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Fracture patterns in non-accidentally injured children at Red Cross Children's Hospital

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Unexplained fractures in infants and children often suggest abuse. Head injury with concomitant skull fracture is the leading cause of death in cases of child abuse. Fractures associated with child abuse vary from 11% to 55% in non-accidental injury (NAI) presentations.[1] Distinguishing accidental from abusive fractures is vital; failure to recognise and prevent further abuse may result in unnecessary psychological trauma, injury or death of the child.[1,2] The fracture patterns with high specificity for abuse are well documented;[1] however, in practice, these patterns occur infrequently, and abused children may present with a wide spectrum of bony injuries.[3] The majority of reports suggest that fractures of long bones are those most frequently seen in cases of abuse,[4-7] although some studies have reported higher numbers of skull[8] and rib fractures.[9] Furthermore, socio-economic factors have been reported to influence the incidence and pattern of injuries in child abuse.[10] The present study was a retrospective review of the Child Accident Prevention Foundation of South Africa (CAPFSA) database of children seen over a 14-year period at Red Cross War Memorial Children's Hospital (RXH), Cape Town, to identify those who had sustained fractures as a result of child abuse.

Methods

Patients were identified from the CAPFSA database of children treated at RXH. The medical records of all children admitted between January 1991 and October 2005 were reviewed, and children with fractures resulting from NAI were included in the study. The diagnosis of NAI was made by the attending clinician and confirmed by an approved social worker. Data were collected for demographic details, mechanism of injury and fracture site(s). Injuries were grouped anatomically into 'head and neck', 'upper limb' (including shoulder girdle), 'lower limb' and 'trunk' (thorax, abdomen and pelvis). Data are presented as mean, median, standard deviation or percentage, as indicated. Differences in the demographic distribution or mechanism of injury across different fracture sites were analysed by chi-square test or *t*-test as appropriate, and significance was set at $p<0.05$.

Of the 149 fractures, 57 were of the skull (the most common fracture site).

Results

During the 14-year study period, 99 586 trauma patients were treated at RXH, of whom 1 037 (1.04%) were confirmed as victims of NAI. More than two-thirds were male (64%). The median age of the study group was 16.5 months; the average age was 44.8 months with a standard deviation of 49.2 months and a range of 1 to 158 months. A quarter of the children were younger than 6 months; 38.2% were older than 3 years (Fig. 1).

Of the 1 037 patients diagnosed with NAI, 121 (11.7%) sustained a total of 149 fractures; of the latter, 21 (17.3%) had multiple fractures (16 with 2 fractures, 3 with 3 fractures, and 2 with 4 fractures). The mechanisms of injury are shown in Table I. Fractures were most commonly caused by blunt objects (51%) or the child having fallen or been thrown (18%). The head and neck was the most frequently fractured anatomical area (53%), followed by the upper limbs (24%) and lower limbs (18%). Only 7 fractures in the trunk area were seen. The gender distribution did not vary across the anatomical regions. However, children sustaining fractures of the head and neck were significantly younger than those sustaining fractures to other areas (29 months and 62 months respectively; $p=0.00031$, one-tailed *t*-test).

Of the 149 fractures, 57 were of the skull (the most common fracture site), 15 of the radius/ulna, 15 of the femur, 14 of the humerus, and 11 of the tibia/fibula. These are represented in Fig. 2.

The mechanism of injury of skull fractures was predominantly blunt trauma (61.4%) but there was no significant difference in the mechanism between fractures of the skull and other fractures ($p=0.17$). However, skull fractures were more likely to involve the use of an implement (28%) than other fractures (4%). This difference was significant ($p=0.00012$). Additionally, skull fractures were the fracture most commonly involved in multiple fractures – nearly two-thirds of the multiple fractures involved skull fractures.

TABLE I. MODE OF ASSAULT AND ANATOMICAL DISTRIBUTION OF FRACTURES

	Blunt object	Sharp object	Sexual assault	Gunshot	Thrown/fall	PVA/MVA	Other	Unknown	Total (%)
Head and neck	44	5	3	1	9	1	10	6	79 (53)
Trunk	4	0	1	0	1	1	0	0	7 (5)
Upper limb	18	1	3	0	9	0	4	1	36 (24)
Lower limb	10	1	0	1	8	1	4	2	27 (18)
Total	76	7	7	2	27	3	18	9	149

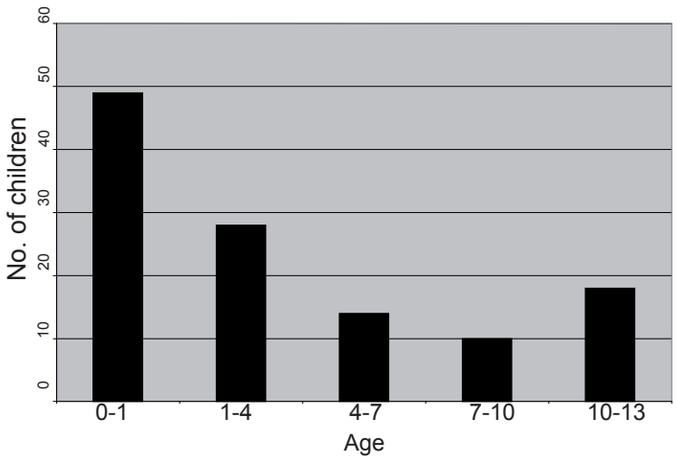

Fig. 1. Age distribution of study group.

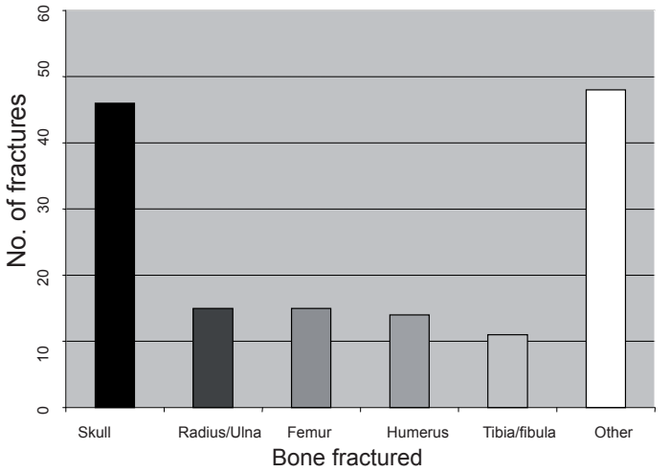

Fig. 2. Anatomical sites of fractures.

Discussion

The present study reviewed a large population of paediatric trauma cases over a 14-year period. The rate of confirmed NAI at the RXH Trauma Unit was approximately 1 per 100 attendances, which is similar to studies among Western populations.[11] The incidence of fractures in abused children was 11.7%, in line with the reported literature.[1] However, the rate of multiple fractures was lower than some studies,[3] but as only acute injuries were included in the present study, this may explain the difference.

The composition of our study group by gender varied little from the composition of the database. The age distribution of our study population conformed closely to the classic age distribution reported in physical abuse, whereby a third of patients are younger than 6 months, a third are younger than 3 years, and a third are older than 3 years (p=0.13).[12] The average age of the abused children in our study group was approximately 4 years – lower than the reported average age of physically abused children, which is 7 years.[12] However, in common with several reports,[1-3,8] we found that fractures were more common sequelae of NAI in younger patients. The group of children who had suffered skull fractures was significantly younger than children who had sustained other fractures, with an average age of 29 months. This association was also reported by King *et al*.[3] There was no difference in the fracture pattern across gender and ethnic groups.

The established consensus on fracture patterns in NAI is that long-bone fractures are the most frequently experienced in clinical practice. The principal finding of our study was that skull fractures were considerably more common; nearly 40% of all fractures were skull fractures. Skull fractures were associated with violent injury; approximately one-third were reported to have been inflicted with an implement/weapon, and one-quarter of these children had multiple fractures at the time of presentation. It has previously been reported that the majority of abused children with head injury admitted to RXH have suffered direct blows rather than shaken-impact injury,[13] the classic mechanism of head injury in abused children. These contradictory findings of the present study in relation to established norms, underline the importance of local studies, as sociocultural issues underpin many of the aetiological factors related to disease burden in general, and to child abuse in particular.[10]

The aetiology, characteristics and presentation of child abuse are the product of a complex interaction of social, cultural and interpersonal factors. Patients with skull fractures resulting from NAI are more likely to attend hospitals due to the relatively serious nature of the injury. The problems associated with making a diagnosis of NAI with uncomplicated, single, long-bone fractures are well documented,[3,4] so the number of these fractures linked to abuse may be artificially low. Lachman investigated the prevalence of reported child abuse in Cape Town and reported that the incidence of physical child abuse was lower than anticipated. He suggested that this might be a product of under-recognition of child abuse in the context of a high burden of violence-related trauma in this community.[14]

A significant aetiological factor in the higher rate of skull fractures could be the high levels of violence in South Africa, including violence towards children. The incidence of violence is among the highest in the world. Between April 2004 and March 2005, nearly 90 000 children in South Africa were the victims of murder, attempted murder, and physical or sexual assault.[15] Comparing rates of child mortality due to violence around the world, Matzopoulos found that the mortality rate in Cape Town in 2003 was 50/100 000 due to violence, compared with the global rate of 32/100 000,[16] with another paper reporting the US rate as 2.1/100 000 for the same age group.[17] In the present study, skull fractures were associated with multiple fractures, blunt trauma and assault with an implement – typically household objects such as broomsticks, bottles and bricks. This implies that a culture of violent behaviour extends to violence towards children (a relationship

demonstrated by Fieggen *et al.*),[13] and skull fractures may thus occur more frequently in instances of child abuse.

The high incidence of skull fractures in abused children in our study population is of considerable clinical significance. Recognising non-accidental head injury is essential for all health care workers caring for children. Head injuries are the most common cause of death in child abuse[18] and are associated with severe long-term morbidity and disability.[19-21] The outcomes of physical abuse in the population of children served by RXH, and similar communities, may be significantly worse than that of abused children in other settings. A missed opportunity of making a diagnosis of child abuse is more likely to result in a serious subsequent presentation. We would advocate that, in this kind of setting, clinicians should be particularly alert and ready to instigate more rigorous investigation where NAI is suspected. All children with suspected NAI should have a skeletal survey, as suggested by James *et al.*,[22] in accordance with the British Society of Paediatric Radiology Guidelines. Those with head injury should also have fundoscopy performed by a trained neuro-opthalmologist, since retinal haemorrhages may sometimes be subtle in cases of child abuse.[23] It has been recommended that all children suspected of NAI in whom a skull fracture is found should undergo computed tomography (CT) even if they have no neurological signs.[21] In simple accidental skull fractures, it is rare to find intracranial injury, therefore its presence supports a diagnosis of abuse.[24]

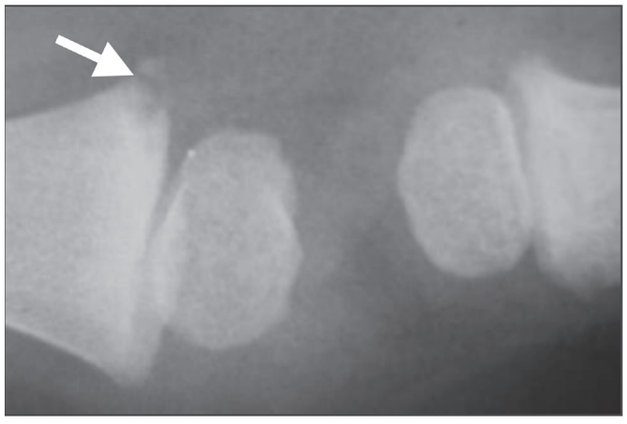

Fig. 3. Metaphyseal corner fracture – a typical fracture in child abuse. The corner of the metaphysis is avulsed as a result of pulling on the distal part of the limb.

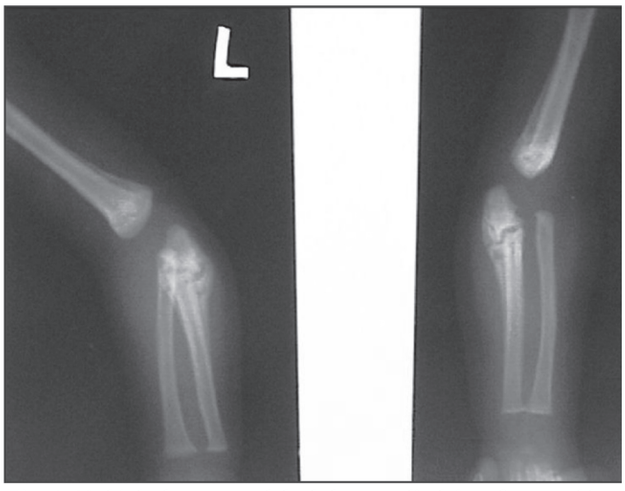

Fig. 4. Multiple fractures of the left upper limb in a 2-year-old child. Note the periosteal reaction of both humerus and ulna, and the recent fracture of the proximal ulna.

In this retrospective study, we did not have any information on the types of fracture sustained. According to King, the most common fracture in child abuse is a single, transverse diaphyseal fracture, typically involving the middle or distal third of the bone.[25] Although, classically, metaphyseal corner fractures (Fig. 3), posterior rib fractures and fractures of the scapula, sternum and spinous processes, as well as depressed skull fractures, are typical fractures of child abuse, these are in fact all relatively rare. The far more commonly encountered fractures in child abuse are the 'ordinary' fractures such as long-bone fractures, linear skull fractures and clavicular fractures (see Fig. 4). We are currently in the process of commencing a prospective analysis in order to study the exact types of fractures in our patient population.

Conclusion

The incidence of abuse remains high in our population, and a significant proportion of abused children will present with fractures. In the present study, the most common site of fracture was the skull, particularly in very small children. Skull fractures were associated with presumed higher levels of violence and use of implements. Abuse is an important differential diagnosis in any child presenting with a skull fracture or other suspicious head injury.

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