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RESEARCH ARTICLE

Which Has Better Dosimetry in Retroperitoneal Sarcoma: Rapid Arc or 3D Conformal Radiotherapy Techniques?

MW Hegazy[1,2*], B Moftah[3] and O Hassad[3]

[1]*Section of Radiation Oncology, King Faisal Specialist Hospital & Research Centre, Riyadh, Saudi Arabia*

[2]*Department of Clinical Oncology & Nuclear Medicine, Zagazig College of Medicine, Egypt*

[3]*Department of Biomedical Physics, King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia*

***Corresponding author:** *Mohamed W Hegazy, Section of Radiation Oncology, King Faisal Specialist Hospital & Research Center, KSA, PO Box 3354, Riyadh 11211 MBC 64, Saudi Arabia, Tel: +966-550-742-859, E-mail: mohamed_wahba_1@yahoo.com*

Abstract

Aim: To compare which radiotherapy technique is better in retroperitoneal sarcoma (RPS) rapid Arc (RA) or 3D-Conformal Radiation Therapy (3D-CRT).

Methods and materials: Our study was on 10 patients with RPS diagnosed and treated at king Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia, planned for pre or postoperative radiation therapy with prescribed dose of 45Gy in 25 fractions. In both techniques, we looked at planning target volume (PTV) coverage, dose homogeneity and organs at risk dose (stomach, bowel, liver, kidneys and spinal cord).

Results: The PTV coverage, liver and stomach doses were similar in both plans however; RA significantly had better dose conformity (0.8 vs. 0.4, p = 0.034), dose homogeneity (1.08 vs. 1.3, p = 0.026), less bowel volume (V45 140cc vs. 243cc, p = 0.03) and lower Spinal cord dose (61% vs. 80%, p = 0.043).

Conclusion: Both plans achieved similar target coverage and organs at risk sparing however; RA showed statistically significant better dose homogeneity, bowel sparing volume and lower spinal cord dose in treating RPS by pre or postoperative radiation therapy.

Keywords

Retroperitoneal sarcoma, Pre or postoperative, Conformal, Rapid arc

Background

Retroperitoneal sarcoma (RPS) accounts to nearly 15% of all soft tissue sarcoma cases. The most common types are liposarcoma followed by leiomyosarcoma [1]. At time of presentation, RPS has a large size due to late diagnosis. The most common symptoms are vague abdominal pain, weight loss and anorexia. The liver and lungs may represent the most common sites of metastasis [2].

Surgery is the mainstay treatment of RPS, however achieving a gross total resection is critical [3-8]. The incidence of local recurrence is high, so radiation therapy has a potential important role for RPS. There is no answer to the better timing of radiation therapy either pre or postoperative. Pre and intraoperative radiation are done by Pawlik, et al. [9] and Gronchi, et al. [10] who added concurrent chemotherapy. Other studies applied the same regimen with encouraging RT results [11-13].

Aim

To compare which radiotherapy technique is better in RPS, RA or 3D-CRT.

Methods and Materials

Study design

Our study was on 10 patients with RPS diagnosed and treated at king Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia, 5 planned for preoperative and another 5 for postoperative radiation therapy with prescribed dose of 45Gy in 25 fractions. Dose constraints are shown in Table 1.

CT simulation and contouring

Planning CT scan was 4D performed with our de-

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partmental scanner (Philips Medical Systems, Cleveland, OH); with a slice thickness of 2 mm. Patients were placed supine with fully abducted arms with scanning from the upper thoracic to mid sacral spines. Fusion with preoperative CT, PET/CT or MRI scans was done to aid the delineation of gross target volume (GTV). GTV was expanded by 1.5 cm to create the clinical target volume (CTV), however in postoperative cases we have included the surgical clips as part of CTV then editing of organs at risk from CTV which then expanded by 1 cm to create the planning target volume (PTV). In both techniques, we looked at planning target volume coverage, dose homogeneity and organs at risk dose (stomach, bowel, liver, kidney, spinal cord).

Conventional 3D planning

Eclipse treatment planning system (Varian Medical Systems, Inc., Palo Alto, CA) was used along with the analytical anisotropic algorithm (AAA, Version 11.031) dose calculation algorithm. The plans were created with mixed 6 and 10 MV using 3-4 anterior, posterior and/or oblique fields.

Rapid arc

Eclipse treatment planning system was used with optimization using progressive resolution optimizer (PRO) Version11.031. All plans generated using True Beam linacs with 120 leaf millennium MLC and KV imaging, 2 arcs (full and/or partial), Arc mode, 6 and 10 MV. Arcs had the same isocenter at the center of the PTV.

Table 1: Dose constraints.

PTV95	95-98% of the dose
Bowel	V45 < 195cc
Kidneys	Mean dose < 15Gy
	V18 < 50%
Liver	Mean < 26Gy
Stomach & duodenum	V45 < 100%
	Max dose 50Gy
Spinal cord	Max dose 50Gy

Treatment plan evaluation

Dose-volume histogram statistics, dose conformity and dose homogeneity were analyzed to compare treatment plans. Both homogeneity (HI) [14-16] and conformity indices (CI) [17] were evaluated and calculated.

Statistical analysis

The planning target volumes, organs at risk, HI and CI endpoints were analyzed using non-parametric Wilcoxon signed rank test due to small sample size (SPSS, V19, USA), a probability value of < 0.05 considered to be statistically significant (two tailed).

Results

Target volume coverage

PTV coverage was achieved and comparable in both plans, (Table 2).

Comparison of dosimetric parameters

The CI and HI of RA were better and statistically significant than 3D plan (CI 0.8 vs. 0.4, p = 0.034) and (HI 1.08 vs. 1.3, p = 0.026).

Normal tissue sparing

We analyzed the dose parameters (mean and maximum doses) of the liver, stomach and duodenum, kid-

Table 2: Preoperative cases.

	Patient 1		**Patient 2**		**Patient 3**		**Patient 4**		**Patient 5**		**Mean**	
	3D	**RA**	**3D**	**RA**	**3D**	**RA**	**3D**	**RA**	**3D**	**RA**	**3D**	**RA**
PTV												
Mean%	102	100	102	101	101	101	103	101	102	103	102	101
Max%	105	105	106	105	107	105	107	106	107	107	106	106
SB, LB	150	80	190	100	200	110	190	105	210	100	188	119
V45 < 195cc												
SB, LB												
Mean%	50	44	50	40	70	60	40	36	30	28	48	42
Max.%	106	101	105	105	104	102	107	101	106	100	106	102
Kidney												
Mean%	25	18	30	23	15	14	11	10	32	30	23	19
Max.%	100	90	60	50	70	50	30	25	60	61	64	55
Liver												
Mean%	12	11	3	2	15	20	20	18	19	18	69	69
Max.%	80	82	10	15	95	96	100	101	98	100	77	79
St & du.												
Mean%	60	50	10	12	66	64	16	14	4	12	31	30
Max.%	100	95	80	75	104	100	101	105	10	35	79	82
SC												
Mean%	90	25	10	15	50	20	20	15	30	35	40	22
Max.%	100	75	40	42	95	60	70	95	95	70	80	58
HI	1.3	1.1	1.4	1.1	1.2	1.1	1.0	1.4	1.1	1.1	1.3	1.08
CI	0.3	0.7	0.4	0.8	0.4	0.7	0.4	0.8	0.4	0.8	0.4	0.8

Table 3: Postoperative cases.

	Patient 6		Patient 7		Patient 8		Patient 9		Patient 10		Mean	
	3D	**RA**	**3D**	**RA**	**3D**	**RA**	**3D**	**RA**	**3D**	**RA**	**3D**	**RA**
PTV												
Mean%	103	101	98	100	100	100	102	100	101	102	101	100
Max%	107	106	105	106	105	106	106	107	106	107	106	106
SB, LB	350	120	300	140	320	220	230	170	290	150	298	160
V45 < 195cc												
SB, LB												
Mean%	66	60	32	30	72	70	38	36	42	36	50	46
Max.%	107	103	103	108	104	104	105	101	104	102	105	104
Kidney												
Mean%	22	17	30	24	10	10	3	9	34	34	20	19
Max.%	101	87	51	61	59	41	28	23	53	68	58	56
Liver												
Mean%	14	13	0.5	3	17	22	24	22	31	26	17	17
Max.%	99	100	5	14	101	104	105	107	104	107	83	86
St & du.												
Mean%	72	56	12	14	70	68	12	10	2	9	33	33
Max.%	105	102	87	84	101	104	103	106	11	38	79	87
SC												
Mean%	79	31	6	10	43	27	19	13	28	44	35	25
Max.%	105	81	30	33	94	65	75	48	97	88	80	63
HI	1.4	1.1	1.1	1.0	1.2	1.1	1.4	1.1	1.3	1.1	1.3	1.08
CI	0.4	0.8	0.4	0.7	0.4	0.8	0.4	0.8	0.3	0.7	0.4	0.8

SB: Small Bowel; LB: Large Bowel; St: Stomach; Du: Duodenum; SC: Spinal Cord; HI: Homogeneity Index; CI: Conformity Index.

Table 4: Statistical results.

	Mean		P value
	3D	**RA**	
PTV			
Mean%	102	101	0.5
Max%	106	106	-
V45 SB, LB			
volume	243	140	0.03
SB, LB			
Mean%	49	44	0.4
Max.%	106	103	0.5
Kidney			
Mean%	22	19	0.5
Max.%	61	56	0.4
Liver			
Mean%	52	52	-
Max.%	122	83	0.08
St & du			
Mean%	32	32	-
Max%	79	85	0.2
SC			
Mean%	55	36	0.03
Max.%	80	61	0.043
HI	1.3	1.08	0.026
CI	0.4	0.8	0.034

neys, spinal cord and bowels (V45, mean and maximum doses) for all patients (Table 2). All parameters were comparable in both plans especially liver, stomach and duodenum, and bowel doses; however, RA has statistically significant less bowel volume (V45 140cc vs. 243cc, p = 0.03) and lower Spinal cord doses (mean 36% vs. 55% and maximum 61% vs. 80% with p value = 0.03 & 0.043 consequently) (Table 2, Table 3 and Table 4).

Discussion

The role of radiation therapy using both external beam and intraoperative radiation techniques for higher dose escalation to target volume either in naïve or recurrent RPS is still controversial with some studies achieved encouraging results [11-13,17-19]. Preoperative radiotherapy is preferred over postoperative one due to displacement of organs at risk especially bowel by the tumor itself with also better target coverage [20-22]. In our study we tried to look at which technique is better RA or 3D-CRT in RPS.

Using the same concept Paumier, et al. [23], Koshy, et al. [24] and Bossi, et al. [25] have been compared between 3D-CRT and IMRT of RPS, the first one [23] was for postoperative while the latter [24,25] was in the preoperative setting.

Regarding to the target coverage, it was identical in all the previous studies including our study except Koshy, et al. [24] who noticed increase of V95 (98.6% vs. 95.3%), PTV maximum and minimum doses (6% & 22%, P = 0.011 & P = 0.055) with IMRT arm.

Regarding to dose homogeneity, Paumier, et al. [23], Koshy, et al. [24] and Bossi, et al. [25] showed that CI was better in IMRT arm, similar to our results (CI 0.8 vs. 0.4, p = 0.034, HI 1.08 vs. 1.3, p = 0.026).

Regarding to organs at risk, Paumier, et al. [23] reported reduced bowel V50 and V40 five- and twofold, respectively with IMRT as in our study (V45 was 140cc vs. 243cc, p = 0.03), while Koshy, et al. [24] noted the lower small bowel volume receiving > 30Gy (63.5 to

43.1%, P = 0.043) with IMRT which was the same as by Bossi, et al. [25].

Paumier, et al. [23] reported the mean contralateral kidney dose increased from 1.5 (3D-CRT) to 4-4.4 Gy with IMRT, contrary to Bossi, et al. [25] who noticed that IMRT allows better sparing of the ipsilateral and contralateral kidney as well as in Koshy, et al. [24] while our results showed relative sparing of both kidneys by RA which was statistically insignificant, however bigger volume of the contralateral kidney received more doses in the RA arm.

Conclusion

Both plans achieved similar target coverage and organs at risk sparing however; RA showed statistically significant better dose homogeneity, dose conformity, bowel sparing volume and lower spinal cord dose in treating RPS by pre or postoperative radiation therapy.

Compliance with Ethical Standards

All authors declare that there is no conflict of interest. For retrospective review of data with less than minimal risk to the patients, no consent was required by the ethics committee.

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