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Irreversible electroporation of the porcine kidney: Temperature development and distribution

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Introduction: Although irreversible electroporation (IRE) does not depend on thermal energy, the application of frequent repetitive high intensity pulses has the potential of substantially heating the targeted tissue and causing thermal damage. Lethal cellular damage will occur within 4 to 6 minutes at temperatures above 50°C and almost instantaneously when temperatures reach 60°C. Since the exact effect of IRE remains unclear it is difficult to differentiate between IRE outcome and thermal damage upon histological examination. Therefore, this study evaluates the risk of possible thermal damage by measuring temperature development and distribution during IRE of a porcine kidney tissue.

Methods: In four domestic farm pigs, weighing approximately 60 kg, IRE ablation was performed on both kidneys. Four kidneys were treated with a 3-needle configuration (fig. 1A) and the remaining 4 with a 4-needle configuration (fig. 1B). All IRE ablations consisted of 70 pulses of 90µs at a timing of 90 pulses/min. The pulse intensity was set at 1500V/cm. The temperature was measured internally using 4 fiberoptic temperature probes (fig. 1) and externally (superficial) using a thermal camera.

Results: Complete ablation cycles were performed in 3 kidneys for both needle configurations. The IRE console due to a high current, exceeding the safety threshold of 50A, automatically aborted the remaining two ablations.

For the 3-needle configuration a peak temperature of 68°C was measured within the ablation zone and 50°C at 1 cm outside of the ablation zone, from a baseline temperature of 32-34°C. For the 4-needle configuration the peak temperature reached 79°C within the ablation zone and 42°C at 1 cm outside of the ablation zone, from a baseline of 32°C. The thermal camera recorded the peak surface temperatures at the core of the ablation zone, reaching 31°C and 35°C for the 3 and 4 IRE needle configuration (baseline 22°C).

Conclusion: The application of repetitive high intensity pulses during IRE ablation in porcine kidney causes a lethal rise in temperature within the ablation zone. Temperature monitoring should be considered when performing IRE ablation in the vicinity of vital structures, minimizing the risk of severe collateral damage.