Letter to the Editor

Radiobiological case study of volumetric modulated arc therapy planning techniques for treatment of low-risk prostate cancer in patients with bilateral hip prostheses

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Dear Editor,

Prostate cancer remains to be one of the commonly diagnosed cancers among the male population in the USA. One of the available techniques for cancer therapy is the external beam radiation therapy. In our previous study[1] published in South Asian Journal of Cancer (SAJC), we performed a dosimetric analysis for the prostate case with bilateral metallic hips, and compared the dosimetric impact of RapidArc planning using 2 arcs (2-RA), 3 arcs (3-RA), and 4 arcs (4-RA) techniques. The results showed that the 4-RA technique produced lower rectal and bladder dose and better dose conformity across the planning target volume when compared to 2-RA and 3-RA techniques.

Recently, SAJC published a letter to editor[2] entitled "Are results from dosimetric studies sufficient enough to determine the quality of treatment techniques in radiation therapy?" And the author suggested to further investigate the planning techniques (2-RA, 3-RA, and 4-RA) using radiobiological parameters. In most of the clinics, it is a common practice to evaluate the treatment plans using dose-volume (DV) parameters. Hence, in our previous study,[1] we reported the results using DV parameters, which were obtained from DV histogram (DVH) of the treatment plans. Nevertheless, evaluation of treatment plans using radiobiological parameters could provide an accurate prediction of tumor control or normal tissue complications.[3] This report is the continuation of our previous study,[1] and we have evaluated the radiobiological impact of 2-RA, 3-RA, and 4-RA techniques in terms of equivalent uniform dose (EUD), tumor control probability (TCP), and normal tissue complication probability (NTCP).

Case description, treatment planning techniques, and DVH results remained same as in our previous study.[1] However, for the radiobiological evaluation of planning techniques, following the methodology has been used. First, the cumulative DVHs of each plan were exported from the treatment planning system. The DHVs were exported using the dose bin size of 50 cGy. Second, MatLab program[4] was used to calculate the Niemierko's EUD-based NTCP and TCP values. Descriptions on the EUD, NTCP, and TCP can be found elsewhere.[4,5] The EUD was calculated for prostate tumor (α/β =1.2), rectum (α/β =3.9), and bladder (α/β =8.0). The NTCP was calculated for the rectum and bladder, whereas the TCP was calculated for the prostate tumor. Table 1 shows the parameters that were used to obtain the EUD, TCP, and NTCP values.

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All 3 plans (2-Arc, 3Arc, and 4-Arc) were generated for the total prescription dose of 79.2 Gy.[1] Results for the prostate tumor from Table 2 showed that the 4-Arc technique produced the highest EUD, and 2-Arc technique produced the lowest EUD. However, TCP was almost identical among three techniques.

The results for the normal tissues (rectum and bladder) showed that the lowest EUD was achieved using 4-Arc technique. Our dosimetric results also showed the lowest dose using 4-Arc technique when compared to 2-Arc and 3-Arc techniques.[1] All three techniques produced NTCP of bladder <0.1%. However, the rectal NTCP ranged from 2.8% to 4.3%, with 4-Arc and 2-Arc techniques producing the best (lowest NTCP) and worst (highest NTCP) results, respectively.

The results of the current study showed that 4-Arc technique produced better radiobiological results when compared to 2-Arc and 3-Arc techniques, especially for the rectum. In our previous study,[1] we also observed the superiority of 4-Arc technique over 2-Arc and 3-Arc techniques in terms of dosimetric results. Based on the dosimetric and radiobiological results of this single case, 4-Arc technique would be more suitable in the treatment planning when prostate cases with bilateral metallic hips are involved. Since metallic hips will produce the computed tomography artifacts, which can contribute to the uncertainty in the dose calculations, accurate contouring of the artifacts along with the correct electron density override is essential in order to prevent monitor unit miscalculations. Furthermore, it has been reported that the superposition-convolution algorithms tend to produce dose prediction errors when inhomogeneity is present along the photon beam path.[6-8] Treatment plans of this study were computed using superposition-convolution algorithm called anisotropic analytical algorithm, which may have contributed some uncertainties in our dosimetric and radiobiological results. Dose computations using more advanced algorithms like Acuros XB may further improve the accuracy of the clinical treatment plans.[9,10] In this study, we have used photon beam energy of 6 MV and the use of different energy may produce different results.[11] Hence, it would also be interesting to find out if the photon beam energy will have any impact on the dosimetric and radiobiological results of this study.

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Table 1: Parameters used to calculate Niemierko's EUD-based TCP and NTCP values

Tissue	Volume type	100% dpf	#f	a	γ_{50}	TD_{50} (Gy)	TCD_{50} (Gy)	Dpf (Gy)	α/β (Gy)
Prostate	Tumor	1.8	44	−10	1.0	-	28.34	2	1.20
Rectum	Normal	1.8	44	8.33	4	80	-	2	3.90
Bladder	Normal	1.8	44	2	4	80	-	2	8.00

100% dpf=100% dose per fraction, #f=Number of fractions, a=Unit less model parameter that is specific to the normal structure or tumor of interest, γ_{50}=Unit less model parameter that is specific to the tumor/normal tissue of interest and describes the slope of the dose response curve, α/β=Alpha-beta ratio, Dpf=Parameter's source data's dose per fraction, EUD=Equivalent uniform dose, TCP=Tumor control probability, NTCP=Normal tissue complication probability, TD_{50}=Tolerance dose for a 50% complication rate at a specific time interval, TCD_{50}=Tumor dose to control 50% of the tumors when the tumor is homogeneously irradiated

Table 2: Radiobiological results of 2-Arc, 3-Arc, and 4-Arc techniques for the prostate tumor, rectum, and the bladder

Parameters	Prostate tumor		
	2-Arc	3-Arc	4-Arc
EUD (Gy)	77.08	77.22	77.49
TCP (%)	98.21	98.22	98.24
	Rectum		
	2-Arc	3-Arc	4-Arc
EUD (Gy)	65.62	65.05	64.13
NTCP (%)	4.03	3.53	2.83
	Bladder		
	2-Arc	3-Arc	4-Arc
EUD (Gy)	49.94	48.95	48.48
NTCP (%)	0.05	0.04	0.03

EUD=Equivalent uniform dose, NTCP=Normal tissue complication probability, TCP=Tumor control probability

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