Radiological features of non-accidental skeletal injury

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Abstract

Imaging plays a significant role in confirming the extent of non-accidental skeletal injury (NASI) and excluding any predisposing cause. Most NASI occurs in the pre-mobile child, where a clear history of injury is not always evident. In the older child the history is crucial to differentiating accidental from inflicted injury.

When one injury is found, a skeletal survey is usually performed that may reveal other bony injuries or an underlying bone disorder. Whether the presenting injury is skeletal or not, a skeletal survey is important to detect occult injury in an infant presenting with symptoms of non-accidental injury. This should be performed to the agreed standard and checked by a radiologist for adequacy. The local radiologist should offer an opinion and refer onwards for a specialist opinion if they lack experience in paediatric trauma imaging. Supplemental or follow-up radiographs may confirm a diagnosis of non-accidental injury and assist in dating fractures.

Clear communication by the radiologist is important for management, and forensic assessment re-timing, anticipated mechanism and symptoms of injury for the fractures identified. This involves multidisciplinary clinco-radiological correlation.

Common presentation of NASI includes a fracture that is either unlikely from the child's developmental level, or an explanation for an injury that alters between seeing the general practitioner, Accident and Emergency department and paediatrician. A careful family history and clinical examination are needed to identify any predisposing disorder, supplemented by imaging and appropriate laboratory investigations.

Multidisciplinary working is essential to enable paediatricians, radiologists, child protection services and the police to assist the court to determine the true cause of injury.

Keywords child abuse; non-accidental injury; paediatric skeletal injury; radiography

Introduction

Skeletal injury is only one part of the spectrum of paediatric non-accidental injury (NAI), including bruising, head injury, thermal injury, neglect or other forms of maltreatment such as sexual abuse. Skeletal injury may be an isolated problem or occur combined with other injuries. Non-accidental skeletal injury (NASI) is a common presentation in the infant – e.g. a baby presenting with a limp or swollen limb due to a fracture.

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An infant who has feeding difficulty or cries persistently may provoke a frustrated carer to apply inappropriate force causing NASI in the pre-mobile child. NASI should be considered with unexplained skeletal injury, or an injury that does not match the explanation offered by the carers. A first attendance at the emergency department (ED) may be misdiagnosed as an accidental injury, but repeated attendance for trauma is suspicious. The first responsibility of a doctor is to ensure the child is assessed thoroughly, to protect the child from further harm, and to ensure placement where it is not at risk. This may mean separation from carers until matters are resolved.

Accidental fractures are common in older children, but occasionally can be inflicted due to forceful handling, hitting, kicking or with deliberate intent.

Further investigations are performed to exclude any underlying bone disorder and to try and determine how the injury occurred. Carers may not be forthcoming as to how a solitary fracture occurred if it was due to carelessness, or may conceal if they fear criminal prosecution or the children being 'taken away' if they reveal the truth. When carers cannot or will not give an adequate account for injuries this raises suspicion of NAI.

Epidemiology

The true incidence of all forms of NAI is unknown, possibly up to 10% of all children. There is a risk of an escalating pattern of injury if the child is not protected. NAI is potentially fatal – 250 children die from NAI in the UK annually, others may have residual disability. About 50% of all fatally injured children are seen by a healthcare professional within the preceding month.[1] A total of 80% of abusive fractures occur in children under 18 months old. A total of 85% of all accidental injury occurs in children over 5 years old.[2]

Clinical assessment

The role of the general practitioner (GP) and ED staff is critical, as they may be the first to suspect NASI. Paediatric input at triage can improve risk assessment although the overall incidence is low.[3] If an infant presents with a suspicious injury, a complete clinical examination and accurate history are vital. The history of injury is suspicious for NASI if it changes on serial telling or produces various accounts of increasing in force almost matching what the paediatrician expects.

A thorough history of injury should be taken from the older child, preferably outside the carer's hearing. Children may not always tell the truth about how an injury occurred, whether accidental or inflicted, but a contemporaneous record assists.

Skeletal injury commonly presents via the GP or the ED. The paediatric experience of doctors or nurses in a general ED may vary, so there should be a close liaison with the paediatric team in all infants who have skeletal or other suspicious injury. Healthcare professionals should have a low threshold for referral to a paediatric assessment. The paediatrician determines whether further investigation is needed.[4]

The affected limb should have high quality radiography, reported by a radiologist. With any suspicious injury in children under 2 years of age, a full skeletal survey is performed to detect

clinically occult injury – especially skull, rib or metaphyseal fractures.

Consent for a skeletal survey

A skeletal survey looks for other skeletal injuries and helps exclude underlying bone disorders. The carers must understand why the examination is being performed before the child leaves the ward. The radiographer is not responsible for justifying the examination to an accompanying carer.

Gathering data

Skeletal survey

When there is a suspected NASI, a full skeletal survey is performed to detect other fractures and exclude underlying dysplasia. A senior paediatrician should liaise with radiology to ensure that the examination occurs when radiographers with paediatric experience are available, and have time to perform all the views. This usually occurs within normal working hours. If a skeletal survey is needed 'out of hours,' it should be discussed directly between consultants.

The accompanying nurse and radiographer are both responsible for ensuring continuity of evidence for forensic purposes by identifying the patient and marking the films correctly.[5]

Skeletal surveys are performed to agreed standards (see http://www.bspr.org.uk). This includes x-rays of all the bones of the body including localised views of all limbs, chest, pelvis, hands, feet, spine and skull. This is time-consuming and involves about 20 x-rays of individual bones, which can be exhausting for the child, carers and staff. Sedation is usually unnecessary. It is not acceptable to perform a single whole body x-ray (babygram). This gives poor quality imaging.

If the hands, feet or spine are excluded important information may be missed. Although fractures at these sites are uncommon in infants they imply forceful handling and are a marker for NASI. Vertebral collapse may also occur in osteogenesis imperfecta (OI).

Initially a single view is taken of each area, but supplemental localised views may be needed to confirm an abnormality, especially with metaphyseal fractures. A metaphyseal fracture may only be clearly visible on one of several views. Similarly frontal and both oblique views of the whole chest will detect more rib fractures than a single view, for minimal extra radiation dose.[6] A repeat full skeletal survey a few weeks after presentation may identify further fractures but as a minimum a follow-up chest film is essential.

A radiologist must view the images to ensure that they are technically adequate and all areas have been covered appropriately and decide if other views are needed before the child leaves the department. The radiologist should communicate their opinion to the referring paediatrician verbally and in writing, mentioning if their report is provisional or subject to later review by another radiologist.

The radiologist also advises on the need for follow-up radiographs of a limb, or ribs to assess suspicious areas as they start to heal (see later re-dating). These supplementary images needed for orthopaedic management. If the child is discharged to a place of safety, the paediatrician is responsible for co-ordinating additional imaging.

Follow-up imaging

When there are areas that are suspicious but unclear on the first skeletal survey further films may be needed – e.g. of an ankle or of a chest or long bone to assist in confirming a fracture or dating it. This can be difficult to achieve if moved to a place of safety outside the parental home. It is the responsibility of the paediatrician to ensure that the child returns for follow-up imaging as guided by the radiologist, since without further imaging some fractures may not be confirmed at all or dated accurately.

Although a skeletal survey may appear intrusive, to miss a case of NAI may have significant implications for the infant, especially if it is returned to the perpetrator and there are further injuries with escalating force. A child may return later with a more serious NASI or sustain neurological damage following a 'herald' injury.

Performing a skeletal survey rarely alters the management of the presenting injury, but is important for forensic imaging – that is, to aid the court in a full assessment. Accepting the limits of radiological dating, a skeletal survey may assist in including or excluding various parties from a pool of potential perpetrators of the injury(s) and influence final placement.

Head injury – is a skull film needed?

Computed tomography (CT) will identify intracranial complications of trauma but may fail to identify a skull fracture. Even if a head CT is performed, two views of the skull must be included in a skeletal survey to detect and characterise skull fractures. Skull radiography may also identify features of an underlying bone disorder (e.g. excessive Wormian bones in OI) that escape detection on axial CT.

In accidental injury in infancy, skull fractures are usually unilateral linear fractures of the parietal bone. Paradoxically this is the most common fracture in non-accidental head injury. There is usually a clear history of a hard impact following a fall from above adult waist height. Skull fractures that branch, cross suture lines and are widened (diastatic), multiple, occipital or depressed indicate a forceful injury suspicious for non-accidental head injury (see Figure 1).

Imaging siblings?

When one child presents with possible NAI, other children in the family are assessed. All co-twins should undergo a full skeletal survey as they have a high risk of occult injury. Current opinion is that all siblings aged less than 2 years should have a full skeletal survey performed.

If there is a significant suspicion of skeletal injury (e.g. pain or marks or deformity) in a child aged over 2 years, then localised views can be performed, supplemented by a chest film and skull films as a minimal survey. There is no clear scientific basis for when asymptomatic older siblings need a full skeletal survey. A full skeletal survey adds little if the older sibling gives a reliable history excluding skeletal trauma.

Paediatric nuclear medicine imaging

Nuclear medicine imaging (bone scanning) can be useful but it is best in selected circumstances. A small amount of radionuclide is given intravenously. This accumulates within the bones and