ABSTRACT

Purpose: Breast brachytherapy may be applied peripherally without piercing the skin as currently performed with interstitial and MammoSite applicators. By virtue of being a producing and delivering organ, the breast lends itself to peripheral brachytherapy by non-invasive applicators. A novel delivery system was designed by Advanced Radiation Therapy to implement the development treatment modally using real-time mammographic image guidance for stereotactic applicator positioning and CTV localization. In the design, therapeutic dose to the lumpectomy cavity is delivered by externally placing opposing plaque-like applicators at multiple orientations to provide conformity while not exceeding skin toxicity threshold. Initial assessment of the system was performed to determine clinical feasibility.

Materials & Methods: The applicator geometry comprises two curved plates which slightly compress the breast to minimize slab thickness, parallel to the opposed plaque. Within the plaque, a circle of parallel HDR 192Ir catheters spaced 1 cm apart. For a 4-cm thickness, the breast geometry and applicators were simulated using analytical (Pinnacle) treatment planning system and a commercial MCNP5 code. A breast phantom was used for CT-based treatment planning; however, conventional brachytherapy dose planning assumes an infinite water phantom. CTV ellipsoid ranged from 24.4 cm³ to 36.6 cm³. Sources were positioned within the catheters to create a circular loaded region (5-9 cm diam.) to provide uniform CTV coverage. Dose homogeneity index (DHI) for the skin was determined.

Results & Discussion: Average ratio of skin-to-tumor dose was < 0.3. Pinnacle and MCNP5 results gave DHI = unity for the CTV-studied. Dose was typically > 25 Gy, large, and other critical organs. These results suggest that the technique may be an attractive APBI option.

CONFLICT OF INTEREST

Advanced Radiation Therapy provided the applicator used in this study.

OVERVIEW

A novel system has been developed employing geometric advantage and the penetrative capabilities of HDR “flying through narrow tissue such as a compressed breast,” women with early-stage breast cancer and pathologically-confirmed negative surgical margins following lumpectomy are eligible to receive this therapy. The therapy lends itself to SBT treatments with alternating compression orientations across the breast to spare healthy tissue and minimize normal tissue complications such as desquamation. A scheme is given below illustrating how the therapy will be applied.

RESULTS

The first type of SBP applicator employed parallel plates. Simulated dose rate distributions with and without collimation at right, and uncollimated source at top; right, compare results from Pinnacle® (left) and finite element analysis (bottom), and show both good agreement and the nonuniform dose distributions using the normalized 0–9 loading pattern and relative dwell positions given in the table.

MATERIALS & METHODS

Two types of applicators were examined using Monte Carlo methods to simulate radiation transport. For both studies, the MCNP5 radiation transport code was used with the F6 energy deposition tally estimator. The voxel size was 1x1x1 mm³ for a breast compressed to 5 and 7 cm thick. The resulting breast breast cross-section was ellipsoidal with a maximum lateral dimension of 14 cm. CTV ellipsoid ranged from 24.4 cm³ to 36.6 cm³. The coordinate origin was located 7 cm from the chest wall. The 192Ir source spectrum was simulated using 44 discrete lines, and positioned where the actual source would be for therapy. Mass densities used were Pb = 11.3; ICRU 44 Breast / Lesion = 1.02; and acrylic = 1.19 g/cm³.

For the second type of applicator, a cylindrically symmetric design similar to a mammographic spot paddle was developed. Here the source design was much simpler, and used only a single collimator to control the direction of the exposure field. The field produced at each source dwell position. This feature allows unimpeded irradiation of the target volume while minimizing the superficial skin exposure. Furthermore, aperture orientation near the chest wall minimizes exposure to the heart and lungs.

SUMMARY

A novel means of applying breast brachytherapy has been developed. The apparatus described has recently received 510k clearance by the FDA. Preliminary analysis of calculated dose rate distributions may have a significant DHI, lesion conformity, and skin dose advantage over all other APBI modalities. Additional research is underway to validate these results with measurements and develop protocols for clinical implementation.