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## Evaluation of tumor motion interplay effect on dose distribution in stereotactic radiotherapy

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### Introduction of the Study:

Intrafraction organ motion is a major concern for lung stereotactic ablative radiotherapy (SABR) during the delivery of treatment. It may cause substantial differences between actually delivered dose distribution and the planned one, due to the effect of tumor movement and multileaf collimator leaf motion. Motion management techniques allow to decrease the planning target volume which effects lower dose on healthy tissues and reduces the toxicity.

In the work presented here, it was investigated the dose delivery accuracy for not gated treatment of moving target to evaluate dosimetric deviations that is induced by respiration.

### Methodology:

The investigation in this study was carried out by using a linear accelerator and a helical tomotherapy (HT) on moving phantom. The first group of measurements was done with 10 MV flattening filter-free (FFF) volumetric-modulated arc therapy (VMAT) on a TrueBeam linac (Varian Medical Systems, Palo Alto, CA). By default, for VMAT plan, it was with two arcs instead of one for reducing the dose deviations. Treatment plans were generated using the Eclipse treatment planning system (Varian Medical Systems). The plans delivered on CT-scanned Quasar (Modus Medical Devices Inc., ON, Canada) phantom. The Quasar respiratory phantom containing a plastic spheres as a target, is a motorized phantom that can reproduce the motion. The phantom's wooden cylinder can move in the inferior-superior direction according to the input breathing trace, as well as the capability of performing more complex nonlinear motion. The tumor volume was delineated on a four-dimensional CT image of phantom to take into account the tumor movement. The irradiation was delivered on normal free breathing pattern that it was simulated in an oscillation mode of phantom motion program. The second group of investigation was a treatment technique that is delivered from a 6 MV fan beam in HT at the same operating parameters.

Gafchromic EBT2 film (Ashland, Covington, KY) was placed inside the lung inset of phantom. The measurements were acquired while the phantom moved under the described breathing pattern, as well as in a different stationary tumor position. The phantom was adjusted to have residual target in a range of -15, -10, 0, 10, 15 mm on static pattern. It was used to simulate the clinical situation of starting the therapy at random starting respiratory phase in the patient breathing cycle.

A calibration curve was created to a known dose with a 10x10 cm<sup>2</sup> field to correlate the measured film's optical density with the delivered dose. The films were scanned using a Vidar Dosimetry PRO film digitizer. Films were scanned with the 48 bit and a spatial resolution of 72 dpi. Data were saved in a tagged image file. Due to different light scattering films were maintained in the same orientation. FilmQA Pro software (Ashland) was used for comparison of the films with the treatment planning system.

### Results:

It was maintained the same time difference between the film irradiation and scanning for both experimental and calibration to expel the effect of color growth.

Quantitative analysis of gamma function distributions and dose profile comparisons were analyzed. Therefore, measured and planned doses were compared using gamma analysis (3%, 3 mm) for each breathing phase.

AAPM Report No. 91 recommends that respiratory motion should be considered when tumor respiratory movement exceeds 5 mm. On the contrary, a superior-inferior tumor movement over 2 cm is relatively unusual. The results for moving and static dose delivery indicated the very poor agreement between the

calculated plan and measured 2D dose distribution, as shown in figure 1. In all film measurements the tumor dose was underestimated in the lung SABR.

**Conclusion:**

The phantom study showed dose variation in different phases of tumor motion, the normal breathing mode that CT scan was done and different phases of breathing. Breathing changes can be happened in some patients cause of some health problems or coughing during the treatment. The findings increase the need of using in vivo dosimetry during the radiation therapy for small tumor volumes with smaller margins and especially for delivering of very high dose per fraction. It is crucial that high dosimetric and geometric accuracy is maintained at each step of the treatment process. Clearly, it was easy to see on irradiated films the tumor volume is different than the irradiated targeted volume because of the tumor motion. The findings were completely independent of the treatment planning system or radiation therapy unit. In small tumor volumes to reduce the impact of the interplay effect it is recommend to use a smaller slice thickness for imaging and should be given sufficient tumor margins.

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