Dosimetric accuracy of low dose (V5-V10) for TomoThaerpy lung IMRT

Introduction: The volume of lung receiving at least 5 Gy (V5) over the course of treatment is of particular concern as several published studies have suggested a relationship between this factor and radiation toxicity. Although it is important to understand dose distribution in the low dose regions, commissioning of TPS algorithms for dose calculation focuses on characterizing primary radiation. The effect of this is that secondary radiation is often ignored, meaning that there is incomplete understanding of low dose regions where the main dose contribution is from scattered radiation. Furthermore, routine quality assurance emphasizes high dose target regions, overlooking dose deposition in out-field and low dose regions. There are also likely difficulties in areas of heterogeneity such as the thorax due to considerations of charged particle equilibrium. As a result, the accuracy of Tomotherapy's TPS was investigated for low dose regions as well as areas of homogeneity.

Materials and Methods: CIRS anthropomorphic thorax phantom was used in this study. A series of treatment plans were created for delivery using standard planning parameters. A prescription dose of 7000 cGy (200 cGy over 35 fractions) was to be delivered to a contoured tumor volume in the right lung of the phantom. Treatment planning was done with three different field widths (1.0, 2.5, 5.0 cm). The phantom was constructed to allow for two points of measurement (medial and posterior) in the contralateral lung, both of which fell within the defined low dose (V5 to V10) region. A PTW Farmer chamber was used to determine dose at the points of interest. Comparison was then made to the results of dose calculation by the TPS.

Results: The results of the study are summarized in the following tables 1 and 2. Although all measurements were performed on the same day, there are small fluctuations in the output throughout delivery. To account for this, the measurements were normalized to the expected number of monitor units necessary for delivery and this is reflected in table 2. For the medial point of measurement there was a slight overestimation by the TPS calculation compared to the experimental results as evidenced by the 4.0 – 5.0% range in percent difference. For the posterior point of measurement, a slight underestimation was observed in the range of -2.8 – 3.3%. Based on the measured data, there appears to be no correlation between the difference in calculated versus measured dose as a function of field width. Variation in as a function of field width is 0.5 – 1.0%. Over the entire course of treatment (35 fractions), an absolute difference of 35 cGy between the TPS and measurement was determined for all field widths at all points of measurement.

Conclusions: At low dose levels (V_5 to V_{10} regions), dosimetric accuracy of conventional TPS systems is often underestimated, but our experimental results suggest the TomoTherapy TPS is reasonably accurate under the given conditions. Tomotherapy's TPS provides acceptable dosimetric accuracy in lung region areas of low dose.

Table 1. Comparison of TPS dose calculation and ion chamber measurements in the CIRS phantom

Chamber Position	Field Width (cm)	Measured Dose (Gy)	Treatment Plan Dose (Gy)	Percent Difference (%)
Medial	2.5	0.22	0.21	5.41
Medial	5	0.23	0.22	4.60
Medial	1	0.22	0.21	4.27
Posterior	2.5	0.17	0.18	-3.37
Posterior	5	0.18	0.19	-3.40
Posterior	1	0.17	0.18	-3.41

Table 2. Comparison of TPS dose calculation and ion chamber measurements in the CIRS phantom normalized to machine output

Chamber Position	Field Width (cm)	Measured Dose (Gy)	Treatment Plan Dose (Gy)	Percent Difference (%)
Medial	2.5	0.22	0.21	5.04
Medial	5	0.23	0.22	4.64
Medial	1	0.22	0.21	3.96
Posterior	2.5	0.17	0.18	-3.03
Posterior	5	0.18	0.19	-2.79
Posterior	1	0.17	0.18	-3.28

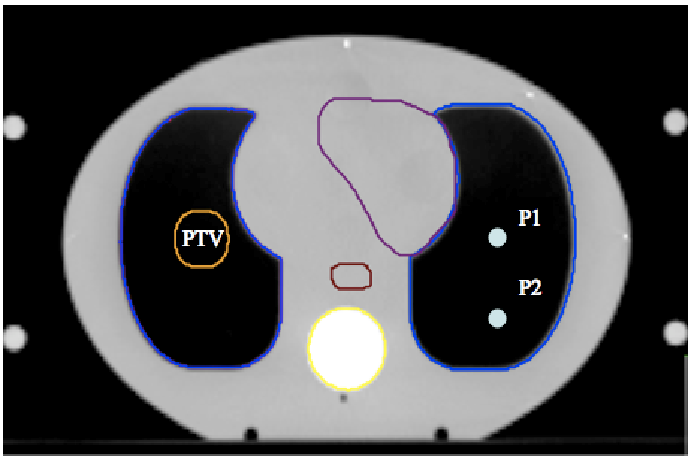

Figure 1: Transverse CT slice of the CT showing the PTV, contoured structures, and the points of measurement. P1 is the medial point and P2 is the posterior point of measurement on the contralateral lung equivalent material.

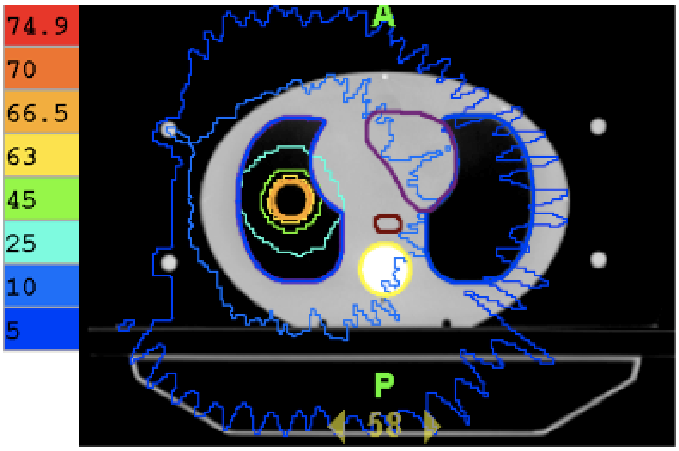

Figure 2: A transverse CT slice showing several isodose lines (including the 5 and 10 Gy lines) for the treatment plan developed with the 2.5 cm field width.

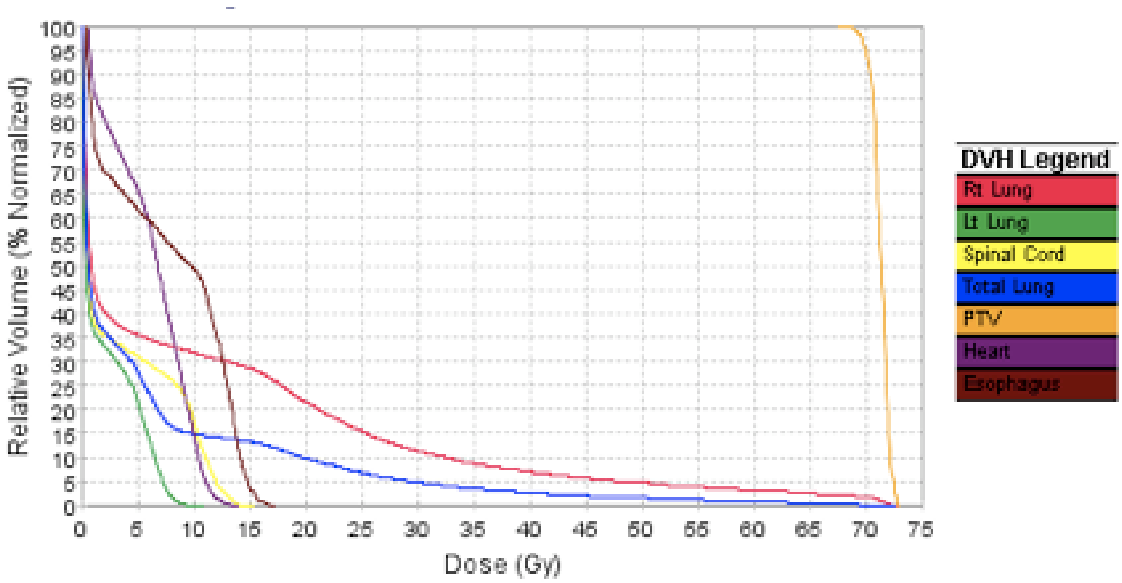

Figure 3: DVH for the 2.5 cm field width treatment plan.