Hippocampal Sparing Whole Brain: Rapid Plan Model

Following the NRG-CC001 Protocol[1]

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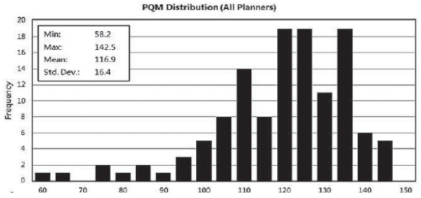
Introduction

Problem: Treatment plans often have high inter-planner variability and are time consuming to create.



There is a large inter-planner variation in plan quality as defined by a quantitative PQM score that mesures the ability of the planner to meet very specific plan objectives. Plan quality was not statistically different between different TPS or delivery techniques and was not correlated to metrics of plan complexity. Certification and education demographics, experience, and confidence level of the planner were not good predictors of plan quality[2]

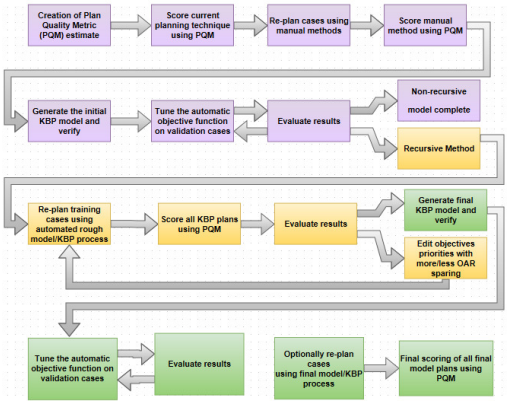
Solution: Use knowledge based planning, which has an origin in artificial intelligence and computer science, it involves training a learning system with a plurality of observed facts[3].

Methods

Model Training:

The Hippocampal Sparing Whole Brain (HCSWB) model was trained with 20 cases.

All cases were planned to 30Gy in 3Gy fractions with 6X energy on a Varian Linac with Millennium120 MLC, and utilized VMAT technique. The training cases were extracted from clinical cases that satisfied the contouring criteria. A recursive method of model creation was utilized to generate a RapidPlan model with very consistent, high quality plans developed with tight DVH prediction bands allowing for aggressive hippocampal sparing optimization objectives to be used.



An initial RapidPlan model is created from 20 manually planned cases. Then, that model is used to re-plan all the cases in that training set and/or others. Different arc geometries and differing combinations of auto-created optimization objectives are systematically used. The best scoring plan from each method is selected for each patient and those plans become the training set for the final model, and a final set of automatic objectives are then established for this final model. One RapidPlan model created from another initial/parent model – the recursive model creation process.

Model Validation:

The HCSWB model was validated using 21 cases which included the 20 final model training cases as well as an independent control case.

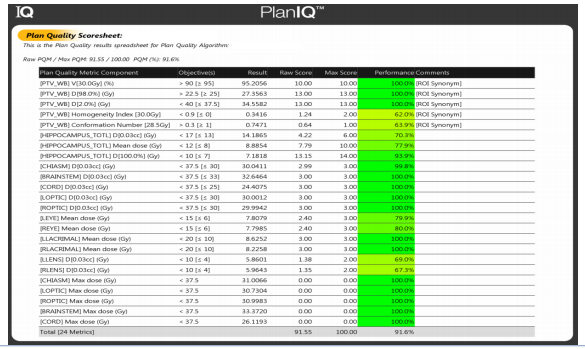
Additional validation was done using 7 cases obtained from a separate outside institution.

Since finalizing this model it has been tested on a number of cases from multiple institutions and the resulting plans were judged to have clinically satisfactory results, with Plan Quality Metric scores all within the expected range.

Methods

Plan Quality Metric (PQM) used to assess quality of plans

Scorecards were created for each plan using a Plan Quality Metric (PQM). The metrics were created from the criteria of the NRG-CC001 Protocol, with direct guidance added from a physician with experience treating hippocampal sparing whole brain patients under protocol. This guidance resulted in a more extreme hippocampal sparing than is requested by the protocol. The PQM scorecards were created using the Plan IQ software from Sun Nuclear Corporation. Building scorecards to guide plan quality throughout the model creation process proved to be critical. PQM scorecards enabled a very minute degree of plan quality control and measure throughout the model creation process and removed subjectivity in judging which plan was superior when assessing multiple plans for the same patient.



IQ PlanIQ™

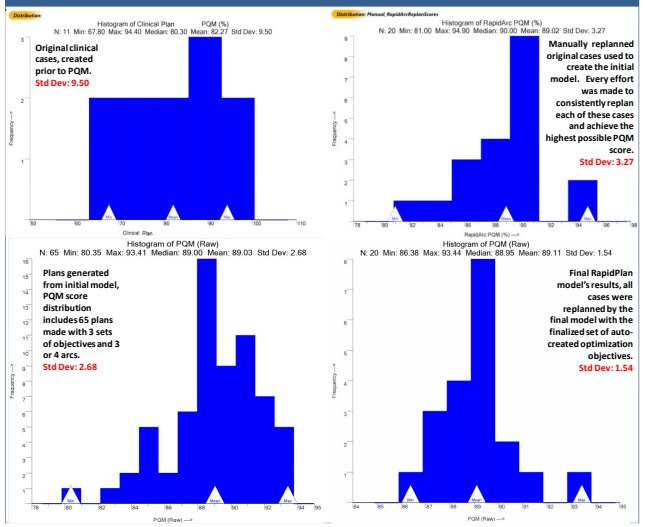
Plan Quality Scoresheet:

This is the Plan Quality results spreadsheet for Plan Quality Algorithm:

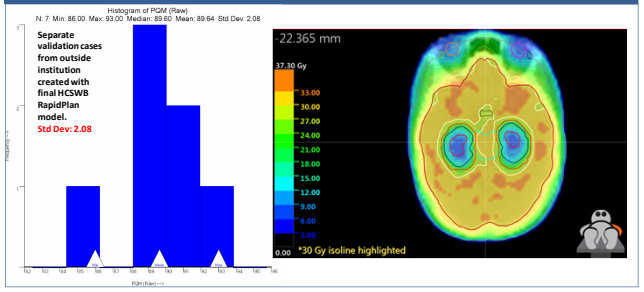
Raw PQM / Max PQM: 91.55 / 100.00 PQM (%): 91.6%

Plan Quality Metric Component	Objectives	Result	Raw Score	Max Score	Performance Comments
[PTV_WB] V(30.0Gy) (%)	> 90 [≥ 95]	95.2056	10.00	10.00	100.0% [ROI Synonym]
[PTV_WB] D(98.0%) (Gy)	> 22.5 [≥ 25]	27.3563	13.00	13.00	100.0% [ROI Synonym]
[PTV_WB] D(2.0%) (Gy)	< 40 [≤ 37.5]	34.5582	13.00	13.00	100.0% [ROI Synonym]
[PTV_WB] Homogeneity Index [30.0Gy]	< 0.9 [≤ 0]	0.3416	1.24	2.00	62.0% [ROI Synonym]
[PTV_WB] Conformation Number [28.5Gy]	< 0.3 [≤ 1]	0.7471	0.64	1.00	63.9% [ROI Synonym]
[HIPPOCAMPUS_TOTL] D(0.03cc) (Gy)	< 17 [≤ 13]	14.1865	4.22	6.00	70.3%
[HIPPOCAMPUS_TOTL] Mean dose (Gy)	< 12 [≤ 8]	8.8854	7.79	10.00	77.9%
[HIPPOCAMPUS_TOTL] D(100.0%) (Gy)	< 10 [≤ 7]	7.1818	13.15	14.00	93.9%
[CHIASM] D(0.03cc) (Gy)	< 37.5 [≤ 30]	30.0411	2.99	3.00	99.8%
[BRAINSTEM] D(0.03cc) (Gy)	< 37.5 [≤ 33]	32.6464	3.00	3.00	100.0%
[CORD] D(0.03cc) (Gy)	< 37.5 [≤ 25]	24.4075	3.00	3.00	100.0%
[LOPTIC] D(0.03cc) (Gy)	< 37.5 [≤ 30]	30.0012	3.00	3.00	100.0%
[ROPTIC] D(0.03cc) (Gy)	< 37.5 [≤ 30]	29.9942	3.00	3.00	100.0%
[LEYE] Mean dose (Gy)	< 15 [≤ 6]	7.8079	2.40	3.00	79.9%
[REYE] Mean dose (Gy)	< 15 [≤ 6]	7.7985	2.40	3.00	80.0%
[LLACRIMAL] Mean dose (Gy)	< 20 [≤ 10]	8.6252	3.00	3.00	100.0%
[RLACRIMAL] Mean dose (Gy)	< 20 [≤ 10]	8.2258	3.00	3.00	100.0%
[LLENS] D(0.03cc) (Gy)	< 10 [≤ 4]	5.8601	1.38	2.00	69.0%
[RLENS] D(0.03cc) (Gy)	< 10 [≤ 4]	5.9643	1.35	2.00	67.3%
[CHIASM] Max dose (Gy)	< 37.5	31.0066	0.00	0.00	100.0%
[LOPTIC] Max dose (Gy)	< 37.5	30.7304	0.00	0.00	100.0%
[ROPTIC] Max dose (Gy)	< 37.5	30.9983	0.00	0.00	100.0%
[BRAINSTEM] Max dose (Gy)	< 37.5	33.3720	0.00	0.00	100.0%
[CORD] Max dose (Gy)	< 37.5	26.1193	0.00	0.00	100.0%
Total [24 Metrics]			91.55	100.00	91.6%

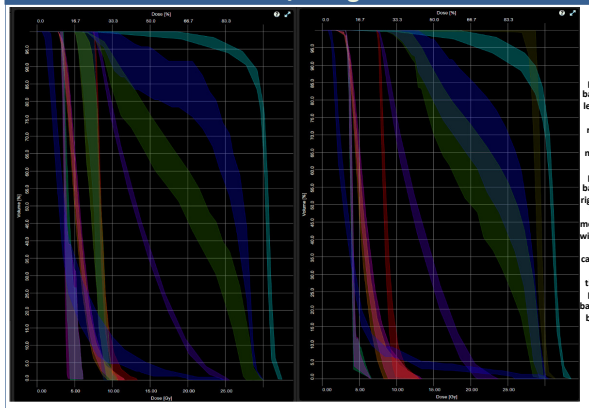
Results



Results



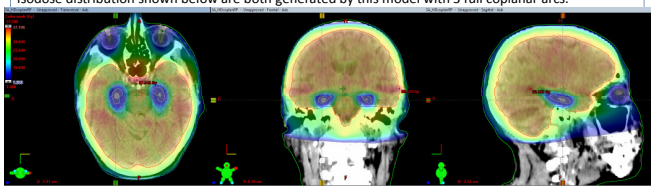
Discussion / Usage Variation



The DVH prediction bands on the left are from the final, recursively trained model. The DVH prediction bands on the right are from the initial model trained with manually planned cases. Notice the much tighter DVH prediction bands created by the final recursive model.

Variation: Number of arcs

This model was validated with 4 arcs (2 vertex). However, in practice, users have had good results using 3-4 coplanar arcs with collimator rotation 315, 45, 90. PQM report score 91.55 (methods section) and isodose distribution shown below are both generated by this model with 3 full coplanar arcs.



Conclusion

This HCSWB RapidPlan model creates high quality plans, with low variability created efficiently (no modification to auto-created optimization objectives) with specific metrics based on NRG-CC001. This RapidPlan model is available to download (free) on www.Oncopeer.com, with the full PDF description document. Like all RapidPlan models it can also be modified, if required, to meet other planning goals.

Contact

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References

1. A Randomized Phase III Trial of Memantine and Whole-Brain Radiotherapy With or Without Hippocampal Avoidance in Patients with Brain Metastases https://www.nrgoncology.org/Clinical-Trials/NRG-CC001
2. Nelms et al, PRO 2(4), 296 (2012)
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