Application of radiation physics to improve dosimetry in early breast cancer radiotherapy

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Radiotherapy for early breast cancer has been shown to be a highly effective treatment in a number of long term studies. The radiation dose uniformity of the current standard treatments is often poor, however, with dose variations across the breast much higher than those recommended in international guidelines. This work aimed to explore methods for improving this aspect of the radiation dosimetry of early breast cancer radiotherapy. An experimental method was validated by applying it to computed tomography data from 14 patients with a variety of breast shapes and sizes. The volume of the breast receiving the desired dose levels increased by a mean of 6.9% (range −0.8% to 15.9%) and this benefit was shown to increase with breast volume. The quality of reference images in the verification of treatments was improved by introducing differential filtering to the imaging beams on a radiotherapy simulator. The positive results from the first two studies were applied in a clinical trial (which used the experimental technique). The unique set of data from the trial was analyzed and confirmation of dosimetric improvement, and the increased benefit, for larger breasted women were found. In addition, an analysis of the position of high doses showed these occurred in the upper or lower third of the breast and affected 46% and 30% of patients, respectively, with standard treatment but only 1% of patients with the improved method. Other published methods for improving breast dosimetry were explored by building a simple physical model and carrying out a comparative planning study. The physical model was shown to be effective in predicting the dosimetric consequences of each method. The planning study showed that there was little difference between the methods generally but dosimetric improvement could be increased for larger breast volumes by an appropriate choice of technique. A final study explored how breathing control could be used to reduce cardiac doses in patients with left breast disease. This work has shown that early breast cancer radiotherapy treatments may be significantly improved by applying principles of radiation physics.