Continual Near-Infrared Spectroscopy Monitoring in Acute Compartment Syndrome: Lessons Learned From a Decade of War

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Background/Purpose: Acute compartment syndrome (ACS) is a prevalent and morbid complication of severe extremity injury in the combat and civilian setting. The leg is most commonly involved (>50%). Early experience from the wars in Iraq and Afghanistan demonstrated a 17% rate of delayed or missed diagnosis of ACS in-theater. This resulted in a doubling of major amputation rate and quadrupling of mortality when compared to patients who underwent timely and complete fasciotomy in-theater. The purpose of this work was to summarize the experience with and lessons learned regarding the ideal management of ACS in the combat setting over the last decade of war, and to specifically recount the work to date evaluating the potential of near-infrared spectroscopy (NIRS) to serve as a technological solution for known deficiencies with the clinical diagnosis of ACS. In addition, the preliminary summary results and 2 illustrative cases from a FDA-IDE (US Food and Drug Administration Investigational Device Exemption) trial evaluating the feasibility of NIRS oximetry as a decision support tool for the diagnosis of ACS are reported.

Methods: The FDA-IDE trial was a prospective observational trial in which subjects were enrolled within 12 hours of severe leg injury or severe trauma not involving the leg. Enrollees underwent a standardized screening and intake and then had NIRS sensors applied to the compartments of each leg and continuous NIRS oximetry values were recorded. Patients with severe leg injuries were observed for up to 48 hours or until they developed ACS. Synchronous data from the injured and noninjured like compartment were compared graphically and statistically. The NIRS values were blinded to the treating providers, and all clinical decision-making was left to standard practice. The primary objective of this preliminary data analysis was to evaluate the feasibility of this approach, as assessed by the time on monitor.

Results: 75 subjects (60 males, average age 39.7 years) were enrolled in the severe leg injury cohort and an additional 23 patients (14 males, average age 36.3 years) were enrolled in the critical control cohort. NIRS data was obtained for at least 2 hours on all patients prior to therapeutic interventions, a median of 40 and 45 hours on monitor for the 2 cohorts, respectively. At least one compartment of the leg could be monitored in all patients for some portion of the study period. An illustrative case demonstrates the hyperemic response, which persisted over the duration of the study period. This hyperemic response is associated with severe leg injury that is not complicated by ACS and has been demonstrated in previous clinical and animal model work.

Conclusion: The reliable and accurate diagnosis of ACS is a critical unmet need in combat casualty care. The ideal solution will leverage technology in the form of physiological monitoring to make or support the diagnosis of ACS. Our preliminary analysis demonstrates that current NIRS oximetry devices can be used to monitor the regional oxygenation of the muscle compartments of the leg in most, but not all, situations. Further development and clinical validation are warranted.

See pages 47 - 108 for financial disclosure information.