Exploration of Novel Contrast Agents for Functional Imaging Using Microwave Tomography

Cameron Kaye*(1), Joe LoVetri(1), Amer Zakaria(1) and Anastasia Baran(1)
(1) University of Manitoba, Winnipeg, MB, Canada

Microwave tomography (MWT) or microwave imaging spectroscopy (MIS) has been studied as a promising low-cost portable alternative or complementary biomedical diagnostic technique for conventional soft-tissue imaging modalities for several years. The ability to quantitatively reconstruct unique, diagnostically useful properties of the tissue of interest (i.e. the permittivity and effective conductivity) at safe, non-ionizing frequency ranges without the need of a contrast agent has been among MWT's frequently quoted advantages, especially in the context of its most developed application in breast imaging. However, recent large-scale studies characterizing the ultra-wideband dielectric properties of freshly excised breast tissues have shown that the contrast between malignant breast carcinoma and normal fibroconnective/glandular tissue is inherently low (M. Lazebnik *et al.*, Phys. Med. Biol. 52, 6093–6115, 2007), making it clear that this emerging technology could benefit from the use of exogenous contrast agents that selectively accumulate in cancerous tissues. This concession has spurred interest in the study of conventional and novel contrast agents in the field of microwave imaging, with recent publications employing microbubbles (S.C. Hagness *et al.*, Phys. Med. Biol., 54, 641–650, 2009), single-walled carbon nanotubes (S.C. Hagness *et al.*, IEEE Trans. BME, 57, 8, 1831–1834, 2010), and magnetic nanocomposites (O.M. Bucci *et al.*, IEEE Trans. BME, 58, 9, 2528–2536, 2011) demonstrating encouraging results. A broad study of contrast agents, including compounds traditionally employed in nuclear medicine procedures (albeit using their radioactively-inert isotopic counterparts) and other conventional anatomical imaging modalities, is conducted to assess their feasibility for microwave imaging. The search is expanded to explore not only tumour markers, but any organic or non-organic chemical compounds whose distribution within live tissues could yield useful functional, physiological information. Examples include potassium analogues (rubidium, cesium), tracers for inflammation and rapid cell division (gallium, flurodeoxyglucose), tissue oxygenation markers (nitroxide and trityl radicals), blood pool agents (gadolinium-based complexes) and functionalized magnetic nanoparticles (iron oxide nanocrystals). Such chemical species with favourable complex permittivity measured in solution over a frequency range of interest are evaluated as potential MWT contrast agents for *in vivo* imaging applications based on similar criteria that govern their selection for other modalities. These criteria include chemical stability and water solubility, pharmacological half-life and method of clearance, ease of administration, cost and availability, and selectivity of the agent's biodistribution. The compound should demonstrate sufficient cellular uptake to significantly affect dielectric contrast in tissues of interest and most importantly, exhibit no biological toxicity at the concentrations required to obtain said contrast.