CLINICAL STUDIES ON LEG INJURIES IN CAR-PEDESTRIAN ACCIDENTS

by

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Abstract

This is a retrospective study of adult pedestrians injured by cars and treated at an orthopaedic department between January 1975 and June 1976. Medical records and police reports were used to analyse the accidents and to correlate the injuries to the impact areas of the vehicles.

Clinical follow-up and interviews were made 1 - 3 years after the accidents. Special interest was focussed on such long term effect of the injuries to the lower extremity as the walking impairment caused by the impact of the bumper and the car front.

Introduction

The aggressiveness of the car exteriour to various parts of the human body in car-pedestrian accidents is an important traffic safety problem. Attempts have been made to evaluate the significance of the bumper level, the bumper lead angle, the bonnet edge height, the wrap around distance and other characters of the car shape (Ashton et al. 1976). The clinical studies referred to in this respect usually describe the short time effects of these injuries as are given by the AIS numbers (Gotzen et al. 1980, Langwieder et al. 1980, Stürtz 1981). The long term effects remain unknown but Gissane et al. (1970) showed that 21% of surviving pedestrian in-patients suffered permanent disability and Baker et al. (1974) stressed the importance to create rating systems to classify the injured patient before and after admission and to measure his outcome in all types of accidents.

Fractures are often described as the results of impacts to the lower extremities caused by the bumper. The presence of soft tissue injuries is seldom reported even if this will influence the healing time and final outcome of the fractures. Delayed union of lower leg fractures is known to occur after high velocity impacts.

Injuries to the knee joint were seen in only 1.5% in patients injured in car-pedestrian accidents as shown by Weinreich (1979). However, intra-articular fractures and extra-articular fractures near the knee joint which influence the joint function or the epiphyseal plates of the child may lead to secondary changes of the joint. This may also be the result of ligament injuries to the knee joint. Ligament injuries are most often overlooked during the first period after the accident but may be an important cause of permanent impairment of joint function. The long time effect of injuries to the lower extremity have to be studied before final judgements can be made of the aggressiveness of the impact area of the car front.

Scope

This is a pilot study of car-pedestrian accidents. The intention was to investigate the injuries in adults treated as in-patients at an orthopaedic department. Special interest was focussed on the long term effect of the injuries to the lower extremities and their relation to the bumper and the bonnet edge. The study was made to prepare a more detailed prospective study. This has been concluded and a 2 - 3 years follow-up is now in progress.

Method and material

A retrospective study was made of adult pedestrians injured by cars and treated at the Department of Orthopaedic Surgery II, Sahlgren Hospital, Göteborg, between January 1975 and June 1976. Information in medical records, interviews with patients and witnesses and police reports were used to analyse the accidents and to correlate the injuries to the impact area of the vehicles. Medical examinations and interviews were made 1 - 3 years after the accidents.

The population of Göteborg is 450.000. The main part of the accidents occurred in the central part of the city where many old people live. The speed limit was 50 km/h in all accidents which could be analysed. The impact velocity was estimated from the breaking distance, the throw-off distance of the body after the impact and statements of the witnesses.

Some of the results were analysed statistically. The χ^2 - test with Yates correction for small samples was used.

Results

Age and sex distribution (Fig. 1)

Thirty-four accidents with 34 injured pedestrians were investigated. Eighteen were women, 16 were men. Fifty per cent of the patients were 65 years old or more.

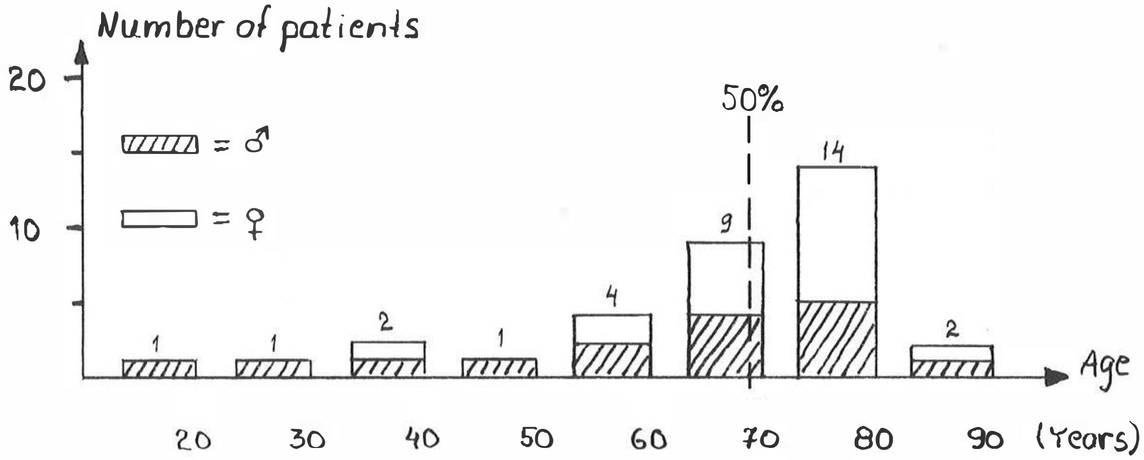

Fig. 1 - Age and sex distribution.

Time at hospital (Fig. 2)

Fifty per cent stayed at hospital more than 2 months. Four patients died at the hospital. Three due to serious injuries to different body parts. One in a malignant disease.

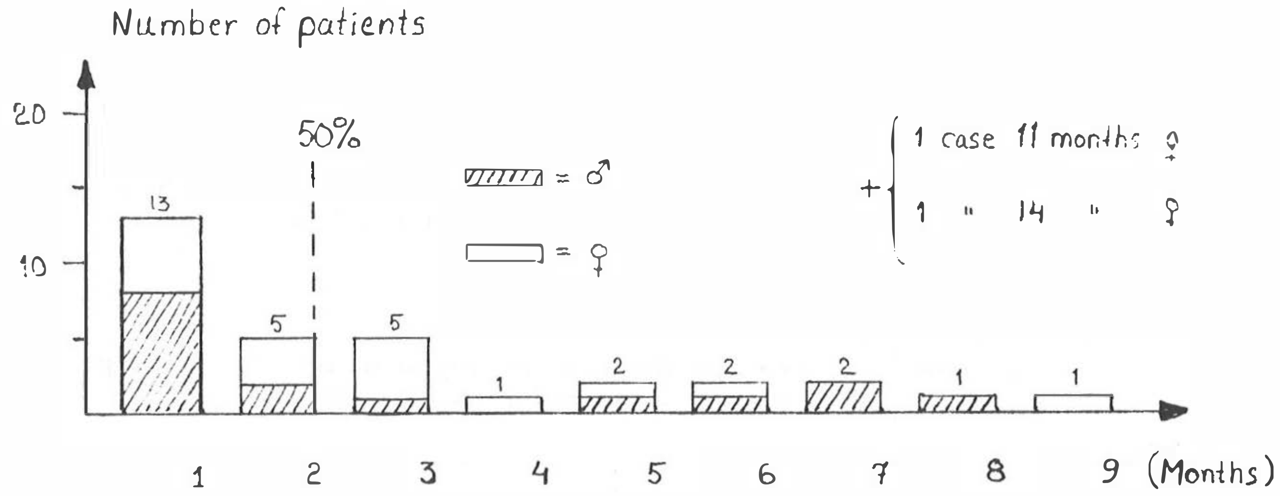

Fig. 2 - Time at hospital.

Injury distribution and severity (Table 1)

The injuries were multiple in most cases. In half of the cases the accident caused two or more fractures. Almost 90% sustained injuries to the lower extremities. In 7 cases (21%) both legs were injured. All head injuries were noted. Minor injuries (AIS = 1) were omitted in the other body regions.

Table 1 - Injuries in the different body regions

Body region	Number of patients with injuries in this body region	Per cent injured in this region	AIS-range
Head	20	59	1-5
Trunc incl. pelvis	13	38	2-4
Upper extremities	14	41	2-3
Lower extremities	30	88	2-3

Injuries related to the shape of the car front

In 33 acidents the injuries were caused by a direct blow of the vehicle. One pedestrian sustained a patella fracture as a result of the fall on the ground after the collision. In another case the victim was overrun by the car after the collision which resulted in several severe injuries. In 28 cases the impact sequence could be reconstructed. In 23 of these the impact was caused by the middle of the car front and in 5 by the front corner.

In the frontal impacts, the bumper level and the bumper lead angle were used as test parameters for injuries in the different body regions. Thus, injuries caused by bumpers below 40 cm level were compared to injuries caused by bumpers at or above 40 cm level. In the same way injuries were compared for bumper lead angles below 70^{o} and equal to or above 70^{o}. The bumper level is defined as the "static bumper level" i.e. the distance between the ground to the midpoint of the bumper width if the car is not braking.

Lower leg injuries

Tibia and fibula diaphyseal fractures were seen in 14 accidents (41%). Twelve of these were comminuted and dislocated and 4 were open.

Ankle joint injuries

Ankle joint injuries were noted in 6 patients (18%). Four of these were fractures. In one of them the fracture was combined with a lower leg fracture on the same side.

Leg injuries, bumper level and impact velocity

An attempt was made to correlate the type of leg injuries to the bumper level and the impact velocity. Some typical injuries were noted (Fig. 3).

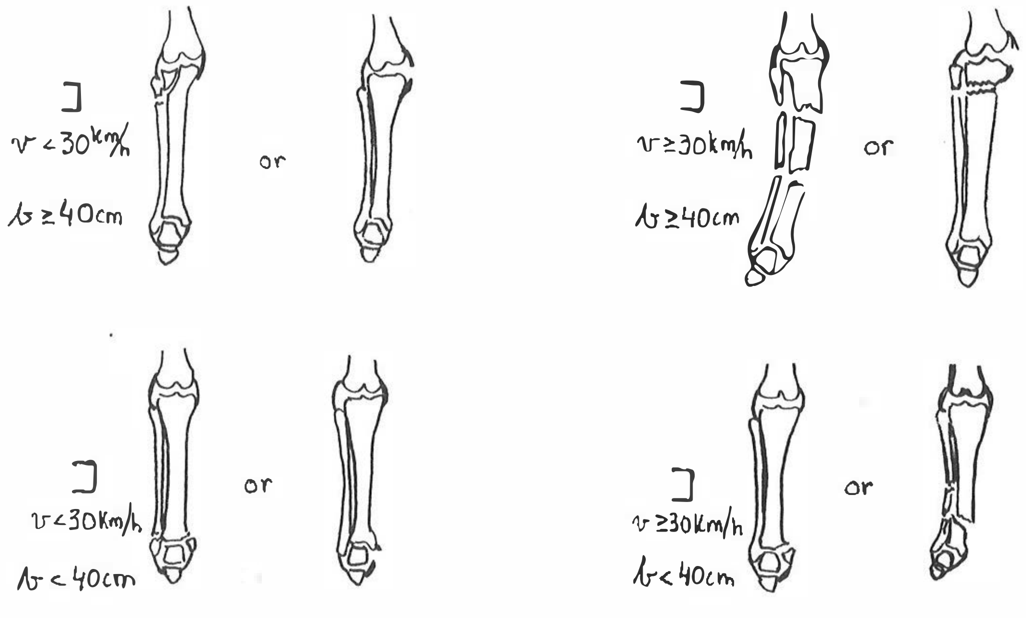

Fig. 3 - Typical injuries related to the static bumper level (b) and the impact velocity (v).

Knee condylar fractures or knee ligament injuries were observed if the bumper impacted near the knee level at lower speeds (<30 km/h). The same type but more serious injuries were seen at higher velocities with this bumper level. Above 30 km/h very comminuted lower leg fractures also occurred. Bumper levels below 40 cm caused low tibia shaft fractures or ankle joint injuries.

The tibia fractures were located 0 - 13 cm below the static bumper level. Severe (AIS > 2) knee injuries were not observed with the bumper level below 40 cm.

Head injuries

Head injuries including minor injuries were noted in 20 cases (59%) all in frontal collisions. These injuries resulted from a blow on the bonnet, the upper part of the wings, the windscreen or the windscreen frame. The bumper level and the bumper lead angle did not influence the incidence of head injuries in these cases. The windscreen frame gave the most severe head injuries. The fall on the ground after the impact also caused head injuries but those were less serious.

Injuries to the trunc and the upper extremities

Injuries to the trunc were noted in 13 cases (38%) and to the upper extremities in 14 (41%). The bonnet and the upper part of the wing caused the major part of these injuries. The bumper level and the bumper lead angle did not influence the injuries in this regions. Pelvic injuries were noted in 7 cases. The bonnet edge was an important cause of injuries to the pelvic region. The fall on the ground after the car impact also caused hip and pelvic injuries as well as injuries to the upper extremities.

Injuries to the lower extremities

Fractures or ligament injuries to the lower extremities were noted in 30 accidents (88%). In 29 of these the injuries were caused by the car impact and in 28 accidents injuries were noted at or below the knee level. The bumper was the most important cause of these injuries. The bonnet edge caused injuries to the thigh and hip. Fractures of the femur diaphysis or the hip were noted in four accidents. In some accidents the bonnet edge may have caused injuries to the knee joint.

Knee injuries

Thirteen pedestrians (38%) sustained knee injuries. Seven of these (21%) were intra-articular fractures. If any of these were combined with ligament injuries was not noted in the medical records. In all 7 cases the lateral joint compartment was injured and 5 of these were fractures of the tibial condyle.

In 6 patients (18%) isolated knee ligament injuries were noted including avulsion fractures of the ligament attachments.

The mechanism of the leg injuries caused by the car impact were studied in 27 frontal collisions. The knee injuries (fractures and ligament injuries) related to the static bumper levels and the bumper lead angles are illustrated in Table 2.

Table 2 - Knee injuries (fractures and ligament injuries), static bumper level and bumper lead angle.

Knee injury	Static bumper level		Bumper lead angle	
AIS $\geq$ 2	<40 cm	$\geq$40 cm	<70^0	$\geq 70^0$
Yes	1	11	2	4
No	6	9	1	13
p	0.14		>0.4	

Healing time of leg injuries

The healing time in 12 cases that survived with tibia shaft fractures were determined. The variation was 4 - 34 months. Half of the fractures were healed within 8 months. In three of these the impact velocity was below 30 km/h. Fractures of the upper, middle and lower third of the tibia shaft had approximately the same healing time. There was no difference between the healing time of tibia shaft fractures caused by bumpers above or below 40 cm level.

The healing time of the knee and ankle joint injuries were 2 - 7 months.

Walking impairment

Four patients who died within one year from the accident were excluded as well as 3 patients with injuries only to the upper extremities. Twenty-two patients with leg injuries were re-examined 1 - 3 years after the accident when the fractures were healed. Of these 17 had leg injuries caused by impacts of the car front. The walking impairment of these patients were estimated in relation to their walking capacity before the accident. The following complaints were noted:

A Limited walking range

B Limited staircase climbing

C Limp at walking

D Use of walking aid (stick or crutches)

E Feeling of instability.

The patients were divided in two classes, those who complained of 0 - 2 impairments (I) and those who complained of 3 or more (II). The influence of the bumper level and the impact velocity on the walking impairment is illustrated in Table 3.

Table 3 - Walking impairment, bumper level and impact velocity

Impairment	Bumper level		Impact velocity	
Class	<40 cm	≥ 40 cm	<30 km/h	≥ 30 km/h
I (8)	4	4	5	3
II (9)	1	8	3	6
p	0.2		>0.5	

Fifteen patients had no complaints from the knee joints. Seven patients had walking impairment caused by a knee injury. In 6 of these the injuries were caused by bumpers at or above 40 cm level.

Discussion

The patients in this study represent a small number of one category of injured pedestrians in car-pedestrian accidents in an urban area: Those who were treated at an orthopaedic department. The number of cases corresponds to an incidence of 10/100 000 per year with these types of injuries. Children were not included. The age distribution (Fig. 1) indicate a high percentage of elderly people. Half of the patients were 65 years old or more, half had multiple fractures and almost 90% sustained injuries to the lower extremities. This explains the long time at hospital, 50% of the patients stayed at least two months. This is more than two times the hospital time as reported by Weinreich (1979) in a clinical study including children.

Leg injuries related to the shape of the car front

The bumper and the bonnet edge cause injuries by direct impact forces which are related to the impact velocity. These forces are probably the main cause of impaired fracture healing. The walking impairment at follow-up was not well correlated to the impact velocity (Table 3). Knee injuries are easily caused by impacts of the bumper even at low speeds because of the ground reaction force during the stance phase of walking and the inertia of the lower leg and foot during the leg acceleration after impact (Bunketorp et al. 1981). The bonnet edge probably also caused knee injuries in some cases when the body was "wrapped around" the bonnet. Two patients sustained fractures of the lateral condyle of the femur above the bumper level. The car fronts in these accidents both had prominent bonnet edges.

Knee injuries seemed to be correlated with the bumper level (Table 2). Severe knee injuries (AIS = 3) were not seen in accidents with a static bumper level below 40 cm. Six of 7 patients with walking impairment caused by knee injuries were injured by cars with the bumper levels equal to or above 40 cm. The less walking impairment in those patients which were injured by bumpers below 40 cm level could not be explained by lower impact velocities as no serious walking impairment was seen at impact velocities above 30 km/h with bumper levels below 40 cm.

Head injuries were not noticed more frequently with bumper levels below 40 cm.

A follow-up time of 1 - 3 years is too short to evaluate the final outcome of the leg injuries. As many as 14 of 17 had any kind of impaired walking ability. The majority of these would probably not improve with time.

Conclusions

Even if the material is small and the follow-up time is short the following conclusions could be made:

Old pedestrians are more severely hurt than younger in car-pedestrian accidents.

The main cause of the long time at hospital are the leg injuries.

Knee injuries are caused by the bumper as well as the bonnet edge.

Walking impairment seems to be correlated to static bumper levels above 40 cm.

The long term effect of leg injuries in car-pedestrian accidents is not well correlated to the primary injury severity or the impact speed. Further investigations of the long time effect of leg injuries are needed.

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