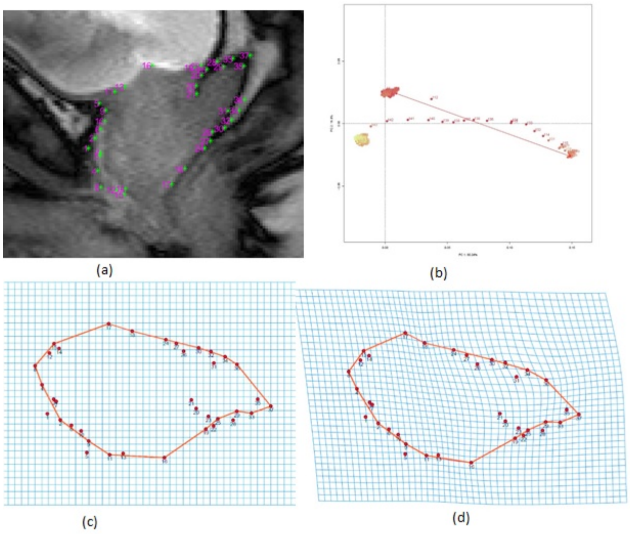


Figure 1. Patient example (a) Extracted landmarks (b) First two principal components of shape changes. The vector indicates changes between the initial landmark configuration and the configuration with the largest Procrustes distance from the mean shape. (c) Initial landmark configuration (d) Transformation grid produced by thin-plate spline between initial and landmark configuration with maximum Procrustes distance from mean shape.

**PO-1723 A first-in-human prospective study on respiratory gating with mechanical ventilation for lung SABR**

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**Purpose or Objective**

Gated irradiation during limited time windows for lung SABR allows the use of small safety margins. This strategy therefore requires high in-treatment tumor repositioning accuracy. This could be achieved by sophisticated on-board imaging technology (fluoroscopy, MRI) providing real-time information on patient's internal anatomy. However, conventional linear accelerators are not equipped with such devices. Moreover, patients referred for this indication often suffer from co-morbidities that challenge the feasibility of repeated and prolonged apneas. Mechanically-assisted and non-invasive ventilation (MANIV) has the potential to reduce the patient's work of breathing while ensuring excellent positional breath-holds reproducibility. We present here the first patient successfully treated with this technique as part of a prospective trial.

**Materials and Methods**

A 66-year-old patient was diagnosed with stage I lung carcinoma for whom an indication of stereotactic radiotherapy (5 x 11 Gy) was retained. A gold fiducial was implanted in close vicinity to the tumor. Seven days later and after one hour of coaching, the 3D planning CT was acquired during a mechanically-induced apnea. A back-up 4D CT was also performed. The clinical PTV was generated by a 7 mm isotropic dilation of the GTV. The treatment workflow is illustrated in Figure.1: once positioned on the couch, the patient is connected to the mechanical ventilator which produces perpetual cycles of exhalations and 30 seconds apneas by alternating two pressure levels with oxygen-enriched air ($FiO_2$ = 60%). Using surface imaging, the beam was automatically interrupted when the monitored surface was out of tolerances. The 3D residual fiducial motion during irradiation was reconstructed off-line with a 2D-3D inference model based on intra-fraction CBCT frames. The delivered dose to the GTV was then recomputed based on the tumor trajectory and imaging logfiles for different PTV sizes.

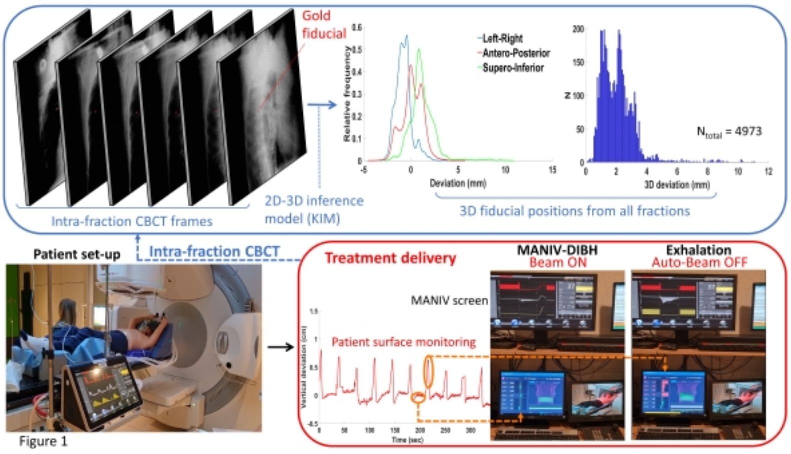
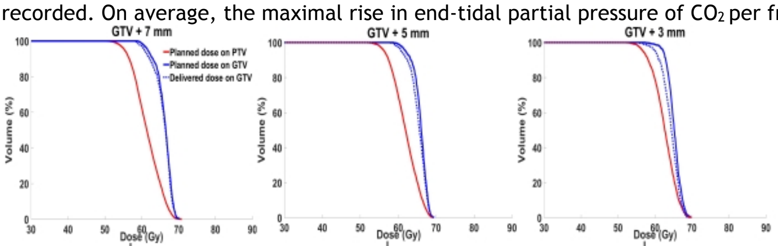



Figure 1

**Results**

PTV volumes generated by an isotropic GTV extension of 3 mm, 5 mm and 7 mm were 5.4 cc, 9.8 cc and 16.0 cc, respectively while $PTV_{ITV}$ volume was 17.9 cc. For all fractions, 98.2% of the 3D fiducials deviations during breath-holds were below 5 mm. As shown in Figure.2, this results in high GTV dosimetric coverage for PTV of 7 and 5 mm. The total slot time was on average 45.2 minutes [43.3 - 50.7] while the mean irradiation time was 15.6 minutes [13.5 - 19.5]. The mean ventilation comfort score assessed on a visual analogue scale was 79.8% [70.3 - 87.9]. No abnormal vital parameters values were recorded. On average, the maximal rise in end-tidal partial pressure of $CO_2$ per fraction was 18.8 mmHg [17.5-20.5].




GTV + 7 mm

| GTV | Planned dose (Gy) | Delivered dose (Gy) | Δ |
|---|---|---|---|
| $D_{mean}$ | 66.10 | 65.81 | - 0.44 % |
| $D_{99\%}$ | 59.81 | 58.87 | - 1.57 % |
| $D_{95\%}$ | 61.58 | 60.67 | - 1.48 % |
| $D_{2\%}$ | 69.24 | 69.27 | + 0.04 % |
| $D_{max}$ | 69.49 | 69.39 | - 0.14 % |

GTV + 5 mm

| GTV | Planned dose (Gy) | Delivered dose (Gy) | Δ |
|---|---|---|---|
| $D_{mean}$ | 65.82 | 65.30 | - 0.79 % |
| $D_{99\%}$ | 60.05 | 58.59 | - 2.43 % |
| $D_{95\%}$ | 62.01 | 60.83 | - 1.90 % |
| $D_{2\%}$ | 68.53 | 68.52 | - 0.01 % |
| $D_{max}$ | 69.25 | 69.41 | + 0.23 % |

GTV + 3 mm

| GTV | Planned dose (Gy) | Delivered dose (Gy) | Δ |
|---|---|---|---|
| $D_{mean}$ | 65.17 | 64.21 | - 1.47 % |
| $D_{99\%}$ | 59.82 | 56.96 | - 4.78 % |
| $D_{95\%}$ | 62.23 | 60.15 | - 3.34 % |
| $D_{2\%}$ | 68.66 | 68.13 | - 0.77 % |
| $D_{max}$ | 69.75 | 68.88 | - 0.23 % |

Figure 2

**Conclusion**

Mechanical ventilation appears to be a promising motion management technique allowing to perform accurate, safe and well-tolerated gated stereotactic radiotherapy in the environment of a conventional linear accelerator. More inclusions are needed to confirm the feasibility and to recalculate dedicated safety margins according to residual motion.

## Poster (digital): Optimisation and algorithms for ion beam treatment planning

### PO-1724 Dose-averaged LET may not be the best RBE-descriptor for proton therapy

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**Purpose or Objective**

A clinical relative biological effectiveness (RBE) of 1.1 has been broadly used for proton therapy. Variable RBE models have however been proposed due to strong *in vitro* evidence and as unexpected toxicities have been observed by the end of the proton tracks. The input variable for these models has typically been dose averaged linear energy transfer (LETd), but the way the LETd was defined or calculated is usually not consistent, which may impact the corresponding RBE value. Some other quantities have, however, been suggested to better predict RBE using arguments from track structure theory. This study investigates these alternative quantities as input variables for a phenomenological RBE model and compares them with LETd with respect to their suitability as RBE predictors for proton radiotherapy.