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Research paper

Dynamic compressive response of bovine liver tissues

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ARTICLE INFO

Article history:
Received 12 November 2009
Received in revised form
17 September 2010
Accepted 19 September 2010
Published online 25 September 2010

Keywords:
Kolsky bar
Mechanical response
Liver tissue
Strain rate effect

ABSTRACT

This study aims to experimentally determine the strain rate effects on the compressive stress–strain behavior of bovine liver tissues. Fresh liver tissues were used to make specimens for mechanical loading. Experiments at quasi-static strain rates were conducted at 0.01 and 0.1 s^{-1}. Intermediate-rate experiments were performed at 1, 10, and 100 s^{-1}. High strain rate (1000, 2000, and 3000 s^{-1}) experiments were conducted using a Kolsky bar modified for soft material characterization. A hollow transmission bar with semi-conductor strain gages was used to sense the weak forces from the soft specimens. Quartz-crystal force transducers were used to monitor valid testing conditions on the tissue specimens. The experiment results show that the compressive stress–strain response of the liver tissue is non-linear and highly rate-sensitive, especially when the strain rate is in the Kolsky bar range. The tissue stiffens significantly with increasing strain rate. The responses from liver tissues along and perpendicular to the liver surface were consistent, indicating isotropic behavior.

1. Introduction

The human body can be subjected to sudden impact loading such as blasts, falls and traffic accidents. Due to this impact, the human organs and interconnecting tissues are subjected to stress wave loading which subsequently causes damage or injury. Impact-induced damage to liver is a major factor of fatality in accidental crashes and falls. Abdominal organ injuries also appear frequently during defense operations, which have been estimated as high as 20% of all battlefield injuries (Imes, 1945). The liver is the largest internal organ and gland in the human body. Despite its size and relatively protected location, the liver is the most commonly injured intra-abdominal organ. High velocity impacts cause disintegration of the hepatic parenchyma with laceration of vessels and massive intra-peritoneal hemorrhages due to cavitation effects (Uravic, 2003). In deceleration injuries commonly seen in traffic accidents, the liver usually tears between the posterior sector (Couinaud segment VI and VII) and the anterior sector (Couinaud segments V and VIII) of the right lobe. However, crushing tears the central portion of the liver (Couinaud segments IV, V and VIII) (Parks et al., 1999). The mortality and morbidity rates increase with the severity of grade of liver injury (Brammer et al., 2002). With the invention of modern surgery techniques, liver injury related mortality has decreased from 60% before World War II to 10%–20% (Uravic, 2003). However, the prevention of liver injuries still remains a challenge.

Due to the mechanical nature of the cause of damage, it is possible to develop predictive capabilities to pin-point

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1751-6161/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jmbbm.2010.09.007