BIOMECHANICAL ANALYSIS OF LATE AIRBAG DEPLOYMENT IN MOTOR VEHICLE CRASHES

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INTRODUCTION

Severe motor vehicle crashes often result in serious injuries or fatality to the occupants in the motor vehicles [1-5]. The use of safety measures such as airbags in motor vehicles has proven to result in considerable reduction in injuries and mortality [6-8]. The advent of airbag technology has helped to reduce injuries to belted occupants in motor vehicles during the moderate to severe frontal and near frontal crashes. Although the airbags have saved many lives, they are also responsible for fatalities and serious injuries when the airbag deployment is delayed. Even properly restrained occupants sustain injuries showing the harmful effects of delayed airbag deployment with a low speed impact. The purpose of this study is to delineate the injury mechanism due to late deployment of the airbag using the biomechanical sled tests. Two sled tests were conducted in low speed crashes.

METHODS

Three sled tests were conducted using a vehicle buck. The standard 5th percentile Hybrid III female dummy was used. The dummy was placed in the driver's seat and restrained using the three-point shoulder and lap belt restraint system. The dummy was instrumented with a Denton 1716-A upper neck six-axis load cell and a three-axis accelerometer array (Endevco 7264-2000) at the center of gravity of the head. A three-axis accelerometer (3031-200) was placed at the center of gravity of the vehicle. The six axis load cell data was filtered with the SAE class 1000. A high-speed camera was used to collect the dummy kinematic data. The dummy's face and lips were painted with grease paint to delineate the interaction of the dummy with the airbag. Video and still photos were taken.

All three tests were conducted at a change in speed of 27 to 28 kph. The first test (test 1) was conducted with no airbag deployment. In second and third tests, the dummy upper torso and pelvis was ballasted with a weight of 9 kg and wrapped with foam to simulate a larger size occupant. The second test (test 2) was conducted with the normal airbag deployment (triggered at 37.5 ms). The driver seat angle was 15 degrees and seat was positioned 15.2 cm forward of full rearward. The third test (test 3) was conducted with a late airbag deployment (triggered at about 100 ms). Except for this, the same test protocol used in test 2 was adopted in test 3. The temporal responses of the upper neck tension and extension moments were investigated to examine the neck injury potential. The neck injury parameter, Nij (neck injury criterion) proposed by National Highway Traffic Safety Administration (NHTSA) was computed. This criterion is widely used to establish the probability of neck injury. The NHTSA has recommended a tolerance value of 1.4 to represent the 30 % neck injury risk of serious nature (AIS $\geq$ 3).

RESULTS AND DISCUSSION

Table 1 summarizes the peak neck tension and extension. For test 1 and test 2, the peak tension force and extension moment in upper neck are well below the neck injury critical intercept values of 3200 N and extension moment of 60 Nm proposed by the NHTSA. In contrast, for test 3 with late airbag deployment, the peak tension and extension moment are well above the neck injury tolerance. This suggests the high probability of serious neck injury with late deployment airbag.

Table 1. Peak upper neck tension and extension

	Test 1 (No airbag)	Test 2 (Normal deployment)	Test 3 (Late deployment)
Tension (N)	616.5	1056.8	4171.5
Extension (Nm)	11.8	14.3	82.6

As noted above, test 3 failed the Nij criteria. Figure 1 compares the Nij values of three tests. The computed Nij values for test 1 (no airbag deployment) and test 2 (normal airbag deployment) are well below the neck injury tolerance. In contrast, the computed Nij value for test 3 (late airbag deployment) is 2.0 which is significantly higher than the tolerance value (1.4), suggesting serious neck injury to occupants.

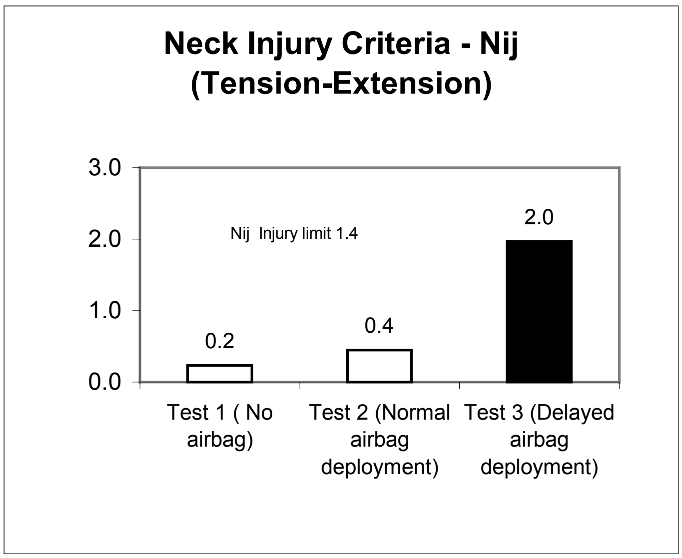

Figure 1: Neck Injury Criteria (Nij) calculation

In summary, three sled tests were conducted to delineate the biomechanics of neck injury due to late deployment of the airbag. The change in speed of the sled was in the range of 27 to 28 kph. The upper neck force and moment significantly increased with the late deployed airbag. The present study forms a first step to better understand the biomechanics of airbag injuries in late deployment situations.

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