Estimation of Specific Effective Energy of Surrounding Organs with Prostate as the Source Organ

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1. Introduction

The incidence of prostate cancer has increased rapidly due to such as aging population and western dietary habits and it is the fifth most common cancer among male cancers and the most common cancer in urinary system[1].

Prostate cancer is treated in various ways, but suitable treatments are selected case by case instead of particularly superior treatments chosen.

One of them is cancer treatment via irradiation and it is widely available because of its simplicity and outstanding effectiveness; however compromised local selectivity inevitably results in side effects in surrounding tissues like bladder, urethra and rectum[2].

These tough problems have been able to be solved since mid-1980s when radioisotope seeds such as ^{125}I or ^{103}Pd which could be implanted in the body were produced, and now much less invasive brachytherapy is widely used in the US and Europe[3].

But there is a lack of investigations related to this therapy in Korea.

In the present study, we intend to estimate specific effective energy of prostate and surrounding organs using ^{125}I and ^{103}Pd and thus provide basic data of radiation exposure assessments during prostate brachytherapy.

2. Methods and Results

2.1 Calculation by Monte Carlo Method

The mass and body size of mathematical dummy used in this study were determined based on the data of Korean reference adult male.

We assume that organ material used in the study is the same as the one presented in TM-8381 of the ORNL report: Lung, bone or skeleton and other organs are composed of soft tissue.

The densities are 0.296 g/cm^3, 1.40 g/cm^3 and 1.04 g/cm^3, respectively[4].

For calculating photon transportation and energy assignments, the Monte Carlo particle transport code of MCNPX was used.

For the photon energy, we used the energy of ^{125}I and ^{103}Pd as presented in ICRP-38[5] and assumed that point sources in the form of seeds in the prostate were distributed uniformly.

2.2 Construction of Mathematical Phantom

In this study, mathematical phantom was constructed by using the basic data from Korean reference man[6] and modifying MIRD-type phantom.

The position of prostate among organs was determined by using two dimensional equations like the following formula 1.

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

Then we calculated specific effective energy of surrounding organs with prostate as the source organ.

2.3 Estimation of Specific Effective Energy of Surrounding Organs with Prostate as the Source Organ

With prostate as the source organ and surrounding organs as the target organs, we calculated specific effective energy of ^{125}I and ^{103}Pd for each organ as shown in Table 1.

As a result, specific effective energy of ^{125}I was found to be higher than ^{103}Pd in all organs.

In addition, it was demonstrated that organs with higher specific effective energy were relatively adjacent organs to prostate like sigmoid colon's wall, penis and scrotum, testis, and bladder in decreasing order.

Table 1. Estimation of specific effective energy of the surrounding organs with prostate as the source organ

Organ	SEE(Unit: MeV/g)	
	I-125	Pd-103
Penis & Scrotum	4.27E-07	8.43E-08
Penis & Scrotum Skin	1.18E-07	1.68E-08
pelvis	8.19E-09	1.01E-10
spine	7.37E-12	5.99E-15
stomach	5.23E-12	1.77E-26
small intestine	3.61E-10	8.36E-13
ascending colon wall	3.89E-10	1.11E-12
Transverse colon wall	6.15E-11	1.78E-25
Descending colon wall	3.63E-09	5.5E-11
Sigmoid colon wall	4.75E-07	4.08E-08
Kidneys	2.31E-12	-
Liver	1.45E-12	-
Lungs	3.68E-14	1.18E-15
Testicles	3.12E-07	5.05E-08
Urinary Bladder	1.19E-07	9.34E-09
Prostate	2.28E-06	5.77E-07

3. Conclusions

This study focused on the brachytherapy of prostate cancer that is the most common cancer in urinary system of Korean men and aimed to find therapeutic doses to minimize exposure doses of surrounding organs. Therefore, mathematical phantom was constructed based on the data of Korean reference man to estimate specific effective energy of surrounding organs with prostate as the source organ. Consequently, it was found that organs with higher specific effective energy were relatively adjacent organs to prostate like sigmoid colon's wall, penis and scrotum, testis, and bladder in decreasing order and specific effective energy of ^{125}I was higher than ^{103}Pd in all organs.

These findings suggest that radionuclides with relatively greater energy, intensity and range are considered to have more influence on surrounding organs and ^{125}I can produce higher therapeutic dose than ^{103}Pd during brachytherapy of prostate cancer with the same radioactivity.

Thus exposure of surrounding organs can also become greater, so radionuclides should be selected carefully when treatment methods are decided.

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