Causes of fatal childhood accidents involving head injury in Northern region, 1979-86

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Abstract

Objective—To examine the causes and circumstances surrounding fatal accidents involving head injuries in children in the Northern region.

Design—Retrospective review of the hospital case notes, necropsy reports, and records of the coroners' inquests.

Setting—Northern Regional Health Authority.

Patients—All 255 children aged <16 years who died with a head injury during 1979-86.

Main outcome measures—Cause of injury and circumstances of accident according to reports of inquests; injury severity score; number of fatal accidents and mortality per 100 000 children in 10 groups of local authority wards ranked according to their score on the overall deprivation index; and distance of site of accident from child's home.

Results—Of the 255 children who died after a head injury, 136 (53%) children were playing at the time of the accident. 195 (76%) children sustained the head injury in road traffic accidents, 135 as pedestrians, 35 as cyclists, and 25 as passengers in a vehicle. In 120 accidents in child pedestrians the primary cause of accident was the unsafe behaviour of the child. 172 (67%) accidents occurred within one to two km of the child's home and 153 (63%) between 3 pm and 9 pm. The mortality was significantly related to social deprivation; excluding eight children injured while on holiday in the region, 15-fold decrease in mortality was recorded between the local authority wards that ranked highest on the overall deprivation index and those that ranked lowest (14·0/100 000 children, group 10 *v* 0·9/100 000, group 1 respectively, $p<0·00001$).

Conclusions—The finding that most accidents occurred in children living in deprived areas who were playing unsupervised near their home suggests that childhood mortality might be appreciably reduced if children at play were protected from traffic, particularly in socially deprived areas.

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Introduction

Head injury is the most common cause of death in children aged 1 to 15 years, accounting for 15% of deaths in this age group.[1] It is even more important in children aged 5 to 15 years, in whom a quarter of deaths result from head injury.[1] Effective strategies to protect children from accidental head injury would therefore appreciably reduce childhood mortality. Few data, however, are available on the cause and the circumstances surrounding fatal head injury in children in Britain. Such information is required to allow strategies for preventing head injury to be devised, implemented, and evaluated.

The aim of this study was to determine the causes and circumstances surrounding fatal accidents involving head injuries in children in the Northern region during 1979-86.

Patients and methods

We identified all children aged below 16 years who died with a head injury during 1979-86. Head injury was defined according to the diagnostic codes of the International Classification of Diseases (ninth revision) as: fracture of vault of skull, N800; fracture of base of skull, N801; fracture of bones involving the skull or face with other bones, N802; other unqualified skull fractures, N803; multiple fractures involving skull or face with other bones, N804; concussion, N850; cerebral laceration or contusion, N851; subarachnoid, subdural, and extradural haemorrhages after injury, N852; other and unspecified intracranial haemorrhage after injury, N853; intracranial injury of other and unspecified nature, N854. The children who died were identified from the statistics of the Office of Population Censuses and Surveys and the Hospital Activity Analysis. We studied the reports of the inquests held into all these deaths to determine the cause of injury and the circumstances surrounding each accident and also reviewed the necropsy report in all cases to ascertain if there had been other associated injuries and to calculate the injury severity score.[2,3]

The Northern region comprises 678 local authority wards. These wards were ranked according to the score they obtained on the overall deprivation index devised by Townsend *et al*.[4] The 678 wards were then divided into 10 groups according to the order of their ranking on this score; group 10 comprised the 66 wards with the highest score for overall deprivation, and the remaining nine groups each comprised in sequence the next 68 less deprived wards. Thus group 1 comprised the 68 least deprived wards in the region. The local authority ward in which each child lived was determined from his or her home address. With population data from the 1981 census the mortality from head injury per 100 000 children in the ward group was calculated for each of the 10 groups of wards. Finally, the distance from the child's home address to the site of the accident was determined.

Results

In the eight year study period 255 children had a fatal accident involving a head injury; 174 (68%) were boys. One hundred and twenty two children (48%) sustained other additional injuries. The overall mortality was 5·3 per 100 000 children per year. The mortality increased with increasing age of the child so that for children aged 0 to 4 years it was 4·2 per 100 000 children per year for those aged 5 to 9, 4·9 per 100 000, and for those aged 11 to 15, 6·8 per 100 000.

CAUSES OF HEAD INJURY

Table I shows the causes of the head injuries in the 255 children.

ROAD TRAFFIC ACCIDENTS

Most children (195; 76%) were fatally injured in road traffic accidents, and there was a high incidence of associated injuries in this group. Figure 1 shows the incidence of fatal accidents in relation to the month, the day of the week, and the time of day. The 12 children who sustained non-accidental injury were excluded from this analysis as the time of the accident was unknown. Overall, there was no consistent variation in the number of the accidents according to

TABLE I—*Cause of head injury in 255 children in Northern region 1979-86*

Cause	No of children	Median (interquartile range) age (years)	No (%) with associated injury	Median (interquartile range) injury severity score
Road traffic accident	195	10 (6-13)	125 (64)	34 (25-50)
Fall	34	11 (7-13)	9 (27)	25 (16-34)
Non-accidental injury	12	0·9 (0·3-1·6)	1 (8)	25*
Struck by object	8	6 (2·5-14·5)	1 (13)	25 (21-59)
Shot	4	11 (7·5-13·5)		25 (25-75)
Hit by train	2	2, 5†	1	(36, 75†)

* Score=25 in all but one child with a score of 57.
† Actual values.

TABLE II—*Circumstances of injury in fatal road traffic accidents in 195 children in Northern region, 1979-86*

Circumstance	No of children	Median (interquartile range) age (years)	No (%) with associated injury	Median (interquartile range) injury severity score
Pedestrian	135	9 (6-12)	91 (67)	36 (25-50)
Cyclist	35	13 (9-14)	22 (63)	29 (25-34)
Passenger in vehicle	25	8 (2-11)	12 (48)	29 (25-41)

the month or the day, but there was an appreciable variation according to the time of day, with 153 of the accidents occurring between 3 pm and 9 pm. Table II shows the circumstances in which 195 of the children sustained their injury.

INJURIES TO PEDESTRIANS

Accidents to pedestrians were the single most common cause of fatal head injuries, involving 135 children, and most (97; 72%) occurred between 3 pm and 9 pm. The vehicles concerned were cars (93 children), lorries or vans (13), motorcycles (11), buses (eight), ice cream vans (seven), and other miscellaneous vehicles (three). Legal action against the vehicle driver or owner was recommended by the police or coroners' court in only 15 (11%) of the 135 accidents. Seven accidents involved defects in the upkeep of the vehicle, six reckless or careless driving, one drink driving, and one underage driving. The police investigation and inquest proceedings into the remaining 120 accidents concluded that the primary cause of the accident was the unsafe behaviour of the child. One hundred and twelve children had run or stepped into the road without looking, five had fallen while crossing the road, and three infants had been playing unseen behind a vehicle which subsequently reversed over them. One of the children had impaired visual acuity which was considered to have contributed to the accident and two children were intoxicated, one with alcohol and the other as a result of glue sniffing. No contributory factors were identified for the other accidents.

Table III shows details of the circumstances of the accidents. Seventy one children (53%) were playing in the street at the time of the accident, and the remainder were making a journey. Children injured while playing were often very young; 34 (48%) were aged under 7. Only one child was under adult supervision at the time of the accident. Many children were being supervised by older siblings or childhood friends, but these children were often also very young.

The 64 child pedestrians injured while making a journey were significantly older than those injured while playing (Mann-Whitney U test, $p<0·0001$); 31 were older than 12 years. Ten children were accompanied by an adult at the time of the accident.

TABLE III—*Circumstances of injury in fatal pedestrian accidents to 135 children in Northern region, 1979-86*

Circumstance	No of children	Median (interquartile range) age (years)	Median (interquartile range) distance from home (km)
Playing in street	71	7 (4-10)	0·20 (0·00-0·53)
Travelling to or from school	21	10 (8-12)	0·80 (0·00-2·01)
Travelling elsewhere	43	12 (9-14)	1·61 (0·48-2·41)

ACCIDENTS TO CYCLISTS

Thirty five children were fatally injured as cyclists (table II), and none of them was wearing a crash helmet. Two of them were riding motorcycles, one as a driver and the other as a pillion passenger. The remaining 33 accidents involved bicycles. Twenty one of these children were playing on their cycles in the street at the time of the accident, and 12 were making a journey. Thirty of these accidents involved another vehicle. The police concluded that the accident had been caused by the driver of this other vehicle in only three cases, the remaining 27 resulting from unsafe behaviour on the part of the child. Twenty three children had cycled into the path of the other vehicle without looking, either from the pavement (14 children) or at an intersection (nine); a mechanical defect of the bicycle contributed to the accident in three of these cases. The remaining four children had fallen off their bicycles in front of a vehicle.

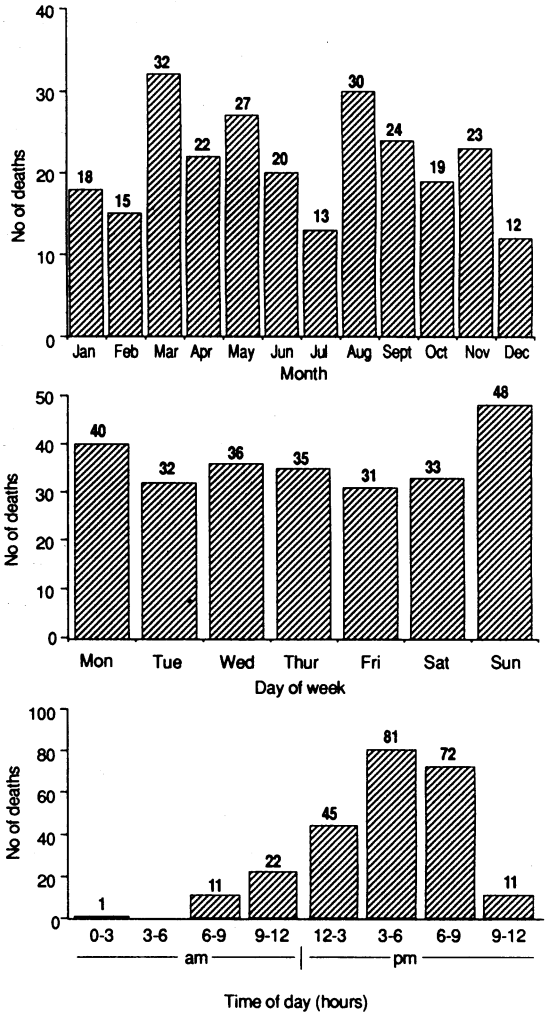

FIG 1—*Deaths from childhood accidents involving head injury in Northern region 1979-86, according to month, day of the week, and time of day*

INJURIES TO CHILDREN AS PASSENGERS IN MOTOR VEHICLES

Twenty five children died as passengers in a vehicle (table II). Two children were included in this group for simplicity but are not included in the discussion below: one was injured while driving a motorised go kart and the other was riding a sledge. In the remaining 23 children 16 were seated in the back of the vehicle and six in the front; the position of one child was not stated. Only three children were wearing a seat belt, two of whom were front seat passengers.

INJURIES FROM FALLS

Falls were the second most important cause of fatal accidents involving a head injury (table I), accounting for the deaths of 34 children. Two children fell from a horse; neither child was wearing a hard hat. The remaining 32 children fell while playing; only three were being supervised by an adult at the time of the accident. Three accidents occurred at school and two in a fairground. The remaining 24 accidents occurred while the children were playing near their home. Nine children fell from cliffs, seven from roofs, two from swings, two from walls, two from windows, one from a balcony, and one from a ladder. One child was intoxicated as a result of inhaling glue, but otherwise there were no predisposing factors.

INJURIES FROM OBJECTS

Eight children sustained fatal head injuries as a result of being struck by miscellaneous objects (table I). There was no clear pattern to the circumstances surrounding these injuries. Six children were playing at the time of the accident, of whom only one was supervised by an adult.

SHOTGUN ACCIDENTS

Four children were fatally shot in the head by another child while playing (table I). In all these the gun belonged to the father of the child or the father of a friend. All the guns had been left loaded in a place that was easily accessible to children. None of the children realised that the gun was loaded, and all the shootings were accidental.

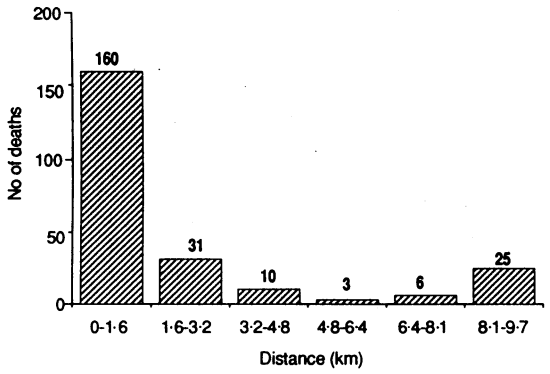

FIG 2—*Deaths from childhood accidents involving head injury in Northern region 1979-86, according to distance between the scene of the accident and child's home (n=235)*

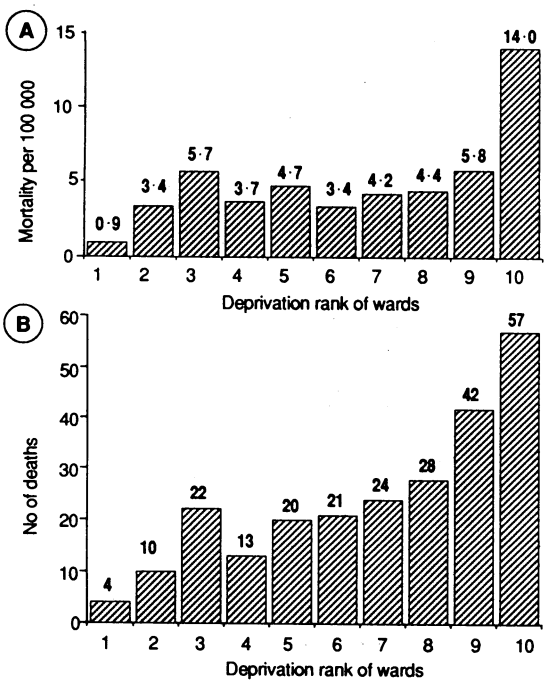

FIG 3—*Mortality (A) and number of deaths (B) from childhood accidents involving head injury in each of 10 groups of wards in Northern region ranked according to position on the overall deprivation index,[4] (group 1 represents the least deprived wards and group 10 the most) (n=235)*

ACCIDENTS INVOLVING TRAINS

Two children received fatal injuries by being run over by a train (table I). One child wandered on to the line while playing at a station; the other was playing on a railway line close to her home. Neither child was supervised at the time of the accident.

NON-ACCIDENTAL INJURY

Twelve children were injured intentionally, five by their mother, two by their father, two by an older sibling, two by an unrelated caretaker, and one by an unknown person or persons (table I).

DISTANCE FROM HOME TO SCENE OF ACCIDENT

The 12 children who were the victims of non-accidental injury were excluded from this part of the analysis; in all these children the injuries had been sustained at home. A further eight children came from outside the Northern region and were on holiday at the time of the accident; they were also excluded. Thus the distance from home to the scene of the accident was recorded in 235 cases (fig 2). Most accidents occurred close to the child's home, 79 (34%) occurring within 0·4 km and 160 (68%) within 1·6 km, and this was particularly so for pedestrian accidents, 80% (108/135) of which occurred within 1·6 km of the child's home.

Mortality in relation to social deprivation

The eight children injured while visiting the region were excluded from this part of the analysis. To determine whether the risk of sustaining a fatal head injury was significantly related to social deprivation the mortality for head injury per 100 000 children was calculated for each of the 10 ward groups (fig 3A). The mortality was highest (14·0/100 000) in group 10, which comprised the 66 most deprived wards; was less than half this figure (5·8/100 000) in the 68 wards comprising group 9; and was lowest (0·9/100 000) in group 1, which represents the 68 least deprived wards. The relation between deprivation and mortality was highly significant ($p<0·00001$, χ^2 test).

There was a significant relation between deprivation and mortality from head injury ($p<0·0001$, χ^2 test) for injuries resulting from pedestrian road traffic accidents, the mortality being 9·10/100 000 in the 66 wards that constituted group 10, and only 0·23/100 000 in the 68 wards of group 1 (fig 4A). There was also a significant relation between deprivation and mortality from head injury resulting from a fall (fig 4B) ($p<0·001$, χ^2 test) but not, in contrast, between deprivation and mortality from head injury sustained as a passenger in a vehicle or as a bicyclist. The number of children in the remaining subgroups was insufficient to allow this analysis.

The density of children was highest in the most deprived wards of the region. Figure 3B illustrates the numbers of children who died from head injury in the 10 groups of wards ranked according to their score on the overall deprivation index.[4] Ninety nine (42%) of 235 fatal head injuries occurred in the 134 wards constituting groups 10 and 9 whereas only 14 (6%) occurred in the 136 wards that constituted groups 1 and 2.

Discussion

The results of this analysis show that most of the fatal accidents involving head injury occurred in

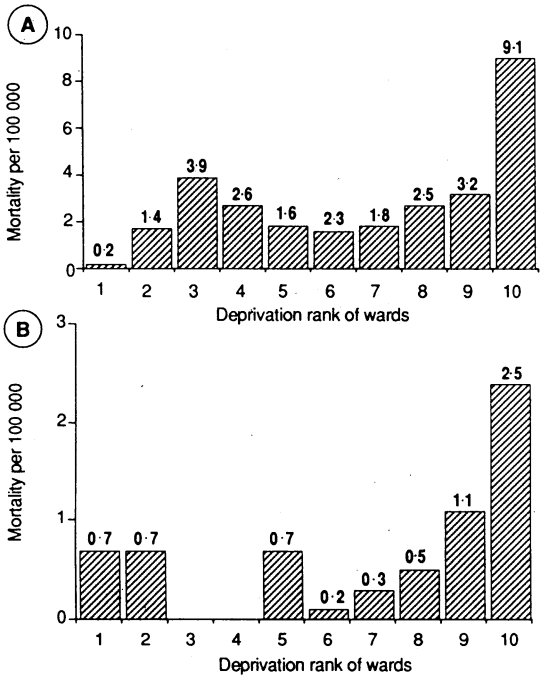

FIG 4—*Mortality from childhood accidents involving head injury sustained in pedestrian road traffic accidents (A) and in falls (B) in each of 10 groups of wards in Northern region ranked according to the position on the overall deprivation scale[4] (group 1 represents the least deprived wards and group 10 the most)*

children living in deprived areas who were playing unsupervised close to home. Though this is the first analysis of the epidemiology of this type of fatal accident in children in Britain, other studies also showed a relation between deprivation and childhood accidents.[5,6] Appropriately targeted preventive measures may thus lead to an appreciable reduction in childhood mortality.

Most children died as pedestrians in road traffic accidents. This is a similar finding to that of Illingworth, who considered all injuries arising from road traffic accidents.[7] The incidence of negligence among drivers in this study is much lower than that reported by Rivara and Barber[5] or Baker *et al*.[8] In the study by Baker *et al*[8] injuries to all pedestrians and not just those affecting children were considered. The definition of negligence in this study may, however, have led to an underestimate of factors related to the driver[8]; a driver's behaviour may be inappropriate to the situation while not necessarily breaking the law.

Other authors studied the behaviour of children in traffic also concluded that their behaviour is often unsafe.[9,10] Some reported encouraging results after intensive programmes of road safety education for children.[11-15] Improvement in theoretical knowledge, however, may be greater than that in behaviour at the roadside.[10] Children aged under 12 years have difficulties coping with traffic, irrespective of their degree of knowledge[16-20] whereas those aged over 12 possess the maturity to behave properly in traffic but often lack the motivation to do so.[9]

An alternative approach is to educate parents, emphasising the importance of supervising children at play. Certainly Sadler found that many mothers were unrealistic about the age at which children could be expected to cope with traffic.[21] In overcrowded neighbourhoods lacking safe places where children can play outside, however, it is probably unrealistic to expect parents to provide constant supervision. The incidence of childhood accidents is higher in large families[22]; those headed by a single parent[23]; of if the mother is mentally or physically ill,[24,25] caring for younger siblings, working outside the home, or caring for an elderly relative.[25] In these situations the ability of the parent(s) to provide effective supervision is likely to be impaired.

An alternative approach to preventing accidents is to make the environment safer for children. The report on traffic safety and children produced by the Organisation for Economic Cooperation and Development highlighted the appreciable reduction in deaths of childhood pedestrians in countries where these issues have been taken seriously by governments and town planners.[26] Interventions varied from simple measures, such as installing flashing lights on ice cream vans,[27] promoting the use of bicycle helmets[28] and of child restraints in vehicles,[28] to more ambitious town planning modifications,[29,30] such as establishing a network of pedestrian-cyclist routes[30] and the Dutch "Woonerf" or "living street" plan, in which motor traffic in areas of high housing density is restricted and pedestrians and cyclists have priority over vehicles.[31]

One hundred and thirty six (53%) of all the fatal accidents in this study occurred while the child was playing. Play is an essential part of child development, and the need to provide play areas in housing estates is already accepted. Despite this the provision of children's play areas in cities is much less generous in the United Kingdom than in several other European countries.[32,33] Moreover, simple provision of a play area is not sufficient. Children will use playgrounds that provide stimulating and varied play opportunities, particularly if they are consulted about the playground design; they are more likely to play in the street than use traditionally designed playgrounds.[34] It is unlikely, however, that children will ever play exclusively in playgrounds,[35] and 119 (47%) of the 255 children in this study were not playing at the time of the injury. Providing designated playgrounds should therefore not be regarded as a substitute for a safe environment for children within areas of high housing density.

The recent legislation enacted by parliament concerning the use of rear seat belts for children is an important preventive measure, and it has highlighted road safety for children to the media and the general public. Our findings that 214 (84%) children during eight years were fatally injured as pedestrians, cyclists, or while playing emphasises the importance of extending preventive measures much further. There is an urgent need to provide safe and stimulating play areas close to home in overcrowded and deprived areas and to institute town planning measures to make the urban environment safer for child pedestrians and cyclists.

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Unsuspected renal artery stenosis in peripheral vascular disease

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An appreciable proportion of patients with heart failure or hypertension requiring treatment with an angiotensin converting enzyme inhibitor have widespread atherosclerotic disease. Angiotensin converting enzyme inhibitors have recently been proposed as the treatment of choice in patients with hypertension and peripheral vascular disease as they are free of many of the side effects of other antihypertensive agents such as β blockers.[1] They can, however, induce acute renal failure in patients with renal artery stenosis.[2] Retrospective studies in the 1960s suggested a high incidence of coexisting renal artery stenosis and peripheral vascular disease.[3] In a prospective study, therefore, we carried out renal arteriography in 100 patients referred for investigation of their peripheral vascular disease to determine the prevalence of anatomical renal artery stenosis in this population.

Patients, methods, and results

We performed renal and peripheral angiography in 100 consecutive patients (70 men, 30 women; mean age 67 (range 38-87)). All the patients had been referred for peripheral angiography to assess symptoms of intermittent claudication or pain of vascular origin in the legs at rest. The renal arteries were examined by intra-arterial digital subtraction angiography. Patients were defined as having hypertension if they were receiving antihypertensive treatment (information obtained from the clinical folders) or a blood pressure of >150 mm Hg systolic or >95 mm Hg diastolic was recorded in the ward before angiography. Serum creatinine concentration was measured before angiography in 83 patients and found to be raised in 30 (>125 μmol/l).

Both renal arteries were normal in 41 patients; 24 patients had bilateral stenoses. Seven patients had an occluded renal artery, of whom four had a stenosis of >50% of the contralateral artery. Hypertension, abnormal renal function, and male sex did not predict the presence of renal artery stenosis in this population (table).

Comment

We showed that most patients with peripheral vascular disease referred for angiography have either stenosis or occlusion of the renal arteries. A high percentage of these patients had bilateral stenoses. Furthermore, seven of these patients had a single functioning kidney.

Angiotensin converting enzyme inhibitors may induce reversible renal failure, which may be a specific effect of reducing production of angiotensin II. Efferent arteriolar dilatation may lead to a fall in glomerular hydrostatic pressure, resulting in a glomerulus with a blood supply but no filtration. Such an effect is likely to occur only when the glomerular pressure falls to very low levels, but this may occur in renal artery stenosis. In a patient with unilateral disease this may not be disastrous, but in those with only one kidney or bilateral disease acute reversible renal failure may ensue.[2] Angiotensin converting enzyme inhibitors may also, however, induce acute irreversible renal failure. This is not specific to this group of agents but due to a reduction in perfusion pressure leading to thrombosis in the stenosed renal artery.[4,5] During the course of this study two patients (not included in the study) who had been treated with angiotensin converting enzyme inhibitors for hypertension and peripheral vascular disease were admitted to our hospital with acute renal failure. In both cases this proved to be reversible, although haemodialysis was required. Subsequent angiography showed bilateral renal artery stenoses in both cases.

Peripheral vascular disease seems to be the best clinical marker for the presence of anatomical renal artery stenosis. Normal renal function has been assumed by other workers to preclude appreciable renal artery

Results of renal and peripheral angiography in 100 patients with peripheral vascular disease. Figures are numbers (percentages) of patients

Risk factor	Normal arteries	Stenosis of one artery		Bilateral stenosis	Occluded artery
		≤50%	>50%		
Sex:					
Male (n=70)	31 (44)	12 (17)	7 (10)	13 (19)	7 (10)
Female (n=30)	10 (33)	5 (17)	4 (13)	11 (37)	
Blood pressure:					
Hypertension (n=38)	18 (47)	7 (18)	2 (5)	10 (26)	1 (3)
Normotension (n=62)	23 (37)	10 (16)	9 (15)	14 (23)	6 (10)
Renal function:					
Normal (n=53)	22 (42)	12 (23)	7 (13)	12 (23)	
Abnormal (n=30)	10 (33)	5 (17)	2 (7)	7 (23)	6 (20)