

Theme: Physics
Abstract No: PTCOG-AO2025-ABS-0041
Dosimetric Comparison of IMPT and VMAT for Left-Sided Breast Cancer with regional nodal irradiation including the IMN: Preliminary Results from a Prospective Trial

Ren Wei, Faye Lynnette Lim Wei Tching, Ng Wee Loon, Ashley Ong Li Kuan, Wong Fuh Yong, Chua Eu Tiong, Richard Yeo Ming Chert, Bryan Ho Shi Han, Gail Chua Wan Ying, Nelson Yit Ling Fung, Lim Li Hoon
Department of Radiation Oncology, National Cancer Centre, Singapore

Objective:

To evaluate the dosimetric benefits of intensity-modulated proton therapy (IMPT) compared to volumetric modulated arc therapy (VMAT) for left-sided breast cancer with regional nodal irradiation including the internal mammary node (IMN), focusing on target coverage and organ-at-risk (OAR) sparing in our prospective trial at Singapore National Cancer Centre, where breast cancer is not yet a standard indication for proton therapy.

Methods:

Eight patients with left-sided breast cancer requiring regional nodal irradiation, including IMN, were enrolled in an ongoing trial (target: 20 patients). IMPT and VMAT plans were generated to a prescription dose of 40Gy in 15 fractions. IMPT used pencil-beam scanning with robust optimization (± 5 mm setup, $\pm 3.5\%$ range uncertainties), while VMAT employed three partial arcs with a 5 mm PTV margin. Dosimetric parameters for the clinical target volume (CTV), IMN_CTV, and OARs (heart, left anterior descending artery [LAD], lungs, contralateral breast, spinal canal, esophagus, thyroid, humeral head, skin, body) were assessed, including D95%, D98%, Dmax, mean dose, V5Gy, and V20Gy. Paired T-tests determined statistical significance ($p < 0.05$).

Result:

IMPT significantly improved CTV coverage over VMAT, with D95% (40.32 ± 0.20 Gy vs. 39.04 ± 0.59 Gy, $p = 0.0005$), D98% (40.10 ± 0.27 Gy vs. 37.98 ± 0.92 Gy, $p = 0.0003$), and D99.5% (39.83 ± 0.28 Gy vs. 36.62 ± 1.30 Gy, $p = 0.0002$). For OARs, IMPT reduced doses, notably heart mean dose (0.78 ± 0.34 Gy vs. 5.64 ± 1.79 Gy, $p = 0.0001$), LAD Dmax0.03cc (15.21 ± 10.80 Gy vs. 31.93 ± 7.52 Gy, $p = 0.0017$), total lung V5Gy ($20.08 \pm 4.34\%$ vs. $46.68 \pm 6.69\%$, $p = 0.0002$), and contralateral breast mean dose (0.36 ± 0.21 Gy vs. 7.87 ± 3.10 Gy, $p = 0.0003$). Table 1 summarizes all 25 parameters, including reductions in spinal canal Dmax (8.65 ± 3.98 Gy vs. 18.87 ± 1.42 Gy, $p = 0.0012$), esophagus mean dose, and body V5Gy, with IMN_CTV coverage similar ($p = 0.4940$).

Table 1. Dosimetric parameters and p-values

Parameter	IMPT (Mean $\pm$ SD)	VMAT (Mean $\pm$ SD)	p-value
CTV D95% (Gy)	40.32 $\pm$ 0.20	39.04 $\pm$ 0.59	0.0005
CTV D98% (Gy)	40.10 $\pm$ 0.27	37.98 $\pm$ 0.92	0.0003
CTV D99.5% (Gy)	39.83 $\pm$ 0.28	36.62 $\pm$ 1.30	0.0002
CTV Dmax0.03cc (Gy)	43.53 $\pm$ 2.14	44.95 $\pm$ 2.20	0.0001
CTV D2% (Gy)	42.39 $\pm$ 1.43	43.67 $\pm$ 1.58	0.0002
IMN_CTV D98% (Gy)	39.95 $\pm$ 0.39	40.20 $\pm$ 0.98	0.494
Spinal Canal Dmax (Gy)	8.65 $\pm$ 3.98	18.87 $\pm$ 1.42	0.0012
Heart Dmean (Gy)	0.78 $\pm$ 0.34	5.64 $\pm$ 1.79	0.0001
LAD Dmax0.03cc (Gy)	15.21 $\pm$ 10.80	31.93 $\pm$ 7.52	0.0017
Total Lungs V5Gy (%)	20.08 $\pm$ 4.34	46.68 $\pm$ 6.69	0.0002
Total Lungs V20Gy (%)	8.61 $\pm$ 2.62	11.68 $\pm$ 1.48	0.0444
Total Lungs Dmean (Gy)	4.24 $\pm$ 0.99	8.27 $\pm$ 0.69	0.0002
Left Lung V5Gy (%)	44.03 $\pm$ 10.06	62.32 $\pm$ 11.10	0.0188
Left Lung V20Gy (%)	19.80 $\pm$ 6.00	26.31 $\pm$ 3.71	0.0625
Left Lung Dmean (Gy)	9.26 $\pm$ 2.33	13.17 $\pm$ 1.49	0.0108
Right Lung V5Gy (%)	1.74 $\pm$ 0.81	34.68 $\pm$ 10.14	0.0001
Right Lung Dmean (Gy)	0.40 $\pm$ 0.16	4.54 $\pm$ 0.74	0.0001
Humeral Head (Left) D1cc (Gy)	19.34 $\pm$ 8.48	32.44 $\pm$ 4.10	0.0005
Thyroid Dmean (Gy)	16.09 $\pm$ 2.10	19.57 $\pm$ 2.46	0.014
Esophagus Dmean (Gy)	5.79 $\pm$ 1.04	8.59 $\pm$ 1.50	0.0005
Esophagus Dmax (Gy)	40.14 $\pm$ 1.47	40.10 $\pm$ 2.22	0.9381
Skin D1cc (Gy)	41.87 $\pm$ 0.63	41.40 $\pm$ 2.30	0.5127
Contralateral Breast Dmean (Gy)	0.36 $\pm$ 0.21	7.87 $\pm$ 3.10	0.0003
Contralateral Breast Dmax (Gy)	9.23 $\pm$ 8.80	25.44 $\pm$ 5.49	0.0001
Body V5Gy (%)	13.93 $\pm$ 2.87	30.96 $\pm$ 5.12	0.0001

Conclusion:

In this preliminary analysis, IMPT outperformed VMAT, enhancing target coverage and sparing OARs, particularly heart, LAD, lungs, and contralateral breast. Table 1 details these advantages, supporting continued trial enrollment to evaluate IMPT's clinical benefits of proton therapy in this patient population. Long-term follow-up will determine whether these dosimetric advantages translate into meaningful clinical outcomes, potentially establishing proton therapy as an option for selected breast cancer patients in Singapore.