Real-World Injury Patterns Associated with Hybrid III Sternal Deflections in Frontal Crash Tests

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I. INTRODUCTION

Belted occupants in vehicles that perform well in frontal crash tests sustain serious injuries to the thorax at rates greater than those to the head, abdomen, spine, or pelvis. Regulatory and consumer test programs almost exclusively use the Hybrid III 50th percentile male dummy in front-seat positions, but there are questions regarding its ability to accurately predict thoracic injury risk in a range of real-world frontal crashes.

II. METHODS

Dummy sternal deflection data were obtained from the Insurance Institute for Highway Safety's 64 km/h, 40 percent overlap crash tests for vehicles with seat belt crash tensioners, load limiters, and good-rated structure. The National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) was queried for frontal crashes of these vehicles in which the driver was restrained by a seat belt and airbag. Injury probability curves were calculated by frontal crash type using the injuries coded in NASS-CDS and peak dummy sternal deflection.

III. RESULTS

For center impacts, moderate overlaps, and large overlaps in NASS-CDS, the probability of the driver sustaining an AIS≥3 thoracic injury, or any non-extremity AIS≥3 injury, increased with increasing dummy sternal deflection measured in crash tests. For small overlaps, however, both probabilities decreased with increasing deflection. Figure 1 shows the non-extremity injury probability curves for the two groups of frontal crashes.

IV. DISCUSSION AND CONCLUSIONS

Restraint systems that reduce peak Hybrid III sternal deflection in a moderate overlap crash test are beneficial in real-world crashes with similar or greater overlap, but likely have a disbenefit in crashes with small overlap. This may occur because belt-force limiters employed to control sternal deflections allow excursion that could produce contact with interior vehicle components in small overlaps, given the more oblique occupant motion and potential inboard movement of the airbag. Although based on a limited number of cases, this interpretation is supported by differences in skeletal fracture locations among drivers in crashes with different overlaps (Fig. 2). Current restraint systems could be improved by designs that reduce sternal deflection in moderate and large overlap crashes without increasing occupant excursion in small overlap crashes.

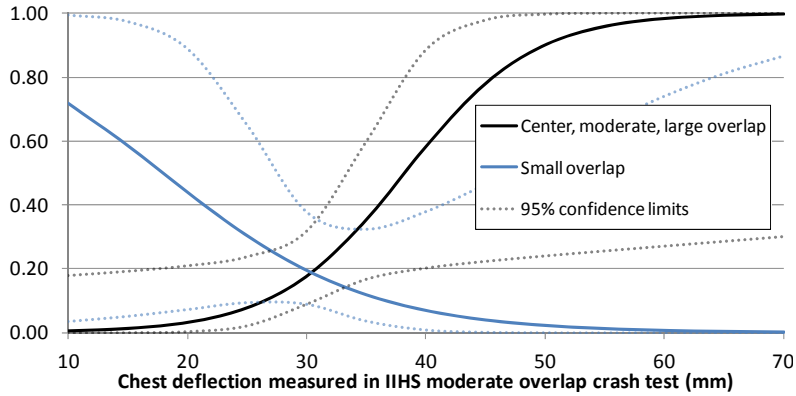

Fig. 1: AIS≥3 non-extremity injury probability curves for NASS-CDS drivers by front crash type.

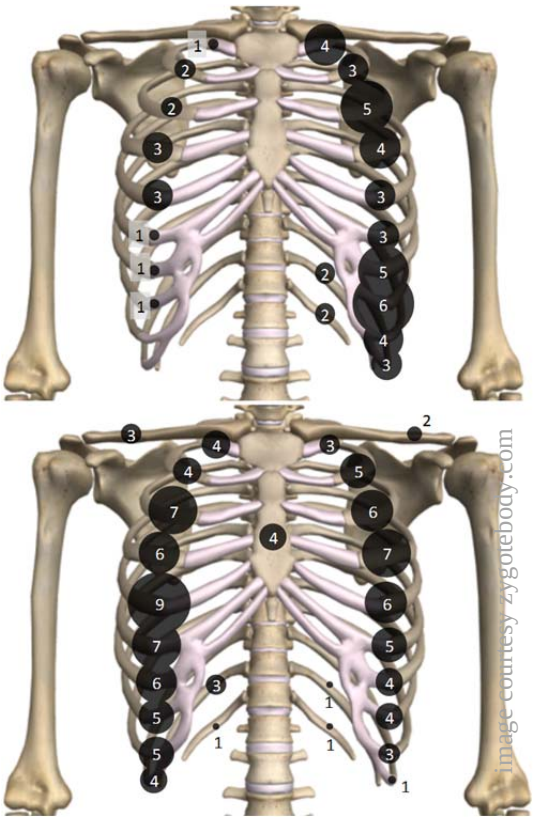

Fig. 2: Counts of NASS-CDS drivers with skeletal fractures at various locations in small overlap crashes (top) and in moderate, large overlap, and center impacts (bottom).

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