Microwave thermal ablation for cancer treatment: clinical gaps and research challenges to develop predictive models for treatment planning

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ABSTRACT

Microwave thermal ablation (MWA) procedures for the treatment of cancer rely on very high temperatures obtained in the target tissue (55-60°C at minimum) through the absorption of electromagnetic energy at microwave (MW) frequencies (typically 915 MHz or 2.45 GHz) in order to induce an irreversible thermal damage. MWA has remarkably developed in the last years, showing many promising advantages for local treatment of soft-tissue pathologies as tumours, with minimally invasive applicators. [1-5].

In tumours ablation procedures, MWA treatment planning is based on the definition of the MW power to be radiated by the antenna and on the time of irradiation needed to achieve an ablated zone sufficiently wide to cover all the cancerous tissue plus a safety margin of about 5 - 10 mm [6]. Yet, several factors influence the outcome of MWA procedures, as the radiation properties of the antenna applicator, the dimension and position of the tissue to be treated, its composition (e.g. whether it is a fatty or muscle tissue), the presence of blood vessels, and so on. To reduce the uncertainties related to MWA treatment procedures, the development of personalized protocols could be very useful. However, up to know, many factors have not been studied in detail so that the ultimate planning of a MWA procedure is still left to the experience of the physician; this leads to relatively high recurrence rates and weaken the reliability of the technique which consequently limit the spreading of such a procedure [7],[8]. In particular the changes in the dielectric, thermal and morphological properties of tissues due to the very high temperatures reached during a MWA treatment are directly linked to the electromagnetic power absorption and to the corresponding temperature increase achieved in the target zone [9-11]. Deeper understanding of these phenomena could allow the development of optimised ablation antennas and of predictive tools for personalised treatment planning in clinical practice [12],[13] exploiting also the availability of high-resolution digital models (e.g. from MR or CT scanners) and automated tools for the EM model generation.

This presentation will give an overview of the recent studies devoted to the characterization of the dielectric, thermal and morphological properties of tissues during MWA, underlying the research that is still needed in order to fill the knowledge gaps and help improving clinical protocols design and real-time temperature monitoring.

Collaborations within a multidisciplinary network of experts (researchers, clinicians and technical specialists) are essential to tackle the different aspects of a MWA treatment, which involve clinical requirements as well as physical and engineering aspects, biological insights and so on.

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