2021 International Nuclear Atlantic Conference - INAC 2021
Virtual meeting, Brazil, November 29 - December 2, 2021

ISBN: 978-65-594-1256-3

Experimental Dosimetry of Pulmonary Region in TBI Protocol

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1. Introduction

The total body irradiation (TBI) is a method of radiotherapy treatment that consists of the whole body irradiation of a patient in a cancer situation. This technique is used in the case of disseminated tumors or in cases of immunosuppression of patients with leukemia in order to minimize rejections. The treatment protocol is to split the total radiation dose into six fractions every six hours. This procedure is based on the redistribution of the individual's cell cycle, taking into account the phase where there is the greatest cellular radiosensitivity, that is, the mitotic phase of the cell. In this way, it is possible to inactivate the patient's tumor cells or, in case of immunosuppression, the method allows the bone marrow transplant to be satisfactory. Due to dose heterogeneity, as a consequence of the large irradiation fields, a more detailed study of the dosimetry parameters, using simulators or physical phantoms are necessary to promote and/or ensure quality in TBI treatments. Particularly, the lung have low tolerance dose limit thus, dosimetry studies are needed for the optimization of dose distribution in cases of TBI for radiosensitive organs such as the lungs [1] [2] [3] [4].

Here, the physical phantom, Rando Alderson [5] was used to estimate the absorbed dose delivered to the target organs. The Alderson male phantom is 175 cm height and weights 73.5 kg, and it is made of soft tissue of 1.08 g/cm^3, cortical bone of 1.18 g/cm^3 and trabecular bone of 1.17 g/cm^3 which gives a total density average of about 1 g/cm^3. Figure 1 and Figure **??** shows the Alderson male phantom and a slice of its body, showing the cavities used to insert the detectors. The thermoluminescent detectors (TLD) and physical phantoms are well-used to measure and study the dose distribution in experimental procedures in hospitals [6] [7] [8] [9]. The TLD 100 [10] made of lithium material doped with magnesium and titanium (Li:Mg, Ti) with 0.9 mm thickness and 4.5 mm in diameter[10] was used together with the Alderson male phantom to obtain the absorbed dose in the lungs while executing a TBI treatment procedure. The experiments were performed in the Hospital São Francisco in Belo Horizonte, Minas Gerais, Brazil using a 6 MV LINAC.

2. Methodology

190 thermoluminescent dosimeters (TLD 100) were used for investigating the absorbed dose into the lungs of the Alderson male phantom for a protocol of TBI procedure in the Hospital São Francisco. To obtain the absorbed dose in the lungs' region of the Alderson phantom, the TLD detectors were placed in the cavities of the slices number 12 up to 21 which correspond to the lung's region of the phantom. It was used 10 TLDs per cavity to have a good statistic uncertainties in the dose distribution. The irradiation procedure, used a 6 MV photon beam with

Figure 1: Phantom Alderson male

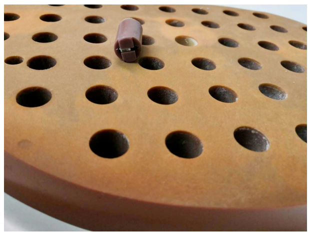

Figure 2: Slice Phantom

the maximum field size of 40 cm x 40 cm. The phantom was placed in lateral position on the floor of the treatment room, see Figure 3. This is the usual procedure in TBI protocol in the hospital. The geometric parameters for the TBI procedure depend on the hospital's physical structure, in which case the linear accelerator, table, distances, target, irradiation field are modified to assemble each new physical setup. Normally, the patient is irradiated off the table and each radiotherapy center has different treatment room dimensions, it can be said that TBI is an adaptable technique to each institution, with non-standardized clinics, equipment and treatment rooms. The distance of the source to the floor was of 260 cm. After the irradiation, the TLDs were removed and read using the RISØ reader - model TL / OSLDA-20 - of the Luminescent Dosimetry Laboratory of the Nuclear Technology Development Center (LD/SECDOS/CDTN). The dose deposited in the lungs were analyzed, and the results were done by comparing the dose distribution between both left and right lungs.

Figure 3: The Alderson phantom in the room floor treatment

3. Results and Discussion

The results presented in Table 1 show an average variation of the dose deposited between the right and left side of the lung of the Alderson phantom positioned in the supine position. It was irradiated with a 6MV Elekta linear accelerator at a distance of 260 cm from the source at the São Francisco Radiotherapy Center located in the city of Belo Horizonte / MG. In other works [8], [12], smaller variations are described for the region of interest following limits limited by ICRU 50 (5 %) along the target volume. However, [1] shows that 10 % is acceptable for TBI just as [13] conveys even more significant amounts.

It is extremely difficult for variations smaller than 10 % without the use of shielding or protection mechanisms [1]. In our work, we do not use any type of apparatus for in the experimental process yet. The purpose here, was to investigate the heterogeneity of the dose deposited in the lungs. New experiments are going and further methodologies will be proposed.

Table I: Absorbed dose in cGy for slice of the lung's Alderson.

Slice number	Right lung (cGy)	left lung (cGy)	Δ(%)
12	1.04	0.83	20.20
13	1.07	0.77	28.00
14	1.20	0.76	36.70
15	1.09	0.88	19.30
16	1.22	0.81	33.60
17	1,12	0.87	20,90
18	1.12	0.77	31.30
19	0.96	0.89	03.50
Total dose (cGy)	1.10	0.82	24.20

4. Conclusions

The absorbed dose were obtained for the Alderson Rando Phantom using TLDs 100. The lungs of the phantom were filled with detectors and the TBI procedure was used in order to study the variation on the doses due to phantom-source distance and photon beam energy. The experiments were performed at the Hospital São Francisco in Belo Horizonte, MG, Brazil. The study is the first performed and new results are ongoing tasks which may be possible to show and compare to other studies published in literature. It is also possible to expand the findings to the quality control in relation to this treatment modality, which consequently minimizes the uncertainties of radiotherapy treatment and ensuring better application of the technique for cancer patients.

Acknowledgments

The authors acknowledge the School of Engineer the Federal University of Minas Gerais, National Council and Technological Development - CNPQ, the Nuclear Technology Development Center-CDTN and the hospital São Francisco for technical support and cordiality to supply the materials for this study.

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