Magnetic mediators for ultrasound theranostics

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The theranostics paradigm is based on the concept of combining therapeutic and diagnostic modalities into one platform to improve the effectiveness of treatment. Combinations of multiple modalities, enabled by nano- and micron-sized mediators, provide numerous medical advantages. Ultrasounds are used in many biomedical applications, such as imaging and therapy, therefore they are the perfect candidate for theranostic treatment.

Hyperthermia is one of the earliest medical applications of ultrasound. The efficiency of ultrasound heating can be improved by using mediator materials called sonosensitizers, materials that enhance the attenuation and dissipation of acoustic energy. Herein, we propose the use of magnetic nanoparticles as sonosensitizers owing to their biocompatibility, nontoxicity, and common use in various medical applications. We showed that sonosensitizers improve heat generation in tissue-mimicking phantoms due to the increase in ultrasonic attenuation.

Recently, a lot of effort has been put into combining more modes of heating into one treatment. Multimodal hyperthermia provides a better alternative to a single heating method. We showed that the application of dual sono-magnetic heating gives better results than either of them used independently. The advantage of the sono-magnetic bimodal treatment lies not only in the cumulative heating of target volume, but also in the synergistic interaction between the two mechanisms. Ultrasound sonication can improve the thermal effect of magnetic hyperthermia through the unblocking of the Brown relaxation mechanism.

Unfortunately, multimodal approaches remain limited, due to difficulties associated with the lack of accurate control of their therapeutic efficiency. Thus, we propose the use of ultrasound transmission tomography (UTT) measurements to track nano mediator-based ultrasonic heating. Our results showed that UTT is sensitive to the presence of magnetic nanoparticle-based materials and induced temperature rises.

References:

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