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REVIEWS

Diagnosing physical child abuse: the way forward

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Each year in England and Wales, as many as 40 000 children are the subject of a case conference for suspected physical abuse. Abuse has major physical and psychological consequences for the health and welfare of the affected children. The evidence indicates that a significant proportion of abused children experience serious long term effects and they carry the legacy of their abuse with them into adult life.^{1 2} The management and diagnosis of abuse in children is therefore of great importance.

The management of child abuse must start with accurate diagnosis. With such an important subject one would expect there to be a considerable number of publications giving quantitative evidence on which to base diagnosis. Unfortunately, this is not the case and there has been little work giving probabilities for diagnosis, risk, and outcome for the abused child.

In this article, we will review the evidence we have on the diagnosis of physical abuse in children. We will also review the differential diagnosis, the process of differentiation of physical abuse from accident, and what basis we have for giving evidence to the child protection process.

Who should assess a child with physical abuse?

The initial recognition of the possibility of abuse is in some ways the most important step in the child protection process. This is done by social workers, health visitors, neighbours, teachers, and many other people involved with children. It is also the responsibility of all doctors who deal with children.

There are, of course, many disincentives for this happening. Some doctors may be unhappy about even recognising the possibility that parents could have harmed a child. Doctors

may feel uncertain about the diagnosis and they may accept accidental explanations readily.

Every doctor who may suspect a child is abused should have access to expert advice. One should never walk alone in child protection! Help is available by consulting social services under the child protection procedures or by consultation with a paediatrician with expertise in this field. It is not widely appreciated that the management of child protection cases is an expert procedure, like any other field of specialist clinical practice.

Assessing a child for the diagnosis of physical abuse

As with any other type of medical work, good notes and accurate examination are important. They may be required in preparation of evidence for court many months later. The purpose of the examination should be clear. It is to make a diagnosis of definite or possible abuse. It is not to make a decision about what happens to the child: in the short term that is the social services' responsibility, in medium term that of the case conference, and in the long term that of the courts. The purpose of the examination is also not to identify the perpetrator: that is the role of the police. The history and examination should be taken in a non-judgemental manner and in a calm medical context. Injuries should be accurately measured and entered on a topographical chart. Careful examination of the child, documentation of bruising with use of body charts depicting size in two planes, and the colour of each contusion observed is vital in the investigation of abuse. A photographic record should be obtained wherever possible and especially if there may be a prosecution.

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Combination of probabilities

It is important to assess the whole child and all the injuries present. Barristers are very adept at seeking accidental explanations for each injury separately, but this approach is flawed. Clearly a child with two suggestive injuries is more likely to have been abused than if there is only one injury.

What we do at present is to put an informal probability on each injury and make a combined assessment of the likelihood of abuse. It would be an advance if we could put actual figures to these probabilities and then combine them. An example of what can be done is the work of Warlock and colleagues,³ who calculated that a spiral fracture in a baby had a probability $p < 0.01$ of being the result of an accident. Probabilities can be combined using a well recognised mathematical theorem, Bayes's theorem. In the Department of Child Health in the University of Wales, we have been investigating Bayes's theorem to combine probabilities of bruises being caused by abuse.⁴

Bruising

Bruising is probably the most common reason for referral to child protection teams and for medical assessment for child abuse. The overall assessment of the child is an informal combination of probabilities of abuse or accident with respect to all the bruises a child has.⁴ The more bruises there are, the greater the likelihood of abuse.

Several factors help us decide on the probability of abuse. These are:

- the age and development of the child;
- the site of the bruising;
- the pattern of the bruise.

AGE OF THE CHILD

We must consider the *age* and *stage of development* of the child when evaluating an injury. Infants who "don't cruise rarely bruise"⁵; indeed bruises are rarely seen in children under nine months. Bruising is a very important physical sign in non-mobile babies and must be investigated thoroughly to exclude fractures and in some cases subdural haemorrhage.⁶

In walking toddlers, however, bruises may be seen commonly on the forehead and upper leg and shins. Bruising at atypical sites should prompt consideration of child abuse,⁵ for instance accidental facial bruising is rare in infancy.⁷

SITES OF BRUISING

Bruising in some areas of the body that are not commonly injured in childhood accidents may be highly significant.^{4 7-9} These include:

- the ears (bruising may be subtle and may be missed without careful inspection);
- the buttocks;
- the thighs;
- the face;
- the anterior chest and abdomen.

On the other hand bruising over bony prominences, such as the shins and elsewhere on the limbs, is more suggestive of accident.

Bruising on the shins is best ignored in the assessment of non-accidental bruising. We have confirmed these findings in a recent study in south Wales.

PATTERN OF BRUISING

The bruise pattern commonly mimics the object causing the injury. With high impact injuries there will be a *negative image* of the object used, surrounded by a rim of petechiae where capillaries have been stretched and torn. Injuries that are more forceful present as a *positive image* of the object when vessels are ruptured directly. Clues to the shape of the object involved can be derived from the pattern of the bruise. Common objects used include sticks, cords, belts, slippers, and of course hands. The pattern may be highly specific, for example punctate bruising from a hairbrush. Slap marks are common injuries.

AGING BRUISES

We are often requested to determine the age of a bruise acquired non-accidentally so that the perpetrator may be identified or confirmed. Regrettably, the aging of bruises remains an inexact science. Many factors will determine the colour of a bruise, including the depth of injury, the location (for example, where tissues are loose and vessels poorly supported bruising will readily appear), force, vascularity, time lapsed from injury, skin colour, and ambient lighting. Furthermore bruising probably resolves at variable rates in different individuals, even those of the same age, and possibly more rapidly in those often injured. All that can be determined is that bruising will show a progression of colour changes with time and that initially the colours red, purple, and blue will be seen, and some time later brown, green, and yellow may appear, often in combination. It appears likely that bruises sustained at the same time may be of different colours. All that a doctor can do is to make general observations. For example, a red or purple bruise is fairly fresh, perhaps 1 or 2 days old, and a predominantly yellow bruise is unlikely to have been sustained in the last day or so.¹⁰⁻¹²

MEDICAL EXPLANATIONS FOR BRUISES

Occasionally there will be a medical explanation for bruises, and this must be considered during the consultation. It should be clinically apparent if the child has, for example, idiopathic thrombocytopenic purpura or leukaemia, and there should be clues in the history, examination, or family history if there is a clotting disorder or a connective tissue disorder such as the Ehlers-Danlos syndrome or osteogenesis imperfecta which might predispose to easy bruising. It is important to recognise that any affected children might also be victims of abuse.

It is prudent to document a full coagulation screen and platelet count at the time of examination to exclude a coagulation problem. If the injury is diagnostic, for example a slap mark in an otherwise healthy toddler, such investigations may not always be necessary clinically, but failure to do them might leave the doctor

exposed legally when the case comes to court. Occasionally soft tissue injuries may require more specific radiological investigation such as ultrasound or magnetic resonance imaging, for example to delineate an intramuscular haematoma.⁹

Clearly bruising may coexist with other injuries, even when unsuspected, and a skeletal survey should be arranged in all children under 30 months of age where abuse is suspected, and in older children with more severe bruising or clinical suspicion of fracture.

Subdural haemorrhage and other brain injuries

Subdural haemorrhage is a major cause of death and handicap in babies. It has been known for many years that this problem is often caused by shaking abuse. In 1860, Tardieu described thickenings of blood on the surface of the brain in Parisian street boys who were victims of child abuse.¹³ In 1946, a paediatric radiologist, John Caffey, suggested that multiple unsuspected fractures of long bones concurrent with infantile subdural haematomas were also the result of trauma.¹⁴ In the early 1970s, Guthketch and later Caffey established the term "whiplash shaken infant syndrome," encompassing a form of abuse involving vigorous manual shaking of infants with induced intracranial and intraocular bleeding.¹⁵⁻¹⁷ Subdural haematomas during the first two years of life are usually acute; the majority of these are thought to result from child abuse.¹⁸⁻²¹

The difficulty now is ascertaining whether an individual child has been abused or not. We have recently undertaken a population based case series of children under the age of two years who sustained a subdural haemorrhage.²² This study was in south Wales and part of south west England from 1 January 1993 to 31 December 1995. We ascertained all children under the age of two who sustained a subdural haemorrhage. We excluded neonates who developed subdural haemorrhages while still in neonatal units and children who had had neurosurgical interventions. Of 33 cases—23 boys and 10 girls—who had a subdural haemorrhage, 27 were highly suggestive of abuse. We identified only one case who had an accidental cause for the subdural haematoma. This was after a severe road traffic accident. From published reports and the findings of our research, we believe that subdural haematomas are caused either by severe shaking abuse or by severe accidental trauma.

We believe it is essential to investigate all cases of subdural haemorrhage in infancy, as follows:

- a full multidisciplinary social assessment;
- ophthalmoscopy by an ophthalmologist;
- a skeletal survey supplemented by a bone scan or a repeat survey at 10 days;
- a coagulation screen;
- computed tomography or magnetic resonance imaging.

GLUTARIC ACIDURIA

There have been recent reports²³ that glutaric aciduria can cause subdural haematomas in childhood. This is a very rare diagnosis and unfortunately cannot easily be screened for biochemically. Nevertheless, it appears that all cases of glutaric aciduria are associated with frontal lobe hypoplasia. Therefore if there is no frontal lobe hypoplasia the diagnosis can be excluded. It is also useful to note that glutaric aciduria is not associated with fractures.

Fractures

Fractures are a serious manifestation of child physical abuse. Considerable force is needed to cause a fracture, and they cause a lot of pain. In considering the diagnosis of non-accidental fractures, we need to consider:

- the age of the child;
- the type and site of the fracture;
- exclusion of medical disease.

THE AGE OF THE CHILD

Non-accidental fractures occur most commonly in the under threes, in contrast to accidental fractures which tend to occur in older children.³ In one comparative study of accidental and non-accidental fracture, no child over five years had a fracture resulting from abuse.³ We have found similar results in a study from Wales, with no child over 33 months having a non-accidental fracture. We found that non-accidental fractures are at their most frequent in the first six months of life.

THE TYPE AND SITE OF FRACTURE

Non-accidental rib fractures

These are a problem in babies under one year; they are often multiple and occur posteriorly. They are caused by compression injury in infants and not by direct trauma except in exceptional circumstances. Rib fractures are rarely present in isolation but are found during the investigation of other injuries.³ There is a particular association with subdural haemorrhage where the infant is squeezed and shaken.²²

Long bone fractures

These are found, in descending order of frequency, in the humerus, femur, tibia, and radius.²⁴

- *Metaphyseal fractures* (corner and bucket handle) are much more common than long bone shaft fractures in children who die of child abuse and are highly specific for abuse.²⁵⁻²⁶ They result when fragments of bone become separated from the ends of long bones as a chip or plate. They occur as a result of pulling, twisting, or shaking injury with rapid acceleration/deceleration forces at a site distant from the site of fracture.
- *Spiral fractures* of long bones in babies are always very suggestive of abuse and in cases of a spiral fracture of the humerus are diagnostic of abuse.³⁻²⁵⁻²⁶ Femur fractures in children under one year are likely to be caused by abuse, whereas children old enough to run and fall, especially with a twisting motion, can accidentally fracture

the femur with a diaphyseal spiral or oblique fracture.²⁷ However, in older children a spiral fracture of the mid or lower tibia—a typical “toddler’s fracture” or childhood accidental spiral tibial (CAST) fracture—is unlikely to be caused by abuse and can occur after trivial trauma when the toddler stumbles when running.^{28–29}

- *Subperiosteal haemorrhage* or “bone bruises” can be a manifestation of abuse. They occur when the limb is grabbed or pulled, resulting in tractional and torsional forces on the periosteum. They may take 10–14 days to be visible on x ray.^{25–30}

Skull fracture

Skull fracture in association with intracranial injury in babies is usually caused by abuse.²⁵ It may be possible to diagnose abuse from a skull fracture alone, the characteristics being multiple or complex fractures, non-parietal fractures, depressed fracture, and growing fractures (leptomeningeal cysts).^{3–31} A depressed occipital fracture in an infant is virtually diagnostic of abuse,³² in contrast to the single, linear, parietal fracture, which is usually the result of accident.³¹ In a study of children under five years who fell from heights of around 90 cm in hospital and where there was no suspicion of abuse, skull fractures were rare, unilateral, and non-diastatic, with no sequelae. A history of fall from a cot, bed, or sofa as the cause of a skull fracture should be questioned.³³

Spinal injury

This can occur in abuse from a hyperflexion-extension injury. The anterior superior edges of the vertebral bodies—often in the upper lumbar and lower thoracic regions—may be affected, with narrowed disk spaces and often multiple levels. The spinous processes may also be fractured. Spinal cord injury may result.²⁵

Multiple fractures

Multiple fractures in different stages of healing are strong indicators of abuse.³ It is important to note that there may not be external signs of bruising in association with non-accidental fractures.^{34–35} The absence of contusion implies neither underlying bone disease nor increased possibility of abuse.³⁶

EXCLUDING MEDICAL CONDITIONS

In diagnosing a fracture or fractures as being due to abuse, it is usually prudent to exclude medical conditions that could be predisposing causes of a fracture. Of these conditions the most important is osteogenesis imperfecta. However, metabolic bone disease in neonates, rickets, osteoporosis, copper deficiency, osteomyelitis, leukaemia, and disseminated neuroblastoma can all cause fracture and should be excluded.³⁷

Osteogenesis imperfecta

Osteogenesis imperfecta remains important in the differential diagnosis of skeletal injury, and the topic has been widely debated. Sometimes the condition may present as child abuse. Although there is no doubt that this is a rare

occurrence, lawyers representing the family in such cases often bring up the possibility. This diagnosis therefore needs to be excluded when fractures in children are thought to be caused by abuse.

There are four classifiable types:

- *Osteogenesis imperfecta type I* is the important differential diagnosis in abuse. It is usually diagnosed by a positive family history (it is dominantly inherited) and the presence of blue sclerae. A skeletal survey may show reduced bone density and multiple wormian bones on the skull film. Though normal children often have several wormian bones on skull x ray, in osteogenesis imperfecta they are multiple and occupy the whole bone structure in a mosaic pattern.
- *Osteogenesis imperfecta type II* is lethal.
- *Osteogenesis imperfecta type III* usually causes severe deformity and therefore should not present a diagnostic problem.
- *Osteogenesis imperfecta type IV* (white sclerae, dominant inheritance) has been suggested as a common differential diagnosis in child abuse. However, it is very rare and associated with deformity and reduced bone density.

Copper deficiency

Copper deficiency has also been suggested as a differential diagnosis of child abuse. This is very unlikely as there is adequate copper in breast milk and in all the formula feeds available in the United Kingdom.³⁸ The only children who might be deficient in copper are preterm babies who have been parentally fed.³² Copper deficiency presents as much more than increased bone fragility. There will also be developmental delay, hypotonia, sparse hair, and anaemia or neutropenia. Much has been written about copper in the context of fractures, but these do not occur in the absence of other skeletal changes (osteoporosis, and cupping and irregularity of the metaphyses of the long bones).

Despite the fact that copper deficiency is extremely rare and can be recognised on clinical grounds, lawyers may sometimes bring up the possibility. It is therefore wise to check the serum and urinary copper and serum caeruloplasmin in children who have been preterm babies and received parenteral feeding.

Metabolic bone disease

Metabolic bone disease mostly affects sick, often parenterally fed, low birthweight infants, and is caused by inadequate intake of dietary minerals (calcium and phosphate) and other processes.³⁹ The peak time for appearance of fractures, rickets, and osteoporosis is 36–40 weeks postconceptional age.³⁷ While metabolic bone disease is more common in preterm infants, the prevalence of short gestation in children presenting to emergency departments with fractures under the age of six years is not increased compared with controls presenting without fractures, or with all inborn surviving infants.⁴⁰ Occult rib fractures are seen in sick preterm infants, as are long bone fractures, but

these usually occur while the infant is in the neonatal unit or shortly after discharge.

Temporary brittle bone disease

"Temporary brittle bone disease" has not been proven as an entity and is not accepted as an explanation for fractures by the majority of child abuse experts.^{41–42}

What investigations should we do to exclude fractures due to child abuse?

A skeletal survey is recommended in all children under 30 months suspected being abused or neglected, in older children with severe bruising, where there is localised pain, deformity, or reluctance to move, and in unexpected child death. Views of the entire axial and appendicular skeleton are required, including a lateral view of the spine. A "babygram" is diagnostically inadequate. A bone scan will be highly sensitive in detecting rib and diaphyseal fractures, which might not be obvious on ordinary film⁴³; however, uptake of tracer around the metaphysis/ diaphysis makes identification of fractures in this area difficult. The role of the bone scan is still controversial because of practical considerations such as cost, radiation exposure, and technical and professional staff availability.³⁰

When child abuse is strongly suspected, a follow up skeletal survey two weeks after the initial study is recommended to provide an accurate assessment of skeletal injury, and information for more accurate dating.⁴⁴ Dating is not possible from a bone scan. Fractures heal in distinct stages to a set time scale. The peak times seen for the various stages are as follows: resolution of soft tissue change, 4–10 days; periosteal new bone formation, 10–14 days; loss of fracture line definition, 14–21 days; soft callus, 14–21 days; hard callus, 21–42 days; remodelling, 1 year (25). Fractures carrying a high specificity for abuse may be missed in the acute stages but may be identified later, especially rib and subtle metaphyseal fractures.⁴⁴

Burns and scalds

With burns and scalds, the differentiation between accident, neglect, and deliberate abuse is not easy. The doctor has to assess the history and the findings and attempt to ascertain whether they are likely to be compatible. For instance, injuries on both front and back are unlikely to result from a child spilling a hot drink.

If abuse is not suspected it can easily be overlooked as the cause, especially as children are likely to present as emergencies and may not be seen initially by a professional experienced in child abuse, and when the clinical priority will be to dress the wound. Unfortunately the clues as to the aetiology will be most apparent at the initial presentation, and a high level of suspicion is needed at this stage if the correct cause is to be identified.

Burns are a common method of child abuse. American studies have reported a 9–25% incidence of child abuse in paediatric burn victims who are admitted to hospital,^{44–49} although in

Britain a lower incidence has been reported,⁵⁰ possibly reflecting previous underreporting. Younger children are more often affected in the age range from five months to six years, and there is a peak in older toddlers (third year) in contrast with other forms of physical abuse, when infants are most at risk.^{46–51}

Contact or dry burns in abuse can arise from a wide range of household appliances: irons, curling tongs, heated metal implements, heating grids, light bulbs, radiators, and relatively commonly from cigarettes. They result in a positive image or brand mark and the object used may be easily identifiable.^{52–55}

CIGARETTE BURNS

Cigarette burns are a common diagnostic problem. Staphylococcal bullous impetigo is important in the differential diagnosis and often results in confusion. To make a definite diagnosis of cigarette burns there must be at least two lesions the diameter of a cigarette end.

BATH SCALDS

The recognition of non-accidental bath scalds presents difficult problems for the clinician, in particular when giving evidence in court. These are significant injuries, often leading to lifelong scarring. The numbers of cases seen by individual paediatricians are small, even if they have a special interest in child protection. Consultant plastic surgeons may not have an extensive experience of child protection.

We have studied this problem.⁵⁰ From our results and from an examination of published reports, we have identified some factors that may be of help in recognising abuse in this situation (table 1).

Our findings are consistent with the pattern of injury that might be expected in a child who is held in a premeditated way in hot water. The injuries are likely to be more severe and to have a clear cut off point when prolonged contact with hot water is maintained. A child who accidentally falls into the bath or is exposed to running hot water will quickly try to withdraw and will suffer irregular scalds.

A forced immersion burn area with a central area of sparing, resulting in a "doughnut" appearance, has also been reported. This occurs when the child's buttocks are pressed against the bottom of the container.^{52–56}

Abdominal injuries

Abdominal injuries are a rare but definite feature of abuse in childhood. They may be fatal; there was a 45% mortality in one American study.⁵⁷ The features that differentiate abuse from accident have not been fully

Table 1 Features suggesting non-accidental bath scalds

Accident	Forced immersion
Irregular geographical marks	Clear tide mark with more than erythema
History which fits the injuries	Story does not fit injuries or no real story
No associated injuries	Associated injuries
Asymmetrical	Symmetrical
Less likely to be severe	More likely to be severe

delineated; however, abuse must be considered in cases of abdominal injuries where there is no clear explanation. Abdominal injuries can involve the rupture of any abdominal organ including liver, spleen, pancreas, and bowel. There is some suggestion that injuries to the small bowel may be more common in abuse than after accidents.⁵⁸ Internal abdominal injury must also be suspected with cases where abdominal bruises are caused by abuse.

Munchausen syndrome by proxy and non-accidental suffocation

Physical injury occurs in some cases of the Munchausen syndrome by proxy.⁵⁹ There are also cases of two related conditions, non-accidental suffocation and non-accidental poisoning.

Non-accidental suffocation can be fatal; some cases of sudden infant deaths are caused by deliberate suffocation, though it is difficult to know how many. In our follow up of a series of cases of non-accidental suffocation in the United Kingdom,⁶⁰ we found that there were many who had siblings who died from supposed sudden infant death syndrome. This suggests that the risk of further abuse in a sibling is at least 50%.

In living children, non-accidental suffocation should be considered in cases where there is petechial bruising on the head, neck, and face. Ligature marks can also sometimes be seen. Cases of non-accidental poisoning usually present with bizarre symptoms rather than with poisoning as such.

Bites

Children may receive bite marks from adults, other children, or animals. They are a common problem in children presenting for medical attention and in day care settings. Many of these bites are easily explicable and do not cause concern; however, some do raise the possibility of abuse. The assessment of bite marks when child abuse is suspected poses significant challenges for the clinician. It may be difficult to determine whether bruising and abrasions are caused by a bite, because bite marks are often incomplete, distorted, and change over time. Bites may also be confused with skin eruptions.

Wherever possible it is important to determine whether bites are caused by an adult, a child, or an animal. If caused by an adult, the bite marks may enable the perpetrator to be identified. Procedures for assessing bite marks are therefore potentially of great importance in possible child abuse, especially if the child is unable to provide information about how the bite took place.

We have found that a partnership between paediatricians and a forensic dentist is essential. We have described such a partnership started in our area of south Wales.⁶¹ We concluded that:

- the assessment of the forensic dentist is a valuable part of the team assessing the potentially abused child;
- human bites can be discriminated from those of animals;

- adult bites can be differentiated from those of children, and half the adult perpetrators can be identified.

Non-accidental drowning

Small children may be deliberately drowned. Sometimes the differentiation between abuse and accident can be difficult as small babies may drown accidentally if they are left in the bath unattended. The work of Kemp and her colleagues is helpful. In a study of drowning in the whole of the United Kingdom,⁶² they found that there were no cases of accidental bath drowning over the age of 18 months. All the cases over this age were drowned because of abuse or epilepsy.

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Medical Anniversary

Camille Guerin, 22 December 1872

Camille Guerin (1872–1961) was born in Poitiers, son of a public works contractor. He graduated as a veterinarian (1896) and then became an assistant to Calmette at the Pasteur Institute, Lille. Together they produced Bacille Calmette-Guerin (BCG) for protection against tuberculosis. The new BCG laboratories in Paris were opened in 1931 and Guerin became its chief. He died in Paris on 9 June 1961 and was buried at Châtelleraut near Poitiers, where a town, a hospital, and a lycée now carry his name.—D G James