Abdominal implantable cardioverter-defibrillator placement in a patient requiring bilateral chest radiation therapy

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Introduction

The prevalence of cancer in the United States in 2012 was 13.7 million.[1] According to the National Cancer Institute,[2] approximately one half of all patients with cancer will receive some sort of radiation therapy (RT) during the course of their treatment. In a recent single-center case series,[3] nearly 1% of patients receiving RT had cardiac implantable electronic devices (CIEDs). We can therefore deduce that there are a sizable number of patients receiving RT for cancer who also have CIEDs.

Modern CIEDs use integrated circuits built with complementary metal-oxide-semiconductor technology, which make them smaller, reliable, and energy efficient but more sensitive to ionizing radiation from RT, as compared with older devices, which used nonprogrammable bipolar semiconductors.[4] These effects range from mild programming corruption to power-on-reset or even total device failure and tend to increase with cumulative radiation exposure. RT machines also cause electromagnetic interference or scatter radiation of neutrons that can disrupt device function.[5,6]

Optimal management of patients with CIEDs undergoing RT is unknown. We present a case of a patient with an implantable cardioverter-defibrillator (ICD) with single-coil defibrillator lead who required whole chest radiation and demonstrate an innovative solution.

Case report

A 69-year-old former smoker with coronary artery disease status post–myocardial infarction in 1998 and ischemic cardiomyopathy (left ventricular ejection fraction 10%–15%) status post-ICD implantation in 2001 for inducible ventricular tachycardia was referred for evaluation by oncology, given plans for RT. His right ventricular (RV) lead was a single-coil Medtronic Sprint model 6943 (Minneapolis, MN), and his right atrial lead was a Medtronic CapSureFix model 4568, which has demonstrated progressively falling impedances since implantation. Given the lack of atrial pacing requirement, his system was programmed to VVI mode. He was on amiodarone from 2001 to 2006, which was discontinued because of reduced diffusing capacity of the lung for carbon monoxide. He has a history of appropriate ICD discharge and antitachycardia pacing for recurrent monomorphic ventricular tachycardia. He underwent ICD generator change in 2005 and 2013; his most recent generator was a Medtronic Maximo II DR model D284TRG (Figure 1).

In August 2015 he developed hoarseness with cervical lymphadenopathy. A computed tomographic scan of the chest showed a right upper lobe mass that was compressing the laryngeal nerve. He was determined to have stage IIIb adenocarcinoma of the lung. He started chemotherapy but needed external beam radiation (photon therapy) to a large bilateral thoracic field to a dose of 60 Gy in 30 fractions; therefore, the radiation oncologist requested repositioning of the ICD generator. It was anticipated that with cancer treatment his prognosis for survival would approach 3 years, but treatment was unlikely to be curative.

Electrophysiological procedure

The patient was brought to the electrophysiology laboratory in the fasting state. After informed consent was obtained, left upper extremity venography was performed, which revealed that the subclavian vein was completely occluded with bridging collaterals. This precluded ipsilateral implantation of a superior vena cava (SVC) coil or azygous lead to allow for an RV coil → RV can/SVC defibrillation option. The decision was made to relocate the ICD to the left upper quadrant and add a subcutaneous coil. A 6-cm incision was made over the ICD header, carried down to the device pocket, and the generator was removed. The

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KEY TEACHING POINTS

- There is no standard approach to dealing with patients with cardiac implantable electronic devices who need radiation therapy as they are susceptible to both ionizing radiation and electromagnetic interference in a non–dose-dependent manner.
- In particular, those who need chest radiation are problematic and we chose repositioning the generator to the abdomen as a permanent solution. An individualized approach is necessary, and we present various options for implanters to consider.
- There are limited data on an active abdominal can and single-coil defibrillator lead configuration, and a subcutaneous lead will offer more defibrillation vectors.

right atrial lead was capped, given a history of falling impedances.

Next, an 8-cm incision was made in the left upper quadrant and a subcutaneous pocket was created. The chronic ICD lead IS-1 connector was attached to a 37-cm Medtronic IS-1 lead extender model 6984M, which was then tunneled to the abdominal pocket. The chronic ICD lead DF-1 connector was attached to a 25-cm Medtronic DF-1 Y-Adaptor/Extender model 6726, which was then tunneled to the abdominal pocket. A 41-cm Medtronic subcutaneous coil model 6996SQ was tunneled from the pectoral pocket to the left side of the chest. The subcutaneous coil was connected to a 25-cm Medtronic DF-1 Y-Adaptor/Extender model 6726, which was then tunneled to the abdominal pocket. A port plug was used in each DF-1 Y-adapter to convert them into a straight (non-Y) extension. DF-1 Y-adapters used as no straight DF-1 adapters of equivalent length were commercially available. The 3 lead extenders were connected to a new Medtronic Evera S VR model DVBC3D1 ICD, and the generator was placed into the abdominal pocket (Figures 2, 3A, and 3B).

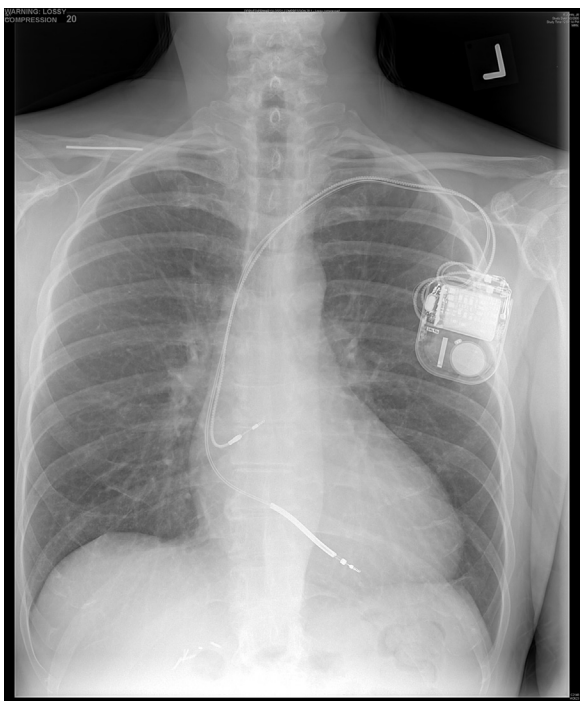

Figure 1 Radiographic image of the original implantable cardioverter-defibrillator system in the anterior-posterior projection.

Next, defibrillator threshold (DFT) testing was done; ventricular fibrillation was induced with a T-wave shock and defibrillated with a 30 J internal shock in the B > AX (RV coil → RV can/subcutaneous coil) configuration. Shock impedance was 38 Ω. Both chest and abdominal wounds were closed with 2-0 vicryl in layers, and the skin was approximated with staples.

Discussion

Management of patients with CIEDs who need RT can be challenging. Unfortunately, there are no current national or international standards or guidelines regarding CIEDs and RT exposure. The American Association of Physicists in Medicine published a consensus statement in 1994, which is now outdated, although a new task force has been created to address the issue.[7,8] The complexity of RT (peak dose, total cumulative dose, dose rate, scatter radiation, and concomitant electromagnetic fields) makes it difficult to predict device function and safety.[9] The generally accepted safe radiation dose is 2–10 Gy for pacemakers (PPMs) and < 1 Gy for ICDs, which is well below the curative dose for breast or lung cancer (50–60 Gy); there are reports of CIED malfunction at low doses as well.[9] We reviewed 2 of the largest in vivo studies of patients with CIEDs undergoing RT.

Brambatti et al[3] performed a single-center prospective study of 261 patients with CIEDs undergoing RT. They were classified as low risk (not PPM dependent, no chest radiation, or cumulative dose < 20 Gy), acute high risk (PPM dependent), or chronic high risk (chest radiation and/or cumulative dose > 20 Gy). CIED relocation was recommended only if cumulative dose > 20 Gy or PPM dependent with a cumulative dose of 2–20 Gy. Forty-one patients received chest radiation contralateral to the CIED, 25 received chest radiation ipsilateral to the CIED, and 15 received bilateral chest radiation. Of the study cohort, 4 had inappropriate device function. Three of these had radiation to the central chest with total radiation dose < 2 Gy. Of those 3, 1 (ICD) had a power-on-reset and 2 (PPM) had maximum sensory pacing. Therefore, it appears that with chest exposure, even smaller doses of RT can affect CIEDs.

Zaremba et al[9] performed a population-based multicenter cohort study of 560 patients with CIEDs undergoing RT. Of the 14 patients with device malfunctions, 4 received chest RT, 7 received abdomen and pelvis RT, and the remaining received RT to the head and neck, spine, or lower extremity.