Mechanically-Assisted and Non-Invasive Ventilation can improve the motion management strategies while treating thoracic or upper abdominal tumours with protontherapy

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Objectives: Protontherapy of mobile tumours faces many uncertainties given their breathing-related motion, but also the proton range variations within the crossed tissues and the interplay effect that can unpredictively distort the dose distribution. Mechanically-assisted non-invasive ventilation (MANIV) could stabilize breathing with the volume-controlled (VC) mode, reduce amplitude with the shallow-controlled mode (SH) or prolong breath-hold with the slow-controlled mode (SL). Patient's tolerance and tumour motion reproducibility were evaluated in this trial.
Material and methods: In lung, liver and breast cancer patients, the tumour motion was assessed with MANIV and compared to spontaneous breathing (SP)(Figure1).
All the patients underwent 2 dynamic MRI sessions with each breathing mode. Tolerance was assessed through oxymetric analyses and questionnaires. The tumour/nipple motion was tracked and analysed within each MRI and between MRI (intra- and inter-session reproducibility).
Results*:* Twenty patients (49-83 years old) were included (Table 1). They all tolerated MANIV very well. The breath rate (BR) was always more stable in VC/SH than in SP. With SH, the motion amplitude was reduced of 0.6mm to 9mm proportionally to the BR increase (1.5 to 3.4-fold increase). With SL, the breath-holds were as stable as in SP in terms of range within a same plateau (0.9mm) or position between plateaus (0.2mm). Breath-holds in SL lasted on average 16,7sec.
Conclusion: MANIV and its different ventilation modes offers exciting perspectives for motion management in protontherapy. MANIV may thus be proposed in clinical practice for different dedicated applications (reduced margins with SH, breath-hold with SL, gating with VC or SL).

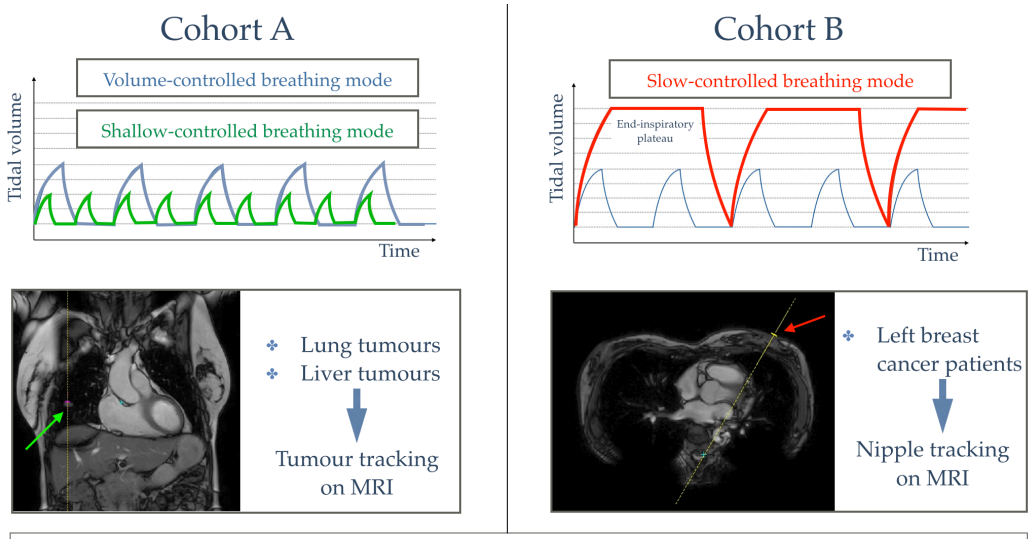

Figure 1: **Cohort A** included lung and liver cancer patients to track tumours on dynamic MRI during Mechanically-Assisted and Non-Invasive Ventilation (green arrow). Tumour motion was first assessed with the Volume-controlled mode that regularises the breathing motion by constraining the tidal volume and the breathing rate in physiologic conditions. Then the tumour motion was evaluated with the Shallow-controlled mode that increases the breathing rate in order to reduce the breathing amplitude and thus the tumour motion amplitude. These 2 modes were compared to spontaneous breathing. **Cohort B** included left breast cancer patients. The nipple was tracked on dynamic MRI images (red arrow). Repeated end-inspiratory breath-holds were obtained with the Slow-controlled mode and compared to spontaneous breath-holds.

	Cohort A	Cohort B
Total (n)	10	10
Region of interest (n)	Lung tumour (5) Liver tumour (5)	Left breast nipple (10)
Sex ration (M/F)	8/2	0/10
Age (years)		
Median	66	58
Min - max	61 – 83	49 – 77
BMI (kg/m2)		
< 18	0	0
18-25	3	6
25,1 - 30	4	3
> 30	3	1
Tobacco use (n)		
no	7	8
former	3	1
active	0	1
COPD (n) (GOLD stage)	1 (GOLD II)	0
OAS With CPAP (n)	1	2
Performance status (n)		
ECOG 0	5	9
ECOG 1	4	1
ECOG ≥ 2	1	0
Previous chemotherapy (n)	4	3

Table 1: Demographic data of Cohort A and Cohort B
(M = male; F = female; BMI = Body Mass Index; COPD = Chronic Obstructive Pulmonary Disease; OAS = Obstructive Sleep Apnea Syndrome; CPAP = Continuous Positive Airway Pressure device)