Training Lung Cancer Patients to Tolerate Mechanical Ventilation for Breathing Regularisation and Extended Breath-Hold

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Introduction

Respiratory motion remains a major challenge in lung radiotherapy, particularly for stereotactic treatments delivered using systems such as CyberKnife that rely on accurate motion modelling. In this work we show the feasibility of using mechanical ventilation via a facemask for extended periods of time for patients with lung, renal cell and oligometastatic cancers. Combined with 60% oxygen preoxygenation, and mechanical hyperventilation we can enable patients to achieve safe, prolonged breath-holds of up to 5 minutes (Parkes et al., 2016). In this work we consider the advantage of extended mechanical ventilation and prolonged breath-holds to improve tracking capabilities of mobile radiotherapy treatment targets during radiotherapy delivery.

Aim

A) To train patients to tolerate ventilator-controlled breathing and achieve regular, predictable respiratory patterns for prolonged treatment periods.

B) To train patients to tolerate ventilator-induced hyperventilation with 60% oxygen to enable deep inspiration followed by extended breath-hold (up to five minutes) sufficient to deliver a radiotherapy treatment field.

C) To quantify differences in potential radiotherapy tracking image exposures using sham procedures, comparing ventilator-assisted breathing and breath-hold with spontaneous breathing.

Materials and Methods

22 patients undergoing SABR were prospectively recruited. Following consent and eligibility screening, patients attended RTT-led training sessions (typically 3–4 visits; maximum 2.5 hours per visit).

Training established comfortable ventilator-controlled breathing (up to one hour), individualised ventilation parameters (inflation pressures ≤40 cmH_2O; tidal volumes ≤3.0 L), and controlled hyperventilation (target end-tidal CO_2 ≥2.6 kPa) using 60% oxygen. Continuous physiological monitoring with predefined safety stopping criteria was undertaken throughout.

A paired within-patient design was used. Chest surface motion was quantified using CyberKnife optical tracking, and in selected patients internal organ motion was assessed using X-ray tumour tracking during spontaneous breathing, ventilator-controlled breathing, and prolonged breath-hold.

Results

We have been able to demonstrate that lung cancer patients are able to be trained with mechanical ventilation by RTTs, and are able to maintain prolonged breath holds. We have translated this to the clinical setting for 5 patients, who were mechanically ventilated during their CyberKnife radiotherapy treatment with dynamic tracking of the tumour position. 1 patient was able to achieve a significant breath hold on-set. We shall show that mechanical ventilation improves motion management tracking, and breath-hold improved the clarity of x-ray images used for tracking.

Conclusion

Mechanical ventilation–assisted respiratory management is feasible, safe, and deliverable within a SABR pathway, offering improvements in respiratory stability, and a more predictable motion that can be tracked with motion management techniques.

References

Parkes, M.J., Green, S., Stevens, A.M., Parveen, S., Stephens, R. and Clutton-Brock, T.H., 2016. Safely prolonging single breath-holds to >5 min in patients with cancer: feasibility and applications for radiotherapy. British Journal of Radiology, 89(1063), 20160194.