

Severity and types of head trauma among adult bicycle riders

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ABSTRACT. A retrospective review of bicycle-related head trauma, in Madison, Wisconsin was carried out during the fair weather months of 1981-1984. One-hundred and eighty-seven (187) cases of head injury were identified through review of emergency department and inpatient records. Thirty-three percent (33%) of the cases had injuries of moderate severity and 3% sustained severe or life-threatening injuries. Thirty-two percent (32%) had evidence of brain injury. Within the brain-injured group, 55 (93%) had a concussion and 4 (7%) had an abnormal computerized tomographic (CT) scan. One-hundred and four (56%) of 187 patients were contacted for followup information. There was no significant association between type of collision and severity. Most serious injuries took place under daylight and dry conditions and did not involve motor vehicles. Only 1 of 104 respondents to the questionnaire was wearing a helmet at the time of injury. The results show that transient loss of consciousness or amnesia occurs commonly among bicycle riders who require emergency department treatment for head trauma.

Key words: Head trauma; Bicycle-related injuries; Helmet use; Emergency treatment; Adult bicycle riders

BICYCLES HAVE become an important mode of transportation in the United States. The number of bicycles in this country has increased from 28 million in 1960 to 105 million in 1983.¹ This has been accompanied by a significant increase in bicycle-related morbidity and mortality, particularly among older riders. Of the 1100 bicycle-related deaths in 1982, 67% of the

victims were over 14 years old. In 1960 only 22% of the 460 fatalities were in this age group.¹ According to the Consumer Products Safety Commission (CPSC), bicycling is the most common cause of recreational injury, accounting for over 570,000 emergency department visits in 1983.² Epidemiologic studies indicate that head trauma is associated with the more serious injuries.³

This study was designed to retrospectively evaluate the type and severity of head trauma in adult bicycle riders and describe injury circumstances along with rider characteristics. The study took place in Madison, Wisconsin where there are an estimated 25,000 college students who ride bicycles among a total population of 175,000.⁴ The age range of the study group was

restricted to adults for two reasons. First, little literature has covered this age group despite an increasing proportion of fatalities among adult riders during recent years. Secondly, for followup purposes it was thought that recall, consent, and cooperation would be easier to achieve and more reliable among older riders.

METHODS. Emergency department record review. Emergency department patient registrations or log books from three of the four general hospitals in Madison were reviewed for the period April 1 to October 31 during the years 1981-1983, and from April 1 to July 31, 1984. The total emergency department admissions for these three hospitals was 46,694 in 1982, the approximate mid-year period of the study.* We were able to estimate that this sampling scheme missed approximately 12% of all bicycle-related injuries during the study period; *ie*, those occurring during the winter months. This estimate was derived by reviewing data collected by the CPSC National Electronic Injury Surveillance System (NEISS, a computerized emergency department registry) at one of the city hospitals.

Emergency department log books were reviewed for any injury to the head with noted circumstances of injury suggesting that the incident occurred while riding a bicycle. At one hospital, all bicycle-related head injuries were identified through the NEISS computerized listings. The actual emergency department record and/or inpatient chart of each preliminary case was reviewed by an emergency department physician (EB or MB) to determine the type(s)

*Data derived from the 1983 Wisconsin Hospital Directory published by the Wisconsin Department of Health and Social Services and the Wisconsin Hospital Association.

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and severity of head injury and to confirm bicycle involvement. Each case of bicycle-related head trauma was assigned to one or more of the following injury-type categories: (1) cranial vault fracture, (2) basilar skull

fracture, (3) facial bone fracture, (4) concussion, (5) subdural hematoma, epidural hematoma, cerebral contusion or hemorrhage documented by computerized tomography [CT], or (6) soft tissue injury. The injury was classified as a concussion if there was reported loss of consciousness or changes in mental status such as disorientation or amnesia. Patients who sustained a more severe brain injury such as cerebral contusion or subdural hematoma were not classified as having a concomitant concussion.

The severity of head injury was classified according to the criteria in Table 1. All categories except "minor" utilize brain-injury criteria developed by Kraus et al.⁵ In our study their criteria were modified to allow the inclusion of concussions and skull fractures in the "moderate" severity category even if the patient was not hospitalized. For our purposes, the term "brain injury" refers to those patients classified as having moderate, severe, or life-threatening head trauma, excluding those patients with isolated facial fractures.

A questionnaire was mailed to each injured bicyclist to elicit information regarding crash circumstances, rider characteristics, and helmet use. Data was elicited on: (1) helmet use at the time of injury, (2) circumstances of injury [bicycle-motor vehicle, bicycle-pedestrian, bicycle-fixed object, fall without collision, etc], (3) road conditions [wet or dry] and light conditions [day or night] at the time of injury, (4) type of bicycle [1-speed, 10-speed, etc], (5) frequency of riding

[days/month], and (6) length of intended trip at the time of the injury.

Those people who did not respond to the questionnaire received a followup mailing or phone call. Case-finding techniques included efforts to determine current addresses through state motor-vehicle registration records, university alumni records, and telephone directories. Police records were used to gather information on the one fatality in the study.

The analysis gives the results of the entire study group and the brain-injured patients. P values below .05 (two-sided tests) were considered significant.

RESULTS. One-hundred and eighty seven (187) cases of bicycle-related head trauma were identified from the three hospitals during the study period. The mean age of the patients was 27 years. The highest frequency of cases was in the 18- to 22-year-old age group (Table 2). Males comprised 56% of all patients and the age distribution for each gender was similar.

The distribution of severity levels is shown in Table 3. The proportion of males and females was similar in the minor and moderate injury severity categories. All six patients with severe or life-threatening injuries were male. One hundred eighteen (63%) of 187 patients had injuries consisting of soft tissue contusions or lacerations.

Fifty-nine (32%) of the 187 patients had evidence of brain injury. The distribution of specific injury types in the brain-injured group is shown in Table 4. The four patients with structural brain injury had abnormalities documented by CT scan or autopsy. Three of these four patients sustained a life-threatening injury. Four out of six cranial vault fractures and the single basilar skull fracture occurred in patients with severe or life-threatening injury. Three (5%) of 55 patients with a concussion had an associated skull fracture.

A CT scan was done on 10 (17%) of the brain-injured patients. The scan was normal in six patients, but two of these patients were classified as having severe brain injury based on hospitalization greater than 48

Table 1—Severity scale definitions

Minor:	All isolated soft tissue injuries and tooth fractures.
Moderate:	All concussions, skull fractures, and facial fractures with Glasgow coma scale greater than 12; no evidence of brain injury on CT scan (if done).
Severe:	Cerebral injury with hospitalization greater than 48 hours and one of the following: abnormal CT scan, Glasgow coma scale of 9-12 on admission, or brain surgery.
Life-threatening:	Cerebral injury with Glasgow coma scale of 8 or lower on admission.

Table 2—Age distribution of adult head injuries; 1981 to 1984 emergency department sample, Madison, Wisconsin

Age Group	Number	(%)
18-22	79	(42)
23-27	51	(27)
28-32	22	(12)
33-37	13	(7)
38-42	10	(5)
43+	12	(6)
TOTAL	187	(100)

Table 3—Distribution of the severity of adult bicycle-related head injuries (n = 187); 1981 to 1984 emergency department sample, Madison, Wisconsin

Severity Level	Number of Cases	(%)
Minor	119	(64)
Moderate	62	(33)
Severe	3	(2)
Life-threatening	3	(2)
TOTAL	187	(100)

Table 4—Brain-injured patients; distribution of injury types (n = 59); 1981 to 1984 emergency department sample, Madison, Wisconsin

Type of injury	Number*	(%)
Basilar skull fracture	2	(3)
Facial bone fracture	3	(5)
Structural brain injury	4	(7)
Cranial vault fracture	6	(10)
Concussion	55	(93)
TOTAL	70	—

*Patients may have more than one injury type.

hours and a Glasgow coma score of 9-12. Neither patient had a repeat CT scan and both were discharged from the hospital within one week of admission. All other cases with normal scans had a concussion and were classified in the moderate severity group. Abnormal scans included three cerebral contusions (one with mass effect) and one epidural hematoma. One patient had a compound skull fracture and intracerebral hemorrhage documented by autopsy. A facial bone fracture was present in three (5%) of 59 patients with brain injuries. All of these patients had an associated concussion and none had serious or life-threatening injuries.

Information from the followup questionnaire was collected from 104 (56%) of the 187 patients with head trauma. Among 59 patients with brain injury, thirty-two (54%) were followed up. The contacted and noncontacted groups were comparable in terms of age, gender, and proportion of severe or life-threatening injury. The lack of followup in 44% of the cases was mainly attributable to an inability to locate current addresses and phone numbers.

Overall, one of 104 patients with head trauma reported wearing a helmet at the time of injury. The one helmeted rider suffered a concussion. The mean frequency of bicycle use (days per month) was 21.9 (SD, 8.5) for the whole group and 22.6 (SD, 8.6) for the brain-injured patients. The mean distance for the trip in which the injury occurred was 10.5 miles (SD, 15.7) for the entire group and 16.7 miles (SD, 22.1) for the brain-injured patients. In the followup group, the injury was reported to occur during daylight hours under dry conditions by 79 of 100 (79%) respondents and 22 of the 30 (73%) patients with brain injury.

Table 5 shows the distribution of severity levels for each collision type. There was no significant difference in the proportion of minor versus more severe injuries for each collision type.

COMMENT. The results of this study show that transient loss of consciousness or amnesia occurs commonly among bicycle riders who require

emergency department treatment for head trauma. In this series over 35% of patients sustained head trauma sufficient to cause loss of consciousness without major disability. The proportion of patients with brain injury in this series is similar to what was found in a one-year survey of injured bicyclists at the University Hospital of Umea, Sweden.⁶ In their series of 447 injured bicycle riders, the head was the site most commonly injured and accounted for 34% of all injuries. Thirty percent (30%) of all patients with head trauma sustained a concussion or more severe brain injury. Other studies have demonstrated that head injury often occurs in association with bicycle falls or collisions, although functional disability was not assessed.^{3,7} Similar results have been obtained in studies of bicycle injuries in children.^{8,9}

Computerized tomographic (CT) studies were abnormal in four out of ten (40%) of those who were scanned, including one patient with a correctable neurosurgical lesion (epidural hematoma). Although this study was not designed to assess the indications for a CT scan, the high proportion of abnormal scans along with their overall infrequent use (17% of brain-injured patients) suggest that utilization was appropriate.

While the personal and societal consequences of severe brain injuries are obvious, there also is evidence to suggest that the large number of patients with concussions may have mild but persistent neurological deficits. One study of minor head injury, defined as a Glasgow coma score of 12-15 and less than 48 hours hospitalization, showed that 59% of the patients complained of memory deficits three months post-injury.¹⁰ Sustained attention deficits were also noted on neuropsychological testing.

The followup questionnaire in our study failed to reveal any significant association between collision type and severity. Impact force and the severity of the resulting injury are dependent upon a combination of many factors including road speed, angle of impact, vertical height, and physical characteristics of the impacted surface. These variables could

not be measured through our retrospective questionnaire. Findings from the followup questionnaire showed that most bicycle-related head injuries occur during daylight hours under dry conditions. This presumably is a reflection of greater bicycle use under favorable environmental conditions.

The followup indicated that bicycle-motor vehicle collisions were responsible for less than 20% of all brain injuries. While fatality studies have shown that bicycle and motor vehicle collisions are frequently associated with severe or fatal injuries¹¹, this study, based on emergency department records, points out that the majority of bicycle-related head trauma requiring hospital visits are associated with other types of collisions and falls. Further studies are needed to assess the incidence and severity of brain injury among both helmeted and unhelmeted bicycle riders and long-term cognitive impairment or neurological symptoms following mild to moderate closed head injury.

From the prevention perspective, a recently published epidemiological survey of helmet use and head injuries in a population of "cycling enthusiasts" reported a significant association between helmet use and reduced severity of head injury.¹² The authors further estimated "that the risk of death from head injury was considerably reduced for helmeted relative to unhelmeted bicyclists, depending upon helmet type."

Table 5—Collision type for minor versus moderate and life-threatening injuries; 1981 to 1984 emergency department sample, Madison, Wisconsin

Type of collision	Minor		Moderate and life-threatening		Total	
	#	(%)	#	(%)	#	(%)
Fall	19	(29)	12	(32)	31	(30)
Bike-motor vehicle	17	(26)	7	(19)	24	(24)
Bike-fixed object	11	(17)	9	(24)	20	(20)
Bike-bike	12	(18)	5	(14)	17	(17)
Bike-pedestrian	2	(3)	0	(0)	2	(2)
Did not remember	0	(0)	1	(3)	1	(1)
Other	4	(6)	3	(8)	7	(7)

Although other efficacy studies are rare or nonexistent,⁹ the wisdom of helmet use is also supported by a wealth of biomechanics research,^{13,14} and studies comparing the incidence and pattern of head injuries among helmeted moped, motorcycle, and competition bicyclists to unhelmeted bicycle riders.¹⁵⁻²⁰ In conclusion, properly designed and used bicycle helmets will reduce the risk of serious head injury among bicycle riders and should be recommended to and worn by all riders.

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