Construction and evaluation of RapidPlan™ models for radical lung planning

Y Flanagan, P Kelso & S Smith
Radiotherapy Physics Department
Beatson West of Scotland Cancer Centre (BWoSCC), Glasgow, G12 0YN

Background

In 2010 the BWoSCC began implementing Volume Modulated Arc Therapy (VMAT) for certain treatment types. Since then this service has expanded to include many other sites including radical lung patients.

	Expansion of radical lung VMAT service						
Technique	2010	2011	2012	2013	2014	2015	2016
ARC	0	0	4	45	146	162	113
CONFORMAL	181	153	203	130	105	63	16
Total	181	153	207	175	251	225	129
% Starting RT with VMAT	0.0%	0.0%	1.9%	25.7%	58.2%	72.0%	87.6%

Table 1.

This technique is now well established as can be seen in table 1, above, which illustrates the migration to VMAT for patients receiving a 55Gy in 20 fraction treatment schedule. Attention has now turned towards how this service can be improved further. The RapidPlan™ package had already been used to great effect in our Prostate service and so was assessed for its potential in radical lung planning.

Method

Three different RapidPlan™ models were created using the Eclipse Treatment Planning System [Varian Medical Systems] v13.6: a model consisting of 50 randomly selected radical right lung patients (M_R), a model consisting of 50 randomly selected left lung patients (M_L) and a combined model using all 100 of these same patients (M_COM). The models were assessed statistically and geometrically using the standard RapidPlan™ tools as can be seen in figures 1.1, 1.2 and 1.3. Any outliers that may affect performance were removed.

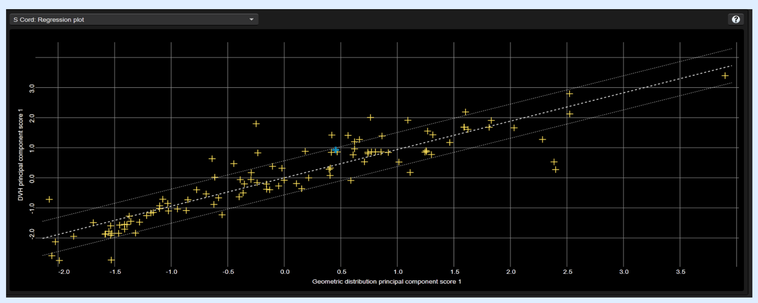

Figure 1.1

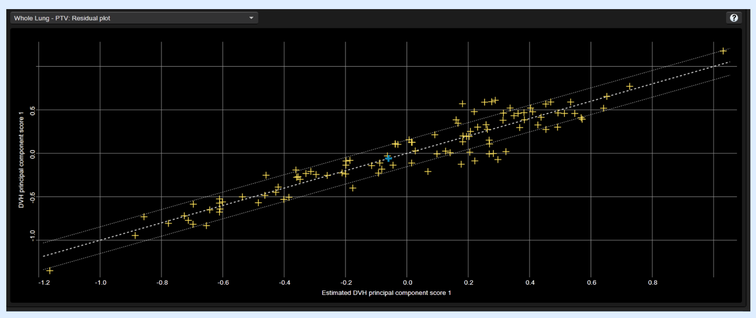

Figure 1.2

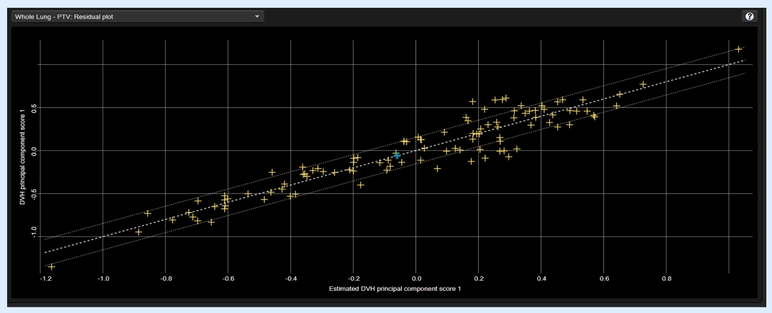

Figure 1.3

A retrospective planning study was performed for 10 right lung and 10 left lung patients. Each of the 20 patient treatments were replanned using each model. All plans were normalised to ensure that the target mean was 100% and compared to the manually optimised plan (O_P)

The PTV (Planning Target Volume) coverage was assessed using dose homogeneity indices:

HI_{95} defined as D5%/D95% and
HI_{98} defined as (D2%-D98%)/100

where:

Dx is the target volume receiving x% of the dose

Differences in organ at risk (OAR) dose volume histogram parameters were calculated to assess plan quality. The plans were compared on a variety of criteria including but not limited to whole lung V_5 (with tolerance considered 70%) and V_{20} (with tolerance considered 30%) and the maximum dose to spinal canal (tolerance considered to be 80 %).

Significance was assessed by two-tailed t-test ($p<0.01$).

Results

All three models gave a clinically acceptable plan. However some differences were observed. M_COM gave significantly better HI_{95} when compared with both the other two models and the O_P plans. M_COM also gave significantly better HI_{98} than the other two models with no difference in O_P observed.

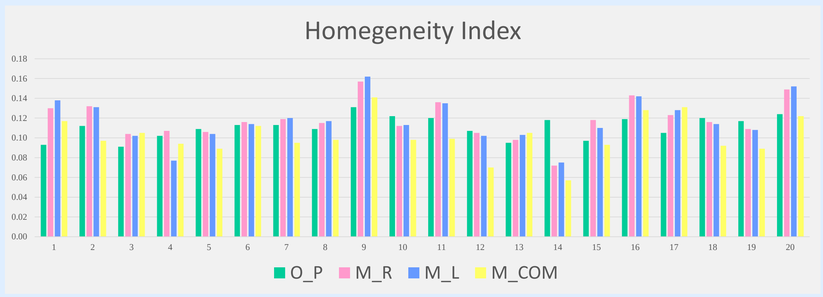

Figure 2.1

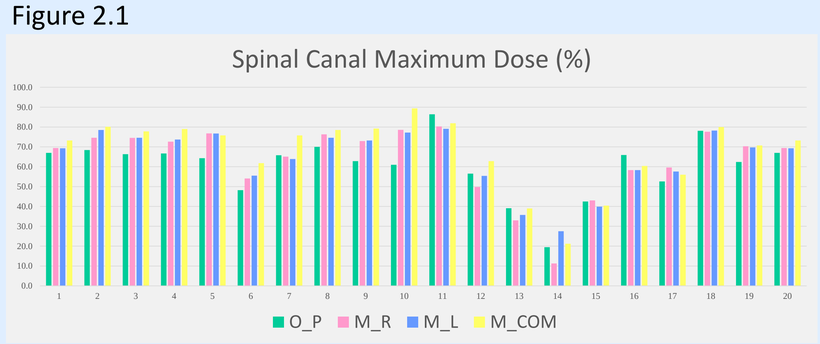

Figure 2.2

As can be seen in Figure 2.2 M_COM plans had a statistically significant increase in maximum spinal cord dose when compared to the other plans set, however doses were within tolerance.

An increase in mean whole lung and whole lung minus PTV V20Gy was also observed.

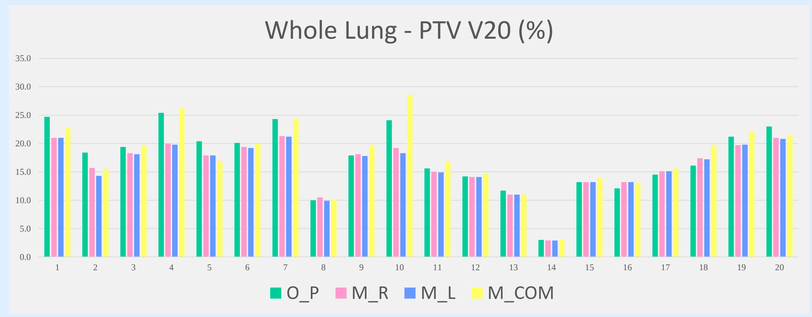

Figure 2.3

Contra Lateral lung, which could only be compared in 19 out of the 20 patients as one patient had bilateral disease showed no statistical difference nor did Whole Lung-PTV V5Gy.

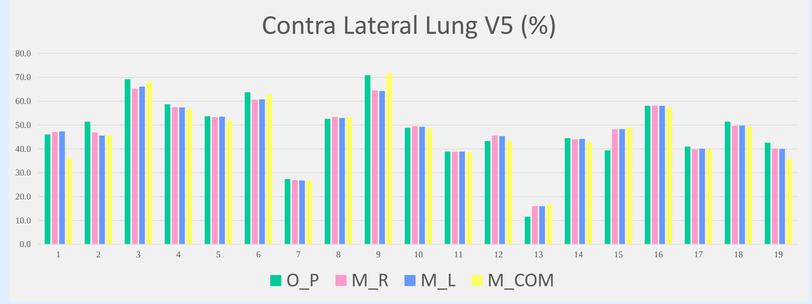

Figure 2.4

There was no statistical difference observed when comparing right sided tumour patient calculated with M_L and left sided tumour patients planned with M_R.

Conclusion

M_COM outperformed the other models and O_P in relation to PTV coverage without impacting clinically acceptable OAR constraints. This model demonstrated improvement when compared to M_L and M_R suggesting that 50 plans are insufficient to perfect a lung model and that 100 plans is more effective. When compared with manually optimised plans the M_COM model demonstrates an improved relationship between balancing OAR objectives and PTV conformity.

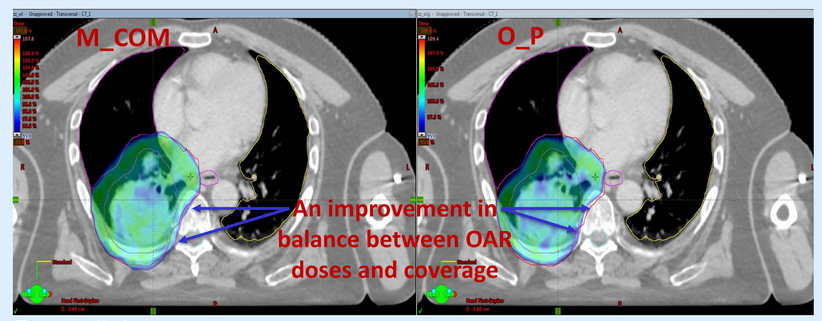

Figure 3.1