Numerical simulations and experimental verification of the extent of HIFU-induced necrotic lesions

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Objectives
Development of a theoretical model to predict the extent of necrosis induced locally in *ex vivo* tissue exposed to a single or multiple HIFU beam.

Methods
The proposed tool was based on the modelling of non-linear acoustic wave propagation and heat transfer in heterogeneous media using the k-wave toolbox. The wave propagation equations were solved for two-layer (water-tissue) media. The distribution of heat sources was determined from the calculated acoustic pressure distribution in the HIFU beam. The obtained temperature distributions during heating and cooling allowed to calculate the thermal dose and predict the extent of the necrotic lesion.

Results
The obtained simulation results were compared with the experimental data from previous studies. The mean difference between the numerically simulated and measured length or diameter of a single necrotic lesion was 1.37 ± 0.64 mm and 0.27 ± 0.25 mm, respectively. The axial and radial cross-sectional area of the larger cylindrical necrotic lesion (formed after multiple exposure to the HIFU beam) measured from the photos and MR images was also compared with the results of numerical simulations. The mean difference between the calculated cross-sectional area of a necrotic lesion planned for treatment, and that determined experimentally was approximately 11.2 %.

Conclusions
Due to the good agreement of the obtained results of numerical simulations with the experimental data, the applied numerical model describes well the thermal field induced locally in the examined tissue. Therefore, it can be used to optimize the planning of the treatment of solid tumors by the HIFU technique.

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