Online phase-collection based correction of MR thermometry for breast HIFU ablation: evaluation under various respiratory motion susceptibility conditions in phantom.

M. Lepetit-Coiffe, B. Denis de Senneville, P. Lourenco de Oliveira, C. Mougenot, B. Quesson, J. Palussiere, and C. Moonen

1Laboratoire IMF CNRS UMR 5231 / Universite Bordeaux 2, Bordeaux, France, Metropolitan

Introduction

High intensity focused ultrasound (HIFU) should be an efficient technique to treat tumor in the breast under real time temperature monitoring. Whereas a dedicated platform was developed for this application (1), MR temperature remained problematic under in vivo respiratory condition because of large variation of magnetic field degrading the precision of temperature (2). The proposed online phase-collection based correction of non gated MR temperature was tested in a home made respiratory mimicking phantom under various HIFU power conditions.

Material and Methods

Under breathing conditions, although no apparent motion can be detected on the anatomical images, phase vary periodically masking a temperature increase. Therefore, phase-collection based correction started with a 20 dynamics learning step during which the all images were collected; During the second step, in a non heated region of interest, the standard deviation of MR temperature, calculated by difference of the current phase image with each collected phase image should be found minimum to select the correct collected phase image, used as reference image in the calculation of temperature following the proton resonant frequency shift (PRF) method. An home made phantom was built in order to simulate respiratory conditions: 3% agar-3% silicate gel was used as detailed in the figure 1. An air cushion with a piece of same gel positioned on permitted to create cyclic perturbations of local magnetic field with various frequency and amplitude. The same HIFU protocol consisting in a fixed time and power application was applied after 120s of acquisition at the focal point without simulated respiration and without any correction; variation of temperature at focal point served as reference standard and was compared to the condition with respiration perturbations and phase atlas based correction. The MR thermometry imaging was performed simultaneously with the HIFU application using a segmented gradient echo-echo planar imaging (GRE-EPI) sequence. 6 slices were acquired each 2.1s; echo train length of 19, binomial water selective RF pulses, TR = 50 ms, TE = 25 ms, flip angle = 35, matrix = 128 x 128, FOV of 128 x 128 mm², in-plane spatial resolution of 1 x 1 mm² and slice thickness of 5 mm. Average and standard deviation (SD) of MR temperature over the all dynamics were systematically mapped. Differences between temperature variation at the focal point under correction and simulated respiration, and referenced evolution were also compared with condition without correction.

Results

Without any perturbation, SD of temperature in a non heated area was found around 1°C whereas with phase atlas based correction, it improved to 0.5°C (Figure 2). Under simulated respiration, SD deviation of temperature was 3°C and 0.5°C respectively without and with proposed correction. After a 50W–60s HIFU application, a systematic increase of temperature of about +15°C was found (Figure 3). Differences with reference evolution curve at the focal point showed systematic improvement of the SD from 3.3°C to 0.8°C.

Conclusion

Using a dedicated novel breast HIFU platform, MR temperature guided HIFU ablation was significantly improved using the phase-collection based correction. Further in vivo studies will be the next step.

References