

Purpose: The attraction of Partial Breast Irradiation (PBI) is related to minimizing the potential negative side effects of radiation therapy and the potential to reduce the total effective tumor dose. Heat has also proven to be a significant radiosensitizer. In this paper, we propose a novel technique for delivering combined partial breast irradiation and hyperthermia (PBHI) to gain the added benefits.

Methods: Manufacturing of a prototype balloon applicator for PBHI delivery is currently underway at our institution. This new device will use a modified central lumen for heating of the surrounding fill solution by a removable miniaturized resistive heating element. The temperature of the fill solution will be controlled by a feedback loop system utilizing a thermocouple and proportional-integral-derivative (PID) industrial temperature controller unit. The feasibility of our system has been verified through mathematical modeling using the finite-element partial differential equation solver package COMSOL Multiphysics (COMSOL Inc., Burlington, MA).

Results: We modeled our balloon as a 6 cm diameter water filled sphere within a 20 cm diameter sphere of breast tissue. The temperature at the balloon surface was kept at 46°C for one hour. The results show a temperature at the 1 cm margin around the balloon of approximately 41°C is maintained during 30 minutes of heating. The temperature gradient between the balloon wall and the 1 cm margin is very steep due to the low thermal conductivity of the modeled breast tissue.

Conclusion: Hyperthermia, in combination with radiation, is a proven method of reducing local recurrence rates of breast cancer as an adjuvant treatment. Modeling of the proposed system confirms the viability for construction of a prototype system which is currently in development. The device will further expand the potential patient population qualifying for partial breast irradiation thus providing an enhanced treatment option with minimized side effects.