

Feasibility of using Magnetic Resonance-guided High Intensity Focused Ultrasound (MRgHIFU) to perform ablative and hyperthermia interventions in the neck area: A preliminary *in vivo* study.

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Introduction. Tumours in head and neck represent a challenge in oncology because the important presence of critical organs in that area. A more targeted treatment is desired to reduce risks of morbidity. This paper presents preliminary results to establish the feasibility of performing ablation and hyperthermia treatments in the neck area with Magnetic Resonance-guided High Intensity Focused Ultrasound (MRgHIFU) using an acute pig model. The target audience includes research groups in the areas of interventional MRI, MRgHIFU, and therapy of head and neck cancer.

Methods. Six 17-18-kg pigs were treated in the omohyoid muscle at the middle section of the neck area. The protocol was approved by the local animal care committee (AUP 121). Experiments were performed using an MRgHIFU system Sonalleve V2 (Philips Healthcare) and a 3T Achieva scanner (Philips Healthcare). Animal was under anesthesia (Isoflurine 2%) during the procedure using a respirator with a breathing rate of 20 breaths per minute and a breathing volume of 200 mL. The head and neck of the pig was immobilized using a mold built with a foaming agent (AC 250, Alpha Craddle, North Canton, OH, USA). A custom-made water bag was used as a coupling medium between the acoustic window in the MRgHIFU system and the neck area. Thermometry maps were calculated using a technique based on the water-proton resonance frequency shift¹. Baseline temperature was measured with an optic fiber inserted in the gluteus muscle. After procedures were completed and prior to euthanasia, contrast enhancement imaging was performed using a gadolinium-based agent (Magnevist, Bayer). Lesion volume was calculated with contouring of lesions on contrast images using the Osirix software package.

Hyperthermia. The right side of the neck (Fig 1) was treated with hyperthermia with a target temperature of 41 °C during 30 minutes. A target region of 16-mm diameter and 34-mm in length was used to cover the muscle region. First 3 pigs were treated using the automatic control algorithm included in the standard Sonalleve software (V3.1.1010.343). The remaining 3 pigs were treated with a manual control of the sonication using real-time toolboxes for the control of the MRgHIFU system and MR scanner². In both groups, ultrasound frequency was set to 1.2 MHz. In the group using the manual control the acoustic power was controlled by the user and drift in thermometry caused by the static magnetic field was corrected using a 2nd order spatial-temporal compensator³.

HIFU lesions. The left side (Fig 1) of the neck was treated with a cluster of individual HIFU lesions, each with a diameter of 8 mm and a length of 20 mm. Duration of exposure of was set to 20 s and frequency to 1.2 MHz. The standard Sonalleve software (V3.1.1010.343) was used to induce the HIFU lesions.

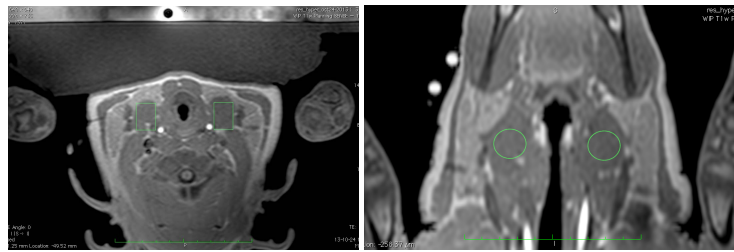


Figure1. Transverse (left) and coronal (right) plans of the middle section of the neck where treatments regions are shown by green contours. HIFU lesions were performed on the left side of the neck and hyperthermia on the right side of the neck

Plane / Method	Average temperature		Peak temperature	
	Automatic	Manual	Automatic	Manual
Focal coronal	37.3±2.6	40.3±1.8	44±4.5	42.6±0.5
Focal sagittal	38.5±2.7	39.6±1.4	52±9.8	42.5±1.8
Pre-focal sagittal	37.8±3	41±0.7	54±6.6	45±3.4

Table 1. Average and peak temperature (°C, ± s.d.) over central 20 min of treatment in the focal and prefocal regions of the treatment using the automatic and manual methods.

from 100 to 200 s.

Lesion formation. As shown in Table 1, three (3) experiments were conducted with a target power level of 110W and the 3 remaining with a power level of 140W. The number of individual lesions ranged from 4 to 12 to cover the target zone with an expected treated volume ranging from 3.52 to 10.56 mL. Experiments with a power of 110W showed very low success rate when compared to high power. One experiment at 140W developed post-focal region in the adjacent muscle. Nevertheless, the lesion volume observed in contrast imaging was inferior to the planned volume for all experiments. Exposures located in proximity of the carotid artery were unable to produce lesions regardless the applied power.

Contrast imaging and post-mortem tissue analysis. HIFU lesions were clearly observable as a reduction in contrast on the left side of the neck where HIFU lesions were intended, while no observable difference in contrast was observed in the right side treated with hyperthermia. Macroscopic analysis of tissue corroborated contrast-imaging findings. Lesions were localized at the intended targeted locations

Discussion and Conclusions. A plausible reason for the need to increase the power during hyperthermia treatments is an augmentation of the perfusion in the target zone and the relative proximity to the carotid artery. The fast decay in the temperature at end of hyperthermia treatment suggested that tissues were highly perfused. The important effect of cooling of the carotid artery was also observed in the HIFU lesion formation for exposure regions located right in proximity of that artery. Furthermore, the relative high power required to induce lesions suggest that perfusion in that region is important. However, for tumour tissue this scenario of high perfusion may not be necessarily valid. Noise in thermometry by breathing motion may be compensated using a multi-base line

correction algorithm. Results indicated that it is feasible to both induce lesions and sustain hyperthermia levels in the neck area using MRgHIFU.

References:

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