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Dose-rate constant evaluation of a new 192-Ir brachytherapy source using Monte-Carlo and experimental parameters.

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Introduction : The aim of this work was to evaluate the dose-rate constant of a 192-Ir source for brachytherapy produced in the Laboratory of Sources Production for Radiotherapy (IPEN-CNEN/SP). Brachytherapy is a cancer treatment based on the exposure of the ionizing radiation to the tumor, where the source is placed near the tissue to be treated(1,2,3). Nowadays, cancer is one of the leading causes of death and morbidity worldwide, circa 14 million new cases were estimated for 2018(4,5). The increase of publications on brachytherapy in middle 90's made it necessary to develop a new formalism for calculating the dosimetry of interstitial sources, the American Association of Physicists in Medicine Task-Group 43 report (AAPM TG 43) was then established.

Using the formalism of TG 43 and the dose-rate constant it is possible to calculate the dose distribution for the clinical practice, this is an important parameter for validation of the source produced.

Methodology : A new 192-Ir source for brachytherapy produced in the Laboratory of Sources Production for Radiotherapy (IPEN-CNEN/SP) was used for this work. The methodology for this study may be divided in two steps : experimental measurements (activity and thermoluminescent measurements) and Monte-Carlo simulation for parameters definition.

Activity measurement **-** was performed in the CAPINTEC® model CRC-15W well-ionization chamber. The initial activity was measured and activity during the realization of the experiment was calculated through the exponential decay calculation.

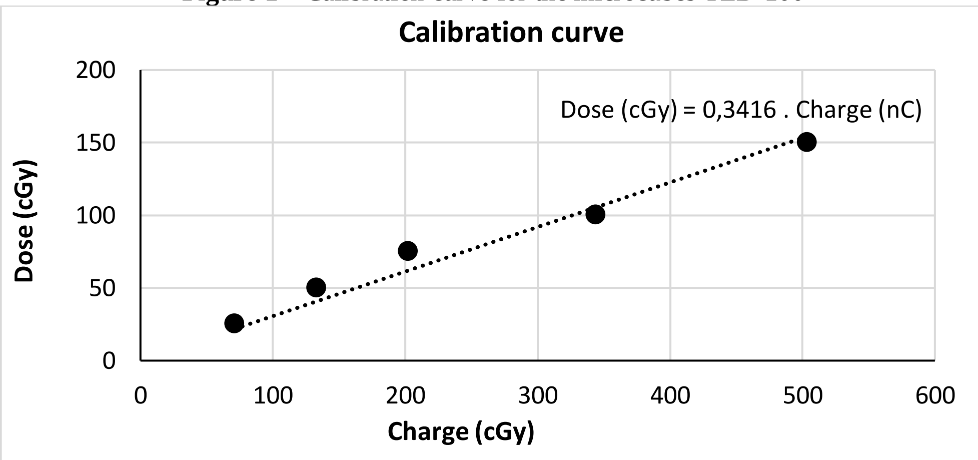
Thermoluminescent measurements - LiF:Mg,Ti microdosimeters (microcubes TLD-100) purchased from Harshaw were used as the thermolumisnescent dosimeters. Before each irradiation the dosimeters were cleaned by a thermal treatment following the manufacturer's recommendation. Themoluminescent readings were performed in the Thermo-Harshaw 3500. For the acquisition of the TG 43 parameters protocols, an experiment in a solid water RW1 phantom was performed.

Monte-Carlo simulation – MCNP4C was used to perform Monte-Carlo (MC) simulations for this source. MC had a major role in this work once it was fundamental for calculate the S_k parameter. S_k can be simply defined as the value of the kerma-air intensity at distance d (far enough so the source S_k doesn't depends on d, carried in the vacuum) by the square of the distance. For the simulation the iridium source was defined surrounded by vacuum and with an air ring at a the distance of 1 meter, using tally *F6. This is how the standard of measurement of S_k is defined by the protocol. This value refers to an ideal seed, as simulated.

Results : Activity measurement – The initial activity of the source was 48.8 mCi (1.8 GBq), the considering that Iridium-192 has a half-life of 73.83 days and its dose rate constant is 3.91×10^{-4} hours, the activity for the day that the dosimetric measurements were performed was calculated following the radioactive decay law, the value obtained was 29.18 mCi ± 0.01 mCi.

Thermoluminescent measurements – To perform the thermoluminescent measurements a calibration curve of the dosimeters is necessary, since the value of the charge (nC) measured may be converted into dose (6, 7). The Figure 1 presents the calibration curve obtained for this work, coefficient of slope of the line was 0.3416, this value was used to obtain the dose value.

Figure 1 – Calibration curve for the microcubes TLD-100



The comparisons between different iridium-192 source models performed by other research entities are just possible due to the value of the dose rate constant.

In this work the dose rate constant value was calculated using the Monte Carlo method as described. The result for the dose rate constant was 1.115 cm^{-2}, and experimentally the result obtained was 1.084 cm^{-2}. The relative difference between the two values of dose rate constant was 2.48%, this result is similar to the ones found in the literature.

Conclusions: Brachytherapy is a well stablished cancer treatment, but it study still is very important once different radioisotopes or geometries may be used for different applications.

This work present the dose-rate constant value for a new Ir-192 source developed in IPEN-CNEN/SP. The value is close to similar seeds found in literature (8). Two methods were used to evaluate the dose-rate constant, MC simulation and thermoluminescent dosimetry. The relative difference between the values of dose rate constant obtained by these two methods was 2.48%, the literature reports similar results to that one.

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