Severe head injury in children — a preventable but forgotten epidemic

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Objective. To determine the outcome of seriously head-injured children and to analyse the factors that affect their prognosis.

Design. A retrospective analysis of all severely head-injured children treated between 1990 and 1993.

Setting. Red Cross War Memorial Children's Hospital's trauma unit and neurosurgery service.

Patients. One hundred and two children under the age of 14 years with admission Glasgow Coma Scores (GCSs) of below 8.

Results. There were 57 boys and 45 girls. The average time of assessment after injury was 2.8 hours. Eighty-three injuries were caused by pedestrian motor vehicle accidents. Thirty-seven were associated with other serious organ system injuries. Fifty-eight children died and only 36 made a good recovery. All children with a GCS of 3 - 4 died. Factors that were particularly associated with a poor prognosis were: (*i*) age less than 3 years; (*ii*) associated extracranial injury; (*iii*) GCS 3 - 4 following resuscitation; and (*iv*) diffuse cerebral swelling on computed tomography.

Conclusion. Pedestrian motor vehicle accidents are the most common cause of serious paediatric head injury in the Cape Town area. Children with a presenting coma score of less than 8 have an extremely high mortality and morbidity rate, despite modern intensive care. Preventive strategies are essential.

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Childhood head injury in South Africa could well be described as a silent or forgotten epidemic. International studies have shown that trauma is the leading cause of death in children between the ages of 5 and 15 years in industrialised and some developing countries.[1,2] In South Africa injury kills more children over 4 years of age than all other diseases combined.[3] Head injuries account for 25 - 80% of these childhood trauma-related deaths.[4] The public appears to be unaware or disinterested in this carnage, and the importance of trauma as a major child health problem continues to go unrecognised or ignored by the health authorities. An accident continues to be thought of as a consequence of uncontrollable acts of God about which we are powerless. However, childhood accidents cannot be dismissed as random, unpredictable events; they occur when a vulnerable child meets an injurious agent in a hazardous or compromised environment.[3] As such, injury must be regarded as a disease, with identifiable causative factors.

Severe head injury in a child is a sociological disaster that crosses all sociological boundaries, not only for the disability it causes the child, but also because of the load it places on the family, the medical profession and the State. It encompasses all aspects of child health care and takes an enormous toll on society as a whole.[3]

It is often assumed that children fare better than adults who sustain severe head injury. Statistically, it is correct to believe that a 10-year-old child will cope better after a head injury than a patient over 60 years.[5] It is fallacious, however, to extrapolate this to children of all ages with differing severities of head injury. Children are not a homogeneous population. There is a vast difference between a 9-month-old baby and a teenager in their response to trauma. Here in South Africa 3 000 children under 15 years of age are permanently disabled each year as a result of accidental injury.[6] Over a 5-year period 57 468 patients were seen at Red Cross War Memorial Children's Hospital's trauma unit and in 17.1% of these cases head injury was the principal indication for admission. Despite the fact that most of these injuries were minor, hospital mortality has been shown to be directly related to the presence and severity of head injury alone.[7]

We performed a retrograde analysis of all children admitted with severe head injuries to the trauma unit of Red Cross War Memorial Hospital during the last 4 years. Our goal was to determine the nature and severity of this problem in our environment as well as to assess the outcome.

Patients and methods

During the period 1 January 1990 - 31 December 1993, all head-injured children (< 14 years) with a Glasgow Coma Score (GCS) of 8 or less who were admitted to Red Cross War Memorial Children's Hospital's trauma unit and the Department of Neurosurgery of the University of Cape Town were entered into this study. A total of 102 severely head-injured children were analysed. For children less than 3 years of age the initial assessment made was with the Children's Coma Scale and a severe head injury was defined as a score less than 6/11. Once the child had been intubated with an endotracheal tube, the GCS was applied to all children, as verbal responses were no longer applicable. The GCS was indicated by the number followed by a 'T'.

After resuscitation, emergency CT was performed. Patients with operative lesions underwent immediate surgery and were then transferred to the ICU if ventilation was required. Children who did not have surgically amenable lesions were transferred directly to the ICU. Routine management consisted of ventilation, clinical and biochemical monitoring, measurement of arterial oxygen and carbon dioxide, fluid restriction and anticonvulsant therapy.

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Repeat CT was undertaken on all patients who did not show a significant improvement within 24 hours.

Outcome was measured using the Glasgow Outcome Scale (GOS),[8] but in this study a good outcome was defined as a normal neurological state or a disability, whether the child was independent or not. A poor outcome was defined as death or a persistent vegetative state. In adult studies, a good outcome is usually defined as a normal neurological state or a situation in which the patient is independent, despite any degree of neurological deficit.[8]

In this series we decided to include in the 'good result' category those patients with persistent neurological deficits and who were not independent, for the following reasons.

1. Young children are not usually independent of parental care and it therefore becomes more difficult to assess whether they will be independent when they mature.

2. Children are neurologically immature and there is therefore considerable potential for development, even after severe head injury. It is also difficult to predict the exact degree of recovery that may occur in the months immediately following injury.

3. The potential for children to recover after a severe head injury may be greater than that of adults.[9]

4. The recovery process may extend over an indefinite period of time.[10]

5. With this approach it is accepted that there will be a number of patients who do not make a good recovery as defined by the GOS in the long term, but the children who have the potential to improve to an adequate level of function by the time they reach adulthood are not treated as patients doomed to a poor quality of life.

The results of this study were then analysed retrospectively by examination of the patient records, investigations and their follow-up in the outpatients' department.

Results

There were 102 patients who satisfied the criteria for severe head injuries. These included all patients who arrived at Red Cross War Memorial Children's Hospital with a severe head injury, even those who did not survive the resuscitation. The initial assessment by the neurosurgical staff was done, on average, 2.8 hours post-injury. The average length of outpatient follow-up was 7.5 months, but if fatalities were excluded then the average length of follow-up was 17 months.

Age and sex

Fifty-seven boys and 45 girls had sustained severe head injury, and were divided into groups according to their ages: 0 - 1 year; > 1 - 3 years; > 3 - 7 years; > 7 - 13 years. Older children of school-going age made up the majority of patients (Fig. 1).

Aetiology

The majority (83%) of children with severe head injuries were victims of pedestrian motor vehicle accidents. Falls accounted for 11% and the remaining 6% were victims of passenger motor vehicle accidents, bicycle accidents or assaults (Fig. 2).

Associated injuries

There were 37 patients who had sustained an injury to at least one other organ system in addition to the head injury. Seventeen of these patients had multiple injuries involving three or more organ systems, musculoskeletal injuries occurred in 12 children and abdominal and chest injuries were found in 4. The outcome of 26 patients (70%) with associated injuries was poor. The Paediatric Trauma Score (PTS)[11] was also applied to all patients and the outcome compared with the admission GCS (Fig. 3).

Operative procedures

Nine children underwent neurosurgical operations, 6 of these for intracranial haematomas (Fig. 4). The 4 children who survived following surgery had extradural haematomas. Of the children who died, 1 had a subdural haematoma, 1 an extradural haematoma, 1 a depressed skull fracture in association with severe head injury and 2 missile injuries (Fig. 5).

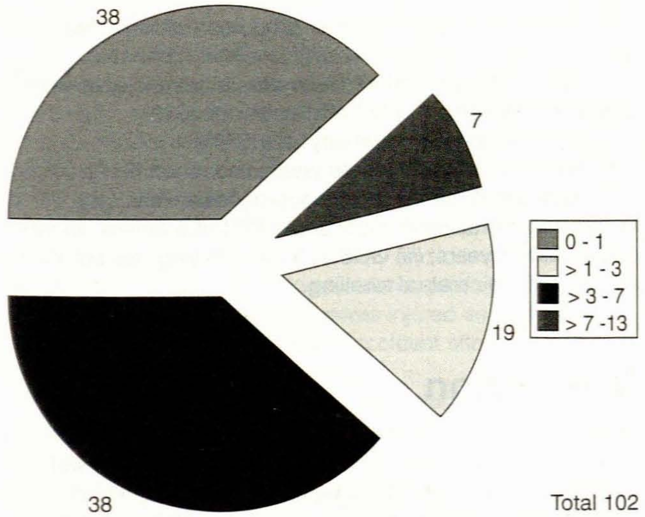

Fig. 1. Age distribution.

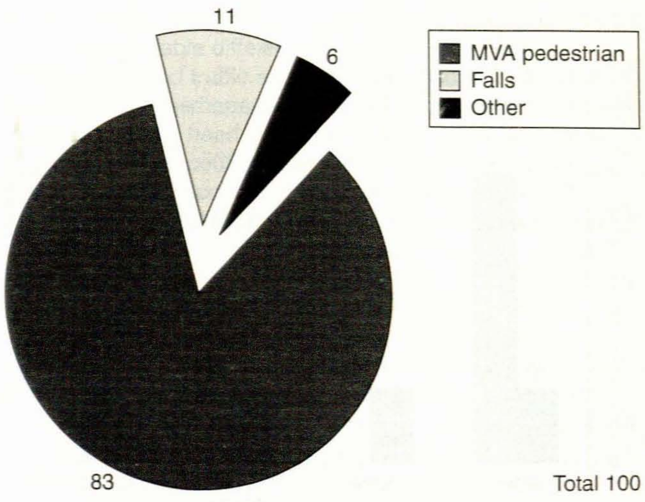

Fig. 2. Mechanism of injury.

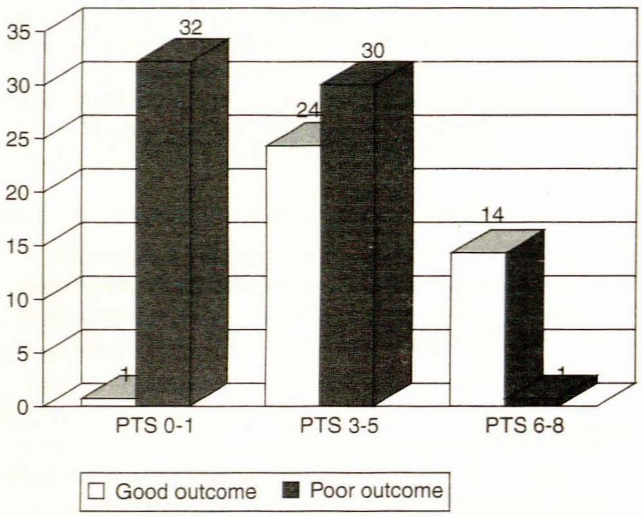

Fig. 3. Paediatric Trauma Score (PTS) compared with neurological outcome as defined by the Glasgow Outcome Score.

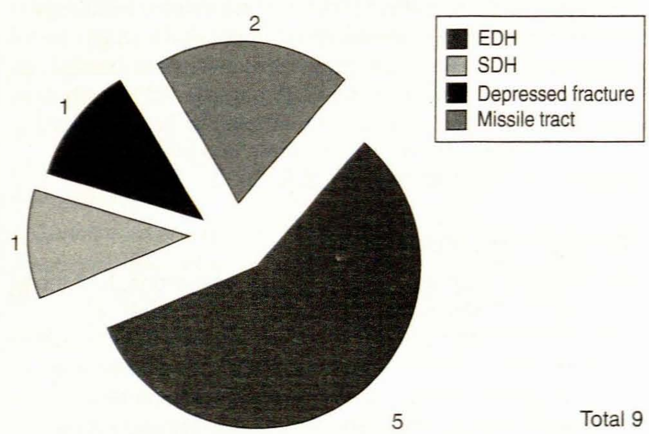

Fig. 4. Operative procedures.

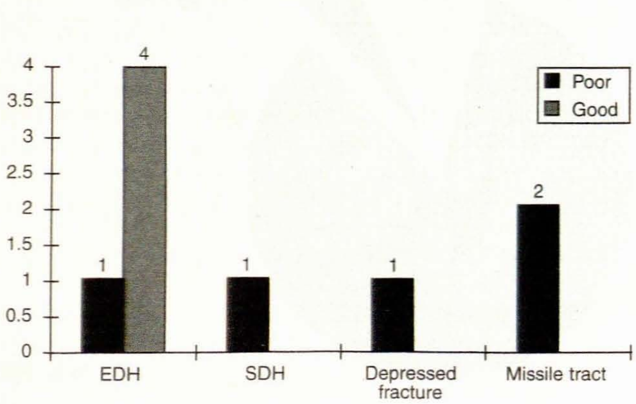

Fig. 5. Outcome of operative procedures.

Outcome

Of the 102 patients who reached hospital, 58 died. On the basis of the GOS, 66 patients had a poor outcome and 36 a good outcome. However, in children under 3 years of age, there was a higher proportion with a poor outcome (18/24, 75%).

Outcome v. Glasgow Coma Scale

The outcome, based on GCS following resuscitation, was analysed and patients were divided into two groups; those with a GCS of 5 - 8 and those with a GCS of 3 - 4.

There were 40 children with a GCS of 3 - 4 following resuscitation. Twenty died prior to CT. Twelve had isolated head injuries and 8 had sustained polytrauma. Of the 20 patients who underwent CT, 17 were shown to have diffuse cerebral swelling and 3 had features of diffuse axonal injury. All the children who had a GCS of 3 - 4 following resuscitation died. The single patient from this group with a good outcome had two seizures immediately prior to examination and was thus effectively excluded as the GCS rapidly improved postictally. Sixty-two children had a GCS of 5 - 7 following resuscitation and 60 underwent CT. Twenty-nine of these patients had diffuse swelling on CT and all 9 intracranial haematomas in this series occurred in this group. A good outcome was obtained in 38/62 (59%) of these patients.

Radiology

The pathological findings, as seen on CT, were compared between the group of patients who had a good outcome and those who had a poor outcome. Of the 38 patients who had a good outcome, 12 had diffuse swelling on CT. However, in the 44 patients who had a poor outcome but survived to undergo CT, 34 had diffuse cerebral swelling. Therefore diffuse cerebral swelling was found in both the poor and good outcome group but it was twice as common in the patients who had a poor outcome.

Summary of the results

1. Severe head injuries occurred more commonly in older children.
2. There was a slightly higher proportion of boys than girls.
3. The majority of children with severe head injuries were victims of pedestrian road traffic collisions (83%).
4. There was a high mortality rate (57%).
5. Intracranial haematomas were uncommon (9%).

Factors associated with a poor prognosis were: (*i*) associated extracranial injury and a PTS of 5 or less; (*ii*) age of less than 3 years; (*iii*) GCS of 3 - 4 following resuscitation; and (*iv*) diffuse cerebral swelling.

Discussion

There was a small predominance of boys over girls with severe head injuries in our study, which is in keeping with most studies throughout the world. That the majority of severely head-injured children were in the older group is not surprising. The older child is more independent and is beginning to explore the world without the constant supervision of adults, resulting in increased time spent away from the protective custody of parents in a hostile environment that he or she has not yet fully learnt to assess.

In the majority of developed countries, falls are the most common cause of head injury,[12-14] although in poor socio-economic areas pedestrian motor vehicle injuries predominate.[14] In Cape Town 83% of our severe head injuries were caused by pedestrian motor vehicle accidents and this was thought to be due largely to socio-economic factors, with the majority of patients coming from the poorer areas.[15] The most common problems identified were: (*i*) poor parental supervision due to both parents working and care being delegated to an older child; (*ii*) lack of play areas such as parks and public open spaces; (*iii*) fewer traffic and pedestrian control devices; (*iv*) higher traffic volumes and density; (*v*) lack of pavements and street lighting; and (*vi*) lack of education in road safety. In Cape Town there is a disproportionate prevalence of head injuries sustained in coloured and black children and this relates to the poorer socio-economic circumstances of these two groups.[4,16]

There is no consensus in the literature on the expected mortality associated with severely head-injured children, with reported rates ranging from 6% to 60% (although the most frequently reported mortality statistics occur within the range of 25 - 30%). There are many reasons for this vast disparity in mortality statistics. Luerssen and Klauber have reviewed these reasons,[5] drawing attention to the fact that the majority of studies do not differentiate between mild and severe injuries; this biases mortality statistics towards the patients with a better outcome. In addition, there is often a variation in the definition of what constitutes a severe head injury, with some authors defining a GCS of 3 - 7 and others a score of 3 - 8 as indicative of severe head injuries. Another factor is the 6-hour rule of assessment whereby the patient's GCS is assessed 6 hours after resuscitation. This excludes many of the early deaths. In our study we reported all patients who were admitted and treated in our trauma unit.

Another important variable is the disparity in the age groups reported. It is clear from this study that the children in the younger group, particularly under the age of 3 years, have a worse outcome, so if there are more children in this group, the statistics will be skewed toward the group with the less favourable outcome.

Unquestionably, however, the most important factor determining outcome is the mechanism or aetiology of the head injury. If the patients suffer a severe acceleration injury, such as occurs with a pedestrian motor vehicle accident, the brain is globally damaged and the pathology is often one of diffuse axonal injury. These children have a far worse outcome than those in whom other mechanisms, such as falls, produce impacts of low velocity and cause localised rather than diffuse injury. In pedestrian motor vehicle injuries the child may have multiple systems injured as well as secondary injuries inflicted at the accident site or during transportation to hospital.

These factors are all pertinent to our study and undoubtedly account for our high mortality rate. In Cape Town the vast majority of severe paediatric head injury patients are taken directly to our trauma unit and there is therefore no triage of patients towards other hospitals. All patients who arrived at our hospital with a severe head injury were included in this study, no matter what the length of their survival after attempted resuscitation. Consequently, a large number of patients included had a head injury so severe that survival was impossible. Another local factor thought to be important is that head injuries tend to occur in the daylight when transportation of the patient is more rapid; this results in some children's reaching the hospital despite having fatal and unsalvageable head injuries; they would otherwise have been declared dead at the site of the accident. The fact that pedestrian motor vehicle accidents account for the majority (83%) of our severe head injuries is nevertheless the most pertinent reason for our high mortality rate.

Most children with extradural haematomas did well in this series, but unfortunately their occurrence is very low (5%).

There were 24 children under the age of 3 years and all those whose GCS was 3 - 4 died. Many authors have commented on the vulnerability of the infant's brain to severe head injury. Humphreys *et al.* report that children under the age of 5 accounted for two-thirds of the deaths from severe head injury in a series from the Hospital for Sick Children in Toronto.[17] Raimondi and Hirschauer also noted the poor outcome of infants with open fontanelles who sustained serious head injuries in Chicago.[18]

The level of consciousness, as determined by the GCS, has always been regarded as a good indicator of prognosis and in our study, children with a GCS of 3 - 4 did much worse than those with a GCS between 5 and 7. CT of the brain, if used in combination with the clinical state, can help the clinician to prognosticate. Diffuse swelling has been identified as more common in children who did badly in this series, but it must be noted that it was also encountered in some children who did well.

Conclusion

In reviewing our own study and the literature, it is clear that severe head injury in the child is a situation best avoided. The primary injury sustained at the time of impact is irreversible and management is aimed at preventing secondary injury.

The findings of the Red Cross War Memorial Children's Hospital study are similar to those of many other published series. One notable difference, however, is the high incidence of road traffic accidents in the Cape Town area. Not only is this perhaps the most significant determinant of the outcome of a head injury, but it is also the one area in which prevention could eradicate this epidemic from our midst. The Child Accident Prevention Foundation of Southern Africa, established with the objectives of research, education and soliciting legislated measures, provides us with the opportunity to prevent childhood injury instead of picking up the pieces afterwards. The valuable work of Cumpsty[19] and De Villiers *et al.*[16] in obtaining original research data on the epidemiology of paediatric head injury in the Cape has identified areas in which these preventive measures are most needed. Educational strategies have been instigated with the assistance of the Traffic Department, but this is only a small beginning if this unnecessary epidemic and the devastation it inflicts on our children, families and society are to be curtailed.

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Gunshot injuries in infants and children in KwaZulu-Natal — an emerging epidemic?

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Objectives. To determine the pattern of firearm injuries in children under the age of 13 years admitted to a paediatric surgical unit in KwaZulu-Natal and to assess the impact of such injuries on hospital resources.

Design. Retrospective review of the Department of Paediatric Surgery and hospital databases for all gunshot admissions, 1983 - 1995 inclusive.

Setting. King Edward VIII Hospital, Durban.

Subjects. Children aged 12 years and under admitted to the care of the Department of Paediatric Surgery for management of gunshot injuries.

Methods. Data retrieved included demographic details, circumstances of injury, duration of hospital stay, management and outcome in terms of mortality and long-term morbidity.

Results. One hundred and six patients were identified, of whom 96 were available for review. There has been a rapid escalation of numbers presenting. During 1994 - 1995, an additional 38 children with gunshot injuries were admitted to other units within Durban academic hospitals. The mean age of injury in patients admitted to the Department of Paediatric Surgery was 6.4 years and the abdomen was the most frequently injured area. Multiple injuries were common. The in-hospital mortality rate was 10.4%. Major morbidity, including paraplegia, hemiplegia, amputation and major peripheral nerve deficit, was seen in 11.4%. Duration of bed occupancy in the general surgical ward reached 247 days in 1995.

Conclusion. There is an increasing incidence of gunshot injuries in this region. Of children surviving to reach hospital, 10% die and 11% are left with lifelong major morbidity. Most victims are innocent bystanders and too young to be considered active participants. Prevention will require sociopolitical stability and the disarming of the community.

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