Exposure to high-powered microwave frequencies may cause brain injuries

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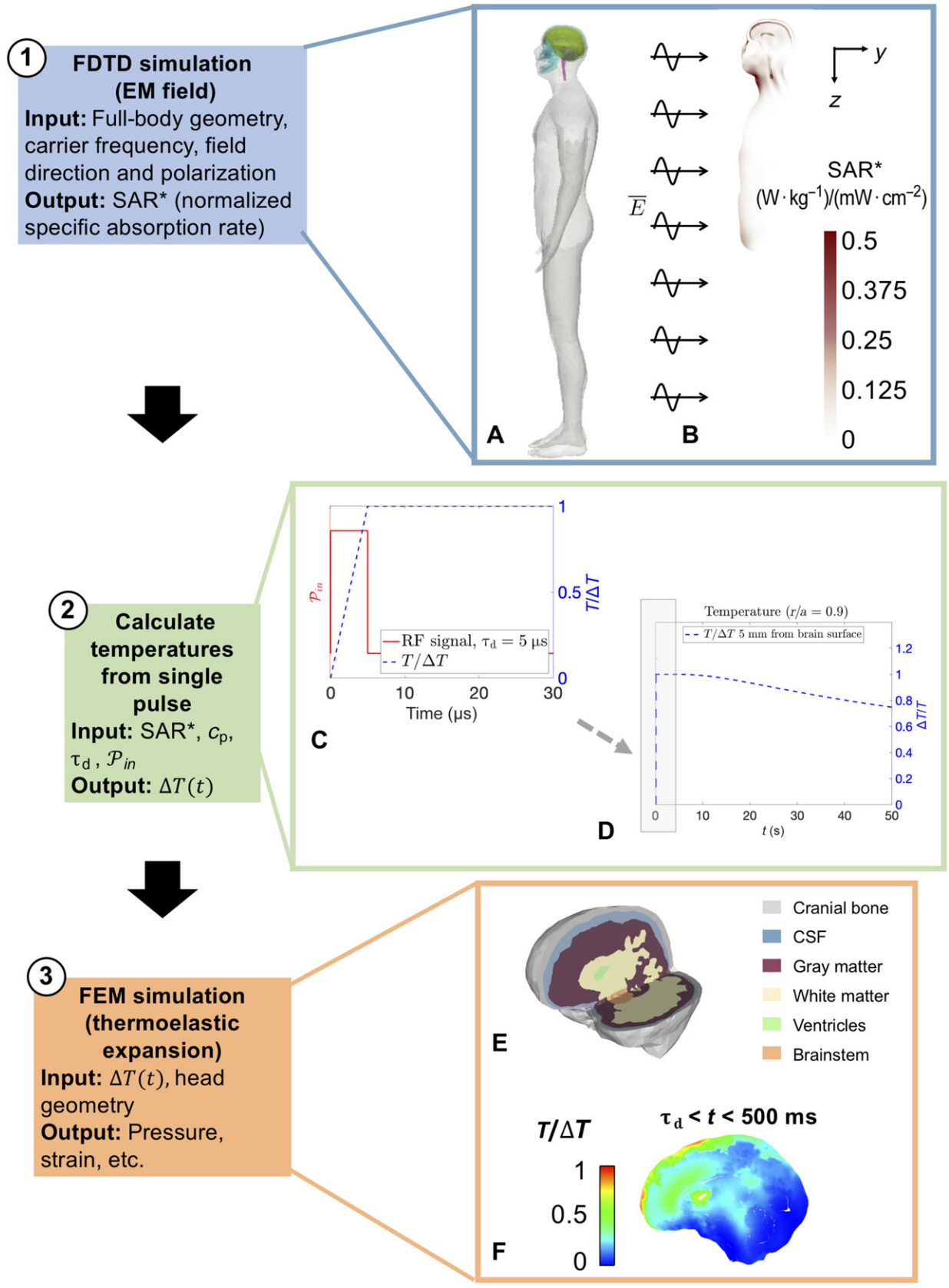
1
FDTD simulation (EM field)
Input: Full-body geometry, carrier frequency, field direction and polarization
Output: SAR* (normalized specific absorption rate)
A
B
$\overline{E}$
y
z
SAR*
$(W \cdot kg^{-1})/(mW \cdot cm^{-2})$
0.5
0.375
0.25
0.125
0
2
Calculate temperatures from single pulse
Input: SAR*, c_p, τ_d, $\mathcal{P}_{in}$
Output: $\Delta T(t)$
$\mathcal{P}_{in}$
RF signal, $\tau_d = 5$ μs
$T/\Delta T$
Time (μs)
C
Temperature ($r/a = 0.9$)
$T/\Delta T$ 5 mm from brain surface
t (s)
D
3
FEM simulation (thermoelastic expansion)
Input: $\Delta T(t)$, head geometry
Output: Pressure, strain, etc.
E
Cranial bone
CSF
Gray matter
White matter
Ventricles
Brainstem
$T/\Delta T$
$\tau_d < t < 500$ ms
F

Flow chart of the computational approach. First, a simulation of full-body irradiation with microwaves (A and B) is used to find the normalized SAR (SAR*) within tissues. The SAR* values are used to compute temperature changes (C) and registered as initial conditions to a 3D FEM. At the end of the pulse duration (e.g., $\tau_d = 5$ μs), the temperatures are maintained constant in the FEM simulations because of the slow time scales of thermal conduction, as shown by the idealized approximation of cooling at the surface from a single pulse in (D). The FEM (E) is prescribed as temperature initial conditions for computation of the early time (