C11 Unrecognized Spinal Injury Risk to Restrained Occupants in Rear-End Vehicle Impacts

Carley C. Ward, PhD, Jennifer A. Ward, BS, and Hrire der Avanessian, PhD, Biodynamics Engineering, Inc., 860 Via de la Paz, Suite C3, Pacific Palisades, CA 90272*

This presentation will inform attendees of the misconceptions regarding injuries in moderate velocity (change in velocity less than 30mph) rear-end impacts. This is accomplished through analysis of actual injuries sustained, sled test results and restraint system effectiveness testing. Frontal impact protection for vehicle changes at velocities up to 30 mph is required by Federal Motor Safety Standard 208 and is enforced by the National Highway Traffic Safety Administration (NHTSA). However, no such protection is provided for rear impacts in this speed range.

This presentation will impact the forensic community and/or humanity by informing attendees of the misconceptions regarding spinal injuries in moderate velocity rear-end impacts.

Seatback yielding/failing in moderate velocity impacts (20 to 30 mph range) is not uncommon based on the New Car Assessment Program (NCAP) rear barrier impacts tests. Unfortunately, when seat backs fail rearward in real world crashes, paralyzing injuries to vehicle occupants can result. Although these catastrophic injuries occur to belted occupants, test data from restrained anthropomorphic dummies indicates a minimal-to- nonexistent risk. Test data, using the Federal Neck Injury Criteria (NIJ), would indicate that the probability of severe spinal injury is rare. Even though each test with seat back failure results in compressive neck loads higher than in similar tests without seat failure, the loads seldom reach the severe injury level.

An examination of ten paralyzed individuals was performed to explain the anomaly between the actual injuries and test data. The injured individuals ramped up their reclining seat backs and impacted the rear seat backs and/or the front of the rear package shelves. Either the lower cervical or upper thoracic spine was fractured as a result of compression or flexion- compression loading. The fracture location was dependent upon the orientation of the occupants' head and neck, as well as the angle of the rear seat when contact occurs. Similar to diving injuries, the velocity of the thorax is critical, since it is the momentum of the thorax that provides the force to fracture the spinal vertebrae. Velocities of the thorax toward the rear seat back in excess of 7.3 mph can produce vertebral fracture.

Slack introduced into the restraint system by the reclining seat backs was determined for four men and three women of different sizes and weights in two different vehicles. Male surrogates' height and weight ranged from 64.5 to 79 inches and to 168 to 254 pounds, respectively. The range for the female surrogates' height and weight was 64.25 to 66 inches and 161 to 237 pounds, respectively. Circumference of the thorax at three locations was recorded for each surrogate. Comparable anthropomorphic dummy data is also included. The occupants' dimensions, as well as their weight versus the slack introduced for the upright and reclined seat positions were plotted.

Girth circumference was found to be a critical measure. The results show that as much as 13.75 inches of slack can be introduced into the restraint system when an obese individual's seat back reclines. This amount of slack renders the restraint system ineffective when it is needed to control the momentum of the thorax. The heavier the individual, the less effective their restraint system becomes when their seat back fails. To illus- trate the effect of belt slack on a reclined obese occupant, a rear impact was simulated using the MADYMO occupant simulation computer program. The slack introduced by a 50th percentile anthropomorphic dummy in a reclining seat was considerably less than that of the obese individuals. This difference in belt slack and the limited biofidelity of the dummy in rear impacts contributes to the relatively safe neck loading experienced by the dummy in sled tests. Results of this study show that dummy tests cannot be used to analyze the response of restrained overweight occupants in mod- erate rear-end impacts. Such dummy data would be misleading, indicating good protection actually, when the reverse is true.

Spinal Injury, Rear-End Impacts, Seat Back Failure

 ** Presenting Author*