Radiological features of child maltreatment

Amaka C Offiah

Abstract

Child maltreatment is serious, highly prevalent and topical. Approximately 1% of children are neglected or psychologically maltreated and 4%—16% are physically abused each year.

Once child abuse is suspected, the radiological investigation must include a full skeletal survey and a computed tomography or magnetic resonance imaging brain scan. These should be followed by a repeat chest radiograph 10—14 days later. The radiological investigation is **not** complete without the follow-up chest radiograph.

While no single injury is in itself diagnostic, there are certain findings that prompt the radiologist to suspect abuse. These include multiple fractures of varying age, long bone fractures in a non-ambulant infant, unexplained injuries, an explanation incompatible with the identified injury, multiple and differing explanations for the same injury, and certain fractures rarely seen in infants and young children except following major trauma (e.g. spine, scapula, pelvis).

The role of the radiologist is to offer a mechanism for the identified injury, to date the injury and to exclude underlying skeletal or metabolic disease.

The radiologist does not work in isolation, and close collaboration is required between radiologists, paediatricians, geneticists, pathologists, etc. in order that a correct and timely diagnosis is reached.

Keywords bone; bone diseases; child abuse; fractures; fracture healing; metabolic; radiography

Background

Child maltreatment includes non-accidental injury, emotional abuse, sexual abuse, neglect and fabricated or induced illness. It is a serious issue, highly prevalent and topical in the UK and around the world. It is estimated that each year approximately 1 in 10 children is neglected or psychologically maltreated, while between 4% and 16% are physically abused. In the UK, for the year ending 31st March 2011, there were 50,552 children subject to a child protection plan, compared to 34,623 for the year ending 31st March 2007.

The physical abuse of a child by an adult or adults responsible for the care of that child most commonly occurs in children less than 2 years of age. These children and infants are neither able to vocalize their symptoms nor are they able to localize their pain. In the worst-case scenarios, they do not survive the traumatic episode.

Close collaboration is required between the various health specialists, social workers, police, etc. involved with child protection. The clinician must not only take a detailed history but must relay key points of that history and clinical examination to the radiologist. A radiologist identifying an unexpected injury (e.g. a rib fracture on a chest radiograph taken for suspected pneumonia) must relay this to the clinician. Pathologists and radiologists should be aware that their findings may be complementary and not contradictory; e.g. histology is superior to radiology for the identification of acute rib fractures, but inferior to radiology for the identification of healing rib fractures.

Sites of clinical bruising may not necessarily indicate underlying bony fracture; conversely fractures may occur without overlying clinical bruising. The history cannot be taken from the children themselves and the radiological hallmark of child abuse is the finding of multiple unexplained fractures of varying age. For these reasons, when child abuse is suspected, a full skeletal survey must be obtained. Not only this, but the radiographs must be of high quality in order to correctly identify the often subtle fractures that are an indication of physical abuse.

The skeletal survey

Once abuse is suspected, imaging must be performed. Any child in whom abuse is suspected must have a complete skeletal survey. In the UK, this should be based on the Royal College of Radiology (RCR) and Royal College of Paediatrics and Child Health (RCPCH) guidelines, and a recommended schedule is shown in Table 1.

Imaging should be of high quality, ensuring the absence of artefact (e.g. jewellery, assistant's hands ECG leads, etc.). Full details of the child, the date of imaging and the operators' initials should be recorded; remember that images may subsequently be required as evidence should the case proceed to Court.

A suitably experienced radiologist should supervise the procedure and review all images before the child leaves the imaging department. This radiologist is responsible for ensuring that adequate views of all sites are available and that a complete survey has been performed. It is highly recommended that all skeletal surveys in suspected abuse are double-reported and that at least one of the reporting radiologists has an interest (if not expertise) in paediatric imaging. Generally speaking, although it is advisable to have an authorized report within 48 hours of the child's presentation, the skeletal survey is not an emergency procedure and is best performed within working hours.

Skeletal injuries in child abuse

Any skeletal injury may occur in a child in the context of accident, disease or abuse, and no one single injury is pathognomonic of the latter.

The radiological hallmark of abuse is the identification on the skeletal survey, of multiple fractures of varying age. Other indicators of abuse include long bone fractures in a non-ambulant infant, unexplained injuries, an explanation incompatible with the identified injury, and multiple and differing explanations for the same injury. The radiologist should therefore have some idea of the mechanisms that lead to specific fractures and the likely forces

Amaka C Offiah *BSc MBBS MRCP FRCR PhD FRCPCH is HEFCE Clinical Senior Lecturer at the University of Sheffield, Academic Unit of Child Health, Sheffield Children's Hospital, Sheffield, UK.* *Conflict of interest: Dr Offiah acts as an expert witness for Her Majesty's Courts in cases of suspected child abuse and lectures widely on the topic, occasionally receiving remuneration.*

Recommended imaging in suspected child physical abuse (modified from RCR and RCPCH guidelines)

Site	Routine		As indicated	
	Projection	Comment	Projection	Comment
Skeletal	Skull: anteroposterior (AP) and lateral	In addition to CT head		
	Townes	If occipital injury suspected		
	Chest: AP	Including the clavicles		
	Left and right oblique	To show the ribs		
	AP	10–14 days after initial survey		
	Abdomen: AP	Including pelvis and hips		
	Spine: lateral (cervical, thoracic and lumbar)	AP spine visible on AP chest and AP abdomen		
	Limbs: AP upper arms	Image both left and right upper and lower limbs	Immediate and or delayed coned AP and / or lateral	Of suspicious or poorly visualized sites
	AP forearms			
	PA hands	Ensure separate views of hands and feet		
	AP thighs			
	AP lower legs			
	PA feet			
Neurological	CT head	Day 1 (no contrast, before CT abdomen/chest)		
	MRI head	Day 3–5 (if initial CT is abnormal)		
	MRI head	3–6 months (for prognostic information)		
Abdominal/thoracic	Abdomen/chest		CT	With contrast
	Abdomen/chest		US	As adjunct to CT

Table 1

Fracture mechanism and specificity for abuse

Specificity for abuse	Site	Mechanism
Low	Skull (simple, linear, parietal)	Direct impact, forces equivalent to a fall from 3.5 to 5 feet
	Diaphyseal (ambulant child or child with neurological deficit)	Spiral/oblique: twisting force
		Transverse/angulated: direct/blunt impact or levering force
		Impacted: direct force along length of bone
Moderate	Skull (simple, linear, non-parietal)	Direct impact, forces equivalent to a fall from 3.5 to 5 feet
	Metaphyseal	Twisting, pulling, grabbing
	Humerus	Lateral or supracondylar: hyperextension of elbow
High	Diaphyseal (non-ambulant infant)	Spiral/oblique: twisting force
		Transverse/angulated: direct/blunt impact or levering force
		Impacted: direct force along length of bone
	Isolated subperiosteal new bone formation	Gripping, twisting and shearing force
	Epiphyseal fracture/separation	Complex forces involving hyperflexion/hyperextension/pulling
	Metacarpals, metatarsals, phalanges	Forceful gripping/squeezing of hand or foot
		Twisting/bending
		Direct impact
	Skull (complex, crossing sutures)	Direct impact, forces equivalent to a fall from at least 6 feet
	Vertebral body	Hyperflexion/axial loading (may also be a rotational component)
	Scapula	Acromion: rotation/traction applied to shoulder/upper limb
		Body: uncertain (possibly direct impact)
	Rib	Arc: compressive/squeezing
		Costochondral: direct impact, squeezing with thumb at CCJ[a]
	Superior pubic ramus	Uncertain (possibly direct impact)

[a] CCJ = costochondral junction.

Table 2