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Injury Patterns in Motor Vehicle Fatalities

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ABSTRACT: A retrospective pilot study of motor vehicle incident fatalities was conducted to determine what relationships exist between injuries received by deceased drivers, passengers, and a control population of pedestrians, and some of the environmental factors existing at the time of the incident. A number of correlations were established between the types and locations of injuries received, seat belt use, position of the injured party, and so forth. A study of this type, if performed on a large enough population, could lead to predictive models for the determination of position of the victims within a motor vehicle at the time of a fatal crash, based on a unique clustering of injuries.

KEYWORDS: pathology and biology, injuries, motor vehicle accidents

In the analysis and reconstruction of a motor vehicle incident, an investigator needs to have as much information as possible about the scene and the circumstances surrounding the incident to arrive at accurate conclusions. An incident scene may be profoundly disturbed before the investigator arrives, especially one at which vehicles and injured parties must be moved from the immediate scene to prevent obstruction of traffic or for safety reasons, or in the case of hit-and-run incidents. In those cases where a vehicle ends up partially or totally submerged in water, it may be removed from the scene before the investigator has a chance to examine it. Secondary impacts, resulting from the involvement of additional vehicles after the primary incident, can also complicate reconstruction.

There have been a number of studies that seek to relate some of the observable results of an incident to the possible contributing circumstances that gave rise to it [*1-4*]. Such factors include skid marks, prior vehicle damage, damage to stationary objects, the use of seat belts, positions of passengers, and environmental factors. All of these can be used to help the investigator reconstruct an incident scene and make certain assumptions and predictions concerning some missing or obscure factors.

There has been relatively little scientific examination of the injury patterns of the deceased victims of motor vehicle incidents. There is little doubt that certain combinations of vehicle dynamics, position of passenger or passengers within the vehicle, and the external environ-

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ment will give rise to similar injury patterns in deceased victims. It follows, therefore, that such patterns of injury could be predictors of some of the factors contributing to an incident, including position within the vehicle at the time of the incident, which may be otherwise unavailable to the investigator because of circumstances which have altered the scene.

The results reported herein were obtained from a pilot study which sought to uncover basic relationships between injury patterns in motor vehicle incident fatalities and some of the common vehicular and environmental characteristics of the incident. The intent is to develop models whereby specific incident characteristics, such as position in the vehicle, can be determined on the basis of injury patterns. A secondary goal of the study is to determine the role of drugs, alcohol, and the use of seat belts in the number, types, and severity of injuries in motor vehicle incidents.

Materials and Methods

A retrospective study was undertaken of all autopsies performed at E. W. Sparrow Hospital, Lansing, Michigan, on traffic fatalities in Ingham County, Michigan during the years 1980 to 1983, inclusive. There were a total of 164 cases, which included some cases referred from adjacent counties. The autopsies included examination of the cranial, thoracic, and abdominal cavities, toxicologic evaluations on all cases, and X-rays as needed. The toxicology exam included ethanol and drug screens on all individuals and carbon monoxide levels when necessary. Photographic records of all significant injuries were made.

Data concerning the vehicles and the scene were obtained from a review of records of the Traffic Services Division of the Michigan State Police. Information was collected on all incidents where there was a victim or victims who had been included in the pathology reports. Once collected, the data was entered into a data file on Control Data Cyber 750 Mainframe computer at Michigan State University and verified for accuracy. This file was then converted into a Statistical Package for the Social Sciences (SPSS) systems file and all statistical manipulations were done using the SPSS.

Results

Frequency studies were performed using five victim study groups: driver using seat belts, driver not using seat belts, passenger using seat belts, passenger not using seat belts, and pedestrians. Pedestrians served as a control group throughout this study. Table 1 contains the frequencies in each of these groups.

The locations of significant injuries are presented in Table 2. The pedestrians as a group have a greater frequency of brain stem pathology and leg fractures than the driver-passenger group, but have fewer injuries of the heart and aorta. All three groups have a high frequency of abdominal injuries which include fractures of the liver. Those victims who had received massive head injuries or heart lacerations did not survive long enough to have substantial hemoperitoneum.

TABLE 1—*Frequencies of 5 victim study groups (164 total).*

Victim Study Group	No.
Drivers with seat belts	6
Drivers without seat belts	70
Passengers with seat belts	2
Passengers without seat belts	52
Pedestrians	34

TABLE 2—*Areas of significant injury to victims (numbers in percent).*

Injury	Driver—No Seat Belts	Passenger—No Seat Belts	Pedestrian
Brain stem	38	38	61
Heart laceration	24	25	18
Aorta tear	27	31	15
Abdomen	71	67	68
Fracture (leg)	48	46	76

A comparison of the study groups and the frequency of various injuries was performed. These results are presented in Table 3. Those outside the vehicle are identified as "pedestrian." Those inside the vehicle are identified as "driver with no seat belt." The "pedestrian" group has a greater frequency of injuries to the brain, posterior fossae of the skull, and bones of the lower extremity. "Pedestrians" also have fewer injuries of the sternum and aorta, and have fewer facial lacerations.

Laterality of injury was studied. The physical proximity of the driver to the left side of the car and of the front seat passenger to the right side of the car would be expected to cause greater numbers of injuries to the body surface immediately adjacent. The results of this study are presented in Table 4. The groups presented are "driver (no seat belts)," "passenger (no seat belts)," and the "pedestrian" (control) group. Contrary to expectations, no significant laterality of injury was demonstrated in the study or control groups.

In an effort to determine if any injuries occurred in association with others, a study of injuries was undertaken using Pearson correlation coefficients. The frequencies of ten common injuries were compared with each member of the group; only those correlations with

TABLE 3—*Incidence of injuries of pedestrians compared to drivers—no seat belt (numbers in percent).*

Injury	Driver	Pedestrian
Brain stem injuries	38	61
Fractured femur	24	41
Posterior fossae-skull	21	35
Fractured tibia	24	35
Facial lacerations	49	34
Sternum fracture	23	8
Aorta tear	27	15
Anterior fossae-skull	37	26

TABLE 4—*Laterality of injury (numbers in percent).*

	Driver—No Seat Belts		Passenger—No Seat Belts		Pedestrian	
Injury	Left	Right	Left	Right	Left	Right
Facial laceration	47	51	42	46	32	35
Facial abrasion	40	46	33	40	47	44
Fractured ribs	41	44	48	48	44	35

$p = 0.05$ or less were considered significant. The ten injuries compared in this study are given in Table 5.

The Pearson correlation study was carried out on four populations. These were "driver—no seat belt," "pedestrians," "right front seat passenger—no seat belt," and "front center passenger—no seat belt." Table 6 gives the results of the study for all of those injury pairs with $p = 0.05$ or less. The following is a description of how this table is constructed.

A matrix is established so that the ten injuries studied are listed first horizontally and then vertically. The correlations are then calculated so that each injury in turn is matched with each of the other nine injuries in the series. The calculations are performed separately for each of the named patient populations. In Table 6, the injury listed as the "Target Injury" appears in the far left column of the matrix and is the one to which all other injuries are correlated. The injuries with which there are significant correlation and the "p" value are listed.

The "driver—no seat belt" population had the largest number of injuries which occurred in statistically significant clusters. All of the clusters had injuries which involved the abdomen (liver or spleen or both). All of the clusters had injuries which included members of three of the four areas studied (brain, thorax, abdomen, extremities). None of the clusters included members of all four areas.

The "right front seat passenger—no seat belt" population included one group which had injuries involving all four areas studied. This was the group which had aorta tear (ARTATR) as the target injury and the only group to include an injury of the brain. All of the clusters had injuries which included the thorax.

The "front center passenger—no seat belt" population had no clusters which included injuries of the brain. Most of the groups included at least one injury of the extremity.

Within the "pedestrian" population, most of the groups included at least one injury of the brain or thorax or both. Injuries of the extremities occurred in fewer of the injury clusters than the other patient groups.

Discussion

One third of each of the larger groups tested, that is, "pedestrians," "driver—no seat belt," and "passenger—no seat belt," had blood alcohol levels greater than 0.10% by weight ethanol. Other chemicals found included tranquilizers and barbiturates, but the numbers of individuals were too small for statistical evaluation.

The number of individuals who were wearing seat belts also was too small to analyze their injury patterns. This group numbered only 6% of the in-car fatalities.

One of the important issues that arises from motor vehicle fatalities is determination of who the driver was at the time of the incident. In those cases where witnesses are not available or not reliable, there should be an independent means of identifying the driver. Helpful data would include clothing fiber and hair or blood on the steering wheel or driver's side of the passenger compartment. An imprint of brake or accelerator pedal design on the shoe

TABLE 5—*Injuries studied in Pearson Correlation Study.*

Brain:	Thorax:
Convexities (BRNCVX)	Cutaneous laceration (THORLR)
Stem (BSTEM)	Heart perforation (HEART)
	Aorta tear (ARTATR)
Abdomen:	Extremities:
Liver fracture (LIVER)	Femoral fracture (FMFR)
Spleen fracture (SPLEEN)	Femoral abrasions (FMABR)
	Tibia fracture (TBFR)

TABLE 6—*Pearson correlations for ten common injuries (*p *value).*[a]

Population	Target Injury	Other Significant Injuries				
Driver	SPLEEN	FMFR (0.004)	LIVER (0.001)	HEART (0.001)	THORLR (0.006)	
	THORLR	LIVER (0.031)	FMFR (0.033)	SPLEEN (0.006)		
	HEART	LIVER (0.001)	TBFR (0.040)	ARTATR (0.027)		
	ARTATR	LIVER (0.001)	BRNCVX (0.002)	FMFR (0.017)	BRSTEM (0.002)	
	LIVER	BRNCVX (0.002)	FMFR (0.018)	TBFR (0.018)	BRSTEM (0.005)	
	FMFR	TBFR (0.032)	LIVER (0.018)	ARTATR (0.017)	THORLR (0.033)	SPLEEN (0.004)
	BRNCVX	BSTEM (0.027)	LIVER (0.002)	ARTATR (0.002)		
Right front passenger	SPLEEN	THORLR (0.008)				
	HEART	LIVER (0.001)	ARTATR (0.008)	FMABR (0.003)		
	THORLR	FMABR (0.012)				
	ARTATR	LIVER (0.001)	FMABR (0.002)	BRNCVX (0.048)		
Front center passenger	SPLEEN	FMABR (0.002)				
	HEART	THORLR (0.031)				
	ARTATR	FMABR (0.033)				
	FMFR	TBFR (0.001)				
Pedestrian	SPLEEN	LIVER (0.037)	BRNCVX (0.007)			
	HEART	BRNCVX (0.007)	FMABR (0.017)	ARTATR (0.033)		
	THORLR	LIVER (0.011)				

[a]See Table 5 for explanation of abbreviations.

sole would also be helpful. In addition to these findings, there should be consideration of the type, extent, and laterality (right-left) of injuries. This study is a preliminary exploration of the value of injury patterns in the development of an injury-position model. This model will be used to assign statistically a position either within a vehicle or as a pedestrian at the time of impact.

It was found that the "driver—no seat belt" group had the broadest range of injury clusters. All of these injury clusters included at least one intra-abdominal injury. The "right front seat passenger—no seat belt" group also had a similar percentage of intra-abdominal injuries, but they did not have the same broad range of injury clusters.

Brain stem injuries occurred with the greatest frequency in the "pedestrian" population. This group also had a high incidence of extremity trauma with fractures of the femur or tibia or both. Pedestrians had a high frequency of thoracic injuries, as did all the other groups studied. The thoracic injury clusters included tears of the aorta as well as thoracic abrasions and lacerations.

It has been conventional wisdom that laterality of injuries is a useful aid in determining position in the vehicle at the time of impact. The current study did not demonstrate a preponderance of left side injuries in victims identified as drivers or of right side injuries in victims identified as passengers. The injuries evaluated included facial abrasions or lacerations or both, and rib fractures. A modifying factor may be the fact that 94% of the study population did not wear seat belts.

There may have been significant tumbling within the vehicle. One injury suggests impact of the victim with the side window glass. These "dicing" lacerations were present on the posterior surfaces of the fingers and hands. Drivers tend to have injuries on the left hand, passengers on the right hand or surface closest to the side window.

The current study has attempted to address the question of position within a motor vehicle at the time of a fatal crash by statistical correlation of traumatic alterations of anatomy with development of several injury clusters. These clusters have been calculated for the driver, passenger, and pedestrian (control) groups. There appears to be a unique clustering of injuries in each of these groups studied.

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