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)
- ...

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


Novelli et al, ESHO Congress, 2014

WT mice

Parp1-/- mice

Macrophages and Kupffer cells

Lymphocytes T

Cavagnaro et al, BioEM Congress, 2013

EM study

Thermal study

Maxwell’s equation (FDTD)

Bio-heat equation (FD)

Delta T

Dielectric properties ε, σ

Thermal properties C, K, A, B

ε (T); σ (T)

C (T); K (T)


Brace et al, WClO Conf. 2011

Novelli et al, ESHO Congress, 2014
**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
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
Thank you for the attention!

Questions are welcome