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Traumatic Brain Injuries in a Well-Defined Population: Epidemiological Aspects and Severity

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ABSTRACT

The aim was to describe epidemiological and medical aspects of 449 cases of traumatic brain injury (TBI) from a well-defined geographical area with a population of 137,000 inhabitants. An episode of disturbed consciousness was a prerequisite for inclusion in the study. The incidence of TBI was 354/100,000 inhabitants. Median age was 23 years, range 0–91 years; 55% were men and 45% were women; 33% children 0–14 years, 50% adults 15–64 years, and 17% elderly persons 65–91 years old. Severity classification was based on Glasgow Coma Scale (GCS) on arrival; mild TBI 97% (GCS 13–15), moderate 1% (GCS 9–12), and severe 2% (GCS 3–8). The most common injury events were falls (55%) and vehicle-related events (30%). The percentage of falls was high among children and elderly persons but among adults vehicle-related injury events were also prominent. At least 17% of all patients were under the influence of alcohol, especially adult male bicyclists. CT was performed on 163 cases (36%) revealing 34 cases with intracranial hemorrhage (ICH) which is 21% of the examined or 8% of all the injured. The rate of ICH increased with increasing age (from 3% among children to 17% among the elderly persons) and also increased with decreasing GCS from 6% in the group of mild TBI to 60% among those with severe TBI. Attention should be directed to acute management of mild TBI in order to detect potentially dangerous ICH as well as to preventive actions against falls and vehicle related accidents.

Key words: epidemiology; head trauma; traumatic brain injury

INTRODUCTION

THE INCIDENCE OF MILD TRAUMATIC BRAIN INJURY (mild TBI) treated in hospitals is 100 to 300/100,000 population, but the total incidence is probably >600 (Cassidy et al., 2004). TBI is a common cause of injury deaths in younger individuals (Paden et al., 2002). Although only a few percent of TBI is classified as severe or moderate in the acute stage, TBI is also the main cause of disability in

this age group (Thurman et al., 1999), since a considerable number of patients with brain injury classified as mild in the acute phase suffer from long-lasting sequelae (Johansson et al., 1991; Middleboe, 1991). Thus, TBI constitutes a major health problem which has been acknowledged recently by a number of authorities. In the United States, both in a report from the National Institute of Health (1999) as well as in a report to the Congress (2003), it was declared that mild TBI is a major health problem in soci-

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ety and that efforts should be made to improve its recognition, diagnosis and treatment in order to reduce disability following these injuries. The World Health Organization's (WHO's) Task Force on Mild Traumatic Brain Injury arrived at a similar conclusion, i.e., that "there is evidence that mild traumatic brain injury is an important public health problem" and that "we need more high quality research in this area" (Cassidy et al., 2004). The results of such research are also a necessary prerequisite for designing preventive, therapeutical, rehabilitative and general health care measures in order to minimize the burden of this condition on the individual and on society.

Thus, there is substantial awareness of the fact that the present state of knowledge on TBI necessitates new research. As there are only a few recently presented population-based studies on epidemiological aspects of TBI and since the latest Swedish study accounts for data obtained during 1993–1994 (Emanuelson et al., 2003), there is a particular need for updated studies of this kind as the spectrum of different injury events may have changed.

The aim of the present study was to investigate the incidence, causes and consequences of all types of TBI treated in a well-defined population and geographical area. The data might also give an indication of areas suitable for injury preventive measures.

METHODS

The data set originates from the Umeå University Hospital's injury register (10,000 cases/year). To be included in our data set, the injured person should have arrived alive at the hospital within 24 h after a brain trauma causing any degree of disturbed consciousness (e.g., unconsciousness, disorientation), amnesia, neurological deficit, severe headache, nausea, or vomiting. Of 485 injury events, 449 met these criteria.

The Umeå University Hospital is located in northern Sweden, and is the only hospital and medical facility that treats brain injuries within a well-defined catchment area of 137,000 inhabitants in 2001. At the emergency department (ED), both inpatients and outpatients from the area are treated. Also the general practitioner on call (outside ordinary working hours) for the area is located at the hospital. There is a well-established ongoing injury registration of all cases of trauma at the hospital. On arrival at the ED the injured person answers a questionnaire about the circumstances of the injury event. Data are also retrieved from ambulance personnel, bystanders and relatives. In some cases, supplementary details are retrieved by interview during the recovery phase. Data from all available medical records and in some cases police reports are included in the data set. All data are then eval-

uated to determine the type of injury event, characteristics of the scene, involved objects, symptoms etc according to guidelines for different types of trauma. By checking against the hospital's compulsory E-number registration for "external cause" of inpatient treatment, the problem of losing inpatients in the data set is eliminated. The ICD-numbers for brain injuries included are within S 06 (International Classification of Diseases ICD-10, 1997), but in our search also the "unspecified" ICD-codes are scrutinized in order to find "hidden" cases. If the patient has multiple injuries, up to two additional injuries are also registered. The proportion of registration misses in the group of outpatients is usually about 10% in the monthly control of the register's quality (i.e. when all registered patients during three randomly selected days are compared with all hospital visits for the same period of time). This implies that less than five cases could have been missed in our data set. Being under the influence of alcohol is assessed by self-reporting, by data in medical records, or by blood sample testing.

The classification of mild, moderate and severe traumatic brain injury was based solely on the Glasgow Coma Scale (GCS) (Teasdale and Jennett, 1974) of the injured person as assessed on arrival at the ED. GCS 13–15 was classified as mild TBI, GCS 9–12 as moderate, and GCS 3–8 as severe. The GCS score was in some cases not available in the hospital or ambulance records. In these cases the authors have extracted the information needed to set a GCS score from data in these medical records. All clinical data were re-evaluated by the authors to ensure a uniform interpretation of the medical data.

All cases (i.e., all the hospitalized and non-hospitalized ones) were included in the calculation of mean and median length of stay in hospital.

RESULTS

Number of Cases, Age, and Gender

Of the 449 injury events, 247 (55%) involved men (median age 23; range 65–91 years) and 202 (45%) women (median age 22; range 0–91 years). One woman was involved in two different injury events, each of which was accounted for.

The numbers of cases within different age and gender groups were as follows:

- Children (0–14 years): 149 cases—75 (50%) boys, 74 (50%) girls
- Youth and adults (15–64 years): 225 cases—137 (61%) men, 88 (39%) women
- Elderly persons (65–94 years): 75 cases—35 (47%) men, 40 (53%) women

The number of cases per age group was highest among those under the age of 25. In the age group 70–89, the number of injured men decreased, while the number of women showed an increasing tendency from 55 to 89 years of age (Fig. 1A). The TBI incidence was 354/100,000 people, with a distribution between different age groups as shown in Figure 1B. The incidence was highest among children, adolescents, and elderly persons.

Type of Injury Events

The most frequent type of injury event was falls (245; 55%), followed by vehicle-related events (135; 30%), and injury events caused by “contact with object” (69; 15%). The distribution within the different age groups is shown in Figure 2. The percentage of falls was highest among elderly persons and children, while among adults, vehicle-related injuries were as common as falls. Among children, falls from one level to a lower level were more common than falls on the same level (Table 1).

Boys were overrepresented with respect to “contact

with object” in the age group 5–14 years; 12 of 17 in this age group were injured in sports events. In the group of adults, men were in a majority especially regarding “contact with object” (28; 71%), and in motorcycle, moped, and snowmobile crashes (10; 77%). Among the elderly persons, women constituted the majority of those suffering falls on the same level (26, 63%). Ten of 16 cases of falls from one level to a lower level among elderly persons were falls on stairs.

Length of Time from Injury to Arrival at the Emergency Department

The length of time between the injury event and arrival at the ED could be extracted from 74% of the records. The median length of time from injury to arrival was 1.5 h (mean 2.4 h; range 10 min to 23 h): 1.5 h for children and adults and 2.5 h for elderly persons. The mean length of time from injury to arrival was about 1 h longer in cases when patients had fallen on the same level compared with the other types of injury events.

FIG. 1. (A) Number of injured men and women by age group. (B) Number of injured men and women per 100,000 population by age.

FIG. 2. Proportion (%) of different types of injury events by age group (n = number of cases in different age groups).

Glasgow Coma Scale

On arrival at the ED, 434 cases (97%) were classified as mild TBI (GCS 13–15, four cases as GCS 13), five (1%) as moderate TBI (GCS 9–12), and 10 (2%) as severe TBI (GCS 3–8). Except for one elderly man, all of the cases with moderate or severe brain injury (GCS 9–12 and 3–8 respectively) were adults 15–64 years of age.

Loss of Consciousness, Amnesia, and Computed Tomography

Loss of consciousness (LOC) was documented in 28% of the cases. In many cases, it could not be determined whether or not LOC had occurred. Amnesia was documented in 39% of the cases (Tables 2 and 3).

Computed Tomography (CT) of the brain was carried out in 163 cases (36%). Of those cases with GCS 13–15, 150/434 (35%) were examined, four of five cases with GCS 9–12 and nine of 10 cases with GCS 3–8 were examined. The percentages in the different age groups were

children 32/149 (21%); adults 86/225 (38%); and elderly persons 45/75 (60%).

Intracranial Hemorrhages and Cranio-Facial Fractures

Altogether, 34 cases of intracranial hemorrhage (ICH) were found, i.e., 21% of those who underwent CT or 8% of all injured. The rate of ICH increased with increasing age (ICH was encountered in 3% of the children, 8% of the adults and 17% of the elderly persons) and with decreasing GSC (ICH was encountered in 6% of the cases with GCS 13–15, 40% of the cases with GCS 9–12, and 60% of the cases with GCS 3–8; Table 4). Since CT was carried out only in 36% of all cases, the figures of ICH represents minimum numbers. ICH was more often diagnosed in cases of vehicle-related injury events than in falls (Table 5). The 34 cases with ICH suffered contusion hemorrhage in 22 cases, subdural hemorrhage in 17, epidural hemorrhage in seven, and subarachnoidal hemorrhage in eight. Interestingly, five cases with ICH had

TABLE 1. NUMBER OF CASES IN DIFFERENT INJURY EVENTS DISTRIBUTED BY CHILDREN, ADULTS, AND ELDERLY PERSONS (ROW %)

	Falls		Vehicle-related events			CWO	
	Horizontal falls	Vertical falls	Car/bus/truck crash	Bicycle crash	M/M/S-crash	Ped-Veh	
All cases	148 (33%)	97 (22%)	53 (12%)	55 (12%)	21 (5%)	6 (1%)	69 (15%)
Children	45 (30%)	52 (35%)	4 (3%)	15 (10%)	7 (5%)	1 (0.5%)	25 (17%)
Adults	62 (28%)	29 (13%)	45 (20%)	36 (16%)	13 (6%)	1 (0.5%)	39 (17%)
Elderly	41 (55%)	16 (21%)	4 (5%)	4 (5%)	1 (1%)	4 (5%)	5 (7%)

Horizontal falls, falls on the same level; vertical falls, falls from one level to a lower level; M/M/S-crash, motorcycle, moped, or snowmobile crash; Ped-Veh, pedestrian hit by vehicle.

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TABLE 2. LOSS OF CONSCIOUSNESS (LOC), NUMBER OF CASES DISTRIBUTED BY CHILDREN, ADULTS, AND ELDERLY PERSONS (ROW %)

	LOC				No LOC	Unknown whether or not LOC had occurred
	<5 min	5–30 min	>30 min	Unknown time		
All cases	106 (24%)	14 (3%)	5 (1%)	55 (12%)	103 (23%)	166 (37%)
Children	42 (28%)	3 (2%)	0 (0%)	2 (1%)	56 (38%)	46 (31%)
Adults	47 (21%)	9 (4%)	5 (2%)	43 (19%)	38 (17%)	83 (37%)
Elderly	17 (23%)	2 (3%)	0 (0%)	10 (13%)	9 (12%)	37 (49%)

no history of LOC (Table 6; F9 with CWO, M22, M29, M56, and M73).

Facial fractures and concomitant fractures of the skull were encountered only in adults and elderly persons. Fourteen cases had a skull base fracture, and 12 of these (86%) also suffered ICH. In contrast, only six (32%) out of 19 cases with solely facial fractures showed ICH.

In seven cases, intracranial pressure monitoring was used for surveillance, and in nine cases, the patients were treated surgically (e.g., evacuation of hematomas, revision of impression fractures). The offensive pharmacological intracranial pressure-reducing therapy—according to the concept by Nordström (2005) and Grände et al. (2002), aiming at reducing cerebral energy consumption, capillary hydrostatic pressure and cerebral blood volume, and at maintaining colloid osmotic pressure and fluid balance—was used in 11 cases. None of the admitted patients died.

Additional Injuries

The cases were divided into three groups with respect to other injuries. The first group consisted of 226 cases (of which 99% were mild TBI) and comprised TBI with no additional extracranial injuries. This first group contained five cases of ICH.

The second group contained 186 cases (of which 96% were mild TBI) with 235 other concomitant injuries. Some of these injuries were related to the impact on the head such as fractures on the cranium ($n = 12$), nose and teeth

fractures, and wounds of the scalp. Also other minor injuries that by themselves would not lead to inpatient care, for example, fractures of fingers, toes, and clavicle, small wounds, and superficial contusions were included in this second group. This group comprised 20 cases of ICH.

The third group consisted of 37 cases (of which 86% were mild TBI) and included 42 major extracranial injuries. Injuries such as fractures ($n = 32$) or luxation ($n = 2$) of major bones and joints, limb amputation ($n = 1$), major contusions ($n = 6$), and major bleeding ($n = 1$) were included in this group. This group comprised also nine ICH and five fractures of the skull.

As a whole, additional injuries were more common in adults and elderly persons than in children (Table 7).

Alcohol

Among all the 449 cases, at least 75 (17%) had signs of having been under the influence of alcohol (58, or 23% of all men; 17, or 8% of all women; 0% of the children; 64, or 28% of the adults, and 11, or 15% of the elderly persons). The results for the different age groups are shown in Figure 3. Alcohol inebriation was most common in the age group 20–49 years among men ($n = 38$; 45%) and in the age group 40–49 years among women ($n = 3$; 27%).

The highest rates of alcohol inebriation in different injury events were found to be in vehicle-related injury events (25, or 19%), of which the bicycle-related cases had the highest rate (15, or 27%). Regarding those injured in car, bus, or truck crashes, at least six (11%) were

TABLE 3. AMNESIA PRESENTED AT THE EMERGENCY ROOM, NUMBER OF CASES DISTRIBUTED BY CHILDREN, ADULTS, AND ELDERLY PERSONS (ROW %)

	Presence of amnesia	Absence of amnesia	Unknown whether or not amnesia had been present
All cases	177 (39%)	96 (21%)	176 (39%)
Children	52 (35%)	33 (22%)	64 (43%)
Adults	88 (39%)	49 (22%)	88 (39%)
Elderly	37 (49%)	14 (19%)	24 (32%)

TABLE 4. INTRACRANIAL HEMORRHAGE, NUMBER OF CASES DISTRIBUTED BY CHILDREN, ADULTS, AND ELDERLY PERSONS

	<i>GCS 13–15</i>	<i>GCS 9–12</i>	<i>GCS 3–8</i>
All cases	26/434 (6%)	2/5 (40%)	6/10 (60%)
Children	4/149 (3%)	0/0 (0%)	0/0 (0%)
Adults	10/211 (5%)	2/5 (40%)	5/9 (56%)
Elderly	12/74 (16%)	0/0 (0%)	1/1 (100%)

Since computed tomography (CT) was carried out only in 36% of the cases, these are minimum numbers.

GCS, Glasgow Coma Score.

under the influence of alcohol. Among the 245 cases injured by falls, 36 (15%) were probably under the influence of alcohol. Six of the 34 cases with ICH displayed signs of being under the influence of alcohol.

Length of Stay in Hospital

Of the 449 cases, 396 (88%) were treated as inpatients (of which 50% had additional concomitant injuries) and 53 (12%) were discharged after the physical examination (of which 44% had additional injuries). The total hospitalization time was 1115 days, with a distribution between age groups as shown in Figure 4. Most cases (297, or 66%) were treated as inpatients for 1 day and 38 (8%) for 2 days. The longest time in hospital was 120 days (caused by the brain injury). The mean number of inpatient days was highest for the elderly persons and lowest among the children.

DISCUSSION

The strength of the present study is that it comprises a total data set from a well-defined population and geographical area (a middle-sized Swedish city and its surrounding neighborhood). Together with the well-established injury registration procedure, our epidemiological data thus seems to be representative for the area and study group, with minimal bias and drop-out. Furthermore, all clinical data has been re-evaluated to ensure a uniform interpretation. However, it should be remembered that generalization must be done very cautiously as the data are only representative for the study area and time.

The incidence of TBI found in our study, i.e., 354 per 100,000 inhabitants of which the incidence of mild TBI was 342 per 100,000 inhabitants, was at the top of the span given in the state-of-the-art paper on mild TBI by Cassidy et al. (2004). In a Swedish study from 2004, Peloso et al. concluded that the mean incidence of all mild TBI in Sweden during the period 1987–2000 was

175 (Peloso et al., 2004). The figure we have found is close to the corresponding data from the years before and after the study years as well as from the beginning of the 1990s (Wahlberg and Björnstig, 1994). However, the incidence of TBI in our present study is lower than that from 1992–1993 reported by Andersson et al. (2003), who studied an area in south-western Sweden. However, their inclusion criteria were wider than ours were.

The injury incidence was highest among children, adolescents, and elderly persons. It is a well-known fact that children, adolescents, and young adults constitute the majority of TBI patients and that their incidence of TBI is high (Cassidy et al., 2004). Evidence that elderly persons are also at high risk could not be shown by Cassidy et al. (2004), but several other previous studies have found high incidence rates among elderly persons (Kleiven et al., 2003; Yates et al., 2006; Bruns and Hauser, 2003). Even if the age-related injury incidence was high for elderly persons, the total number of treated elderly patients was not so high. However, the length of stay in hospital was longer for the elderly patients than for the other age groups, so 37% of the total number of inpatient days was used by the elderly patients. These results indicate that the focus of head trauma prevention should be directed at children, adolescents, and elderly people.

The patients were divided into three age groups: 0–14, 15–64, and 65–94 years of age. We chose to divide the adults from 15 to 64 for several reasons, namely, from 15, adolescents are allowed to drive a moped and other motor vehicles, and many of them start drinking alcoholic beverages. Viewing children and the elderly persons as groups, the gender distribution was even, but among adults men dominated (61%). In fact men prevailed in all age groups from 10 to 79 years. A similar pattern was shown previously by Bordignon and Arruda (2002) in a study of 2000 cases of mild TBI in Brazil. Cassidy et al. (2004) reported that men ran about twice the risk of women for mild TBI. In another review of 12 studies of TBI, Bruns and Hauser (2003) concluded that the highest male/female ratio typically occurred in ado-

TABLE 5. PROPORTION OF INTRACRANIAL HEMORRHAGE IN DIFFERENT TYPES OF INJURY EVENTS

Falls on the same level (<i>n</i> = 148)	6%
Falls from one level to a lower level (<i>n</i> = 97)	5%
Contact with object (<i>n</i> = 69)	1%
Car/bus/truck crash (<i>n</i> = 53)	17%
Bicycle crash (<i>n</i> = 55)	11%
Motorcycle/moped/snowmobile crash (<i>n</i> = 21)	5%
Pedestrian hit by vehicle (<i>n</i> = 6)	50%

Since computed tomography (CT) was carried out only in 36% of the cases, these are minimum numbers.

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TABLE 6. PATIENTS WITH INTRACRANIAL HEMORRHAGE: GENDER AND AGE RELATED TO GCS, TYPE OF INJURY EVENT, TYPE OF INTRACRANIAL HEMORRHAGE AND OPERATION

<i>Gender/age</i>	<i>GCS</i>	<i>Type of injury event</i>	<i>Computed tomography findings</i>	<i>Operation</i>
F6	15	C/B/T-Crash	SDH/C	PS
F9	15	C/B/T-Crash	SAH/C	No op
F9	13	CWO	C	RIF, PS
F13	14	B-crash	EDH	Evac
M19	7	C/B/T-Crash	C	PS
M21	15	C/B/T-Crash	C	PS
M21	10	C/B/T-Crash	C	PS
M22	15	B-crash	EDH/C/SDH	Evac
F24	12	C/B/T-crash	SDH	PS
M24	3	B-crash	EDH/C	PS
F25	14	B-crash	EDH/SDH/SAH/C	No op
M29	14	C/B/T-Crash	EDH/C	RIF, Evac, VD, PS
M37	6	Ped-Veh	SDH/C	Evac, PS
M39	15	Fall H	C	No op
M40	3	Fall V	EDH	Evac, PS
F45	15	Fall H	SAH/C	No op
F50	15	C/B/T-Crash	SDH	No op
M56	15	B-crash	SDH/C	No op
M56	15	B-crash	SDH/C	No op
M57	15	C/B/T-Crash	SDH/C	PS
M61	4	Fall H	SAH/C	DBC
M66	15	Fall H	SAH	No op
F69	15	Fall H	SDH	No op
M70	15	M/M/S-crash	SDH/C	Evac
M71	15	Fall V	SDH	No op
M71	15	Fall H	C	No op
F73	15	Fall V	SDH	No op
M73	14	Ped-Veh	SAH	No op
M76	15	Fall H	C	No op
M81	14	Ped-Veh	SAH	No op
F85	14	Fall H	SDH	No op
M88	15	Fall H	EDH/SDH	No op
M89	8	Fall H	SDH/C	Evac
F91	14	Fall V	SDH/SAH/C	No op

GCS, Glasgow Coma Score; F, female; M, male.

Type of injury event: C/B/T-crash, car, bus, or truck crash; CWO, contact with object; B-crash, bicycle crash; Ped-Veh, pedestrian hit by vehicle; Fall H, (horizontal) fall on the same level; Fall V, (vertical) fall from one level to a lower level; M/M/S-crash, motorcycle, moped, or snowmobile crash.

Computed tomography findings: SAH, subarachnoidal hemorrhage; C, contusion; EDH, epidural hematoma; SDH, subdural hematoma.

Operations: No op, no operation; PS, pressure surveillance; Evac, evacuation of hematoma; RIF, revision of impression fracture; VD, ventricle drainage; DBC, decompressive bilateral craniectomy.

lescence and young adulthood. In the previous study from south-western Sweden, Andersson et al. (2003) showed figures indicating that boys ran a higher risk of TBI than girls, as children but not as adolescents. In our study, from age 55 to 89, the incidence of injured females increased steadily while the opposite was true for men in the age groups 70 to 89. The fact that the risk of injury increases with age is probably due to slower avoidance

reaction in the event of an incident and increased vulnerability (Evans, 2000).

Falls were the most frequent cause of injury in both children and elderly persons. Among children falls from one level to a lower level were especially frequent but in addition every fifth elderly person had suffered a fall from one level to a lower level, often on stairs. Of course the trauma energy will be higher for falls from one level to

TABLE 7. CASES WITH ADDITIONAL INJURIES RELATED TO AGE AND LENGTH OF STAY IN HOSPITAL (Row %)

	<i>All cases</i>	<i>Children</i>	<i>Adults</i>	<i>Elderly persons</i>
Group 1	226/1.1/1	107 (47%)/0.8/1	97 (43%)/1.1/1	22 (10%)/2.6/2
Group 2	186/3.1/1	38 (20%)/1.0/1	103 (55%)/3.3/1	45 (24%)/4.3/2
Group 3	37/7.9/2	4 (11%)/9.8/10	25 (68%)/3.6/2	8 (22%)/20.3/7

Group 1, traumatic brain injury (TBI) with no additional injuries; group 2, TBI with additional head injuries and minor extracranial injuries; group 3, TBI with major extracranial injuries.

No. cases/mean hospitalization (days)/median hospitalization (days).

a lower level indicating that avoiding these situations would reduce these injuries. In the adult group, vehicle-related injuries were as frequent as falls. Car and bicycle crashes were the most frequent vehicle related incidents. It is intriguing that the proportion of vehicle-related injury events was more than twice as high among adults than among the other age groups. One factor contributing to this might be the low usage of seat belts among those who are injured in motor vehicle crashes. In another study we have shown that nearly half of the seriously injured persons, and a quarter of those with moderate injuries in our district have not used seat belts (Bylund and Björnstig, 1996, 2001). The introduction of seat belt reminders in most modern cars will be a positive factor from this point of view (Krafft et al., 2006). In Sweden, bicycling is common among all age groups, and in our medical district, a majority of traffic injuries are bicyclist injuries, of which nearly 1/10 suffer concussion (Björnstig et al., 1992, 2006).

The median length of time from injury to arrival at the ED was 1.5 h for children and adults, but 2.5 h for elderly persons. This may reflect several factors, e.g., dispatch pri-

ority for ambulances, resulting in shorter response time for traffic incidents and longer for falls (patients who had fallen on the same level arrived at the ED on average 1 h later than victims of other injury events). However, it must be emphasized that in the case of more severe brain injuries this time period is unacceptably long, considering the fact that “prompt diagnosis and treatment are extremely important” (Committee of Trauma, 2004). Furthermore, it is also a well-established fact that brain injury cases that are under definitive treatment within 2 h have a better outcome than those treated after a longer delay. In the light of these facts, it is worth considering that the elderly patients, who often had fallen, suffered nearly 40% of all the intracranial hemorrhages found. The period of time preceding definitive care was thus unacceptably long for these cases (median 2.5 h). One complicating pitfall might have been that their GCS was 13–15 in all cases except one, and thus they might have been classified as mild brain injury and given low priority. All cases with GCS <13, except for one single elderly person, were adults.

Of all cases, 28% had a documented history of LOC and 39% had documented amnesia. For the majority of

FIG. 3. Proportion (%) of men and women under the influence of alcohol by age group (numbers above columns = number of inebriated men and women, respectively, in the age group).

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FIG. 4. Length of stay in hospital distributed by children, adults, and elderly persons.

the cases the duration of LOC was less than 30 min which is in line with the definition of mild TBI by the Mild Traumatic Brain Injury Committee of the American Congress of Rehabilitation Medicine (1993). For a large number of cases, information about LOC or amnesia was not available. This may be due to deficient handling routines for these patients or to the fact that the patients were not able to recall. However, the presence of LOC or amnesia is not an obligatory criterion for mild TBI (American Congress of Rehabilitation Medicine, 1993). Management routines of patients with TBI in our hospital include an examination by the general surgeon on call who then makes decisions about a CT scan and/or hospitalization.

The severity of the brain injury was assessed by the GCS score on arrival at the hospital. Most cases in our study were classified as mild TBI (97%) with GCS 13–15. This is a higher percentage than the 80–91% Kraus and Nourjah (1988), von Wild and Wenzlaff (2005), and Kay and Teasdale (2001) reported. These differences may be partially explained by different characteristics of the injury panoramas in the hospitals' catchment areas and different structures of the medical care in the areas. One bias factor is of course that GCS varies with time after the injury event.

A CT scan was performed on 36% of all cases and on 35% of cases with mild TBI. In a Swedish study from 1998 the proportion of patients with mild TBI who underwent a CT scan was reported to vary from a few percent to 80%—on average, 22% (Borg et al., 2000). Several studies have proposed that the early use of a CT scan after mild TBI instead of in-hospital observation saves costs (Stein et al., 1991; Ingebrigtsen and Romner, 1996; Borg et al., 2000; Af Geijerstam and Britton, 2003). However, even though most patients with mild TBI have normal CT findings, every clinician should be aware that

there will always be a few patients who can develop hemorrhagic lesions (Borg et al., 2000).

ICH was encountered in half of the cases of severe and moderate TBI. This is more than shown by Teasdale et al. (1990) in an extensive study that reported risk of acute ICH in patients with moderate and severe head injuries. In a recent, thorough population-based prospective study of patients with all types of TBI, the mortality due to brain injury after admission to the hospital was found to be only 1.4% (Von Wild and Wenzlaff, 2005). Yet, in the present study none of the hospitalized patients died. A combination of short transport distances (at most 60 km) and direct access to adequate neurosurgical management, including modern intensive care according to Nordström (2005) and Grände et al. (2002), together with the low total number of patients with moderate and severe brain injuries, may possibly explain the absence of fatal outcome in the present study.

In 6% of the cases of the present sample with signs only of mild TBI, ICH was encountered and one-third of this group of patients was treated surgically. In a meta-analysis of epidemiological high-quality studies of mild TBI, Af Geijerstam and Britton (2003) concluded that about 8% of the patients will show pathological findings on CT and about 1% will require surgery. Thus, TBI classified as mild may have serious, sometimes life-threatening, complications. Such complications may occur even in patients who have had no loss of consciousness and who are neurologically unaffected (GCS = 15) on arrival at the hospital.

Identifying which head trauma patients will develop complications is a challenge for the physician. The problem is illustrated by the fact that of the 34 cases with intracranial hemorrhage in our study, 26 (77%) had GCS 13–15 on arrival and nearly half of these cases had no reported loss of consciousness.

The proportion of patients that underwent CT increased with increasing age, comprising 60% of the elderly patients. These CT scans were obviously well motivated, as at least 13 (17%) of all the injured elderly persons had an ICH. Only four (3%) of the children were diagnosed to have an ICH. Maybe the extensive use of bicycle helmets among children under the age of 10 (Wahlberg et al., 1995) has contributed to this low number of ICH cases. The number of ICH may have decreased even further after the introduction in 2005 of the bicycle helmet law for children under 15.

The patients with the highest proportion of ICH were all injured in traffic (in 50% of pedestrians; 17% of four-wheeled motor vehicle occupants and 11% of bicyclists ICH was encountered). Skull base fractures (ICH was encountered in 86%) and face fractures (ICH was encountered in 32%) are other possible indicators of ICH.

At least one fourth of the adults and the elderly patients gave signs of being under the influence of alcohol, which is the same fraction as reported by, for example, Nygren de Boussard et al. (2004) and Stålnacke et al. (2005). Our data is based on clinical signs, self-reporting and in some cases blood sample tests, making them minimum numbers. Honkanen et al. (1977) have shown that, by using clinical signs, physicians in an ED in Finland identified two-thirds of all those who were under the influence. If this were valid at our ED too, the proportion under the influence of alcohol might have been one third. The proportion was highest in the age groups 20–49 years with a maximum of over 50% among injured males 40–49 years old. Vehicle-related incidents, especially bicycle incidents, had the highest proportion, but falls also had a high proportion. The fact that middle-aged bicyclists with brain injuries are often under the influence of alcohol has also been reported by Bylund et al. (2005). In Sweden, however, it is not illegal to ride a bicycle when being under the influence. Maybe a deterioration of the reaction capacity to protect the head in an incident (or to avoid an incident) is a major contributing factor to the relatively high proportion of alcohol-influenced cases in the group of head injuries. A clinical problem for the attending physician is of course to assess signs of brain injury vs. signs of alcohol influence, factors that may increase the indication of CT examination.

Most patients (88%) were treated as inpatients. The mean time spent in hospital increased with increasing age both among solely brain injured patients and patients with additional injuries. This may reflect the injury severity and recovery time for different age groups. A Swedish epidemiological study of mild TBI by Peloso et al. (2004) has previously shown that the length of time stayed in hospital varies according to age. They found that one-third of the patients over 65 years stayed longer than 5 days in hospital. They counted the first 24 h as 0 days as

opposed to our study where an observation for less than 24 h was counted as 1 day. Regarding the patients with additional injuries, the mean and median number of inpatient days appears to be higher than for the solely brain injured. One additional factor contributing to this might have been higher trauma energy. Of the 34 cases of ICH, 85% were diagnosed to have additional injuries opposed to only 50% of the total data set. This might suggest that the presence of additional injuries could be associated with complications such as ICH.

Even if the age-related incidence was high for the elderly persons in our study, the total number of injured elderly persons in need of medical treatment was limited. On the other hand, the few patients who needed medical attention were on average treated as inpatients two to five times longer than adults and children, which meant that more than one-third of the total number of hospital days was used by the elderly patients.

In conclusion, this study revealed that TBIs were common especially in young and elderly persons. A great majority of TBIs were classified as mild. A considerable number of the mild TBIs were associated with ICH, and some of them necessitated neurosurgical treatment. Accordingly, there is a need for preventive measures concerning especially young and elderly persons. Moreover, attention should be directed to acute management of mild TBIs in order to detect potentially dangerous ICH.

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