Microwave thermal ablation for cancer treatment

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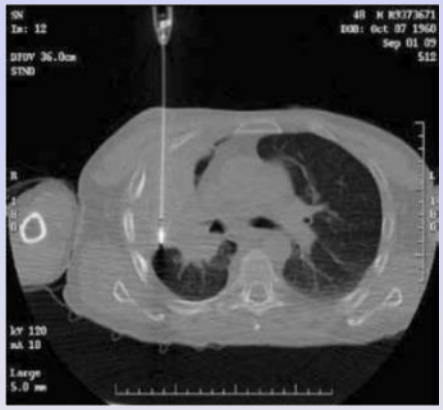
Microwave thermal ablation (MWA)

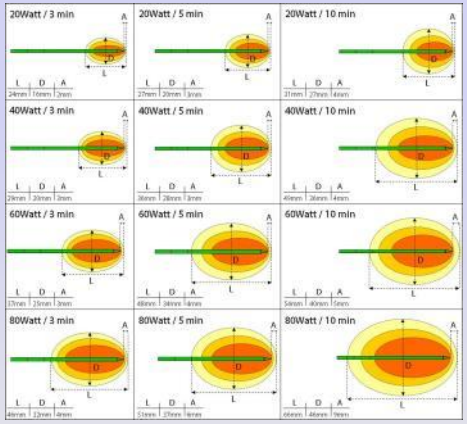
Electromagnetic energy at MW frequencies (915 MHz or 2.45 GHz) is used to achieve very high temperature increases in target tissue location (> 55-60 ° C) inducing coagulative necrosis

Clinical applications:

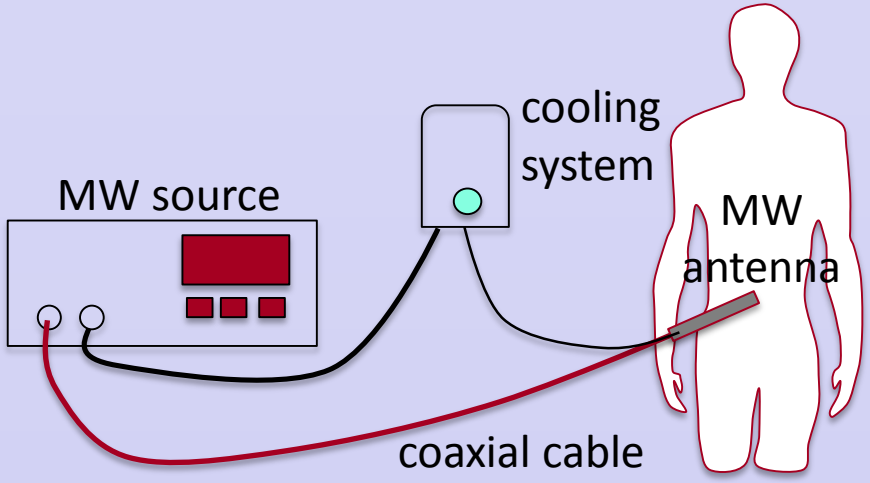
- cardiac arrhythmias
- endometrial disorders
- tumours (interventional oncology)
- …



Radiological Society of North America



Courtesy of HS Hospital Service S.p.A.



Minimally invasive technique (interstitial antennas)

MWA in interventional oncology

- Largely employed for potential eradication of hepatocellular carcinoma (HCC) and other secondary liver tumours (e.g. colorectal cancer metastasis) in non-surgical patients
- Minimally-invasive therapy by exploiting MW interstitial antennas
- Lesions up to 5-cm diameter (single-need/single ablation) can be treated by MW ablation (vs 3-cm diameter of RF ablation)
- Larger lesions can be treated by multi-probe or overlapping ablations
- About 15,000 clinical procedures (RF/MW) performed every year in Western Europe
- Over 100,000 clinical procedures (RF/MW) per year world-wide
- Rapidly increasing trend for MWA clinical procedures over last years due their outstanding coagulative performances

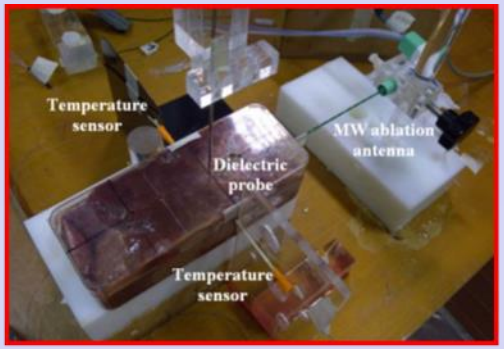
Gaps and challenges

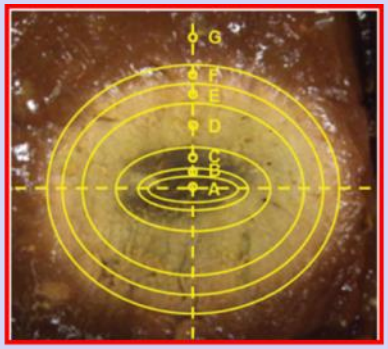
Clinical gaps
- ablation not completely predictable
- lack of standardised clinical protocols
- lack of techniques for real-time monitoring during treatment

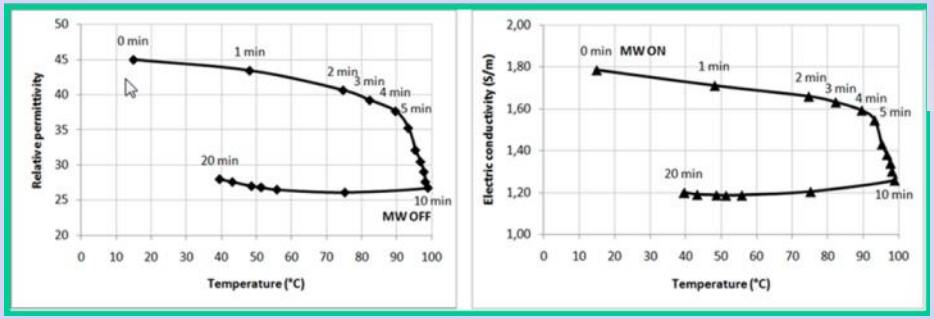
Predictive models for treatment planning
- patient-specific simulation models
- automated tools for electromagnetic model generation
- high-resolution digital models (MRI or CT)

Research challenges
- tissue properties changes with temperature
  (e.g. dielectric, thermal, morphological)
- thermal sensitivity of tissues
- inflammatory/immune response

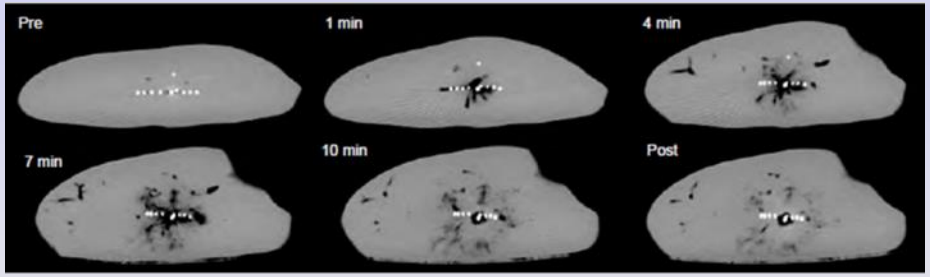
Research challenges





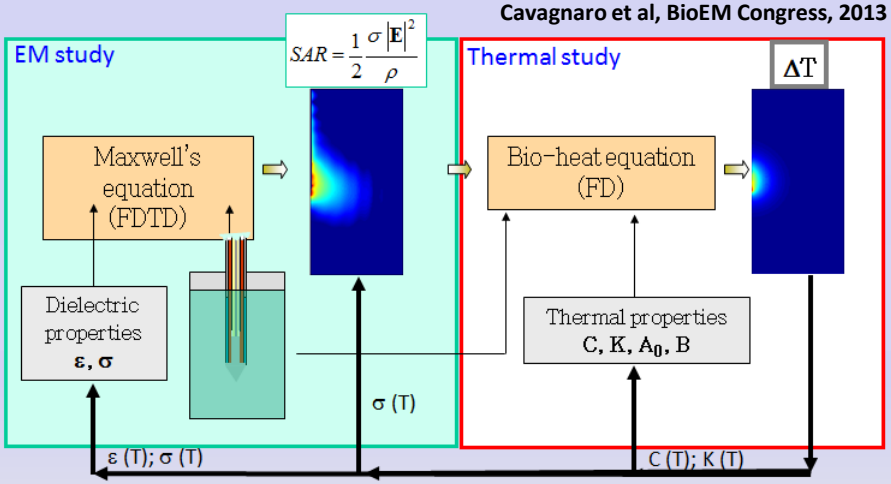


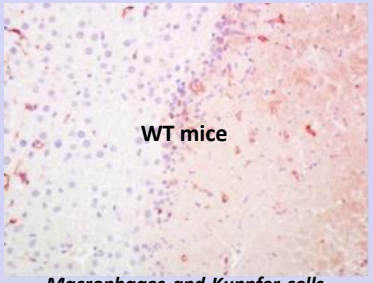
Lopresto et al, Phys. Med. Biol., 2012; Lopresto et al, Int. J. Hyperthermia, 2014



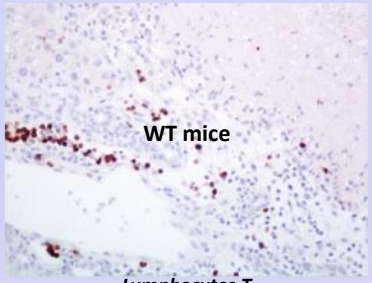
Brace et al, WCIO Conf. 2011

Cavagnaro et al, BioEM Congress, 2013

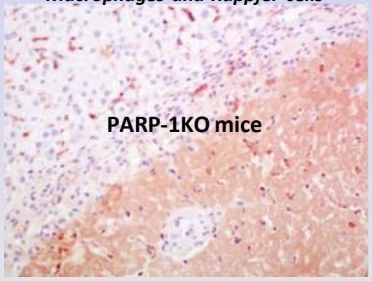


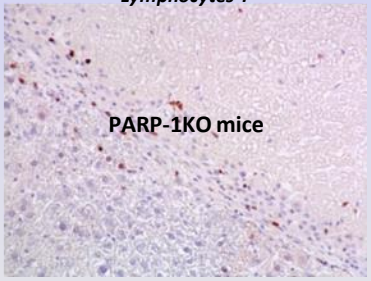


Macrophages and Kuppfer cells



Lymphocytes T





Novelli et al, ESHO Congress, 2014

ENEA/Sapienza research & collaborations

Research on predictive models for treatment planning

ENEA UT BIORAD (V. Lopresto, R. Pinto), DIET Sapienza (M. Cavagnaro)

- Experimental methodologies for characterization of RF/MW thermal ablation process
- Investigation on dielectric, thermal and morphologic properties of tissues
- Numerical predictive models for treatment planning

Research on inflammatory response induced by RF/MW thermal ablation

ENEA UT BIORAD (C. Pioli, F. Novelli)

- Inflammatory process and immune response induced by thermal ablation

HS Hospital Service S.p.A., Rome, Italy

Regina Elena National Cancer Institute, Rome, Italy

Hadassah Hebrew University Medical Center, Israel
Harvard Medical School, USA

MW thermal ablation in Europe

- About 15,000 thermal ablation clinical procedures performed every year in Western Europe
- Rapidly increasing trend for MW thermal ablation procedures
- Clinical practice and research (list is not exhaustive):
  - Italy: General Hospitals, Busto Arsizio, Dr. Solbiati
  - Spain: Clinic Liver Cancer, Barcelona, Dr. Bruix
  - France: Institut Gustave Roissy, Villejuif, Prof. De Baere
  - Germany: University Clinic, Heidelberg, Dr. Sommer; University Clinic, Tubingen, Prof. Pereira
  - The Netherlands: University Medical Centre, Amsterdam, Dr. van der Tol
  - Israel: Hadassah Medical Centre, Jerusalem, Prof. Goldberg

Scope of the WM “Microwave thermal ablation for cancer therapy”

- WM proposed within WG1
  - Build up a multidisciplinary network of experts: researchers, clinicians and technical specialists
  - Promote synergistic research on specific topics concerning microwave thermal ablation
  - Propose novel methodologies and solutions for improving clinical applications and quality assurance
- WM activity ideally developed over the Action lifetime

Goals to be achieved by the WM

- Extensive review on the state of the art of the research and clinical practice
- Establishment of new links with industrial partners, by converging academic, clinical, and industrial research
- Development of robust real-time thermal dosimetry methods for improving clinical applications
- Analyses and development of methods for the evaluation of local and systemic inflammatory responses and effects on anti-tumour immunity
- Provide inputs and recommendations for quality assurance in the research and clinical practice

Proposed research activities (1)

- Review on the state of the art of the research and of the clinical practice
- Investigation on differences in the dielectric and thermal properties of healthy and malignant tissues
- Characterisation of changes in the dielectric and thermal properties of tissues with the temperature
- Development of a comparison among different MTA techniques and frequencies used
- Investigation on thermal sensitivity of tissues and thermal dose for tissue coagulation (both *ex vivo* and *in vivo* models should be considered)

Proposed research activities (2)

- Development of robust real-time thermal dosimetry methods for improving clinical applications
- Development of methods for the evaluation of local and systemic inflammatory responses and effects on anti-tumour immunity
- Establishing minimal recommendations for quality assurance in the research and clinical practice

➢ From synergistic discussion among involved experts, further research needs could be identified and proposed for investigation

Discussion

Thank you for the attention!

Questions are welcome

QUAE MEDICAMENTA NON SANAT
FERRUM SANAT. QUAE FERRUM NON
SANAT IGNIS SANAT.
QUAE VERO IGNIS NON SANAT
INSANABILIA REPUTARI OPORTET.

(HIPPOCRATES)