Occupant-Restraint-Vehicle Interaction in Side Impact Evaluated Using a Human Body Model

Donata Gierczycka[1], Duane S. Cronin[1]

[1]University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, tel. 519-888-4567 x.31734, dgierczy@uwaterloo.ca

Abstract

Outline of the problem

In 2012, side impacts accounted for 38% of car accident fatalities in the US, with nearly 60% of severe to fatal injuries to thorax. Contact with the door was identified as the most common source of thoracic injuries. Passive safety in side impacts remains a challenge due to the limited crush zone and crash databases analyses published in 2015 (NHTSA, GIDAS) indicated that side airbags did not achieve the expected reduction of injuries compared to other safety systems. Previous studies identified that the effectiveness of restraint systems in side impacts was sensitive to the occupant pre-crash position. Understanding occupant response and the potential for injury in side impact scenarios is necessary to improve occupant safety and Finite Element (FE) Human Body Models (HBMs) enable parametric studies through controlled boundary conditions to address these challenges. Although HBMs can predict occupant response at a global level through measurement of accelerations, velocities, and displacements, a primary benefit is tissue-level injury prediction.

Study objective

This study aims to identify the kinematic response and the potential for thorax injury in side impact using tissue level injury metrics, in addition to standardized injury criteria, and demonstrate the benefits of detailed HBMs in a crash environment.

Methodology

A FE HBM with detailed thoracic section [1] was integrated with a side sled model representing a mid-sized sedan and Moving Deformable Barrier (MDB) lateral impact. The model included simplified vehicle door and seat models validated previously [2,3], a seatbelt, and a configurable side airbag. The HBM was positioned in a standard driving position, and other non-standard configurations including varying arm position. Simulations were run with the airbag varying the inflation and venting parameters, and without the airbag.

Data to be included

The injury response was assessed using chest deflection and Viscous Criterion (VC) evaluated at three chest band levels, and through analysis of potential for pulmonary contusion [4,5].

Summary of results and current conclusions

The pre-crash position was observed to have an effect on the HBM response with the arm position being the most significant. Positioning the arm in the load path increased the injury metrics: chest deflection was more than two times higher, VC almost five times higher than for the case with arm positioned away from the load path. The predicted contused lung volume pattern was in agreement with the chest deflection and VC metrics, demonstrating more contused volume when the arm was located in the load path. The extent of the change in injury metrics when the airbag was present was affected by the occupant pre-crash position. In next steps, the airbag will be integrated with an existing full vehicle-MDB-HBM model [6,7] to investigate side impact response.

[1] Forbes PA, Cronin DS, Deng Y-C, and Boismenu M, 2005. ”Numerical Human Model to Predict Side Impact Thoracic Trauma”, in *IUTAM Proceedings on Impact Biomechanics: From Fundamental Insights to Applications*, pp. 441-450.

[2] Campbell BM, 2009. “A Numerical Side Impact Model to Investigate Thoracic Injury in Lateral Impact Scenarios”. MASc thesis, University of Waterlo, Waterloo, ON, Canada.

[3] Campbell B, Cronin DS, 2014. “Coupled Human Body and Side Impact Model to Predict Thoracic Response”. International Journal of Crashworthiness, Vol. 19 (4), pp. 394-413.

[4] Yuen K, Cronin DS, Deng Y-C. Lung response and injury in side impact conditions. IRCOBI, Bern, Switzerland, 2008.

[5] Yuen K, Cronin DS. Comparison of Lung Response and Thoracic Injury Metrics. World Congress of Biomechanics WCB. Singapore, 2010.

[6] Watson B, and Cronin D, 2009. “Study of Vehicle Dynamics and Occupant Response in Side Impact Crash test”, in *Proceedings of the 21st Technical Conference on the Enhanced Safety of Vehicles.* Paper No. 09-0016.

[7] Gierczycka D, Cronin D, 2015. “Investigation of Occupant Arm Position and Door Properties on Thorax Kinematics in Side Impact Crash Scenarios – Comparison of ATD and Human Models”. International Journal of Crashworthiness, 20 (3), pp. 242-269.