Optimizing Surgical Debridement for Acute Compartment Syndrome Using ICG-Based Fluorescence Muscle Perfusion Imaging

Leah Gitajn, MD, MS*; Yue Tang; Shaofeng Yen; Jonathan Elliott, PhD; Lillian Fisher; Chelsey L. Recendez; Eric R. Henderson, MD; Shudong Jiang*

Purpose: Acute compartment syndrome (ACS) can pose a significant threat to limbs, particularly when it occurs after the found-down phenomenon. When diagnosis is delayed or missed, the risk of infection and poor outcome is increased due to insufficient removal of nonviable muscle tissue. Currently, there are no objective and intraoperative techniques available for assessing muscle viability and the thoroughness of debridement. To address this, we conducted a preliminary study to determine whether dynamic contrast-enhanced fluorescence imaging (DCE-FI) based on indocyanine green (ICG) can provide quantitative data on muscle perfusion to guide intraoperative debridement.

Methods: To date, we have imaged 11 limbs undergoing treatment for ACS. After imaging, 8 tissue samples, each measuring 10 x 3 x 3 mm, were excised from designated locations along the length of the targeted muscle. Samples were fixed, embedded, sectioned, stained, and analyzed. The area of severe necrosis was compared with the total area of muscle sections to produce a percentage of necrosis (necrosis%). To understand the relationship between the necrosis% and perfusion imaging parameters, 8 regions of interest (ROIs) with a diameter of 16 mm were selected. The data sets were divided into 2 groups of high (4) and low (7) necrosis%, based on a 50% threshold of the average necrosis% over the 8 samples. Perfusion-related parameters, including maximum ICG intensity Imax, blood flow (BF, and volume transfer constant Ktrans were assessed in each ROI

Results: Cases in the high necrosis group exhibited significantly lower Imax mean: 22.4, standard deviation [SD] 28.5; unit: relative fluorescence units), BF (mean: 2.3, SD: 3.6; unit: mL/min/100g) and K trans (mean 0.8, SD 1.2; unit: mL/min/100 g) (P 0.05, 0.01, and 0.005, respectively), indicating a substantially reduced muscle perfusion.

Conclusion: The results from this study suggest that intraoperative ICG-based perfusion imaging can identify devitalized muscle tissue resulting from ACS in real time in the operating room. This has the potential to help surgeons optimize surgical debridement and minimize risk of additional complication, particularly in challenging cases of delayed or missed compartment syndrome or those in patients with ACS as a result of being found down.

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