SUPPLEMENT

The analysis presented here describes the models we have constructed which allow the theoretical prediction and comparison with lab data of the temperatures in saline samples exposed to high intensity E-fields. An expression for bath temperature as a function of saline concentration is possible with consideration of the 0.5 mL bath geometry, physical material properties and their variation with temperature, and a reasonable thermal model for the Eppendorf tube in air. Simple models can be constructed [33] using the electrical equivalent circuit of Fig. S1. Using the model of Fig S1, the real power delivered to the saline medium as a function of saline conductivity, σ_{sal}, at a frequency f, shows the dissipation power peak at a saline conductance of

$$\sigma_p \cong 2\pi f \varepsilon_0 \varepsilon_{sal} \quad , \qquad \text{(S1)}$$

where ε_0 and ε_{sal} are the dielectric constants of free space and saline respectively. Historically, at 13.56 MHz the peak conductance has been estimated as 0.06 S/m. A modified model is now presented which compares well with laboratory data collected for saline bath heating in small plastic Eppendorf tubes with the EM heating system.

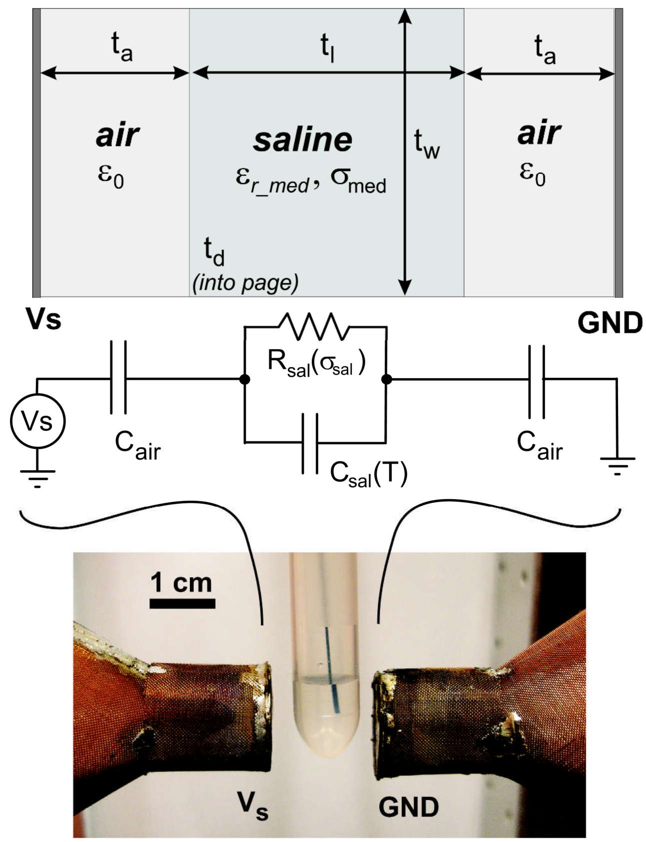

Fig. S1. Macroscopic modeling of the E-field exposed sample in a non-contact RF-EM system. A 0.5 mL sample is shown between two 1cm diameter electrodes; a fluoroptic sensor measures temperature post-heating.

A custom tester has been built, calibrated and implemented to measure saline bath conductance, σ_{sal} (S/m), as a function of concetration, c_{sal} (mol/L). This relation appears to be approximately linear as expressed by

$$\log_{10}(\sigma_{sal}) = 0.9292 \log_{10}(c_{sal}) + 0.8885 \quad , \qquad \text{(S2)}$$

and produces less than 10% error with lab data in the range of 0.0002M to 0.154 M (largest error at bottom of range). With consideration for the cylindrical bath geometry of the Eppendorf tube, the effective saline bath electrical resistance as a function of saline conductivity, $R_{sal}(\sigma_{sal})$, and the saline bath electrical capacitance as function of temperature, $C_{sal}(T)$, can be easily estimated. The relationship between temperature and the relative dielectric constant of saline, ε_{r_sal}, can be approximated in the range between 0°C and 100°C with the expression for water from Ellison et al. [44] given by

$$\varepsilon_{r\_sal}(T) = 0.0006T^2 - 0.3857T + 87.822\,, \qquad \text{(S3)}$$

where T is in units of Celsius.

Following again the simple circuit of Fig. S1 the voltage $V_{sal}(\sigma_{sal},T)$ can be described as a function of the driving voltage V_s, the air coupling capacitance C_{air}, with $R_{sal}(\sigma_{sal})$ and $C_{sal}(T)$. This squared voltage magnitude, P_{sal}, is related to the power dissipation in the saline bath as

$$P_{sal}(\sigma_{sal},T) = \frac{1}{2}\left(\left|V_{sal}(\sigma_{sal},T)\right|\right)^2\left(\frac{1}{R_{sal}(\sigma_{sal})}\right), \qquad \text{(S4)}$$

and is abbreviated as P_{sal} below. This rate of heat production is translated into a temperature using simple heat transfer relationships. This is justified by examination of a simple lumped capacitance thermal model (LCTM) and the unitless Biot number (hL/k, where the tube convection coefficient is ~30 W m^{-2} K^{-1}, L is the equivalent length, or approximately 0.001 m, k is the saline bath thermal conductivity, 0.6 W m^{-1} K^{-1}). Since the Biot number is much less than 1 (the bath heat conduction is much greater than the external convective heat loss, P_{conv}), the LCTM is reasonable. To account for the convective heat loss from the Eppendorf tube, we used both lab measurements and FEA models to estimate a peak loss of 0.66 W at a peak dissipative power of 3.8 W.

The power balance can then be represented by a piecewise linear, LCTM as

$$P_{sal} - P_{conv} = \rho\, vol_{sal}\, C_w\left(\frac{\Delta T(\sigma_{sal})}{\Delta t}\right), \qquad \text{(S5)}$$

where ρ is the saline density, vol_{sal} is the saline volume, C_w is the specific heat for water, and $\Delta T(\sigma_{sal})$ is the change in saline temperature over a time period Δt. Rearranging and scaling the result to the peak temperature rise condition, the complete expression for saline bath heating is

$$\Delta T(\sigma_{sal}) = \frac{P_{sal}}{(P_{sal})_{peak}}\left(\frac{(P_{sal} - P_{conv})_{peak}}{\rho\, vol_{sal}\, C_w}\right)\Delta t\,, \qquad \text{(S6)}$$

where the factor in the bracket is the rate of temperature rise per second at the peak heating condition. This factor is 1.35° C s^{-1} for the peak heating case and a saline bath conductivity of 0.04 S m^{-1} (as shown in Fig. 4 of main text).