Dosimetry of ^{125} I Seed interstitial brachytherapy

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【Abstract】

Objective To calibrate and assess the dose distribution of ^{125} I seed brachytherapy.

Methods Twenty ^{125}I seeds with an activity of 12. 2 MBq were implanted on the circumference of a circle with a diameter of 15mm across in a phantom., 70 ^{125}I seeds were implanted into a designed prostate model in four planes. The absorbed dose rate of the target volume was monitored by Farmar 22570 dosimeter and thermoluminescence dosimeter (TLD) with the isodose curves drawn on Kodak films.

Results The central absorbed dose rates of the circular target volume assessed by Farmar 22570 and TLD were 8.4cGy/h and 7.9cGy/h respectively in the phantom, and those were 12.0cGy/h and 11.1cGy/h in the prostate model. For the target volume of the prostate model, the total absorbed dose was 24219cGy. The dose 4cm away from the prostate cencer as shown by the isodose curves was only 10% of the central dose.

Conclusions The doses in a central target volume measured by the 2 methods are similar.

【Key words】 Iodine 125 seed; Brachytherapy; Dosimetry

The dosimetric characteristic of ^{125}I seeds is suitable for interstitial brachytherapy, and ^{125}I seeds have been widely used in the treatment of prostate cancer [1]. After having implanted ^{125} I seeds into a phantom and a prostate model, the author determined the absorbed dose in a simulation of tumor tissue in the phantom and drew isodose curves on films to estimate the total cumulative absorbed dose.

Method and Material

1. ^{125} I seeds: The Type BT212521 ^{125} I seeds for brachytherapy

provided by Syncor Shanghai Pharmaceutical Co., Ltd. which were produced in accordance with ANSI/HPS N43.621997, and approven for sale by FDA. The diameter is 0.8mm and length 4.5mm for each seed, and it is covered with a 0.05mm-thick titanium alloy. The radioactivity of each seed was marked before it left the factory, and the dispersion of radioactivity of each batch must be less than 5%. The average radioactivity of each seed used in this experiment is 12.2MBq (0.33mCi), microcomputer radioactivity meter is 11.9MBq (0.32mCi) determined by samples with a FJ2391A, so the dispersion meets the requirement.

2.Dosimetry after the ^{125} I seeds have been implanted into the phantom

The phantom used is the Type SM22 Phantom self-developed by our institute (a non-uniform equivalent human body simulation model made of material of paraffin, polyethylene and human bones), and it was divided into 13 pieces by cutting transversely. 20 holes with a diameter of 1mm and a depth of 5mm were drilled evenly on the circumference of a circle 15mm across in the location of the muscle near the left lobe in the 6th cross-section of the phantom, 20 ^{125}I seeds were implanted into the holes, a hole with a diameter of 8mm and a depth of 16mm were drilled in the middle, and a dosimeter probe and a thermoluminescence dosimeter (TLD) components were placed. The Farmar 22570 Dosimeter was calibrated with the on-site temperature and atmospheric pressure, and 0.6ml graphite ionization chamber was placed into the above hole with a diameter of 8mm to carry out a measurement for 20min.

The thermoluminescence components were the LiF(Mg Cu and P) TL glass components (GR2200T) provided by Chinese anti-chemical Institute with a diameter of 2mm and a length of 12mm. They were irradiated with 33kV low-energy x-ray after being grouped, calibrated with a FJ2377 Thermoluminescence Dosimeter (TLD), and dose-response curves were drawn. 3 TLD components were placed into the above hole with a diameter of 8mm, taken out after irradiated for 48h, and carried out a dosimetry with the same thermoluminescence dosimeter (TLD). The same 10 seeds were implanted evenly on the circumference of a circle 15mm across in the above phantom, and carried out a dosimetry with the TLD components using the same method [2].

3.Dosimetry after ^{125} I Seeds were Implanted into a Prostate Model

The model was made of the human body equivalent material of paraffin and polyethylene in the shape of an elliptic cylinder with a large upper part and a bit smaller lower part, the dimensions of which was a×b×c=4.0cm×3.0cm×2.5cm. The prostate model was horizontally cut in two, 70 holes with a diameter of 1mm and a depth of 5mm were drilled respectively in the 4 cross-sections for placing ^{125} I seeds, and a hole with a diameter of 8mm was drilled in the middle of the model for placing a dosimeter probe and a thermoluminescence dosimeter (TLD) components as shown in Fig. 1. A Type Farmar 22570 0.6ml ionization chamber was placed into

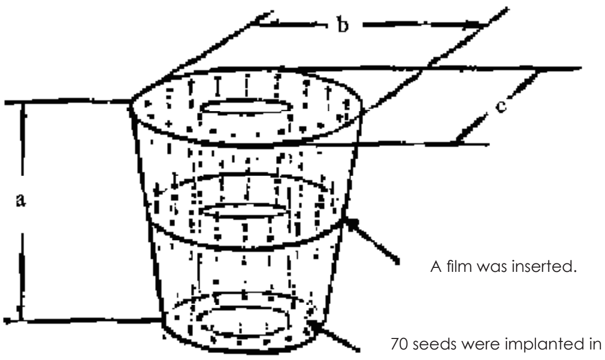

Fig. 1 Prostate Model into Which ^{125} I Seeds were Implanted

the above hole to measure the cumulative absorbed dose for 10min in the target center after 70 ^{125} I seeds were implanted, the cumulative absorbed dose was converted into the average absorbed dose rate, and the average absorbed dose was measured with thermoluminescence dosimeter (TLD) using the same method in 2.

4.Determination of Isodose Curves

An PDI210 SAKURA Blackness-measuring Instrument and Kodak X2omat V films were used. An experiment was made with the linear district of the blackness-dose response curve. One of the films (10cm×15cm) was inserted between the 5th and 6th cross-sections of the phantom (20 ^{125}I seeds were implanted on the circumference of a circle 15mm across in the 6th cross-section.), and the radiation time was 3.5h. One of the films was inserted between the two part of the prostate model into which 70 seeds were implanted (the middle part of Fig. 1), the prostate model and the film between the two part of the prostate model were placed back to the location of the prostate model between the 11th and 12th pieces of the phantom, the radiation time was 2.5h, and the isodose curves were drawn respectively after the films had been developed.

Results

Result of Dosimetry of Phantom into Which ^{125}I Seeds were implanted: The cumulative absorbed dose for 10min in the target center of the prostate determined with the Farmar 22570 Dosimeters was 2.0cGy, and the average absorbed dose rate was 12.0cGy/h. The average absorbed dose determined with the TLD components was 528.9cGy, the average absorbed dose rate was 11.0cGy/h, and it was 11.13cGy/h after disintegration amendment. ^{125}I seed interstitial brachytherapy is usually a permanent radiation.

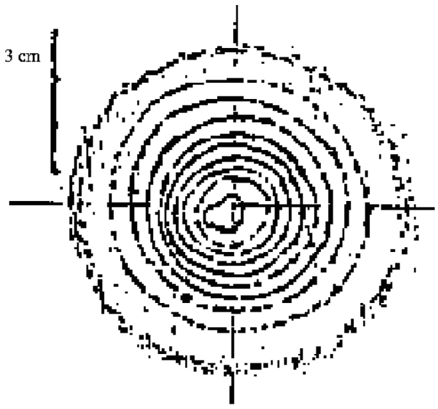

Fig. 2 Isodose Curve after 20 ^{125} I Seeds were Implanted on the Circumference of a Circle 15mm across in the Phantom

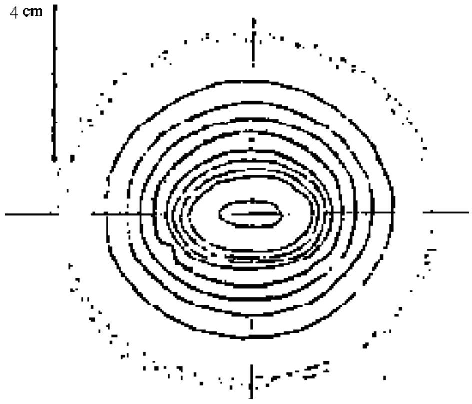

Fig. 3 Isodose Curve after 70 ^{125}I Seeds were Implanted into a Prostate Model

The total absorbed dose of 70 seeds, each of which was 12.2MBq (0.33mCi) in the location of the tissue in the target, was $D=ÛD_0 \times 1.44T_{1/2}$[3], in which the $ÛD_0$ was the initial average absorbed dose rate (11.56cGy/h), $T_{1/2}$ was the half-life (60.1d here), and total absorbed dose was D=24 219cGy.

Result of Dosimetry Determined with Isodose Curves

See Fig. 2 and Fig. 3.

Discussion

One can see from the isodose curves of Fig. 2 and Fig. 3 that their shapes and scopes are different because the numbers and arrangements of the ^{125}I seeds are different. The arrangements of the isodose curves of Fig. 2 and Fig. 3 are respectively circular or oval. The dose rate of the center of theisodose curves is the highest, and it decreases by 10% along with each circle. In the isodose curve of Fig. 2, the absorbed dose rate in the place 2cm away from the center is only 40% of that in the center; the result of calculation of the value determined with these two kinds of physical methods is about 3.25cGy/h; the absorbed dose rate in the place 3cm away from the center is only 10% of that in the center. In the isodose curve of Fig. 3, the absorbed dose rate in the place 2cm away from the center of the abscissa axis is 70% of that in the center, namely about 8.1cGy/h; the absorbed dose rate in the place 4cm away from the center is only 10% of that in the center, and namely 1.2cGy/h.

It is know from all the above: (1) ^{125}I seeds are characteristic by low photon energy able to be easily absorbed by tissue, especially by tumor tissue, and less harmful to surrounding tissues and organs. (2) The results of the determinations of the seeds with an ionization chamber and TLD in the two models are similar. (3) The determination with the films can provide the two–dimensional isodose curves of the two models, and doctors can refer to the isodose curves to estimate the actual dose distribution in a human body in clinical application.

References

1. Ling CC. Permanent Implants Using Au2198, Pa2103 and I2125 : Radio2biological Considerations Based on the Linear Quadratic Model . Int. J Radiation Oncol Biol Phys, 1992 ,23: 81.

2. Sou T ,Chiu T. Dose rate determination for ^{125}I seeds. Med Phy, 1990, 17: 816.

3. Medical Administration Department, Ministry of Health of People's Republic of China, Standards of Nuclear medicine Diagnosis and Therapy, Beijing, Science Press, 1997, 281.