Investigating the Variabilities in the Spinal Cord Injury in Pig Models Using Benchtop Test Model and Ultrasound Analyses

Amirhossein Borjali[1], Kitty So[2], Brian Kwon[3], Peter Cripton[4]

[1]School of Biomedical Engineering, University of British Columbia, Canada
[2]International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Canada
[3]Department of Orthopaedics, University of British Columbia, Canada
[4]School of Biomedical Engineering, University of British Columbia, Canada

Introduction:

Spinal Cord Injury (SCI) is a debilitating condition often resulting in long-term neurological deficits. Animal models, particularly porcine models, are crucial for understanding the pathophysiology of SCI and testing therapeutics. These models offer superior biofidelity to human anatomy and fluid dynamics, crucial for translational success. However, our current porcine model of SCI exhibits excessive variability, undermining our ability to reliably translate findings. To address this, we are dedicated to minimizing variability by refining the impactor design and utilizing ultrasound to examine stress risers on the ventral surface of the spinal canal.

Materials and Methods: This study utilized porcine models to simulate human SCI using a weight-drop method, selected for its replication of burst fractures and fracture dislocations seen in human SCIs. The experimental design included 8 setups, distinguished by two electronic conditioning boxes (box 2 and box 3), two weight drop impactors (4.0 and 4.1), and two rail heights for drop tests (16.73cm and 20cm). We refined our impactor device to reduce inconsistencies and integrated ultrasound (US) into our methodology to assess the ventral surface of the spinal canal for the potential to create stress risers during the SCI impacts. A new load cell calibration jig and benchtop test were also developed to validate the enhanced impactor device. The distance between the injury epicenter and intervertebral discs was investigated via ultrasound in different studies, employing both manual and semi-automated analysis of the hemorrhage associated with the injury.

Results: Analysis of 214 benchtop tests revealed that the coefficient of variation (CV) for the 8 different setups remained below 3%, indicating high consistency essential for reliable animal model testing. Our study did not establish a consistent trend correlating the distance between the intervertebral disc and the injury epicenter across different study groups in manual US quantification between different studies. Consequently, semi-automated hemorrhage quantification was favored and is ongoing to eliminate variability inherent in manual measurements.

Conclusion: The control and reduction of variability in our porcine SCI model improves our ability to derive novel insights for diagnosis and treatment. Our methodological advancement in the porcine model setup enhances the reliability of mechanical trauma simulation. Although the relationship between the injury epicenter and intervertebral disc distance remains inconclusive by manual US quantification, our ongoing semi-automated approach ensures objectivity in hemorrhage quantification. These enhancements facilitate a deeper understanding of pathological changes, therapeutic safety, and treatment efficacy, and underscore the significance of mechanical parameters in SCI research.