COST EMF - MED (Action BM1309):
European network for innovative uses of EMFs in biomedical applications

STSM Report:

Quality assurance measurements of MR-compatible deep hyperthermia systems

Researcher: Dr. Sergio Curto
Email: s.curto@erasmusmc.nl

Home Institution: Erasmus MC Cancer Institute, Netherlands. Contact: Prof. Dr. Gerard C. Van Rhoon.
Email: g.c.vanrhoon@erasmusmc.nl

Host Institution: Ludwig Maximilians University, Germany. Contact: Prof. Dr. Lars H. Lindner.
Email: lars.lindner@med.uni-muenchen.de

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Abstract:

The Pyrexar BSD2000-3D-MRI installed in Erasmus MC is currently the most clinically used system for hyperthermia treatment of deep-seated tumours. The latest generation of this system, the Pyrexar Universal applicator, has been developed and recently installed in University Hospital of Munich, Ludwig-Maximilians University (LMU). While our applicator in Erasmus MC is installed inside the GE 450W 1.5T, the one in LMU operates inside the Philips Ingenia 1.5T.

A. Purpose of the STSM

The main purpose of this Short-Term Scientific Mission (STSM) is the realization of quality assurance (QA) measurements in LMU to evaluate the performance of the system and compare with the one in Erasmus MC, with the same set of phantoms. The Pyrexal Universal applicator consists of three rings with four dipole-pair antennas per ring. The 12 dipole-pairs operate at 100 MHz and are fed with a 12 channel DODEC amplifier capable of providing individual amplitude and phase to each antenna dipole-pair.

Before the realization of this STSM, I developed two sets of phantoms of different complexity to specifically evaluate the performance of the applicators. The first set of phantoms is a 25 cm inner diameter cylindrical homogeneous phantom. The second set of phantoms is a realistic human-shape anthropomorphic phantom containing pelvic bones and spine. Both phantoms comprise catheters to facilitate the location of Bowman temperature sensor probes. The phantoms are shown in Figure 1.

B. Work Description

Prior to the start of this STSM I sent to the host institution a detailed description of all the measurements I planned to perform. The STSM started with an in-deep discussion on the measurements I planned to carry out and the objectives of each measurement. To perform the QA measurements and facilitate a quantitative comparison with the results obtained in Erasmus MC, the measurement work flow and specific settings had to be carefully replicated.

Figure 1. Cylindrical homogeneous phantom (left) and human-shape anthropomorphic phantom (right).

The objective of the measurements performed during the first two days was the adaptation of the applicator settings to obtain a defined central heating focus. Once the applicator settings were defined, the subsequent measurements aimed at evaluating:

1. Shape of generated thermal distribution
2. Steering capabilities of the applicator
3. Quality of the magnetic resonance thermometry vs. Bowman probe measurements
4. Forward and reflected power measurements for each of the antennas; evaluated inside the MR bore and outside the MR bore for different applied powers levels
5. Signal-to-noise ratio in the phantom image with and without the applicator and with different applied power levels
6. Effect of water circulation on thermal distribution
7. Required waiting time after water in waterbolus is circulated
8. Geometrical evaluation
9. System efficiency

C. Results

The location of the focus can be selected into the Pyrexar console which controls the amplitude and phase delivered to each of the dipole-pair of the power amplifier. Measurements were performed aiming to have the focus at (0, 0) cm (center of the phantom) and also with different offsets. It was found that settings with an offset of 1 cm from the center, towards patient's right were required to obtain a focus centered in the phantom. Preliminary results indicate that for central targets, homogeneous and centrally located heating focus is achieved both for the cylindrical and anthropomorphic phantoms. Figure 2 shows the magnetic resonance temperature maps at an axial slide through the applicator center for both phantoms. The waterbolus satisfactorily covers the full exposed area of both phantoms. The four in-built fat-like references used for BO drift correction located at the top and bottom of the applicator are clearly visible. Steering capabilities were assessed in the cylindrical phantom aiming to have an eccentric focus at 3 cm towards patient left. Temperature monitoring showed that more than 3 °C higher temperature increment was reached at this location compared with the symmetric location after 600 sec. More detailed analyses are ongoing.

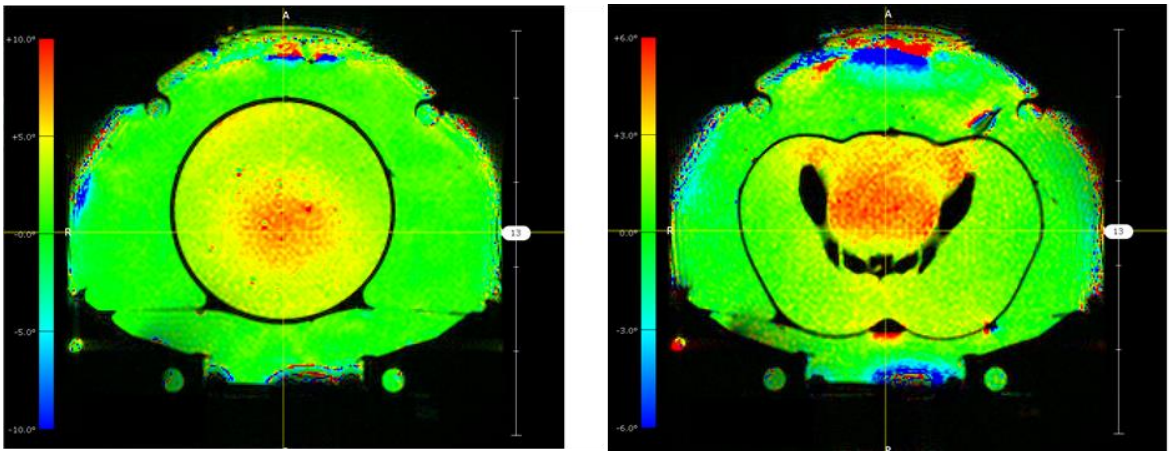

Figure 2. Magnetic resonance thermometry after 11 minutes of heating for central target with 1000W applied power for the cylindrical phantom (left) and 600W applied power for the anthropomorphic phantom (right).

D. Future collaboration with host institution

LMU has been very supportive to conduct this research. Both LMU and Erasmus MC have expressed their commitment to work together on further improving MRT monitoring in tumors located in the pelvic area. MR thermometry in the pelvic area is especially challenging due to patient movement during treatment, bowel peristalsis, internal gas movement, as well as B0 drift.

This STSM has fostered the research collaboration not only between Erasmus MC and LMU, but also with the Heinrich-Heine-University Düsseldorf, the University Hospital Erlangen and the University Hospital Tübingen, which are all the centers who perform MR-guided hyperthermia for deep-seated tumors in Europe. The personnel responsible of the Hyperthermia-MR of all institutions have expressed their interest in collaborating and work together to develop a QA guideline for MR-guided hyperthermia systems.

E. Expected Publications

An abstract has been submitted to the ESHO 2018 meeting to present the results of measurements performed during this STSM. A comparison of the data from measurements in LMU and Erasmus MC is being processed and a publication with this valuable information is foreseen. A publication with a QA guideline for MR-guided hyperthermia systems is also foreseen.

F. Other Comments

I would like to express my special gratitude to the COST Action BM 1309 EMF-MED for the support on performing this STSM. My profound appreciation to the entire hyperthermia team of LMU for their indispensable support, specially to Dr. Bassim Aklan for his enthusiasm, enriching discussions and tireless collaboration to perform all the measurements.

This STSM has provided me with an unique opportunity to increase my insight and knowledge of state of the art MR-compatible hyperthermia systems for the treatment of deep-seated tumors, and also to expand my networking and research collaborations.

I believe that this STSM will contribute to the development of universal quality assurance procedures for hyperthermia systems, and ultimately to improve cancer patient treatments.

Confirmation by the host institution of the successful execution of the STSM:

We confirm that (Researcher's Name) has performed the research work as described above.

Contact Person of Host Institution

Prof. Dr. Lars H. Lindner

Signature

Name of researcher

Dr. Sergio Curto

Signature