

传递现象

## 低温手术过程组织瞬态热应力有限元分析

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**摘要** 通过有限元分析, 给出使用同时具有冷冻和加热能力的两种新型冷刀进行低温手术过程中组织瞬态应力场, 考察“低温手术-热疗结合型冷刀”与“Endocare型氩氦冷刀”两种新型冷刀的共性和差别, 从热应力角度揭示冷刀的杀伤半径。充分考虑组织物性和内热源的非线性, 使用基于有限容积法的大型商业有限元软件Ansys双向耦合求解经典生物传热方程与应力方程。结果表明: (1) 组织内水的相变导致的体积膨胀是热应力引发的主要因素, 而温度梯度则是产生热应力的次要因素; (2) 两种冷刀在低温手术过程中均会导致相变区域内出现应力集中; (3) 低温手术-热疗结合型冷刀由于可提供更大的冻结区域, 使其经历高应力, 从而具有更大杀伤半径; (4) 低温手术过程中, 组织会发生明显的热应变。

**关键词** [低温手术](#) [冷刀](#) [应力场](#) [相变](#) [Ansys](#)

分类号

## Finite element analysis of transient thermal stress during cryosurgery

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### Abstract

The thermal stress fields of the target tissues during cryosurgery using two kinds of cryoprobe capable of both cooling and heating (the new type combined cryosurgery/hyperthermia cryoprobe and the Endocare cryoprobe) were studied comparatively. The intrinsic merits of the new type cryoprobe were revealed as compared with the Endocare cryoprobe from the point of view of thermal stress by studying the commonness and difference between these two kinds of cryoprobes. The enthalpy form of the classical bioheat equation coupled with the stress equations was solved by using the commercial software Ansys (version 7.0). The tissues were treated as nonideal materials freezing over a temperature range, and their thermophysical properties were taken as temperature dependent. Volumetric expansion associated with phase change of the tissue water appearing in this study was the main reason for the thermal stress concentration, and the thermal gradient might also have a minor effect on thermal stress. Thermal stress concentration would appear in the phase change region for both cryoprobes. The new type combined cryosurgery/hyperthermia cryoprobe could generate a much lower temperature and a wider frozen region, a much wider region that might experience stress concentration, and have a larger killing radius. Apparent thermal strain could be observed during the cryosurgery processes.

**Key words** [cryosurgery](#) [cryoprobe](#) [thermal stress field](#) [phase change](#) [Ansys](#)

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