Characterization of Brain Tissue under High Rate Shear Loading: a novel test method with low noise

Soroush Assari, Kurosh Darvish
Biomechanics Lab, Department of Mechanical Engineering, Temple University

ABSTRACT

Recent studies suggest that the pressure changes occur at the rates of 0.5 to 1.5 kHz. Therefore, studying brain tissue at blast-rate deformations requires a test method with loading duration of about 1 ms. Although the material properties of brain tissue have been studied since 1960's, a limitation of the previous studies is that in most of them the strain rates were below 100 s^{-1}*; making the results unsuitable for Blast-Induced Neurotrauma (BINT) modeling purposes. This study aimed at characterizing the material behavior of brain tissue in large deformation shear with strain rates ranging from 300 to 1000* s^{-1}*. A major challenge in such test setup, due to vibration of the system, is to increase the signal to noise ratio. For this purpose, a novel test method was developed using a shock tube to drive a linear actuator with velocity of 3 to 14 m/s to deform the samples in a parallel plate shear configuration. The sample deformation was determined via high-speed imaging at the rate of 10k fps. The sample shear modulus was determined from the velocity of propagation of shear wave along the sample. The results of tests on cylindrical samples (10 mm diameter, 10 mm height) of bovine brain showed that the instantaneous shear modulus (about 6 kPa) increased about 3 times compared to the values reported in the literature. The results of this study can enhance the prediction of brain injury in finite element models of TBI in general and models of BINT in particular.*