

The Study About Protective Effect after Application of Radioactive 125I Seeds with the Shielding Material

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ABSTRACT

AIM: The purpose of the experiment is to investigate the protective effect after 125I seeds implantation with 0.35mmpb shielding material and to guide the radiation protection scientifically.

METHODS: With or without covering the 0.35mmpb shielding materials, the dose rates were measured of 30cm and 100cm from the body surface within 24 hours after operation using a pocket radiometer. Calculate the corresponding effective dose and precaution time according to the relevant formula.

RESULTS: With or without covering the 0.35mmpb shielding material, the precaution time of an adult family member that lives with but does not sleep with the patient, a pregnant family member and a child that lives with the patient, a co-worker that does not live with the patient and a nonpregnant adult family member that lives and sleeps with the patient were 0d and 0d, 0d and 61d, 0d and 87d, 0d and 94d respectively.

CONCLUSION: 0.35mmpb shielding material can effectively block radiation damage to human body and distance protection is not necessary.

Key words: 125I seed; Shielding material; Protective effect; Precaution time

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INTRODUCTION

The radioactive 125I seeds implantation therapy not only increases the dose of the target area, but also reduces the radiation damage to the surrounding tissues. It can increase the local control rate of the tumor and the survival rate of patients. It has advantages of less trauma and faster recovery after operation. More and more applications are used in clinical treatment of malignant refractory tumors, including prostate cancer, lung cancer, thyroid cancer and so on. While paying close attention to the curative effect, the following radiation safety problems have also aroused the attention. In this experiment, we measured the dose rate of 30 cm and 100 cm from the body surface when 0.35 mmpb shielding material covered within 24 hours after operation, and compared the protective effect without covering 0.35 mmpb shielding material, in order to guide radiation protection scientifically and avoid unnecessary radiation damage.

MATERIALS AND METHODS

Clinical Materials

From March 2018 to October 2018, twenty patients underwent 125I

seeds implantation under the guidance of CT in the department of oncology of Hebei General Hospital. There were 8 males and 12 females, aged 45-81 years, with a median age of 59.5 years. Among cases, renal carcinoma, thymoma, pancreatic cancer, primary liver cancer, metastatic parotid carcinoma, esophageal cancer, prostate cancer, chordoma in 1 case, breast cancer in 2 cases, lung cancer in 5 cases, cervical cancer in 5 cases. The matched peripheral dose (MPD) was 80-120 Gy; And the number of implanted seeds was 23-90, with a median number of 50; The total activity of implanted seeds was 0.3-0.8 mCi, with a median activity of 0.6 mCi, (1Ci = 3.7X10¹⁰Bq); The median depth of seeds from the body surface was 9.03 cm (1.83-16.8 cm).

125I seeds radioactive source and monitor

Type 6711 radioactive 125I seeds produced by Beijing Zhibo High-tech Biology Technology Co., Ltd. (Chinese Medicine Standard No. H20083013); FD-3007K-A pocket radiometer manufactured by China Nuclear Engineering Group Co.

Monitoring methods

The vertical distance from the center of 125I seeds implanted into the tumor to the body surface was measured on CT images after operation and labeled on the corresponding body surface. Within 24 h after operation, the corresponding dose rates were measured at a distance of 30 cm and 100 cm from the body surface using a pocket radiometer.

Observation index

(1) **Dose rate:** The postoperative dose rate was calculated according to the radiation dose decay rule of radioactive sources: $D(n) = D(0)e^{-\lambda n}$, $D(0)$ is the dose rate measured within 24 hours after operation, $D(n)$ is the dose rate obtained after 125I seed decay n days, λ is the decay constant of radioactive source, $T_{1/2}$ is the half-life of 125I seed, and the relationship between λ and $T_{1/2}$ is: $\lambda = \ln 2 / T_{1/2} \approx 0.693 / T_{1/2}$.

(2) **Effective dose:** The dose rate is converted to effective dose by formula: $E(\infty) = 34.56 \text{ TpD}(0) \text{ Tr}^{[2]}$, “ ∞ ” refers to the time required for complete radioactive decay of 125I seeds, $E(\infty)$ refers to the cumulative dose of a time period; 34.56 refers to conversion factor of integration equal to 1.44×24 (h/d); Tp refers to physical half life of radioactive 125I seeds (59.6 d); Tr refers to occupancy factor at index distance. The occupancy factor, index distances and effective dose limits of an adult family member that lives with but does not sleep with the patient is 0.25, 1.0 m, 5.0 mSv; The occupancy factor, index

distances and effective dose limits of a nonpregnant adult family member that lives and sleeps with the patient is 0.33, 0.3 m, 5.0 mSv; The occupancy factor, index distances and effective dose limits of a pregnant family member and a child that lives with the patient is 0.25, 1.0 m, 1.0 mSv; The occupancy factor, index distances and effective dose limits of a co-worker that does not live with the patient is 0.33, 1.0m, 1.0 mSv. The effective dose constraint values were found in the reference^[3-4].

(3) **Precaution time:** Precaution time refers to the time when the effective dose is less than 50% of the effective dose constraint values.

Statistical analysis

The metrological data were expressed by mean \pm standard deviation ($\bar{x} \pm s$). Using SPSS 21.0 software, the dose rate and precaution time were analyzed by paired T test, $p < 0.05$ indicates statistical significance.

RESULTS

With and without 0.35 mmpb shielding material, the dose rates measured at 30 cm and 100 cm from body surface are shown in Table 1. It can be seen from the table that the dose rate decreases with the increase of distance; When 0.35 mmpb shielding material is covered, the dose rate is smaller than that without shielding material, and the difference was statistically significant (30 cm: $t = 4.225$, $p(0.000459) < 0.05$; 100 cm: $t = 3.966$, $p(0.001) < 0.05$).

DISCUSSION

The three elements of radiation protection are time, distance, shielding. The experiment shows that with the extension of distance, the radiation dose decreases; with the passage of time, the radiation dose also decreases; with shielding, the radiation dose decreases obviously. International Commission on Radiological Protection and (ICRP)^[5] and Nuclear Regulatory Commission (NRC)^[6] stipulate that the maximum effective dose for people who are in close contact with patients after 125I seeds operation is 5 mSv and the public (including colleagues), minors and pregnant women shall not exceed 1 mSv. There are few researches on radiation protection at home and abroad, much less on radiation protection after covering shielding materials, so this experiment explored the radiation dose rate and precaution time of covering and not covering 0.35 mmpb shielding material.

The results of Zhuo *et al*^[7] show that the radiation dose is close to the naturalbackgroundradiation dose after 6 months. Wang *et al*^[8] pointed out that more than 99% of the radiation can be shielded using 0.25 mmpb shielding material. Yang *et al*^[9] reported that when the radiation intensity is low, the 0.25 mmpb shielding material can shield about 95% ofthe radiation, and the 0.5 mmp bshielding material can shield almost all the x-y rays of low energy. When the radiation intensity is high, it can still shield about 90% to 97% of the radiation. Expert Consensus on Radiation Protection Management Standards for Radioactive 125I Seeds Wards^[10] recommends that 0.25 mmpb shielding material should be covered after 125I seeds surgery to avoid radiation damage. Yan *et al*^[11] reportedthat after covering the 0.125 mmpb shielding material, the radiation dose at 0 cm distance is close to the naturalbackgroundradiation dose. The results of Qiao *et al*^[12] show that with and without 0.35 mmpb shielding material, the dose rate at 30 cm was 19.39 uSV/h and 0.23 uSV/h, and at 100cm was 3.12 uSV/h and 0.23 uSV/h. Qian *et al*^[13] reported that the radiation dose of 0.5 mmpb shielding material covered significantly decreased, and the difference was statistically significant.

Table 1 With and without 0.35 mmpb shielding material, the dose rates measured at 30cm and 100cm from body surface within 24 hours after operation (uSv/h, $\bar{x} \pm s$).

Distance (cm)	With 0.35 mmpb shielding material	without 0.35 mmpb shielding material
30	0.357 \pm 0.239	9.340 \pm 9.301
100	0.226 \pm 0.162	1.750 \pm 1.724

Table 2 With and without 0.35 mmpb shielding material, the precaution time of different populations (d).

populations	Shielded	Unshielded
an adult family member that lives with but does not sleep with the patient	0	0
a nonpregnant adult family member that lives and sleeps with the patient	0	94
a pregnant family member and a child that lives with the patient	0	61
a co-worker that does not live with the patient	0	87

The results of this experiment showed that the radiation dose was not completely shielded. However, the cumulative radiation dose to human body is lower than the prescribed dose, so it does not harm human body and does not need distance protection. In this experiment, the precaution time of an adult family member that lives with but does not sleep with the patient, a nonpregnant adult family member that lives and sleeps with the patient, a pregnant family member and a child that lives with the patient, a co-worker that does not live with the patient with 0.35 mmpb shielding material was 0d. In the case of unshielded protection, seed rays can directly radiate the human body, which exceeds the prescribed dose and may have a random effect on the human body. So the distance protection should be carried out within the precaution time. However, Xia *et al*^[14] reported that after covering with 0.05 mmpb shielding material, an adult family member that lives with but does not sleep with the patient and a pregnant family member and a child that lives with the patient do not need radiation protection; a nonpregnant adult family member that lives and sleeps with the patient, a co-worker that does not live with the patient need distance protection within 7d and 54d. The results of this experiment are different from those reported by Xia *et al*^[13], the reason may be that the lead equivalent of shielding material used in the study of Xia is relatively small. Therefore, different radiation guidance suggestions should be given according to the shielding materials with different lead equivalent in practical application.

In order to minimize the damage caused by radiation to the surrounding population, patients should actively conduct standardized and reasonable shielding protection after operation. In the absence of shielding protection, the distance protection should be done well during the precaution time, and no shielding protection is needed outside the precaution time to avoid excessive protection.

REFERENCES

1. International Atomic Energy Agency. Radiation oncology physics: a handbook for teachers and students. Vienna: IAEA, 2005.
2. Kono Y, Miyamoto Y, Oohashi S, Fukushi M. Radiation exposure to general public after permanent brachytherapy for prostate cancer. *Radiat Prot Dosim* 2011; **146(1-3)**: 229-230. [PMID: 21511724]; [DOI: 10.1093/rpd/ncr156]
3. Dauer LT, Kollmeier MA, Williamson MJ, St Germain J, Altamirano J, Yamada Y, Zelefsky MJ. Less-restrictive, patient-specific radiation safety precautions can be safely prescribed after permanent seed implantation. *Brachytherapy* 2010; **9(2)**: 101-111. [PMID:19853532]; [DOI:10.1016/j.brachy.2009.06.006]
4. National council on Radiation Protection and Measurements. Report NO.151: management of radionuclide therapy patients. Bethesda: NCRP, 2006.
5. ICRP. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103. *Ann ICRP* 2007; **37**: 1332.
6. USNRC. Consolidated guidance about materials licenses. Programspecific guidance about medical use licenses.Final report. Washing-ton. DC: Division of Industrial and Medical Nuclear Safety, Office of Nuclear Material Safety and Safeguards, United States Nuclear Regulatory Commission; 2005. Nureg-1556, vol.9, rev1.
7. Zhuo SQ, Chen L, Zhang FJ, Zhao M, Zhang L, Liu J, Li K, Wu PH, Zheng QS, Wang Y.Environmental radiation dose monitor after 125I radioactive seed implantation. *Ai Zheng*. 2007; **26(6)**: 666-8. [PMID: 17562278]
8. Wang JJ, Xiu DR, Ran WQ. Interstitial implant of radioactive seeds in the brachytherapy for tumor(Second Edition). *Beijing: Peking University Press* 2004: 1.
9. YangQ, Jia YM, Liu J, Zhou F, Han DQ. Investigation of radiation dose and how to protect ourselves during 125I particle imitative planting process. *Healthmust-Readmagazine* 2017: 108-111.
10. Committee of Minimally Invasive Therapy in Oncology seeds therapy branch, Chinese Anti-Cancer Association. Expert consensus on radiation protection management standards for radioactive 125I seeds wards. *Natl Med J China* 2017: 1455-1456.
11. Yan CX, Tang JP, Chen R, Yang TM, Peng S. A study of the effect of interstitial 125I seed implantation on ward nurses'hemogram and relevant protection investigations. *Natl Med J China* 2013, **93(41)**: 3269-3271. [PMID: 24401620]; [DOI: 10.3760/cma.j.issn.0376-2491.2013.41.006]
12. Jiao J, Jing XG. Study on 125I seeds radiation protection of Medical Staff. *J Mod Med Health*, 2018; **34(17)**: 2760-2762. [DOI: 10.3969/j.issn.1009-5519.2018.17.057]
13. Qian JD, Zhang Y, Yu CJ. Radiation dosage assessment of CT guided implantation of 125I seeds for medical personnel. *Int J Radiat Med Nucl Med*. 2018; **42(4)**: 337-339. [DOI: 10.3760/cma.j.issn.1673-4114.2018.04.009]
14. Xia HS. The comparative study about protection effect itself after application of radioactive 125I seeds with the Shielding material. *Hebei, Hebei Medical University* 2014: 1-44.