Mechanical Characterization of the Liver and Kidney: A Systematic Review

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INTRODUCTION

- Liver and kidney injuries are common in blunt trauma and automotive collisions.
- Accurate organ mechanics are critical for injury prediction and computational modeling.
- Existing data primarily reflects high strain-rate impact testing.
- Time-dependent mechanical behavior remains poorly characterized.

OBJECTIVE

This review examines the current state of liver and kidney mechanical characterization and identifies gaps limiting injury prediction and computational modeling.

- Abdominal injuries occur in approximately 15% of all blunt trauma cases.
- About 80–90% of kidney injuries are due to blunt trauma.
- Liver Injury is the most injured organ in blunt abdominal trauma and the second most common in penetrating trauma.

METHODS

1. **PUBLISHED STUDIES IDENTIFIED**
   Studies were identified through database searches using predefined keywords and inclusion criteria.
2. **STUDIES CATEGORIZED BY:**
   - Organ type
   - Loading mode
   - Loading rate
3. **MECHANICAL RESPONSES EXTRACTED**
   Reported mechanical properties and material responses were extracted from each study.
4. **TIME-DEPENDENT BEHAVIOR EVALUATED**
   Studies were evaluated for characterization of time-dependent behaviors including stress relaxation, creep, and load redistribution.

DATABASES SEARCHED

PubMed	Scopus	Web of Science	EMBASE	PMC	Cochrane Library	Google Scholar

KEYWORDS USED

liver biomechanics | kidney mechanics | viscoelasticity | stress relaxation | creep | mechanical testing | constitutive modeling

STUDY CHARACTERISTICS

ORGAN TYPES INCLUDED
Studies included human, porcine, bovine, and perfused organ tissue models.

SCOPE OF REVIEW
Approximately 40 studies were included in the final analysis.

FUTURE WORK

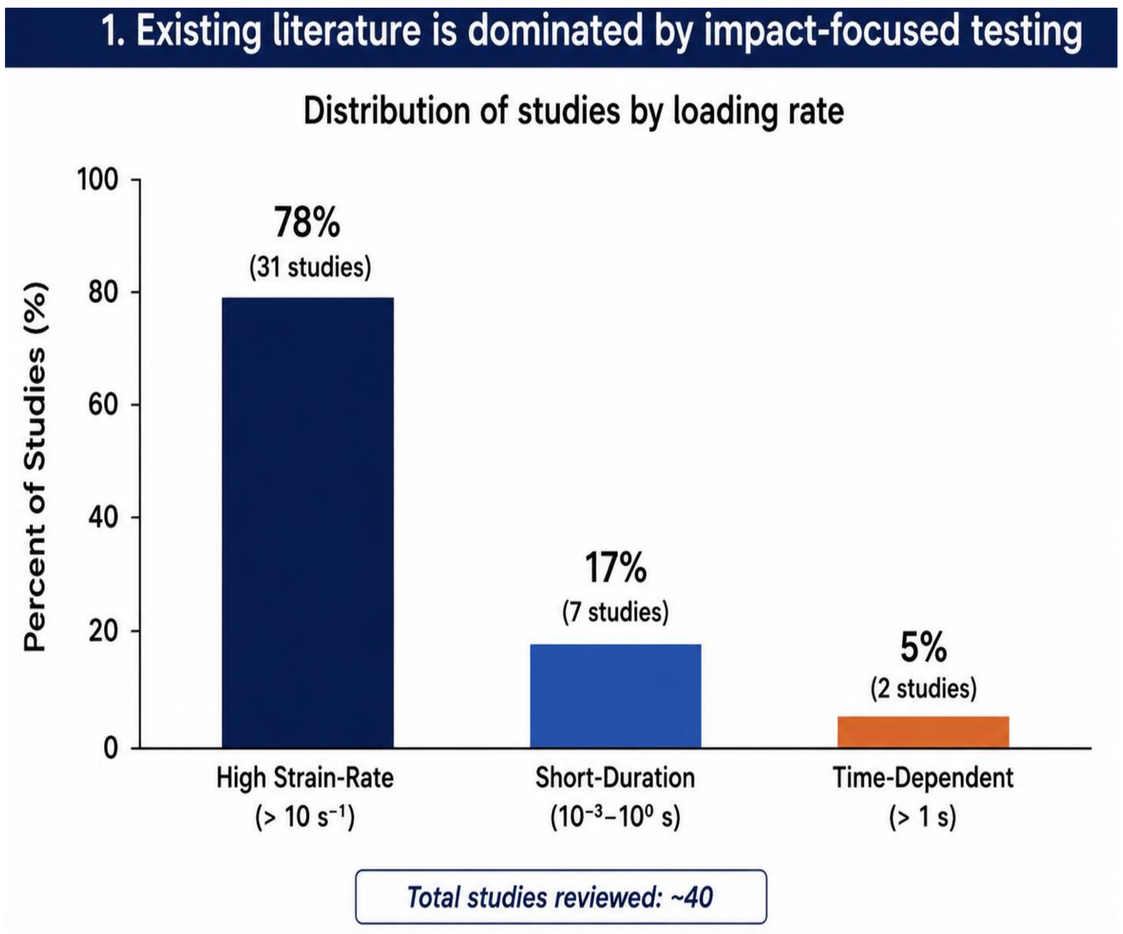
- Organ-specific viscoelastic characterization (creep, relaxation, load distribution)
- Development of standardized testing protocols for time-dependent behavior
- Exploration of physiology-relevant loading conditions and boundary constraints
- Improved constitutive material models incorporating viscoelastic behavior
- Enhanced computational injury prediction through improved model inputs

REFERENCES

Scan for a complete reference list.

RESULTS

1. Existing literature is dominated by impact-focused testing



Most available liver and kidney mechanics data are derived from impact-focused testing conditions.

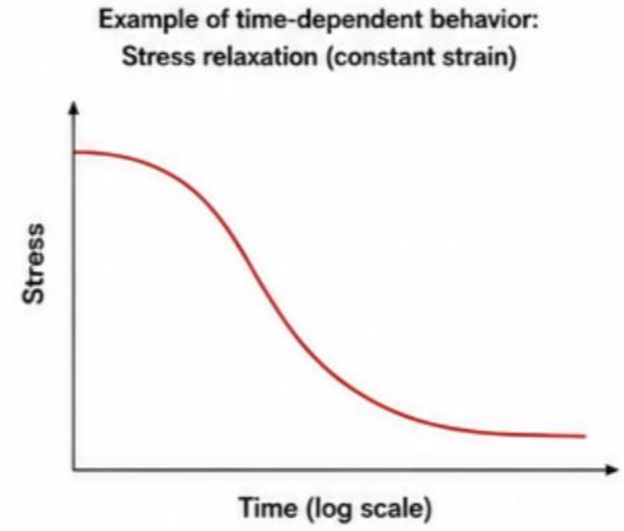
2. Viscoelastic behavior remains underrepresented

Existing Areas of Characterization

- High strain-rate loading response
- Compression-focused testing
- Short-duration impact mechanics

Underrepresented Behavior

- Stress-relaxation response
- Creep behavior
- Redistribution under sustained loading
- Physiology-relevant loading conditions



Stress within a material decreased over time under constant strain. This time-dependent behavior is lacking in liver and kidney mechanics literature

SUMMARY

- Liver and kidney injuries are common in blunt trauma and automotive collisions.
- Existing liver and kidney mechanics literature is heavily weighted toward high strain-rate, impact-focused testing conditions.
- Time-dependent viscoelastic behaviors, including creep, stress relaxation, and load redistribution, remain substantially underrepresented.
- These gaps limit human body model biofidelity and reduce injury prediction accuracy.
- Expanded organ-specific viscoelastic characterization under physiology-relevant loading conditions may improve prediction of injury onset, progression, and severity.

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