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CASE REPORT

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Safe Delivery of Postoperative Radiotherapy for Thymic Carcinoma Located on the Outflow Graft of a Left Ventricular Assist Device

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Introduction

Implantation of a left ventricular assist device (LVAD) improves survival rates for patients with severe heart failure.[1] Because cancer incidence increases with age,[2] there is a risk of developing cancer subsequent to the implantation surgery. Therefore, safe treatment of cancer in patients with LVAD is an important concern for thoracic oncologists. Several reports have assessed the feasibility of treatments for cancers distant from the LVAD graft site.[3–5] However, treatment of cancers directly involving the LVAD graft has not been addressed. Here, we report the first case of postoperative radiotherapy (PORT) for thymic squamous cell carcinoma located on the outflow graft of an LVAD.

Case Report

A 69-year-old man, implanted with a cardiac resynchronization therapy defibrillator (CRT-D) for arterial fibrillation 8 years ago, exhibited dilated-phase hypertrophic cardiomyopathy and was fitted with an LVAD as a bridge to the transplant 4 years ago. During follow-up, he was diagnosed with a thymus tumor on the outflow graft of the LVAD by computed tomography (CT) (Fig. 1*A*–*C*). The clinical diagnosis of the tumor was thymoma, and he underwent surgery for total resection by a median sternotomy. The tumor was resected with a sufficient safety margin to the naked eye, and the intraoperative frozen section confirmed malignant thymoma and tumor-free resection lines. However, the final pathologic diagnosis was thymic squamous cell carcinoma with a microscopically positive margin (R1 resection), which was classified as pT1aN0M0 stage I according to the guidelines of the Union for International Cancer Control version 8. As the surgical margin was positive at the outflow graft of the LVAD, PORT was indicated. This decision was made by a multidisciplinary thoracic oncology team, including thoracic surgeons, pulmonologists, diagnostic radiologists, and radiation oncologists. Written informed consent was obtained from the patient.

A total dose of 66 Gy in 33 fractions with 6-MV photons was administered: 50 Gy in 25 fractions for the tumor bed and an additional 16 Gy in eight fractions at the surgical margin (Fig. 2*A* and *B*). The LVAD controller and CRT-D were placed outside the radiation field. Maximum doses were calculated as 68.3, 0.00, and 0.99 Gy for the graft, LVAD pump, and CRT-D, respectively. PORT was completed without device errors; the

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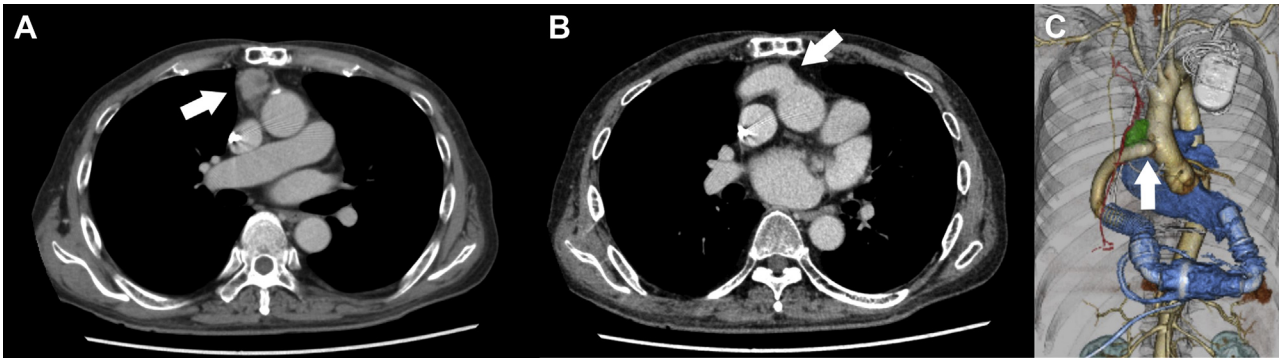

Figure 1. Diagnostic CT images before the surgery. (*A*) Axial view of CT (white arrow, thymic carcinoma). (*B*) Axial view of CT revealing the graft and anastomotic region (white arrow). (*C*) Reconstructed image of CT (green object, thymic carcinoma on the outflow graft of the LVAD; white arrow, the anastomotic region between the outflow graft and ascending aorta). CT, computed tomography; LVAD, left ventricular assist device.

settings of the LVAD and CRT-D were confirmed to be unchanged. Both warfarin and aspirin were used as antithrombotic therapy in peri- and post-PORT periods with a target international normalized ratio of 2 to 2.5. After the completion of PORT, the graft and anastomotic region were assessed by CT every few months. In the 13-month follow-up period, no evidence of cancer recurrence and no radiological change in the graft or anastomotic region were observed (Fig. 3*A* and *B*). However, the patient suddenly died at 18 months after PORT. LVAD was checked, and no problems were noted. An autopsy and a clinicopathologic conference were conducted to ascertain the cause of death. No macroscopic thrombosis or hemorrhage was observed in any of the organs, including the thorax. Microscopic examination around the graft and anastomotic region revealed only fibrosis without recurrence of malignancy, owing to the surgery and PORT for thymic carcinoma. The autopsy did not suggest any cause of death. Ultimately, it was concluded that no association existed between the death of the patient and PORT.

Discussion

Several studies have reported that electrical devices such as LVADs should be placed outside the radiation field during PORT and that lower-energy photon beams ($\leq$10 MV) should be used to prevent device errors induced by the photons and photoneutrons generated by the linear accelerator.[5] On the basis of this recommendation, we successfully performed PORT without any induced device errors.

The effect of PORT on the stability of device grafts and anastomotic regions was previously untested in humans. The material of the outflow graft is Dacron, reported to be tolerant of radiotherapy; 80-Gy irradiation did not affect the nature of the

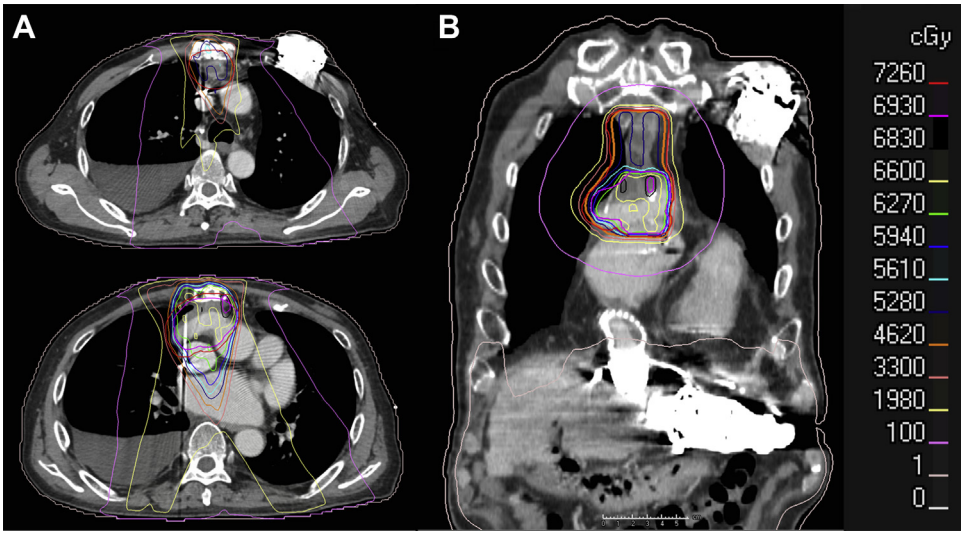

Figure 2. Dose distribution of PORT in (*A*) axial view and (*B*) coronal view. PORT, postoperative radiotherapy.

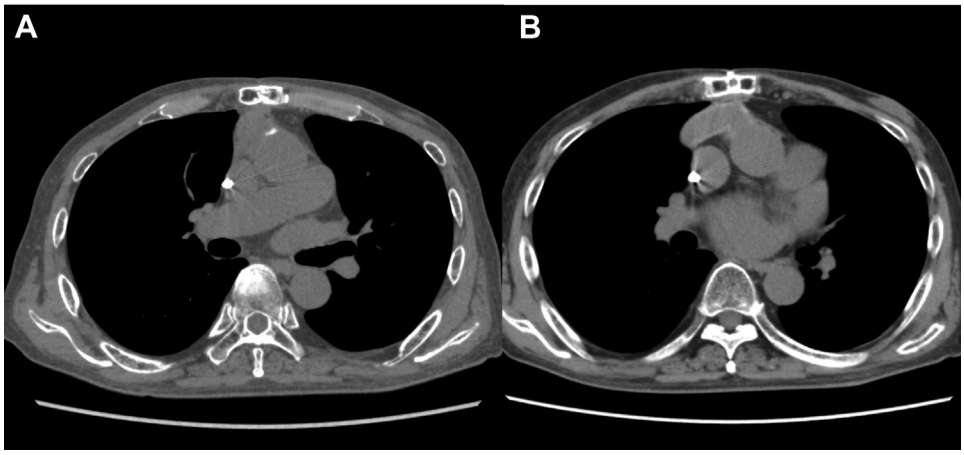

Figure 3. Follow-up CT images at 13 months after the initiation of PORT. (*A*) No evidence of cancer recurrence was observed. A soft tissue mass can be noted in the tumor bed. This mass revealed no change in size from immediately after the surgery until this CT, leading to its diagnosis as a postoperative scar. (*B*) No significant change was noted around the graft or anastomotic region. CT, computed tomography; PORT, postoperative radiotherapy.

Dacron tube.[6] Regarding irradiation to the anastomotic regions, a study in canines revealed that PORT for the anastomotic region of an abdominal aortic graft was feasible; the patency rate of the grafts was 100%, and no disunion, rupture, or aneurysm was observed.[7] However, minor thrombosis in the luminal surface was noted in one case, suggesting the irradiated graft and anastomotic regions should be closely monitored. In our study, the graft and anastomotic region of the LVAD were inevitably included in the radiation field owing to the location of the tumor. As thrombosis in the graft and extravasation from the anastomotic region are lethal events, these regions were closely monitored by CT for early detection and confirmed to be stable. Standard antithrombotic therapy could be given during that period. On the basis of the results of the autopsy and the clinicopathologic conference, PORT for the graft and anastomotic region was confirmed to be feasible in this case. Although it is difficult to come to a definitive conclusion regarding the safety of PORT, our study reveals that definitive cancer treatment by PORT may be feasible even if the tumor is located on the graft or anastomotic region.

Declarations

Ethics Approval and Consent to Participate

This study followed all dictates of the Helsinki Declaration.

Consent for Publication

Written consent was obtained from the patient for publication of this report and any accompanying images.

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The English in this document has been checked by Editage (https://www.editage.jp/). Dr. Sato contributed to writing—original draft of the manuscript, Dr. Matsuo contributed to supervision of the manuscript. Drs. Kanemitsu, Minatoya, Nakajima, Date, Nakagawa, and Mizowaki contributed to writing—review and editing of the manuscript.

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