Interpreting fractures in child maltreatment

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Abstract

All paediatricians and health professionals working with young children need to be aware of the potential for child abuse to be a cause of physical injuries, such as fractures. Clinical experience, Serious Case Reviews and research show us that maltreatment should be kept in mind, in order for investigations to be carried out where appropriate and to prevent further harm. Whilst accidental fractures are common, fractures may also be the sentinel injury that alerts professionals to the possibility of child abuse, presenting clinically or detected as an occult injury on imaging for other reasons or when investigating a case of suspected maltreatment. The health professional evaluating a child with any fracture should be aware of features that raise the suspicion of abuse as a cause and be familiar with current recommendations for further investigations. This article outlines the current research concerning abusive fractures in children. It offers guidance on how to optimize radiological investigations and avoid common pitfalls in clinical practice.

Keywords child abuse; diagnosis; fracture; non-accidental injury; skeletal survey

Introduction

Physical abuse is preventable, yet in spite of increased public awareness it remains a significant cause of injury and death in children. The Child Death Review process in England identified 60 children who died as a result of physical abuse or neglect in the year ending 31st March 2015. On analysis, over half of these cases were felt to have modifiable factors. A missed diagnosis of maltreatment may mean a child returns to an abusive home to suffer further injury or even death. At the other extreme are the potential implications of subjecting a child and family to a child protection investigation or incorrect suspicion of abuse. Multi-agency working is vital in this field and no single injury in isolation should give a diagnosis of physical abuse or neglect.

Fractures in children

Studies have shown that, after bruises, fractures are the most common injury in physical abuse. The majority of fractures in children are, however, accidental and a part of growing up. The incidence of fractures in the child population in the UK has been looked at in a variety of studies with an incidence ranging from 10 to 30/1000/year depending on the population studied.

The majority of accidental fractures are seen in children over 5 years of age and numerous studies show that the frequency of accidental fractures increases with advancing age and mobility, with up to 66% of boys and around 40% of girls sustaining a fracture by their 15th birthday.

The younger the child with a fracture, the greater is the likelihood of the fracture being abusive and the majority of abused children with fractures are less than 18 months old. Although in child physical abuse cases overall, the prevalence of skeletal injuries is relatively small, it is vital that they are not missed or misinterpreted when they do occur.

History of radiology in child abuse

Child abuse has existed throughout history. Early descriptions in medical literature indicated that physicians accepted that those caring for children might injure them. Until the 18th century, society regarded children as the possessions of their parents, who were entitled to treat their children in any way they wished. Indeed, in the UK, legislation was introduced to protect animals before children. The late 19th century was a time of great hardship for children and society as a whole has been slow to recognize child abuse as a problem.

In the 1940's American paediatric radiologist, John Caffey, described multiple skeletal fractures and subdural haematomas resulting from 'non accidental trauma' and Radiology has played an integral part in the investigation of maltreatment ever since. The radiographic depiction of inflicted injuries helped to increase the awareness of child physical abuse in the medical community by enabling many of the injuries to be visualised. In 1962 the seminal paper by Kempe gave a clear description of child abuse as a recognizable clinical entity, "The Battered Child Syndrome".

What radiological investigations optimise identification of occult fractures?

It is well recognised that abusive fractures are often not clinically apparent. This may be because the fractures are subtle and undisplaced such as rib or metaphyseal fractures, with minimal or no deformity or bruising or because they are in the later stages of healing and likely to be less painful. Some of these influences are greater in babies and younger children who are unable to give an account of events or their symptoms. Investigations are therefore targeted at this group to give the highest yield.

In the UK, guidelines on imaging in suspected abuse published in 2008, from the Royal College of Radiologists with the Royal College of Paediatrics and Child Health were based on the best evidence for optimal detection of fractures in suspected physical abuse. This guidance recommends imaging with a full skeletal survey (SS) in all children under 2 years of age where physical abuse is suspected. The standard SS optimises quality and accuracy utilising 19 separate X-rays, with supplementary projections if deemed necessary by the radiologist at time of the imaging. These may include coned metaphyseal views or alternative projections if fractures are detected. Recognition of rib fractures is greatly improved by oblique views of the ribs and these should now be included routinely as part of the initial SS.

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Follow-up imaging in suspected physical abuse

A second skeletal investigation is then recommended, as either SS or bone scan alone have been shown to miss fractures. A single skeletal survey will miss up to 20% of fractures in suspected physical abuse, predominantly rib fractures. A single bone scan predominantly misses skull or metaphyseal fractures. A second radiological investigation with contemporaneous radionuclide bone scan or follow-up skeletal survey after 11–14 days is required for optimal fracture detection.

Studies, though variable in their methodology, have consistently shown increased detection of new fractures in 8.4–37.6% of children who have a follow up skeletal survey. The second SS is to look for fractures that may have become visible as the radiological changes associated with healing start to appear and can therefore aid fracture dating. It can also provide additional information about an area of previous concern to enable a fracture to be confidently diagnosed or excluded.

In order for the second SS to be an accurate reflection of any potentially abusive injury present at the time of original imaging, it is vital that the child is kept in a place of safety in the interim. This could mean a supervised placement or foster care and may pose additional challenges for children, families and social care. Robust practice is necessary to ensure the child is returned for the follow up SS as the return rate may be low without protocols to ensure this.

Bone scintigraphy

Alternative complementary imaging with bone scintigraphy (BS) is suggested in the Joint College guidance when follow-up SS is not a viable option due to concerns about child safety or certainty of attendance for follow-up imaging. Bone scans demonstrate pathophysiological abnormalities and thus any scintigraphic findings must be correlated with the clinical and radiological context. Bone scans do not provide any information about fracture dating and may remain positive for years after trauma. A recently published study looking at use of BS over a period of 10 years found it to be a time effective alternative to follow-up full or limited SS at 10–14 days. Not all units however have the expertise to perform and report paediatric BSs and it is not widely used.

When infants and young children present with fractures who should have a skeletal survey?

Recent studies have shown disparities in rates of performing skeletal surveys in young children presenting with fractures. Furthermore a lack of clarity regarding what is meant by "suspected physical abuse" can lead to difficulties in decision making around when to apply guidance and there is potential for over investigation of certain vulnerable groups. Balancing risks of radiation exposure with the risk of missing injuries and potentially returning a child to an abusive environment is the chief consideration. Recent guidelines from Wood et al in America were produced by a consensus method and aim to provide the clinician with specific criteria as to when imaging is indicated in children less than 24 months of age with fractures.

Published in 2014 they emphasise the need to perform a SS in infants under 12 months presenting with any type of fracture, with a few notable exceptions that include:

- A cruising child over 9 months of age with a common accidental fracture e.g. toddlers fracture of the tibia or fibula or buckle fracture of the distal radius or ulna
- A child over 6 months with a simple linear, unilateral skull fracture following a history of a significant fall
- A clavicular fracture related to birth injury

SS should be requested in all children 0–23 months with a fracture where there is:

- Over 24 hours delay in presentation of a fracture associated with significant pain and/or physical findings
- Confessed abuse
- A fracture occurring in the context of domestic violence
- A fracture attributed being hit with a toy
- A fracture with no history of trauma
- Inappropriate explanation for the fracture
- Cases where there are additional injuries such as burns or bruises unrelated to the fracture

In children 12–23 months the guidance allows some discrimination, depending on fracture type, with skeletal survey deemed necessary with certain fractures that are more strongly indicative of abuse:

- Rib fracture
- Classic metaphyseal fracture (CML)
- Complex or depressed skull fracture
- Humeral fracture due to a fall of less than 1 m
- Femoral fracture due to a fall from any height

In older or vulnerable children with disabilities, radiological investigations should be carried out in accordance with clinical indicators where there are concerns about the possibility of inflicted injury.

Neuroimaging

Neuroimaging is advised in all infants under 1 year old who are being investigated for suspected physical abuse as well as any child with focal neurology or encephalopathy. Computed tomography (CT) examination of the head is the first line investigation and is good at demonstrating acute injury and haemorrhage. It has the advantage of being quick and readily available without the need for sedation. CT is increasingly used to provide 3D bone reconstruction images that have been shown to increase sensitivity in the diagnosis of linear skull fractures.

In cases where the initial head CT is abnormal or there is ongoing neurological concern magnetic resonance imaging (MRI) with diffusion weighted imaging (DWI) of the head is recommended and enables more in depth neuro-radiological evaluation.

Clinicians should be aware of the existence of spinal injury in physical abuse including the potential for coexistence with abusive head trauma. Abusive spinal injury can take the form of fractures, haemorrhage, soft tissue and neurological injury. Any of these can have potentially devastating consequences in infants and young children where a history of clinical symptoms may be absent. All skeletal surveys for suspected abuse must include lateral views of the whole spine to look for bony injury and an MRI of the spinal column should be considered in any child where abusive head trauma is suspected.