INTRALUMINAL HEATING DEVICES FOR TREATMENT OF OESOPHAGEAL TUMOURS

P.M.A. van Haaren, H.P. Kok, J. Sijbrands, P.J. Zum Vörde Sive Vörding,
M.C.C.M. Hulshof, N. van Wieringen, J. Crezee
Dept. Radiation Oncology, Academic Medical Center, University of Amsterdam,
The Netherlands

Introduction: Hyperthermia (HT) treatment of oesophageal tumours using external heating devices is suboptimal in achieved tumour temperatures and in power steering capabilities. To improve HT treatment of oesophageal cancer patients we are developing intraluminal heating devices to be combined with the 70 MHz AMC-4 waveguide system.

Methods: In cooperation with Ella-CS, we developed prototypes of Hot Water Balloons (HWBs, \( \varnothing 1 \text{cm} \)), containing two channels for water circulation and one channel for a guide wire. Flow rate was set to \(~20 \text{ ml/min} \), sufficient to minimize axial temperature gradients. The temperature distribution around a HWB was calculated by solving the heat-transfer equation in cylindrical coordinates, and measured with thermocouples in a tissue-equivalent solid phantom (without perfusion), containing a hollow tube representing the oesophagus. Furthermore, we developed prototypes of microwave antennas using different types of coaxial cable (\( \varnothing 1-5 \text{mm} \)). Several antenna configurations were created, including coaxial monopoles, dipoles and helical antennas. Power distributions of the antennas were calculated analytically using antenna theory or numerically using our FDTD-based hyperthermia treatment planning system, and measured in liquid phantoms containing a LED-matrix (without tube). Temperature distributions were measured in the above mentioned solid phantom.

Results: The measured temperature distribution around a HWB (figure 1A, 1B) developed with a time constant of \(~5 \text{ min} \) and was well described by the analytical profile, with a thermal penetration depth of \(~2 \text{ cm} \) (figure 1C). Measured axial and radial power profiles of the microwave antennas were in good agreement with calculated distributions, with a power penetration depth of \(~0.5-2.5 \text{ mm} \), dependent on coax type and antenna configuration. An example of the resulting temperature distribution for a monopole is shown in figure 2A, 2B, which developed with a time constant of \(~25 \text{ min} \), and had a thermal penetration depth of \(~3 \text{ cm} \) (figure 2C).
Conclusion: Intraluminal heating devices such as hot water balloons or microwave antennas can induce an additional temperature rise in the vicinity of these probes. The focal region of the AMC-4 system is ~20 cm, so these intraluminal probes have no influence outside this region and may therefore be useful for heating oesophageal tumours in conjunction with external hyperthermia devices. Clinically applicable HWBs are available by now and will be applied in patients in the near future.

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