Monitoring Patients With Implanted Cardiac Rhythm Devices Receiving Radiation Therapy

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Diagnosed in 2007 with chronic lymphocytic leukemia (CLL), S.B. was a 78-year-old man. Treatment consisted of a course of rituximab with stable blood counts. About two years after the initial diagnosis, S.B. presented with a moderately rapidly enlarging mass in his left-anterior shoulder. Biopsy of the mass revealed a Merkel cell carcinoma and, within a month, another mass was noted in his left axilla that was again positive for Merkel cell. S.B. underwent wide local excision with skin grafts. A restaging positron-emission tomography/computed tomography (PET/CT) scan was carried out to determine what treatment modality would best serve S.B.

S.B. had a significant history of cardiac disease that included coronary artery disease requiring coronary artery bypass graft. A former history of myocardial infarction and congestive heart failure predisposed S.B. to symptomatic bradycardia requiring implantable cardiac pacemaker (ICP), hypertension, and peripheral vascular disease.

S.B.'s CLL was stable at presentation, but had the potential for future clinical challenges. Despite S.B.'s age and medical history, he was active, walked one mile per day, lived alone, and was able to carry out activities of daily living in an independent manner. As defined by the Eastern Cooperative Oncology Group (ECOG), his performance status was rated as "1," which means he was restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature (Oken et al., 1982).

Consultation between S.B.'s medical and radiation oncologists determined that he was not an optimal candidate for chemotherapy because of his comorbidities.

The PET/CT scans were negative for any distant metastasis. S.B.'s disease was limited to the left shoulder and axillary region and, therefore, definitive radiation therapy was determined to be the best option to eradicate his disease locally before it became widespread. The fact that his pacemaker was located in the left-upper chest wall just a few centimeters away from the original lesion was a matter of concern to the radiation therapist. During radiation CT planning and simulation, it was determined that the pacemaker was within the intended radiation field. Therefore, S.B. was scheduled to have his pacemaker explanted from the left chest and a new pacemaker reinserted in the right chest area away from the radiation field. After a two-week period of recovery, S.B. proceeded with his prescribed radiation therapy treatments.

Radiation Precautions

According to the American Heart Association (2009), the leading cause of death in the United States continues to be heart disease, with cancer running a close second. Therefore, a clinician in a radiation oncology setting quite likely will face challenges in treating a patient population with cancer and heart disease. Patients who have implanted cardiac devices, such as an ICP or a cardioverter defibrillator, present concerns because of the potential effect that ionizing radiation can have on the function and reliability of the devices. An estimated 500,000 patients in the United States will have implantable cardiac devices, with pacemakers implanted at a rate greater than 115,000 per year and defibrillators at 228 implants per million (Solan, Solan, Berdnarz, & Goodkin, 2004).

Significant breakthroughs have occurred in the technology and delivery of radiation as well as in the circuitry of newer cardiac implantable devices such as implantable cardioverter defibrillators and cardiac resynchronization therapy pacemakers. Manufacturers of implantable devices have improved technology to produce devices that have low current consumption, which prolongs generator lifespan while maintaining a small size for ease of implantation and patient comfort. However, the complementary metal oxide semiconductor circuits that are a part of these devices can be more susceptible to therapeutic radiation and electromagnetic interference (EMI) (Kapa et al., 2008; Medtronic USA, Inc., 2008; St. Jude Medical Technical Services, 2008).

Effects of Ionizing Radiation

The risk of radiation effects on the operation of cardiac rhythm devices rises with increasing cumulative exposure, but no exact threshold (i.e., safe dose) has been determined. Recommendations differ from manufacturer to manufacturer (Solan et al., 2004). The range has been as low as 2,000 cGy and as high as 15,000 cGy (St. Jude Medical Technical Services, 2008). Medtronic USA, Inc., (2008) has carried out research to establish a safe threshold, with internal tests conducted on their proprietary pacemakers revealing minor damage at accumulated radiation doses greater than 500 cGy. The potential negative effect on implanted devices can range from permanent damage (rare) to temporary loss of sensing, temporary device inhibition, loss of capture, rate changes, and device reset back to demand mode when the patient is device dependent—all of which are uncommon (Kapa et al., 2008; Medtronic USA, Inc.; St. Jude Medical Technical Services).

The most common documented effect is a temporary increased sensor rate that makes the device more sensitive to "noise" around it (e.g., EMI or microwave frequencies generated by power sources) and potentially delivering inappropriate therapy (e.g., delivering a shock when not indicated, causing asystole) (St. Jude Medical Technical Services, 2008). Direct exposure of implantable cardiac devices to radiation can damage the circuitry, which