Supplemental Material

Influence of coil geometry, supply conditions and nanoparticle heating properties on magnetic hyperthermia in mouse models

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Table S1. List of the physical properties of the tissues and organs in the mouse model considered in the analysis (σ: electrical conductivity, ρ: density, C_p: heat capacity k: thermal conductivity, W: tissue-blood perfusion rate, Q_m: specific metabolic heat generation rate) [1-3].

Tissue	σ [S/m]	ρ [kg/m^3]	C_p [J/(kg·K)]	k [W/(m·K)]	W [kg/(s·m^3)]	Q_m [W/m^3]
Brain cavity	0.234	1045.5	3630	0.513	10.218	11883.7
Midbrain	0.234	1045.5	3630	0.513	10.218	11883.7
Cerebellum	0.66	1045	3653	0.506	14.078	16373.1
Cerebral hemisphere	0.239	1044.5	3695.8	0.547	13.956	16230.6
Cerebral spinal fluid	0.178	1007	4095.5	0.573	0	0
Spinal cord	0.234	1075	3630	0.513	3.016	2669.3
Ethmoid bone	0.004	1908	1312.8	0.32	0.334	295.5
Eye vitreous humour	1.55	1004.5	4047	0.595	0	0
Eye aqueous humour	1.55	1004.5	4047	0.595	0	0
Eye sclera	0.62	1032	4200	0.58	6.861	6073.3
Eye lens	0.345	1075.5	3132.8	0.433	0	0
Eye cornea	0.62	1061.6	3615	0.539	0	0
Lacrimal glands	0.481	1027.5	3512.5	0.443	26.206	23196.9
Ear auditory canal	0	1.2	1003.7	0.027	0	0
Thymus	0.175	1023	3043.4	0.336	4.422	3914.6
Pharynx	0	1.2	1003.7	0.027	0	0
Trachea	0.342	1080	3568	0.487	0.661	585.4
Hypophysis	0.481	1053	3687	0.514	16.304	14432.3
Diaphragm	0.355	1090.4	3421.2	0.495	1.889	2662.5
Lung	0.105	394	3886	0.387	2.764	2446.4

Heart	0.381	1080.8	3686	0.558	19.403	42640.2
Stomach	0.164	1088	3690	0.525	8.762	7756.3
Oesophagus	0.164	1040	3500	0.527	3.457	3060.2
Liver	0.221	1078.8	3540.2	0.519	16.24	10712.9
Large intestine	0.164	1088	3654.5	0.542	14.567	12894.0
Small intestine	0.164	1030	3595	0.493	18.494	16370.2
Spleen	0.293	1089	3596	0.534	29.665	26258.9
Kidneys	0.403	1066.3	3763	0.535	70.796	19247.7
Adrenal glands	0.481	1027.5	3512.5	0.443	26.206	23196.9
Bladder	2.95	1023.6	4178	0.56	0	0
Uterus	0.391	1104.5	3676	0.527	8.841	7825.7
Vagina	0.164	1088	3654.5	0.542	1.865	1651.3
Rectum	0.164	1088	3654.5	0.542	14.567	12894
Urethra	0.232	1101.5	3306	0.462	3.623	3207.1
Blood vessels	0.232	1101.5	3306	0.462	2.891	2558.8
Fat	0.057	911	2348.3	0.211	0.521	461.5
Glands	0.481	1027.5	3512.5	0.443	26.206	23196.9
Bones	0.004	1908	1312.8	0.32	0.334	295.5
Bone marrow	0.002	980	2065	0.192	0.514	455.3
Intervertebral discs	1.01	1099.5	3568	0.487	0.673	596
Connective tissue	0	1026.5	2372.4	0.395	0.668	591.4
Nails	0.004	1908	1312.8	0.32	0.334	295.5
Muscles	0.355	1090.4	3421.2	0.495	0.701	988
Nerves	0.265	1075	3613	0.49	3.016	2669.3
Cartilage	1.01	1099.5	3568	0.487	0.673	596
Skin	0.17	1109	3390.5	0.372	2.064	1827.1
Tendons	0.368	1142	3432	0.469	0.579	512.9
Tumour	0.8	1045	3760	0.51	9.973	31872.5

Table S2. Analysis of the influence of the uncertainty in the most impactful tumour properties (electrical conductivity σ, thermal conductivity k and tissue-blood perfusion rate W) on the average and maximum temperatures observed in the tumour, and relative temperature increases.

Case	σ [S/m]	k [W/(m·K)]	W [kg/(s·m^3)]	T_{avg} [°C]	T_{max} [°C]	ΔT_{avg} [°C]	ΔT_{max} [°C]
Reference	0.8	0.51	9.973	40.53	41.53	3.75	4.6
T+	0.88	0.459	8.976	40.74	41.88	3.96	4.93
T-	0.72	0.561	10.97	40.29	41.17	3.51	4.25
T++	0.96	0.408	7.98	41.03	42.33	4.25	5.38
T--	0.64	0.612	11.97	40.11	40.9	3.32	3.98

- The "reference case" corresponds to the results obtained for configuration #1, when using FeO@citrate (JHU) NPs uniformly distributed in the tumour with an iron concentration [Fe] equal to 1.25 mg/cm^3. The supply current has a peak amplitude of 100 A and a frequency of 150 kHz. In the manuscript, the results relative to the "reference case" are shown in Fig. 4a.
- In "case T+" the electrical conductivity is increased by 10%, whereas the thermal conductivity and the tissue-blood perfusion rate are decreased by 10%. These variations in the tumour properties lead to a greater temperature increase with respect to the reference case.
- In "case T-" the electrical conductivity is decreased by 10%, whereas the thermal conductivity and the tissue-blood perfusion rate are increased by 10%. These variations in the tumour properties lead to a reduced temperature increase with respect to the reference case.
- In "case T++" the electrical conductivity is increased by 20%, whereas the thermal conductivity and the tissue-blood perfusion rate are decreased by 20%. These variations in the tumour properties lead to a greater temperature increase with respect to the reference case.
- In "case T--" the electrical conductivity is decreased by 20%, whereas the thermal conductivity and the tissue-blood perfusion rate are increased by 20%. These variations in the tumour properties lead to a reduced temperature increase with respect to the reference case.

References

[1] IT'IS Foundation, Tissue Properties, https://itis.swiss/virtual-population/tissue-properties/overview/ (accessed: December 2023).

[2] A. Trakic, F. Liu, S. Crozier, Transient temperature rise in a mouse due to low-frequency regional hyperthermia, Phys. Med. Biol., 51 (7) (2006), pp. 1673–1691.

[3] A. Attaluri et al., Magnetic nanoparticle hyperthermia enhances radiation therapy: A study in mouse models of human prostate cancer, Int. J. Hyperthermia, 31(4) (2015), pp. 359–374.