

EFFECT OF TIME ON THE MECHANICAL PROPERTIES OF CAPRINE ORGAN TISSUE

Jared Koser^{1,3}, Sajal Chirvi^{1,3}, Alok Shah^{1,3},
Frank A. Pintar^{1,2,3}, Narayan Yoganandan^{1,2}, Brian D. Stemper^{1,2,3}

¹Department of Neurosurgery, Medical College of Wisconsin (MCW), Milwaukee, WI

²Zablocki Veterans Affairs Medical Center, Milwaukee, WI

³Joint Biomedical Engineering Department, Marquette University and MCW, Milwaukee, WI

ABSTRACT

Computational modeling of high-rate loading injuries requires accurate material properties derived from high-rate tissue testing. Animal surrogates are often used in lieu of human tissues due to their availability and the possibility of shorter time durations, post mortem, before testing can begin. Because of the possibility that tissues may not be available until several hours post mortem, the effect of time on the mechanical properties of organic tissue needs to be understood. In this study, caprine liver tissue properties tested between 1.7 – 25.7 hours post mortem could not be shown to be significantly different. However, the properties were significantly different between 1.7 and 49.7 hours. Heart tissue on the other hand, demonstrated significant differences in stress-strain properties between 2.4 hours and 4.3 hours. However, the properties did not change significantly after 4.3 to 50.0 hours post-mortem.

Keywords: Time, compression, split-Hopkinson, mechanical properties, liver, heart, caprine

INTRODUCTION

Computational modeling is currently used to predict internal mechanisms of load transfer such as stress-strain profiles in high-rate loading scenarios. The accuracy of these models depends on construction of the model, i.e., geometry and material properties. Many studies substitute porcine or bovine tissues to simulate the properties of human tissues for reasons including the availability of healthy tissues a short time post mortem [1]–[4]. A literature review revealed gaps in the high-rate compression properties of several thoracic tissues, notably heart and cartilage. To fill those gaps, a local abattoir was contacted and willing to provide tissues, but due to the processing procedures and distance from abattoir to laboratory, it was common for tissues to be tested three to six hours post mortem. To know if this time delay was acceptable, the effect of time on the mechanical properties of tissue would need to be understood.

A study by Chatelin *et al.* compared the viscoelastic properties of porcine liver *in vivo* and *in vitro* [4]. This study showed a significant change in viscoelastic properties as post mortem time varied between 6 – 18 hours but was conducted at strain rates between 0.1 – 4/s. Because other studies have shown the compressive properties of tissue to be highly rate-dependent [2], [3], it could not be determined if conclusions drawn by Chatelin *et al.* could be applied to tissues tested at a much higher rate.

The aims of this study were to determine the effect of post mortem time on the mechanical properties of tissue under high-rate compression and to determine whether tissues tested up to 6 hours post mortem displayed similar stress-strain profiles as those tested earlier. Due to the unavailability of more commonly used porcine tissues, caprine liver and heart were chosen for this study. Articles comparing the anatomy of goats to that of humans or pigs are scarce. However, caprine tissues have previously been used in studies related to human heart conditions [5]–[7].