10.3.1 Hyperthermia Therapy for Cancer Treatment

Numerous clinical trials worldwide have studied hyperthermia as an auxiliary therapy in combination with radiation therapy and/or chemotherapy for cancer treatment in European countries since 1970 (Kim, 2012). Unlike healthy tissues, cancerous cells are not capable of surviving high temperatures (Aspasio et al., 2016a). Hyperthermia is aimed at heating targeted tissues between 41°C and 46°C, leading to loss of membrane integrity, reduction of cancer blood flow and vessel destruction, and ultimately tissue necrosis (Frenkel, 2008). Moreover, the increase in tumor temperature can alter the permeability and fluidity of the plasma membrane and cause protein denaturation, allowing greater oxygen and chemotherapeutic drugs uptake by these cells, potentiating the effect of treatments by radiotherapy and chemotherapy, respectively, thus leading to a cytotoxic effect in tumor cells (Jiang et al., 2011; Cui et al., 2014). The increase in temperature during treatment can kill tumor cells not only by thermal stress, but also by potentiation of ionizing radiation and chemotherapeutic drugs (Cui et al., 2014; Wust et al., 2002). All of these mechanisms work together for an efficient treatment. Therefore, healthy cells do not suffer any nonreversible damage and no significant side effects are shown for this treatment (Jiang et al., 2011; Arcos et al., 2003; Shah et al., 2010a). Hyperthermia treatment can be categorized as localized and regional. Localized hyperthermia involves microwave antennae applicators, ultrasound beans, small magnetic seeds, and radiofrequency plate applicators to destroy the cancerous cell (Cherukuri et al., 2010). For regional hyperthermia, the most common technique is the application of hot water (Aspasio et al., 2016a). However, it exposes large areas of healthy tissues to temperature elevation and causes risks and systemic physiologic responses (Aspasio et al., 2016a). In this aspect, the usage of localized hyperthermia has been more emphasized, mainly through the use of magnetic seeds (Baronzio and Hager, 2006; Oleson and Dewhirst, 1983).

Magnetic hyperthermia is based on a mechanism of magnetic nanoparticles converting external electromagnetic energy from an oscillating external magnetic field to thermal energy/heat originating from (1) the magnetic hysteresis loss process during reorientation of spins causing an irreversible magnetization, and consequently conversion of magnetic energy into heat (Shliomis, 1963), or (2) by frictional losses due to the rotation of the particles in an environment with sufficiently low viscosity, allowing for the conversion of mechanical energy into heat (Aspasio et al., 2016a; Hergt et al., 1998). Both mechanisms depend on the thermal conductivity and heat capacity of the medium surrounding the material, and consequently weaken and/or destroy cancer cells while preserving healthy ones (Alcaide et al., 2012). Therefore, if magnetic nanoparticles are placed inside a tumor and the patient is placed in an oscillating magnetic field of adjusted intensity and frequency, only the tumor temperature will rise.