Extremely Low Frequency Magnetic Field Effects on Microcirculation and Circulation

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Abstract

Experiments by our lab indicate that specific pulsed extremely low frequency magnetic field (Cnp -complex neuroelectromagnetic pulse) exposure is effective in providing analgesia in various species. In this experiment, Cnp and 60Hz sinusoidal (100, 200, 500μT) effects on blood flow and pressure were investigated in rats using Doppler flowmetry and aortic insertion of a pressure catheter. Thirty-sixty min of 200μT Cnp exposure on blood flow had no effect; remaining analyses are pending. These findings further highlight the specificity of the Cnp and contribute to the larger, inconsistent data pool of magnetic field effects on microcirculation.

1. Introduction

The circulatory and microcirculatory systems are important for the maintenance of proper health and conversely they are often implicated in various disease states. The ability to locally or systemically manipulate blood flow and blood pressure would be advantageous in controlling a variety of medical problems, including wound healing, re-perfusion-ischemia, hypertension, and others. The effects of magnetic fields of various intensities and forms on blood flow and blood pressure have been investigated by several labs, although results are mixed [1].

Previous experiments by our lab indicate that exposure to a specific pulsed extremely low frequency magnetic field called the complex neuroelectromagnetic pulse (Cnp) is effective for providing analgesia in a variety of species. The main objective of this research, thus, is to determine how exposure to the Cnp alters blood flow and blood pressure, and ultimately determine whether these potential effects can be used therapeutically.

2. Methods

2.1. Methods – Blood Flow

The *extensor digitorum longus* (EDL) hind-limb muscle of 103 male Sprague-Dawley rats was surgically exposed. Individual rats were placed within a set of Helmholtz-like coils (1.2 m diameter for the coil that generates the vertical low frequency magnetic field), and laser Doppler flowmetry was used to assess blood flow directly from the EDL surface. The Cnp is characterized by a 200 μT peak (400 mT/s), and 5 pulse segments (each 853 ms) with a dominant frequency of 72 Hz that are each separated by an increasingly long refractory period (110-1200 ms).

Blood perfusion measurements were made at three time-points: ‘Time 0’ (prior to Cnp/corresponding sham exposure), and 30 and 60 min after the start of exposure (‘Time 30’ and ‘Time 60’ respectively). Acetylcholine (Ach), in one of three concentrations (0.1, 1, or 10 mM), was used to create a deviation from normal blood flow (vasodilation), and was dropped on the EDL at the start of each blood flow recording. The Time 30 and 60 peak blood flow values in response to Ach were normalized to the Time 0 peak values. At the end of the experiment, rats were euthanized.

2.2. Methods - Blood Pressure

To elucidate the above data, blood pressure was measured simultaneously to blood flow in a set of animals via insertion of a pressure transducer (mounted in a catheter) in the right aorta. The same experimental procedure and timeline detailed in Methods 2.1 was followed. At each time-point where blood flow was measured, a blood pressure (mmHg) recording was also made. Cnp intensities of 100 µT, 200 µT, and 500 µT (peak) were tested using this model, as was a 60 Hz sinusoidal field of 100 µT, 200 µT, and 500 µT (peak) for comparison.

3. Results

A mixed design ANOVA was performed to test the effects of 200 µT Cnp exposure on blood flow, using time as a repeated measure. There was a significant difference in peak blood flow response across the 3 tested time points ($p < 0.001$), where the Time 60 values were lower than the Time 30 values. Also, as expected, there was a significant interaction between Ach concentration (positive control) and length of exposure ($p < 0.05$). Of main interest, there was no significant interaction between time, Ach concentration, and exposure type, nor was there any main effect of exposure type. Analysis of the blood pressure and other data is pending at the time of abstract submission.

4. Discussion and Conclusion

After both 30 and 60 min of 200 µT Cnp exposure, no effect on peak blood perfusion response was found. A very small effect size was observed (0.2 %), thus we can confidently report that even by increasing the power of the study, no meaningful effect would be reported. In light of this null finding, additional experiments and analyses are on-going to rule out potential confounds; analysis of the blood pressure data will strengthen this finding. Overall, these results are important in that one potential 'side-effect' of magnetic field exposure to this particular sequence seems unlikely. Furthermore, these findings help highlight the specific effects of the Cnp and contribute to the larger pool of data in the literature, which is inconsistent, involving the effects of magnetic fields on circulation and microcirculation.

5. Acknowledgments

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6. References

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