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How to stop a tumor that moves with respiration ?

Percussion Assisted Radiotherapy (P.A.R.T.)

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Genève

4D Wokshop, Delft, Nov 2021

Percussion Assisted RT

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1/ Introduction of PART

2/ Adaptations and applications in Lausanne (CHUV)

First in man experience

- For Radiation therapy
  - Conventional RT
  - Stereotactic RT
  - Proton therapy
- For Imaging
  - Nuclear medicine (PET/CT)
  - Radiology (Chest MRI)

3/ Perspectives

No conflict of interest

Only the one of my patients!

1/ Intro of PART

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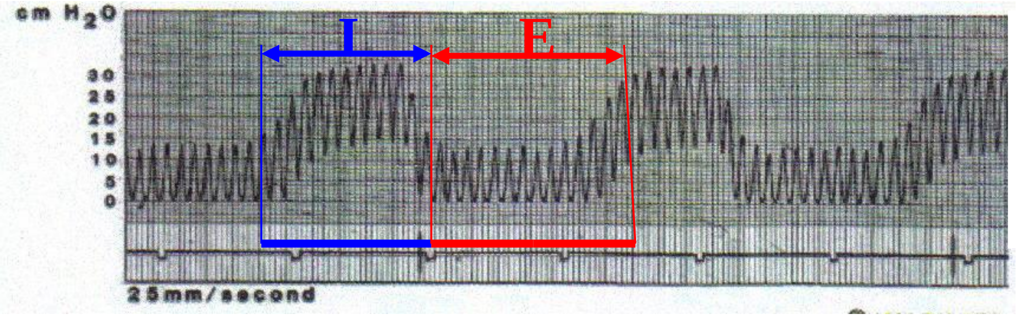
Use of high Frequency Percussive Ventilation (HFPV)

1/ Inventor

Forrest BIRD – (1921- 2015) - Massachusetts USA
Pilote – Engineer – Medical Doctor - Inventor

2/ Principle of HFPV® :



Curves P/T under HFPV

I Inspiratory
E Expiratory

3/ Indications of HFPV

Ventilation and oxygenation / lung recruitment / Mobilization of secretions

Already in use in all your hospitals for obstructive or restrictive disease !!!!

2/ Adaptations and Applications

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2.1/ Adaptations (CHUV Lausanne)

First step: Adaptation of the existing device to minimize breathing movements

Second step: Adaptation of the device for MRI use

2.2/ Experimental applications

- **Explore 2 parameters using 10 volonteers**

  Chest stabilization feasability
  - Reduction of 2/3 of Chest Amplitude
  - for at least 3 min 30sec

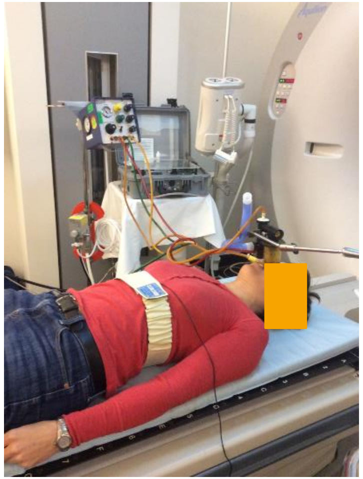
  Reproductibility

  2 series of 3 consecutive tests for each volonteer

  60 tests performed in total

- **Describe**

  Different times registered and clinical parameters (PtcCo2, SatO2, Heart Rate, tolerance)



A reminder

Physiological Apnea << 1min

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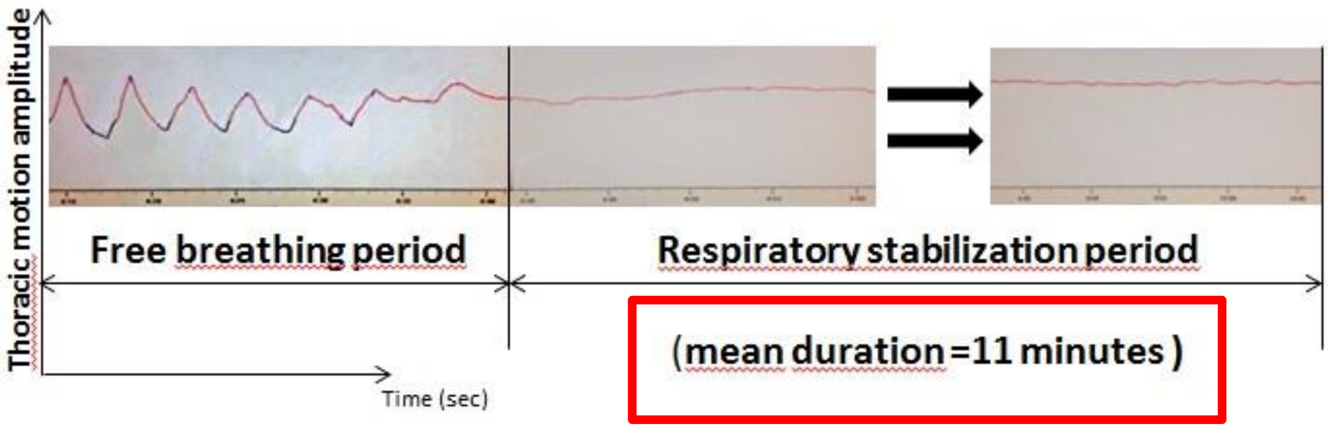

11 times normal performances of chest stabilization

Success rate 93% for volonteers

2.3/ Clinical application

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1/ For Radiotherapy

- After ethical approval, a pilot clinical study to evaluate tolerance and feasability .
- RT: 4 clinical situations (700 measurments studied)
  - Breast cancer (3DRT – 25 fx)
  - Early lung cancer (SBRT – 8 fx)
  - Locally advanced lung cancer (VMAT – 17fx)
  - Palliative pleural metastases

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Contents lists available at ScienceDirect
Radiotherapy and Oncology
journal homepage: www.thegreenjournal.com

First in man

Apnea-like suppression of respiratory motion: First evaluation in radiotherapy

CrossMark

Nicolas Péguret [a,1], Mahmut Ozsahin [a,1], Michele Zeverino [c], Bastien Belmondo [b], André-Dante Durham [a], Alban Lovis [d], Julien Simons [b], Olivier Long [b], Fréderic Duclos [a], John Prior [e], Alban Denys [e], Catherine Beigelman [e], Wendy Jeanneret Sozzi [a], Kathleen Grant [b], Véronique Gautier-Dechaud [f], Solange Peters [a], Monique Vienne [f], Raphael Moeckli [c], Jean Bourhis [a,*]

February 2016

- **PART offered favorable dosimetric profiles in 3 out of 4 patients**

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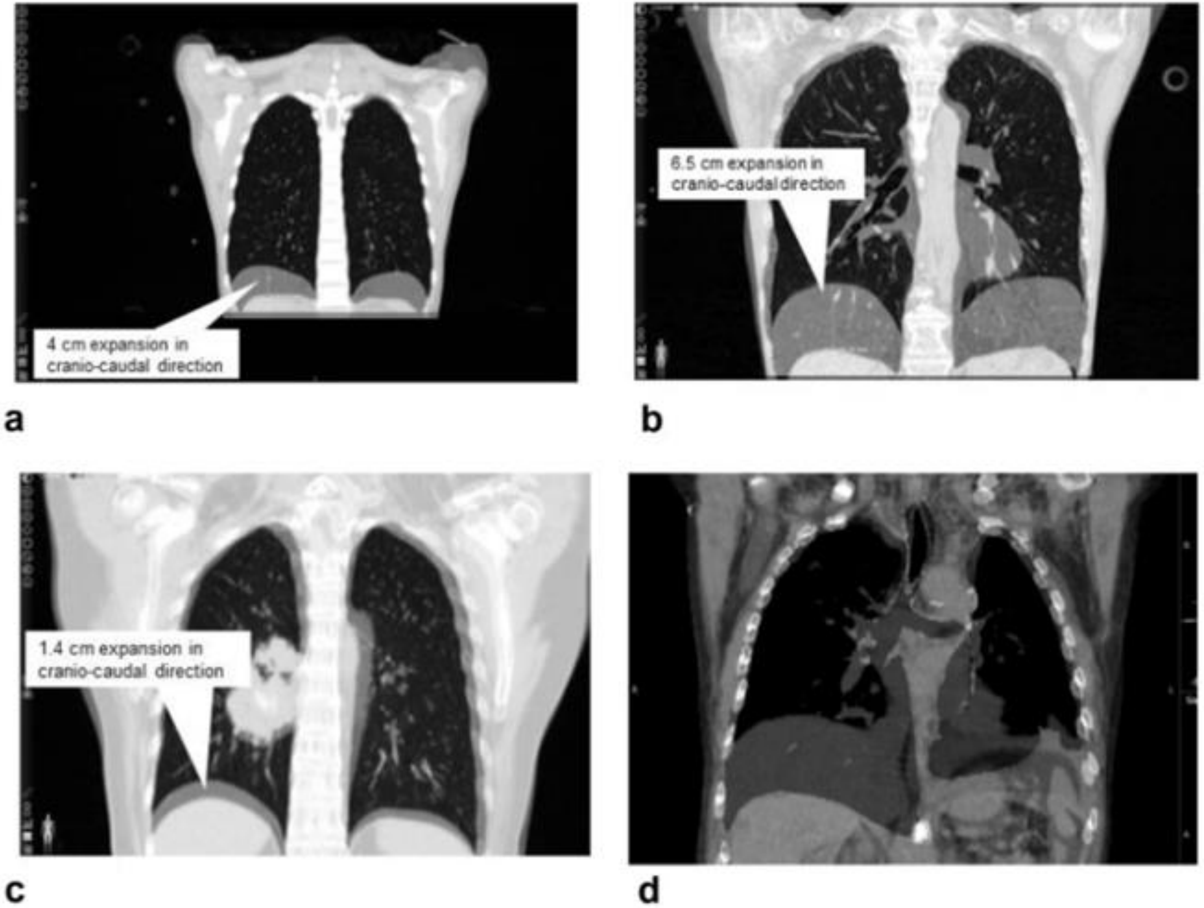

a, b, c/ 3 patients with dosimetric gain due to lung expansion

d/ 1 patient without gain due to a unilateral lung expansion only

Comparison of chest inflation in maximal inspiration and in PART conditions

Mean duration of chest stabilization during 50 RT fractions 7.61 min

	Duration (min:sec)	
	Mean (SD)	Median (range)
Breast 3D RT (patient No. 1)		
BhD for "beam on"	5:41 (0:51)	5:48 (3:07–7:11)
Lung SBRT (patient No. 2)		
BhD for CBCT No. 1 and 2	4:56 (1:04)	5:48 (3:1–7:38)
BhD for "beam on" +CBCT No. 3	10:00 (0:43)	9:58 (8:33–12:41)
Locally advanced NSCLC (patient No. 3)		
BhD for "beam on" +CBCT	9:21 (0:39)	9:08 (8:10–11:35)

1.1/ 1st clinical application: left side breast cancer 34yo

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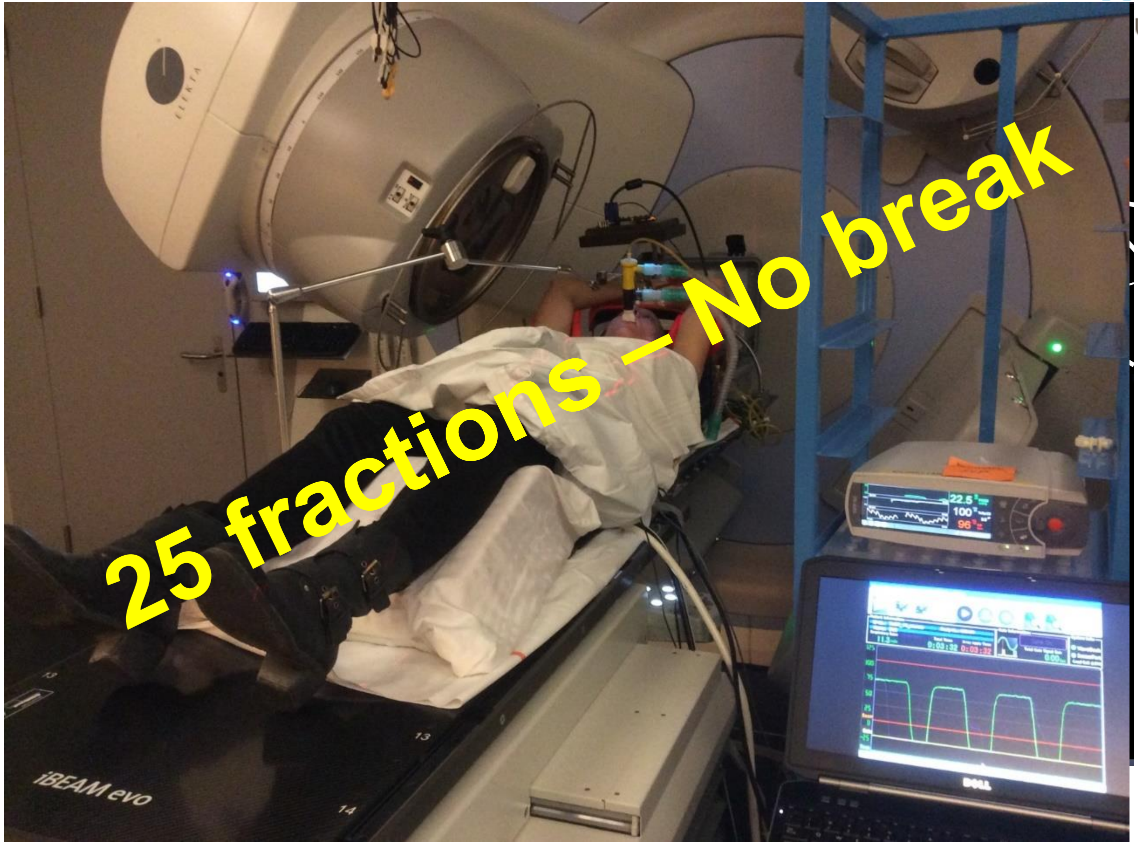

Visualisation of breathing status

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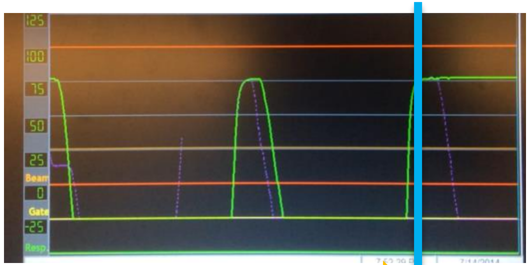
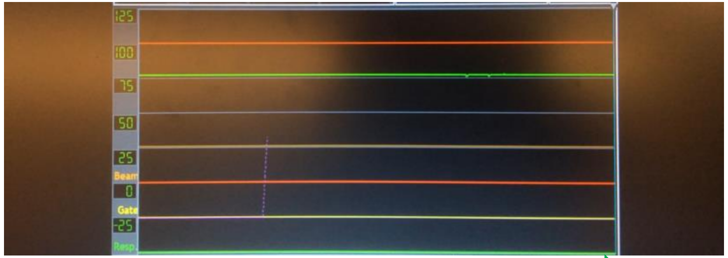
Patient view





Preparation in free breathing (FB)

Stabilisation phase in maximal inspiration (start)

RTT view
(video screen)

Stabilisation phase (end)

Uninstall and recovery phase in FB

1.2/ 2nd clinical application: lung SBRT

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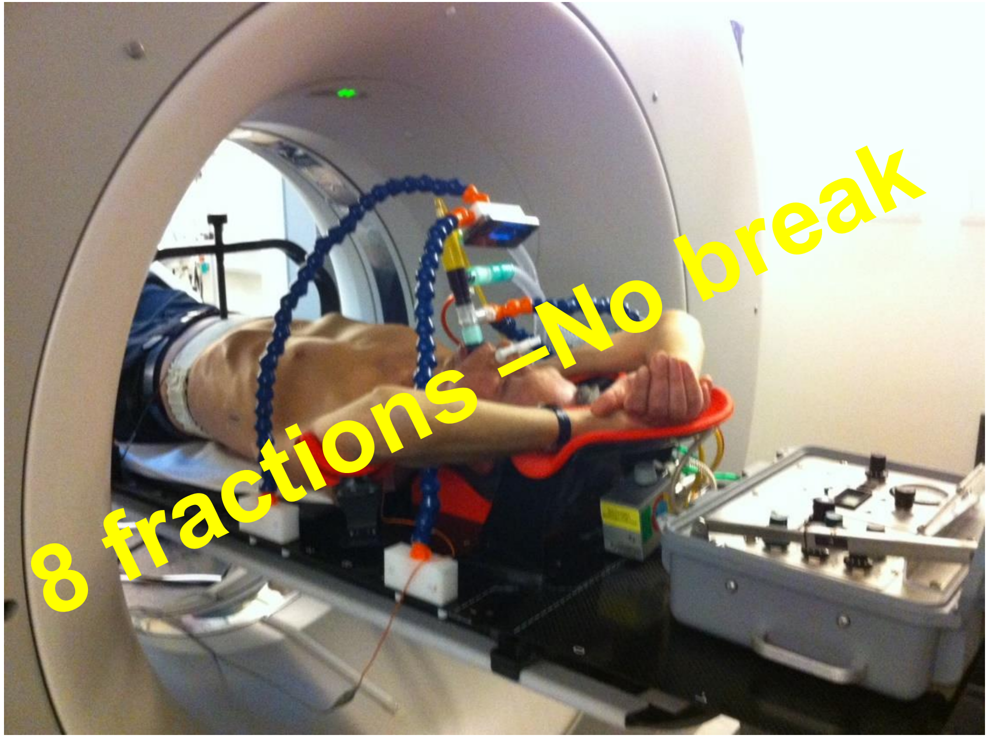

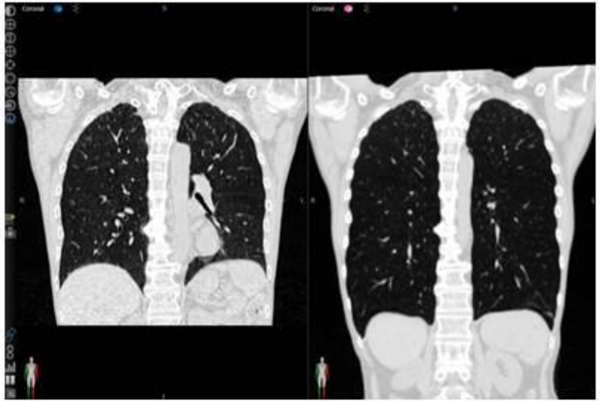

Fig a. Simulation CT in maximal inspiration (left) and in PART position (right)

		FB	MI	PART
Lungs	V20	5.64 %	5.52 %	3.77 %
	Mean dose	4.3 Gy	4.25 Gy	3.35 Gy
	mean dose CL lung	1.12 Gy	1.1 Gy	0.86 Gy
	Total Lungs volume	5602 cc	5702 cc	10468 cc
Spinal cord	Dmax	14.8 Gy	14.9Gy	10.3 Gy
Oesophagus	Dmax	14.1 Gy	14.1 Gy	11.3 Gy
Trachea or bronchus	Dmax	0.3 Gy	0.3 Gy	2.5 Gy
Heart	Dmax	29.6 Gy	30 Gy	27.6 Gy
	Mean dose	5.63 Gy	4.6 Gy	3.71 Gy
Chest Wall	PRV cote	37 cc	37 cc	40 cc

Dmax= maximal dose, CL= controlateral, FB= Free breathing by Midventilation
MI=Gating in maximal inspiration, PART= Gating in PART conditions

Fig b. Dosimetric parameters for different technics to deliver fractionated SBRT for a lung case

PART has a capacity to expand the lung and markedly reduce the lung tissue electron density as compared to MI

Using PART, the volume of healthy lung tissue included in high dose irradiated volume was halved

1.3/ 3rd clinical application: Locally adv. lung cancer

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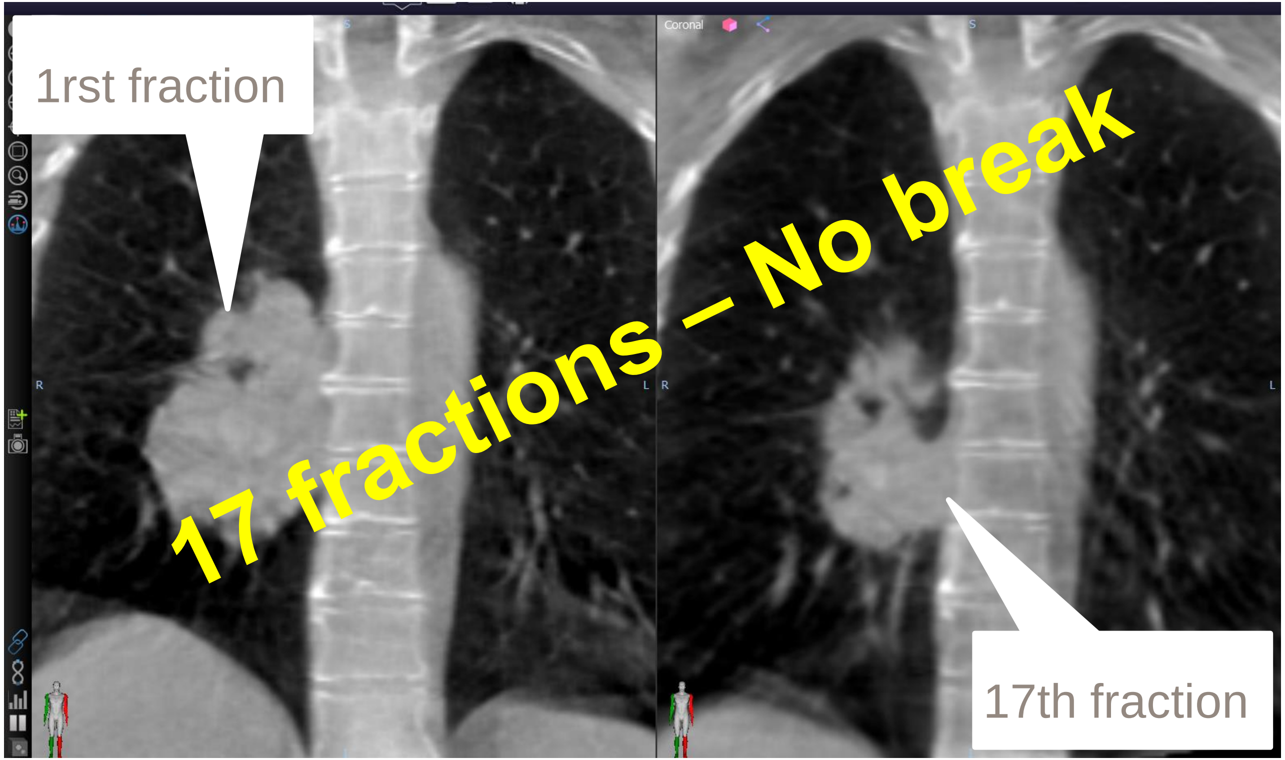

Radiation effect enhanced due to the use of O2 with PART
Needs to be confirmed by further studies

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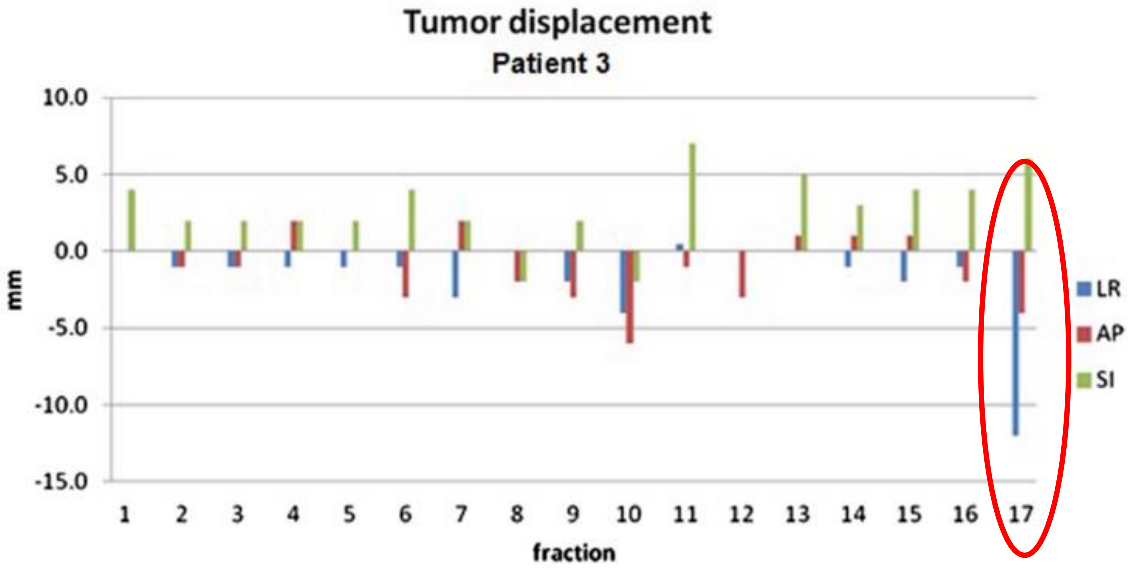

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1.4/ 4rd clinical application: Hodgkin disease

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Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original Article

Percussion assisted radiation therapy in Hodgkin lymphoma allows a marked reduction in heart dose

45 fractions – No break

Durham AD et al., Radiother Oncol, Nov 2020

3Gy reduction mean heart dose with PART
Needs to be confirmed by further studies

2/ For Imaging

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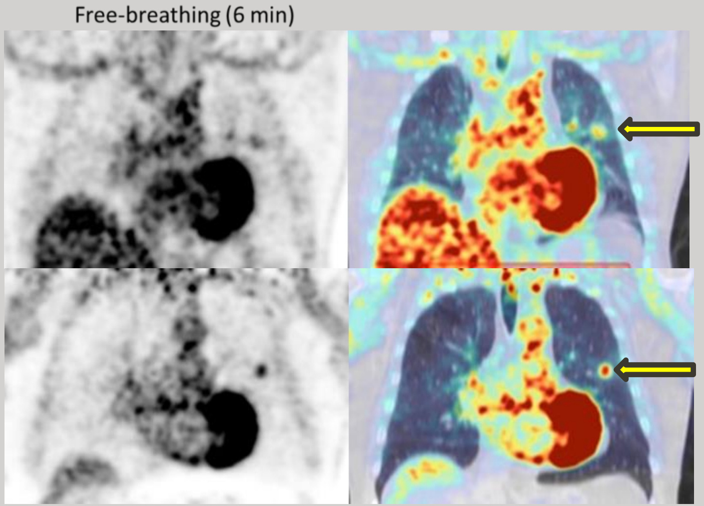
NUCLEAR MEDICINE: PET-CT under HFPV

- a/
- b/



- 4 PET/CT performed under HFPV,
- **11 minutes of chest stabilization necessary for PET**

PET/CT FDG for the same patient without HFPV (a) and with (b). SUVmax increases of **29% for PET** under HFPV (b) compared to PET without HFPV (a)

Reduction of Respiratory Motion during PET/CT by Pulsatile-Flow Ventilation (PFV-PET/CT): first clinical evaluation

J Prior*, N Peguret* et al. *co-authors. J Nucl Med. 2015 Dec 3.

RADIOLOGY: Thoracic MRI under HFPV

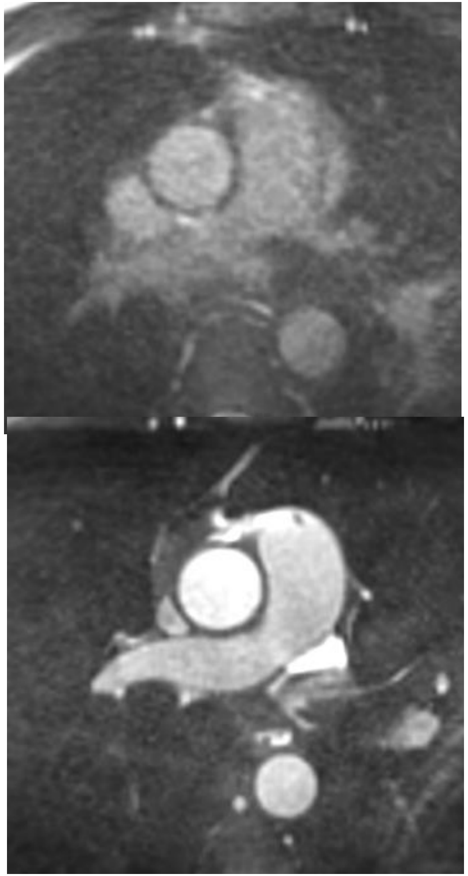
- 4 MRI performed under HFPV,
- **8 minutes of chest stabilization**

a/

b/

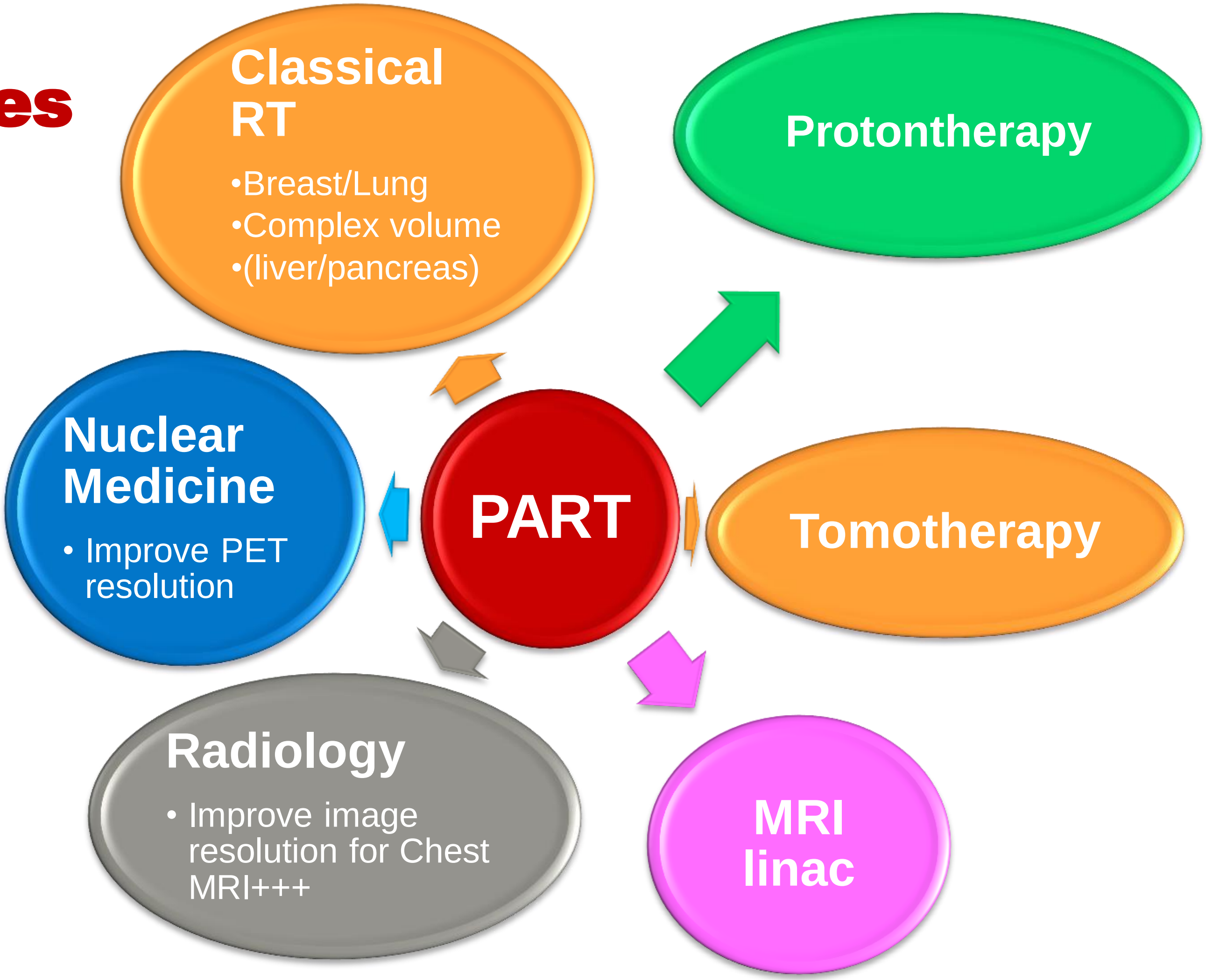
3D radial sequence sagittal reformat showing the Aorta without HFPV (a) and with (b). The cardiac structures and the contour of the aorta are much better in b) than in a). Images without contrast.

Beigelman-Aubry C., Peguret N. PlosOne 2017



High signal within blood pool without contrast
Sharp borders

3/ Perspectives



- **In total, PART is a promising technique**
  - ✓ **Feasible with high success rate**

    (77% for patients, 93% for volonteers after 175 tests performed)
  - ✓ **Well tolerated**
  - ✓ **Perspectives especially with new machines in RT and in the field of diagnosis**
- **More studies required to confirm its use in these different areas**

Thank you for your attention!
Let me take a breath to answer your questions!