Restoration of breathing after drug overdose and spinal cord injuries

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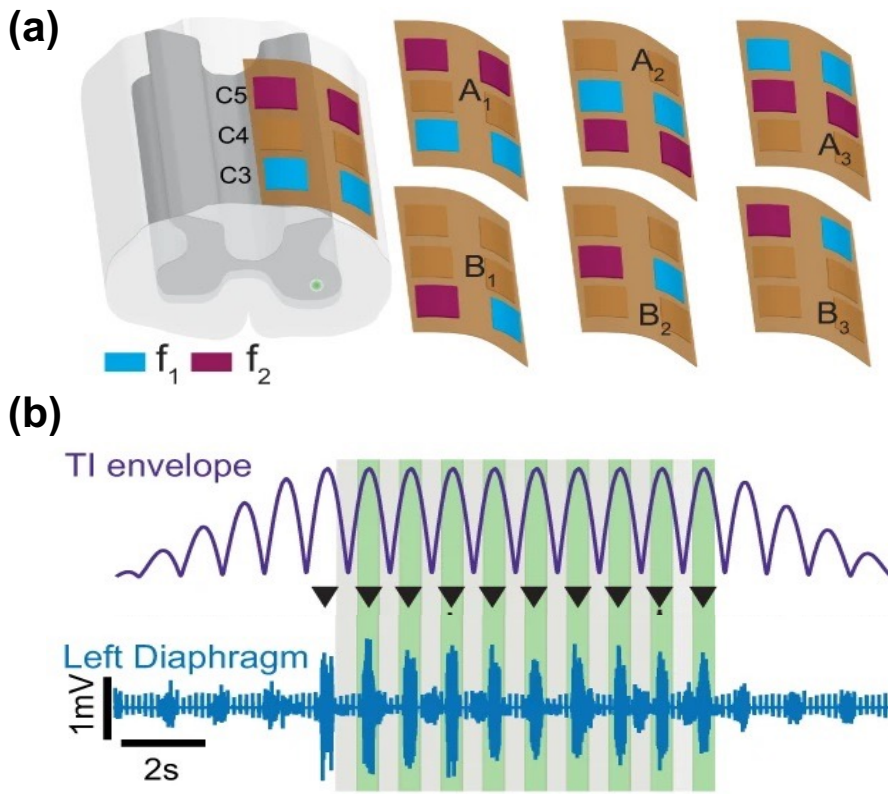
Respiratory insufficiency is a leading cause of death from opioid overdose. Electrical stimulation under a temporal interference (TI) protocol could be used to restore breathing while first responders apply other life-saving treatments.

Electrodes placed onto the neck can activate the diaphragm to rhythmically stimulate a respiratory rate of 12-16 breaths per minute. The evoked response to this electrical activation may sufficiently restore ventilation and arterial blood oxygenation during the overdose period. Additionally, this method may be introduced through epidural insertion directly to the cervical spine, to prevent fatality from cessation of breathing in patients with chronic spinal cord injuries, thus providing an attractive alternative to manual ventilation techniques.

MRI was used to monitor neurological and physiological behavior in healthy and spinal cord injury rat models using the 4.7 Tesla scanner at the AMRIS Facility. Important to this study, shown in the **figure on the right**, *the MRI scanner was also used to determine placement of intramuscular electrodes relative to spinal segments, in order to determine which electrode locations, waveforms, and configurations could sufficiently activate the diaphragm* while reducing off target effects, such as forelimb muscle activation.



(a) Epidural electrode grid C3–C5 with three bipolar (A1, A2, and A3) and three monopolar configurations (B1, B2, and B3); actual wire width is 25 μm.
(b) Temporal interference (TI) stimulation of respiratory activity during TI peak (green boxes) and trough (gray boxes) over the period of stimulation.

Facilities and instrumentation used: AMRIS Facility, Gainesville, FL; 4.7T Oxford MRI/S system with VNMRS console

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