Magnetic resonance thermometry brings hyperthermia quality assurance to the next level

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Quality assurance (QA) is defined as the systematic evaluation of system performance. In general the objective is to perform QA with the most advanced measuring tools available in order to allow a quantitative decision based on objective criteria whether a system operates according to specifications. HT applicators require formal QA to ensure accurate, precise and consistent treatments.

Most commonly used HT QA measurement techniques to evaluate hyperthermia system performance rely on temperature probes, infrared (IR) cameras, Diode E-field sheets, single E-field sensors and lamp phantoms. Although, these techniques in principle provide objective, quantitative information they have serious drawbacks for pre-treatment quality control. Limitations include invasiveness (all), a limited set of points or single plane measurements (temperature probes and single E-field sensors), poor spatial or temporal resolution (IR cameras, E-field sheets, lamps), long sampling time (scanning devices) and a limited dynamic range (lamps). As a result the decision whether a system meets the QA assurance demands, is often based on either a low number of data points covering only a small volume of the whole energy distribution or at best on a qualitative 2D registration of the E-field distribution in one of the major cross-sectional planes of the phantom.

In contrast, magnetic resonance thermometry (MRT) offers a non-invasive 3D view of temperature distribution, thereby being the only system that provides the ability to register 3D energy distribution in solid anatomical phantoms.

For the introduction of the Pyrexar BSD2000 3D MR HT applicator in combination with the GE 450w MR scanner at the Erasmus MC Cancer Institute in Rotterdam, the proton resonance frequency shift (PRFS) method was used to acquire temperature maps. We made an anthropomorphic phantom as well as several cylindrical phantoms to check different properties of the system and to match the HTP simulations to the MRT. By carefully controlling positioning the phantom in the applicator we were able to verify phase and amplitude steering resolution with the MR-compatible Sigma Eye applicator and to demonstrate it to be accurate at sub-cm level. Further, the 3D imaging of the temperature distribution in anthropomorphic phantoms with MRT facilitates investigating the sensitivity of translating hyperthermia treatment planning settings to clinically relevant conditions and resembles a major step forward in adaptive image guided hyperthermia.