AbstractID: 2922 Title: Variability of four dimensional CT patient models

Purpose: Several studies address the use of 4D CT to increase the geometrical accuracy of radiotherapy for lung cancer patients. A single 4D CT scan, however, gives a 'snapshot' movie loop of the patient's respiratory motion. In this study, we investigated the variability of respiratory motion over the course of radiotherapy using repeated 4D cone beam CT (4DCBCT) scans.

Method and Materials:
4DCBCT scans of 10 lung cancer patients were acquired on the linac just prior to irradiation for 7-13 fractions. The diaphragm motion, extracted automatically from the projection images, was analyzed in terms of period and phase-histogram (relative time spend in [exhale, exhale-to-inhale, inhale and inhale-to-exhale]). Tumor motion was determined by registering a region of interest from the planning CT to each phase of the 4DCBCT.

Results:
The average breathing period ranged from 2.1 s to 5.6 s for different patients, with an inter- and intra-fraction variation of 0.8 s SD. The average phase histogram was [0.3 0.23 0.2 0.27] with little variation between fractions and patients, i.e., patients generally spend more time at exhale than inhale. The mean (over all patients) intra-fraction variation (SD) of the average tumor position relative to the bony anatomy was 1.6 mm LR, 2.7 mm SI and 2.3 mm AP, reflecting baseline breathing variation. The peak-to-peak tumor motion ranged from 0.4 to 2.0 cm, with an inter-fraction variability of 16% (1SD).

Conclusion:
Substantial variation in respiratory frequency, mean tumor position and peak-to-peak amplitude was found. These uncertainties can be taken into account by adapting the CTV-to-PTV margin accordingly. 4D-patient models should be regularly updated, e.g., by acquiring 4DCBCT prior to treatment, for safe implementation of precision 4D radiotherapy techniques like gating and tracking.

Conflict of Interest (only if applicable):
This research was sponsored by Elekta Oncology Systems Ltd.