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Evaluation of radiation dose on people adjacent to implant patients during brachytherapy for prostate cancer using ^{192}Ir

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1. Introduction

The incidence of prostate cancer is rapidly increasing due to aging of the population and westernization of dietary habits, etc. As a result, the frequency of prostate cancer has become the fifth highest among all male cancers and the first among urologic cancers[1].

Brachytherapy is commonly used for locally progressing prostate cancers. Since the mid 1980s, therapies using radio-isotopes, such as low-invasive ^{125}I, ^{103}Pd and ^{192}Ir, have been widely performed in the U.S. and Europe[2]. However, brachytherapy involves implanting radio-isotopes into the human body which is of concern because it may expose the healthcare professionals administering the therapy to unnecessary radiation[3].

Accordingly, this study intends to predict the radiation dose that people adjacent to patients implanted with a radio-isotope are exposed to during prostate cancer radiation therapy by using a mathematical anthropomorphic phantom and ^{192}Ir.

2. Methods and Results

2.1 Mathematical Anthropomorphic Phantom Configuration

In this study, we configured a mathematical anthropomorphic phantom based on a standard Korean male by modifying the MIRD type human phantom. For prostate glands, we selected a position within the organ by using the quadratic equation (Equation (1)) below.

$$4.84 = x^2 + (y + 6.808)^2 + (z - 2.477)^2 \qquad (1)$$

2.2 Methods of Radiation Dose Evaluation on People Adjacent to Implanted Patients

The mass attenuation coefficient of a substance located at the position of the radiation flux and the absorbed dose rate into the substance at this position from Equation (2) below is proportional to the radiation flux density and mass – energy attenuation coefficient of the energy and substance[4].

$$\dot{D} = \frac{\frac{\emptyset \text{photons}/\text{cm}^2}{\text{sec}} \times E\ \text{MeV/photon} \times 1.6\times10^{-13}\ \text{J/MeV} \times \mu_m\ \text{cm}^{-1}}{\rho_m\ \text{kg/cm}^3 \times 1\frac{\text{J/kg}}{\text{Gy}}} \qquad (2)$$

Here, $\dot{D}$: Absorbed dose (Gy or Sv)
μ_m/ρ_m: Mass attenuation coefficient of substance
ϕ: Flux density
E: Energy (MeV)

Also, in general, the total radiation dose $\dot{D}$ can be evaluated using Equation (3) using a given distance from the patient[3].

$$\dot{D}(\infty) = 34.6 T_b \dot{D}(t_0) E \qquad (3)$$

Here, $\dot{D}(t_0)$: Absorbed dose rate (Gy or Sv)
T_b: Physical half-life
E: Occupancy factor to stay adjacent to the implanted patient

2.3 Evaluation of Radiation Dose on People Adjacent to Implanted Patients

Equation (3) was used for evaluating the dosage of people adjacent to patients implanted with ^{192}Ir.

In addition, for absorbed dose evaluation according to distance, it was assumed that an 'adjacent' person was located at a distance of 30, 50, 100 and 200 cm from the implanted patient. The absorbed dose of the person adjacent to the implanted patient was then evaluated.

As a result it was found that the absorbed dose at distances of 30, 50, 100 and 200 cm was 9.1929E-06, 5,0972E-06, 1.8636E-06 and 5.4232E-07 Sv respectively as shown in Table 5. This indicated that the absorbed dose was less than 1mSv, the threshold radiation dose for a normal person.

Table 1. Absorbed Dose According to Distance from Implant Patient

Distance (cm)	Absorbed Dose Rate (Gy/hr)	Absorbed Dose (Sv)
30	3.59E-09	9.1929E-06
50	1.9908E-09	5.0972E-06
100	7.2787E-10	1.8636E-06
200	2.1181E-10	5.4232E-07

3. Conclusions

This study evaluated the radiation dose upon surrounding organs during brachytherapy for prostate cancer, which is the most common infliction among all urologic cancers among Korean males, and the radiation dose people adjacent to implanted patients are exposed to by producing a mathematical anthropomorphic phantom based on a standard Korean male.

As a result of evaluating the radiation dose that people adjacent to implanted patients are exposed to, it was found that the absorbed dose on people at a distance of 30, 50, 100 and 200cm from the implanted patients was 9.1929E-06, 5.0972E-06, 1.8636E-06 and 5.4232E-07 Sv respectively, which was less than 1 mSv, the threshold radiation dose for a normal person.

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