Occupant-Side Airbag–Vehicle Interaction in Side-impact Crash Scenario Using Coupled Vehicle and Human Body Models

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I. INTRODUCTION

Side-impact crash scenarios are the second main cause of fatalities in passenger vehicle crashes, with the most severe injuries occurring to the head and thorax regions of the body. The most common source of injuries to the thorax is contact with the door [1], and enhancement of side-impact protection remains a challenge due to a limited crush zone and aggressive loading scenarios. Recent crash database analyses (NHTSA, GIDAS) have indicated that thoracic side airbags have not resulted in an expected reduction of thorax injuries, although side-curtain airbags were observed to reduce head injury severity [2-3]. Previous studies have demonstrated that the occupant response in side impact is sensitive to the pre-crash position [1][4-8]. The aim of this study was to investigate the effect of varying side-impact conditions using a 50th percentile male Human Body Model (HBM) coupled with a thorax side airbag (SAB), and vehicle model in a side-impact condition. Previous studies have demonstrated that seatbelts do not have a significant effect on occupant response in side impact [9-10], therefore an unbelted configuration was used for this initial study. (Belted configurations will be considered in future studies.) HBMs offer repeatable, controlled test conditions enabling parametric studies essential for the prediction of real-world occupant injuries and the assessment of safety systems [8][11].

(a) (b) (c) (d)

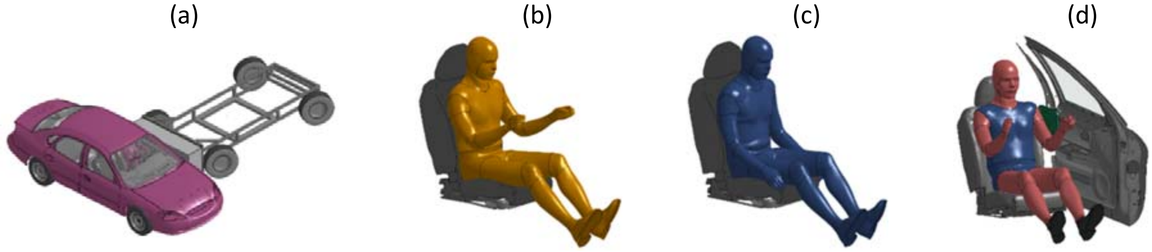

Fig. 1. (a) NCAP MDB impact configuration; (b) HBM in driving position; (c) HBM in vertical arm position; (d) HBM coupled with vehicle and SAB.

II. METHODS

The Global Human Body Models Consortium (GHBMC) 50th percentile male HBM was coupled with a vehicle model (Fig. 1(a)), previously enhanced and validated for side impact, representative for a mid-sized sedan [12-13]. A generic SAB model (rectangular thoracic airbag, 7 l volume, Fig. 2), was integrated with the vehicle model. The vehicle was subjected to impact by a moving deformable barrier (MDB) at 61 kph, corresponding to the NCAP impact velocity [14]. Impact configurations included driving (30 degrees shoulder flexion, Fig. 1(b)) and vertical arm (<10 degrees shoulder flexion, Fig. 1(c)) positions, with and without the SAB (Fig. 1(d), Table I). The HBM response was evaluated based on chest deflection at the level of ribs 4, 6 and 8 [15-16] (Fig. 3).

TABLE I
ARM POSITIONS AND RESTRAINT SETTINGS

Arm position	SAB
Driving	No
Driving	Yes
Vertical	No
Vertical	Yes

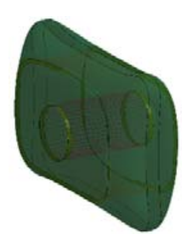

Fig. 2. Inflated SAB.

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The SAB was located on the vehicle door and deployed at the shoulder and upper thorax. Airbag inflation properties were based on an existing airbag model [17], with the mass flow rate scaled down corresponding to the smaller volume of the airbag used in this study, to achieve a peak pressure of 0.3 MPa.

Fig. 3. Location of ribs 4, 6 and 8 with respect to vehicle door.

III. INITIAL FINDINGS

Positioning the arm in the vertical position increased the chest deflection at all levels (Fig. 3). The change of the arm position from driving to vertical increased maximum chest deflection from 49 mm to 79 mm, while for the driving arm position SAB was observed to increase chest deflection response from 49 mm to 67 mm. For the vertical arm position, the SAB did not markedly change the chest deflection (approximately 2–3 mm).

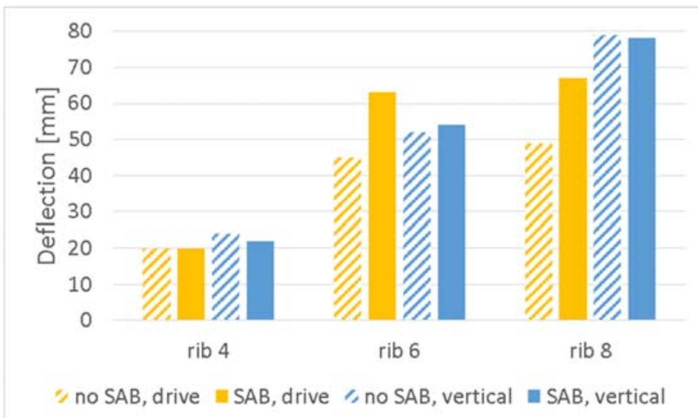

Fig. 4. Chest deflections measured at the level of ribs 4, 6 and 8, comparison of drive and vertical arm positions.

IV. DISCUSSION

The HBM demonstrated sensitivity to the pre-crash position. For cases without the SAB, chest deflection values increased when the arm was located in the vertical position. When the SAB was present and inflated and the arm was in the driving position, the SAB increased the chest deflection values at all levels. For the arm in the vertical position, the SAB did not change the predicted HBM response. For the inflation parameters and single location of the airbag evaluated, it was demonstrated that the SAB may not affect or may have a negative impact on the chest deflection. This observation supports recent epidemiological data regarding SABs. Further research will investigate the response of a belted occupant, evaluation of different methods of assessing occupant thoracic injury response in side impact, and parametric studies on SAB inflation and parameters and location within the vehicle.

V. REFERENCES

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