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Validation of a novel knowledge-based planning (KBP) model for lung cancer treatment with VMAT

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BACKGROUND

Radiotherapy plan design can vary widely depending on planners' experience [1-4]. Furthermore, having met the planning objectives plans may still be still be suboptimal if further reduction in OAR doses is possible without compromising target coverage and deliverability.

CONCLUSIONS

- Our novel in-house KBP models allowed a reduction in heterogeneity in treatment plan quality without impacting deliverability.
- The model has allowed a concurrent decrease in dose to healthy lung volume for VMAT-treated patients.
- The model has now been implemented clinically using Eclipse scripting and has reduced the number of plans failing V_5 criteria that previously necessitated compromised on dose coverage.

AIMS AND OBJECTIVES

- To develop a novel knowledge-based planning (KBP) model to reduce lung plan variability
- To determine what lung characterisation parameters could be used in the KBP model to predict achievable lung dosimetry metrics to then be used as optimisation constraints
- To assess the effect of the model on treatment plan complexity and deliverability

METHODS

- Dosimetric data for normal and target structures were analysed for 36 previously treated lung cancer patients.
- V_5, V_{20} and MLD were correlated against residual lung volume (RLV) (**Figure 1**)

$$RLV = \frac{(\text{Total Lung volume}) - (\text{Expanded PTV})}{(\text{Total Lung volume})}$$

- A lower-bound model was developed to achieve lowest dose metric values as a function of RLV.
- The model was tested by re-planning a further 39 patients, using the model predicted values as ideal constraints to replace protocol values.
- Treatment plan complexity metrics (MU/Gy, islands <1cc, small aperture scores) for the KBP plans were extracted.
- Treatment plans were delivered and measured on a Varian TrueBeam to assess deliverability.

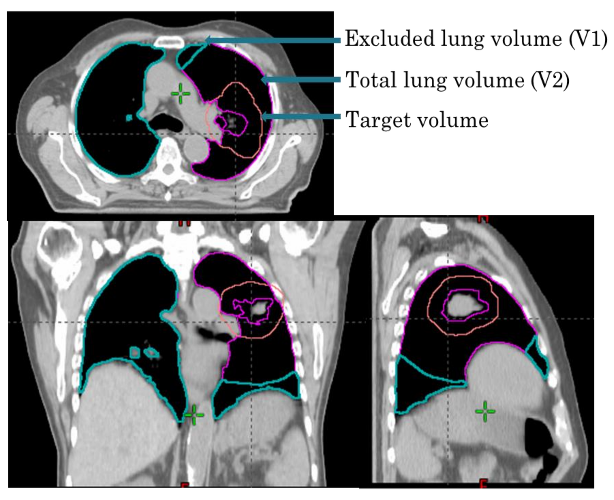

Figure 1: Construction of lung volume excluded from target volume (V1). Total lung volume is also displayed in pink (V2).

RESULTS

- The optimal correlation of V_5, V_{20} and MLD with RLV was found for a 5cm uniform expansion to the PTV
- A considerable reduction in treatment plan variability was observed in the re-planned patients (**Figure 2B**)
- Mean difference, between predicted min and achieved dose, was reduced from 8.8% to 2.2%, 1.8% to 0.8% and 1.1Gy to 0.4Gy for V_5, V_{20} and MLD respectively using the model.
- Significant concurrent reduction in all parameters was achieved whilst maintaining optimal target coverage (**Figure 2C**)
- KBP plans were more complex than the original plans, resulting in a small increase in measured delivery errors in 2/78 arcs

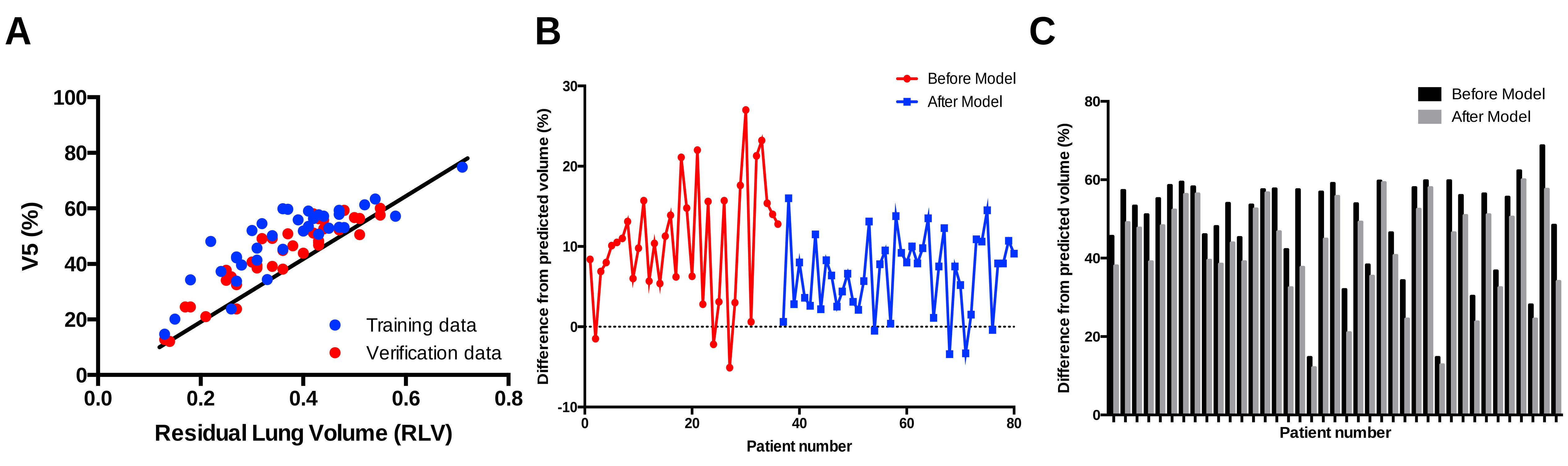

Figure 2: **Validation and application of novel KBP model**
Lower bound model (A) and effect of the model on lung V_5. Reduction in variability in plans is displayed in right (B). Bar plot (C) showing reduction in V_5 for patients planned using model.

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