Results of irradiations performed on Radiological Physics Center's anthropomorphic lung phantom and respiratory simulating motion table

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Introduction

The RPC's lung phantom is used to credential institutions to participate in NCI sponsored lung clinical trials. The techniques under evaluation are 3D-CRT or IMRT as well as the method to account for motion of the target. The following work presents the results of the irradiations performed on the Radiological Physics Center's anthropomorphic lung phantom using a respiratory simulating motion table.

Methods

The RPC's lung phantom includes two lungs with a density of 0.33 g/cm^3, a heart and a spinal cord with densities near 1.2 g/cm^3. A target centrally located is included in the left lung with density of 1.2 g/cm^3. The phantom is shown on Figure 1.

Figure 1: RPC Lung phantom.

TLD and radiochromic film dosimeters were used in the target region. (Fig. 2) The TLD are used for dose determination and are located near the center of the target. Films are located on the axial, coronal and sagittal plane for dose comparison. Films are normalized to TLD dose.

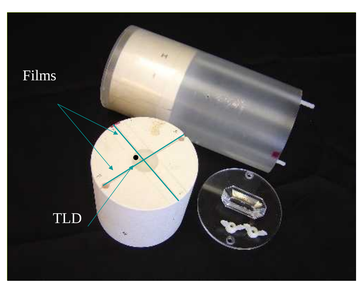

Figure 2: Insert with location of target and dosimeters

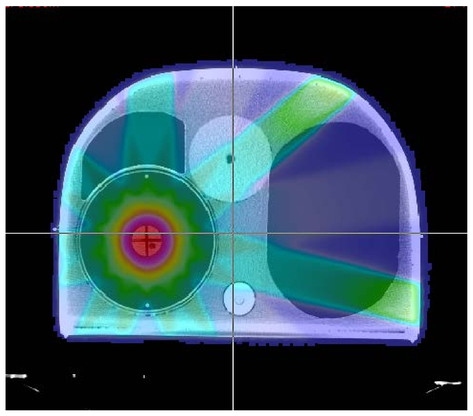

Figure 3: Dose distribution over axial cut

The institutions designed and delivered 3D or IMRT plans that covered an ovoid shaped target located in the left lung. Figure 3 shows a typical dose distribution on the lung phantom. All irradiations in this analysis included heterogeneity dose calculation algorithms approved by the RTOG. The TLD criteria were ±5% about a ratio of 0.97 In the case for Monte Carlo algorithms this TLD criteria is still ±5% but around a ratio of 1.00.

Before March 2012 the film criteria required a DTA ≤5 mm in the fall off regions of orthogonal profiles taken through the center of the target. After March 2012 the film criteria changed to require ≥80% of the pixels in the ROI in each plane to pass a 5%/5mm gamma calculation. The average of the 3 planes must be ≥85%.

When institutions use breath hold, gating, ITV or tracking techniques to account for patient motion, a motion table was included with the phantom. (Fig 4)

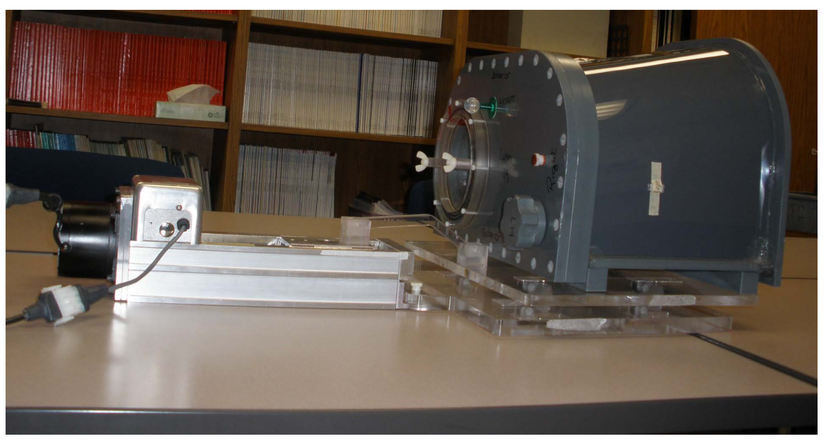

Figure 4: Lung phantom and motion table

Results

The lung phantom was irradiated 427 times by 304 institutions. 124 institutions irradiated it 157 times using the motion platform. Table 1 shows the average and standard deviation of the TLD results from the static and moving irradiations.

Table 1: TLD results for the lung phantom

	Motion	Static	All irradiations
Average TLD (RPC/Inst)	0.96	0.96	0.96
Standard Deviation	0.03	0.04	0.04

79% of the irradiations utilizing the motion table and 87% of the static irradiations passed the criteria. The overall pass rate for the phantom is 84%. Thirty percent of the moving phantom failures and 67% of the static phantom failures were due to failing solely the film criteria. 4 of 4 (100%) breath hold irradiations, 54 of 68 (79%) gating irradiations, 43 of 61 (70%) ITV irradiations and 23 of the 24 (96%) tracking irradiations passed the criteria. Table 2 summarizes the pass rates for the different motion management systems and the static irradiations.

Table 2: Pass rate for the lung phantom

Motion Management	Pass Rate (%)	Attempts	Criteria Failed		
			Dose	Film	Dose and Film
breath hold	100	4	0	0	0
gating	79	68	2	7	5
ITV	70	61	0	13	5
tracking	96	24	1	0	0
static	87	270	8	24	4
total		427	11	44	14

Conclusions

The RPC has developed an end-to-end credentialing process for clinical trials involving lung tumors. The moving phantom has a pass rate that is statistically significantly different ($p < 0.05$) than that for a static phantom.

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