Phonomyography as a Noninvasive Continuous Monitoring Technique to Diagnose Acute Compartment Syndrome

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Background/Purpose: In acute compartment syndrome (ACS), clinicians have difficulty diagnosing soft-tissue hypoperfusion in a timely and noninvasive manner. Once identified, immediate surgical intervention is required to relieve the pressure; left untreated, it may cause loss of limb function. Phonomyography, which detects acoustic signals of muscle contraction, is currently used by anesthesiologists to evaluate neuromuscular blockade in general anesthesia. We hypothesize that alterations in muscle contraction caused by hypoperfusion in ACS and ischemia can be detected with phonomyography.

Methods: An established ischemic model of limb injury in Sprague-Dawley rats was used. 15 rats were tested, with standard duration of injuryof 30 minutes, and 1, 2, 4, and 6 hours. The right leg served as control, and the left common iliac artery was clamped for the ischemic model. Transcutaneous nerve stimulators near the sciatic nerve and phonomyography microphones over the posterior calf of both limbs were used. Nerve stimulation at 10-minute intervals provoked muscle contraction, evaluated using a patented phonomyography device. Routine histology evaluated nerve and muscle damage, correlated with the duration of injury and phonomyography output.

Results: In all ischemic time points there was a statistically significant decrease of the phonomyography signal. In 1 hour of ischemia the signal decreased 55% (n = 12; $P = 0.005$), 5%-10% muscle necrosis. In 2 hours of ischemia the signal decreased 76% (n = 9; $P = 0.015$), 100% muscle necrosis and nerve damage. In 4 hours of ischemia the signal decreased 86% (n = 6; $P = 0.028$), corresponding to 100% of muscle necrosis and nerve damage. In 6 hours of ischemia the phonomyography signal decreased 95% (n = 3; $P = 0.109$), 100% of muscle damage and nerve damage.

Conclusion: Phonomyography, a promising noninvasive technique, detects early changes in muscle physiology that occur as a result of acute compartment syndrome. Further testing is planned to evaluate its potential use in humans.

See pages 99 - 147 for financial disclosure information.