Assessing Inter and Intrafraction Target Motion in Lung SBRT Using Deformable Image Registration

J Liang[1], D Lack[2], Q Liu[1], R Sandhu[3], L Benedetti[1], I Grills[1], C Stevens[1], D Yan[1]

1 Beaumont Health, Royal Oak, MI

2 Beaumont Health, Troy, MI

3 Beaumont Health, Dearborn, MI

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING

Improving Health QUALITY, Increasing Global Reach

EASTERN TIME [GMT-4]

INTRODUCTION

Using pre- and post-delivery 4DCBCT to examine inter and intrafraction motion and its dosimetric impact for SBRT lung treatments.

AIM

Evaluate target motion amplitude and position variation

Evaluate the frequency of geometric target miss during treatment and its dosimetric impact.

METHOD

- Study evaluated 393 pairs of pre- and post delivery 4DCBCTs for 93 SBRT Lung Cancer patients.
- GTV0 was defined on phase-0 of the planning 4DCT and propagated to each phase of the pre-delivery 4DCBCT (with couch correction) and the post delivery 4DCBCTs using deformable image registration (Elekta/Admire) to generate daily phase GTV contours.
- GTV contour's center of mass was used to calculate motion amplitude and target position.
- GTV position and amplitude in Superior-Inferior direction change was reviewed with differences in amplitude and target position between pre- and post-delivery 4DCBCT used to assess intrafraction motion. Interfraction differences in motion amplitude were evaluated by comparing amplitude at the first fraction and subsequent fractions.
- GTV contours were used to examine if target moved out of planning PTV during treatment. (Figure 1)
- Treatment dose was reconstructed and mapped to GTV0

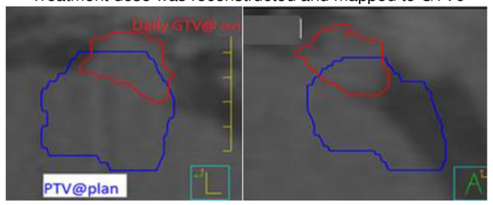
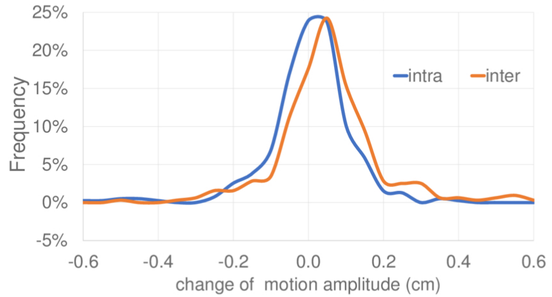


Fig1: Example of GTV on postCBCT moving out of planned PTV

RESULTS

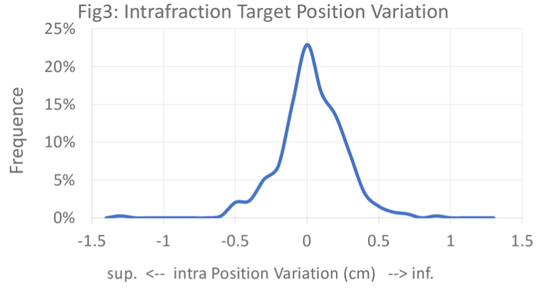
Target motion amplitude from all 4DCBCTs was 0.52±0.44 (0.01 to 1.94)cm. Frequency distributions for inter and intrafraction amplitude variation (Figure 2) were similar (Mann-Whitney U-test, p = 0.315) with average, standard deviation and ranges values of 0.03±0.14 (-0.52 to 0.58) and -0.03±0.11 (-0.60 to 0.35)cm.

Fig2: Motion Amplitude(SI) Variation



Intrafraction target position variation in SI direction was 0.02±0.23 (-1.31 to 0.88) cm as shown in figure 3, and it was not correlated to motion amplitude or amplitude variation ($R^2 \leq 0.08$).

Fig3: Intrafraction Target Position Variation



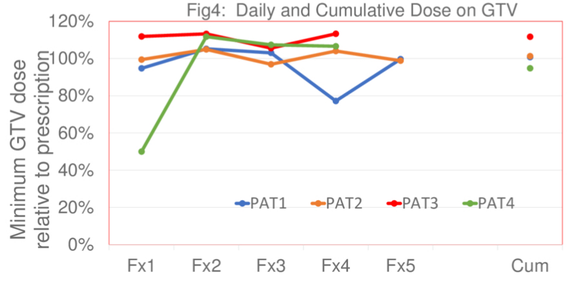
For 4 patients (4.3% of patient population), part of the GTV drifted outside the PTV due to intrafraction motion during 6 fractions by up to 0.98cm. Table 1 lists the distance the daily target moved outside of the PTV edge and its corresponding target motion amplitude.

Review of bony alignment between pre- and post-delivery CBCTs revealed no difference in patient position suggesting target drift was mostly related to internal anatomy motion.

Dosimetric impact of target drift was assessed by reconstructing dose on post-delivery 4DCBCT (Figure 4). For patient 4, a 50% dose reduction for daily GTV was seen for one fraction, with target cumulative dose for the whole treatment slightly below prescription. For the other 3 patients, the cumulative dose delivered remained above the prescription dose.

Compared with Patient1/Fx4, Patient4/Fx1 had less of the GTV located outside the PTV, however the cumulative dose for Patient4 is below prescription while the cumulative dose for Patient1 was not. This is because: 1) Patient1 had a large motion amplitude such that the GTV was able to move back into the high dose region, and 2) because Patient1 had one more fraction than Patient4 making the effects of this single fraction less significant.

Fig4: Daily and Cumulative Dose on GTV



	PAT1		PAT2		PAT3	PAT4
Total Fractions	5		5		4	4
GTV-out Fraction#	FX1	FX4	FX1	FX3	FX3	FX1
Out-side-distance:cm	0.18	0.98	0.21	0.21	0.14	0.67
Motion Amplitude:cm	1.51	1.40	0.65	0.53	1.23	0.28

Table 1. 6 fractions with GTV moving out of PTV during treatment

CONCLUSIONS

- The magnitude of amplitude variation during treatment is smaller than target position variation.
- Large intrafraction target drift can occur due to internal anatomy motion and may result in GTV dose decrease or even target miss.
- The treatment position change was mostly due to the internal target position drift instead of a change in the patient setup position.
- Large dose reduction was observed for a patient with drift of the GTV outside the PTV at post-delivry CBCT. The patient had smaller target motion-amplitude .The small motion amplitude made it less likely for the GTV to periodically move into the high dose PTV region once the taget is out of planed PTV region.
- Effective intrafraction target motion monitoring using 4DCBCT is still an indispensable component of lung SBRT delivery.

ACKNOWLEDGEMENTS

Support in part by Elekta Research Grant

CONTACT INFORMATION

JLIANG@BEAUMONT.EDU, Danielle.Lack@beaumont.org