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# Fractures associated with non-accidental injury—an orthopaedic perspective in a local regional hospital

## 非意外傷害造成的骨折——香港一所分區醫院骨科部門的研究

**Objectives.** To identify the potential risk factors for fractures due to non-accidental injury in children, and to alert clinicians and health care workers to the diagnosis of child abuse.

**Design.** Retrospective review.

**Setting.** Regional hospital, Hong Kong.

**Patients.** Children who were admitted to the hospital with a clinical diagnosis of child abuse with associated fracture(s) between January 1996 and April 2004.

**Main outcome measures.** Demographic data, site of fractures, and investigations performed.

**Results.** Of the 377 children presented with non-accidental injuries, 29 (15 male, 14 female) had bone fractures. The mean age of the 29 children at the time of injury was 5 years and 5 months. Of the nine records showing pregnancy, seven were unplanned. Approximately 75% of the families were living in public housing estates, and 28% were receiving social security subsidy. Over half (52%) of the abused children were aged 3 years or less. A total of 78 fractures were documented with a mean of 2.7 fractures per child. The most common sites of fracture were the forearm (29%), followed by the ribs (24%). Most long bone fractures occurred in those aged 3 years or less. Fractures were detected by skeletal survey and bone scan for 90% of the children.

**Conclusion.** A number of potential risk factors were identified in children with fractures associated with non-accidental injury. They included age younger than 3 years, lower socio-economic status, presentation with long bone fracture, and unplanned pregnancy. Bone scan and skeletal survey are mutually complementary, and both should be performed in cases of suspected child abuse. Subsequent management requires cooperation of multi-disciplinary health care professionals.

**目的：**確定兒童非意外傷害但骨折的潛在因素，藉此為臨床醫生和醫護人員診斷兒童是否受虐提供指引。

**設計：**回顧研究。

**安排：**地區醫院，香港。

**患者：**1996年1月至2004年4月期間，臨床診斷為因受虐導致骨折而入院治療的兒童。

**主要結果測量：**與人口有關的數據、骨折部位和所作的調查。

**結果：**研究期間，醫院共接收377名非意外傷害的兒童，其中29名（15男

***Key words:***
*Child;*
*Child abuse;*
*Fractures/etiology*

***關鍵詞：***
*兒童；*
*兒童受虐；*
*骨折 / 病因*

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14 女）出現骨折。這 29 名兒童平均年齡為 5 年零 5 個月。根據當中 9 名兒童的母親的懷孕記錄，7 名屬意外懷孕。約七成半的家庭居於公共屋邨，28%正領取綜緩。一半以上（52%）的受虐兒童年齡在3歲或以下。在這29名兒童身上，共錄得 78 處骨折，平均每名兒童有 2.7 處骨折，受傷部位通常在前臂（29%）和肋骨（24%）。大部份長骨骨折傷者年齡在 3 歲或以下。九成兒童是在接受骨骼普查攝影和骨骼掃瞄後發現骨折的。

**結論：**兒童非意外傷害而導致骨折有不少潛在因素，包括年齡少於3歲、出身自較低階層的家庭、有長骨骨折，以及母親意外懷孕。為懷疑受虐兒童診斷時，應同時採用骨骼普查攝影和骨骼掃瞄，這兩種檢查方法能起互補的作用。對個案的跟進和處理，需要跨部門的專業醫護人員合作，才能奏效。

## Introduction

Fractures in children differ from those in adults: children have a unique spectrum of injuries (eg physeal injury) and some unique causes (eg child abuse). Child abuse, which can be defined as a non-accidental injury (NAI) or pattern of injuries to a child, may result in minor soft-tissue injuries that recover unnoticed and are not reported, and major injuries that require hospitalisation and may, in the extreme, be fatal. Orthopaedic surgeons encounter only children in whom orthopaedic intervention is required. The remaining cases are managed by paediatricians. Nonetheless, when new or old bone fractures are detected, orthopaedic surgeons play an equally important role in subsequent management.

Reports that focus on local cases of NAI resulting in bone fractures have not been published. This may be because the NAI cases are far less common than accidental injuries in age-matched groups. In addition, associated fractures are more rare. We conducted a retrospective review of all child abuse cases with fracture in our hospital to identify the risk factors of NAI. The information will be enlightening for specialists such as paediatricians as well as other health care providers, including family physicians, psychiatrists, nurses, and social workers in our locality.

## Methods

Data of all children admitted to the United Christian Hospital between January 1996 and April 2004 with a clinical diagnosis of child abuse were retrieved. Medical records of children with associated fracture(s) were reviewed by a single author. The following data, which were obtained from the hospital's Clinical Data Analysis and Reporting System (CDARS), were recorded: sex, age at presentation, type of pregnancy (if applicable), suspected abuser (if applicable), and site(s) of fracture(s). All fractures were counted (eg left 4th and 5th posterior rib fractures were counted as two fractures). Wherever possible, plain X-rays and subsequent skeletal surveys or bone scan reports were also reviewed. All fractures, new or old with callus formation (including skull), were categorised and tabulated.

**Table 1. Demographic data of patients**

| Demographic data | No. of cases, n=29 |
|---|---|
| Sex (male:female) | 15:14 |
| Mean age (range) at presentation | 65 months (3 months-15 years) |
| Growth | |
| Normal | 24* |
| Abnormal | 5† |
| Pregnancy‡ | |
| Planned | 2 |
| Unplanned | 7 |
| Parents | |
| Couple | 26 |
| Single father only | 3 |
| Step-father/cohabitee | 4 |
| Step-mother/cohabitee | 3 |
| Social background | |
| Living in public housing estate | 23 |
| Receiving Comprehensive Social Security Assistance | 8 |

* Normal growth measurement includes body height, body weight, and head circumference

† One child was <25th percentile, one was at the 10th percentile for growth, two children at the third percentile were regarded as failure to thrive, and data were missing in one child

‡ Data were missing in 20 records

## Results

Between January 1996 and April 2004, records of 377 children with NAI, of whom 29 (7.7%) had bone fracture(s), were retrieved through CDARS.

Demographic data of the 29 patients are shown in Table 1. There were similar numbers of boys and girls, with a mean age of 65 months at presentation. Most children (n=24, 82.8%) had normal growth measurements and normal developmental milestones. Of the nine records with pregnancy shown, only two cases were identified as planned. Five fathers and 13 mothers were unemployed (or as housewife), and 51% of parents were aged between 30 and 40 years. Three parents were drug addicts. Eight families were receiving Comprehensive Social Security Assistance (CSSA).

**Table 2. Clinical and radiological findings of patients**

| Finding | No. of cases, n=29 |
|---|---|
| Age at abuse (years) | |
| <3 | 15 (52%) |
| 3-10 | 10 (34%) |
| >10 | 4 (14%) |
| Clinical examination | |
| Delayed presentation | 10 (34%) |
| Inappropriate/contradictory history | 9 (31%) |
| Fracture(s) in a pre-ambulatory child | 4 (14%) |
| Previous history of child abuse or non-accidental injury | 4 (14%) |
| Child and/or caretaker reluctant to disclose detailed history | 4 (14%) |
| Inappropriate action of caretaker, eg over-calm | 4 (14%) |
| Type of fracture not accountable by the given history | 3 (10%) |
| Radiological examination | |
| Fractures with a high specificity for abuse | |
| Fractures of different ages | 11 (38%) |
| Rib fractures | 7 (24%) |
| Bilateral fractures | 5 (17%) |
| Metaphyseal fractures | 3 (10%) |
| Scapular fractures | 1 (3%) |
| Fractures of the outer end of clavicle | 1 (3%) |
| Complex skull fractures | 1 (3%) |
| Vertebral fractures or subluxation | 0 |
| Digital injuries in non-mobile children | 0 |
| Common fractures but with a low specificity | |
| Single long bone fractures | 4 (14%) |
| Mid-clavicular fractures | 1 (3%) |
| Simple linear skull fractures | 0 |

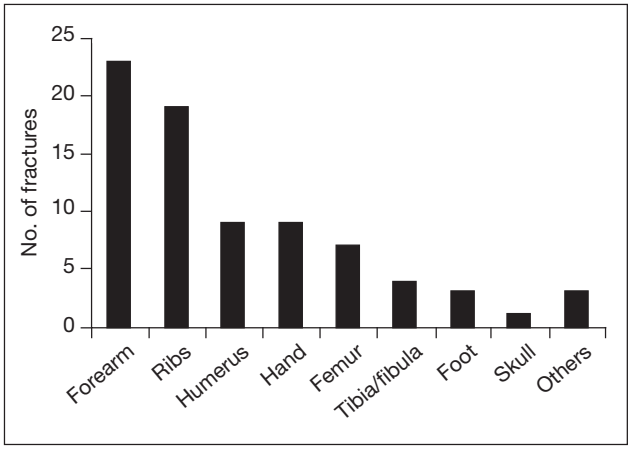


**Fig 1. Anatomical distribution of different fractures**

Of the suspected abusers identified in 23 (79%) cases, parents (including step-parents) were involved in 16 (70%) cases, babysitters in five (22%), and cohabitees in two (9%). Age of the children at the time of abuse, and the clinical and radiological findings are shown in Table 2.

A total of 78 fractures were identified, with a mean of 2.7 fractures per child. Figure 1 shows the anatomical distribution of different fractures. The most common sites of fracture were the forearm—radius and ulna (29%), followed by the ribs (24%). Most (31/43, 72%) long bone fractures (humerus, radius/ulna, femur, tibia/fibula) occurred in those aged 3 years or less. They included femur (5 of 7), tibia or fibula (3 of 4), humerus (8 of 9), and radius/ulna (15 of 23).

Injury occurred due to a variety of causes including twisting of the limb, direct hitting, or hitting with an object, eg rattan, clothes-hanger, or hammer. In a number of cases, causes of injury could not be determined, especially when the abuser was uncooperative. One child aged 3 years and 9 months died in this case review.

A full skeletal survey and bone scan were performed in all except three of our cases (one without bone scan, one without bone scan and skeletal survey, and one died within 24 hours after admission). Skeletal survey was done during hospitalisation, and bone scan was done either within the period of hospitalisation or shortly after discharge. Many of the bony injuries were detected by bone scan (Fig 2). Retrospective review of the relevant plain X-ray (by the reporting radiologist, by orthopaedic surgeon, or both) identified corresponding bony injuries such as periosteal reaction, fresh fracture, healing fracture, or healed fracture.

Most of the fractures could be managed conservatively by plaster of paris or splintage, with or without preceding closed reduction. Three children required operative treatment for their fractures: two involved transphyseal fracture of the distal humerus, one involved the distal radius. All were treated by closed reduction and augmented with Kirschner wires. Using the "Corporate Out-patient Appointment List" of the Hospital Authority, we were able to determine that up to 1 June 2005, no child was readmitted for second abuse in any form. Among the 29 victims, one was admitted to the orthopaedic department of another hospital with a genuine accidental injury (fell from slide in playground) that resulted in a left Monteggia fracture. Another two children were admitted to a paediatric ward in another two hospitals for genuine medical illness.

Medical records of all victims were reviewed. There were no long-term sequelae of the indexed fracture(s) reported except in two instances. All other fractures healed uneventfully. There were two documented complications directly related to the NAI fracture. Both were transphyseal fractures of the distal humerus and cubital varus deformity of 5 degrees and 8 degrees,

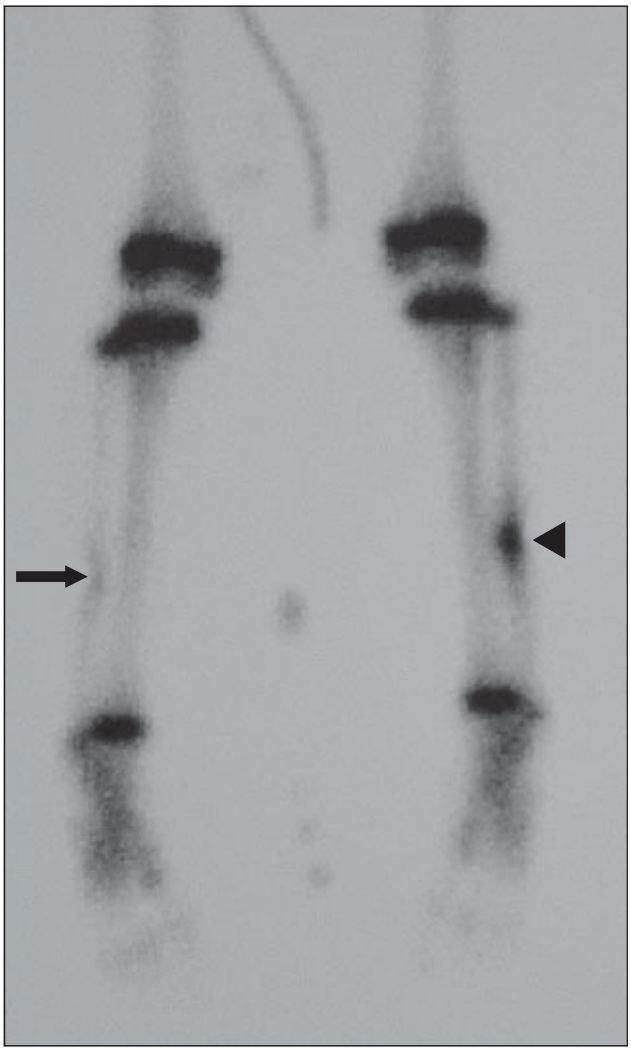

**Fig 2. New (arrow) and old fractures (arrowhead) of both fibula detected by bone scan**

respectively. They were noted in subsequent follow-up. Fortunately, no functional deficit occurred. A girl with a fracture of her left proximal femur at the age of 16 months was found on radiography to have left femoral overgrowth of 1 cm 4 years after the injury. She was clinically asymptomatic.

## Discussion

Definition of child abuse was clearly defined under the Procedures for Handling Child Abuse Cases (Revised 1998) published by the Social Welfare Department.[1] Child abuse may be physical, sexual, psychological, or simply as a result of negligence. Physical abuse is defined as physical injury or suffering to a child, or failure to prevent physical injury or suffering to a child (including non-accidental use of force, deliberate poisoning, suffocation, burning, or Munchausen's Syndrome by Proxy [Box[2]]), where there is a definite knowledge, or a reasonable suspicion, that the injury has been inflicted non-accidentally or knowingly not prevented.

Munchausen's Syndrome by Proxy[2] occurs when a parent or guardian falsifies a child's medical history or alters a child's laboratory test or actually causes an illness or injury to a child in order to gain medical attention for the child which may result in innumerable harmful hospital procedures

Incidents of child abuse in Hong Kong are underreported and likely to be serious.[3] Most involve physical abuse. According to a large-scale study conducted in Hong Kong,[4] there were 592 cases of suspected child abuse reported in 13 public hospitals between July 1997 and June 1999. Among them, 277 (46%) involved physical abuse. In this study, the majority of children (n=293, 78%) suffered from physical abuse, followed by sexual abuse (n=78, 21%) and psychological abuse or negligence (n=6, 2%). Another study of abused children revealed that soft-tissue injuries were present in more than 90%.[5] Fractures are the second most common presentation of physical abuse after skin lesions. Approximately one third of abused children will eventfully be seen by an orthopaedic surgeon.[6]

A more comprehensive and informative report[7] showed that there were 520 newly registered child abuse cases in Hong Kong in 2002, of which 292 (56%) involved physical abuse. The incidence rate per 1000 children aged 0 to 17 years was 0.39. There were 39 (7.5%) cases of child abuse reported in Kwun Tong District (the district in which our hospital is located), which ranked fourth among the 19 districts following Yuen Long, Tuen Mun, and Kwai Tsing for new cases.

The diagnosis of child abuse or NAI is not usually straightforward. Orthopaedic surgeons may be 'distracted' by the presenting fracture and concentrate on its management without noticing that an NAI has occurred. From the clinical features obtained in this study (Table 2), delayed presentation and inappropriate/contradictory history are common in fractures associated with NAI. The former is understandable because the inflicted fracture(s) will not get united within days and remains painful to the child, especially if it is a displaced fracture.

Radiological examination is essential in evaluating a child with suspected injuries from abuse. Fractures in abused children fall into two categories, namely fractures with a high specificity for abuse and common fractures but with a low specificity.[8] This

**Fig 3. Left lateral rib fracture**

study shows that fractures of different ages are undoubtedly highly specific for NAI and were present in 38% of our patients, making our diagnosis of NAI almost definite (Table 2). Nonetheless, vertebral fractures/subluxation and digital injuries in non-mobile children that are also associated with a high specificity for NAI were not identified in our study.

A full skeletal survey and bone scan were performed in 90% of our cases. According to the Department of Radiology and Organ Imaging in our hospital, a full skeletal survey examines the following: skull antero-posterior (AP) and lateral; chest and abdomen AP; spine AP and lateral; pelvis AP; both arms, forearm, hands and wrists AP; and both lower limbs AP. Skeletal surveys and radionuclide bone scans have been criticised for their high false-negative value.[9] Thus both should be performed to ensure the greatest probability of fracture detection.[10] A bone scan is useful for detecting occult fractures that are difficult to recognise on radiographs. In our study, for example, a scapula and a foot injury were detected by bone scan but not visible on X-ray. A skeletal survey also usefully documents and dates multiple episodes of trauma. A bone scan and skeletal survey are mutually complementary; both should be performed in cases of suspected NAI.

The number of fractures per child is slightly greater in our study (2.7 per child) compared with similar studies from other countries (2.0 per child in Detroit[11] and 2.3 per child in Los Angeles[12]). In this study, the highest incidence was of forearm fractures (n=23, 29%) of which fractures of the distal radius or ulna were the common radiological findings. This is significantly higher than the findings of an epidemiological study of fracture in Hong Kong children[13] in which fractures of the upper limb occurred in 20% only. The present study shows that forearm fractures were more common in NAI.

The second common site of NAI-associated fracture was the ribs. In our study, there were 24% of rib fractures. Rib fractures are highly suggestive of physical abuse.[14] The positive predictive value of a rib fracture for NAI was 95%; this increased to 100% once history and clinical circumstances had excluded all other causes of rib fracture.[15] In addition, posterior and lateral rib fractures account for the majority of rib fractures (Fig 3). A similar pattern was found in another study.[16] Many of these fractures were identified by subsequent radionuclide imaging. Rib fractures are notoriously difficult to detect,[16] owing to (1) the frequent superimposition of the transverse process over the rib fracture site, (2) a fracture line that crosses at an oblique angle to the X-ray beam, and (3) non-displacement of rib fragments due to preservation of the posterior periosteum.

Fractures in other anatomical areas occurred less frequently in our study. They were, in descending order of frequency, humeral fracture (supracondylar, transphyseal, condylar) [12%], hand fracture (12%), femur fracture (9%), tibial and fibular fracture (5%), foot bone fracture (4%), clavicle fracture and skull bone fracture (1%).

Among the 43 sites of long bone fractures (humerus, radius/ulna, femur, tibia/fibula), 31 (72%) occurred in children aged 3 years or below. Such children are more prone to long bone fractures as they are unable to defend themselves.

Femur fractures (Fig 4) have traditionally been highly associated with child abuse, although there is no specific fracture pattern that allows differentiation between accidental and non-accidental femoral fracture.[17] If present in an infant younger than 1 year, it is highly suggestive of child abuse.[17-19] All children under 1 year with a fracture should be admitted to hospital and referred to a paediatrician.[20] Among the five children with femoral fracture in our study, one was younger than 1 year and the remaining four were aged under 3 years. All of them had other fractures, making the diagnosis of child abuse more definitive.

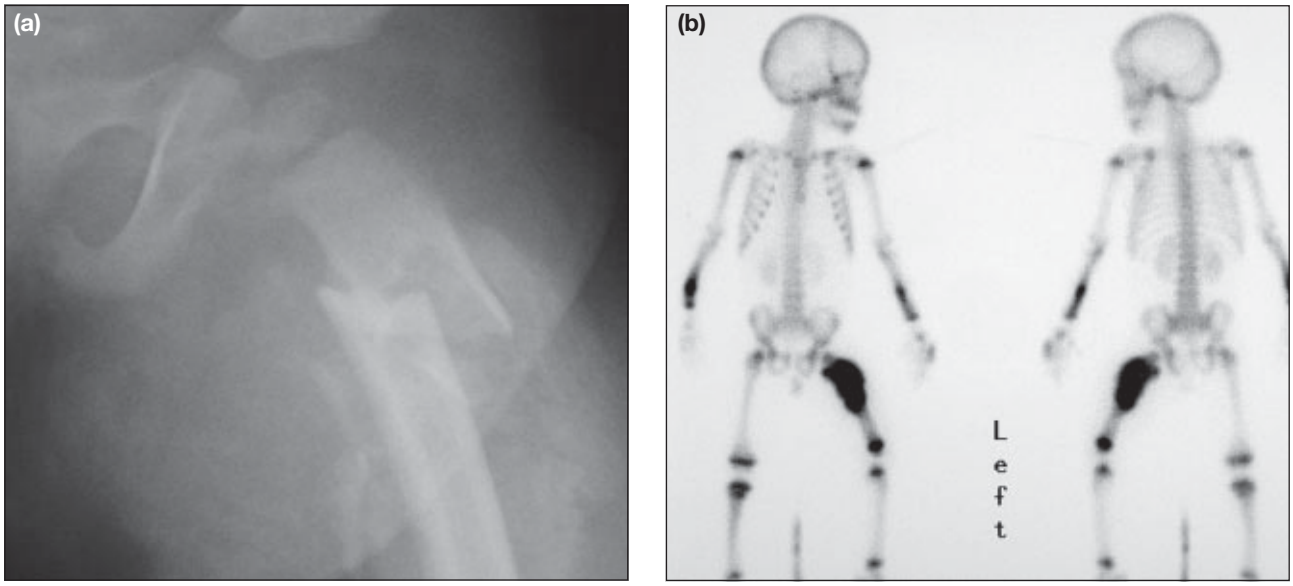


**Fig 4. (a) Left proximal femur fracture, and (b) corresponding femur fracture in bone scan**

According to Hobbs,[21] victims of physical abuse associated with skull fracture have a higher mortality than those with fractures at other sites. Billmire and Myers[22] pointed out that 95% of serious intracranial injuries in children are the result of child abuse. Kasim et al[23] also stated that intracranial haemorrhage and intra-abdominal trauma are the most frequent causes of death in abused children. Among different abusers (parents, grandparents, step-parents, babysitters, etc), fathers form the largest group of perpetrators. In our study, suspected abusers were identified in 79% of cases. Of these, parents (including biological and step-parents) were involved in 16 (70%) cases. Similar percentage of abusers (65%) is also found in local statistics.[7] There was one mortality in this case review: a boy aged 3 years and 9 months was subjected to severe physical abuse by his father. He arrived at our hospital in a comatose state. Computed tomography of his brain showed a subdural haemorrhage together with skull bone fracture extending across the coronal suture to the parietal bone (Fig 5). Resuscitation failed within 24 hours of admission. The case was referred to a coroner and the abuser was prosecuted for murder.

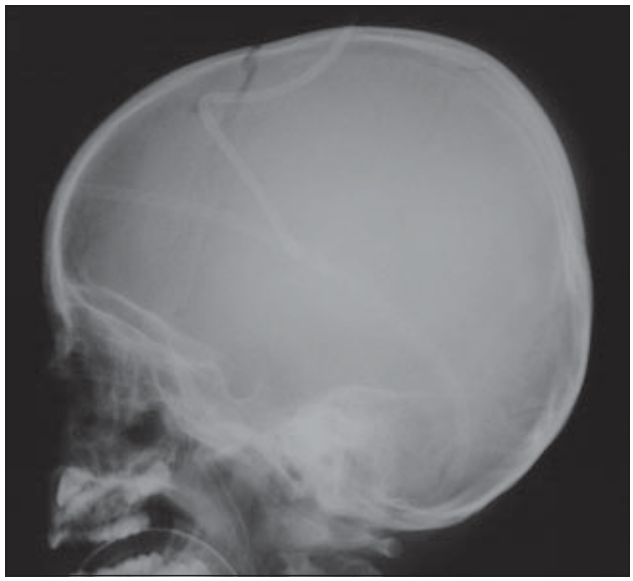

**Fig 5. Computed tomographic scan of the patient's brain**

Subdural haemorrhage together with skull bone fracture extending across the coronal suture to the parietal bone are shown. The patient subsequently died

Although the information of pregnancy is not available for all our cases, it is pertinent to note that of the known cases, at least one fifth of abused children in this study were the result of an unplanned pregnancy. Whether such children are more prone to abuse cannot be confirmed, but it may be considered as one of the risk factors for abuse.

In addition to the eight (28%) families who were receiving CSSA at the time of NAI occurrence, the job nature of employed parents indicated that most families had a low income. Many of them were manual workers or hawkers. Thus, low income or receipt of CSSA may be regarded as another risk factor for child abuse. Unlike other studies, we found no evidence of multiple previous minor injuries and admissions, events that have been confirmed to precede severe battering episodes.

When all these data are reviewed, the warning

signs of NAI that are specific for Hong Kong include the following: a child aged 3 years or less, had a long bone fracture, living in public housing, accompanying to the casualty/clinic with his/her parents aged 30 to 40 years, with one or both parents unemployed, and in receipt of CSSA. If further history reveals that the child is the result of an unplanned pregnancy and if parents can provide no reasonable explanation for the injury, the probability of NAI approaches 100%.

All victims of child abuse in our hospital were managed by a team led by a designated Medical Coordinator on Child Abuse—a senior medical officer or above from the Department of Paediatrics and Adolescence. Other members of the team included orthopaedic surgeons, ward nurses, medical social workers, clinical psychologists, the Child Protective Services Unit from the Social Welfare Department, and the Child Abuse Investigation Units of the police in certain cases. Case conferences were conducted in most instances to establish whether the case was one of child abuse and to determine case management, bearing in mind the best interests of the child.[24] A dedicated group of multi-disciplinary professionals who can devise a comprehensive individual management plan for each child is very beneficial.

## Conclusion

Clinical features of fractures associated with NAI have never been studied locally. The findings of our study have significant implications for everyday practice. Attending clinicians should always be alerted by potential risk factors including a child under 3 years old, presented with long bone fracture, with the background of unplanned pregnancy, and lower social economic status of the family. In the presence of more than one of these risk factors, the probability of NAI increases exponentially. Both skeletal survey and bone scan should be regarded as standard investigations. The subsequent management is individualised and requires a multidisciplinary approach. Appropriate referral not only prevents the child from repeated abuse, but also prevents potential disaster.

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