Evaluation of Different Gyn Pelvic Nodal Boost Planning Strategies to Determine the Optimal Planning and Treatment Approach

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PURPOSE

- Gynecological (GYN) patients with suspected positive lymph nodes often receive external beam radiation therapy (EBRT) boosts to affected nodes in addition to the dose delivered to the nodal chain in order to provide better disease control.[1,2]
- While dose escalation to the pelvic nodes is desired, toxicity to the rectum, sigmoid, bladder, and bowel limits how much dose can be given to the central disease and we must carefully balance EBRT and brachytherapy.[3,2]
- Determine if there is significant or any difference between 3D conformal radiation therapy (CRT) and VMAT plans with varying beam configurations.
- To use the parameters of organs at risk sparing (OAR), planning complexity, time on table, isodose conformality, and homogeneity to determine which technique would result in the best outcome for a range of patient anatomical differences

METHOLODOGY

Patient Selection:

- Fifteen GYN patients treated between Sept 2020 to Sept 2021 were analyzed retrospectively for this study. (Table 1)
- All patients received Primary EBRT followed by brachytherapy and nodal boost.
- Patients were chosen with varying difficulty in boost planning.

Treatment Planning System: RayStation v. 10B

Planning techniques prescribed to 10 Gy, 5 fx:

- Clinical pelvic nodal gross tumor volume (GTV) were expanded uniformly by 7mm to create a planning tumor volume (PTV).
- 3D with two isocenters, 18MV, 6MV, or mixed (fig 1)
- VMAT with one isocenter and two partial arcs (fig 2)
- VMAT with one isocenter and three full arcs (fig 3)
- VMAT with one isocenter and three full arcs (fig 4)
- VMAT with two isocenters and two partial arcs (fig 5)

A mid avoid structure was used for better low dose control for VMAT (fig. 6)
For a list of basic VMAT objectives see fig. 7
For a 3DCRT beam arrangement with 30˚wedges example see fig. 8

Data gathered:

- GTV & PTV coverage, Homogeneity Index (HI), and Conformality Index (CI)
- Max point dose and highest irradiated two cubic centimeter (D2cc) of bladder, rectum, sigmoid, and bowel

Characteristic	All Patients (n=15)	Easy Cases (n=5)	Medium Cases (n=5)	Hard Cases (n=5)
Age at radiation tx start	51.2 (33-75)	50.4 (35-66)	54.4 (41-75)	48.8 (33-72)
FIGO Stage				
I	2	0	1	1
II	1	1	0	0
III	11	4	4	3
IV	1	0	0	1
BMI	31.4 (20.2-47.4)	28.2 (20.2-37.9)	30.6 (23.6-40)	35.3 (26.2-47.4)
Nodal PTV Size (cc)	42.4 (16.9-81.9)	31.0 (16.9-46.7)	44.6 (24.9-65.4)	51.6 (21.1-81.9)
Minimum Node Separation (mm)	7.16 (4.8-11.3)	8.3 (7.2-11.3)	7.4 (5.9-8.9)	5.8 (4.8-6.7

Table 1. Patient demographic data

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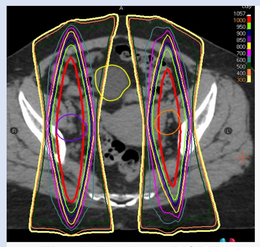

Fig. 1. Two iso 3DCRT

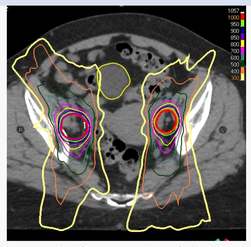

Fig. 2. One iso two full arc

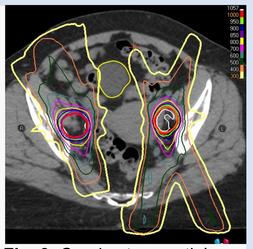

Fig. 3. One iso two partial arcs

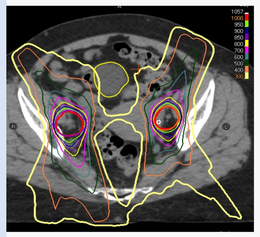

Fig. 4. One iso three full arcs

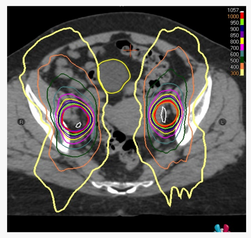

Fig. 5. Two iso two partial arcs

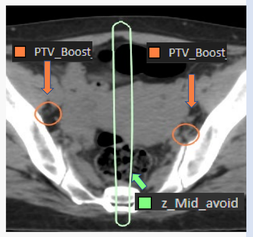

Fig. 6. Mid avoid structure example

PTV_Boost_Nodes	Min dose 1000 cGy
PTV_Boost_Nodes	Uniform dose 1000 cGy
PTV_Boost_Nodes	Max dose 1050 cGy
z_NT_avoid	Dose fall-off [H]1000 cGy [L]500 cGy, Low dose distance 1.00 cm
z_NT_avoid	Dose fall-off [H]500 cGy [L]100 cGy, Low dose distance 5.00 cm
Bladder	Max EUD 50 cGy, Parameter A 1
Bladder	Max EUD 100 cGy, Parameter A 3
Rectum	Max EUD 50 cGy, Parameter A 3
Bag_Bowel	Max EUD 80 cGy, Parameter A 3
Sigmoid	Max EUD 170 cGy, Parameter A 1
Bladder	Max dose 350 cGy
z_mid_avoid	Max dose 280 cGy

Fig 7. VMAT Objective example.

Fig 8. Example 3DCRT Beam arrangement

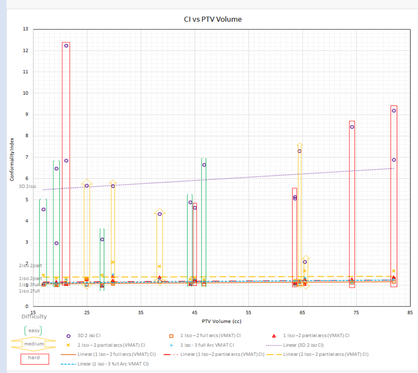

Fig 9. Conformity index vs PTV volume

Fig 10. HI vs PTV volume

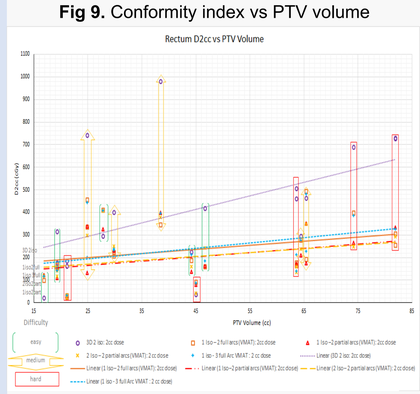

Fig 11. Rectum D2cc vs PTV volume

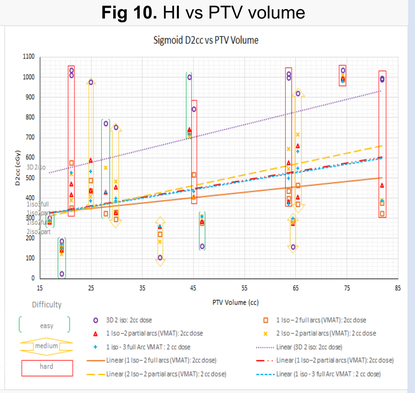

Fig 12. Sigmoid D2cc vs PTV volume

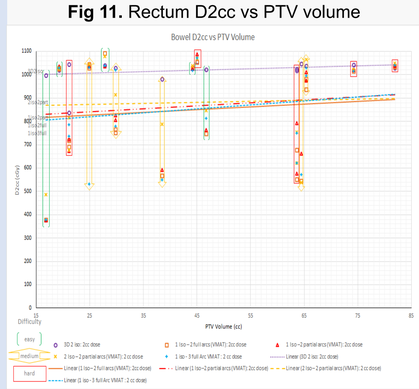

Fig 13. Bowel D2cc vs PTV volume

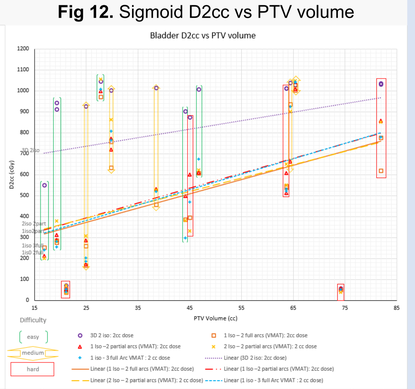

Fig 14. Bladder D2cc vs PTV volume

		3D 2 Iso	2 Full Arcs 1 Iso	3 Full Arcs 1 Iso	2 Partial Arcs 1 Iso	2 Partial Arcs 2Iso
HI_{avg}		1.051 ± 0.013	1.065 ± 0.017	1.069 ± 0.02	1.072 ± 0.017	1.076 ± 0.02
CI_{avg}		5.91 ± 2.37	1.11 ± 0.08	1.16 ± 0.14	1.19 ± 0.13	1.4 ± 0.27
Max Dose (Gy)	Bladder	8.56 ± 3.56	7.74 ± 3.69	7.46 ± 3.79	7.91 ± 3.69	7.86 ± 3.91
	Rectum	6.16 ± 3.12	3.91 ± 2.42	3.62 ± 2.17	3.4 ± 2.2	3.1 ± 2.16
	Sigmoid	8.47 ± 3.28	7.6 ± 3.01	7.68 ± 2.97	7.63 ± 2.94	7.61 ± 3.31
	Bowel	10.42 ± 0.15	10.07 ± 1.21	9.95 ± 1.31	10.18 ± 1.1	10.46 ± 0.53
D2cc (Gy)	Bladder	8.17 ± 3.55	5.02 ± 3.16	5.09 ± 3.40	5.17 ± 3.18	5.06 ± 3.35
	Rectum	4.12 ± 2.64	2.35± 1.31	2.35± 1.3	1.98 ± 1.05	2.06 ± 1.19
	Sigmoid	7 ± 3.9	4 ± 1.88	4.31 ± 1.88	4.36 ± 1.99	4.5 ± 2.26
	Bowel	10.19 ± 0.47	8.5 ± 2.15	8.49 ± 2.16	8.63 ± 2.03	8.81 ± 1.98

Table 2. Conformity Index, Homogeneity index, and OAR average max dose and D2cc values with their standard deviation

RESULTS

- The two full arc and two partial arc plans with one iso plans optimized at the fastest rate among the VMAT techniques in the treatment planning system (TPS)
- The two full arc, one iso technique displayed the best conformality index (table 2).
- VMAT techniques showed better reduction of D2cc for all OARs (table 2).
- Two full arc one iso technique had the lowest D2cc to OARs (table 2).
- 3D-CRT had the best HI (fig. 10, table 2)
- Max point dose in the target was on average lower than the VMAT plans (table 2).
- Two full arc one iso technique showed the best HI amongst the VMAT plans
- HI vs PTV volume trended higher for VMAT plans, with partial arcs having the worse performance (fig. 9)
- 3D-CRT had significantly poor high dose conformality in comparison to VMAT techniques (fig. 9, table 2)
- Target volumes had minimal to negligible effects on conformality in VMAT planning techniques (fig. 9)
- VMAT planning techniques took longer to plan than 3D-CRT

CONCLUSIONS

This study was done to investigate the most optimal way to plan pelvic lymph nodes boost irradiation. No single technique can be labeled as the best planning technique because each clinical situation is different. However, after analyzing the data and considering its simplicity, one iso two full arcs had best overall control of low dose to OARs specifically for organs that were near tolerance due to brachytherapy and EBRT. One iso two full arcs cases were also shown to have better conformality index and D2cc. Higher volume PTV had a direct correlation with higher D2cc to OARs (fig. 11-14). Optimization of one Iso two full arc was the most time efficient planning strategy, and the use of one isocenter reduces time on table and position uncertainties.

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