C5 Relationship Between Vehicular Rear Impact With Seat Back Failure, Delta V, and Occupant Compartment Intrusion

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After attending this presentation, attendees will understand how moderate-to-severe rear-impact motor vehicle accidents can result in debilitating cervical spine injuries when seatbacks fail. The forces involved can cause the front passengers' seatbacks to deform to such a degree that the bodies of the passengers are no longer restrained. The bodies continue to move rearward until they contact structures in the vehicle's rear compartment, causing severe injuries. This presentation addresses the frequent misconceptions in the analysis of such impacts. Following the presentation, the audience will have a better understanding of the important parameters in a rear impact setback collapse.

This presentation will impact the forensic science community by discussing how to protect against cervical injuries, it is important to identify and understand the risk factors.

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To protect against cervical injuries, it is important to identify and understand the risk factors. Unfortunately, misunderstandings related to the kinematics and biomechanics of such events has greatly hindered injury prevention efforts. Without adequate analysis, unproductive arguments regarding seat strength typically result. This presentation will address the following misconceptions: a) delta V of the struck vehicle is the primary risk factor, b) intrusion and or deformation of the rear compartment is a critical factor in the injury causation, and c) protection provided by the occupant's seat back in a moderate-to-severe rear impact is equivalent to protection provided in frontal or side impact at the same delta V.

A new analysis technique will be used, where the motion of the occupant's change of velocity is divided into the five phases. Although there will be some overlap between phases, the separation greatly assists analysis and understanding of the event. The five phases are:

1. Occupant is restrained by the seat back
2. Seat begins to fail and deforms
3. Lap belt friction with the lower extremities slows the body
4. Body moves freely rearward and impacts the rear seat back or other structures in the rear of the vehicle
5. Occupant experiences a ride down with the vehicle.

Since it is the change in velocity in phase four that is causing the injury, not the Delta V of the vehicle, it is this phase that needs to be minimized. The only important velocity is that of the head relative to structures struck once moving freely rearward and released from the seat. Depending on the seat back angle, a change in velocity of seven to ten mph in phase four can produce a serious cervical spine injury. Vehicle rear crush intrusion that limits the seatback excursion can reduce the injury risk. Also, such intrusion can reduce the distance traveled by the occupant and, thus, reduce the change of velocity experienced by the occupant in the impact with rear structures. These phenomena will be demonstrated using a MADYMO simulation of an actual event and comparisons between injured and uninjured occupants in the same rear impact crashes.

The government has no crash criteria for the protection of occupants in rear impacts; the only requirement is that the fuel tank is protected. This Federal Motor Vehicle Safety Standard (FMVSS) is 301. In this test, the rear of the vehicle is impacted by a moving barrier traveling at 30 mph. Depending on the weight of the vehicle, the change of velocity imparted to the vehicle is typically much less than 20 mph. Also, the Anthropomorphic Test Devices (ATD/Dummies) in the vehicle are not instrumented and no ATD measurement criteria have to be met. Frequently, the seat backs deform rearward significantly in the FMVSS 301 test. Even if the seatback fails entirely and the ATD is flat on its back the vehicle passes this Federal standard. In a frontal impact the Federal standard known as FMVSS 208 specifies that the vehicle crash into a fixed barrier at 30 mph and that injury measures in the ATD not be exceeded. Clearly, the protection afforded an occupant is far less in a rear impact than in a frontal impact.

Several case studies will be presented. In these cases, there were varying Delta Vs of the struck vehicle, varying stiffnesses of the occupants' seat backs, and varying degrees of intrusion into the occupant compartment.

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Rear-End Impact, Seatback Collapse, MADYMO

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