Evaluation of targeting accuracy of a robotic ultrasound imaging-guided HIFU ablation device for treating solid tumors in small animals

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OBJECTIVES
Ultrasound Imaging-guided High Intensity Focused Ultrasound technique (USIgHIFU) is dynamically developing thermal technology for treating solid tumors due to its non-invasion and non-ionization nature, repeatability and minimal side effects after treatment. We have designed and built a robotic ultrasound imaging-guided HIFU ablation device for preclinical trials on small animals. Before the device is used, a series of experimental studies on tissues ex vivo were needed to evaluate the accuracy of its targeting. The objective of this studies was to estimate experimentally the accuracy of targeting using ex vivo pork loin samples embedded in a cylindrical reference chamber. The treated volume was predetermined as a small cylinder located coaxially with a chamber at a given depth below the tissue surface.
METHODS
Experiments were carried out using a 64-mm HIFU transducer with 62.6-mm focal length, operating at a 1.08-MHz or 3.21-MHz frequency and integrated coaxially with an ultrasound imaging probe mounted in its central hole. HIFU beams of a 108W acoustic power (0.3s pulse duration, 0.6 duty-factor) propagated in two-layer media: water/tissue (50mm/40mm) and focused at a 12.6-mm depth below the tissue surface were used. Multiple thermal lesions were created by moving the cylindrical tissue chamber using a computer-controlled precise positioning system. For treated cylindrical volumes of about 6mm and 10mm in diameter the ratio of necrotic lesion cross-sections to those intended for treatment was determined using different visualization methods.
RESULTS
The designated ratio for the studied cases was higher than 90%. The accuracy of targeting of the proposed device was found to be around 1 mm.
CONCLUSIONS
The developed robotic USIgHIFU ablation device created well-defined necrotic lesions in the intended targeted volume within the tested tissue without damaging surrounding tissues. It suggests that this device will be effective and useful for treating solid tumors implanted into small animals and for testing new anticancer drugs.
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Keywords
robotic HIFU ablation system, ultrasound imaging, targeting accuracy