

# Knowledge-based planning with dosimetric scorecards for total marrow plus lymphoid irradiation on Halcyon

## Purpose/Objective

To develop and refine a knowledge-based DVH estimation and optimization model, guided by a 130+ metric dosimetric scorecard, for automation of TMLI (Total Marrow plus Lymphoid Irradiation) treatment planning.

Patient	Gender	Sep (cm)	# Lat Iso	Manual Replan	Initial KBP Model	Final KBP Model	Clinical Plan
1	F	57	2	1303.30/1589.50 (81.99%)	1305.08/1589.50 (82.11%)	1308.80/1589.50 (82.34%)	1190.29/1589.50 (74.88%)
2	M	60	2	1213.95/1467.50 (82.72%)	1188.90/1467.50 (81.02%)	1193.87/1467.50 (81.35%)	1134.53/1467.50 (77.31%)
3	F	48	1	1270.62/1589.50 (79.94%)	1262.99/1589.50 (79.46%)	1275.73/1589.50 (80.26%)	1150.15/1589.50 (72.36%)
4	M	47	1	1177.15/1467.50 (80.21%)	1170.53/1467.50 (79.76%)	1178.35/1467.50 (80.30%)	1047.67/1467.50 (71.39%)
5	F	58	2	1295.51/1589.50 (81.50%)	1290.50/1589.50 (81.19%)	1312.91/1589.50 (82.60%)	1025.35/1589.50 (64.51%)
<b>Avg Score</b>				<b>1252.11 (81.27%)</b>	<b>1243.60 (80.71%)</b>	<b>1253.93 (81.37%)</b>	<b>1109.60 (72.09%)</b>
6	M	55	2	1252.36/1467.50 (85.34%)			
7	M	47	1	1126.52/1467.50 (76.76%)			
8	F	48	1	1042.34/1467.50 (71.87%)			
9	M	48	1	1075.50/1467.50 (73.29%)			
10	M	55	2	1152.84/1467.50 (78.56%)			
11	M	55	2	1226.28/1467.50 (83.56%)			
12	F	38	1	1356.39/1589.50 (85.33%)			
13	M	53	1	1087.62/1467.50 (74.11%)			
14	M	58	2	1238.16/1467.50 (84.37%)			
15	M	49	1	1185.74/1467.50 (80.80%)			
16	M	52	1	1073.70/1467.50 (73.17%)			
17	M	54	1	1085.10/1467.50 (73.94%)			
18	F	47	1	1239.40/1589.50 (77.97%)			
19	M	55	2	1264.92/1467.50 (86.20%)			
20	F	48	1	1266.68/1589.50 (79.69%)			
21	M	47	1	1179.59/1467.50 (80.38%)			
22	M	56	2	1266.00/1467.50 (86.27%)			
23	F	42	1	1242.32/1589.50 (78.16%)			
24	F	59	2	1315.27/1589.50 (82.75%)			
25	F	47	1	1272.96/1589.50 (80.09%)			
<b>Avg Score</b>				<b>1228.15 (81.10%)</b>	<b>1222.51/1467.50 (83.31%)</b>	<b>1229.34/1589.50 (76.71%)</b>	<b>1263.58/1589.50 (79.50%)</b>
1	M	56	2		1224.48/1467.50 (83.44%)	1222.51/1467.50 (83.31%)	
2	F	50	1		1217.41/1589.50 (76.59%)	1219.34/1589.50 (76.71%)	
3	F	44	1		1263.58/1589.50 (79.50%)	1273.08/1589.50 (80.09%)	
4	M	55	2		1268.82/1467.50 (86.46%)	1269.71/1467.50 (86.52%)	
5	M	50	1		1166.47/1467.50 (79.49%)	1169.02/1467.50 (79.66%)	
<b>Avg Score</b>					<b>1228.15 (81.10%)</b>	<b>1230.73 (81.26%)</b>	

Fig 1. Total score for clinical plans, manual replans, initial and final KBP model plans, and validation set [1].

## Materials/Methods

A cohort of 25 previously treated cases of 12, 16, 20Gy Rx (10 female and 15 male) were all replanned to 12Gy with an Eclipse V18 treatment planning system using 6MV FFF VMAT on a Halcyon™ ring gantry linear accelerator to create the KBP (Knowledge Based Planning) training set [1]. Target coverage and normal organ sparing goals were defined according to institutional historical dosimetric studies as well as published practice guidelines<sup>1</sup>. Using these clinical goals as guidelines, a dosimetric scorecard quantifying target coverage, OAR sparing and conformity was developed to evaluate plan quality during the manual replanning step [2]. Multiple isocenter positions, with 2 arcs per isocenter (collimator 0 and 90 degrees) were placed 14cm apart in the craniocaudal direction. This isocenter spacing maximizes plan deliverability robustness

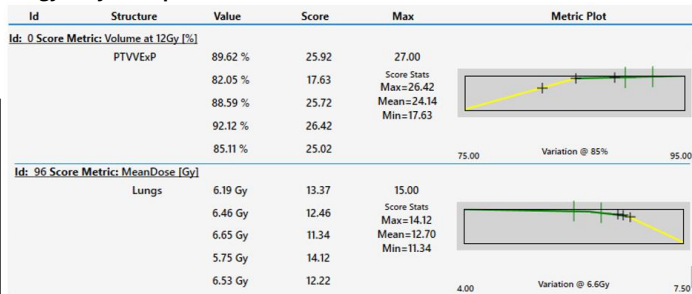


Fig 2. Scorecard quantifying Primary PTV dose coverage/mean lung dose on validation set, and metric point allocations [2].

resulting in 28cm total aperture being overlapped, half from the neighboring superior and half from neighboring inferior isocenters (except the most superior and inferior isocenters) [3]. When the patient's largest lateral total separation was >54cm, two lateral isocenters were placed in the same axial plane, each 7cm from midline (10/25 training set cases), otherwise, no lateral offset isocenters were applied (15/25 training set cases). The KBP model's automatically generated optimization objective priorities were tuned to maximize points on the dosimetric scorecard.

## Results

From the training set cases, five original 12Gy Rx clinical plans scored an average of 1109.60 (72.09%) vs manually optimized VMAT plans at 1252.11 (81.27%) vs KBP model generated plans at 1253.93 (81.37%). Those five training set case scores correlated with key metrics of average PrimaryBonePTV dose coverage (%) and average total lung mean doses of 84.81% / 6.46Gy in the clinical plans, 87.08% / 6.21Gy in the manually optimized VMAT plans and 87.31% / 6.34Gy in KBP model generated plans. In a separate 5 case validation set, the KBP model generated scores averaged 1230.73 (81.26%), with average PrimaryBonePTV dose coverage of 87.50% and average total lung mean doses of 6.32Gy [2]. Dosimetric scorecard metric value ranges were set on historical minimum and maximum values. All metrics on all plans created by the KBP model were within historic value ranges (no zero score metric failures).

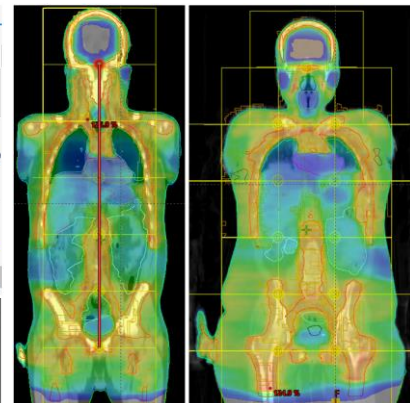


Fig 3. Lateral body separation isocenter positions <54cm=1 lat. iso. (left); >54cm=2 lat. isos. (right) [3].

## Conclusion

Manual planning can be laborious and results are varied based on the skill, time, and effort spent by the planner. After tuning against a dosimetric scorecard as a single objective measure of plan quality, this KBP model allows users to create high quality TMLI VMAT plans for Varian ring gantry linacs with a single button press. Validation on C-arm accelerators are forthcoming. The final model is shared publicly along with the associated dosimetric scorecard on the Varian Medical Affairs website<sup>2</sup>. This model has the potential to relieve treatment planning burden while maintaining dosimetric plan quality for an extremely complex disease site.

## References

- Han, C., Liu, A., Wong, J. Target coverage and normal organ sparing in dose-escalated total marrow and lymphatic irradiation: A single institution experience. *Front.Oncol.Vol12-2022* <https://doi.org/10.3389/fonc.2022.946725>
- <https://medicalaffairs.varian.com/other-tmlivmat2>