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MetroHealth Medical Center

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Abstract Submission Form

Poster Title: **Closed-Loop Multimodal Neuromodulation of Vagus Nerve for Control of Heart Rate**

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Category: **Physical Medicine and Rehabilitation/Cardiac Physiology**

The use of neuromodulation for autonomic regulation requires the ability to both up-regulate and down-regulate the nervous system. Kilohertz frequency alternating current (KHFAC) is a proven technique for blocking action potential conduction to reduce neural activity. KHFAC can be reliably modulated by adjusting the amplitude of the signal. Stimulation of autonomic nerves at frequencies in the range of 1-30 Hz has been well established and titrating the effect has been previously attempted by modulating amplitude. However, frequency modulation of vagus nerve stimulation (VNS) has been shown to provide a more robust response, allowing for more precise control of heart rate. Although there are many types of commonly used closed-loop controllers, many conventional methods do not respond well to long system delays or discontinuities. Fuzzy logic control (FLC) is a state-based controller approach is that can describe the discontinuities of the system linguistically and then translate the state transition to a continuous output signal.

Using these approaches, a bipolar electrode was placed on the rat vagus nerve and controlled by a fuzzy logic controller regulating both stimulation and KHFAC to control heart rate. The FLC was able to modulate the applied stimulation and /or block maintain the heart rate at a constant value in against a physiological perturbation, as well as change the heart rate to a desired setpoint on-demand. This would be valuable clinically to maintain a stable, desired heart rate during cardiac events, as well as being able to modulate heart rate to accommodate intentional changes, such as when exercising. This demonstrates the efficacy of using a single electrode on the vagus to modulate heart rate, as it is able to both up- and down-regulate vagus activity to reach a desired setpoint. The use of frequency modulation to titrate the stimulation effect proved to be successful, and the blocking effect was varied effectively with amplitude modulation. The use of a single, standard bipolar electrode aids in the technique's clinical viability, as this is a much less invasive procedure than other neuromodulatory cardiac treatments, such as neural endpoint ablation. Clinical implementation of advanced controller paradigms can be accelerated by well-tested and standardized platforms. As such, our intention is to eventually port our findings to the COSMIIC HORNET platform to facilitate clinical translation.