DEVELOPMENT OF EARLY DETECTION ALGORITHMS FOR MUSCULOSKELETAL INJURIES USING ULTRASONIC STIFFNESS MEASUREMENT DEVICE.

Company: Luna Labs @ Luna Innovations Inc.

Amount Awarded to Date: $140,000 - Pilot Study

MTEC 21-06-MPAI Desire to Team/Partner

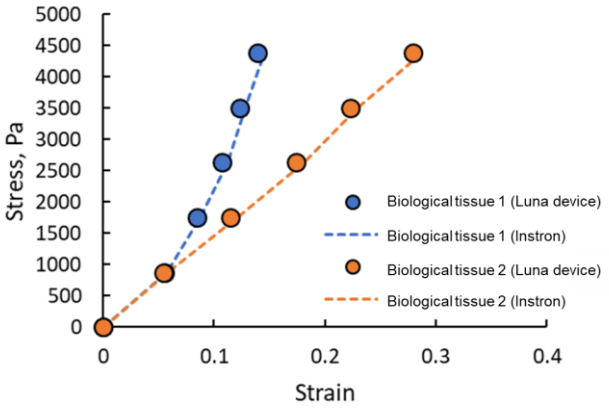
FA2.1 Leader and Provider Tools to Prevent, Reduce, Screen and Diagnose Musculoskeletal Injury in all Settings

Technology Introduction

Musculoskeletal injuries are exceedingly common in the United States Military, including both combat and non-combat injuries leading to a substantial number of lost duty days and compromising mission readiness. Critically, the majority of these injuries are caused by cumulative microtrauma, compared to acute trauma. However, it is hypothesized that a significant portion of acute traumas occur following undetected microtrauma that could have been prevented. To optimize warfighter performance and mission readiness, early detection and prevention is critical; however, there is currently no system with widespread adoption for early detection of these injuries.

Several studies have shown a correlation between muscle stiffness and non-contact musculoskeletal injuries, suggesting the potential to use this noninvasive metric for early prediction of muscle injury. If an injury does occur, both passive and active muscle stiffness can be used to maximize reintegration and return to duty. To achieve this in the field, it is imperative that the tool is rugged, lightweight, easy-to-use, and provides quantifiable results to the user. To address this need, Luna is developing a handheld ultrasound stiffness measurement device that uses dual ultrasound and force sensors with coupled machine learning algorithms to automatically determine local tissue stiffness. To demonstrate feasibility of the ultrasound methods, Luna confirmed that the stiffness of biological tissue measured with the ultrasound hardware fell within 10% of the measurements from a known mechanical measurement system (Instron mechanical tester). Currently Luna is pursuing approvals to complete volunteer studies to demonstrate performance in humans for applications in prosthetic interface design.

In a proposed MPAI effort, Luna will seek partners for completing large scale volunteer studies to collect longitudinal data on healthy volunteers and record injury events. As the algorithms for automatically defining tissue stiffness are defined, the data of interest will track the predictability of these metrics and refine the early detection algorithms for musculoskeletal injuries.



Luna's prototype handheld device accurately measured stiffness of biological tissue as compared to Instron mechanical tester.

MPAI Teaming Needs

In order to continue driving the development of Luna's MSI prediction tool towards clinical testing and regulatory approval, Luna seeks the following partners for teaming on the MPAI effort.

1. Human volunteer study to collect data for injury prediction model development.
2. GMP manufacturing and packaging/sterilization.
3. Regulatory expertise.
4. Military medical device transition expertise.

Contact Information

Kelley Virgilio, PhD
Team Lead, Biophysics
virgiliok@lunainc.com
(434) 220-7699

Christopher K. Tison, PhD
Director, Biotech
tisonc@lunainc.com
(434) 220-2518

FAST PLATFORM: RAPID PORTABLE SERODIAGNOSTIC

Company: Luna Labs @ Luna Innovations Inc.

Amount Awarded to Date: $3,000,000

MTEC 21-06-MPAI Desire to Team/Partner

Focus area 2.13: Infectious Diseases – Rapid Diagnostic and Detection Devices

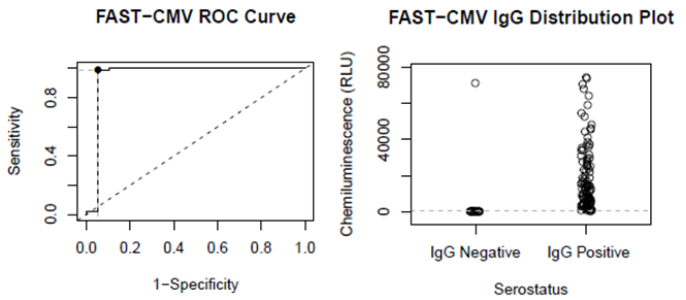
Technology Introduction

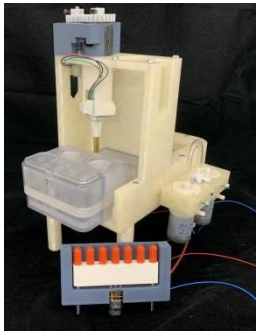
Rapid and accurate diagnostics are critical to the DoD's mission of force health protection and operational readiness of the modern warfighter. In addition to point-of-care (POC) testing to identify and manage infections, these diagnostics are imperative for epidemiological surveillance studies and preventative measures such as vaccination prior to deployment to disease endemic regions. While easy-to-use serodiagnostics amenable to the POC are suitable for some applications (e.g. lateral flow assays), they typically lack the sensitivity and specificity of centralized laboratory tests (i.e. ELISA). Conversely, laboratory testing has significant cost and logistical burdens, including the need for cold-chain transport, resources, and technical expertise. Moreover, laboratory testing prevents immediate clinical management of infection and is not always accessible in the austere environments in which the US military operates.

Luna is developing the FAST platform of fieldable diagnostics to enable rapid, automated, high sensitivity, and high specificity electrochemical ELISAs. The platform is currently being developed for the simultaneous analysis of IgM and IgG antibodies, as well as IgG avidity – a discriminator of acute or convalescent disease states and of primary and secondary infection. ELISAs have been integrated within a low-cost, single use, injection-molded microfluidic cartridge that is automated by a portable, battery-operated, and ruggedized instrument. Diagnostic results are obtained in 15 minutes and require a capillary blood volume of 10 µL obtainable through minimally invasive sampling. *Operational requirements simply include adding the sample to the cartridge and placing the cartridge in the instrument.*

The FAST platform diagnostic performance has been **validated in the benchtop format for dengue virus** (USAMRAA Ph I/II W81XWH20P0032) **and cytomegalovirus** (NIH Ph I/II 75N93019C00032) serological testing. Microfluidic cartridges have been prototyped and tested, and the benchtop reader is under assembly with all subsystems prototyped and tested. Shelf stable lyophilized reagents are currently being formulated. The FAST technology will be evaluated through independent testing by clinical collaborators in 2022. The platform is readily adaptable for the detection of alternative antigens or analytes.

In a proposed MPAI effort, Luna will seek to transition the FAST instrument to cGMP manufacture and scale the manufacture of microfluidic cartridges and reagents. Testing of the device for CMV and/or dengue serology will lead to FDA 510(k) and CLIA waiver submission and a transition to commercialization efforts with distribution and sales partners.





Luna's FAST platform for rapid electrochemical ELISAs enables IgM and IgG antibody detection, and IgG avidity measurements within an automated microfluidic cartridge and instrument system. Left) ROC curve and distribution plots generated in testing human serum samples of mixed CMV IgG reactivity (N=125, Se. 99%, Sp. 95%). Right) FAST instruments are currently being prototyped with the microfluidic cartridge.

MPAI Teaming Needs

In order to continue driving the FAST technology towards clinical testing and regulatory approval, Luna seeks the following partners for teaming on the MPAI effort.

1. Clinical diagnostic expertise.
2. cGMP manufacturing and packaging/sterilization capabilities/expertise.
3. FDA regulatory expertise.
4. Military and civilian medical diagnostic transition expertise.

Luna Innovations Contact Information

Nathaniel D. Talley
Research Specialist, FAST development lead
talleyn@lunainc.com
(434) 972-9951

Christopher K. Tison, PhD
Director, Biotech
tisonc@lunainc.com
(434) 220-2518

SCALE-UP AND PRE-CLINICAL VALIDATION OF TUNECOAT DRESSING TO REDUCE OPIOID DEPENDENCE AND IMPROVE BURN WOUND HEALING

Company: Luna Labs @ Luna Innovations Inc.

Amount Awarded to Date: $1,150,000

MTEC 21-06-MPAI Desire to Team/Partner

FA1.2 Enabling Medical Capabilities to Support En Route and Prolonged Care in Remote, Austere Settings, & Extreme Environments

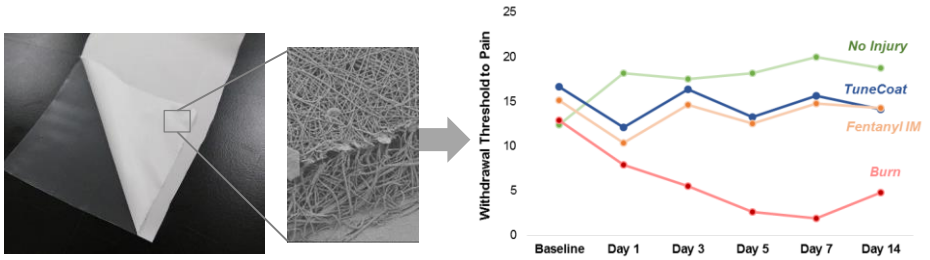
Technology Introduction

The management of intense burn pain relies almost exclusively on systemically administered opioids or other pain medications. These are known to produce side effects as serious as opioid dependence, indicating an alternative to systemically delivered opioids is required. This need can be met by delivering the known effective opioids in lower, controlled concentrations in a localized manner using a topical analgesic wound dressing.

Luna Labs, a Virginia-based CRO with early-stage product development expertise, has developed a topical delivery system known as "TuneCoat" based upon unique nanofiber scaffolds. In prior efforts, Luna successfully produced, characterized, and validated its TuneCoat dressing in a rat model of burn pain. These fentanyl-loaded nanofiber dressings were produced and demonstrated to provide burst- or zero-order release kinetics for fentanyl depending on the dressing chemistry selected. This provided "instant" and "extended" release profiles for pain management, which were both validated *in vivo*. The dressings were characterized for shelf life, sterility, and resistance to degradation from common fluids found on the battlefield. They were shown biocompatible in subcutaneous implantation tests, systemic toxicity tests, skin irritation and sensitization tests, and further verified to be non-pyrogenic and non-genotoxic.

Six different rounds of rat hind-paw burn pain models were performed, and the ability of fentanyl loaded dressings to provide analgesic effect was validated. *Further, based on total loading, this analgesic behavior was found to occur when delivering 80% less drug than was required for similar effect with intramuscular (IM) injection.* There were no complications observed for pain management, as was frequently observed with IM injections, and rats were verified to maintain reduced pain over 14 days of use. Field effect tests were also performed and successfully confirmed that the localized delivery did not affect rat behavior or motor function. These initial preclinical results demonstrate analgesic effect with reduced opioid load and are one of the first instances of fentanyl being used for localized pain management at significantly reduced dosages.

In a proposed MPAI effort, Luna will seek to transition to large-scale GMP manufacture, validate performance in larger animal models of burn pain and wound healing, analyze pharmaco-kinetics and –dynamics, and initiate the regulatory approval process with partners.



Luna's TuneCoat dressings for analgesic delivery to burn wounds have been prepared on medical grade backing and demonstrated to control elution of gabapentin, fentanyl, and lidocaine. These dressings have been demonstrated to provide sustained pain relief in a rat burn pain model over at least 24 hours, while only requiring 20% of the fentanyl dosing needed to obtain the same effect when delivered via injection.

MPAI Teaming Needs

In order to continue driving the TuneCoat technology towards clinical testing and regulatory approval, Luna seeks the following partners for teaming on the MPAI effort.

1. Large animal models of burn pain and wound healing (rabbit, pig).
2. GMP manufacturing and packaging/sterilization.
3. Regulatory expertise.
4. Military medical device transition expertise.

Contact Information

Christopher K. Tison, PhD
Director, Biotech
tisonc@lunainc.com
(434) 220-2518

Lauren Costella
Team Lead, Wound Healing
costellal@lunainc.com
(434) 220-9411