Papers and Originals

Injuries to Hip Joint in Car Occupants

E. GRATTAN,* M.B., B.CH., F.R.C.S. ; J. A. HOBBS†

[WITH SPECIAL PLATE]

Brit. med. J., 1969, 1, 71-73

Summary: Four varieties of fracture, of dislocation, or of fracture dislocation of the hip are described that occur in car occupants after road accidents. It is suggested that, whereas most hip injuries to car occupants are produced by application of force to the knee, one important variety (central fracture dislocation) is the result of the direct application of force to the great trochanter. Central fracture dislocations might be prevented, or their severity minimized, by strengthening the sides of cars and of car doors and by improving the energy absorption characteristics of the fascia panel.

Introduction

Injury to the hip joint is a disabling condition. In the immediate post-accident period stay in hospital is likely to be required for at least six weeks and non-weight-bearing for three months or longer. Between 20 and 50% of posterior dislocations or fracture dislocations of the hip are complicated by partial or complete necrosis of the head of the femur (Apley, 1963) and sciatic nerve paralysis is occasionally seen. Where fracture of the acetabulum has occurred accurate replacement of the fragment or fragments may be impossible, the result being permanent damage to the joint.

Fractures and fracture dislocations involving the hip joints are relatively common in car occupants. Fifty out of 501 unselected car occupants admitted to hospital after a road accident who were investigated between April 1965 and August 1968 sustained such injuries. The magnitude of the problem of injury to the hip joint is therefore not inconsiderable.

Varieties of Injury

Three varieties of injury to the hip joint are described in the standard textbooks on fracture surgery—posterior dislocations and posterior fracture dislocations, anterior dislocations, and central fracture dislocations.

During the course of the present investigation, as is to be expected, no anterior dislocations were seen. Four main varieties of injury to the hip joint were, however, distinguishable. They are shown in the Table.

The Table also shows the directions of vehicle impact that relate to these injuries. It will be seen that except for fractures of the posterior wall there is a clear correlation between direction of impact and the type of injury sustained. One central dislocation was caused by the occupant being ejected, the skin over the great trochanter being heavily bruised.

* Principal Scientific Officer (Surgical).

† Experimental Officer.
Road Research Laboratory, Ministry of Transport, Crowthorne, Berks.

Mechanism of Injury

Posterior Dislocations and Posterior Fracture Dislocations of Hip Joint

The mechanism of injury in this variety of dislocation is well recognized. It is described by Watson-Jones (1955), by Kulowski (1960), and by Gögler (1962). The forward-moving knee makes contact with the fascia, the resulting force being transmitted through the femur to the hip joint, with the hip probably flexed to a right angle or to more than a right angle. It is often stated in the literature that the more adducted the thigh the greater the probability of posterior dislocation occur-

Varieties of Injury to the Hip Joint Related to Direction of Vehicle Impact

Type of Injury	No. of Cases	Direction of Vehicle Impact
Posterior dislocation	9	} All frontal
Posterior fracture dislocation	17	
Fracture of posterior wall of acetabulum	6	} 5 Frontal 1 Side
Fracture of roof of acetabulum	10	
Fracture of roof of acetabulum with posterior fracture dislocation	1	} All frontal
Central fracture dislocation	7	
		6 Side*

* One occupant was ejected.

ring, without fracture of the posterior wall of the acetabulum. We have been unable to demonstrate such a relationship. However, from the examples we have seen (nine posterior dislocations and 17 posterior fracture dislocations) the point of knee contact with the fascia would appear to have been higher for the posterior dislocations than for the posterior fracture dislocations, suggesting that the amount of flexion at the time of knee impact may have been greater for the former than for the latter.

Out of a total of 26 posterior dislocations or fracture dislocations three cases (two drivers who sustained fracture dislocations and one front-seat passenger who sustained a fracture dislocation) were wearing seat belts (two lap and diagonal, one diagonal).

Case 177.—The injured car occupant, a man aged 66, who was not wearing a seat belt, was the driver of an Austin 1100 saloon car. He sustained injuries to his right knee, right hip, face, and right arm. The mechanism of injury was probably as follows. As a result of the frontal impact the driver was thrown forwards, his right knee striking the fascia (Special Plate, Fig. 1). The patella was fractured, the residual force being transmitted through the femur to produce the posterior fracture dislocation of the right hip-joint with fracture of the acetabulum (Special Plate, Fig. 2).

Case 166.—The injured car occupant, a woman aged 42, who was not wearing a seat belt, was the near-side front-seat passenger in a Wolseley 6/110 saloon car. She sustained injuries to her right

lower arm and left hand, right hip, both knees, and left shin. The mechanism of injury was probably as follows. As a result of the frontal impact the passenger was thrown forwards, her right knee striking the wooden fascia (Special Plate, Fig. 3). The knee was grazed, the residual force being transmitted through the femur to produce the posterior fracture dislocation of the right hip, with fracture of the head of the femur and of the acetabulum (Special Plate, Fig. 4).

Fractures of Posterior Wall of Acetabulum

This would appear to be a relatively uncommon injury in car occupants. Six cases have been seen. All were fissure fractures of the posterior wall of the acetabulum (Special Plate, Fig. 5). We have been unable to determine with certainty the mechanism of injury in this variety of fracture; five cases resulted from frontal impacts, one from a side impact. In two instances force was transmitted through the knee. In none of the six cases was the occupant wearing a seat belt.

Fractures of Roof of Acetabulum

The mechanism of injury in this variety of pelvic fracture has, so far as we are aware, not been described in detail in the literature. In using the term "roof of the acetabulum" we mean that part of the acetabulum which bears the weight of the body in the erect position.

We believe that, as with posterior dislocations, force is transmitted from the knee through the femur to the hip joint, but with the hip flexed to less than a right angle and slightly abducted. Force is therefore probably applied mainly to the roof of the acetabulum in an upward, backward, and inward direction rather than to the posterior wall of it. When fracture occurs the line of the fracture lies anteroposteriorly across the roof of the acetabulum, and if there is displacement the iliac segment tends to move upwards and outwards with subluxation of the corresponding sacroiliac joint, with comparatively minimal inward displacement of the pubic and ischial segment (see Case 41, Special Plate, Figs. 9 and 10). Less frequently more complicated and explosive patterns of fracture into the roof of the acetabulum occur, the fracture lines also involving the posterior wall and floor of the acetabulum and extending backwards into the ischium just above the level of the ischial spine (see Case 338, Special Plate, Fig. 12; and Case 148, Special Plate, Fig. 13). In one instance a fracture of the roof of the acetabulum was complicated by a posterior fracture dislocation. It seems probable that in this case the direction of force acting on the hip joint through the knee changed during the course of deceleration to produce first the roof fracture and then, with the hip more flexed, the posterior fracture dislocation.

Fractures of the roof of the acetabulum with displacement have in the past, we think erroneously, sometimes been described as central dislocations. Eleven cases have been seen. In none were seat belts being worn.

Case 352.—The injured car occupant, a man aged 25, who was not wearing a seat belt, was the driver of a M.G. Magnette saloon car. He sustained injuries to his forehead, chest, left hip, and left knee. The mechanism of injury was probably as follows. As a result of the frontal impact the driver was thrown forwards, the left knee striking the fascia (Special Plate, Fig. 6). The knee was grazed, the residual force being transmitted through the femur to produce a typical fracture of the roof of the acetabulum without displacement (Special Plate, Fig. 7).

Case 41.—The injured car occupant, a man aged 44, who was not wearing a seat belt, was the driver of a Hillman Super Minx saloon car. He sustained injuries to his face, chest, right hip, both knees, and both shins. The mechanism of injury was probably as follows. As a result of the frontal impact the driver was thrown forwards, the knee striking the fascia (Special Plate, Fig. 8). The knee received grazes and lacerations, the residual force being transmitted through the femur to produce a typical fracture of the roof

of the acetabulum with outward and upward displacement of the iliac segment (Special Plate, Figs. 9 and 10).

Case 338.—The injured car occupant, a man aged 52, who was not wearing a seat belt, was the driver of a Ford Cortina saloon car. He sustained injuries to his face and scalp, chest, right hip, right knee, left shin, and right elbow. The mechanism of injury was probably as follows. As a result of the frontal impact the driver was thrown forwards, the right knee striking the fascia (Special Plate, Fig. 11). The knee was bruised and grazed, the residual force being transmitted through the femur to produce an "explosive" fracture of the roof of the acetabulum (Special Plate, Fig. 12) with extension into the posterior wall and floor.

Central Fracture Dislocations of Hip

Watson-Jones (1955) suggests that central dislocation may occur as a result of force applied to the knee with the thigh abducted.

McLaughlin (1959) states that a blow on the great trochanter is the cause of this type of dislocation.

We believe, as a result of our studies in car occupants, that central dislocations of the hip invariably occur in side impacts, or occasionally following ejection, and that they are produced by the application of force direct to the great trochanter. Seven cases have been seen. In none were seat belts being worn.

Case 304.—The injured car occupant, a woman aged 23, who was not wearing a seat belt, was the near-side front-seat passenger in a Renault Dauphine saloon car. She sustained injuries to her left hip and thigh. The mechanism of injury was probably as follows. As a result of the side impact she was struck by the incoming door (Special Plate, Fig. 14) in the area of the great trochanter, the head of the femur being forced inwards, driving a section of the roof and floor of the acetabulum into the pelvic cavity (Special Plate, Fig. 15), the inferior ramus of the pubis, as is usual in this type of injury, also being fractured.

Discussion

The research which is described in this paper forms part of a larger investigation into the patterns and mechanisms of injury in vehicle occupants involved in road accidents. The intention is to show the varieties and clinical severity of the injuries that occur, both in unrestrained and in restrained occupants; and, by determining the directions in which force acts on the body, to allow experimental studies to be made of the force required to injure different parts of it.

It is hoped that the examples quoted in this paper will indicate the pattern of hip joint injury seen in car occupants. Some of the varieties and mechanisms discussed are well known; others are not so well known. From them three points of practical interest emerge.

(1) The relation between fractures of the roof of the acetabulum with displacement and fractures of the roof of the acetabulum without displacement. The mechanism of injury would seem to be similar. It is tentatively suggested that the difference in degree of injury lies in the amount of force applied to the hip joint. The latter variety of injury may represent the critical level of magnitude of force which the hip joint, when flexed to less than a right angle, can withstand without suffering extreme damage. Knowledge of this kind may be of value in determining optimal energy absorption characteristics for the fascia panel.

(2) The causation of central fracture dislocation of the hip. Seat belts possess little merit as a protective device in side impacts, apart from their capacity to prevent ejection in these circumstances. Assuming the hypothesis of causation to be correct, then if central dislocations of the hip are to be prevented or their severity is to be minimized, measures to strengthen the sides of cars and of car doors and at the same

E. GRATTAN AND J. A. HOBBS: INJURIES TO HIP JOINT IN CAR OCCUPANTS

FIG. 1.—Austin 1100 saloon. Case 177. Arrow indicates point of impact of driver's right knee. Knee grazed and bruised with comminuted fracture of patella. Residual force transmitted via femur, causing posterior fracture dislocation of right hip joint.

FIG. 3.—Wolseley 6/110 saloon. Case 166. Arrow indicates point of impact of near-side front-seat passenger's right knee. Knee grazed. Residual force transmitted via femur, causing posterior fracture dislocation of right hip joint, with fracture of head of femur.

FIG. 2.—Case 177. Right hip joint—anteroposterior view. Posterior fracture dislocation of right hip joint.

FIG. 4.—Case 166. Right hip joint—anteroposterior view. Posterior fracture dislocation of right hip joint with fracture of head of femur and of acetabulum.

FIG. 5.—Right hip joint—anteroposterior view. Fracture of posterior wall of acetabulum.

E. GRATTAN AND J. A. HOBBS: INJURIES TO HIP JOINT IN CAR OCCUPANTS

FIG. 6.—M.G. Magnette saloon. Case 352. Arrow indicates point of impact of driver's left knee and shin. Cuts to knee. Grazes on shin. Residual force transmitted via femur, causing fracture of roof of acetabulum.

FIG. 7.—Case 352. Pelvis—anteroposterior view. Arrow indicates fracture of roof of left acetabulum without displacement.

FIG. 8.—Hillman Super Minx saloon. Case 41. Arrow indicates point of impact of driver's right knee. Knee sustained abrasions and lacerations; residual force transmitted via femur, causing fracture of roof of acetabulum with displacement.

E. GRATTAN AND J. A. HOBBS: INJURIES TO HIP JOINT IN CAR OCCUPANTS

FIG. 9.—Case 41. Right hip joint—anteroposterior view. Fracture of roof of right acetabulum with displacement.

FIG 11.—Ford Cortina saloon. Case 338. Arrow indicates point of impact of driver's right knee. Knee bruised and grazed. Residual force transmitted via femur, causing "explosive" fracture of roof of acetabulum.

FIG. 10.—Case 41. Pelvis—anteroposterior view taken at a later date than Fig. 9. Fracture of roof of right acetabulum. To show upward and outward displacement of iliac segment.

E. GRATTAN AND J. A. HOBBS: INJURIES TO HIP JOINT IN CAR OCCUPANTS

FIG. 12.—Case 338. Pelvis—anteroposterior view. “Explosive” fracture of roof of right acetabulum, with displacement, extending into posterior wall and floor.

FIG. 13.—Case 148. Right hip joint—anteroposterior view. “Explosive” fracture of roof of acetabulum, showing the same pattern of fracture as in Case 338 (Fig. 12).

FIG. 14.—Renault Dauphine saloon. Case 304. Near-side front-seat passenger's left hip and thigh struck by incoming door, causing central fracture dislocation of left hip joint.

FIG. 15.—Case 304. Left hip joint—anteroposterior view. Central fracture dislocation of left hip joint.

time to improve their interior energy absorption characteristics are likely to have to be devised.

(3) Since there is evidence that posterior dislocations of the hip can occur in the restrained car occupant (three cases were seen out of the 39 knee-impact hip injuries, in each of which the seat belt was being worn correctly and did not break, nor did the anchorage give way), it would seem prudent to accept that the energy absorption characteristics of the facia panel are important even when seat belts are used. It has been established (Lister and Neilson, 1966) that the wearing of diagonal or lap and diagonal seat belts can reduce the serious injury rate of car occupants by rather more than half. However, with car design as it is at present the degree of protection offered to the lower limbs is probably less than that offered, for example, to the head (Lister and Neilson, 1966; Grime, 1968, Grattan and Hobbs, 1968).

Our thanks are due to Mr. C. M. Squire, senior orthopaedic consultant surgeon, Battle Hospital, Reading, and to Mr. G. P. Arden, senior orthopaedic consultant surgeon, Windsor Group of Hospitals, for their assistance in the preparation of this paper; to Dr. H. J. Starks, of the Road Research Laboratory, for his advice; and to Mr. J. C. Scott, director of accident services, United

Oxford Hospitals, Radcliffe Infirmary, Oxford, Mr. F. A. Simmonds, senior orthopaedic consultant surgeon, Royal Surrey Hospital, Guildford, Mr. Graham Apley, senior orthopaedic consultant surgeon, St. Peter's Hospital, Chertsey, and to Mr. J. B. Scott and Mr. P. J. Chesterman, consultant orthopaedic surgeons, Battle Hospital, Reading, for their courtesy in allowing patients to be examined on their wards. We also wish to thank Mr. W. Heath, of the Road Research Laboratory's photographic section, for the care with which the photographs of car interiors have been taken.

This article is contributed by permission of the Director of Road Research. Crown copyright. Reproduction by permission of the Controller of H.M. Stationery Office.

REFERENCES

- Apley, A. G. (1963). *A System of Orthopaedics and Fractures*. London.
Göglér, E. (1962). *Road Accidents*, Series chirurgica No. 5. Basle.
Grattan, E., and Hobbs, J. A. (1968). *Mechanisms of Serious Lower Limb Injuries to Motor Vehicle Occupants*, Report No. 201. Road Research Laboratory, Crowthorne.
Grime, G. (1968). *Auto. Engr.* 58, 292.
Kulowski, J. (1960). *Crash Injuries*. Springfield, Illinois.
Lister, R. D., and Neilson, I. D. (1966). *The Effectiveness of Safety Belts*, Report No. 16. Road Research Laboratory, Crowthorne.
McLaughlin, H. L. (editor) (1959). *Trauma*. Philadelphia.
Watson-Jones, Sir Reginald (1955). *Fractures and Joint Injuries*, 4th ed. Edinburgh and London.

Bronchopneumonia with Serious Sequelae in Children with Evidence of Adenovirus Type 21 Infection

W. R. LANG,* M.B., CH.B., M.R.C.P.ED., M.R.A.C.P.; C. W. HOWDEN,† M.B., CH.B., M.R.C.P.ED., M.R.A.C.P., D.C.H.
JOCELYN LAWS,‡ B.SC.; J. F. BURTON,§ M.D.

Brit. med. J., 1969, 1, 73-79

Summary: Twenty-five cases of severe pneumonitis occurring among children aged 3 to 18 months were observed in Auckland, New Zealand, in 1965. An apparent relationship was established between a uniform disease picture and recovery of adenovirus type 21. Two died, and of the survivors 60% had permanent lung damage, probably resulting from obliterative bronchiolitis. Twenty per cent. were left with proved bronchiectasis. The possible relationships of adenovirus pneumonia to malnutrition or a genetic factor on the one hand and to the development of bronchiectasis on the other are discussed.

Introduction

Few reports in the world literature have so far linked adenovirus type 21 with severe lung disease (van der Veen and Dijkman, 1962; Clarke *et al.*, 1964). Types 7 and 3 have been found in several epidemics or in isolated cases of severe pneumonia in young children (Chany *et al.*, 1958; Kawai, 1959; Hsiung, 1963; Benyesh-Melnick and Rosenberg, 1964; Wright *et al.*, 1964; Becroft, 1967). The clinical features and pathological changes so far described may have left doubt regarding

an exact causal relationship between virus and disease (Maisel *et al.*, 1962).

The present series of 25 cases provides clinical and radiological evidence of pneumonia in which adenovirus type 21 may have had aetiological significance. A notable feature of this series is the high incidence of sequelae, 60% of survivors having residual lung damage.

Material

Twenty-five children ranging from 3 to 18 months of age were studied: 18 (72%) were males and 7 (28%) females. They were admitted to the Princess Mary Hospital for Children and the Infectious Diseases Unit, Auckland Hospital, during June to November 1965.

Table I gives the racial distribution. There is a striking preponderance of Polynesians—that is, both New Zealand born Maoris and immigrants from the Polynesian Islands lying to the north of New Zealand. In a city inhabited by 90%

TABLE I.—Racial Distribution

Race	No. of Cases	% of Series	% in Auckland Population 0-4 Years
Islanders ..	10	40	5.6
Maoris ..	13	52	12.9
Europeans ..	2	8	80.6
Others ..	—	—	0.9

* Senior Physician, Infectious Diseases Unit.

† Visiting Physician, Infectious Diseases Unit.

‡ Scientific Officer, Microbiology Department, Central Laboratory.

§ Virologist, Microbiology Department, Central Laboratory.

Auckland Public Hospital, Auckland, New Zealand.