Thermobrachytherapy

Hyperthermia (HT) has been shown to improve clinical response to radiation therapy (RT) for cancer. Synergism is dramatically enhanced if HT and RT are combined simultaneously, but appropriate technology to apply treatments together does not exist.

A study of Stauffer et al. investigates the feasibility of delivering HT with RT to a 5-10mm annular rim of at-risk tissue around a tumor resection cavity using a temporary thermobrachytherapy (TBT) balloon implant.

A balloon catheter was designed to deliver radiation from High Dose Rate (HDR) brachytherapy concurrent with HT delivered by filling the balloon with magnetic nanoparticles (MNP) and immersing it in a radiofrequency magnetic field. Temperature distributions in brain around the TBT balloon were simulated with temperature-dependent brain blood perfusion using numerical modeling. A magnetic induction system was constructed and used to produce rapid heating (>0.2°C/s) of MNP-filled balloons in brain tissue-equivalent phantoms by absorbing 0.5 W/ml from a 5.7 kA/m field at 133 kHz.

Simulated treatment plans demonstrate the ability to heat at-risk tissue around a brain tumor resection cavity between 40-48°C for 2-5cm diameter balloons. Experimental thermal dosimetry verifies the expected rapid and spherically symmetric heating of brain phantom around the MNP-filled balloon at a magnetic field strength that has proven safe in previous clinical studies.

These preclinical results demonstrate the feasibility of using a TBT balloon to deliver heat simultaneously with HDR brachytherapy to tumor bed around a brain tumor resection cavity, with significantly improved uniformity of heating over previous multi-catheter interstitial approaches. Considered along with results of previous clinical thermobrachytherapy trials, this new capability is expected to improve both survival and quality of life in patients with glioblastoma multiforme [1].

1)
Stauffer PR, Rodrigues DB, Goldstein R, Nguyen T, Yu Y, Wan S, Woodward R, Gibbs M, Vasilchenko IL, Osintsev AM, Bar-Ad V, Leeper DB, Shi W, Judy KD, Hurwitz MD. Feasibility of removable balloon implant for simultaneous magnetic nanoparticle heating and HDR brachytherapy of brain tumor resection cavities. Int J Hyperthermia. 2020;37(1):1189-1201. doi: 10.1080/02656736.2020.1829103. PMID: 33047639.