Simulation of a Magnetic Induction Method for Determining Passive Electrical Property Changes of Human Trunk Due to Vital Activities

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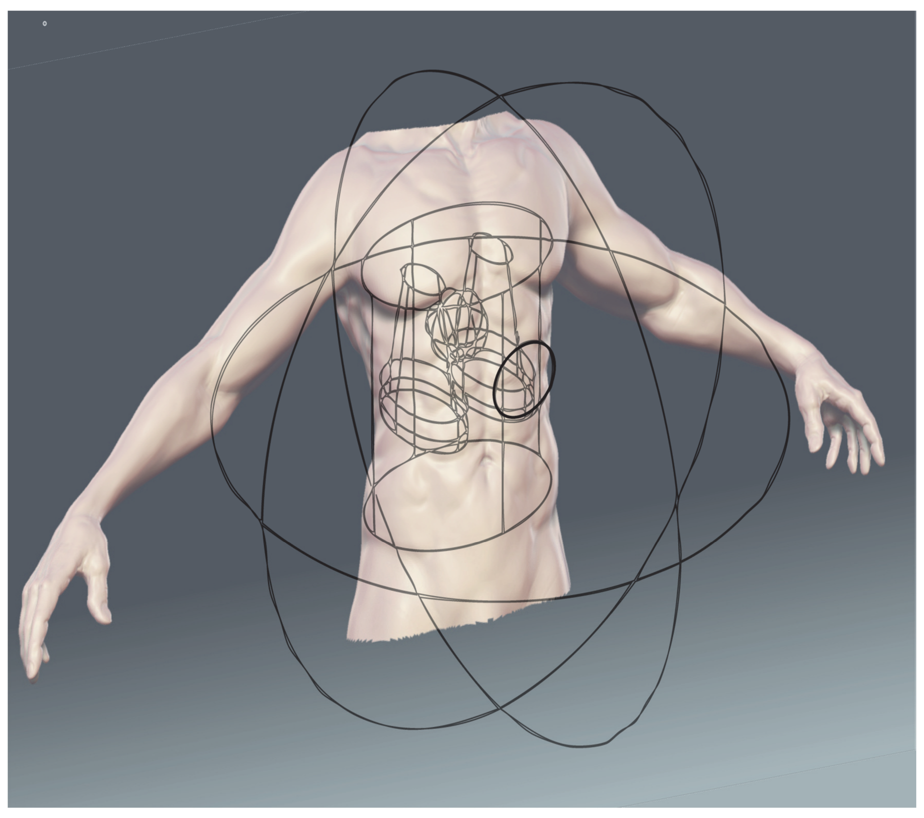
Objective:
To evaluate the feasibility of a Magnetic Induction method for monitoring Breathing and Cardiac activity.



Methods:
The method is based on the creation of a primary magnetic field that will produce eddy currents in the trunk, these currents will produce a secondary magnetic field that has to be detected somewhere around the trunk [1]. This measured signal is a function of the conductivity and geometry of the tissue and the geometry of the excitation and detection antennas. For a sample of material between an excitation coil and a sensing coil:

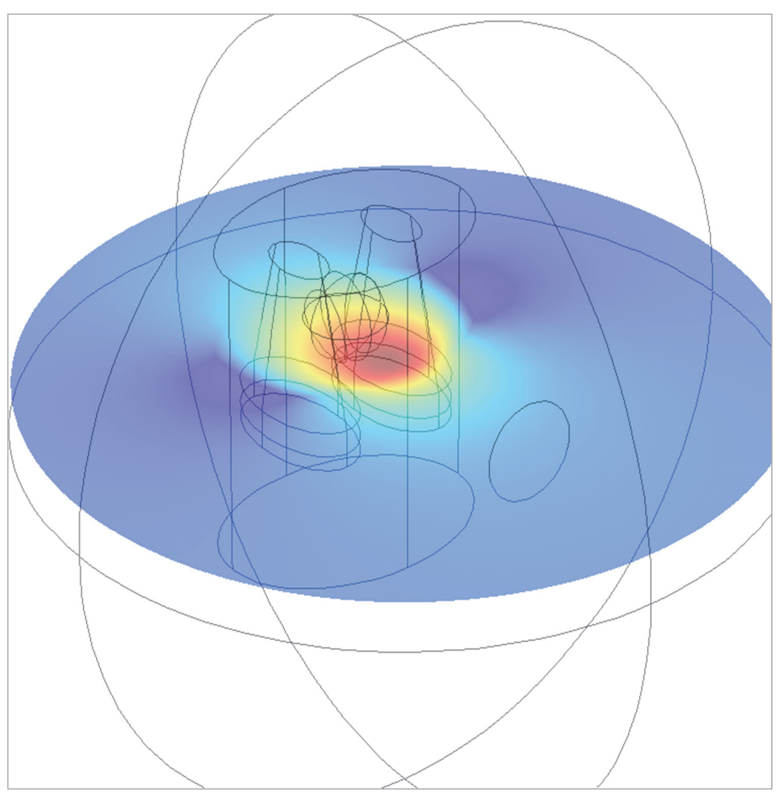
$$\Delta B / B \propto \omega(\omega\varepsilon_0\varepsilon_r - j\sigma)$$

And using the Magnetic Fields interface, the main governing equations are:

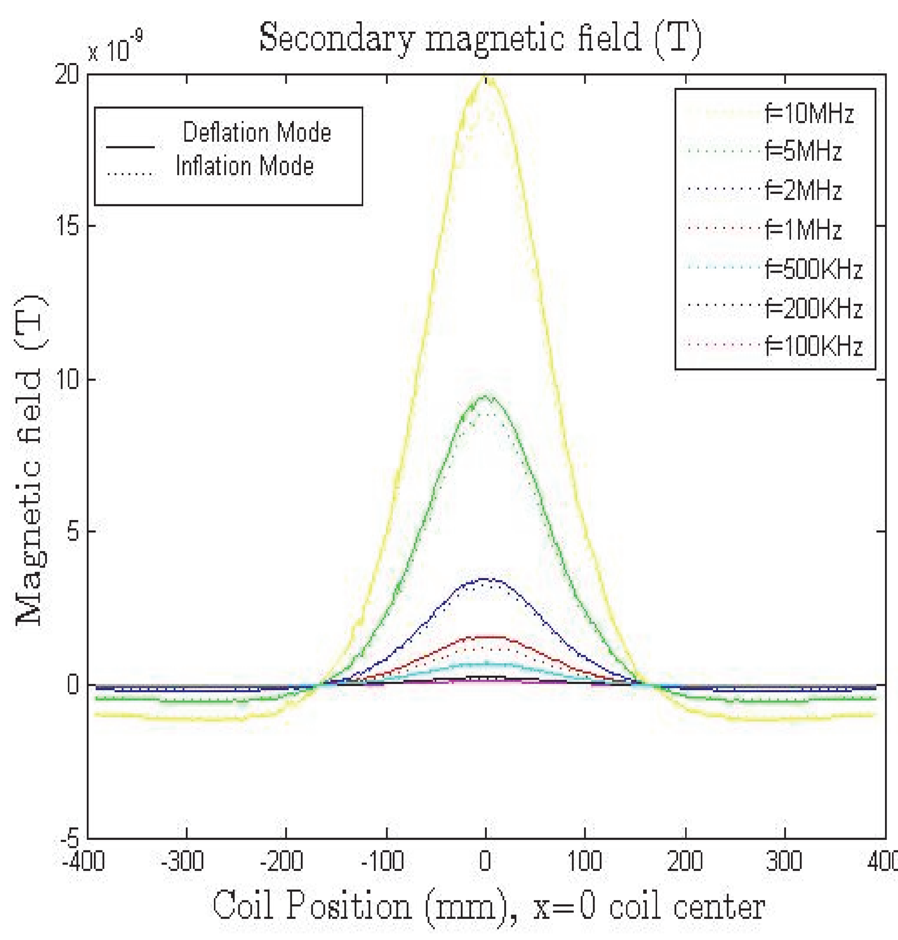
$$B = \nabla \times A$$

$$\left(j\omega\sigma - \omega^2\varepsilon_0\varepsilon_r\right)A + \nabla \times H = J_e$$

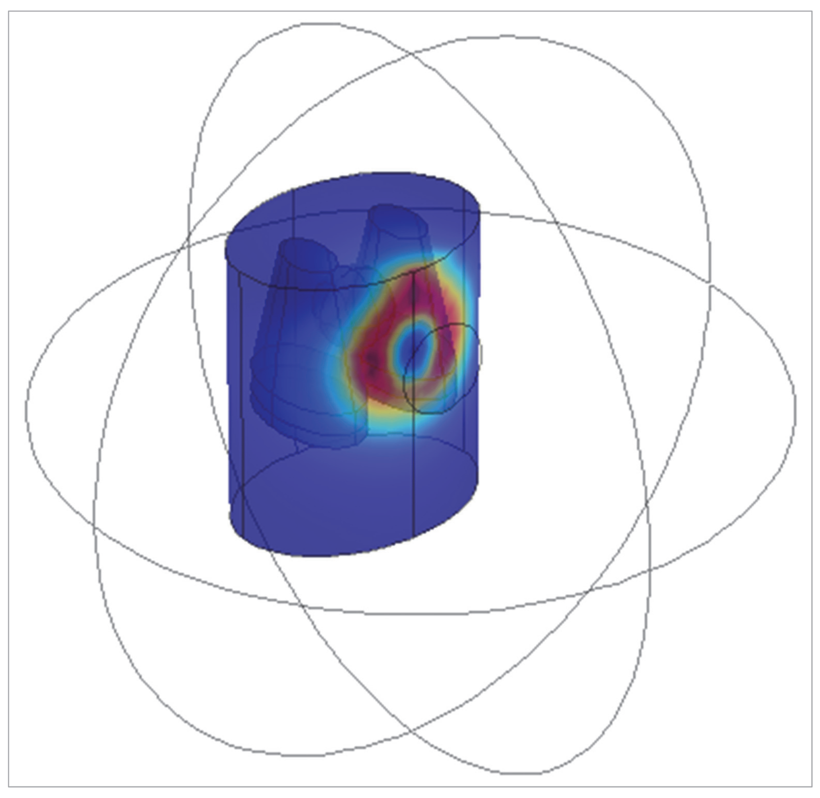
Results:
The induced eddy currents produced a secondary magnetic field, proportional to the properties of the tissues and the geometry.
The secondary magnetic field detected at the same plane where the excitation coil is located, increases as frequency rises. Since the conductivity of lungs is lower when inflated, the secondary magnetic field is lower in this mode.

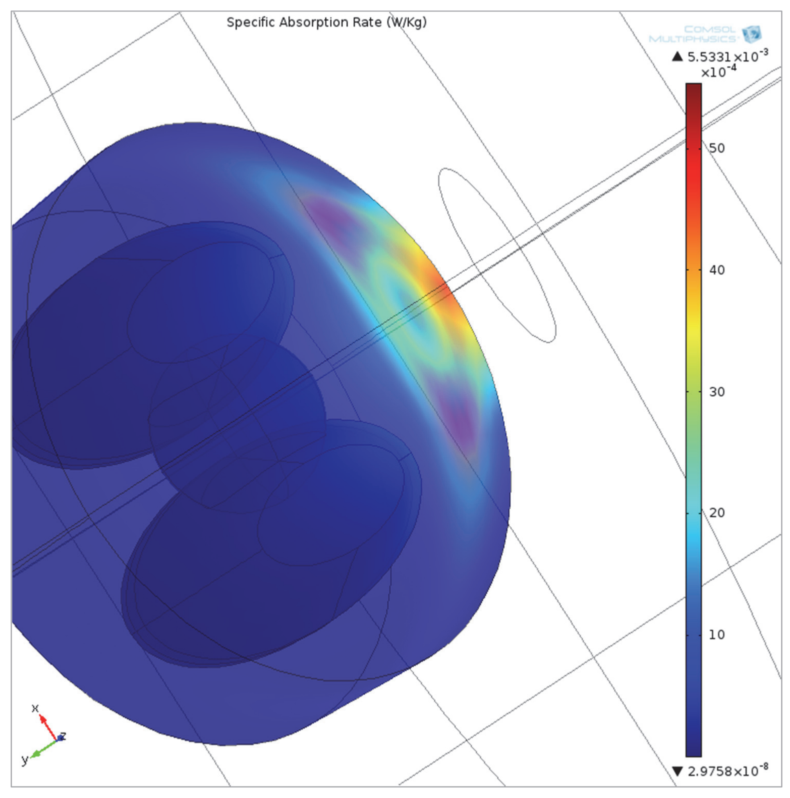


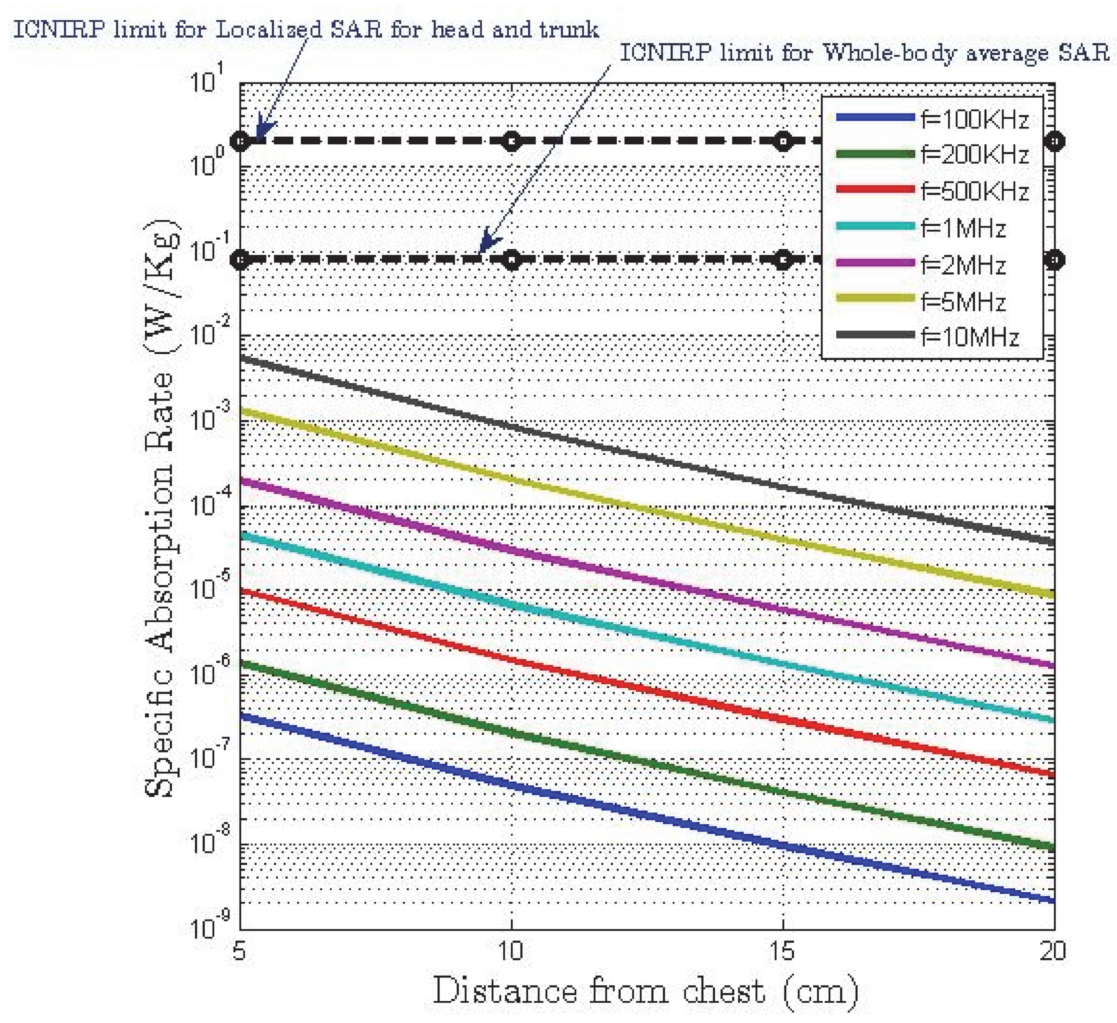
Induced Current Density in a Section of trunk



Specific absorption rate (SAR) has been calculated to ensure the safety of the system according to the international standards [2].
As shown, the SAR value is highest close to the surface of the body and decreases when the distance between excitation coil and the trunk increases.
The results show that, even considering the worst case for exposing to the magnetic field, the maximum absorption rate is orders of magnitude less than the safety standard's limits.







Conclusions:
Results show that the changes in the passive electrical properties of the lungs during breathing produce a noticeable change in the secondary magnetic field detected in the excitation plane.
In addition safety issues have been studied to fulfill the international standards for limiting exposure to magnetic fields.

References:

1. H. Griffiths, W. R. Stewart, and W. Gough, "Magnetic induction tomography. A measuring system for biological tissues.," Annals Of The New York Academy Of Sciences, vol. 873, no. 1, pp. 335–345, 1999.
2. International Commission on Non-Ionizing Radiation, "ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)," *Health Physics*, vol. 74, no. 4, pp. 494–522, 1998.