.

Table 1: Results of the total averages of each dose range of 25 dosimeters

Dose (cGY)	nC	Des.Pad	DPM	DPM/Média
150	9,87	0,39	0,22	2%
200	12,27	1,13	0,65	5%
250	15,68	1,09	0,63	4%
300	19,91	1,86	1,08	5%

All the procedures performed allowed to evaluate which batch presented relatively low uncertainty and adequate for use in dosimetry of clinical bundles.

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