Assessment of Absorbed Dose in Persons close to the Patients during ^{192}Ir brachytherapy for Cervical Cancer

JooYoung Jung, SeSik Kang
Department of Radiological Science, College of Health sciences, Catholic University of Pusan, Bugok 3-Dong, Geumjeong-gu, Busan, 607–757, Republic of Korea
modeljjy@naver.com

1. Introduction

According to the 2007 Annual Report of the National Cancer Registry, cervical cancer showed an occurring frequency of 7th in female cancers and 4rd in females with an age of 35-64 years. Both radiotherapy and chemotherapy are mainly used for the treatment of cervical cancer[1]. In case of radiotherapy, brachytherapy using radioisotopes in conjunction with external-beam radiation therapy (EBRT) using a linear accelerator is used in most cases to improve the outcome of cancer treatment[2]. Brachytherapy, one of the cervical cancer radiotherapies, is a method that can minimize the demage of normal tissues restricting absorbed dose to uterus. It is, however, necessary to conduct a quantitative assessment on brachytherapy because it may cause radiation exposure to medical care providers during the radiotherapy[3]. Therefore, the study provides the basic research data regarding brachytherapy for cervical cancer, estimating the absorbed dose in persons close to the patients using a mathematical phantom during ^{192}Ir brachytherapy for cervical cancer.

2. Methods and Results

2.1 Calculation by Monte Carlo Method

Weight and physique of a mathematical phantom used in this study were determined based on the standard data of Korean female. It was assumed that organs were composed of components that are suggested in TM-8381 of the ORNL report such as lung, bone or skeleton, and soft tissues. Their densities are 0.296 g/cm3, 1.40 g/cm3 and 1.04 g/cm3 respectively.
MCNPX, Monte Carlo transport code, was used to calculate photon transport and photon energy. In addition, photon energy had point sources positioned with an interval of 1 cm distance for above and below each on the center of uterus.

2.2 Makeup of Mathematical Phantom

In this study, the mathematical phantom was constituted by modifying a MIRD-type phantom based on Korean reference adult female. The location of uterus between the organs was determined by the two-dimensional equation as below (1).

$$\left(\frac{x\pm 5.077}{1.147}\right)^2+\left(\frac{y}{0.568}\right)^2+\left(\frac{z-13.25}{1.764}\right)^2 \le 1 \qquad (1)$$

Subsequently, considering uterus as a source organ, the absorbed dose of the person close to the patients was assessed.

2.3 Method for assessing absorbed dose in a person close to the patient

Mass attenuation coefficient of a substance located at the position where radiation flux passes-by and the absorbed dose rate absorbed by the substance at that location are proportional to flux density, energy and substance's mass-energy attenuation coefficient; and have the following equation (2)[4].

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

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

In addition, generally a total absorbed dose, D, at a given distance from the patient can be assessed using the equation (3)[5].

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

where , $\dot{D}(t_0)$: Absorbed dose rate (Gy or Sv)
T_b : Physical half-life
E : Occupying degree of staying around the patient

2.4. Assessment of absorbed dose in a person close to the patient

An assessment of absorbed dose in a person close to the patient with ^{192}Ir brachytherapy was conducted using the equation (3). Also, assuming that medial care providers are located at 30, 50, 100 and 200cm ahead of the patient who is considered a source organ, the absorbed dose by distance in the medical care providers was assessed. As a result, as shown in Table 1, the absorbed dose of front 30, 50, 100 and 200cm was 1.24E-07, 7.18E-08, 2.72E-08, and 8.53E-09 Sv respectively, revealing that the absorbed dose did not exceed 20 mSv/yr, the annual limit of working condition.

Table 1. absorbed dose in a person by distance from the patient

Distance (cm)	Absorbed dose rate(Gy/min)			Absorbed dose(Sv)		
	A	B	C	A	B	C
30	4.80E-11	4.85E-11	4.75E-11	1.23E-7	1.24E-7	1.21E-7
50	2.78E-11	2.80E-11	2.74E-11	7.14E-8	7.18E-8	7.02E-8
100	1.05E-11	1.06E-11	1.06E-11	2.69E-8	2.72E-8	2.71E-8
200	3.23E-12	3.27E-12	3.33E-12	8.29E-9	8.38E-9	8.53E-9

A: uterus center
B: Point toward the legs, 1 cm away from the uterus center A point
C: Point toward the head, 1 cm away from the uterus center A point

2. Conclusion

This study assessed absorbed dose in medical care providers close to the patients during the brachytherapy for cervical cancer that shows the highest occurring frequency in Korean adult females, using a mathematical phantom manufactured based on Korean reference adult female.
As a result, it showed that the absorbed dose in the persons close to the patients was received with the highest radiation exposure at front 30, 50, and 100 cm when the radioactive source inside the uterus was located at the point toward the legs, 1cm away from uterus center A point, and at 200 cm when the source inside the uterus was located at the point toward the head, 1cm away from uterus center A point. The IAEA recommends that the absorbed dose in guardians or care workers during the patients treatment should not exceed 5 mSv/yr. As this study assessed absorbed dose that was received per hour, a sufficient consideration should be required for a management of the absorbed dose in guardians and care workers staying with the patients for a long term period.

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