Impact of respiratory-correlated reconstruction algorithms in the choice of margins in 4D IGRT

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Purpose/Objective: 4D CT imaging based on respiratory-correlated algorithms incorporates organ motion which reduces motion artifacts and allows for an accurate determination of the tumor trajectory. However, breathing irregularities can cause considerable image distortions. Most of 4D CT images are reconstructed using a phase-based reconstruction method that is subject to image misalignments. The aim of this study is to investigate the impact of phase- and amplitude-based reconstruction algorithms in margins definition for lung cancer. These algorithms are studied in terms of image quality and dose distribution in presence of respiratory irregularities.

Materials and Methods: 4D CT images of Dynamic Thorax Phantom are acquired in helical mode (pitch < 0.1) using a 16-slices Toshiba CT. The respiratory signal is tracked by the ANZAI belt. Two irregular breathings are simulated with amplitude and frequency variations. Artifacts are evaluated from the reconstructed images. Four VMAT plans (two simulated breathing models for the two reconstruction algorithms) delivered in two arcs are calculated in Monte-Carlo-based TPS in the exhale phase. The plans are evaluated for Dmin, Dmax, Dmean, homogeneity index (HI) and conformity index (CI).

Results: For breathing amplitude variations, the amplitude-based reconstruction shows a significant reduction of artifacts compared to the phase-based (see Figure). For breathing frequency variations, the phase-based reconstruction is more efficient. Most of the artifacts are partial projection effect and data sampling conditions. There is no significant variation on the evaluated dosimetric parameters (see Table) since the dose calculation is performed on the exhale phase, less subject to motion artifacts. Therefore, for the mid-ventilation strategy, being close to the exhale phase, the choice of image reconstruction algorithm is not of importance for dose distribution which may be not the case for another strategy, e.g. internal target volume (ITV).

Conclusions: Amplitude-based algorithm reduces image distortions associated with respiratory irregularities, as amplitude variations. This is not of importance for mid-ventilation strategy, but it could be for other strategies, like e.g. ITV-based. Additional work will evaluate the robustness of the mid-ventilation strategy in case of amplitude-based reconstruction algorithm and with complex breathing patterns.

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Visually-guided breath hold improves the reproducibility of deep inspiration levels in breast cancer radiotherapy

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Purpose/Objective: At our clinic left sided breast cancer patients with淋巴 node involvement receive their radiation treatment gated with respect to their respiration. We used the free-breathing enhanced inspiration gating (IG) for several years, but now we are testing Deep Inspiration Breath Hold (DIBH). We have performed a comparison study of the two methods with main focus on the reproducibility of the inspiration level and quality of the treatment plan with respect to target coverage and dose to risk organs.

Materials and Methods: Both methods used the same marker-based respiratory monitoring system. For DIBH we used visual feedback and for IG audio coaching, both during Computed Tomography (CT) scan and treatment. For this study, 15 patients were scanned with both methods and on both CT-scans CTV for the breast tissue, the left anterior descending (LAD) coronary artery and the left lung was defined and radiotherapy plans were calculated. Both plans met the guidelines of the Danish Breast Cancer co-operative Group. Out of the 15 patients, 10 completed their treatment in DIBH and were included in the analysis of reproducibility. Those 10 patients were audio coached for about one minute (7-15 breathing cycles) before their treatment at 9 treatment sessions (roughly session 2, 3, 4, 12, 13, 14, 22, 23 and 24). During this minute, the patients did not receive any feedback. The average maximum inspiration level and standard deviation (SD) were calculated for each session. For comparison the peak inspiration level and SD were calculated for the DIBH levels in the subsequent treatment. Comparison were performed with the Wilcoxon signed rank-sum test.

Results: The results showed that the reproducibility of the inspiration level was better with the DIBH method, observed as a significantly smaller SD in most patients (p < 0.008 for 8 out of 10 patients). The left lung volume was higher with the DIBH method compared to IG (p=0.008) with mean increase of 15 %. This lead to a mean decrease in the V20 dose to the left lung of 6 % (p=0.01). There was no significant difference in the CTV coverage or the maximum dose to LAD artery between the two methods (p > 0.2).

Conclusions: The inspiration level for visually-guided DIBH was more reproducible compared to audio coached IG. Furthermore, the DIBH method with visual feedback resulted in a significantly larger lung volume and lower V20 dose for the left lung compared to IG with audio coaching. We could not detect a difference in dose coverage of the breast or sparing of LAD. These findings support the move towards DIBH with visual feedback as the new standard for breathing adapted radiotherapy for left sided breast cancer patients at our clinic.