Using human body models to evaluate the efficacy of cervical collars in cervical instability

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ABOUT SAFER

THIS IS SAFER

We research to save lives, prevent injuries and enable safe mobility. Together.

SAFER is on a bold journey towards zero accidents in traffic.

This will be achieved by open, collaborative research projects where traffic safety is key for the creation of safe, sustainable, connected and automated traffic systems.
THE SAFER RESEARCH AREAS

SAFER's research is conducted in five areas. Each research area is governed by a reference group led by a Research area director. The reference groups include one representative from each SAFER partner and representatives from SAFER's competence areas. All projects are initiated by the reference group and recommended to SAFER's Management group and Board.

SYSTEMS FOR ACCIDENT PREVENTION

ROAD USER BEHAVIOUR

HUMAN BODY PROTECTION

CARE AND RESCUE

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Real world safety

Develop safety systems
- Test prototypes
- Crash dummies

Assess safety
- CAE design Numerical tools
- Human body models
- Experimental tests

Primary prevention

Research Aim:
To provide useful **numerical methods** and **human body models** that are **biofidelic** for a large range of loading scenarios and that can **predict injury**.
Recent HBM projects

Active muscles
Prediction of thoracic, brain and lumbar spine injury risks
Average female HBM

Adipose tissue
Active muscles in child HBMs
Brain injury criteria
ExtricAction
Pre-Study

PhD. Jonas Östh
Introduction

• Extrication of motor crash victims in general concerned with
  — Speed of extrication – crucial to reduce risk of fatality
    (Calland 2005)
  — Cervical immobilization routinely performed to avoid
    secondary injury, although positive effects have not been
    proven (Sundstrøm et al. 2014)

• Published biomechanical studies on the effect of cervical collars
  either with volunteers or human cadavers

• Aim
  — Simulate one previously published study (Ben-Galim et al.
    2010)
Case study – Ben-Galim et al. 2010

- Investigated the effect of a cervical immobilization collar in the presence of a severe dissociative injury
- 9 PMHS subjects (66–88 years old)
Methods: Numerical HBM

- GHBMC 50th percentile male occupant model v4.1.1
  (Elemance, Winston-Salem, NC)
  - 2.2 million elements
  - 1.25 million nodes
- Published validation:
  - Segment-level force-deflection characteristics
    (Panzer and Cronin 2009)
  - Tissue-level failure prediction (DeWit and Cronin 2012)
  - Capsular-ligament response (Fice et al. 2011)
**Methods: Simulated injury**

- Ben-Galim et al. (2010):
  - Fractured dens at its base
  - Severed nuchal, left and right capsular ligaments, tectorial membrane, inferior cruciate ligament, and anterior longitudinal ligament
Methods: Loading to represent cervical collar.

- Model reduced for computational efficiency
- Soft tissues and bones below T1 level constrained to move
- Head displaced vertically

- 4 simulations
  - Uninjured
  - Uninjured with 20% muscle activation
  - Injured
  - Injured with 20% muscle activation
Results

Uninjured

Injured
ΔA = 1.95 mm

Uninjured

ΔP = 1.34 mm

ΔA = 7.81 mm

Injured

ΔP = 3.11 mm
Effect of 20% Muscle Activation

Effect of MA:
More C1–C2 distraction
More anterior increase than posterior in injured case
Discussion

- Similar to PMHS results most distraction happens at weakest point (site of injury)

- The effect of muscle contraction can be studied (in contrast to PMHS)
  - 20% activation → more separation at site of injury
  - Local stretch reflex muscle response likely more relevant to study

- Spinal cord injury risk was not assessed in PMHS study
  - Could be evaluated by inclusion of spinal cord in model and assessment of tissue strain.
Discussion cont.

- Human Body Models needs to be validated with respect to physical test data – can be a difficult process
  - However, once model is validated parameter studies are very easy to perform
  - Levels of collar tension, correlated with for instance spinal cord strain
Recent HBM projects

- Active muscles
- Prediction of thoracic, brain and lumbar spine injury risks
- Average female HBM
- Adipose tissue
- Active muscles in child HBM
- Brain injury criteria
SAFER Active Human Body Model – A-HBM step 3

- Biofidelic HBM for simulation of sequences of events:
  - combined emergency and crash events
  - run off road events
  - other long duration crash events
SAFER A-HBM in Braking events

Autonomous braking*

Driver braking**


Omni-directional SAFER A-HBM
Improved injury prediction using HBM, step 3

- Biofidelic HBM that can predict thoracic, brain and lumbar spine injury risks
Rib strain validation

1. Single rib tests  
2a. Table top tests  
2b. Impactor tests


Rib strain validation / Injury criteria evaluation

3. Sled tests


Fringe=maximum principal strain

4. Accident reconstructions


Crandall (2011)

Winsmash

\( \Delta V \) [km/h]

\( P(AIS3+ \text{ rib fracture}) \)

\( \text{AGE}=30 \)

\( \text{AIS3}+ \)

NASS/CDS

Simulation
ViVA II
Virtual Vehicle Safety Assessment

- To reduce transport gender inequality.
- Create an open source virtual HBM of an average female.
- Propose a virtual test method protocol seat assessment.
ViVA OpenHBM female model

https://www.chalmers.se/en/projects/Pages/OpenHBM.aspx
Acknowledgements

The presented work has been carried out in association with SAFER - Vehicle and Traffic Safety Centre at Chalmers, Sweden.

Simulation resources have been supplied by C3SE.
Questions?

Active muscles
Thoracic injury
Average female

Adipose tissue
Active child
Brain injury criteria

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References


