Development of a Compact, Versatile and Low Cost Mechanomyography Device for Quantitative Train of Four Assessment

Presenting Author: Kelly Michaelsen, M.D., Ph.D.¹

Co-Authors: T. Andrew Bowdle, M.D., Ph.D.¹, Bala G. Nair, Ph.D.¹, Justin Hulvershorn, M.D., Ph.D.²

¹University of Washington, Department of Anesthesiology & Pain Medicine, Seattle, WA
²R8 Labs, Seattle, WA

Mechanomyography (MMG) for assessment of residual paralysis has been in existence since the 1960s¹, and has been considered the gold standard technique for evaluating muscle response. However, there are no current commercially available systems. Despite longstanding use in research, the technique never gained widespread clinical acceptance due to bulky and cumbersome setup. Accelerometry (AMG) has gained some traction in clinical use and measures the acceleration of the thumb during contraction to determine the force. However, absolute measurements are not easily comparable since there is still variation between MMG and AMG results. Additionally, AMG results in consistently overestimates train of four (TOF) measurements and even at a TOF ratio of 1, impaired respiratory function has been observed².

Electromyography (EMG) is another technique that has shown good correlation with MMG³ and measures electrical response rather than mechanical. EMG is far easier to setup than MMG but proper placement of the electrodes is essential. EMG and MMG have been studied and compared extensively in the past⁴, however clinical use of EMG based systems has lagged.

The objective of this project was to develop a compact, easy to use and low cost MMG system that could be integrated with an EMG based system currently in development for clinical use. These two techniques can be directly compared with simultaneous measurements in the same muscle and will be used to evaluate the new EMG based system against the gold standard MMG technique.

Electronic components were selected based on measurement precision, size, and price and include a force transducer, amplifier and analog to digital signal converter. The force transducer is secured to the thumb via a custom 3D printed holder that slings around the palmer side of the digit. In between the thumb and transducer are three pieces of aluminum. Individually, the technician can easily mold each layer by hand to the appropriate angle of the
thumb of the patient in order to hold a preload force of 200-300g. When stacked, the higher resistance can maintain isometric conditions needed to accurately record MMG signals, preventing thumb movement. The hand is further immobilized using a commercial wrist splint.

Due to technological advances since the earliest MMG systems were developed, it is now possible to build a device with a slim profile, easily customizable for individual patients at a cost less than $1,000 that can be used simultaneously with EMG for precise comparison and evaluation of the new EMG based system. The new system was developed and demonstrates expected linearity in measurements for with precision to 5g and accuracy to 25g for measurements examined from 0 to 5kg with a sensitivity to 10g within that range.

The figure demonstrates the development of the mechanomyography system. Several designs were proposed and modeled in CAD before the model shown in (a) was selected. A commercial wrist splint by Donjoy (b) immobilizes the wrist, essential to allow force transmission to the sensors. Electronic components were selected based on small size, expected measurement range and error tolerances as well as price (c). Aluminum splints can be molded for each patient and provide additional strength when stacked together (d). Data is collected on a laptop computer using National Instruments Labview software (e). Force sensor calibration shows excellent linearity in the range of expected forces from muscle contraction (f).

**References:**