

## REVIEW

### The pathology of child abuse

Bernard KNIGHT, MD, FRCPath, DMJ (Path).

*Professor of Forensic Pathology, Wales Institute of Forensic Medicine, United Kingdom*

Though the problem of child abuse is largely one for clinical paediatrics, unfortunately a proportion are fatal and become extremely important medico-legal problems for the pathologist.

Child abuse has a number of synonyms such as "non-accidental injury" (NAI) and the "battered child syndrome." It was formerly thought to be a phenomenon of westernised countries, especially Northern Europe, North America and Australasia, but it has recently been recognised to be almost universal and even an increasing problem in South East Asia.

Child abuse covers a wide spectrum including psychological and sexual abuse, but we are here concerned with severe physical abuse which ends in death. It has been estimated that of children who are non-accidentally injured on a first occasion, about 60% will receive further injuries in the future and up to 10% will be killed, if no intervention is made. In addition to fatalities, very many infants and children suffer permanent disability, including severe neurological damage, so that the total harm resulting from this condition is very considerable.

Fatal cases are really an extension of the severe clinical cases where the lesions are beyond treatment and death occurs. The most common cause of death in child abuse is head injury, notably subdural haematoma and brain damage. The second most common cause of death is intra-abdominal injury to an organ, especially liver and intestines.

The syndrome first came into prominence in the West in the 1950's, when an American radiologist Caffey, described a series of cases where subdural haemorrhage was associated with long bone fracture. He had previously described a similar series in 1946, but then ascribed the cause of some natural disease. Later he first put forward the proposition that this syndrome, at first called Caffey's syndrome, was due to parental violence. From that time on a flood of publications ensued, mostly in North America and Europe until the problem now forms a major part of paediatrics. Incidentally, though the

modern history of the syndrome is ascribed to Caffey, in fact a forensic pathologist, Professor Tardieu of Paris described a classical series of child abuse in the middle of the 19th century, even including descriptions of subdural haemorrhage though radiology had not yet been invented. This was forgotten for almost a century until rediscovered by Caffey.

#### Pathology of fatal child abuse

One of the early papers on fatal child abuse was that by Cameron, Camps and Johnson, who coined the phrase "the skin and bones tell a story which the child is too young or too frightened to tell." This indicates that objective signs of child abuse must be sought mainly in the skin and by skeletal radiology, before a fatal outcome leads to an autopsy.

One of the hallmarks of child abuse is skin bruising due to rough parental or guardian's mis-handling. A child is often grabbed by the most convenient part of the infant, which is likely to be a wrist, elbow, ankle or thorax. Gripping of the wrist and forearm, for example, may leave a number of small circular bruises of 1-2 cm size due to pressure of adult fingers. These may also be seen on the upper arms, especially on older children, and around the ankle and calf. They are less often present around the neck but may be present on the jaw margin and cheeks from gripping the face.

When a small child is grasped around the thorax by adult hands, sometimes bruises are present around the lower ribs either laterally or sometimes anteriorly. Bruises on the abdomen may be due to heavy prodding by fingers.

In addition to gripping, bruising from slaps and punches is common. Again the conveniently presenting parts of the body suffer most, such as the pinnae of the ears and the face. The mouth and lips are often slapped and a characteristic injury, apart from bruising and swelling of the lips, is bruising and tearing of the inner surface of the lips. If the child is old enough to have

teeth there may be lacerations from the lips being pressed against the teeth, but in smaller edentulous infants, a characteristic injury is tearing of the frenulum in the centre of the upper lip bridging to the gum. An injury here is almost pathognomonic of a sideways slap across the mouth, the only alternative being the forceful and mis-directed entry of the teat of a feeding bottle in a small infant. Bruises may be present on the cheeks and around the eyes, sometimes with small scratches from finger nails.

One of the characteristics of the child abuse syndrome is repetition over a period of time, so it is important to determine if bruises are of different ages. The colour changes from blue-red through brown to green and yellow may be difficult to determine if deep racial pigmentation is present. Even in pale skins, it is not possible to accurately date bruises, even by histology. A bruise will begin to change colour in about 2-4 days, smaller ones changing more quickly. Haemosiderin will appear histologically in a minimum period of 36 hours. Even approximate estimation of the date of a bruise is important, as the excuse may be made that a child's injuries occurred during a single innocent accident, but if bruises of different ages exist, this cannot be true.

A large proportion of abused children have internal eye damage and clinicians are alert to the necessity of ophthalmoscopic examination to look for retinal haemorrhages, vitreous bleeding and displaced lenses. The pathologist may be able to detect intra-ocular bleeding by direct vision, but should also always examine the interior of the eye wherever facial or head injuries are suspected, either by total enucleation of the eye or by removing the posterior half of the globe following removal of the orbital plates of the anterior fossa.

Another fairly common lesion is the bite-mark, seen almost anywhere on the body, especially arms, face and buttocks. The marks consist of two opposing curved bruises, sometimes with abrasions. The excuse may be made - some times correctly - that the bite was from another child or even animal. Wherever possible, an experience dentist should examine the bite to compare it with the teeth of any alleged suspect.

### **Head injury**

As mentioned earlier, head injury is the most common cause of death in child abuse. There may be external injuries on the scalp, though these are often absent especially if the child has

been thrown against a flat surface such as the wall, floor etc. Dropping or throwing is more common than a blow upon the head and in child abuse it is not uncommon for a weapon to be used, though a heavy blow with a hand or fist might be considered a weapon.

The exterior of the scalp may be normal, but on reflecting the scalp at autopsy, extensive and sometimes multiple areas of haemorrhage may be seen beneath the galea.

The skull may or may not be fractured, even in cases with extensive intra-cranial damage. The infant's skull is more flexible than the adult and for a given impact relative to the thickness and size of the skull, is less likely to fracture, as deformity can resolve more readily, as illustrated by pressing a table-tennis ball when up to a certain threshold, the distortion will recover on release of the pressure.

However, fractures are common and are most often seen in the parietal area. A common fracture is one which crosses the parietal bone to either the fronto-parietal suture or up to the sagittal suture. Some of the latter fractures may cross over into the contra-lateral parietal bone, often with a step-wise shift for a short distance along the sagittal suture forming a "Z" shaped fracture. The fracture need not be directly beneath the scalp haemorrhage or point of impact, as fractures occur along lines of weakness in a distorted skull, which may be some distance from the impact point. Along the fracture line there is commonly haemorrhage beneath the epicranium, the periostium over the exterior of the skull. Where raised intracranial pressure has followed survival following a head injury, the fontanelles, if still open may be tense and bulging.

Inside the cranium, the classical lesion in child abuse is a subdural haematoma. Extradural haemorrhage is rarely seen in infant head injuries. The subdural haemorrhage may be only a thin film over the surface of the cerebral hemispheres, sometimes extending down onto the interior of the base of the skull. Other haematomata may be extensive space-occupying lesions, either unilateral or bilateral. The blood escapes from cortical veins, especially where they bridge to venous sinuses in the dura.

The brain is rarely lacerated except in very severe injury, but may show cortical contusion, either under the area of impact (the "coup" lesion) or, if the child has been thrown and decelerated against a fixed surface, may be on the opposite side of the brain, the classic "contre-coup" lesion. Sometimes if the impact is on the top of the head, there may be contre-coup damage

on the undersurface of one or other of the cerebral hemispheres.

It must be noted that subdural haemorrhage and brain damage can occur without actual impact. The most common situation is violent shaking, which can cause either lesion. It is now known that both in adults and children, fatal brain damage can occur from pure acceleration or deceleration of the head, usually with a rotary movement but sometimes even in a linear direction, without any actual contact of the head with a hard surface or a blow on the head. This type of damage may give rise to subdural haemorrhage, cerebral oedema or diffuse axonal injury (DAI), the latter being visible microscopically after 15-18 hours' survival. Histologically, axonal bulbs due to leakage of axoplasm may be visible either in H&E or silver stains. After a further delay, microglial reaction may be detected around damaged axons and this may be best seen in thick sections (20 microns) stained with Cresyl Blue. However, it has to be admitted that the histological proof of DAI is less obvious in children than in adults.

Intraocular haemorrhage should be looked for in all infant head injuries, as these can occur from direct injury, shaking or the secondary results of raised intracranial pressure. Retinal haemorrhages are the hallmark, but vitreous haemorrhage is also sometimes seen.

### **Abdominal injuries**

The second most common cause of death in fatal child abuse is a rupture of an intra-abdominal organ. Probably the most common is perforation of the gut and a typical lesion is injury or transection of the duodenum where it crosses the front of the vertebral body. A blow in the abdomen can crush the gut against the bone at this point and sever it almost as cleanly as a scalpel. Alternatively, the gut may be badly bruised and become non-viable, causing a necrotic rupture some days later, with fatal peritonitis. Apart from the duodenum, the intestine elsewhere may be injured by a blow on the front of the abdomen.

Another common organ to be injured is the liver as heavy prodding or blows on the upper abdomen or even lower chest can cause tears in the soft infant liver with consequent haemorrhage.

The spleen is rarely injured in child abuse, though instances are on record. Other organs in the abdomen, such as the kidneys and bladder are rarely injured except in unusual cases of

extreme violence. The pancreas may be damaged in the same way as the duodenum, where it crosses the vertebral column. Haemorrhage and fat necrosis may occur and if survival for some time takes place, then pseudo-cysts may develop.

### **Radiological appearances**

This is mainly a matter for radiologists, but if a suspected child abuse death occurs, then if no clinical radiological skeletal survey is available to the pathologist, it is imperative that a post mortem full-body X-ray be obtained before commencing the dissection. One of the features of child abuse is repetition and therefore skeletal radiographs may show fractures at different stages of evolution. Recent fractures, of both skull, ribs and long bones may be accompanied by evidence of old callus, and also sub-periosteal calcification. Some of the characteristic old lesions include:

- (1) Multiple callus formation in the posterior part of the ribs, in the paravertebral gutters, showing up on X-ray as a "string of beads" running vertically down adjacent to the spine. These are due to old fractures from lateral compression of the thorax, sometimes from adult hands in the axillae pressing inwards during a shaking episode. Anterior fractures of the ribs are less common and although there is some dispute, it seems possible that some, especially on the left, may be due to inept external cardiac massage during attempted resuscitation, though these are said to be very rare in children compared to adults.
- (2) When a long bone is grasped or twisted, the rather loose periosteum in infants may be raised and a sub-periosteal haematoma formed. This calcifies over the course of some weeks and presents a characteristic spindle-shape lesion over the shaft of long bones such as the femur.
- (3) Damage to the metaphyses and epiphyses (especially at the large joints like elbow and knee) are common. The lateral edges of the bones are chipped and avulsed and present a characteristic appearance to an experienced radiologist.
- (4) Fractures of long bones occur and transverse and spiral fractures due to twisting and shearing strains are almost pathognomonic of abuse in small infants.

### The autopsy in suspected child abuse

As with all autopsies, especially paediatric autopsies, particular care must be given to the history and to the external appearances. As just mentioned, it is essential that full body radiology be carried out before the commencement of the autopsy, as it is less satisfactory to have to obtain this once the body cavities have been opened.

It is unusual to attend the scene of a child abuse case, as most infants die in hospital, or are dead on arrival at an Accident and Emergency Department. Sometimes in retrospective, the scene may be visited because of allegations that the child fell from some chair or other object.

The clothing is also usually of little value compared to other types of forensic case and most of the information has to be derived from the interpretation of injuries.

The exterior of the body must be examined carefully for bruises and it is always best to return to see the body a day or two after the autopsy, as it is well known that bruises can appear which were not visible originally and that faint bruises become more accentuated. However, one must be aware of later artefacts on the body, such as the common development of "bruising" around the skull at the line of reflection of the scalp or where the skull cap has been removed.

Every injury should be measured according to its size and its anatomical position, the latter being measured to nearby anatomical landmarks. Photographs should always be taken, usually by the police, but these may be added to for the pathologist's own benefit and for teaching purposes.

All body parameters should be measured, including the weight, crown-heel length, crown-rump length and foot length, together with head circumference. It may be important to relate the development of the child to normal expectations, if any allegations of associated neglect exist.

The interior of the mouth should be examined, especially the frenulum and if the child is old enough to have teeth, to determine whether any injuries on the inside of the lips have occurred from slapping. Some pathologists look in the eyes post mortem with an ophthalmoscope; this admittedly needs considerable experience and cannot be done after any appreciable postmortem interval, due to clouding of the cornea. However, it is sometimes possible to visualise retinal haemorrhages by this means.

The anus and genitals should be examined. Although sexual abuse is common in clinical cases, it is unusual in fatal child abuse of the common chronic type. The murder of a child is unfortunately often associated with sexual assault, but this acute type of homicide is not really typical of the repetitive child abuse syndrome.

However, the female genitalia and the anus in both sexes must always be carefully examined. It is important to realise that the anus in dead children is patulous and dilated and should not be mistaken for sexual assault unless there is associated damage to the anal margin, such as tearing, bruising or bleeding. The mere openness of the canal, so that the interior mucosa is visible is not sufficient evidence of sexual penetration.

In the female infant, the usual signs of sexual assault must be looked for such as bruising, bleeding, tearing etc, but these are usually outside the typical child abuse situation.

Internally, a full careful dissection with weights of all organs, full histology and photographic recording of any abnormalities is required. In head injury, the skull should be opened carefully. In children under about 3-4 months, the skull can be opened by cutting carefully along the suture lines, but at older ages it may be necessary to saw off the skull in the adult fashion. Any subdural blood should be photographed and measured in volume. All brains suspected of injury should always be fixed in suspension in formalin and no attempt made to cut them until full fixation has taken place, even if this means a delay in the final report to the appropriate authorities. Full brain histology should be carried out, and if there is a period of survival between the assault and death, then diffuse axonal injury should be sought microscopically.

In the abdominal cavity, where visceral injury has occurred, then the amount of blood or other fluid in the peritoneal cavity should be measured. Careful exploration of the abdomen should be carried out before any dissection, in order to detect any rupture of an organ or perforation of the gut etc. Intra-thoracic injuries are unusual in child abuse but the procedure should be similar to that in the adult.

Though toxicology is rarely relevant, it is best to keep blood and urine samples in case some circumstance calls for laboratory analysis.

Where fractures have taken place in the past, the bones should be retained and decalcified so

that histological attempts can be made to put an approximate date on the fracture, though admittedly this is very difficult within wide ranges of time.

### **Problems in interpretation of autopsy findings**

There are many problems in the differentiation of true accidents to children and deliberate abuse by parent or guardian. It is almost as bad to falsely accuse an innocent parent, as to miss a real culprit, so the doctor has a heavy responsibility. The standard of proof in criminal cases is very high, so only quite definite facts should be put forward as evidence of abuse. Very often, it is not for the medical witness to make this decision, but to honestly state the facts and not over-interpret them to the legal authorities.

One of the most common problems is the causation of head injuries. A fractured skull may be said to be due to a simple fall from a couch, chair, bed or father's arms. There are many conflicting views in the literature about the height of fall needed to cause fatal head injuries, but they are unlikely to occur from a fall on to a hard floor of less than adult waist height. Shaking the heavy, limp head of a small baby can easily cause sub-dural bleeding and diffuse axonal injury, without any actual impact on the head.

Squeezing the chest can cause posterior rib fractures and even heavy 'prodding' of the abdomen with adult fingers can rupture a liver.

### **Conclusion**

The tragic situation of fatal cot death is a problem which taxes the pathologist to the full, not only in the technical aspects of the autopsy, but in interpretation. There is a vast literature on the pathology of child abuse and the pathologist should try to keep up-to-date with this, especially in the field of head injuries, as new findings are constantly being published.

