Temperature elevation during medical diathermy

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Introduction

A thermoregulatory model is used to assess the targeted tissue heating during short wave diathermy. Moreover, the unintentional heating outside the treatment areas, in particular thermally sensitive tissues such as the eye lens, the central nervous system and the testicles is monitored.

Methods

Two types of applicators, an inductive applicator and capacitive electrodes, are used to compute the temperature elevation during the treatment of the shoulder, hip and spine in a numerical male model (NORMAN). The used thermal model is based on the Pennes Equation and has been extended by additional thermoregulatory mechanism. The blood flow and metabolic rate are elevated as a function of the local tissue temperature. Furthermore, the blood temperature is elevated by the absorbed power. On the skin/air boundary the heat transfer has been accounted for, by means of radiation and convection, as well as by the insensible loss of water and sweating. Simulations are performed for a varying electrode to skin distance of up to 4 cm, a maximum recommended output power of 400 W and an exposure time of 20 min.

Results

The core temperature elevation during the treatment was found to be marginal (<0.07°C). The optimal tissue temperature in the targeted tissue (38-40°C) is reached for most of the investigated treatment scenarios. The capacitive electrodes are heating primarily the superficial tissue, while the inductive applicator is able to heat deeper tissue. The temperature elevation in the thermally sensitive tissues is at most \( \Delta T_{\text{Testis,max}}=0.27^\circ \text{C} \), \( \Delta T_{\text{CNS,max}}=0.56^\circ \text{C} \) and \( \Delta T_{\text{Lens,max}}=0.09^\circ \text{C} \).

Conclusion

Despite the pronounced absorption of energy in thermally sensitive tissues, the temperature elevation remains below the known biological effect limits in these regions. Improved thermoregulatory modelling proved to be useful for risk assessments and can also be used to improve the efficiency of short wave diathermy.