

# Isotoxic Dose Escalation with Real-Time Imaging on an MR-Linac in Lung Radiation Therapy

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## Purpose/Objective(s)

Lung cancer survival is poor with only 5% survival at 10 years. Recent studies suggest that dose escalation in chemoradiotherapy is required to increase survival. However, dose escalation can be limited by dose constraints placed on surrounding organs at risk to limit potentially fatal side effects. MR-Linac offer real-time imaging during radiotherapy. It is hypothesized that MR-Linac tracking techniques may allow PTV margin reduction, leading to a meaningful dose escalation with no expected increase in toxicity.

## Materials/Methods

To calculate a range of CTV-PTV margins required for real-time tracking on an MR-Linac, MR systematic tracking errors were taken from literature, combined with contouring errors (1 mm) and random per-fraction localization errors (1 mm) as per van Herk et al. An ideal case of 0 PTV margin and the standard clinical margin were also used for comparison. 4DCTscans from 10 locally advanced NSCLC patients were used to create a range of isotoxic plans based on the mid-ventilation phase and varying PTV margins. Planning aims and constraints were taken from standard clinical practice and the UK IDEAL-CRT trial, and the PTV dose per fraction was increased until one or more OAR constraint-level was reached. The planned doses were used to estimate the expected two-year disease free survival(DFS) using a radiobiological model in lung cancer by Partridge et al. An increase of  $\geq 5\%$  DFS was considered clinically useful.

## Results

MR systematic tracking errors of 0.2 mm and 1.35 mm were used for  $PTV_{MRtrack\_hi\_acc}$  and  $PTV_{MRtrack\_lo\_acc}$ . Median isotoxically-prescribed doses of 72.8, 74.8 and 76.5 Gy could be delivered to  $PTV_{MRtrack\_lo\_acc}$ ,  $PTV_{MRtrack\_hi\_acc}$  and  $PTV_{MRtrack\_ideal}$  leading to modelled gains in DFS of 4.2, 9.0 and 14.0% respectively when compared to  $PTV_{standard}$  median dose of 71.0 Gy. Depending on tumor location and proximity of nearby OARs, prescribed doses were limited by constraints on the heart, pulmonary artery, esophagus, aorta and trachea in 11, 9, 9, 7 and 4 cases respectively.

Abstract 1102; Table 1. Prescribed doses achieved during isotoxic dose escalation

Structure	Structure composition	Median (range) dose to 95% PTV (Gy)	Median (range) $BED_{10}$ (Gy <sup>-1</sup> )	Median 2-year DFS ratio
$PTV_{standard}$	ITV + 5 mm (CTV) + 5 mm (PTV)	71.0 (64.1 – 90.0)	76.4 (66.4 - 105.6)	0.36
$PTV_{MRtrack\_lo\_acc}$	$GTV_{midV}$ + 5 mm (CTV) + 5 mm (PTV)	72.8 (66.7 – 92.6)	79.1 (70.1 - 109.8)	0.41
$PTV_{MRtrack\_hi\_acc}$	$GTV_{midV}$ + 5 mm (CTV) + 2 mm (PTV)	74.8 (69.7 – 109.9)	82.0 (74.4 - 138.8)	0.45
$PTV_{MRtrack\_ideal}$	$GTV_{midV}$ + 5 mm (CTV) + 0 mm (PTV)	76.5 (70.0 – 131.5)	84.6 (74.9 - 177.7)	0.50

## Conclusion

MR-Linacs with the capability of real-time tracking potentially allow the PTV margin to be reduced, leading to notable increases in isotoxically-prescribed doses, and useful gains in modelled two-year disease free survival.

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