



Forensic Medical Investigation of Motor Vehicle Incidents



Michael P. Burke



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Preface

The most favorable outcome of any forensic case is best served by open discussion between the forensic pathologist, investigating police officers, and other relevant members of the investigation.

In ideal circumstances, in which the pathologist's routine work load permits attendance at the scene of a motor vehicle incident coupled with expert examination of a motor vehicle's exterior and interior damage, a more reasoned analysis of a crash victim's injuries can be made. When conditions dictate that the pathologist cannot attend the scene, the investigators (and courts) will still usually derive sufficient information from the postmortem report, providing accurate documentation of injuries has been performed and important concerns regarding the case have been communicated by the investigating team.

The autopsy examination of a victim of a motor vehicle incident needs to address a number of issues that may be of interest to a variety of different groups. A fundamental purpose of the postmortem examination is to provide a reasonable cause of death. A further important function of the pathologist is to detail the extent of internal injury in those who initially survive the trauma arising from the vehicle impact to allow objective audit for those involved in trauma care. Other interested parties may include researchers and engineers who wish to correlate impact points to motor vehicles and the associated injuries to occupants and pedestrians.

This book is written as a preliminary resource for those interested in the investigation of motor vehicle incidents and it is hoped the reader is stimulated to further study and productive associations with his or her colleagues in related fields of study.

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He was a member of the multidisciplinary team in the forensic investigation of a mass murder committed at the Port Arthur penal colony site, Tasmania, Australia, in 1996.

In 1999, he was part of the British Forensic Investigating Team in Kosovo. Over the past decade, he has developed an interest in the problems associated with the postmortem interpretation of injuries sustained in motor vehicle incidents.

Dr. Burke has published articles in the *American Journal of Forensic Medicine and Pathology*, *Journal of Clinical Neuroscience*, *Emergency Medicine*, *Australian and New Zealand Journal of Medicine*, *Medicine, Science and the Law*, *Epilepsia*, and *Pathology*.

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Motor Vehicle Design and Causation of Injuries

1

Overview

Motor vehicle collisions are the major cause of death in the 15- to 30-year age group, the major cause of injury leading to death in the 5- to 15-year age group, and the source of enormous financial and social cost to the community as a whole.

In developed countries, a large proportion of deaths arising from motor vehicle incidents occur on roads with higher speed limits (i.e., faster than 100 km/hr). On Australian roads, approximately 32% of deaths occur in 100 km/hr zones, 12% occur in 110 km/hr zones, and 21% happen in 60 km/hr zones. Most crashes involving loss of life occur during daytime (56.9%) and the great majority of crashes occur in fine weather (72.3%).¹

For any given collision, it has been shown that the size of the motor vehicles involved is a significant factor in the outcome of a crash. Occupants of a larger vehicle by size and mass have a more favourable outcome than those in a smaller vehicle.² This “vehicle mismatch” is of particular concern in side impact collisions.

Collisions between traditional passenger vehicles and four-wheel drive (4WD) and sports utility vehicles (SUV) lead to more significant injuries to the occupants of the passenger vehicle.³

The increase in injury also occurs when the passenger vehicle has a larger mass than the 4WD vehicle.⁴ The relative and absolute numbers of 4WD vehicles and SUVs on the roads are increasing and the “aggressive” nature of these vehicles in crashes is an important issue for research into vehicle safety design.

It has been estimated that sitting in the rear seat of a passenger vehicle may reduce the risk of death in a motor vehicle collision by approximately 39% and reduce the risk of serious injury by a similar amount.⁵ An earlier study by Brown showed that injured motor vehicle occupants presenting to a hospital emergency department also showed the protective effect of rear seat occupancy.⁶

Introduction

Modern motor vehicles have numerous safety features for drivers and passengers including seat belts with pretensioners, front, side and curtain airbags, collapsible steering columns and pedals, and frontal crush zones.

The dashboard fascia has a moulded, curved configuration with padding to cushion impact from the knees and lower legs. The dashboard padding must be of sufficient thickness and compressibility to cushion impact to the knees in a frontal collision, yet firm enough to prevent forceful contact of the knee into underlying hard materials. The most efficient type and thickness of interior padding has utilised information derived from research on the biomechanics of injury causation.⁷ It has been shown from computer simulation that increasing the thickness of the roof side rail padding to 5 cm reduced the peak acceleration to the head during a motor vehicle collision, with a subsequent 85% reduction in the head injury score.⁸

Research in exterior vehicle designs progresses for strategies to minimise fatalities and long-term physical effects to pedestrians injured in crashes.

Important motor vehicle design features discussed in this chapter include:

- Crashworthiness
- Seat belts
- Airbags
- Antilock braking systems
- Electronic stability control
- Event data recorders
- Pedestrian friendly motor vehicles
- Intelligent vehicle systems
- Improvements in lighting

Crashworthiness

Crashworthiness is the measure of how well a vehicle provides protection to its occupants during a collision. An analysis of British data between 1980 and 1998 on improvements in the crashworthiness of motor vehicles has estimated a

reduction in the number of drivers killed or seriously injured to be at least 19.7%.⁹ Government-regulated tests and a number of private organisations provide objective measures of a vehicle's performance in a number of simulated crash tests. Typically frontal, offset frontal, side impact, rear impact, and rollover tests are employed in various combinations.

The vehicle must impart sufficient stiffness in the body shell to prevent cabin intrusion yet provide frontal crush zones to dissipate kinetic energy and decrease the risk of deceleration injury (Figure 1.1). Deforming elements in the front and rear of modern vehicles include engine support arms, radiator assemblies and longitudinal support arms (Figure 1.2). Cross-bars in the front of a vehicle allow some energy to be absorbed by the “nonaffected” side in an offset frontal collision.

Protection in side impact collisions is afforded by a rigid passenger cell with cross-bars, side impact protectors, and structural designs to absorb energy to the frame and offside of the vehicle. Steering columns and foot pedals are engineered to collapse away from the driver to reduce the probability of significant direct blunt force injury to the chest and feet/ankles.

Vehicles such as trucks, vans, 4WD, and SUV, which have a relatively high center of gravity, have a higher incidence of rollover events. In these vehicles, it is important for manufacturers to address excessive roof crush if identified in controlled rollover tests or real life situations.



Figure 1.1 Frontal crash test showing frontal “crush” zones. (Photo courtesy of BMW.)



Figure 1.2 Longitudinal and transverse components of body shell. (Drawing courtesy of BMW.)



Figure 1.3 Frontal collision of passenger sedan and four-wheel drive vehicle showing override.

SUVs are an increasingly popular choice of vehicle for motorists. Collisions involving SUVs and conventional passenger cars tend to lead to proportionally greater injuries the occupants of the conventional vehicle. In a frontal collision, the SUV may override the bumper and hood of the

passenger vehicle, causing intrusion of the steering column and dashboard in the passenger car. If override occurs, the relatively stiff nature of the SUV front end can lead to marked floor pan intrusion into a conventional vehicle (Figure 1.3). In side impact collisions, some SUVs may override the passenger car door, resulting in significant cabin intrusion.

Seat Belts

The legislative requirement to wear seat belts resulted in a marked decline in the incidence of injury and death associated with motor vehicle collisions in the State of Victoria, Australia. Seat belt use led to reduced deaths from head injury, chest injury, and the effects of rapid deceleration. Seat belts are designed principally for frontal crashes and the protective effect is primarily for these types of collisions. Wearing a seat belt also reduces the incidence of occupant ejection. The use of seat belts has not resulted in a similar reduction in injuries for nearside side impact motor vehicle occupants in which head injury is caused by impact with the adjacent cabin interior and vehicle intrusion.

More recent developments in seat belt design include pretensioners and energy management systems (Figure 1.4). Seat belt pretensioners virtually instantaneously retract excess slack in the seat belt, resulting in better approximation between the occupant and the seat and hence improving the individual's deceleration profile during the collision. The better approximation between the occupant and seat also minimises “out of position” events in which injuries from airbag deployment are more likely to arise. The closer fit between the occupant and seat also decreases the probability of submarining injuries.



Figure 1.4 Seat belt assembly with pretensioner. (Drawing courtesy of BMW.)