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CASE REPORT

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Safe delivery of lung stereotactic body radiation therapy in a patient with a left ventricular assist device and implantable cardioverter defibrillator

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Key Clinical Message

This is the first case to discuss the safe delivery of stereotactic body radiation therapy to a left lower lobe lung nodule in a patient with a third generation left ventricular assist device (Heartware®) and implantable cardioverter defibrillator.

KEYWORDS

implantable cardioverter defibrillator, intensity-modulated radiation therapy, left ventricular assist device, lung carcinoma, stereotactic body radiation therapy

1 | INTRODUCTION

Heart disease and cancer remain the leading causes of death in the United States.[1] The left ventricular assist device (LVAD) was developed and pioneered as a bridge to heart transplant for patients with advanced heart failure. However, with great improvements in LVAD technology, the HeartMate XVE was approved as a destination therapy in 2003 by the FDA.[2] Since 2015, almost 50% of continuous flow LVADs have been implanted with the goal of destination therapy, 26% as bridge to transplant, and 23% as bridge to candidacy.[3] Data from the INTERMACS database have revealed an overall survival of 81% at 12 months and 70% at 24 months for patients with a continuous flow LVAD implanted since 2008.[3] The population of patients with implantable cardiac devices, including implantable cardioverter defibrillators (ICDs), pacemakers, and LVADs, in the United States is large and steadily growing, with millions having one or more of these devices.[4] As lifespan is increased by these devices, an increasing number of patients will be concomitantly afflicted with cancer. The implantable cardiac device-dependent patient with a cancer diagnosis represents a unique and novel challenge to the multidisciplinary oncologic treatment team.

Radiation therapy is frequently part of the multidisciplinary treatment approach for various cancers. Yet, no large clinical studies have been done to establish the safety or dose constraints of radiation in these cardiac devices. The evidence regarding radiation in an LVAD-dependent patient is limited to case reports and in vitro studies.[5-10] Here, we report the first case of thoracic stereotactic body radiation therapy (SBRT) to the left lower lobe of the lung for a suspected solitary lung carcinoma in a patient with a third generation LVAD (Heartware ®) and ICD. This report illustrates that this treatment approach can be safely and successfully used to manage this complex patient population.

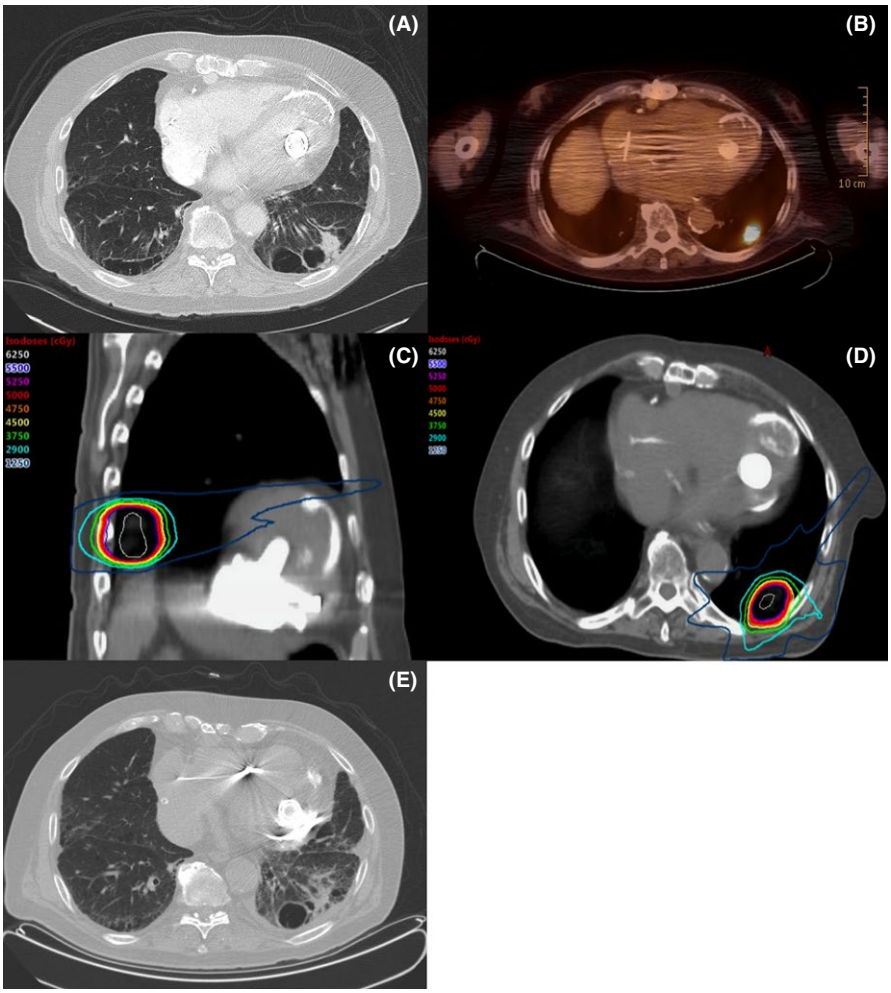

FIGURE 1 (A) Axial computed tomography (CT) of the chest with contrast images revealing a 2.3 × 1.8 cm noncalcified, spiculated solid nodule with irregular lobulated margins in the left lower lobe and multiple prominent bulla lying just medial to the mass (B) Axial positron emission tomography with noncontrast CT (PET/CT) revealing intense uptake (maximum standardized uptake value 8.8) in the lung nodule (C) Sagittal and (D) axial CT images showing the radiation isodoses used for treatment (E) Axial CT showing a contracting left lower lobe nodule

2 | CASE REPORT

An 83-year-old male with a history of chronic systolic heart failure (ACC/AHA Stage D, NYHA Class II-III) status-post HeartWare ® LVAD placement in 2011 and status-post single chamber ICD placement in 2002 with upgrade to Medtronic Bi-Ventricular ICD (Protecta XT CRT-D) in 2009 secondary to worsening heart failure, hypertension, atrial fibrillation, and chronic kidney disease stage III presented to our clinic for a suspicious left lower lobe lung nodule found incidentally during a work-up for abdominal pain. Computed tomography (CT) of the chest with contrast demonstrated a 2.3 × 1.8 cm noncalcified, spiculated solid nodule with irregular lobulated margins in the left lower lobe without mediastinal or hilar adenopathy. It further showed multiple prominent bullae lying just medial to the mass and moderate emphysematous changes throughout both lungs (Figure 1A). The patient reported decreased appetite and minimal weight loss but denied fevers, chills, night sweats, chest pain, hemoptysis, and cough. Positron emission tomography with noncontrast CT (PET/CT) was obtained for further work-up and showed intense uptake (maximum standardized uptake value 8.8) in the lung nodule without evidence of nodal or distant metastatic disease (Figure 1B).

The patient was discussed at multidisciplinary Thoracic Oncology Conference. Given multiple bulla adjacent to the lesion, percutaneous biopsy was deemed high risk. In addition, due to his anatomy and location of the tumor, he was not felt to be a candidate for navigational bronchoscopy and biopsy. Based on the clinical prediction model derived by Swensen et al[11], our patient's pulmonary nodule had a 76.5% chance of being malignant. Given the high probability of malignancy, the decision was made to pursue treatment without confirmatory biopsy. The patient was deemed to be a high-risk surgical candidate secondary to his compromised cardiac function and significant risks of LVAD thrombosis given the need to stop anticoagulation for the perioperative period. Therefore, the decision was made to explore SBRT as a possible treatment option for this patient.

After careful discussion regarding the safety of SBRT with the manufacturer of the patient's LVAD and ICD, we decided to treat this patient with SBRT to 50 Gy in 5 fractions

every-other-day with interrogation of his devices before and after the first treatment and after the second treatment (Figure 1C,D). The patient received 50 Gy in 5 fractions with a 9-field sliding-window intensity-modulated radiation therapy technique with 6 MV photons while free-breathing, making all efforts to avoid significant dose spillover to the LVAD pump. The planned mean dose to the LVAD was 45 cGy, and the maximum dose was 698 cGy. An optically stimulated luminescence dosimeter (OSLD) placed on the skin directly overlying the ICD revealed a fractional dose of 3.6 cGy, with a maximum inferred dose to the device for the course of SBRT of 18 cGy. Treatment was delivered successfully without side effects or impedance of his cardiac devices. Follow-up at 4 months following SBRT completion revealed stable functioning of the LVAD, no new cardiac symptoms, no chest wall pain, and a contracting left lower lobe pulmonary nodule (Figure 1E).

3 | DISCUSSION

This is the first case report of safe delivery of 50 Gy SBRT to the left lower lobe of the lung in a patient with a Heartware ® LVAD and ICD. As in our case, providers are likely to encounter a major challenge in pursuing surgical resection in patients that are high-risk surgical candidates and who require anticoagulation secondary to their life-sustaining implanted cardiac devices. Thus, there is an increasing importance to understand the safety of alternative treatment approaches, such as radiation, in this unique patient population.

Recognizing the increasing number of pacemaker-dependent patients diagnosed with cancer, several professional organizations and hospitals have recently published guidelines for radiotherapy in patients with ICDs, making recommendations for radiation dosage and appropriate follow-up.[12-15] Multiple retrospective case series have also considered the potential effect of radiation on ICDs with reported rates of inappropriate device function ranging between 1.5% and 29%.[14-17] In particular, it has been shown that neutron-producing radiotherapy, especially >10 MV, is associated with malfunction of contemporary implantable cardiac devices (ICDs and pacemakers).[18] Use of a systematic policy of risk assessment and patient management is important in minimizing device-related complications.[15]

Unlike for ICDs, the literature on the effects of radiation on LVADs is extremely sparse. Multiple generations of LVADs are currently on the market,[19] and our patient was implanted with a third-generation HeartWare ® VAD (HVAD) as part of the Endurance Trial. The HVAD pump is housed in a hybrid titanium-ceramic assembly. The impeller contains multiple large rare earth motor magnets, which are driven by electromagnetic force. This device further has an external microprocessor-based controller, connected to the internal pump via a percutaneous driveline, which operates the pump, manages power sources, monitors pump function, provides diagnostic information, and stores pump parameter data.[5,6,20]

In vitro studies have considered the effect of high-dose therapeutic x-rays and proton beam therapy on the HVAD. Gossman et al found that HVADs (n = 2) did not have any changes in pump operation during radiation with X-rays dosed 64-75 Gy, although they did find that the titanium components markedly attenuated the therapy beam. They further suggested that computer modeling underestimates the pretreatment dose in patients when the device is in the radiation field.[5] Similarly, no change in HVAD function (n = 5) was found in response to proton beam therapy up to 70 GyE.[6] No case reports of photon radiation in the specific setting of a third-generation LVAD exist, although 4 case reports of safe treatment with radiation in earlier generation LVADs are available.[7-10]

4 | CONCLUSION

This case demonstrates that SBRT can be safely administered to the lung in a patient with a third-generation LVAD, ICD, and concomitant cancer. Despite the close vicinity of the radiation field to this patient's cardiac devices, no inappropriate device function was found during the device interrogations performed throughout treatment. The current literature on the effects of radiation on cardiac devices, particularly LVAD, is very limited. As an increasing number of cardiac device-dependent patients will need cancer treatment, it is imperative to understand the best treatment approaches that can be safely offered to this unique population. Further research to address the safety of radiation therapy in patients with cardiac devices is needed.

CONFLICT OF INTEREST

None declared.

AUTHORSHIP

CAO-H: conception and design, data acquisition, data analysis and interpretation, drafting the manuscript, critical revision of the manuscript, final approval of the version to be published. JM: conception and design, final approval of the version to be published. DPW: conception and design, critical revision of the manuscript, final approval of the version to be published. BHT: conception and design, data acquisition, data analysis and interpretation, critical revision of the manuscript, final approval of the version to be published. NN: conception and design, data acquisition, data analysis and interpretation, critical revision of the manuscript, final approval of the version to be published.

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