# RADIATION DOSE MONITORING IN A BREAST CANCER PATIENT WITH A PACEMAKER: A CASE REPORT

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A pacemaker-bearing patient with left-sided breast cancer was treated with adjuvant external beam radiation therapy to the intact breast. She was treated via tangential fields and a single anterior supraclavicular field using 6-MV x-rays. The pacemaker, originally in the treatment field, was removed and a new one placed 4 cm outside the radiation field prior to treatment. Silicon diode chamber, Keithley-Farmer type 0.6 cc ionization chamber, and lithium fluoride (LiF) (TLD) chips were used to measure, in vivo, the dose to the pacemaker. From all the fields treated, total dose to the pacemaker was 164 cGy by diode measurements, 182 cGy by ionization chamber measurements, and 171 cGy by TLD measurements. The pacemaker functioned normally throughout the course of treatment. (*J Natl Med Assoc.* 2001;93:278–281.)

**Key words:** breast cancer ♦ pacemaker ♦ radiotherapy

According to the Centers for Disease Control and Prevention, approximately 300,000 pacemakers are inserted each year.[1] A fraction of these patients develop malignant conditions requiring radiation therapy. Such patient numbers are on the rise with the observed increase in breast and lung cancer cases.

Before the 1960s, pacemakers employed conventional bipolar semiconductors. During that time, Cobalt-60 teletherapy machines were used in radiation therapy. Present day multiprogrammable pacemakers employ complimentary metal oxide semiconductor (CMOS) units and silicone dioxide-based integrated circuits that are sensitive to electromagnetic interference fields from modern linear accelerators used in radiation therapy.[2]

There exists an abundance of literature reporting in vitro testing of pacemakers to the effects of electromagnetic interference fields and ionizing radiation.[3,4] Several case reports of radiation therapy in pacemaker-implanted patients exist in literature.[5–8] Most of the patients in these studies were treated for carcinoma of the lung. One case of carcinoma of the breast in a patient with a pacemaker in the treatment field was reported.[6] In all these cases, the pacemaker was replaced after damage was detected, and thus interrupting radiation therapy.

Very few in vivo measurements reporting the dose to the pacemaker, exist in literature. In vivo measurements using a diode in a patient with laryngeal cancer indicated a dose of 50 cGy to the pacemaker, with the pacemaker located 1 cm beyond the inferior border of the anterior field.[9] TLD measurements, in a patient with lung cancer, indicated a dose of 620 cGy to the pacemaker, with the pacemaker 1 cm outside the treated fields.[10] In these

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cases, neither temporary nor irreversible pacemaker failure occurred.

In this paper, we report the management of a pacemaker-bearing patient with breast cancer who was successfully treated to a dose of 5000 cGy using medial and lateral tangential fields and an anterior supraclavicular field, employing 6 MV x-rays.

## CASE REPORT

In October 1999, an 80-year-old female, who had a pacemaker implanted 7 years previously for complete heart block, was diagnosed with stage IIB (T2N1M0) invasive ductal carcinoma of the left breast. Initial management of the patient consisted of partial mastectomy and ipsilateral axillary lymph node dissection. The patient was referred to the Department of Radiation Oncology for postoperative adjuvant radiotherapy. During the initial examination, it was determined that the patient's existing pacemaker generator was within the proposed radiotherapy treatment field. Because of this finding, the cardiologist was consulted and a recommendation was made for the relocation of the pacemaker to the contralateral pectoralis muscle. On October 14, 1999, a new pacemaker was implanted in a subcutaneous pouch overlying the right pectoralis muscle. The original pacemaker was removed but the connecting leads were left in place, in fear of disseminating disease during the process of its extraction.

The new pacemaker was a Pacesetter Affinity DR Model 5330. This is a bipolar, multiprogrammable pacemaker with an operating mode of DDD. This pacemaker has a complementary metal oxide semiconductor. It is 44 × 52 × 6 mm in greatest dimensions and weighs 23.5 g.

The patient commenced postoperative radiotherapy on October 21, 1999. The treatment consisted of left medial and lateral tangential fields measuring 10 × 16 cm each and an anterior supraclavicular field measuring 10 × 16 cm, with the lower half of the beam shielded. The patient was treated with 6 MV photons using a Varian Clinac–1800 linear accelerator. The left breast was treated to a total dose of 5040 cGy in 28 fractions, whereas the left supraclavicular field was treated to a total dose of 5000 cGy in 25 fractions.

Monitoring of the patient was carried out on a weekly basis. Electrocardiograms were obtained prior to, during, and after the course of radiotherapy. The pacemaker's function was checked weekly during the course of treatment. At each pacemaker check, the pacemaker's function was recorded on an electrocardiogram strip. No abnormality was detected by electrocardiogram or pulse analyzer over the entire course of treatment. The measuring instruments used were a Marquette resting ECG analyzer (model MAC 5000) and a Pacesetter APS III pulse analyzer (model 3500).

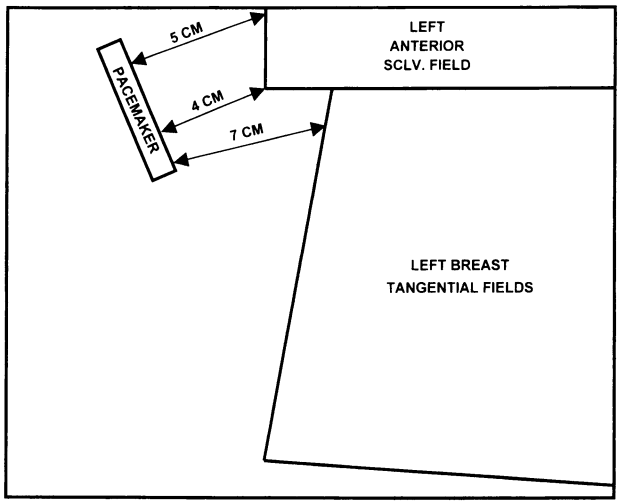


**Figure 1.** Pacemaker location in relation to the radiation treatment fields.

The pacemaker dose was monitored using: (1) 0.3 $cm^2$ × 0.1 cm-thick lithium fluoride TLD chips placed over the pacemaker site, with a 0.5-cm tissue equivalent bolus; (2) a Nuclear Associates silicon diode chamber (model 30–493-8); and (3) a Farmer type 0.6 cc ionization chamber connected to a Keithley digital dosimeter. Although the diode chamber and TLD chips are convenient in vivo measuring devices, their accuracy is inferior to that of an ionization chamber. To arrive at an accurate measurement of the dose to the pacemaker, we have decided to employ all three measuring devices.

The distance from the anterior supraclavicular field border to the pacemaker varied from 4 to 5 cm. The medial tangential field border's distance from the pacemaker varied from 7 to 14.5 cm (Fig. 1). The pacemaker was implanted 0.5 cm deep subcutaneously (Fig. 2).

To simulate dose measurement at the level of the pacemaker, a 0.5-cm bolus was used over the measuring devices. These measuring devices were

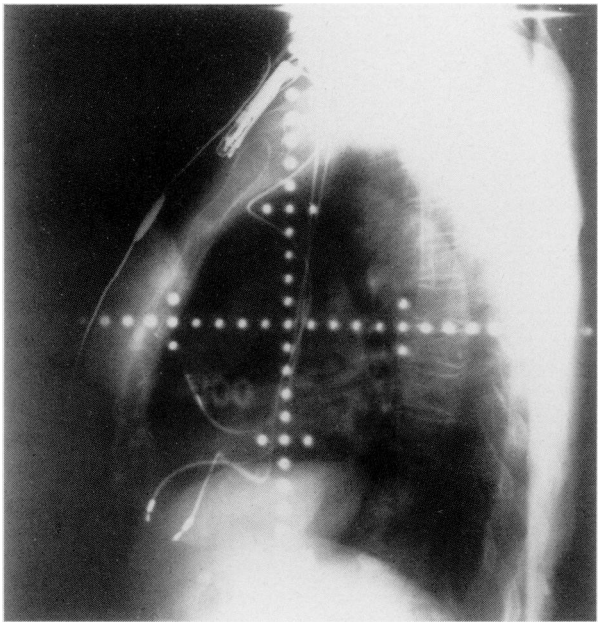

**Figure 2.** Subcutaneous location of the pacemaker.

placed on the patient's skin, directly above the pacemaker generator.

## RESULTS

All the EKG reports showed normal sinus rhythm with atrial sensing and ventricular pacing. The pulse rate varied from 60 to 86 beats per minute.

TLD measurements showed a dose of 171 cGy, the diode measurements showed a dose of 164 cGy, and the ionization chamber showed a dose of 182 cGy to the pacemaker, from all three treatment fields, over the entire course of radiotherapy.

Use of the ionization measuring device allowed for the determination of the dose contribution from each of the three treatment fields, which is as follows: 26.6% from the medial tangential field, 32.4% from the lateral tangential field, and 41% from the anterior supraclavicular field.

No shielding was used over the pacemaker. A 30-degree wedge was used for the lateral tangential field. Of the three treatment fields, the dose contribution from the anterior supraclavicular field was largest because of its close proximity to the pacemaker. The lateral tangential field contributed more than the medial tangent because the radiation beam exited on the right side of the patient, where her pacemaker was located.

## DISCUSSION

With the various advances in the management of cardiac disease, the mortality from heart disease has decreased over the years.[11] With that, more and more pacemaker-dependent patients are presenting with breast cancer. It is incumbent upon the radiation oncologist to be knowledgeable of the potential damage to the pacemaker when radiation therapy is used in the management of breast cancer. This paper describes our unique clinical experience with this type of patient and our successful management of the case.

Although the actual mechanism of pacemaker failure during radiation therapy is not known, there have been two mechanisms proposed to account for the changes observed. One possible method of failure is damage to the CMOS chip secondary to depolarization brought about by ionizing radiation. Another possible method of failure may be the corruption of a memory bit which interrupts the pacemaker software in an unpredictable way.[9] At present, there appears to be no consistent way to predict the reaction of pacemakers to radiation. Clinical observation and in vivo experiments have revealed two main types of pacemaker malfunction induced by radiation: (1) minor malfunctions posing little risk to the patient and (2) significant malfunctions posing a definite risk to the patient.[12] Minor malfunctions manifest as transient or prolonged change to "interference" or "safety" mode pacing, increases in pulse width, changes in paced rate and programming and telemetry function defects. These changes have been detected at doses as low as 200 cGy. Major malfunctions may be in the form of extreme fixed rate output, prolonged pacemaker inhibition or total shutdown. These types of malfunctions require immediate replacement of the damaged pacemaker.

The successful management of any oncology patient requires a multidisciplinary approach. In a pacemaker-dependent patient requiring radiation therapy to the breast for cancer, it is imperative that the radiation oncologist confers with the patient's cardiologist and the pacemaker manufacturer prior to initiating treatment. If the pacemaker is found to be in or close to the proposed radiation treatment fields, it is proposed that the pacemaker be relocated outside of the treatment field. Existing literature has not provided recommendations regarding the optimal distance between a pacemaker and a

radiation field edge that would minimize the dose to the pacemaker. Based on our limited experience, we have found that a pacemaker located at least 4 cm from the nearest field edge receives a dose of less than 200 cGy. Also, it is advisable that the dose to the pacemaker be measured by any available device and then recorded in the patient's chart. The dose to the pacemaker should be kept below the limit recommended by the manufacturer, in general, 200 cGy. Finally, pacemaker function and the patient's cardiac status should be monitored closely before, during, and after the course of radiation therapy. If these guidelines are followed, then a pacemaker-dependent patient with breast cancer can be treated with radiation therapy successfully, without any untoward complications.

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