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Original research article

Dosimetry of the left anterior descending coronary artery in left breast cancer patients treated with postoperative external radiotherapy

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ABSTRACT

Aim: To evaluate the dose distribution to the left anterior descending (LAD) coronary artery in patients treated with postoperative three-dimensional conformal radiotherapy (3DCRT).
Background: Postoperative radiotherapy may increase the risk of heart disease, particularly in patients with left-sided breast cancer. Clinical data on doses to the LAD are limited.
Materials and methods: Retrospective study of 14 patients who underwent postoperative 3DCRT for left breast cancer in 2014. All data were retrieved from medical records. Means, medians, ranges, and percentages were calculated.
Results: The mean dose to the LAD in patients with V25 < 1% was 0.12 cGy. D_{mean}, D_{max} and V25 to the heart were, respectively, 3.7 Gy (range, 0.9–4.18), 40.3 Gy (9.28–62.9), and 1.59 cGy. The mean D_{mean} and D_{max} values in the sample were 9.71 Gy and 33.2 Gy, respectively. The maximum dose to the LAD (D2%) ranged from 3.66 to 53.01 Gy. Due to the spacing of the CT slices (5 mm), it was not possible to completely contour the entire artery. The mean dose to the heart (3.3 Gy) was considered acceptable.
Conclusions: The maximum dose to the LAD was as high as 53 Gy, suggesting an increased risk of cardiac morbidity. This study underscores the value of contouring the LAD and the value of the breath hold technique to reduce maximum cardiac doses. Smaller CT cuts (2.5 mm) can improve contouring. Larger studies with long-term follow up are needed to determine the radiation tolerance dose for the LAD.

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1. Background

The standard treatment for breast cancer is either breast-conserving surgery (BCS) or, in high-risk patients, mastectomy. In both cases, surgery is typically followed by adjuvant whole breast radiotherapy (WBRT). However, postoperative radiotherapy poses an increased risk of radiation-induced heart disease in patients with left-sided breast cancer caused by damage (micro- and macro-angiopathy) to the coronary arteries that may lead to myocardial fibrosis and coronary artery disease.[1]

Previously, the whole heart was considered a single organ at risk (OAR). However, numerous studies have shown that the impact of the radiation dose depends on the heart substructures and, thus, dose restrictions should be modified accordingly.[2] Dose restriction to the whole heart to prevent pericarditis and cardiovascular mortality are well-established; however, the tolerance dose for the left anterior descending (LAD) coronary artery remains to be determined.[3] This is highly relevant because irradiation of the internal mammary chain (IMC) by a direct beam and left tangential fields—which include the distal branches of the LAD—can increase the risk of late heart disease. Given that damage to even a small section of the LAD can lead to severe toxicity or even death, it is crucial to minimize the dose delivered to the artery. Nonetheless, in clinical practice, the LAD is not routinely contoured in left breast radiotherapy, in part because of the difficulties posed in delineating the narrow volume of this artery, but also because data from some studies have shown that it may not be necessary to specifically contour the coronary arteries provided that the Radiation Therapy Oncology Group (RTOG) guidelines are followed.[4,5]

2. Aim

Although several studies have investigated the radiation dose to the LAD during left-sided irradiation,[4,6] more data are needed to better characterize the tolerance dose.[3] In this context, the objective of the present study was to describe the dosimetric distribution of radiation doses to the LAD in a series of patients treated with three-dimensional conformal radiotherapy delivered with tangential fields.

3. Materials and methods

This retrospective study involved 14 patients treated for left breast cancer during the year 2014 at the Radiation Oncology Department of Médica Sur Hospital in Mexico. The whole heart and LAD were contoured separately.

3.1. *Data collection*

Relevant patient and treatment data—including tumour characteristics, treatment details, use of adjuvant endocrine treatment, chemotherapy, and recurrences—were obtained from patient medical records. The radiotherapy records were reviewed to classify the target areas: whole breast plus surgical bed after BCS, and regional lymph nodes (LN) located in the axillary, IMC, and supraclavicular (SCL) areas.

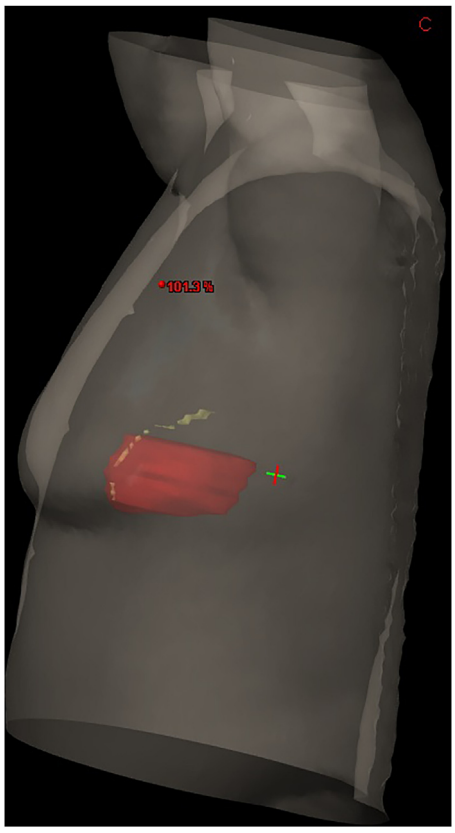

Fig. 1 – 3D reconstruction of 5 mm thickness CT slices with a staggered LAD view.

3.2. *Treatment*

A simulation computed tomography (CT) scan was acquired with the patient in the supine position on an inclined treatment table, with the left arm extended upwards, in a positron-emission tomography (PET)-CT (Siemens Biograph 16). The gantry amplitude was 75 cm, field of view (FOV) of 6 mm, and scanner rotation time of 5.5 s. CT slices were obtained every 5 mm (Fig. 1). No contrast dye was administered.

Contouring of the LAD artery (Fig. 2) was performed by the attending radiation oncologist with the support of a radiologist. The heart was outlined according to the RTOG breast cancer contouring atlas.[5] The Eclipse (v. 11.031) treatment planning system (TPS) was used (Varian Medical Systems; Palo Alto, CA, USA) with the AAA (anisotropic analytical algorithm) and PBC (pencil beam convolution) models.

The treatment technique used was opposite tangential fields with 6 MV photons (Fig. 3). In 6 cases (42%), due to patient anatomy, 18 MV photons were also used to achieve a homogeneous dose distribution.

The treatment plans were optimized individually using beam angles, wedges, and/or collimator angles. Dose-volume histograms (DVH) were created for the OARs. Dose restrictions to the heart were in accordance with RTOG recommendations, as follows: <5% of the heart volume should receive 40 Gy (Vheart 40 Gy = 5%) and less than 10% of the heart volume should receive 25 Gy (Vheart 25 Gy = 10%).