

Cardiac radiation exposure associated with breast cancer radiotherapy: dose distribution to the heart substructures and coronary arteries (BACCARAT study)

Valentin Walker<sup>1</sup>, David Broggio<sup>2</sup>, Sylvie Derreumaux<sup>3</sup> Jérémy Camilleri<sup>4</sup>, Eric Bruguière<sup>5</sup>, Matthieu Lapeyre<sup>5</sup>, Olivier Fondard<sup>6</sup>, Olivier Lairez<sup>7</sup>, Marie-Odile Bernier<sup>1</sup>, Dominique Laurier<sup>8</sup>, Christian Chevelle<sup>4</sup>, Gaëlle Jimenez<sup>4</sup>, Jean Ferrières<sup>7,9</sup>, Sophie Jacob<sup>1</sup>

- 1. Institut de Radioprotection et de Sureté Nucléaire (IRSN), Laboratoire d'Epidémiologie, Fontenay-aux-Roses
- 2. IRSN, Laboratoire d'Evaluation de la Dose Interne, Fontenay-aux-Roses
- 3. IRSN, Unité d'Expertise en radioprotection Médicale, Fontenay-aux-Roses
- 4. Clinique Pasteur, Radiothérapie (Oncorad), Toulouse
- 5. Clinique Pasteur, Radiologie, Toulouse
- 6. Clinique Pasteur, Cardiologie générale et interventionnelle, Toulouse
- 7. CHU Rangueil, Cardiologie, Toulouse
- 8. IRSN, Service de recherche sur les effets biologiques et sanitaires des rayonnements ionisants, Fontenay-aux-Roses
- 9. INSERM, UMR1027, Toulouse

Funding Acknowledgements: Fédération Française de cardiologie, Electricité de France

## **Disclosure Statement of Financial Interest**

Author's name : Valentin Walker, IRSN - Fontenay-Aux-Roses Valentin.walker@irsn.fr

✓ Je n'ai pas de lien d'intérêt potentiel à déclarer

JOURNÉES E UROPÉENNES de la SOCIÉTÉ F RANÇAISE de CARDIOLOGIE 29th E UROPEAN D'AYS of the F RENCH SOCIETY of CARDIOLOGY



Cardiac radiation exposure associated with breast cancer radiotherapy: dose distribution to the heart substructures and coronary arteries (BACCARAT study)

## Background

- Radiation therapy (RT) is a major component of breast cancer treatment. Breast RT used until the 1990s was associated with long term cardiac complications due to cardiac tissues in the irradiation fields.
- Since the 2000s, three-dimensional imaging methods and advanced RT techniques (3D-CRT) allowed reducing the irradiation of healthy tissue. However, the heart often remains partially exposed, mainly depending on tumor laterality and individual anatomy.
- Intra-individual heterogeneity of cardiac exposure is an issue and the *relationships between doses to* cardiac sub-structures, in particular coronary arteries, and subsequent toxicity were poorly studied.
- Detailed individual heart dosimetry information is required to better understand radiation-induced cardiac damage.

## **Methods**

- BACCARAT is a monocentric prospective cohort study that included left or right unilateral breast cancer
  patients treated with 3D-CRT betw een 2015 and 2017 and followed for 2 years with repeated cardiac
  imaging examinations. In
  particular, before RT, a coronary computed tomography angiography (CCTA)
  w as performed.
- CT images (slice 1.25 mm) used for RT treatment planning allow delineation of the hearth and surounding
  organs but the coronary arteries are not clearly visible. Registration of the planning CT and CCTA images
  allow ed delineation of the coronary arteries on the planning CT images.
- A descriptive analysis of the physical doses in Gray (Gy) was performed.
- Using the 3D dose matrix generated during treatment planning and the added coronary contours, dose distributions were generated for the following structures:



2905 JOURNÉES E UROPÉENNES de la SOCIÉTÉ F RANÇAISE de CARDIOLOGIE 2910 E UROPEAN D'AYS of the F RENCH SOCIETY of CARDIOLOGY

Whole Heart	Left Ventricle	Left Anterior Descending Artery
Left Circumflex Artery	Left Main Coronary Artery	Right Coronary Artery
	Conclusion	

Our study indicate that for precise radiotherapy-induced cardiotoxicity studies, it would be *necessary to assess the dose delivered to the whole hearth as well as to the cardiac substructures, in particular the LAD.* For our BACCARAT study, this accurate heart dosimetry should be fruitful in the analysis of precise myocardial dysfunction based on cardiac echography and for precise analysis of coronary artery segments based on CCTA.







To analyze the distribution of personalized individually-determined radiation dose to the heart and its sub-structures, in particular the coronary arteries, and evaluate whether the mean heart dose is a good or poor surrogate parameter for the dose to cardiac substructures, in particular the LAD (Jacob et al. Radiat Oncol. 2016).

## Results

Dose distributions were generated for **104 patients** (89 left-sided breast cancer, 15 right-sided) with a mean age of 58 years, who received a treatment of 50 Gy to the breast delivered in 25 fractions of 2 Gy or a treatment of 47 Gy delivered in 20 fractions of 2.35 Gy.

Hearth sti	ructure	Left-sided BC patients N = 89	Right-sided BC patients N = 15
Whole Heart	Mean Dose (Gy)	2.95 ± 1.49	0.46 ± 0.12
	Max Dose (Gy)	26.80 ± 17.40	2.16 ± 0.90
Left Ventricle	Mean Dose(Gy)	6.25 ± 3.53	0.09 ± 0.04
	Max Dose (Gy)	34.01 ± 16.93	0.34 ± 0.13
Left Anterior Descending Artery	Mean Dose(Gy)	15.68 ± 8.13	0.37 ± 0.15
	Max Dose (Gy)	37.97 ± 15.93	0.45 ± 0.17
Left Circumflex Artery	Mean Dose (Gy)	1.61 ± 0.83	0.14 ± 0.08
	Max Dose (Gy)	1.87 (median)	0.27 ± 0.13
Left Main Coronary Artery	Mean Dose (Gy)	1.28 ± 0.69	0.11 ± 0.05
	Max Dose (Gy)	1.39 (median)	0.25 ± 0.13
Right Coronary Artery	Mean Dose(Gy)	0.74 ± 0.53	1.25 ± 0.41
	Max Dose (Gy)	1.38 ± 1.04	1.77 ± 0.74