Microwave Dosimetry and Medical Imaging: a Fruitful Round-trip Story

Jean-Charles Bolomey(1) and Milica Popovic (2)
(1) Paris Sud University, France, bolomey@supelec.fr
(2) McGill University, milica.popovich@mcgill.ca

This paper provides a historical and technical overview of the round-trip interactions between dosimetry, especially specific absorption rate (SAR) measurement, and microwave-based medical imagery. Both applications are sharing the common feature of dealing with interactions between microwaves and biological structures. They differ in the way microwaves are considered, either as an *effector* on tissue properties (dosimetry) or, reciprocally, as a *sensor* of these properties (imaging). The full story started in the late 1970s within the framework of a dosimetry research project conducted at the Walter Reed Army Institute, aiming to quantify the power absorbed by isolated organs. The early transmission absorption images of these organs produced for that purpose can be now considered as the birth event of microwave-based medical imaging [1]. Then, speculating on specific dielectric contrasts, microwave imaging started a long pursuit toward clinical acceptance [2]. In the same time, the importance of dosimetry was increased at the measure of the development rate of wireless devices for their possible effects on human health. In fact, imaging and dosimetry methodologies remained totally distinct, until the emergence of probe array instrumentation [3]. This paper explains how dosimetry, after triggering the start of microwave imaging, is, in return, now profiting of the technology [4] and the algorithm [5] know-how gained in the field of medical microwave imaging.

The first practical attempted methodology rapprochement between imaging and dosimetry was held in the mid-1980s at Supelec with early experiments conducted by means of a planar microwave camera designed for biomedical imaging. This camera was successively used for characterizing the field and, hence, the related SAR, induced by microwave hyperthermia applicators or mobile phone mockups in plane phantoms [6]. Combining the spirit of near-field antenna testing and medical imaging techniques, the field in the phantom can be indeed retrieved from a limited number of measured data, either by back-propagation or inverse source reconstruction, depending on the phantom shape complexity.

This paper reports the impact of such near-field techniques in the rather utmost conservative standard dosimetry community, which has to face an urgent need for speeding up the currently time-consuming standard characterization procedure that is based on a mechanical scan of the probe in the phantom, especially for newly developed multi-configurations wireless devices. The use of different invasive and noninvasive probe array technologies and related SAR reconstruction algorithms options are discussed, compared and illustrated thanks to examples of fast SAR measurement equipment recently introduced on the market. This hope and intention behind this paper is to attract the interest of the imaging community towards the current dosimetry needs and challenges.

References

1. L.E. Larsen, and J. H. Jacobi, "Medical Applications of Microwave Imaging," IEEE Press Books, Order Nb. 01941, pp. 3-11, ISBN 0-87942-196-7, 1985.
2. N. Nikolova, "Microwave biomedical imaging," Wiley Encyclopedia, Electrical and Electronic Engineering, pp. 1–22, DOI: 10.1002/047134608X.W8214, published on-line April 25, 2014.
3. J.Ch. Bolomey and F.E. Gardiol,"Engineering Applications of the Modulated Scatterer Technique," Artech House, 2001.
4. J.Ch. Bolomey, "Technology-Based Analysis of Probe Array Systems for Rapid Near-Field Imagery and Dosimetry," 8th European Conference on Antennas and Propagation (EUCAP), The Hague, April 6-11, 2014, pp. 3760-3764.
5. R. Chandra, H. Zhou, I. Balasingham and R.M. Narayanan, "On the Opportunities and Challenges in Microwave Medical sensing and Imaging," IEEE Trans. on Biomedical Engineering, 62, 1667–1681, 2015.
6. A. Joisel, D. Picard, O. Merckel, V. Monebhurrun and J.Ch. Bolomey, "Real time Monitoring of Microwave Fields Induced by Portable Phones in Biological Phantoms", 30th European Microwave Conference (EUMC), Workshop on Microwave Imaging, Paris, October 2000.