THE EPIDEMIOLOGY OF INJURY - A REVIEW

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ABSTRACT

This paper outlines first some of the information available on the numbers of accidental deaths and injuries from all sources. Problems of definition are important, but road accidents are identified as the largest single class of event causing trauma by impact. The relative proportions of the major groups of injured road users are outlined for a selection of countries, and then, for pedestrians, motorcyclists and car occupants, a general description of their injuries according to the damaged segments of the body are given. Studies from many different parts of the world provide fairly consistent descriptions of these injuries.

Reference is made to trauma caused by other and new transport modes, and it is suggested that in the future, because of an expected growth in mechanical trauma due to increases in the numbers of road accidents, more attention should be paid to describing the aetiology of injuries in general and traffic trauma in particular.

INTRODUCTION

Accidental trauma, unlike many conventional diseases, has only recently come under the objective scrutiny of the scientific world. The very word "accident" still implies for some people a special extra-rational event, to which the normal causal relationships and probabilities of involvement do not apply. Yet an objective appraisal of accidental phenomena suggest that they may be studied as any other disease may be studied, using the methods of epidemiology for defining the types and incidences of trauma, and the new discipline of biomechanics for understanding the mechanisms of injury. It is to be hoped that this conference will further our objective understanding of this traumatic disease.

Having survived birth, for over half their lives most people in the western world are more likely to die from accidents than from any other cause. This high position of accidents as a source of mortality has not resulted from a large increase in their incidence. Rather, the numbers of accidents has remained relatively static over the last seventy years, although varying in composition, in most western countries, and the more conventional modes of death, particularly infectious diseases, have declined. Vaccines, antibiotics, surgical advances, pure water supplies, improved sanitation and general advances in diet and living standards have virtually eliminated death from typhus, smallpox, diphtheria, influenza, cholera, polio and other diseases which were part of the every-day world of the last century.

Accidents take many forms, the most frequent types of accidental deaths are shown for Britain in Table 1.

These data show that transport accidents constitute the majority of deaths, with accidents in the home also contributing substantially. Of these latter cases in the home, falls make up the great majority (59%), with deaths due to poisoning, burns and suffocation as other significant, but smaller groups. Therefore, it appears that the great majority of accidental deaths are due to transfers of unacceptable amounts of kinetic energy; what may be termed impact trauma.

Looked at in these terms, it would appear, from the U.K. data shown in Table 1, that some 80% of all accidental deaths arise from trauma caused by transfers of kinetic energy into the human frame. Therefore, the subject of this conference, the biokinetics of impacts, represents one of the major sources of death and morbidity in the modern world.

Table 2 describes the numbers of accidental deaths for a selection of countries. It would appear that motor vehicle deaths are between 36% and 50% of the total. Figures such as these however, must be treated with great caution because of problems of definition. Each country has developed over the years procedures for recording the numbers of deaths and injuries; each country using its own definitions. Even the seemingly obvious category of a fatality is defined very differently in different countries. This is because, for administrative convenience, fatalities can be limited to those deaths which occur at the scene, or within twenty four hours, three days, seven, thirty (the World Health Organisation definition) or one year. Further, the several classes of accidents are defined differently because the records are collected by various separate agencies.

This problem is particularly severe when non-fatal accidents are considered. For example, a serious road accident casualty in the U.K. is defined as someone who is admitted to hospital for at least one night, or who has received fractures, concussion, internal injuries, crushings, severe lacerations or severe general shock requiring medical treatment. An industrial accident casualty on the other hand, is defined as someone who is unable to work for three days or longer. The relationships between such divergent definitions are not established, and perhaps one of the first and most useful programmes which could be undertaken internationally in the field of accident research, would be to establish these relationships between different classes and severities of accidental trauma.

Road accidents constitute the largest single class, and it is that group which has so far received the most attention, and about which the most information is available.

TRAFFIC ACCIDENTS

Table 3 lists the numbers of deaths and injuries (caused by motor vehicles) for a selection of European and other countries. For the countries listed, this represents almost 200,000 fatalities each year. Figures are also given for non-fatal casualties, but because of different definitions and reporting procedures the numbers of these casualties should only be considered as an approximate guide.

The relative proportions of the several major classes of road users killed in accidents are shown for the nine member countries of the European Economic Community in Table 4, and compared with the United States.

These data show that car occupants represent only 44% of the total number of traffic fatalities within the E.E.C. This is in contrast to the 63% for car occupants in the United States.

Pedestrians constitute a major group (28%). In Britain, in particular, pedestrians are a major problem (39%).

Cyclists and motorcyclists in the Netherlands, Italy and Denmark represent approximately one third of the total.

A considerable number of studies have outlined the general epidemiological characteristics of traffic accidents for specific environments. This review will only touch on those factors which have a direct bearing on the injuries and their consequences.

PEDESTRIANS

The general characteristics of pedestrians involved in road accidents are well documented in many studies. Pedestrian casualties in most countries are dominantly the young and the old. In the U.K. 31% of serious pedestrian casualties are under 10 years of age, and 26% are 60 and over. Some countries can demonstrate a smaller but distinct group representing intoxicated middle-aged males (1). In general males are involved twice as frequently as females in pedestrian accidents (2).

The great majority of pedestrians are injured in collisions with cars and light vans. Table 5 shows for Britain the relative proportions of serious pedestrian casualties by type of vehicle (3).

A general feature of all traffic casualties, and pedestrians are no exception, is the multiplicity of injury per casualty. Most studies have shown that a seriously injured pedestrian on average receives between 2.5 and 3 injuries to different body areas. A number of studies have described the frequencies of these injuries. Data from different parts of the world show fairly consistent results, and three studies from Germany (4), Britain (5) and Australia (6) are illustrated in Figure 1. These data show the relative frequency with which the main segments of the body receive serious injuries. Of outstanding importance is the large number of head and lower limb injuries.

Some further data are available which show that children, when involved in pedestrian collisions, are generally less seriously injured than adults (7). This is probably due to the less severe speed conditions of most child pedestrian impacts, which involve a considerable number of cases where the vehicle speed is very low, and is not due to more favourable biomechanical circumstances. Experimental tests suggest that for equivalent impact speed conditions, children receive more serious blows to more vulnerable parts of the body than adults (8).

MOTORCYCLISTS

Unlike pedestrians, in most countries the age groups dominantly represented in motorcycle accidents are between 16 and 25 years of age. Males are represented some 10 to 15 times more frequently than females. Doubtless these characteristics represent the population who largely use two-wheeled machines.

A considerable number of studies have outlined the main features of injuries to motorcyclists. These injuries are dominantly to the head and limbs, particularly the lower limbs. The incidence of head injuries to motorcyclists is somewhat lower than for other classes of road user, mainly because of the use of helmets. This question is discussed elsewhere in this conference.

Fractures sustained by motorcyclists have been examined separately in a number of studies. Some data are given in Table 6 from Britain (9) and from California (10), showing the incidence of fractures to severely injured motorcyclists (including pillion passengers). The similarities in these distributions are striking, although the studies come from quite different environments.

Other studies have presented data on all types of injuries to motorcyclists in other forms. Figure 2 shows the relative proportions of injuries by anatomical segments (11,12). As with the previous data, these studies confirm the similarities in the distribution of injuries regardless of the data source.

CAR OCCUPANTS

The characteristics of car occupants and their injuries have been well documented in a great many studies. The age groups most at risk are between 18 and 25 years of age with a gradual decreasing involvement from then on. Some 80% of car drivers are male (in Europe) and between 60% and 75% of front seat passengers are female. Rear seat occupants appear to be evenly distributed between the sexes, with children forming a significant group amongst rear seat occupants.

Multiplicity of injury is again an important feature for this class of road casualty. Figure 3 shows two typical distributions of injuries taken from the widely separated environments of Germany (4) and Australia (1). Other studies in Britain (2), the United States (13), Norway (14) and France (15) confirm the general distributions shown in Figure 3. Head injuries are most frequent, whilst lower limb injuries are important, as are thoracic injuries; the latter increasing in importance as more serious injuries are examined. For fatal injuries some studies show that trauma to the chest is more frequent than fatal head injury (16).

Car occupant injuries have been studied for a sufficient length of time for changes in injury patterns to be examined. These changes occur as a result of changes in the environments in which the accidents take place, or alternatively the changes may result from improvements in vehicle design which reflect on these injury patterns. It is absolutely essential for design changes to be evaluated in the real world of accidental trauma in this way, because only then can the effectiveness of such changes be judged.

A great number of studies have evaluated car occupant injuries in specific environments such as motorways (17), or in specific collision types such as rollover accidents (18) or side impacts (19). Similarly design changes have been shown to be very successful in the case of anti-burst door locks (20) and in the use of seat belts (21). A great number of other characteristics still remain to be investigated however. These include the influence on occupant injury of energy-absorbing steering assemblies, head restraints, passenger compartment deformation, instrument panel design, indeed the whole range of features in vehicles which play a part in injuring occupants. Some types of energy-absorbing steering assemblies have been shown specifically not to work in the real world of accidents in the manner in which they have been designed; this will be discussed later in this conference.

OTHER FORMS OF MECHANICAL TRAUMA

Although traffic accidents are identified as the largest single class of events which give rise to mechanical trauma, as shown earlier there are other types of injury, some new, which deserve study. By examining information from other fields, it is possible to get new insights into both the epidemiology and the biomechanics of trauma. One encouraging, relatively recent development has been the examination of these other forms of injury.

Studies of free falls for example (22) provide insights into human tolerance levels to whole body deceleration. Studies of military operations can reveal useful biomechanical information, on head injuries for example (23).

Other forms of transport have their own specific injury characteristics. Skiers and sledgers have been studied in Norway (14), skiers again in the United States (24), and a new form of transport trauma is now sufficiently widespread to require epidemiological examination with the introduction of snowmobiles. (25).

CONCLUSIONS

This review has aimed to describe some of the general aspects of the epidemiology of mechanical trauma. Subsequent papers in this conference will review the nature and frequency of specific injuries. It is evident that in most of the developed parts of the world, accidental trauma has replaced infectious diseases as a source of mortality and morbidity. It ranks high with other causes of death and is, in fact, for many countries, the leading cause for lost man-years (2).

Transport accidents contribute very largely to the total accident scene. In the future, most countries can look forward to substantial increases, over the next ten years, in the number of traffic accidents, unless more far reaching measures are taken for the control of this type of trauma. Although in the United States the number of vehicles is now more or less stable with two people per vehicle, in Europe the rate of growth at present doubles the numbers of vehicles every ten years. In 1970, for most western European countries there were approximately four people per car. In eastern countries the ratio of people to vehicles ranges from 7 : 1 in Japan to 45 : 1 in U.S.S.R. It can reasonably be suggested that if vehicle growth in those countries follows the same patterns as elsewhere, then on a world wide scale traffic accidents will indeed reach epidemic proportions.

As vehicle and environmental design evolve, it is likely that new injuries and injury mechanisms will be identified. The use of seat belts for example, although greatly beneficial in general terms, have resulted in specific types of trauma to the chest and abdomen. The development of high speed expressways, with a traffic mix of small cars and large trucks, where the mass ratios may be of the order of forty to one, have resulted in crash conditions different from conventional accidents (26).

Therefore, there is likely to be an increase in the numbers of casualties suffering accidental trauma, and changes in the nature of that trauma will occur in the future. The need for continued and intensified epidemiological examinations of these trauma are indicated.

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TABLE 1 - ACCIDENTAL DEATHS IN GREAT BRITAIN - 1970

	No.	%
Road Accidents	7,499	46.7%
Home Accidents	7,301	46.0%
Accidents in Factories and Mines	647	3.9%
Railway Accidents	253	1.5%
Water Transport Accidents	173	1.0%
Farming Accidents	130	0.7%
Aircraft Accidents	46	0.2%
Total	16,049	

(Source: Royal Society for the Prevention of Accidents, 1972)

TABLE 2 - ACCIDENTAL DEATHS BY COUNTRY - 1965

Country	Motor Vehicle	Other Accidental Deaths
France	12,335	21,643
West Germany (1964)	15,893	17,937
United Kingdom	7,952	11,261
Italy (1964)	11,475	11,696
U.S.A.	49,163	58,841
Japan	16,007	23,856

(Source: United Nations Demographic Yearbook, 1967)

TABLE 3 - DEATHS AND INJURIES IN ROAD ACCIDENTS - 1970

	No. Injured	No. Killed
Austria	70,415	2,238
*Belgium	106,233	1,544
Cyprus	3,936	143
*Denmark (1969)	26,174	1,190
*West Germany	531,795	19,193
Finland	16,028	1,055
*France (1969)	331,273	14,664
Greece (1969)	22,007	813
*Ireland	9,269	540
*Italy	228,236	10,208
*Luxembourg	2,367	132
Malta (1969)	849	15
*Netherlands	68,855	3,181
Norway	11,760	560
Portugal	28,849	1,417
Spain	86,455	4,197
Sweden	22,230	1,307
Switzerland	36,026	1,649
*United Kingdom	355,866	7,498
Western Europe	1,958,623	71,545
*E.E.C. Countries	1,660,068	58,151
U.S.A. (1971)	2,000,000	54,600
Canada (1966)	161,000	5,261
Japan (1967)	655,377	17,492
Australia (1967)	78,000	3,180
U.S.S.R.		40,000 (estimated)

(Source: Statistics of Road Traffic Accidents in Europe - 1970
United Nations. New York, 1971)

TABLE 4 - RELATIVE PROPORTIONS OF FATALITIES BY CLASS OF ROAD USER - 1970

	Pedestrians	Cyclist and Motorcyclists	Car Occupants	Other Vehicle Occupants
Belgium	23.4%	22.4%	49.8%	4.4%
Denmark (1969)	27.6%	30.0%	36.1%	6.3%
West Germany	31.6%	17.6%	46.8%	4.0%
France (1969)	21.3%	24.9%	49.7%	4.1%
Ireland	40.5%	20.2%	33.0%	6.3%
Italy	26.0%	30.5%	37.7%	5.8%
Luxembourg	25.8%	37.1%	37.1%	-
Netherlands	19.3%	35.7%	41.5%	3.5%
United Kingdom	39.0%	15.2%	38.4%	7.5%
Average for E.E.C.	28.1%	22.8%	44.3%	4.8%
U.S.A. (1971)	19.4%	5.9%	62.8%	11.9%

TABLE 5 - SERIOUS PEDESTRIAN CASUALTIES BY TYPE OF VEHICLE U.K. (1968)

Striking Vehicle	No.	%
Car	16,747	67.5
Light Van	2,777	11.2
Motorcycle or Moped	2,555	10.3
Medium and Heavy Truck	1,361	5.5
Bus	967	3.9
Bicycle	396	1.6
Total	24,803	100.0%

TABLE 6 - TYPE AND NUMBER OF FRACTURES SUSTAINED BY MOTORCYCLISTS

	Sacramento County (U.S.)		Birmingham (U.K.)	
	No.	%	No.	%
Skull and Face	64	11.4%	27	11.8%
Spine	21	3.7%	8	3.5%
Arms	143	25.6%	48	21.2%
Scapula	8	1.4%	-	-
Clavicle	49	8.7%	17	7.5%
Ribs and Sternum	18	3.2%	14	6.2%
Pelvis	12	2.2%	10	4.4%
Legs and Feet	266	43.8%	103	45.4%
Fractures	561	100.0%	227	100.0%
Persons	370		328	

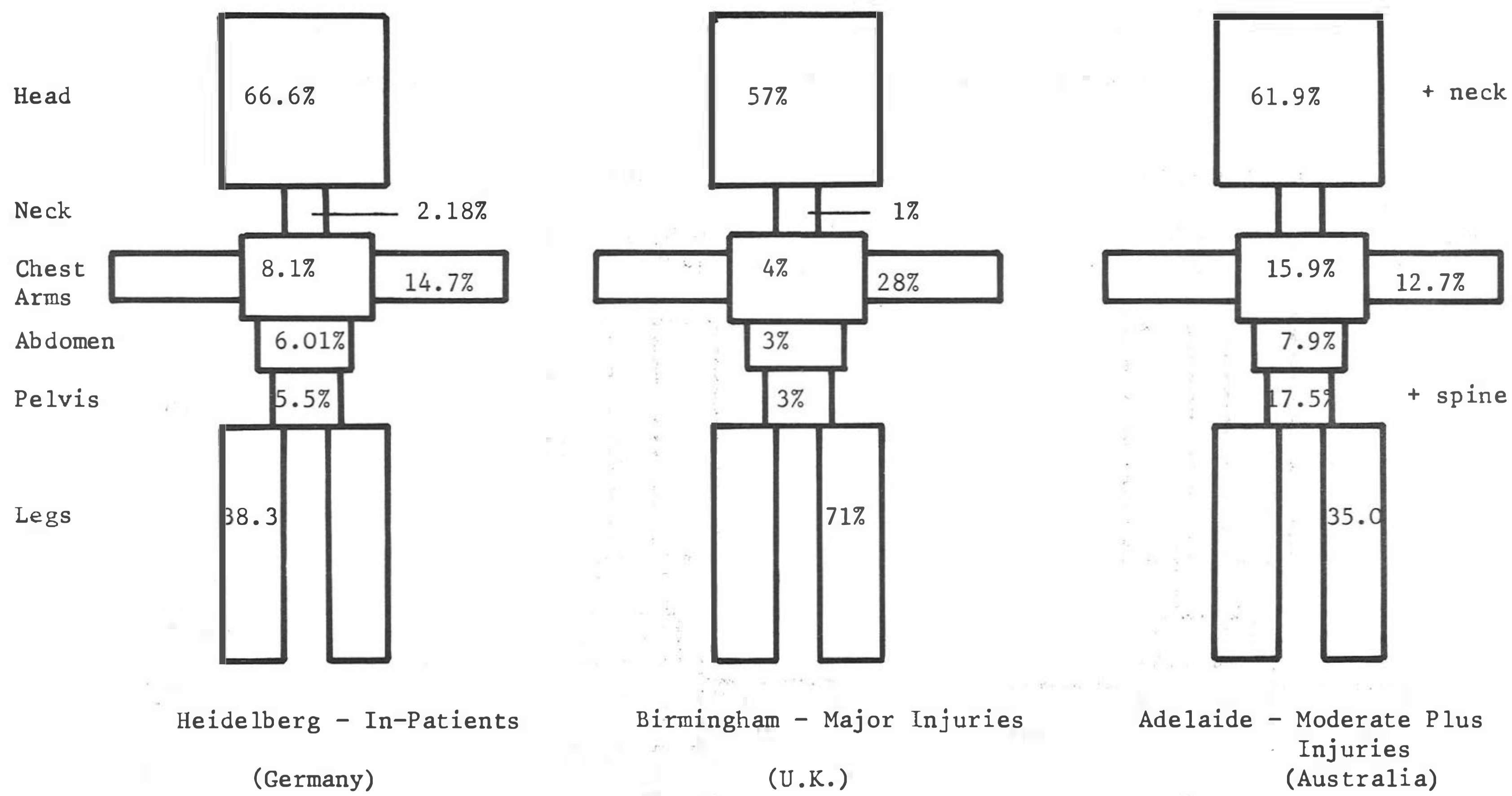
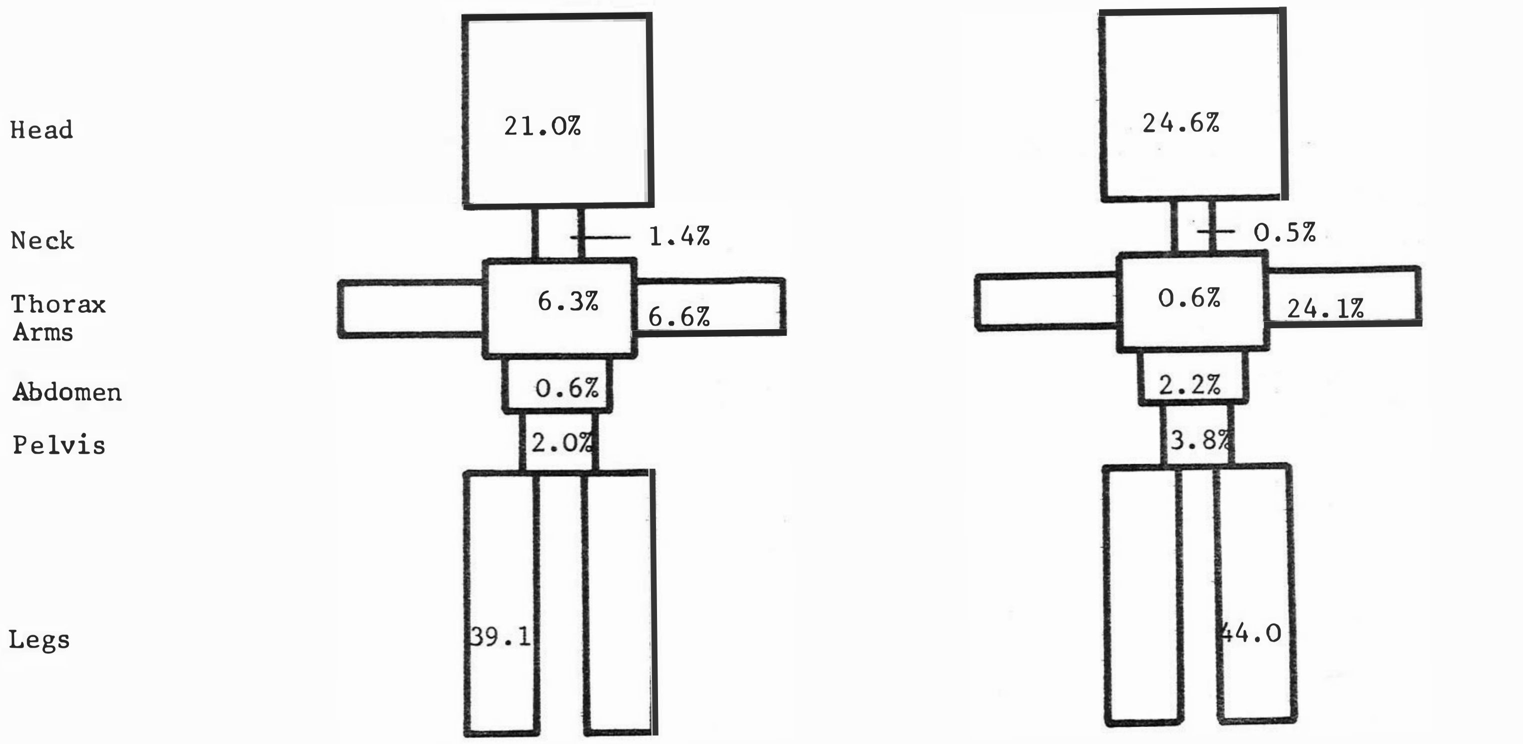


FIGURE 1 - ANATOMICAL DISTRIBUTION OF MAJOR INJURIES TO PEDESTRIANS



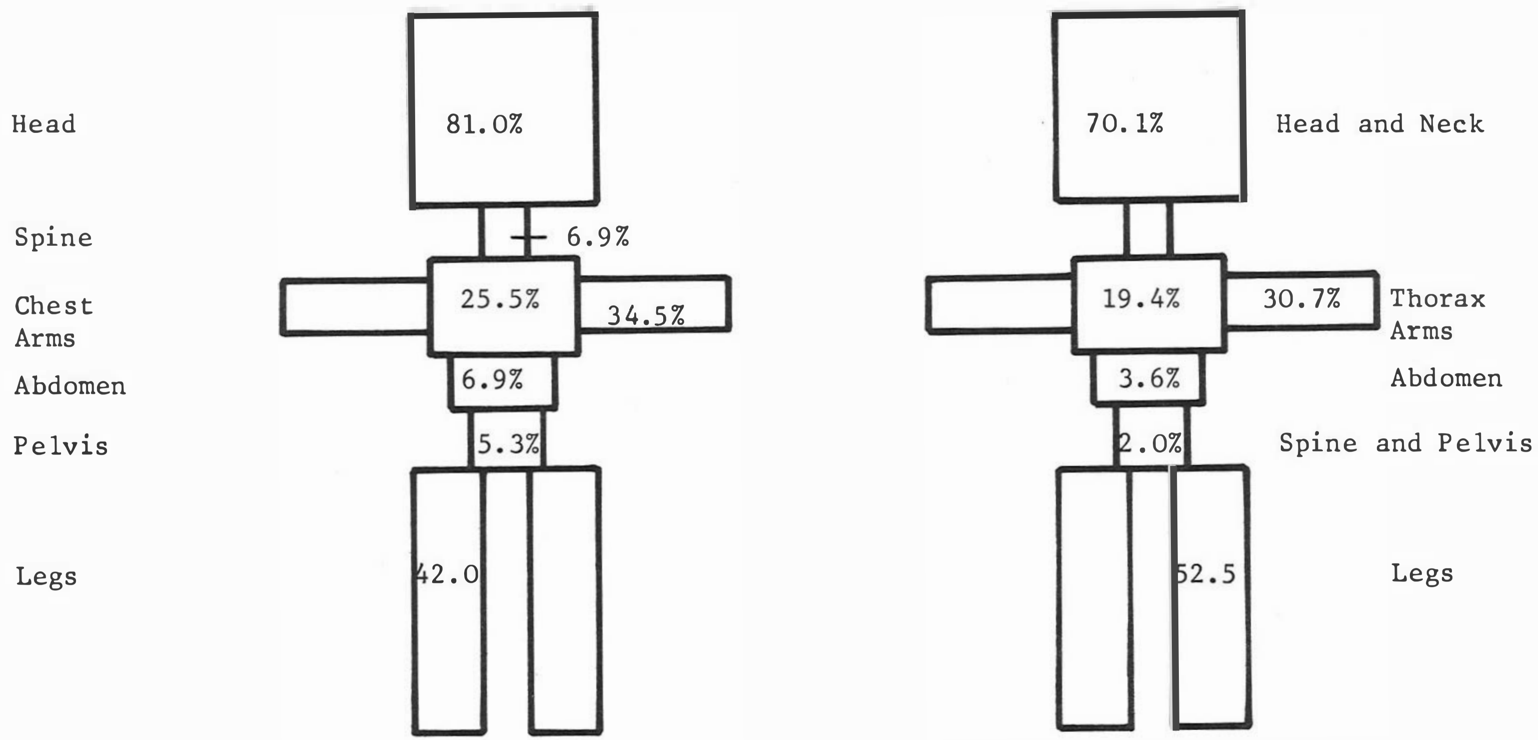
Plus multiple injuries 22.9%
Total number of injuries (35,269)

Japan

Total Number of Injuries (248)
Total Number of Riders (88)

Birmingham U.K.

FIGURE 2 - ANATOMICAL DISTRIBUTION OF INJURIES TO MOTORCYCLISTS



605 In-Patients
All severities of injury

Heidelberg - Germany

502 Casualties
All severities of injury

Adelaide - Australia

FIGURE 3 - ANATOMICAL DISTRIBUTION OF INJURIES TO CAR OCCUPANTS