Deep inspiratory breath hold assisted by continuous positive airway pressure ventilation for lung stereotactic body radiotherapy

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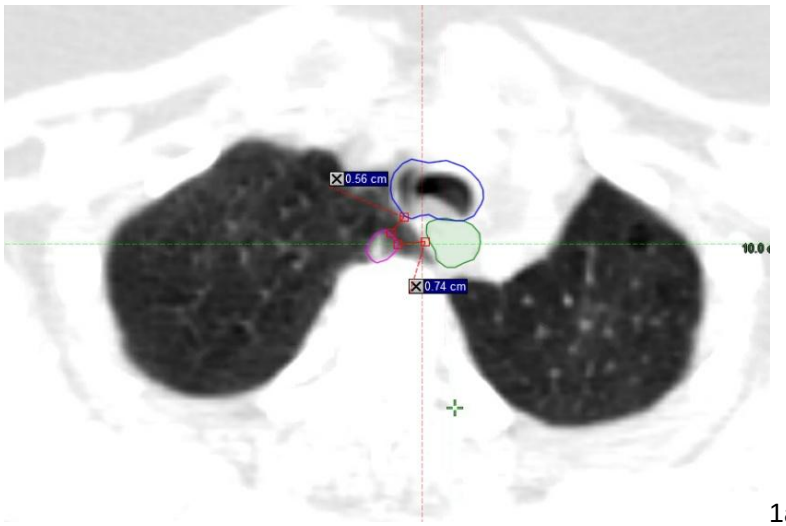
Introduction. Continuous positive airway pressure (CPAP) ventilation hyperinflates the lungs and reduces diaphragmatic motion. We hypothesized that CPAP could be safely combined with deep inspiratory breath hold (CPAP-DIBH) during lung stereotactic radiotherapy (SBRT).
Material and methods. – Patients with stage-1 lung cancer or lung metastasis treated with CPAP-DIBH SBRT between 3/2017–5/2021 were analyzed retrospectively. Patient characteristics, treatment parameters, duration of breath holds in all sessions and tolerance to CPAP-DIBH were recorded. Local control (LC) was assessed from CT or PET-CT imaging. The distances between the tumor and mediastinal organs at risk (OAR) in centrally located tumors using either free breathing (FB) or CPAP-DIBH were compared. Toxicity was graded retrospectively.

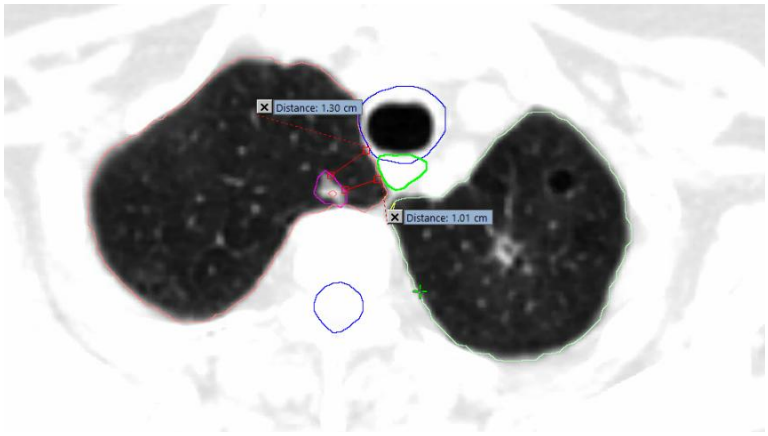
Results. – Forty-five patients with 71 lesions were treated with CPAP-DIBH SBRT. Indications for CPAP-DIBH were prior radiation (35/71, 65%), lower lobe location (34/71, 48%), multiple lesions (26/71, 36.6%) and proximity to mediastinal OAR (7/71, 10%). Patient characteristics were: F:M 43%: 57%; mean gross tumor volume 4.5 cm3(SD 7.9), mean planning target volume 20 cm3(SD 27), primary: metastatic lesions (7%:93%). Mean radiation dose was 52.5 Gray (SD3.5). Mean lung volume was 5292 cm3(SD 1106). Mean duration of CPAP-DIBH was 41.3 s (IQR 31–46.8). LC at 2 years was 89.5% (95% CI 76–95.5). In patients with central lesions, the distance between the tumor and mediastinal OAR increased from 0.84 cm (SD0.65) with FB to 1.23 cm (SD 0.8) with CPAP-DIBH ($p = 0.002$). Most patients tolerated CPAP well and completed all treatments after starting therapy. Three patients did not receive treatment: 2 were unable to tolerate CPAP and 1 had syncope (pre-existing). Toxicity was grade 2 in 4/65 (6%) and grade 3 in 1/65 (1.5%). There was no grade 2 or higher esophageal or tracheal toxicities.

Conclusion. – CPAP-DIBH assisted lung SBRT was tolerated well and was associated with minimal toxicity and favorable LC. This technique may be considered when treating multiple lung lesions, lesions located in the lower lobes or adjacent to mediastinal OAR.

Figure 1: axial images from CT-sim with free breathing (1a) compared with CPAP-DIBH (1b). The distance between GTV and mediastinal OAR is increased with use of CPAP-DIBH, thus allowing for safe SBRT delivery with minimal risk of ulcer of fistula.



1a Free Breathing



1b CPAP-DIBH

Figure 2: CPAP DIBH for lower lobe SBRT. In figure 2a- CPAP-free breathing shows significant tumor excursion resulting in large PTV. With CPAP-DIBH (figure 2b) the PTV is smaller allowing for reduced lung dose and improved local control. Another difference in the waveform- with CPAP FB the chest wall (CW) is oscillating yet with CPAP DIBH the CW is stable with long periods of breath hold.

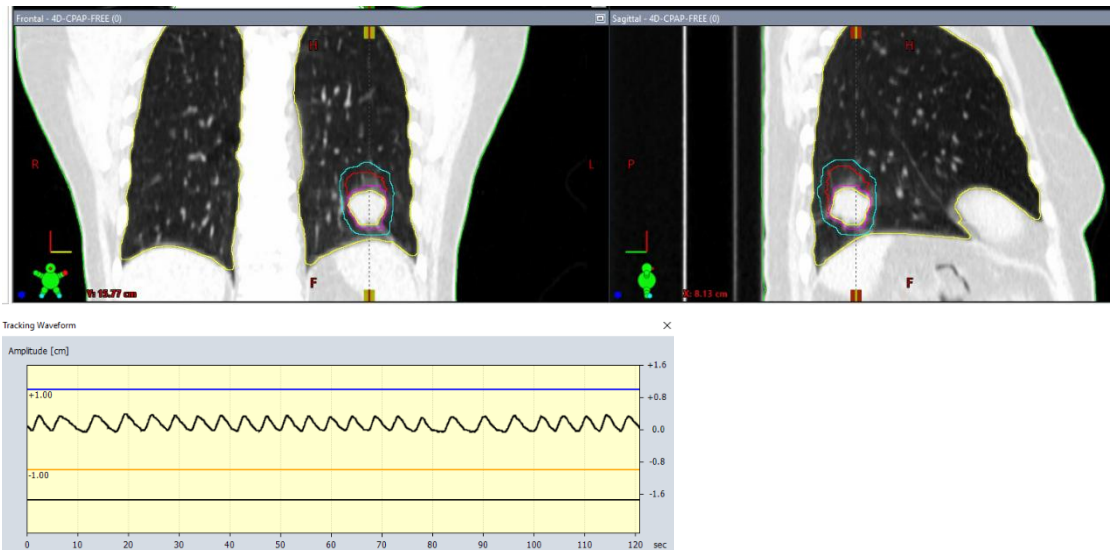


Figure 2a CPAP FB

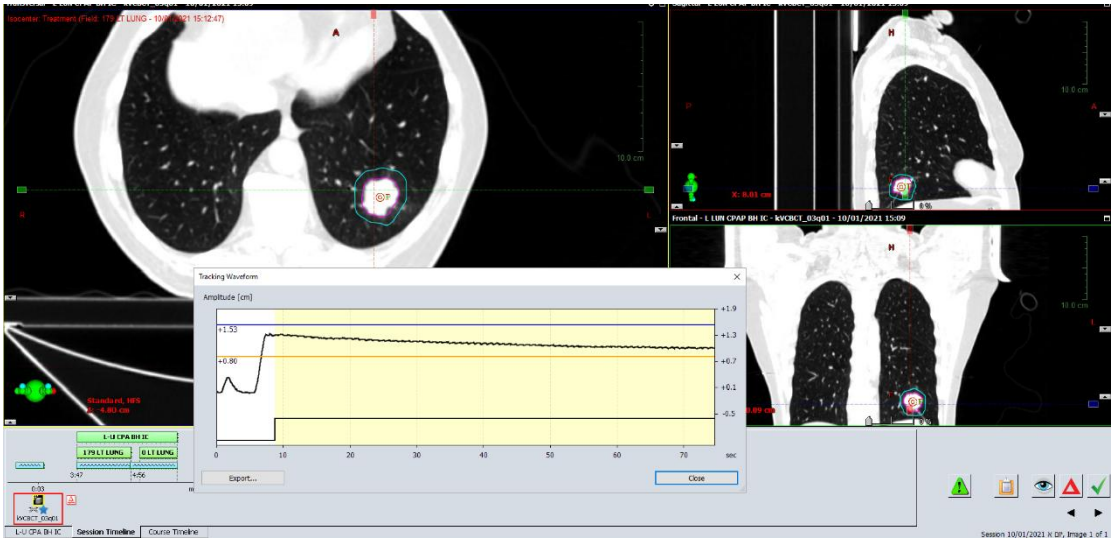


Figure 2b CPAP-DIBH