

An Ultrasound-Based Method for Detecting Elevated Muscle Compartment Pressures: A Prospective Clinical Pilot Study

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Purpose: Acute compartment syndrome (ACS) is a limb-threatening condition associated with elevated muscle compartment pressures (MCPs). The only treatment of ACS is muscle compartment fasciotomy; however, a reliable clinical method for detecting elevated MCPs is lacking. We have previously demonstrated on cadavers the feasibility of using commercially available ultrasound and pressure-sensing technology for detection of elevated MCPs. The goal of this pilot study was to examine the use of this technology in the clinical setting.

Methods: 41 patients with tibia fractures (all OTA/AO types of 41,42,43 and 44) were prospectively enrolled. A standard musculoskeletal ultrasound transducer was combined with a pressure-sensing transducer to obtain a B-mode image of the anterior compartment. The amount of pressure required to flatten the anterior compartment fascia (CFFP) was recorded in the injured and uninjured legs by 1 or 2 observers. The difference in CFFP between the injured and uninjured side was also recorded (Δ CFFP). Interclass correlations were used to test interobserver agreement for measuring CFFP and Δ CFFP. If ACS was suspected clinically, direct pressure measurements were made and 4-compartment fasciotomy was performed. Pearson's product-moment correlation was used to detect correlations between ultrasound-based and direct pressure measurements. The Welch 2-sample t test was used to compare measurements in patient with and without ACS.

Results: 41 patients, ages 14-72 years, were enrolled in the study (male:female = 31:10). Average body mass index was 27.13 ± 6.5 (range, 18.0-45.2). ACS was diagnosed in 6 patients. Direct pressure measurements were performed in 7 patients. CFFP and Δ CFFP had excellent correlations to direct pressure measurements ($R^2 = 0.85$ and 0.73 , respectively) and between themselves ($R^2 = 0.87$). In all ACS cases CFFP was >112 mbar (mean 168.3 ± 51.3) and Δ CFFP was >36 mbar (mean 129.8 ± 57.8). There was a statistically significant difference between patients with and without ACS, in both CFFP (168.3 ± 51.3 vs 60.7 ± 28.0 , $P = 0.003$) and Δ CFFP (129.8 ± 57.8 vs 17.3 ± 22.9 , $P = 0.004$). In 13 patients CFFP was measured independently by 2 observers. Interclass correlations (ICC) were moderate for CFFP (ICC = 0.679, with 0.409 to 0.841, 95% confidence interval) and good for Δ CFFP (ICC = 0.77, with 0.413 to 0.923, 95% confidence interval).

Conclusion: The results of this pilot study suggest that the proposed ultrasound based method is effective in detecting elevated MCPs and may be helpful in the diagnosing ACS or ruling out the need for urgent fasciotomy. Large-scale clinical trials are needed to substantiate these claims.