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研究论文

高强度聚焦超声可治疗区域的仿真研究

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摘要:

数值仿真不同治疗参数条件下高强度聚焦超声(high intensity focused ultrasound,HIFU)可治疗区域的变化,对HIFU治疗剂量的确定具有重要的指导意义。本文采用Westervelt 方程的近似式,结合Pennes生物热传导方程,以离体猪肝组织为例,在考虑组织声学特性对HIFU焦域温度场影响的条件下,通过时域有限差分法(finite difference time domain,FDTD)对HIFU焦域温度场进行仿真研究。研究结果表明,照射时间越长,组织声学特性的影响就越明显;焦点处的最高温升相同时,可治疗区域的大小差异较小;声强越大,形成可治疗区域所需的时间也越短;当声强一定时,随着照射时间的增加,可治疗区域的长、短轴长度均呈非线性增加;在相同可治疗区域的长轴或短轴长度一定时,输入声强和照射时间呈负相关。

关键词: 高强度聚焦超声 组织声学特性 治疗剂量 非线性 时域有限差分法

The Simulation Study of High Intensity Focused Ultrasound Therapeutic Region

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Abstract:

Numerical simulation of the variation of high intensity focused ultrasound (HIFU) therapeutic region at different therapeutic parameters has a great significance in setting HIFU therapeutic dose. In this paper, the approximation of the Westervelt formula and the Pennes bio-heat transfer equation have been used along with the finite difference time domain(FDTD) method to calculate the temperature field by taking the excised porcine liver model as an example. During the simulation, the influence of tissue acoustic properties on HIFU temperature field in the focal region has been considered. Results show that the longer the exposure time, the more obvious the influence of tissue acoustic properties, and when the peak temperatures at the focal position are the same, the size of the therapeutic regions are roughly same. Results also show that the larger the acoustic intensity, the shorter the time needed to form the therapeutic region. In addition, the therapeutic region length and diameter increase nonlinearly with increasing exposure time on a given input acoustic intensity, and, in the case of the same therapeutic region length or diameter, the acoustic intensity and exposure time express a negative correlation relationship.

Keywords: High intensity focused ultrasound Tissue acoustic properties Therapeutic dose Nonlinear Finite difference time domain

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