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Dosimetric Analysis and Comparison of Volumetric Modulated Arc Therapy Versus Intensity Modulated Radiation Therapy For Liver Carcinoma

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INTRODUCTION

Liver cancer is one of the most common cancer around the world. Among all treatment options, radiation therapy is helpful for those can't not be removed by surgery or treated with ablation or embolization. The ultimate goal of radiation therapy is to deliver sufficient dose for target coverage; while limit as much dose as possible for sparing of surrounding normal tissue and organ at risk (OAR). Liver cancer is well suited for Intensity Modulated Radiation Therapy (IMRT) or Volumetric Modulated Arc Therapy (VMAT) because OARs can potentially be spared.

AIM

VMAT, an extension of IMRT, employs modifications in gantry rotation speed, machine dose rate and multi-leaf collimator motion to deliver a 3D dose distribution in rotational mode while using less treatment time than conventional IMRT. This study compared VMAT to IMRT for patients with liver carcinoma.

METHODS

Ten patients with liver carcinoma previously treated with IMRT or VMAT were retrospectively selected for this study. Each patient received a total dose of 54 Gy in 1.8 Gy fractions. For each patient, a multibeam IMRT, or single or double-arc VMAT treatment plan, was generated using Varian's Eclipse RapidArc treatment planning system with the same CT image sets and optimization constraints used for the corresponding clinical IMRT or VMAT treatment plan.

- **DOSIMETRY EVALUATION**

The dose-volume histograms (DVH) for planning target volumes (PTV) and organs at risk (spine, kidneys, stomach) were used.

- **EFFICIENCY EVALUATION**

Monitor units (MU) and beam on times (BOT) were recorded. *The homogeneity index (HI) =* $^{(D_{5\%}-D_{95\%})}/_{D_{prescribed}}$*, and conformality index (CI) =* $^{V_{D99\%}}/_{V_{PTV}}$*, were calculated for all plans.*

RESULTS

Dosimetric analysis for ten IMRT and VMAT plans were performed and listed. All parameters were listed as mean values, standard deviations, and p- values determining statistical significance test.

- **HOMOGENEITY INDEX AND CONFORMITY INDEX**

Compared to IMRT, VMAT plans showed significant difference in the homogeneity index [mean 5.9% (IMRT) vs. 3.8% (VMAT) with (p=0.009)] and insignificant difference in conformality index [mean 1.14 (IMRT) vs. 1.08 (VMAT) with (p=0.257)]

- **ORGANS AT RISK**

Compared to IMRT, VMAT plans also shown insignificant difference in normal tissue sparing [mean spine, L/R kidney and stomach doses of 2.68, 1.18/3.21, and 5.49 Gy (IMRT), vs. 2.55, 1.43/2.68, and 5.13 Gy (VMAT) with (p=0.778, 0.144/0.059, 0.721 respectively)].

- **MONITOR UNITS AND DELIVERY TIME**

VMAT required marginally fewer mean MU and shorter BOT (488 MU, 0.81 minutes) when compared to IMRT (575 MU, 0.96 minutes) with (p=0.380).

Table 1. Dosimetric Comparison of IMRT and VMAT for PTV

	HI		CI	
	IMRT	VMAT	IMRT	VMAT
1	6.44%	4.35%	1.01	1.01
2	3.73%	3.78%	1.07	1.01
3	9.78%	8.33%	1.12	1.12
4	5.83%	3.69%	1.05	1.04
5	4.83%	3.17%	1.07	1.17
6	5.40%	3.98%	1.28	1.03
7	3.84%	2.02%	1.51	1.12
8	4.57%	2.96%	1.21	1.10
9	9.87%	2.69%	1.04	1.10
10	5.14%	2.74%	1.03	1.10
Mean	5.90%	3.77%	1.14	1.08
Std.	2.99%	1.66%	0.15	0.05
p-value	0.009		0.257	

Table 2. Dosimetric Comparison of IMRT and VMAT for OAR

	Spine (Gy)		LT Kidney (Gy)		RT Kidney (Gy)		Stomach (Gy)	
	IMRT	VMAT	IMRT	VMAT	IMRT	VMAT	IMRT	VMAT
1	1.18	1.07	0.31	0.63	1.64	1.42	5.96	5.05
2	3.21	1.81	0.48	0.48	0.67	0.66	22.58	15.69
3	2.81	2.81	2.05	2.05	11.76	11.76	4.42	4.42
4	10.11	7.37	3.75	4.07	5.22	4.83	4.55	5.05
5	0.23	0.74	0.16	0.11	2.47	0.33	2.21	0.18
6	0.62	0.52	0.09	0.09	0.61	0.56	10.60	7.58
7	0.67	0.25	0.35	0.49	3.53	2.22	0.08	0.05
8	0.80	0.26	0.10	0.24	1.37	0.95	0.10	0.07
9	1.10	2.29	0.58	0.61	1.60	1.35	2.42	3.75
10	6.07	8.42	3.92	5.52	*	*	4.05	9.48
Mean	2.68	2.55	1.18	1.43	3.21	2.68	5.49	5.13
Std.	2.99	2.80	1.43	1.79	3.32	3.46	6.47	4.63
p-value	0.778		0.144		0.059		0.721	

Table 3. Plan summary comparison of IMRT and VMAT

	MU		Delivery Times (min)	
	IMRT	VMAT	IMRT	VMAT
1	478	522	0.80	0.87
2	822	516	1.37	0.86
3	956	336	1.59	0.56
4	748	477	1.25	0.80
5	284	680	0.47	1.13
6	1010	668	1.68	1.11
7	277	392	0.46	0.65
8	283	395	0.47	0.66
9	320	425	0.53	0.71
10	569	466	0.95	0.78
Mean	574.70	487.70	0.96	0.81
Std.	275.42	108.05	0.46	0.18
p-value	0.380		0.382	

CONCLUSIONS

For radiation therapy treatment of liver carcinoma, IMRT and VMAT can achieve similar PTV coverage and normal tissue sparing. Treatment time is only marginally shorter with VMAT vs. IMRT, with either technique providing associated benefits (decreased damage from secondary radiation, and treatment delivery uncertainty due to intrafraction tumor motion).

CONTACT INFORMATION

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