Radiation Oncology Consultants

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ROC October 2014 Newsletter

Proton Therapy Spares Cardiac Dose in Locally Advanced Breast Cancer Patients Requiring Comprehensive Nodal Treatment

Adjuvant treatment of locally advanced breast cancer with radiotherapy is known to reduce the risk of local disease recurrence. As was discussed in the ROC September 2014 Newsletter, reduction of heart dose during breast cancer radiotherapy is an active area of research in the field of radiation oncology. When treating locally advanced breast cancer, not only does the intact breast or chest wall require radiation, but often comprehensive lymphatics including the axilla, supraclavicular fossa and internal mammary lymph nodes require radiation treatment is well. With inclusion of the internal mammary lymph nodes sparing radiotherapy dose to the heart becomes more difficult with standard radiotherapy techniques due to beam geometry and proximity of the heart to the internal mammary lymph nodes (Figure 1).

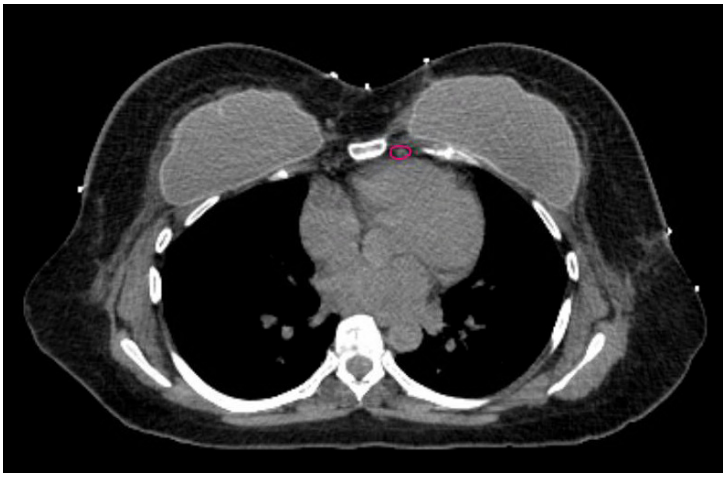


Figure 1. The left internal mammary lymph nodes, outlined in red, are in close proximity to the heart.

When treating locally advanced breast cancer patients with adjuvant radiotherapy, ROC physicians have the option of offering patients proton beam therapy to minimize radiation dose to the heart. Proton beam therapy is one type of external beam radiation therapy that uses a particle beam. Particles such as protons have mass and charge and because of these physical properties can be programmed to stop at a specified depth within tissue which spares dose to normal tissues beyond their range. Protons deposit their energy over a very small area, which is called the Bragg peak. The Bragg peak can be used to target high doses of proton beam therapy to a tumor while doing less damage to normal tissues in front of and behind the tumor (Figure 2).

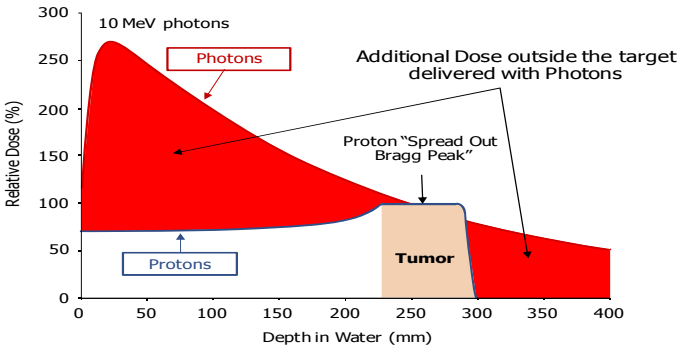
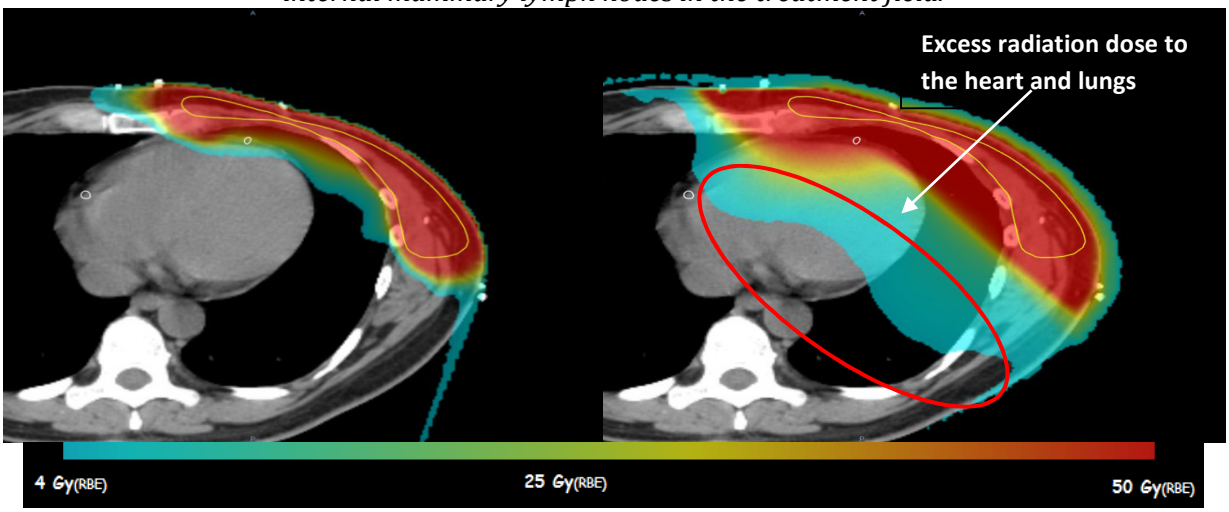


Figure 2. Depth dose curves for photons vs. protons

Proton Therapy and Breast Cancer

Recent studies have shown an increased risk of non-breast cancer morbidity and mortality in patients treated for breast cancer with older photon techniques. Utilizing protons in lieu of photons for locally advanced breast cancer can reduce or eliminate some of these potentially debilitating side effects. A study published in March 2013 in the New England Journal of Medicine that looked at patients between 1958 and 2001 using older techniques concluded that "exposure of the heart to ionizing radiation during radiotherapy for breast cancer increases the subsequent rate of ischemic heart disease. The increase is proportional to the mean dose to the heart, begins within a few years after exposure, and continues for at least 20 years."[i] Potential complications include myocardial infarction, coronary revascularization, or death from ischemic heart disease. A similar study published in the Journal of Oncology in 2006 looking at patients treated from 1970 through 2003 showed that irradiation to the left breast was "associated with an increased rate of diagnoses of coronary artery disease and myocardial infarction compared with right breast treatment."[ii] More radiation may be delivered to the heart in the treatment of left sided breast cancer versus right sided breast cancer thus this study shows that there is a direct link between more radiation to healthy tissues and organs and more serious side effects.

Figure 2: Proton Plan for Post Mastectomy Breast Cancer Patient on Left; IMRT Plan for same patient on right. This illustrates an improved heart dose in a post-mastectomy patient with inclusion of internal mammary lymph nodes in the treatment field.



The most commonly affected vessel in the heart is the left anterior descending artery (LAD). Radiation to the LAD is associated with a 2 to 7 fold increase in moderate to severe stenosis. Located on the anterior surface of the heart, the LAD is closest to the radiation beam and commonly lies within the irradiated area in patients receiving radiotherapy for breast cancer.[iii] The figure above shows the dramatic reduction in radiation that the heart is exposed to when treating with proton therapy versus conventional radiation therapy.

In a dosimetric study published in 2013, a team of radiation oncologists at Massachusetts General Hospital compared the dose distributions to critical structures of post mastectomy breast cancer patients planned with partially wide tangent photon fields (PWTF), photon / electron fields (P/E), and protons. For left sided breast cancer patients they demonstrated the ability to reduce radiation dose to the heart over 20 gray by as much as 87% with protons versus photons.[iv] Of note, none of these techniques included breath hold which is often used today.

Currently, ROC physicians are using uniform scanning proton therapy to treat breast cancer patients. Coming in early 2015, the ROCL physicians will have the next generation in proton therapy treatment technology, pencil beam scanning. In a dosimetric analysis presented at the Particle Therapy Co-Operative Group North America (PTCOG-NA) in October 2014, the pencil beam scanning plans demonstrated further improvements in dosing distribution to the heart. Additionally, with pencil beam scanning, the treatment plans generated were more uniform in their dosing distribution with fewer hot spots. Pencil beam scanning will also allow for shaping of the proximal aspect of the beam which results in relative skin sparing which should result in low rates of acute skin toxicity.

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[1] Darby, Sarah C.; Ewertz, Marianne; McGale, Paul; et al. Risk of Ischemic Heart Disease in Women after Radiotherapy for Breast Cancer. *The New England Journal of Medicine*. 2013;(104): 987-998.

[ii] Harris EER, Correa C, Hwang W-T, et al. Late cardiac mortality and morbidity in early-stage breast cancer patients after breast-conservation treatment. *J Clin Oncol*. 2006;24(25):4100-4106.

[iii] Nilsson G, Holmberg L, Garmo H, et al. Distribution of coronary artery stenosis after radiation for breast cancer. *J Clin Oncol*. 2011;30(4):380-386

[iv] MacDonald, Shannon M., Jimenez, Rachel, et al. Proton Radiotherapy for chest wall and regional lymphatic radiation; dose comparisons and treatment delivery. *Radiation Oncology*. 2013; 8:71.