Measuring Spinal Cord Swelling in vivo using Fiber Optic Pressure Sensors

Jacqueline Soicher[1], Femke Streijger[2], Brian Kwon[2], Peter Cripton[1]

[1]University of British Columbia, Vancouver, BC
[2]International Collaboration on Repair Discoveries (ICORD)

Abstract

Spinal cord swelling is an indication of severe spinal cord injury (SCI). Swelling may have negative effects on neurological outcome by inhibiting the flow of cerebrospinal fluid (CSF) and causing a decrease in blood flow within the spinal cord. Swelling may also contribute to spreading of the spinal cord lesion causing additional damage above and below the injury site days or weeks after the primary injury. Spinal cord swelling is not well understood. It has been observed clinically and in animal models but has never been directly quantified. The purpose of this study was to evaluate the feasibility of using fiber optic pressure sensors to directly measure swelling in the spinal cord in our established in vivo porcine model of SCI. To evaluate this we conducted a two part study with in vivo and ex vivo components.

In these investigations we used Samba fiber optic pressure sensors (Samba Preclin 420, Harvard Apparatus Canada, QC) to measure the pressure within the spinal cord. These sensors are low pressure catheter transducers designed to measure pressure in gas and liquid and have been previously used to measure pressure in the spinal CSF. The spinal cord is comprised of both fluid and structural elements such as nerve fibers and is characterized as a soft biological material. Therefore, the sensors may not be measuring fluid pressure but measuring a quantity proportional to bulk stress in the cord instead.

We conducted an in vivo pilot study to measure pressure in a pig spinal cord prior to, during and after simulated SCI. We inserted the sensors directly into the spinal cord. We used a previously developed weight-drop device which drops 50 gram from a height of 50cm to produce the SCI followed by a 600 gram sustained compression. We observed that the pressure steadily increased by approximately 10mmHg as the cord swelled within several hours after injury, even after decompression surgery was simulated by removing the sustained compression.

For ex vivo test 1, a point load was applied to the spinal cord by placing a 9 mm diameter cylindrical mass with rounded edges onto the spinal cord of a pig within two hours of being euthanized. The pressure in the spinal cord was measured while the applied mass was increased in 0.098N increments. We found that the measured pressure increased non-linearly with increasing mass and returned to baseline once all mass was removed. We believe that hydrostatic pressure is more representative of the in vivo situation; therefore, in the future for ex vivo test 2, we will apply a hydrostatic pressure to the spinal cord using a fluid pressure tank. We will measure the pressure in the spinal cord as well as in the fluid tank.

We expect to find a relationship between applied and measured pressure which will allow us to use fiber optic pressure sensors in the spinal cord to measure swelling pressure. By quantifying

swelling, we hope to better understand its effects on spinal cord injury outcomes which may lead to improved treatments.