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Dosimetric Comparison between the Intensity Modulated Radiation Therapy and Volumetric Modulated arc Therapy for Prostate Cancer- A Case Study

Takeshi Hira*

Tohoku University, Sendai, Japan
*Corresponding author: takeshi45@outlook.com

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Abstract **Purpose**: The main purpose of this study is to perform the dosimetric comparison between Intensity modulated radiation therapy (IMRT) and Volumetric modulated arc therapy (VMAT) for the prostate cancer by using dose-volume histograms (DVH). **Methods**: IMRT plan and VMAT plan were generated using 7 fields and 2 arcs, respectively, for the total dose of 76 Gy. Planning target volume (PTV) was evaluated for the maximum dose, mean dose, minimum dose, and conformity index. Rectum and bladder were evaluated for V_{70Gy}, V_{50Gy}, and V_{30Gy}. The number of MUs between IMRT and VMAT plan was evaluated too. **Results**: The PTV dose evaluation showed that VMAT plan produced values closer to the prescription dose than did IMRT plan. The conformity index was also slightly better in VMAT plan (1.15) than in IMRT plan (1.17). The relative volume of bladder receiving radiation was always lower in VMAT plan for all parameters. However, IMRT was better than VMAT at V_{70Gy} and V_{30Gy}, whereas VMAT was better at V_{50Gy}. The MUs were higher in IMRT plan (812) when compared to the one in VMAT plan (560). **Conclusion**: Both the VMAT and IMRT produced clinically acceptable treatment plan for the prostate cancer. Based on the single case in this study, VMAT produced slightly favorable dosimetric results.

Keywords: *prostate cancer, treatment planning, IMRT, VMAT*

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1. Introduction

Prostate cancer is one of the most common cancers among males in the world. Radiation therapy (RT) is considered to be one of the options to treat the cancer since RT allows to deliver high amount of dose to the tumor. There are various techniques available for the treatment of prostate cancer. Intensity modulated radiation therapy (IMRT) is one of the techniques which can deliver radiation dose to the tumor in the form of sliding window (SW) or step-and-shoot (SS) methods. [1] In the SW method, radiation beam is modulated by continuously moving multi-leaf collimator (MLC), whereas radiation beam is divided into smaller segments of different MLC shape in SS method. [1] Volumetric modulated arc therapy (VMAT) is another type of techniques, which can deliver the radiation dose to the patient by simultaneous adjustment of rotation speed, MLC, and dose rate [2].

Previous studies [2-10] comparing VMAT and IMRT showed that VMAT is more efficient, and it requires less number of monitor units (MUs). However, the results among different studies [2-10] are somewhat contradictory, especially for the dose to the organs at risk (OARs) such as the rectum and bladder. The main purpose of this study is to further investigate the dosimetric results of IMRT and VMAT for the prostate cancer by using dose-volume histograms (DVH).

2. Methods and Materials

The computed tomography (CT) dataset of prostate cancer patient was obtained following the CT simulation, and this process was done with a slice thickness of 3.0 mm. Treatment planning was performed in Eclipse treatment planning system (TPS). First, clinical target volume (CTV) was drawn and planning target volume (PTV) was expanded from the CTV by a 5 mm in all directions. Other contoured structures were rectum, bladder, and femoral heads. Second, IMRT plan was generated using 7 fields at gantry angles 0, 50, 100, 150, 205, 255, and 310. The VMAT plan was generated using two full arcs (one in clock-wise direction, and the other in anti-clock-wise direction). The isocenter of both the IMRT and VMAT plans was placed at the center of the PTV. Furthermore, each plan had the total prescription dose of 76 Gy with 2 Gy per fraction. Treatment plans were calculated with anisotropic analytical algorithm (AAA) using a dose calculation grid size of 2.5 mm.

Dosimetric analysis was done for the PTV (maximum dose, mean dose, minimum dose and conformity index), rectum (V_{70Gy}, V_{50Gy}, and V_{30Gy}), and bladder (V_{70Gy}, V_{50Gy}, and V_{30Gy}). Additionally, number of MUs were evaluated too.

$$\text{Conformity Index} = \frac{\text{Volume of prescription dose}}{\text{Volume of the PTV}}$$

3. Results

Table 1 shows the dosimetric results of IMRT and VMAT plans.

Table 1. Dosimetric results comparing the IMRT and VMAT plans

		IMRT	VMAT	Difference (%)
PTV	Maximum Dose (Gy)	81.2	80.6	0.7
	Mean Dose (Gy)	78.9	77.9	1.3
	Minimum Dose (Gy)	68.5	69.4	-1.3
	Conformity Index	1.17	1.15	1.7
Bladder	V_{70Gy} (%)	15.2	13.6	10.5
	V_{50Gy} (%)	28.4	25.2	11.3
	V_{30Gy} (%)	51.5	48.9	5.0
Rectum	V_{70Gy} (%)	14.5	15.1	-4.1
	V_{50Gy} (%)	32.3	30.5	5.6
	V_{30Gy} (%)	68.5	71.3	-4.1
	Monitor Units	812	560	31

Abbreviations: PTV = planning target volume; V_{xGy} = Relative volume of bladder or rectum receiving dose of x Gy; Difference = (IMRT-VMAT)/VMAT

The results from both the techniques are satisfactory and are clinically acceptable. The PTV dose evaluation showed that VMAT plan produced values closer to the prescription dose than did the IMRT plan. Hence, dose homogeneity was better in VMAT plan than in IMRT plan. The conformity index was also slightly better in VMAT plan.

Similarly, VMAT plan was superior for bladder as well. All dosimetric parameters evaluated for bladder showed less values in VMAT plan than in IMRT plan, hence sparing of the bladder from radiation exposure is better with VMAT technique. However, dosimetric results for the rectum did not show a clear trend favoring one technique over the another. For instance, IMRT was better at sparing rectum at high-dose region (V_{70Gy}) and low-dose region (V_{30Gy}), whereas VMAT was superior in the medium-dose region (V_{50Gy}). The MUs were higher in IMRT plan when compared to the one in VMAT plan.

4. Discussion

A dosimetric case study was performed for a prostate cancer, and two treatment techniques (IMRT) and VMAT were compared using the DVHs generated in the TPS. In general, VMAT produced better results than IMRT; however, IMRT was superior to VMAT for rectal dose. These findings are consistent with the results from other studies [2-10], which showed no significant differences between VMAT and IMRT.

While both techniques are capable of producing clinically acceptable plans, several factors such as optimization and dose calculation algorithms can also affect the dosimetric results. [11,12,13,14,15] Furthermore, IMRT plans generated using 7-field technique could be different from the ones generated using 5-field technique. Similarly, it is possible to have the results in VMAT plan with two full arcs different from the ones in VMAT plan generated using single arc or partial arc technique. [14] It is important to note that experience of a treatment planner could play a significant role in generating a optimum treatment plan. The beam energy used to generate treatment plan can also impact the dosimetric results [16,17].

5. Conclusion

Both the VMAT and IMRT produced clinically acceptable treatment plan for the prostate cancer. Based on the single case in this study, VMAT produced slightly favorable dosimetric results. However, the difference between IMRT and VMAT was minimal.

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