

BENEFITS ASSESSMENT OF HYPNOSIS IN REDUCING 4D-CT SCAN ARTIFACTS: PRELIMINARY RESULTS FROM THE HYPNO-4D TRIAL

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Prospective clinical trial: workflow

25 patients in total, 8 included so far

+ feedback survey

4D-CT scan

Treatment delivery

First treatment session

- Standard protocol: 4D-CT & treatment in **free-breathing (FB)**
- Hypno-4D trial: addition of a 4D-CT scan under **hypnosis**

4D-CT FB 1



exploitable



artifacts +++

4D-CT FB 2

5min hypnosis induction

4D-CT H1

Manual Export:
Average
+ 10 phases

Automatic export:
FB images for
treatment
planning

MIM

ARTPLAN

- Standard protocol in **FB**



- After treatment, second 4D-CT scan under hypnosis → **reproducibility assessment**

5min hypnosis induction

4D-CT H2

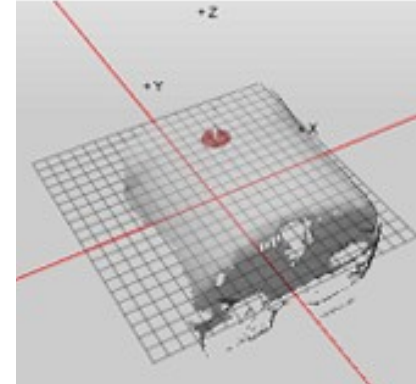
MIM

For each acquisition, **4D-CT scan parameters are adapted to the patient's respiratory parameters**

Materials and methods

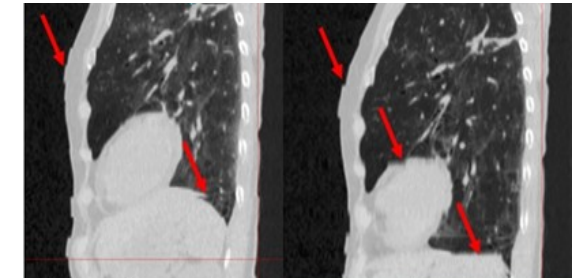
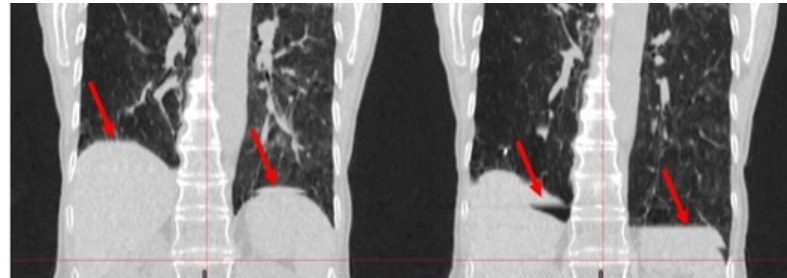
Breathing signals analysis → Python analysis

- *Raw data extracted from Sentinel (CRad)*



Artifacts analysis → visual assessment according to Yamamoto et al. (2008)

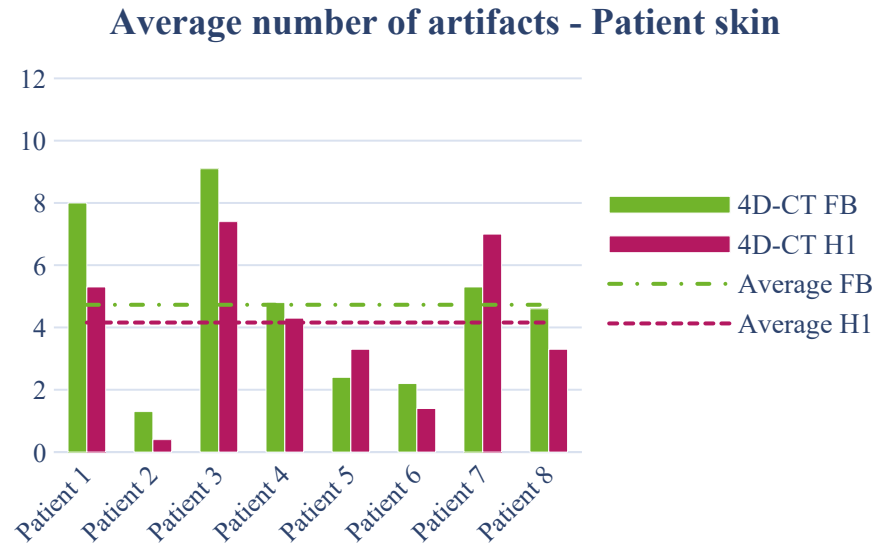
- *Patient skin on sagittal views and diaphragm on coronal views*
- *Tumor on all 3 views*



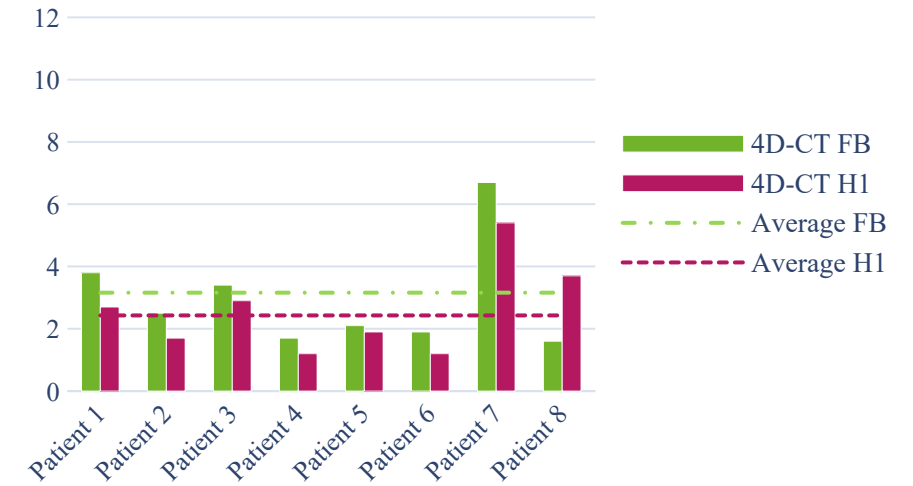
Artifacts analysis → automatic detection algorithm by Bouilhol et al. (2014)

Results: visual assessment

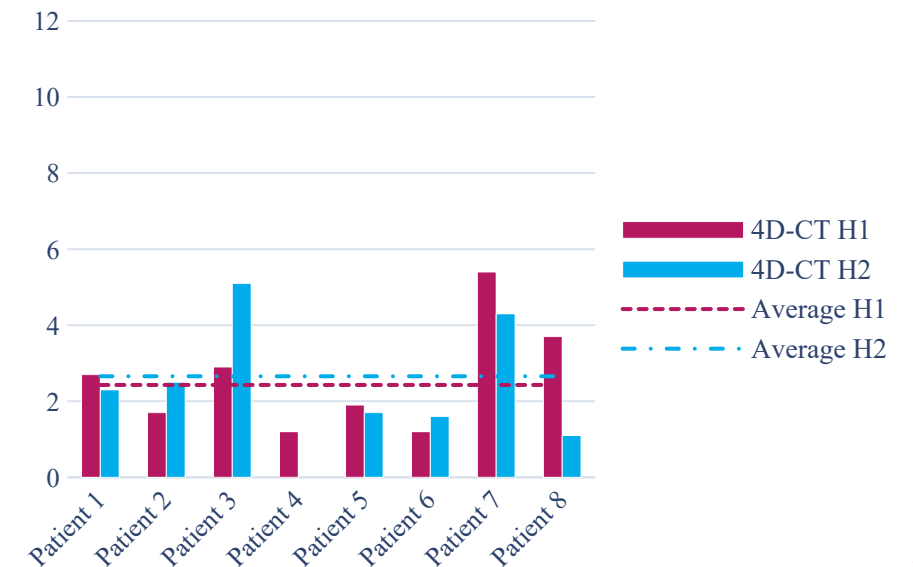
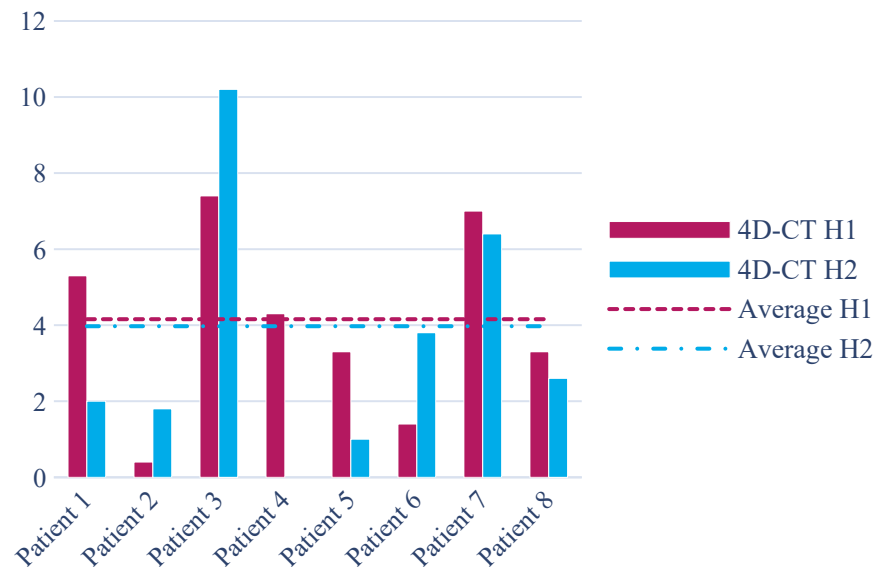
Free-breathing VS Hypnosis 1
(4D-CT scans were performed on the same day)



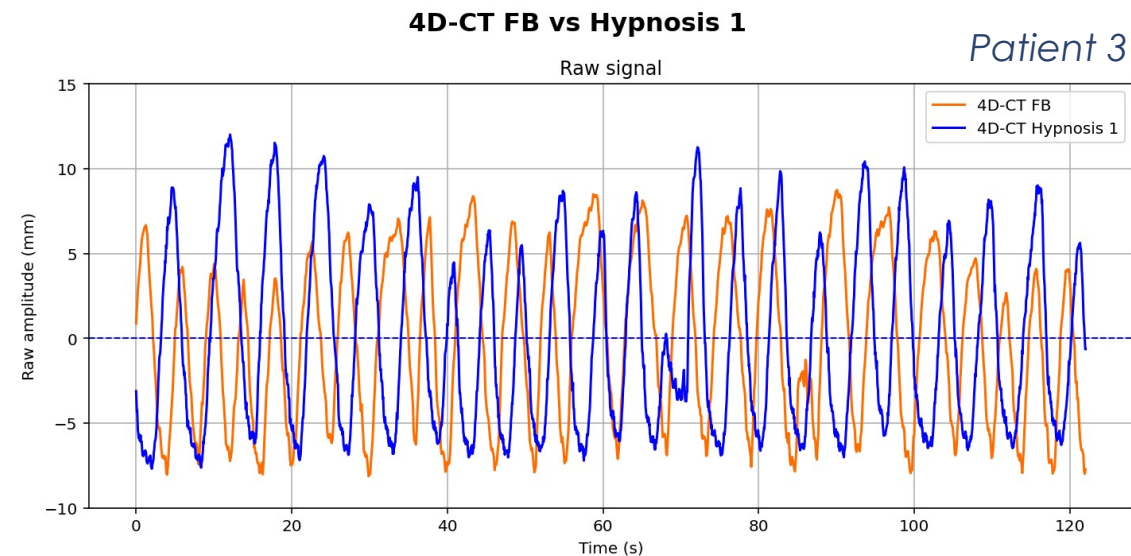
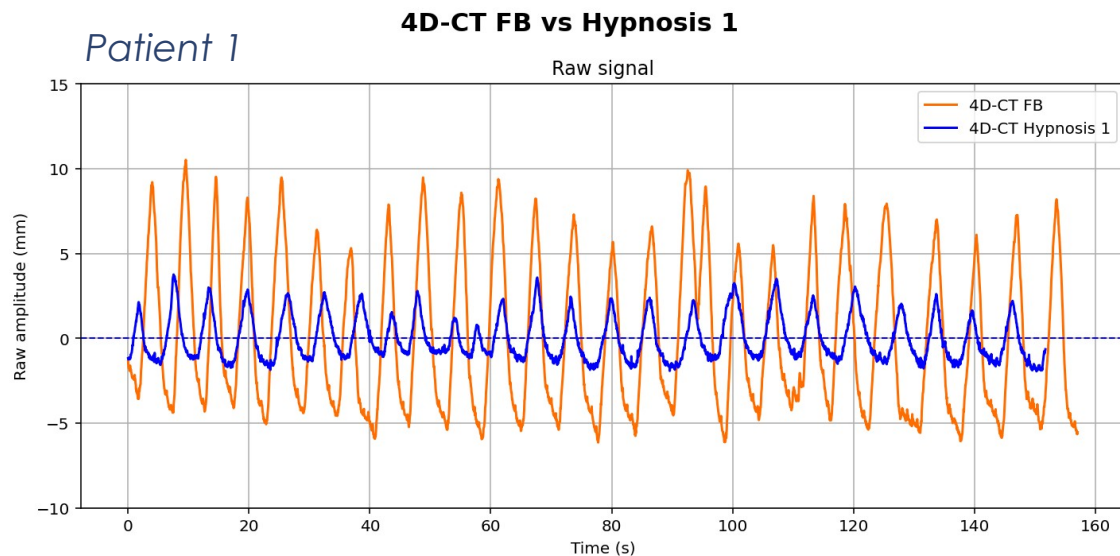
Average number of artifacts - Diaphragm



Hypnosis 1 (ref) VS Hypnosis 2
(H2 4D-CT scan was performed on a different day)



$$y(t) = y_{raw}(t) - y_{mean}(t)$$



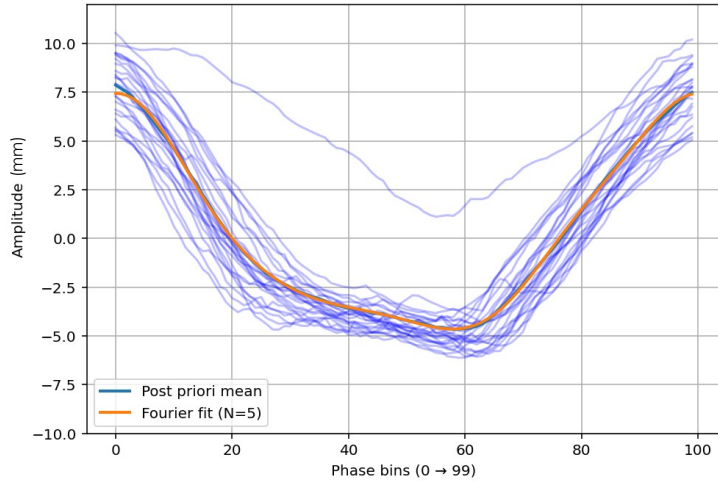
For 8 patients	FB	H1	H2
Mean amplitude (mm)	9,7 SD = 4,1	7,6 SD = 4,9	8,1 SD = 4,0
Mean frequency (bpm)	13,0 SD = 5,4	15,5 SD = 4,8	16,8 SD = 5,0

Results

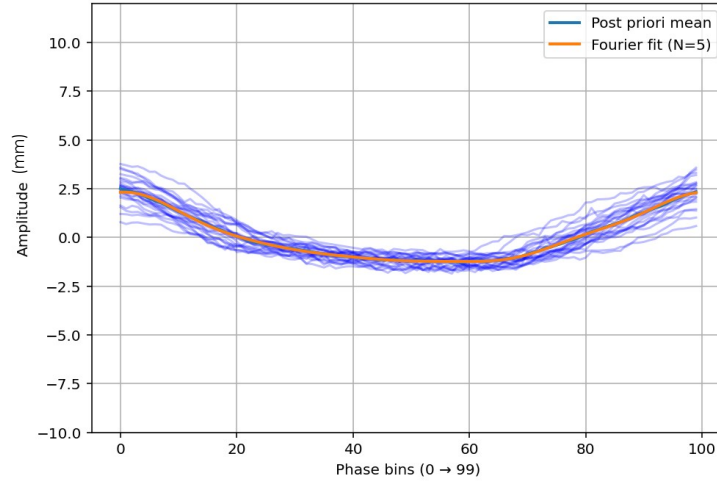
$$RMSE = \sqrt{\frac{1}{N} \sum_{k=1}^{N_c} \sum_{I=1}^{N_\phi} (z_k(\phi_i) - y_{fit}(\phi_i))^2}$$

Patient 1

Phase-normalized cycles (100 bins) - 4D - CTFB

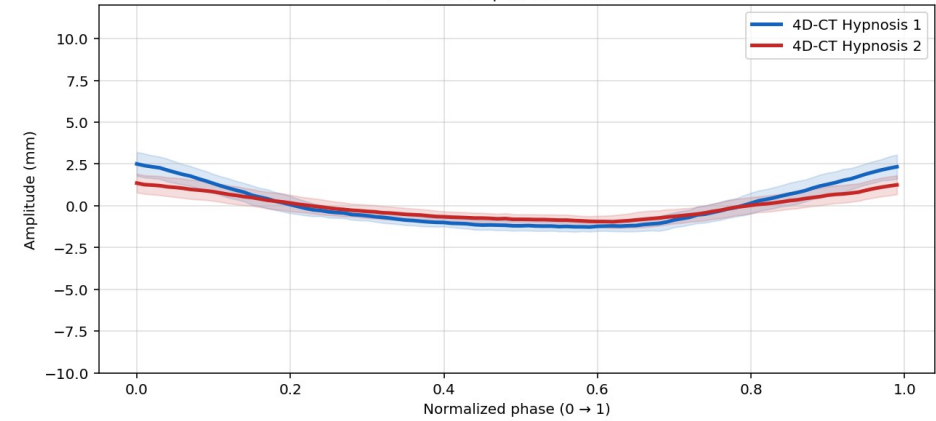


Phase-normalized cycles (100 bins) - 4D - CTHypnosis1



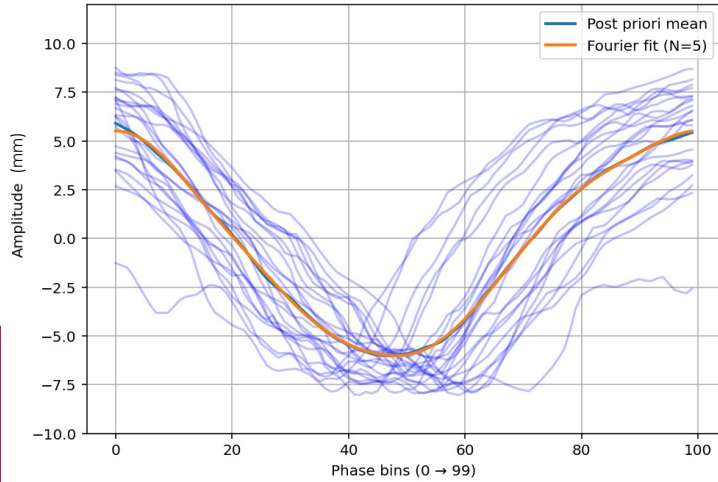
Hypnosis 1 vs Hypnosis 2

Average cycle
 $r = 0.9910$ | $RMSD = 0.5018$

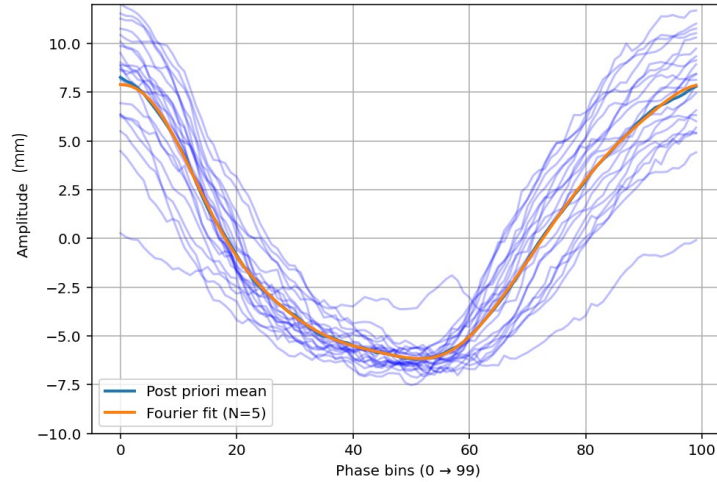


Patient 3

Phase-normalized cycles (100 bins) - 4D - CTFB

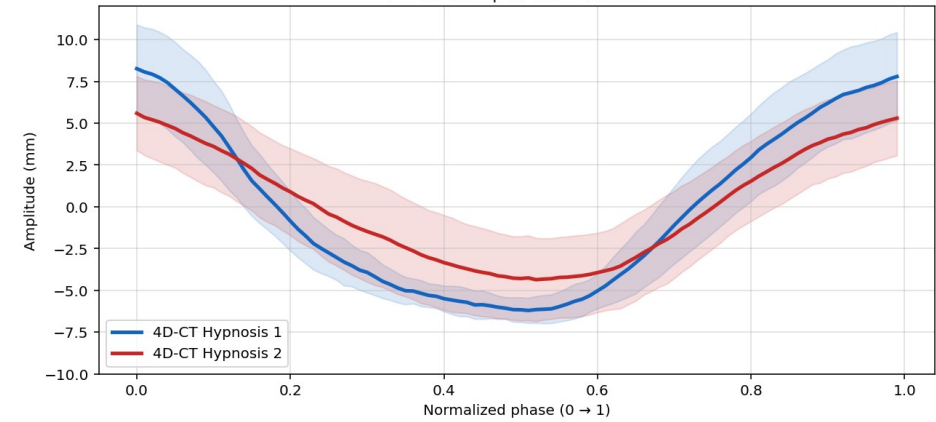


Phase-normalized cycles (100 bins) - 4D - CTHypnosis1



Hypnosis 1 vs Hypnosis 2

Average cycle
 $r = 0.9758$ | $RMSD = 1.8603$



Encouraging trends in our results

- *Amplitude is reduced with hypnosis for 6 of 8 patients*
- *Frequency is increased with hypnosis for 5 of 8 patients*

Artifacts analysis → sensitivity adjustment ongoing for the automatic detection algorithm

With a complete cohort of 25 patients → statistical analysis