



RESEARCH ARTICLE

Volumetric Modulated Arc Therapy versus Conventional Radiotherapy of Early Testicular Seminoma Irradiation: Dosimetric Study

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Abstract

Background: Testicular tumor is a rare tumor in men. Testicular seminoma is less aggressive than nonseminoma of germ cell tumors. Adjuvant nodal irradiation is an option of early stages I, IIA and IIB ≤ 3 cm pure seminoma disease. The aim of this study was to investigate which radiotherapy technique is better in nodal irradiation of early stage II pure seminoma, 3D-CRT or VMAT.

Methods: This study was done on 5 patients with pure seminoma diagnosed at king Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia; all are planned for postoperative radiation therapy with prescribed dose of 30-36 Gy in 15-18 fractions according to nodal size.

Results: Both techniques achieved comparable target coverage; however VMAT had better dose conformity, dose homogeneity and OARs sparing but with exposing bigger volumes (V5) of normal tissues to lower dose of radiation while V10 and V15 are bigger in 3D-CRT.

Conclusion: VMAT is one of the most common techniques used nowadays due to high therapeutic ratio comparable to the conventional technique however low integral dose (V5) is still one of the drawbacks of modern irradiation techniques which are not the case in conventional techniques.

Keywords

Arc therapy, Conventional radiotherapy, Seminoma

Abbreviations

3D CRT: 3 Dimensional Conformal radiotherapy; VMAT: Volumetric Modulated Arc Therapy; 4D: Four Dimensional; RAR: Rapid Arc; CT: Computerized Tomography; PET/CT:

Positron emission Tomography/Computerized Tomography; GTV: Gross Target Volume; CTV: Clinical Target Volume; PTV: Planning Target Volume; OARs: Organs at Risk Dose; CI: Conformity Index; HI: Homogeneity Index; IMRT: Intensity Modulated Radiation Therapy

Background

Testicular tumor is a rare tumor in men and represents less than 1% with peak incidence between ages 20-34 years [1-7].

Testicular seminoma is less aggressive than non-seminoma of germ cell tumors [2,8,9].

Radical inguinal orchiectomy is the main treatment option of pure testicular seminoma [10].

Adjuvant nodal irradiation is an option of early stages I, IIA and IIB ≤ 3 cm pure seminoma disease [11,12].

Para aortic lymph nodes are the target volume in stage I, while paraaortic and proximal ipsilateral pelvic nodes are the targets in early stage II of pure seminoma disease [12]. The radiation dose in stage I is 20 Gy [13] while early stage II is 30-36 Gy of pure seminoma disease [12].

The aim of this study was to investigate which radiotherapy technique is better in nodal irradiation of early stage II pure seminoma, 3D-CRT or VMAT.

Table 1: Patient's characteristics.

	Patient 1		Patient 2		Patient 3		Patient 4		Patient 5	
	3D	RA	3D	RA	3d	RA	3d	RA	3d	RA
PTV										
Mn %	101.4	101	102.4	101.6	102	101.5	101.5	101	101.6	101.4
Mx %	105.8	105	105	104.6	106	105	105.5	104.2	106.1	105
Mm %	94	91	97	94	90	92	91	93	90	93
Kidney										
Rt Mn %	34	31.5	12.1	10.5	35	32	13	11	38	35
Lt Mn %	9.8	11	31.7	17.7	11	12	30	16	12	10
Mn both %	22	21.3	21.9	14.1	23	22	21.5	13.5	25	22.5
Spinal cord										
Mn %	58.5	27.1	63.5	51.9	60.5	45.1	55.4	30.2	50.3	30.2
Bowel										
Mean %	21.1	22.4	34.4	24.8	25.5	26.2	40.2	28	36.7	26.2
Body C.C)										
V5	5990	9005	6090	9210	4500	8400	5600	8200	4900	8500
V10	4980	3490	5010	3450	3560	2200	4550	2950	3800	2250
V15	4505	1770	4470	1630	3010	1520	4010	1720	3050	1450
CI	0.3	0.75	0.4	0.85	0.4	0.75	0.5	0.85	0.65	0.8
HI	1.4	1.1	1.3	1.1	1.2	1.0	1.5	1.2	1.35	1.1

Methods

This study was done on 5 patients with early stage II pure seminoma diagnosed at King Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia, all are planned for postoperative radiation therapy with prescribed dose of 30-36 Gy in 15-18 fractions. In both techniques, we looked at planning target volume coverage, dose homogeneity indices and organs at risk dose (bowel, kidney, spinal cord) and integral dose, [Table 1](#).

CT simulation and contouring

Planning 4D-CT scan was done by departmental scanner (Philips Medical Systems, Cleveland, OH); with a slice thickness of 2.5 mm. Patient's position was supine with arms up and scanned from mid thoracic spine to upper third of both femurs. Penis was put away and contralateral testicle was shielded. Fusion of Planning CT with CT and/or PET/CT scans was done to aid in target contouring of GTV which expanded by 1-2 cm to create the CTV1 then editing of organs at risk from CTV1 which then expanded 0.5 cm in all directions to create the PTV1 [14]. PTV1 was received 30-36 Gy in 2 Gy per fraction according to nodal size. CTV2 (modified dog-leg field) [15,16] is contouring of vascular structures of retroperitoneal and proximal ipsilateral pelvic areas using brush diameter of 1.5-2 cm with editing of surrounding organs then adding uniform 0.5 cm margin in all directions to create PTV2 which received 20 Gy in 2 Gy per fraction. The upper border of the CTV2 is top of 11th dorsal spine and lower border is top of acetabulum [12,17].

Conventional 3D planning

We used Eclipse planning system (Varian Medical Systems, Inc., Palo Alto, CA) along with the analytical anisotropic algorithm (Acuros External Beam, Version 13.3.23) dose calculation. The plans were created with mixed 15 MV using anterior/posterior fields with equal weighting.

Rapid Arc

We used Eclipse planning system with optimization using Progressive Resolution Optimizer (PRO) Version 13.6.23 for VMAT calculation, as far as dose volume dose calculation, Acuros External Beam version 13.6.23 was implemented. All plans generated using True Beam LINACS of 10 MV with 2 arcs (full and/or partial), Arc mode. Arcs had the same Isocenter at the center of the PTV.

Treatment plan evaluation and statistics

Dose-volume histogram, conformity and homogeneity indices were analyzed to compare treatment plans using Wilcoxon signed rank test (SPSS, V19, USA), a probability value of < 0.05 considered to be statistically significant (two tailed).

Results

Target coverage

Both techniques achieved comparable coverage even the minimum of PTV was similar in both plans, [Table 2](#).

Dosimetric parameters

VMAT had better and statistically significant HI and CI than 3D-CRT.

Table 2: Statistical results and P value of both techniques.

	3D	RA	P value
PTV			
Mn	101.8	101.3	0.5
Mx	105.7	104.8	0.42
Mm	91.4	92.4	0.48
Kidney			
Right	26.4	24	0.45
Left	18.9	13.3	0.07
Both	22.7	18.7	0.08
Spinal cord	57.6	36.9	0.03
Bowel	31.6	25.5	0.04
Body			
V5	5416	8663	0.046
V10	4380	2868	0.038
V15	3809	1618	0.028
CI	0.45	0.8	0.026
HI	1.35	1.1	0.034

HI of VMAT was 1.1 versus 1.35 ($p = 0.034$) & CI of VMAT was 0.8 versus 0.45 ($p = 0.026$), [Table 2](#).

Organs at risk dose

Normal tissue sparing was optimal in both techniques however VMAT has statistically significant spinal cord sparing ($p = 0.03$), lower bowel dose ($p = 0.04$) and non-statistically significant kidney dose, [Table 2](#).

Integral dose

The body volume received 5Gy (V5) was lower and statistically significant in 3D-CRT ($P = 0.46$) while V10 and V15 were lower and statistically significant in VMAT ($p = 0.038$ and 0.028 respectively), [Table 2](#).

Discussion

Most modern techniques of radiotherapy have achieved better target coverage, normal tissue sparing while exposing the bigger volume of tissues to lower doses of irradiation. The usual practice of pure seminoma irradiation in our department to use VMAT technique especially in stages IIa and IIb ≤ 3 cm.

Regarding to tumor coverage, in this study, both plans have optimal and similar target coverage as reported by Zilli, et al. [18] and Hoppe, et al. [19] through using IMRT.

In this study, VMAT achieved more OARs sparing than 3D-CRT especially bowel, spinal cord and kidney as in studies noticed by Zilli, et al. [18] and Hoppe, et al. [19].

The lower integral doses (V10 & V15) and OARs sparing delivered by modern techniques as in this study may be added to other studies [18-20] to share in lowering the toxicity and decreasing the incidence of expected second malignancies, however better results can be achieved through proton beam technique via

more OARs sparing and lowest integral dose so that high therapeutic ratio is achieved which means minimal toxicity score and lower secondary malignancy profiles as reported by different studies however proton therapy is not widespread worldwide [18-21].

One limitation of this study is the small sample size due to the rarity of such cases, however this is the case in dosimetric studies.

Conclusion

VMAT is one of the most common techniques used nowadays due to high therapeutic ratio comparable to the conventional technique however low integral dose (V5) is still one of the drawbacks of modern irradiation techniques which are not the case in conventional techniques.

Funding and Conflict of Interest

Ethics approval and consent to participate

For retrospective review, no consent was required by the ethics committee.

Competing interests

No conflict of interest.

Funding

Not applicable.

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