Dosimetric evaluation of I-125 seeds for treatment of portal vein tumor thrombosis

Seongmoon Jung [a, b], Sujeong Lee[c], Sung-Joon Ye [a, b*]

[a] Program in Biomedical Radiation Sciences, Department of Transdisciplinary Studies, Graduate School of Convergence Science and Technology, Seoul National University, Seoul, South Korea
[b] Biomedical Research Institute, Seoul National University College of Medicine, Seoul, South Korea
[c] Department of Nuclear Engineering, Kyunghee University, Suwon, South Korea
*Corresponding author: sye@snu.ac.kr

1. Introduction

The portal vein tumor thrombosis (PVTT) is treated with an aid of a metallic stent to reduce portal vein pressure [1]. However, the inserted stents to the patients become narrowing again due to the tumor invasion. By attaching I-125 seeds to the stent, it was reported that the tumor invasion has been successfully controlled [1]. In this study, a dosimetric evaluation of I-125 seeds was performed by using the Monte Carlo code, MCNP6.1 [2]. Our results provide isodose maps for a current configuration of I-125 seeds and would help to develop an optimized one.

2. Methods and Results

The model 6711 I-125 brachytherapy seed was modeled [3]. Four columns of I-125 seeds were placed at 0°, 90°, 180° and 270° as described in Fig. 1(a). Each column has four I-125 seeds along z-axis (Fig. 1(b)). The diameter of portal vein was assumed to be 12 mm. The material of portal vein and tissue was defined as water.

A cylindrical tmesh tally was used to save the deposited energy at voxels. The voxels were divided by theta (θ) 0° to 360° with an increment of 2°, radius (r) from 6 mm to 15.5 mm with an increment of 1 mm and z-plane (z) from -12.5 mm to 1.25 mm with an increment of 1 mm. Since I-125 seeds were located symmetrically, we defined only two sources of which positions were illustrated in Fig 1(b). We could obtain a total dose distribution by rotating, reversing and summing the results from two sources. All the doses were normalized to the dose at a position z=0, r=6.5 mm and θ=1°.

Isodose curves for z=0, 3, 6, 9 and 12 mm were shown in Fig 2. For each z-plane, the maximum dose appeared at the regions close to I-125 seeds (i.e., θ=0°, 90°, 180° and 270°), while cold spots existed at θ=45°, 135°, 225° and 315°. For z=3 and 6 mm, the maximum dose was about three times higher than that from the normalized point. The dose level at z=12 mm was lower than that from z=0 or 6 mm. Because only four I-125 seed could deposit their energies to the voxels at z=12 mm plane, while eight I-125 seeds could deposit to the voxels at z=0 or 6 mm.
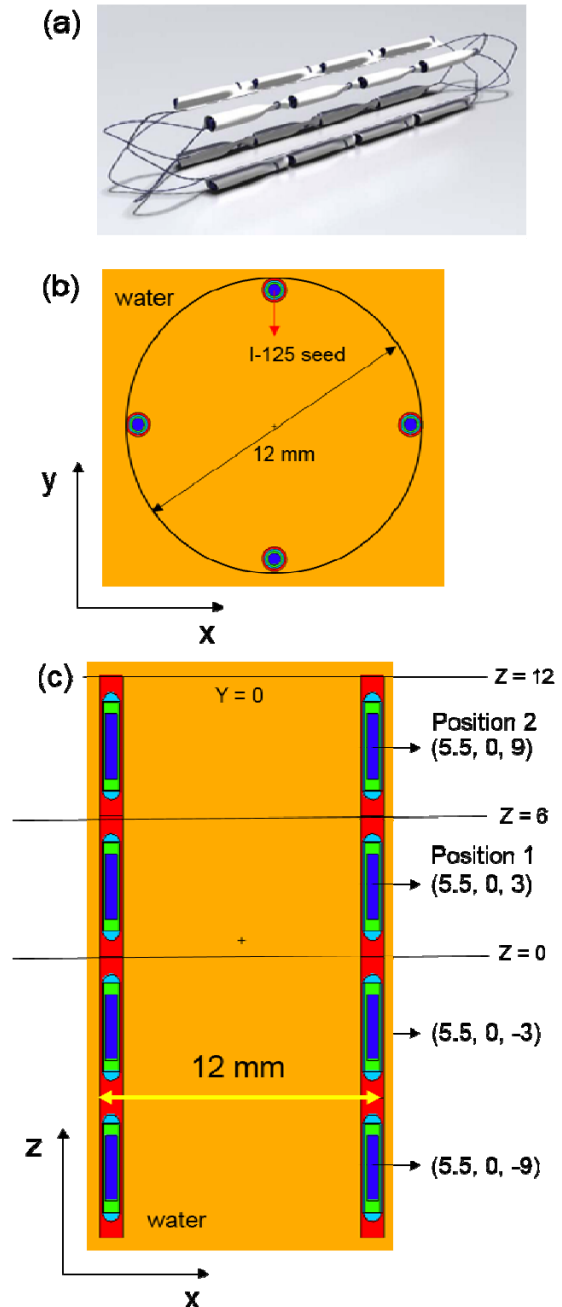
Fig. 1. A picture of I-125 seeds (a) [4] and MC model of I-125 seeds. (b) x-y plane and (c) x-z plane are illustrated. A unit of coordinate is mm.
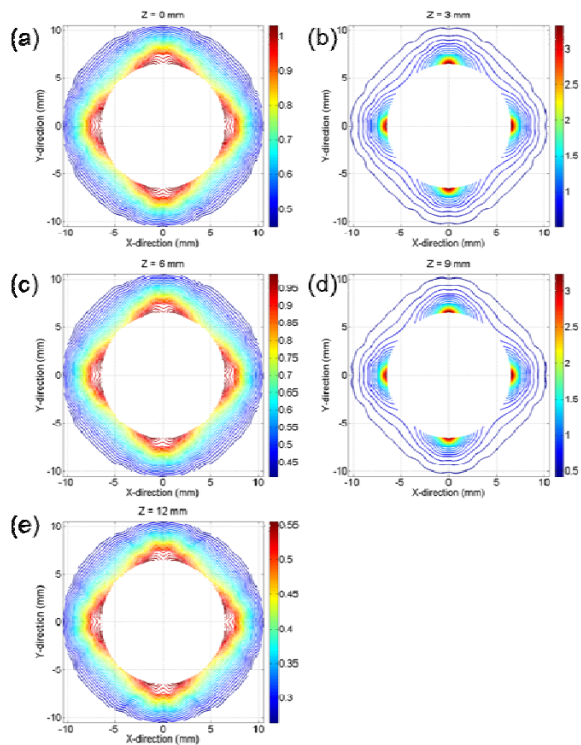
Fig. 2. Isodose curves for z=0 to 12 mm. All the doses were normalized to the dose at z=0 mm, r=6.5 mm and θ=1°.

3. Conclusions

With the current configuration of I-125 seeds for the treatment of PVTT, there were clear hot spots and cold spots, since I-125 seeds were located at θ=0°, 90°, 180° and 270°. In addition, such hot spots and cold spots were observed along the z-axis. The maximum dose was delivered to z=3 or 9 mm at the surface of I-125 seeds. The amount of maximum dose was about 3.4 times higher than the normalized point. By applying our results to the clinical situations, one can change the number of I-125 seeds or its configurations to deliver the prescription dose uniformly and accurately.

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