

CASE REPORT

Mediastinal irradiation in a patient affected by lung carcinoma after heart transplantation: Helical tomotherapy versus three dimensional conformal radiotherapy

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Keywords

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Background

Patients who have undergone solid organ transplants are known to have an increased risk of neoplasia, estimated at 20% after 10 years of chronic immunosuppression, compared with the general population.^{1,2} Even if their survival has distinctly improved, particularly as a result of the introduction of cyclosporine, the prognosis of most solid tumors occurring in these patients remains poor.³ Neoplasia remains the most frequent non-graft related cause of late deaths after heart transplantation.⁴ When lung carcinoma is diagnosed, decisions on treatment are made by a multidisciplinary team.⁵ The aim of our report is to determine the toxicity of mediastinal irradiation on cardiac structures when the patient has a history of heart transplantation.

Case presentation

A white female patient aged 41 years with no history of tobacco use presented to our center. She had undergone a

Abstract

Patients who have undergone solid organ transplants are known to have an increased risk of neoplasia compared with the general population. We report our experience using mediastinal irradiation with helical tomotherapy versus three-dimensional conformal radiation therapy to treat a patient with lung carcinoma 15 years after heart transplantation. Our dosimetric evaluation showed no particular difference between the techniques, with the exception of some organs. Mediastinal irradiation after heart transplantation is feasible and should be considered after evaluation of the risk. Conformal radiotherapy or intensity-modulated radiotherapy appears to be the appropriate treatment in heart-transplanted oncologic patients.

heart transplantation in 1999 for end-stage ischemic cardiomyopathy with severe left ventricle dysfunction. In 2005, she presented with heart rejection and was treated with cyclosporin, azathioprin, and corticoids. In 2013, the patient presented with coughing, weight loss, and asthenia. A chest computed tomography (CT) scan showed a right upper lobe lesion. She underwent ablative thoracic surgery for lung adenocarcinoma, pT1R0N1IIA (information regarding molecular subtype was not available).

A multidisciplinary team established that the patient was not fit for chemotherapy. She was followed-up to assess for clinical or radiologic signs of local recurrence/distant metastasis. A mild obstructive defect was detected at spirometry (forced expiratory volume in 1 second: 75%).

In January 2014, positron emission tomography (PET) showed mediastinal disease progression; thus, the patient was scheduled for radiation treatment. A four-dimensional (4D) technique using a multi-slice CT scanner (CT Multislice GE Healthcare Discovery 590 HT, Lerchenbergstr, Dornstadt, Germany) was utilized for planning. The CT is equipped by

Deviceless 4D, software revision, and post-processing of respiratory movements. The application uses the image data acquired and Smart breath to create a respiratory cycle and maximum, average, and minimum intensity projections, without any abdominal compression.

The target mediastinal volume (clinical target volume, CTV) was delineated considering specific lymph node station (supraclavicular, right and left upper paratracheal, prevascular, right and left lower paratracheal, subcarinal node). The planning target volume (PTV) was generated

from the CTV by adding a 5 mm margin in all directions, using different respiratory phases. Because of the higher risk to the transplanted heart, the cardiac structures and great vessels were contoured along with the pericardial sac, beginning at the level of the inferior aspect of the pulmonary artery passing the midline and extending inferiorly to the apex of the heart. Twenty five fraction treatment was delivered, with a total dose of 50 Gy, only on the mediastinal lymph node. We performed two plans for the study (Figs 1, 2), but we treated the patient with a helical tomotherapy (HT) plan.

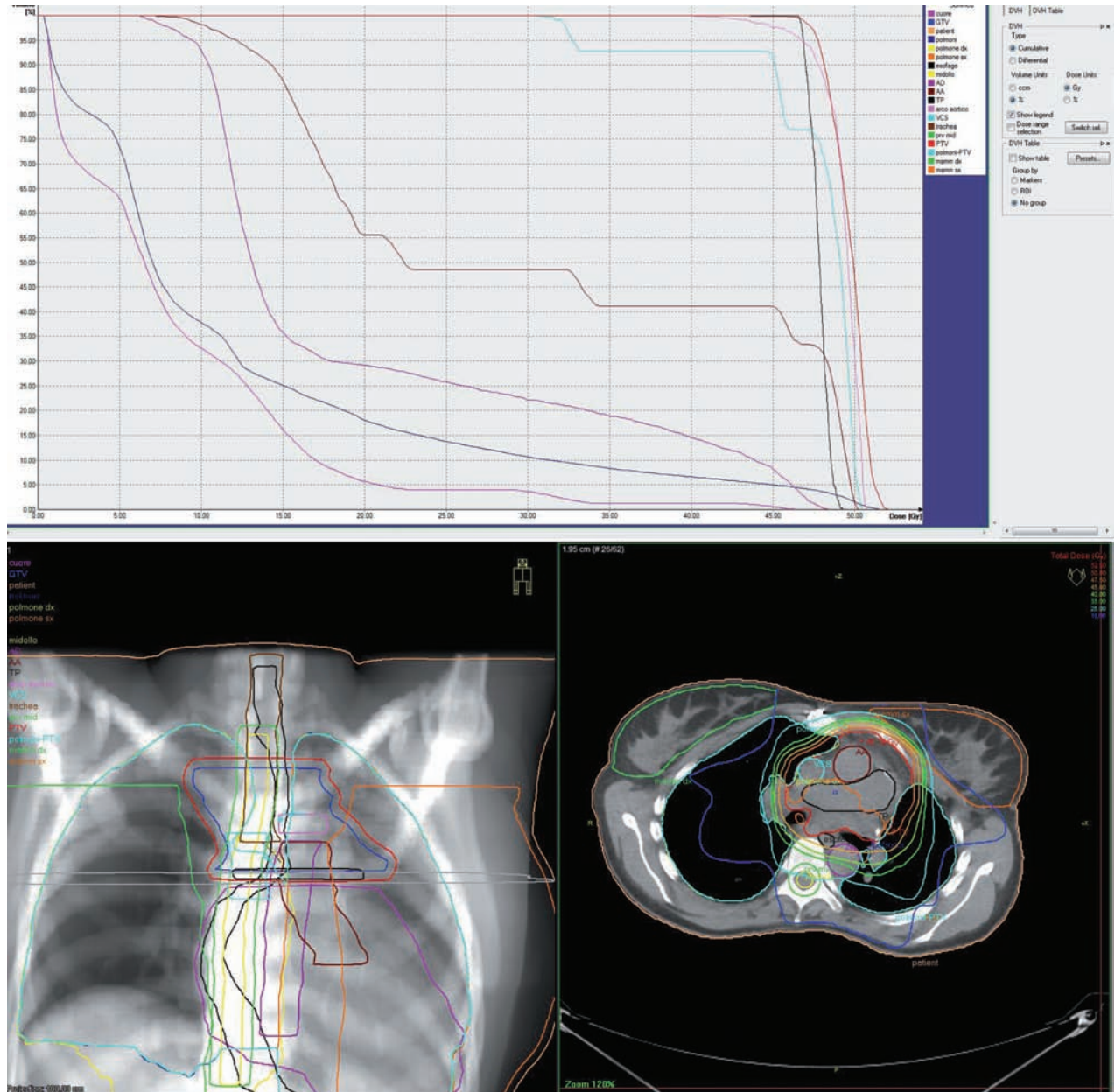


Figure 1 Helical tomotherapy plan. The dose-volume histogram diagram shows the lines around the heart, great vessels, and lung and the planning target volume coverage. Different isodoses were reported.

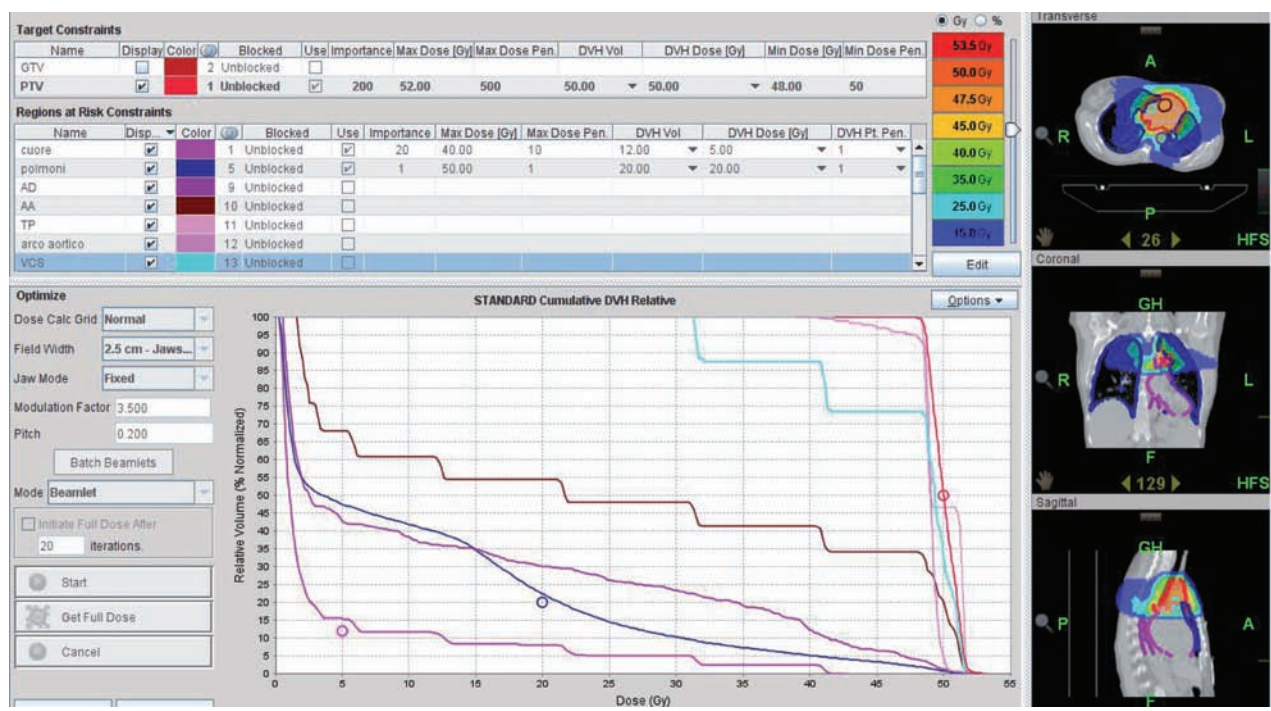


Figure 2 Three-dimensional-conformal radiotherapy plan. The dose-volume histogram diagram shows the lines around the heart, great vessels, and lung and the planning target volume coverage. Different isodoses were reported.

Specific dose parameters were selected to compare the plans; the results are reported in Table 1.

Informed consent was obtained from the patient prior to treatment.

Radiotherapy was well tolerated, with Grade 2 dysphagia reported without any cardiac symptoms. A program of cardiac examinations, cardiac ultrasound, and ejection fraction before (EF 65%) and during (EF 62%) radiotherapy was performed. During follow-up the EF and mild respiratory deficit were stable at 64% and 75%, respectively. A chest CT with iodatum contrast enhancement was performed every three months. Total body PET/CT six months after radiotherapy showed an anterior superior mediastinal node standardized uptake value (SUV) of 2.9 versus 4 (diagnosis) and pretracheal node SUV of 2.6 versus 3.8 (diagnosis; Fig 3). At 12 months after radiotherapy, the anterior superior mediastinal node SUV was 1 versus 2.9 (diagnosis) and the pretracheal node SUV was 1.3 versus 2.6 (diagnosis). At 20 months, complete remission of mediastinal disease was obtained.

Helical tomotherapy planning

The HT system employed a compact 6 MVp Linac placed on a CT ring gantry to rotationally deliver intensity-modulated fan beams while the patient was translated throughout the gantry on a treatment couch, resulting in helical irradiation geometry.^{6,7} Intensity modulation was performed through a

Table 1 Dosimetric results

Organs	Tomotherapy	LINAC
PTV		
D _{max} (Gy)	53.6	52.9
D _{mean} (Gy)	49.94	49.87
D _{min} (Gy)	41.33	47.37
Lung		
D _{max} (Gy)	52.32	52.12
D _{mean} (Gy)	11.10	12.11
V5 (%)	47.2	51
V20 (%)	21.7	18
V30 (%)	10.11	10.5
Spinal cord		
D _{max} (Gy)	33.43	41.06
Heart		
D _{mean} (Gy)	4.09	8.39
V25 (%)	5.03	4.04
Esophagus		
D _{max} (Gy)	51.29	51.02
D _{mean} (Gy)	13.26	16.85
Trachea		
D _{max} (Gy)	51.79	51.02
Left breast		
D _{max} (Gy)	49	50
D _{mean} (Gy)	9.27	5.23
Right breast		
D _{max} (Gy)	25	29
D _{mean} (Gy)	5.62	5.23

Dmax, maximum dose; Dmean, mean dose; Linac, linear accelerator; PTV, planning target volume.

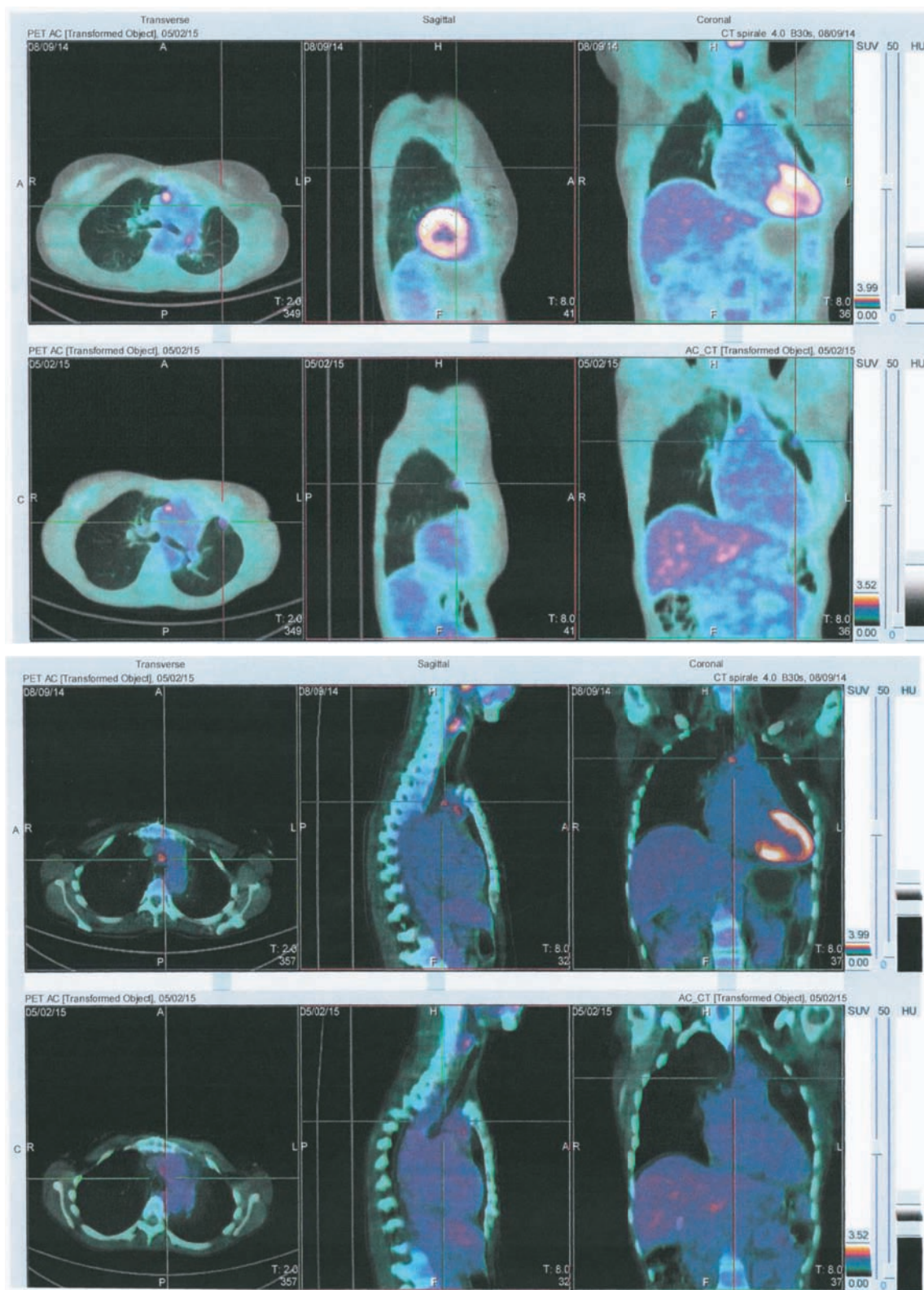


Figure 3 Total body positron emission tomography-computed tomography from diagnosis to six months after treatment.

pneumatically powered, binary multi-leaf collimator. The HT unit also contained a mega-voltage CT detector array located opposite the radiation source for pre-treatment verification, allowing accurate re-positioning. The CT data and the structure sets were transferred to the HT planning station. The treatment was planned using Hi-Art II dose calculation software (TomoTherapy Inc., Madison, WI, USA) using a mean pitch of 0.20, a mean modulation factor of 3.5, and an intermediate field width (2.5 cm). A collapsed cone convolution algorithm and a 5 mm resolution grid were used for dose calculation. Initial dose-volume histogram (DVH) constraints and penalties were adjusted during the optimization to obtain adequate PTV coverage, minimizing heart, spinal cord, and lung exposure. The treatment time was 304 seconds.

Three-dimensional-conformal radiotherapy planning

Mediastinal three-dimensional-conformal radiotherapy (3D-CRT) provided multiple non-coplanar equally weighted fields. The gantry and collimator angles were adjusted using eye-view projection to minimize heart and lung irradiation while maximizing target coverage. For all fields, the energy was 10 MeV. The PTV of the mediastinum received less than 107% of the prescribed dose, and no more than 5% of the PTV received less than 95% of the prescribed dose. The dose distribution was calculated and optimized using Oncentra Masterplan Version 4.3 planning station (Nucletron an Elekta Company, Veenedaal, Netherlands).

Discussion

There is an increased risk of a wide range of cancers associated with solid organ transplantation. We present the clinical case of a woman affected by lung carcinoma after heart transplantation and treated with mediastinal radiotherapy. Our dosimetric study compares the feasibility of mediastinal cancer care using two different radiation techniques, 3D-CRT and HT, in terms of PTV coverage and normal tissue sparing, especially for cardiac structures. The results showed that PTV coverage was achieved with both techniques. Despite the heart, as entire volume and as different cardiac structures we noted a better sparing in HT planning with mean dose (Dmean) 4.09 Gy versus 8.36 Gy in 3D-CRT planning. The difference between V25 Gy value upon the heart was not remarkable: 5.3% with the HT plan and 4.04% with the 3D-CRT. The dose to the lung, in terms of Dmax (maximum dose; Gy), Dmean (Gy), V5 (%), V20 (%), and V30 (%), did not reveal any difference between the two plans. In terms of Dmax to spinal cord, the difference between the techniques was remarkable, with the HT plan proving advantageous. We noted disadvantages using HT, with a mean dose to the left breast of 9.27 Gy versus 5.23 Gy.

Kirova *et al.* reported their experience of a patient with mediastinal irradiation using a linear accelerator in patients with esophageal carcinoma after heart transplantation. A total dose of 45 Gy in 25 fractions was delivered. Complete remission of the esophageal carcinoma was obtained, without any cardiac toxicity. The last follow-up was performed seven months after the completion of radiotherapy, as the patient committed suicide.⁸

Frist *et al.* reported a case of chronic myelogenous leukemia diagnosed five years after heart transplant and successfully treated with total lymphoid irradiation. The patient presented a recurrent cardiac rejection. The authors suggested that chronic myelogenous leukemia may be a long-term sequela of previous total lymphoid irradiation, although the long-term effects of total lymphoid irradiation in the heart transplant population have not been reported.⁹

Our knowledge regarding the heart's tolerance of mediastinal radiation is not sufficient, therefore, further data are required.^{10,11}

We conclude that irradiation of the mediastinum after heart transplantation is feasible. The differences in the HT plan of the Dmax to spinal cord and the Dmean to the heart must be considered as these patients may be recruited for re-treatment.

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Disclosure

No authors report any conflict of interest.

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