SPATIAL DOSE DISTRIBUTION IN A SYNTHETIC BREAST ON A THORAX PHANTOM INDUCED BY SODIUM PERTECNETATE-^{99m}Tc ($Na^{99m}TcO_4^-$) SILICON BALLON

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INTRODUTION

Breast cancer is the most frequent malignant neoplasm in women, especially after age of 50, ranking first in developed countries. It is the fifth cause of death worldwide and the third in Europe, after lung and colorectal cancer, causing half million deaths every year. The use of radiotherapy as a component of breast-conserving therapy or after mastectomy has been proven to reduce the risk of loco-regional recurrence and improve long term breast cancer specific and overall survival. Despite of that, it is necessary to improve the radiation therapy doses on the tumor *in situ*, reduce the collateral effects from the treatment and make medical expanding lower.

MATERIAL AND METHODS

Ten 1,5 x 0,5 cm pieces of radiochromic film were sealed and placed in plastic support immersed in water, 1 cm away from one another from the surface of the balloon to 10 cm. It was taken care that the guidance and direction of the films were the same for all the pieces when they were irradiated and scanned. The set were numbered from 1 to 10 from closest to farthest and subsequently analyzed. The activity of saline liquid inserted on the silicon ballon was 632 mCi in a volume of 3 mL. Exposure of the films was maintained for 24 h, equivalent to four half-lives of the radioisotope.

The spatial dose distribution in a synthetic breast on a thorax phantom was evaluated too. A silicon balloon was placed internally in the left synthetic breast of a thorax phantom at the lateral superior quadrant of the armpit. A radiochromic film of 10 x 10 cm was affixed on near the balloon in the sagittal direction, having the balloon centered. The balloon was filled with 3 mL of 37 GBq (1000 mCi) of $Na^{99m}TcO_4^-$ and held by 24 h, equivalent to four half-lives ($T_{1/2}$) of radioisotope. The radiochromic films was sensitized and removed.

The scans were made in transmission mode at 300 dpi and 48-bit RGB (Red, Green and Blue), without any color correction and adjustment. The scanned images were analyzed using the reading of the intensity of the RGB components (red-R, green-G, blue-B) in red and green. ImageDIG program was used to decompose each RGB image in their R and G compontes. The RGB value of each component is established in a band ranging from 0 to 255. Therefore the amount of radiation absorbed in the film was nominated for the intensity of the component in red and green of the scanned image. The mean levels of the RGB components in red and green were used to calculate the optical densities at the selected positions in the films sensitized. A voxel model of the breast including various tissues, with the balloon positioned within the glandular breast tissue was used to generate the spatial dose distribution with the aid SISCODES and MCNP-5.

RESULTS AND CONCLUSION

The spatial distribution of the theoretical and experimental dose was presented on a comparative basis. From the analysis of dosimetric films and computer simulations were generated correlation dose versus optical density. The radiochromic films sensitized by $Na^{99m}TcO_4^-$ depicted in Figure 1, shows the exposed areas.

The measured OD values, its standard deviations and their correlation to the absorbed dose measured at the red component are shown in Table 1. The dose values generated in MCNP were adjusted to an activity of 631 mCi.

Figure 1 - Image films irradiated taken after exposure at 1 cm up to 10 cm (right to left).

Table 1 - Values of OD, standard deviation, and dose rate from MCNP (cGy.s^{-1}) and accumulative dose in Gy after 24 h exposure at 631 mCi.

d	σ (OD)	D_i (MCNP) $[Gy.h^{-1}$	D_i [Gy] at 631mCi
1,196795	0,07754439	8,00E-03	4,10E+01
0,482205	0,00878817	1,91E-03	9,81E+00
0,317271	0,01734468	8,58E-04	4,40E+00
0,231812	0,02233584	4,85E-04	2,49E+00
0,181175	0,01152985	3,10E04	1,59E+00
0,134239	0,01000775	2,13E-04	1,09E+00
0,114566	0,01319566	1,55E-04	7,94E+01
0,084265	0,0050412	1,17E-04	5,97E-01
0,077242	0,00917485	8,79E-05	4,50E-01
0,063526	0,00682467	7,05E-05	3,61E-01

It is shown, in Figure 2, the mathematical correlation of the OD to absorbed dose sensibilizated by gamma emissions. In the experiment of calibration, with the increase of distance decreased the optical density and the dose absorbed.

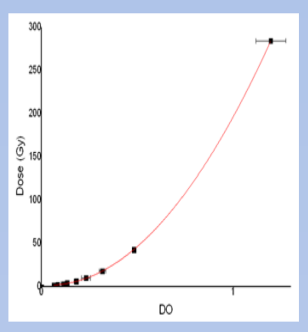

Figure 2 - Curve of the optical density versus dose in Gy.

Figure 3 presents the digitalized red component, in gray level, taken from the 7 x 11.5 cm radiochromic film in which the Tc-99m balloon was filled with 1000 mCi. The hole with 20 mm diameter was prepared to insert the balloon.

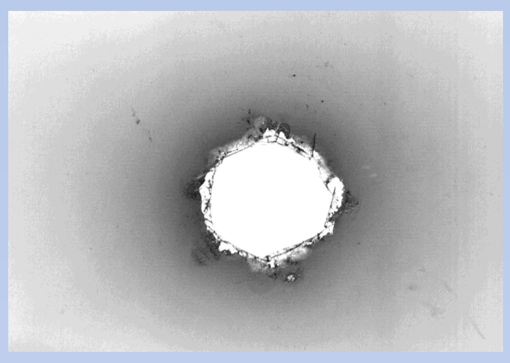

Figure 3 – Digitalized, red component in Gray level, of the 7 x 11,5 cm radiochromic film.

Figure 4 shows the spatial dose distribution taken from the radiochromic film into the left synthetic breast. The data from Fig.3 was converted on dose by Eq. 1. Figure 4b presents the dose values at the central axis of the Fig4b.

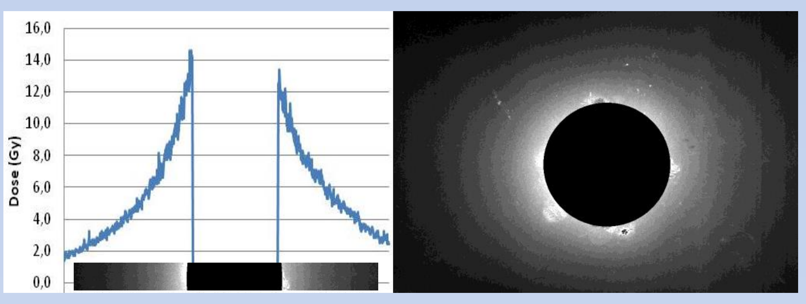

Figure 4 – (a) dose versus pixels position taken from dose distribution in gray level.
(b) Spatial dose distribution in gray level, taken at radiochresponse

A depth dose profile generated by MCNP-5 code for the issuing emitted gamma rays is illustrated in Fig 5.

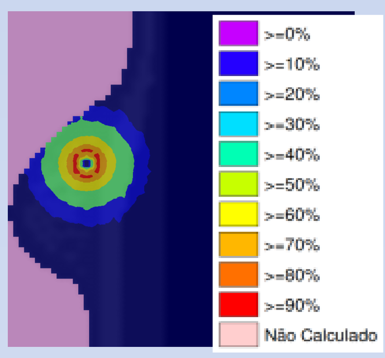

Figure 5- Profile of percentage depth dose at an arbitrary saggital section for the$Na^{99m}TcO_4^-$ballon.

The results shown that the application $Na^{99m}TcO_4^-$ balloon held high dose in the breast tissue adjacent to a supposed tumor bed and preserves vital adjacent structures. In conclusion, the balloon presents itself as a viable option for the adjunctive treatment of breast cancer in patients who have appropriate indication.

CONCLUSION

The balloon presents itself as a viable option for the adjunctive treatment of breast cancer in patients who have appropriate indication. Irradiation with sodium $Na^{99m}TcO_4^-$ generates high doses in breast tissue and consequently in the tumor bed. This treatment has low cost, availability and reduced time of treatment, decreasing the side effects of conventional radiotherapy.