forms of treatment tried proved of value less than half the time.

Surgery is definitive, can be done under local anesthesia and carries no significant morbidity. As symptoms tend to recur with successive pregnancies, surgical decompression seems to offer considerable advantages over therapy with analgesics, sedatives and diuretics, which carries risks, and over splints, which are inconvenient, especially to the primigravida with early, severe, bilateral involvement.

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Head injuries in childhood: a 2-year survey

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A retrospective study was conducted of the 880 children with head injuries consecutively admitted to the Children's Hospital of Eastern Ontario in Ottawa from July 1976 to June 1978. It confirmed a boy:girl ratio of about 2:1, with a peak of 3.5:1 around 7 years of age. The largest number of head injuries was in children under 1 year of age. Injuries were most common in summer and spring, and most were caused by falls. The most common place for head injuries was in the home, but the single most common cause of injuries was bicycle accidents, which were responsible for 12% of all the head injuries. Skull fractures were found in 30% of all the patients. Of the 34 patients with severe head injuries 8 (24%) died, 9 (26%) had a moderate residual disability and 17 (50%) made a good recovery. There were no other deaths, so the mortality for the entire group of 880 patients was 0.9%.

On a mené une étude rétrospective portant sur 880 enfants souffrant de traumatisme crânien qui ont été admis consécutivement à l'hôpital pour enfants de l'est de l'Ontario, à Ottawa, de juillet 1976 à juin 1978. Cette étude a confirmé un rapport garçon:fille de 2:1, avec un maximum de 3.5:1 vers l'âge de 7 ans. Le plus grand nombre de traumatismes crâniens a été enregistré chez les enfants de moins d'un an. Les blessures étaient plus fréquentes en été et au printemps, et la plupart avaient été causées par des chutes. Les traumatismes crâniens survenaient le plus souvent à domicile, bien que la cause la plus fréquente de blessures fût l'accident de bicyclette, responsable de 12% des traumatismes crâniens. Des fractures du crâne ont été découvertes chez 30% des patients. Des 34 patients souffrant de traumatismes crâniens graves 8 (24%) sont décédés, 9 (26%) montraient une incapacité résiduelle modérée et 17 se sont bien remis. On n'a enregistré aucun autre décès, de sorte que le taux de mortalité pour l'ensemble des 880 patients fut de 0.9%.

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Accidents cause more than half of all childhood deaths. Head injury is the most common form of trauma for which children are admitted to hospitals. Here we analyse the causes and types of head injuries and their sequelae.

Method and patients

The Children's Hospital of Eastern Ontario in Ottawa serves a pediatric population of about 600 000 and has an average of 12 000 admissions a year, of which about 5000 are emergencies. We reviewed the records of 880 patients consecutively admitted to our hospital for the observation or treatment of head injuries, excluding injuries occurring during birth, between July 1976 and June 1978. These patients constituted 8.8% of the emergency admissions and 3.6% of the total admissions during the survey period.

The criteria for admission to hospital, only one of which had to be met, were: a history of a head injury, with amnesia or a loss of consciousness; any alteration of consciousness at the time of examination; a skull fracture, irrespective of how well the child appeared; and any doubt about the circumstances of the injury or difficulty in assessing the child's condition (e.g., because of drowsiness or vomiting).

Results

Almost one third (29%) of the head injuries were in children below the age of 3 years, and the largest number were in those under 1 year of age. Below the age of 4 years there was a slight preponderance of boys, but after that age boys predominated, with a peak ratio of 3.5:1 by the age of 7 years (Fig. 1). Of the 880 patients, 558 were boys and 322 were girls (ratio 7:4).

There were more head injuries in summer (283) and spring (237) than in fall (183) and winter (177) (Fig. 2). The times of arrival at the hospital clustered in the afternoon, with a peak between 6 and 9 pm (Fig. 3). Within 24 hours 38% of the children were discharged from hospital; 20% were observed in hospital for 48 hours, 31% stayed in hospital from 3 to 7 days, and 12% stayed in hospital for more than 1 week; of the last group 3% stayed in hospital longer than 1 month.

The children less than 3 years of age were more commonly injured indoors, while the older children were usually injured outdoors. Two thirds of the head injuries resulted from falls and one fifth from traffic accidents. The children were pedestrians in 73% of the traffic accidents, cyclists in 17% and passengers in 10%. Head injuries caused by blunt objects accounted for only 4% of the injuries. The blunt objects included hockey pucks, sticks, rocks, baseball bats and golf clubs; golf clubs produced depressed skull fractures in five out of six children. The remaining 9% of the head injuries were caused by other means, including tobogganing, collision at play, assault, diving and, in a few cases, child abuse.

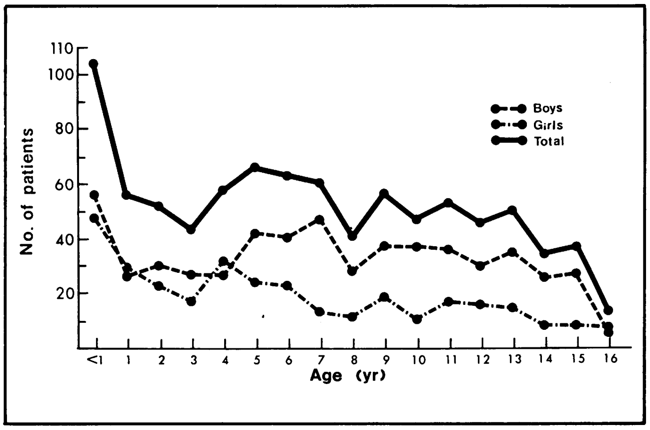

FIG. 1—Age and sex distribution of 880 children with head injuries seen at the Children's Hospital of Eastern Ontario, Ottawa over 2 years.

Of the 581 falls (Table I) those from bicycles and those during sports accounted for 19% and 11% respectively. While falls down stairs and from furniture together accounted for 28% of all the falls, those from heights, such as from windows, roofs, balconies and trees, accounted for only 9%. Of the 24 children who fell 2.5 m or more, 21 suffered concussions and 13 received skull fractures, 2 of which were depressed.

Vomiting and drowsiness were the most common symptoms, occurring in 46% and 33% of all the children respectively. Other symptoms and signs included headache (in 28%), loss of consciousness (in 27%) and amnesia (in 18%).

A history of early post-traumatic seizures was documented in 13 cases at the time of admission to hospital. There were five facial palsies and five palsies of the third cranial nerve; one palsy of each type was bilateral and related to a basal skull fracture. Three palsies of the sixth cranial nerve were documented. Decerebrate rigidity was noted in 14 patients and hemiparesis in 8 at the time of admission.

Of the 178 electroencephalograms obtained, 39% were abnormal. Echoencephalography was performed in only 60 cases (it is no longer used in patients with acute cerebral trauma); in 5 cases the results were abnormal, but in 4 of these they were false-positive. Of the 21 angiograms made, 12 were abnormal, demonstrating cerebral swelling in seven cases, epidural hematoma in

Table I—Nature of falls in 581 children

Nature of fall	No. (and %) of children
From a bicycle	109 (19)
From furniture	84 (14)
At play	83 (14)
Down stairs	80 (14)
During sports	65 (11)
From a height	54 (9)
On ice	18 (3)
From playground equipment	16 (3)
From a horse	14 (2)
Accidentally dropped	13 (2)
Other	45 (8)

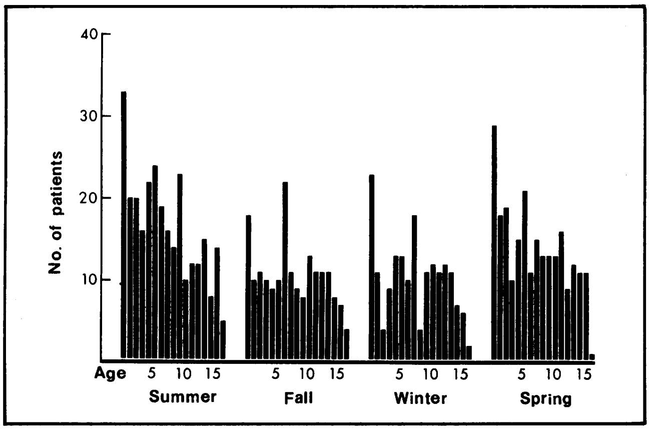

FIG. 2—Seasonal incidence of the injuries. Ages in years.

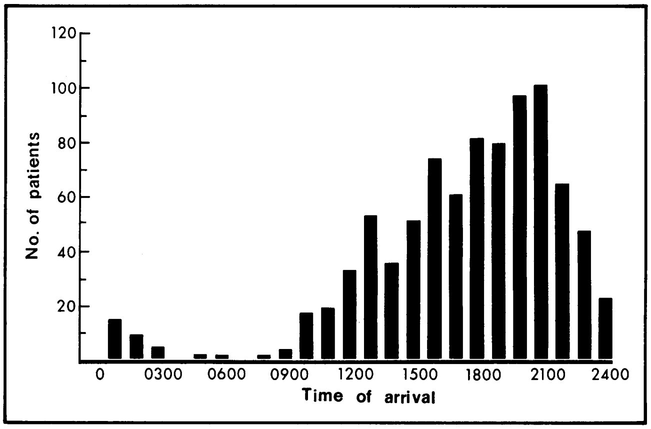

FIG. 3—Time of arrival at hospital of the 880 children.

two cases and acute subdural hematoma, slow circulation and the absence of intracranial circulation in one case each. Computer-assisted tomography (CT) was not available in our hospital during the period studied.

A total of 872 skull roentgenograms were taken (Table II). There were 208 simple linear fractures, 13 closed depressed skull fractures and 11 compound fractures, 8 of which were depressed. All the depressed fractures were operated on for elevation of the depressed fragment within 24 hours.

There were 92 children (10%) who had fractures in addition to head injuries, and 28 of them had fractures involving more than one bone. Only four fractures involved the cervical spine: two, a fatal fracture–dislocation of the atlas and a hangman's fracture, were caused by traffic accidents; an undisplaced fracture of the odontoid process was caused by a fall down stairs; and a compression fracture of the seventh cervical vertebra resulted from a diving accident.

We saw 34 children with severe head injuries in this series. Assessment of outcome (i.e., good recovery, moderate disability, severe disability, vegetative state or death) was based on the criteria defined by Jennett and Bond.[1] Eight (24%) of these children died; six of them had been in automobile accidents. Of the patients who survived, 9 had moderate disabilities and 17 made a good recovery.

Of the 34 children with severe head injuries 3 had post-traumatic seizures. Decerebrate posturing was noted in 14 patients; 4 made a good recovery, 5 had moderate residual disability and 5 died. Electroencephalograms were taken in 31 of the 34 children, and 27 (87%) were abnormal. Psychometric testing was done during the hospital stay and regularly after discharge in 16 patients. Between 6 and 24 months after the injury it yielded normal results in only six; it showed mild to moderate impairment in nine and scattered deficits in one.

Intracranial pressure was monitored with the Ladd fibreoptic epidural system (Ladd Research Industries, Burlington, Vermont) in 11 of the children with severe head injuries.[2,3] Six patients (54%) had increased intracranial pressure. One patient, who later died, had a pressure that was persistently over 50 mm Hg and reached a peak of 100 mm Hg. Of the five patients who had an intracranial pressure of between 20 and 50 mm Hg three made a good recovery and two had moderate disability. The five patients whose intracranial pressure was normal made a good recovery.

Table II—Results of skull roentgenography in 880 children

Finding	No. (and %) of children
No fracture seen	616 (70)
Linear fracture	208 (24)
Basal skull fracture	19 (2)
Depressed fracture	13 (1)
Compound fracture	11 (1)
No roentgenogram	8 (1)
Other*	5 (1)

*Including comminuted fractures (2), stellate fracture (1), suture diastasis (1) and penetrating injury (1).

Discussion

This review covers the last 2 years before the institution of CT scanning at our hospital and before the use of barbiturates for the treatment of comatose patients. The data therefore represent a standard against which the benefits of newer techniques can be measured. Such a study, funded by the Department of National Health and Welfare until 1985, is currently in progress. Here we also present findings that will be useful in accident prevention.

That the home is a dangerous environment for toddlers is shown by the 80 falls down stairs and the 84 falls from furniture in our series. Nearly one third of all the head injuries occurred in children below 3 years of age, and most of these were caused by falls at home. The group with the largest number of head injuries was under 1 year of age, much younger than the largest group in Burkinshaw's series of 238 children[4] and that in Jamison and Kaye's series of 857 children[5] but similar in age to the largest group in Hendrick and associates' series from the Hospital for Sick Children in Toronto.[6] Obviously there are too many unprotected stairs and dangerous walkers and furniture that invite head injuries.

Older children are more liable to be injured outdoors, and here again most head injuries are caused by falls. The single greatest cause of falls outdoors in our series was bicycling. Road accidents caused 20% of all the injuries in our series, a relatively small proportion, but 73% of the children so injured were pedestrians hit by a car. This formidable proportion, also encountered in other large series,[7,8] should be emphasized to motorists and parents.

Of the 54 head injuries in our series resulting from a fall from a height, none of which were fatal, almost half were in children who fell from a height of 2.5 m or more. One child fell from a fourth-storey window and survived, although with hemiparesis. Apart from this case there was no severe brain damage from this type of injury. The relatively favourable outcome of these falls was probably due to the lesser momentum of the children's bodies and the relatively greater flexibility of their skulls.[9]

In our hospital skull roentgenography is routinely performed on a patient with a history or clinical evidence of head injury. Such a policy has been controversial.[4,10,11] The argument is that too many skull roentgenograms that prove to be normal are obtained for legal reasons, and that routine skull roentgenography is therefore wasteful and expensive. We feel, however, that the costs of one missed fracture with serious consequences can wipe out the savings of several years obtained by not doing skull roentgenograms. Moreover, knowing that a skull fracture is present or absent is an important guide to management. For example, a hairline fracture in the parietal area and a linear fracture of the posterior fossa reaching the foramen magnum generate totally different types of concern even though the patients may both have suffered a minor head injury without loss of consciousness and without neurologic signs. The roentgenogram may, of course, reveal other information that may be relevant.

For these reasons we feel strongly that skull roentgenograms are necessary and useful in the management of head injuries.

We started to use intracranial pressure monitoring routinely for severe head injuries only towards the end of the study period. This is why monitoring was done in only 11 of the 34 cases of severe head injury in this series. Now, using the Ladd fibreoptic system we monitor all patients with severe head injuries who have a score of 8 or less on the Glasgow Coma Scale.[12] Even from the small amount of data obtained from our earlier study[2] it was obvious that patients with an intracranial pressure above 50 mm Hg who failed to respond to therapy had a grave prognosis, whereas patients with a pressure of less than 20 mm Hg had a good chance of recovery.

It has been known for decades that head injuries of children have a more favourable outcome than those of adults.[13] The mortality of severe head injuries in our series was 24%, which compares favourably with the data in some[1,5,14-16] but not all other reports.[17] Our rate was closest to the 22% rate for patients up to 20 years of age cited by Becker and colleagues.[16] It is important to recognize that in children decerebrate posturing does not always indicate a poor prognosis. For example, of our 14 patients with decerebrate posturing at the time of admission, 4 made good recovery and 5 had moderate residual disability.

The use of electroencephalography in our hospital was limited to patients in whom early seizures had occurred or in whom brain death had to be confirmed or ruled out. It was also used as a method of monitoring recovery from coma. Because of these considerations, electroencephalography was performed on only 31 patients in our series between 1 and 7 days after the injury. All 31 patients had severe head injuries, and for 27 (87%), including those who had electrocerebral silence and died, the tracings were abnormal. For the remaining 151 patients in whom electroencephalography was performed, some of whom had presented with early seizures, serial tracings showed disappearance of the abnormalities in 80% of cases. Even in some patients with significant neuropsychologic deficit the electroencephalogram returned to normal.

Only 16 patients, all with severe head injuries, underwent psychometric testing during the hospital stay and regularly after discharge. More than half retained some abnormality after 2 years of follow-up. Recent experience, including our own, indicates that neuropsychologic changes may follow relatively minor head injuries.[18,19] Klonoff and collaborators[18] studied the neurologic, electroencephalographic and neuropsychologic status and the intelligence quotient (IQ) of 117 children for 5 years following injury. Levin and Eisenberg[19] assessed IQ, memory, language, somatosensory perception and motor speed in 64 children with injuries. The findings of those two groups and ours point to the need for more accurate and extensive assessment of children following all head injuries. Subtle changes that may be noticed by parents or teachers following head injury may not be detected with any other techniques, including neurologic examination, CT scanning and electroencephalography. For this reason we have started a new assessment protocol with a battery of neuropsychologic tests that allow us to monitor the progress of every child who spends more than 48 hours in the hospital following a head injury.

Head injury in childhood is not only the leading cause of death within the broad category of trauma[8] but may also be the cause of many subtle changes in the individual. The magnitude of this latter problem will be known only by pooling data from many centres. We believe that many head injuries can be prevented by better design of houses and better education of parents, teachers and manufacturers of walkers, toys and sports equipment. That the single commonest cause of head injury among children was bicycle accidents supports the wearing of helmets, as was pointed out in a *CMAJ* editorial.[20]

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