Managing Respiratory Motion During Radiation Treatment of the Left Breast

Robyn Walker, RT; Janet Horton, MD; Sua Yoo, PhD
Department of Radiation Oncology, Duke University Medical Center

INTRODUCTION

Breast cancer is the most common malignancy in American women. However, with improvements in detection and treatment, more women are surviving longer. An estimated 2.4 million American women have survived breast cancer long enough to be at risk for cardiovascular disease (CVD).[1] Radiation treatment for breast cancer has been identified as a risk factor for developing CVD. Although modern radiation techniques provide lower cardiac mortality risks than older techniques, cardiovascular injury can occur.[2, 3] In particular, some studies suggest that patients treated with left-sided radiation have a higher risk of radiation-associated cardiovascular damage than patients receiving right-sided treatment.[4] Because toxicity to the heart is affected by the volume of the myocardium included in the radiation field, respiratory maneuvers, such as breath-hold on inspiration, have been tried and demonstrated to be effective in moving the heart outside of the planned treatment volume.[5]

At Duke University, appropriate patients undergoing left-sided radiotherapy for breast cancer and deemed to be at risk for cardiac toxicity are treated only on deep inspiration during breath-hold. Imaging systems on the linear accelerator along with respiratory-gating systems help radiation therapists align patients accurately for treatment, verify the position of the heart relative to the treatment fields, and monitor breathing to decrease irradiation of the heart.

CASE REPORT

A 53-year-old white female was surgically treated with mastectomy in 2007 for a 2.7-cm lesion of the left breast diagnosed as invasive adenocarcinoma. Sentinel nodes and surgical margins were negative at the time of initial treatment. The patient received five cycles of adjuvant chemotherapy. Six months later, she reported a lump in her left axilla. Twenty-one lymph nodes were surgically dissected, six of which tested positive for the recurrence of cancer. The largest metastasis was 4 cm and extended through the capsule to involve adjacent adipose tissue. Radiation of the chest wall and regional lymph nodes was recommended. The patient had a history of cigarette smoking which, added to the effect of radiation treatment, increased the risk of late CVD.[2]

Treatment

The patient was treated with radiotherapy to the chest wall and regional lymph nodes concurrently with radiosensitizing Xeloda intended to improve the efficacy of the treatment. The primary treatment plan consisted of five fields: the lateral and medial chest wall tangents and the supraclavicular, axillary, and internal mammary fields. A boost plan was added enface to the mastectomy scar. For the primary plan, the patient received a radiation dose of 50 Gy delivered in 25 2-Gy fractions. For the boost plan, she received 10 Gy over 5 fractions. Treatment was delivered on a Varian Clinac® 21EX linear accelerator equipped with the On-Board Imager® kV imaging system and an electronic portal imaging device to permit daily imaging for reproducible patient setup and positioning.

During CT simulation, two sets of scans were taken of this patient: one during free breathing and another during deep-inspiration breath-hold. For breath-hold CT simulation, the patient was coached on the technique while being monitored with the Varian Real-Time Position Management™ (RPM)

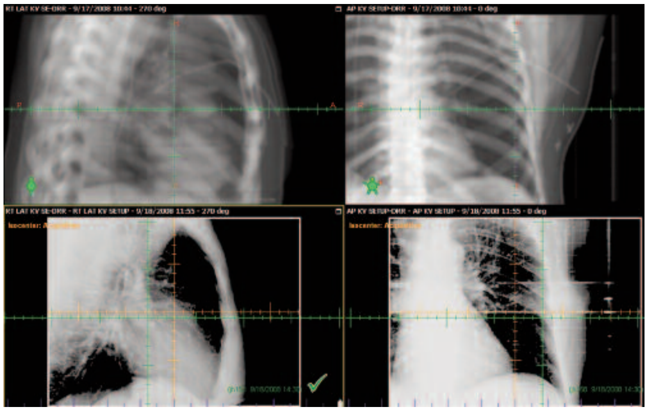

Figure 1. On the first day of treatment, we began the set-up process with orthogonal anterior-posterior and lateral kV images taken with the On-Board Imager kV imaging system to confirm the isocenter. After isocenter was confirmed, we acquired medial tangent, lateral tangent, anterior-posterior supraclavicular, and posterior-anterior axilla MV images. Field edges were matched using bony anatomy as references.

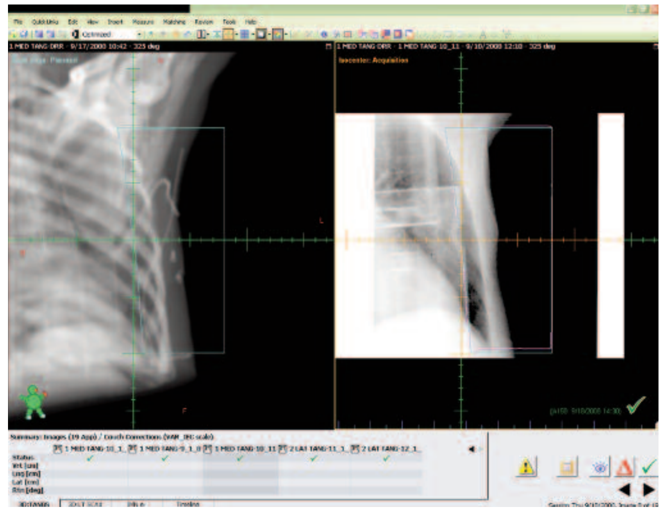

Figure 2. Medial tangent set-up image.

system. To determine the patient's most natural and comfortable breath-hold, we asked her to take a shallow breath followed by increasingly deeper breaths. This gradual assessment helped to prevent a forced or uncomfortable breath-hold that could not be easily reproduced. The free-breathing and breath-hold CTs were compared side-by-side to determine (1) if the heart appeared inside of the tangential beams in the free-breathing CT and (2) if the breath-hold could significantly spare the heart. If answers were "yes" for both criteria, we proceeded with breath-hold. This patient's heart was within the tangential beam in the free-breathing CT and showed displacement from the chest wall during inspiration. Based on these images of the heart, the physician decided that breath-hold during the treatment was necessary to protect the heart.

Daily imaging during treatment was necessary because of the many fields to match. MV and kV images of the bony structures were used to line up and position the patient. On the first day of treatment, we began the set-up process with orthogonal AP and lateral kV images to confirm the isocenter for the tangent treatment (figure 1). After the isocenter was confirmed, we acquired medial tangent, lateral tangent, anterior-posterior supraclavicular (figures 2, 3, and 4), and posterior-anterior axilla MV images. Using bony anatomy as references, we clinically matched the field edges to prevent hot spots from overlap or cold spots from gaps on the patient's skin.

Imaging on all subsequent days consisted of a medial tangent and a supraclavicular MV image that were overlaid for 2D matching. We took these images because structures at risk in these areas—especially the heart—can move with breathing. Standard MV port films of all fields were taken once a week. Daily respiratory monitoring was also critical during treatment because this patient was often short of breath and had difficulty holding her breath at times.

In addition, breath-hold verification MV images were taken in cine mode during the treatment and reviewed offline by the physician. These images provided documentation and verification that the heart was out of the field and not exposed.

In summary, our process for daily imaging was as follows:

1. Set up the patient on the breast board.
2. Set up the RPM system.
3. From outside the treatment room, instruct the patient to take a deep breath in and hold, and take the MV 2D images of the medial tangent field.
4. Compare the images to the plan images. Match the fields by lining up bony landmarks and verify that the heart shadow is out of the field.
5. Adjust patient position to make certain the heart shadow is out of the field.
6. Apply the couch shifts.
7. Treat and capture MV images during treatment in cine mode for offline review.

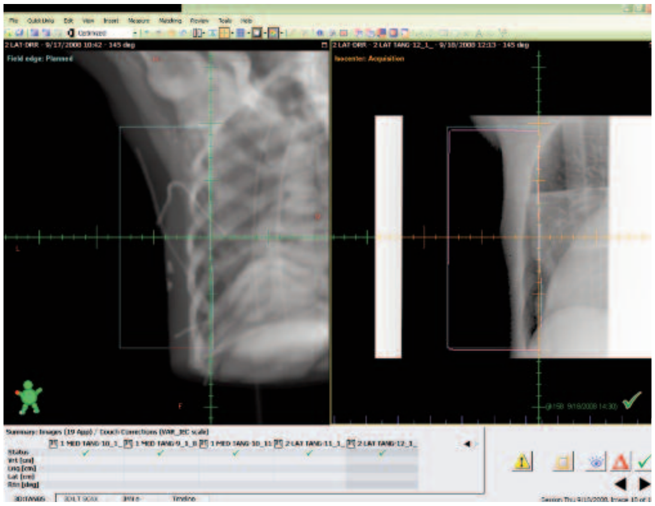

Figure 3. Lateral tangent set-up image.

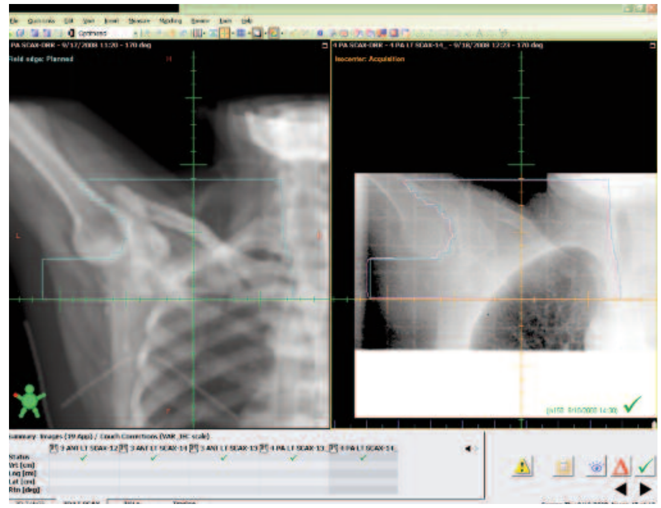

Figure 4. Anterior-posterior supraclavicular set-up image.

Results

This patient tolerated the radiation treatment well, with no side effects beyond the expected skin redness. She developed bright erythema and some small areas of desquamation by the end of her treatment. First follow-up was scheduled for three months post-treatment. As with all left-breast patients, she will be monitored for signs of disease recurrence or treatment toxicity at three-month intervals. In this case, no radiation toxicity to the heart is expected because imaging at the time of treatment showed sparing of the heart during treatment.

CONCLUSIONS

At Duke University, we have practiced image-guided radiation therapy (IGRT) since 2005, and have delivered thousands of image-guided treatments. IGRT has become the standard therapy for many sites, including treatment of the left breast. The patient in this specific instance represented a challenge for reproducible setup due to the variability of her breathing, which affected cardiac motion. The ability to image at the time of treatment and monitor the patient's breathing increased our confidence that we were delivering the planned treatment and sparing her heart from damage that could contribute to cardiovascular disease in the future.

References

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