

# Implementation of advanced techniques in radiotherapy and comparison to standard 3DCRT plans- initial institutional experience

Borislava Petrovic<sup>1,2</sup>, Nemanja Golubovac<sup>1</sup>, Ozren Cudic<sup>1</sup>, Laza Rutonjski<sup>1,2</sup>, Milana Marjanovic<sup>1</sup>, Ivan Gencel<sup>1</sup>

1 Radiotherapy department, Institute of oncology Vojvodina, Sremska Kamenica, Serbia

2 Department of physics, Faculty of Sciences, University of Novi Sad, Novi Sad, Serbia

**Purpose.** The transition from three-dimensional conformal therapy (3DCRT) to intensity modulated (IMRT) or volumetric modulated arc therapy (VMAT) requires implementation of complex advanced dosimetry, fully commissioned treatment planning system (TPS), machine and other equipment and skills of employees. IMRT/VMAT is implemented in our clinic one year ago.

**Methods.** Twenty one gynecological patient treated in our clinic was selected for the study. Patients were planned for 3D CRT, but due to unacceptable doses to organs at risk (QUANTEC), treatment plans for IMRT or VMAT were generated, and dosimetrically verified before treatment delivery. The TPS used was Monaco 5.11 (Elekta) with Monte Carlo (VMAT) and Collapsed Cone (3DCRT) algorithm. The treatments were delivered by Versa HD (Elekta, Crawley, UK) using 10 MV (VMAT) and 15MV (3DCRT). The patients were prescribed 50.4 Gy/28 fractions (4) and 45 Gy/25 fractions (17 patients). The coverage of PTV and doses to organs at risk were recorded, both for VMAT/IMRT treatment and 3DCRT.

Table 1. Coverage of significant PTV volumes in both 3DCRT and VMAT plans

Patient ID	Prescription	Homogeneity index HI											
		VMAT/IMRT					3DCRT						
		D98 [Gy]	D95 [Gy]	D50 [Gy]	D2 [Gy]	Dmax [Gy]	HI VMAT	HI 3DCRT	D98 [Gy]	D95 [Gy]	D50 [Gy]	D2 [Gy]	Dmax [Gy]
1	50,4Gy/28fr	47.9	48.5	51.1	54	56.5	0.12	0.09	48.4	49.2	51.7	53.1	53.7
2	50,4Gy/28fr	47.8	48.4	50.9	54.1	57.6	0.12	0.09	48.5	49.3	51.2	53	53.7
3	50,4Gy/28fr	48.5	49.1	51.5	53.1	54.7	0.09	0.12	47.2	48.3	50.8	53.3	54.1
4	50,4Gy/28fr	48.1	48.7	51.2	53.4	55.6	0.10	0.09	47.7	48.4	50.7	52.4	52.9
5	45Gy/25fr	43.3	43.8	46	48.5	50.8	0.11	0.09	42.6	43.3	45.2	46.5	47.2
6	45Gy/25fr	42	42.7	45.3	47.9	50.1	0.13	0.08	43.5	44.1	45.6	47.2	48
7	45Gy/25fr	43.1	43.5	45.7	47.3	48.7	0.09	0.07	43.9	44.5	46	47.1	47.8
8	45Gy/25fr	42.1	42.9	45.1	47	49.1	0.11	0.09	43.2	43.9	45.8	47.1	48.4
9	45Gy/25fr	43.5	43.9	45.9	47.5	48.9	0.09	0.10	42.7	43.4	45.7	47.4	48.1
10	45Gy/25fr	41.92	42.6	44.9	47.4	49.9	0.12	0.10	42.8	43.6	45.5	47.5	48.1
11	45Gy/25fr	42.2	43	45.6	48	49.9	0.13	0.10	42.1	43	45.2	46.6	47.6
12	45Gy/25fr	43.7	44.2	46	47.8	49.7	0.09	0.09	42.7	43.5	45.5	46.9	47.7
13	45Gy/25fr	42.6	43.2	45.5	47.5	49.1	0.11	0.08	43.1	43.8	45.6	46.7	47
14	45Gy/25fr	42.7	43.2	45.3	47.4	49.1	0.10	0.09	42.6	43.3	45.1	46.6	47.6
15	45Gy/25fr	42.5	43	45.3	47.4	49.3	0.11	0.10	42.6	43.4	45.4	47.2	47.8
16	45Gy/25fr	42.6	43.1	45.4	48.2	51.1	0.12	0.09	43.3	44	45.9	47.3	47.7
17	45Gy/25fr	42.7	43.2	45.5	47.7	50.5	0.11	0.10	42.7	43.3	45.4	47.4	48.1
18	45Gy/25fr	41.6	42.5	45.5	47.5	49.5	0.13	0.09	42.7	43.2	45.2	46.8	47.3
19	45Gy/25fr	42.9	43.6	46.2	48	49.9	0.11	0.11	42.2	43.4	45.8	47.4	47.9
20	45Gy/25fr	41	41.9	45.5	48.2	50.3	0.16	0.09	42.7	43.5	45.9	46.9	47.5
21	45Gy/25fr	43.1	43.7	45.7	47.4	50.3	0.09	0.06	44.5	44.8	45.9	47.3	47.9
						average	0.11	0.09					

**Results.** Coverage PTV: The ICRU 83 criteria for PTV coverage were fulfilled in all 3DCRT /VMAT/IMRT plans. Doses to OARS: in average, the V45 in small bowel in IMRT/VMAT plans was approximately 6 times smaller than the same of 3DCRT plans. The V45 of small bowels was in average 45cm<sup>3</sup> in IMRT/VMAT plans, while in 3DCRT plans it was 233 cm<sup>3</sup>. In case of femoral head, significant reduction in V30 (9.8 % vs. 33.1%) and mean dose in case of IMRT/VMAT plans. Rectum was planned with significantly less dose in terms of V30 (79.5% vs 95.2%) in IMRT/VMAT plans. Bladder was better spared in VMAT plans in terms of V40 (51% vs. 91%), but maximum dose was higher in VMAT plans than in 3DCRT (50.1 Gy to 48.1 Gy in average). Homogeneity index was in average 0.11 for VMAT plans and 0.09 for 3DCRT plans.

Table 2. Coverage of significant volumes of OARs, both in 3DCRT and VMAT treatment planning technique

Patient ID	Bladder						Rectum		Left femoral head		Right femoral head		Small Bowels							
	VMAT/IMRT			3DCRT			VMAT	3DCRT	VMAT	3DCRT	VMAT	3DCRT	VMAT/IMRT			3DCRT				
	V40 [%]	V45 [%]	Dmax [Gy]	V40 [%]	V45 [%]	Dmax [Gy]	V30 [%]	V30 [%]	V30 [%]	V30 [%]	V30 [%]	V30 [%]	V35 [cc]	V40 [cc]	V45 [cc]	Dmax [Gy]	V35 [cc]	V40 [cc]	V45 [cc]	Dmax [Gy]
1	48.7	38	54.9	99.1	97.5	52.9	91	100	37.7	100	30.7	100	23.4	18.7	13.7	54.5	199.2	160.9	116.7	51.5
2	43.1	35.2	57.3	89.4	84.4	53.6	65	100	4.5	31.4	4.7	30.7	209.5	153.3	103.6	55	236	191.5	150.8	53.7
3	56.6	44.1	54.5	72.6	66.8	53.9	97.7	99.1	1.8	31.5	5.1	36.2	34.1	15.8	5.8	51.6	33.5	19.4	7	50.4
4	58.8	48.2	54.6	100	100	51.8	84.7	99.5	7.3	64.7	10.7	44.4	231.2	179	132	54.6	290.7	249.4	210.5	51.8
5	58.3	32.5	50.1	96.9	58.7	46.6	71.4	89.7	2.7	4.2	6.5	7.1	129.5	80	20.8	49.4	160.9	135.2	69.4	46.5
6	67.9	41	49.4	97.5	94.8	47.8	73.6	100	2.6	9.3	3.7	22.8	159.6	110.7	18.3	48.7	224.5	195.3	152.5	47.8
7	30.6	9.1	47.9	87.9	63.9	47.5	79.7	86.3	23.5	40.4	27.3	39.8	74	28.7	1.8	46.4	157.2	118.5	67.4	46.7
8	70.6	32.8	48.5	99	0.9	45.2	94.8	86.6	0.57	52.9	2.9	45.1	188.1	151.5	68.6	48.7	549.6	528.1	469.8	47.4
9	53.6	31.8	48.7	97.8	36.9	47	74.2	99.3	10	19.5	11.7	19.6	239.5	147	47	48.2	584.9	536.9	407.8	47.1
10	74.7	42.2	48.3	93.4	61.7	46.4	69.6	78.3	12.2	22.2	15.8	29.9	331.1	273.1	62.9	48.4	515.3	503.8	400.5	47.7
11	41	19.6	49	96.5	86.7	47.88	80.6	95.3	3	10.7	4.9	14.55	237.7	166.6	60	49	387	320.4	163.4	46.8
12	48.2	24.8	48	62.4	22.1	46.2	73.3	98.6	9.6	29.6	3	13.1	266.1	173.8	66.8	48.9	585.8	475	247.8	46.6
13	45.9	21.7	48.5	98.15	76	46.8	57.8	89.6	3.4	24.8	3.8	21.5	200.3	118.4	16.7	47.7	285.9	240.4	128.2	46.1
14	37.6	8.6	47.8	92.5	83.1	47.3	100	100	18.4	39.1	14.8	29.9	441.4	277.6	81	48.6	585	510.5	296.1	47.3
15	70.5	25.7	48	99.6	68.7	47.6	81.9	95.6	22.3	31.5	30	37.7	168.6	106.8	27.8	48.3	200.5	183.5	149.4	47.8
16	62.1	30.2	49.4	96.8	87.3	47.5	98	100	10.5	11	8.1	4.5	308.8	233.7	81.2	49	313.1	267	154.7	47.4
17	46.8	19	49.5	95.8	83.4	47.5	83.7	99.8	11.1	33	13.1	33.6	190.1	126.5	41.6	48.2	177.7	147.9	78.6	47.5
18	37	12.3	47.8	83	33.6	46	65.1	95.5	1.3	0.9	4.2	2	247.3	160.4	45	47.9	522.9	483.1	362.2	46.9
19	36.9	16.1	48.8	99.6	90.9	47.5	73.1	89.5	12.8	17.5	6.9	10.2	186.7	119.7	39.9	48.2	304.8	263.2	149.4	46.8
20	33.8	6.8	49.3	76	11.9	45.5	60.6	100	2.4	24.6	4.2	13	250.6	168.3	42.4	50	723.4	675.3	535.7	47.6
21				Infiltrated bladder			93.7	97.3	7.8	96.3	14.7	86.2	202.4	146.7	59.7	47.8	210.3	182.8	126.7	47.6
AVERAGE	51.14			91.70			79.50	95.24	9.78	33.10					45					233

**Conclusion.** Both 3DCRT and IMRT/VMAT provided good coverage of PTV, but analysis of dosimetric data revealed significant differences in normal tissue doses. The advanced treatment planning, evaluation, dosimetric evaluation and delivery is far more complex than the same for 3DCRT, but patient benefit in terms of OAR sparing confirms necessity for implementation of advanced techniques.