Chapter 9: Recognition of Physical Abuse

Good Practice Recommendations

1. The paediatrician needs to adopt a forensic approach to the assessment of a child with suspected physical abuse, matching the history to the clinical findings to determine the likelihood of intentional injury. Ask the question: 'Does the explanation match the clinical findings?'.
2. The explanation for injury should always be considered in the context of the child's development.
3. Children less than two years of age are at an increased risk of severe physical abuse. When physical abuse is suspected, thorough investigation to exclude occult injury (e.g. fractures, intracranial injury, retinal haemorrhages (RH) and intra-abdominal injury) is required:
    - A full skeletal survey with repeat imaging: a single skeletal survey will miss fractures and additional imaging according to the Royal College of Radiologists (RCR) radiological guidance[1] may be required
    - Computerised tomography (CT) head scan in children less than one year of age and considered between 12 and 24 months
    - Ophthalmology examination within 24 hours.

    This investigation strategy is not limited to infants and toddlers and should be considered according to severity of injury in older children.
4. Caution should be exhibited when ageing injuries. This is an imprecise science: fractures can be aged by a radiologist from inspection of the extent of healing on X-rays in broad time frames only. Bruises cannot be aged accurately from an inspection of their colour.

9.1. Introduction

9.1.1. This chapter provides a guide to the features of childhood injury that should raise suspicion of physical abuse and the assessment and investigations that should be performed to determine the likelihood of physical abuse.

9.1.2. The Royal College of Paediatrics and Child Health (RCPCH) Child Protection Evidence systematic reviews, formerly Core-info (Cardiff Child Protection Systematic Reviews), provide a summary of the scientific evidence to complement this chapter and are updated on a regular basis.

9.1.3. The following chapter uses the terminology of unintentional injury when referring to accidental injury in reference to current accepted international terminology.

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9.2. Physical abuse: medical history

9.2.1. Children under the age of two years are at an increased risk of serious physical abuse and are rarely able to contribute to the history themselves. A thorough investigation strategy is recommended to exclude occult injury.

9.2.2. Features in the history of an injury that raise suspicion of physical abuse include:

- A significant injury where there is no explanation
- An explanation that does not fit with the pattern of injury seen
- An explanation that does not fit with the motor-developmental stage of the child
- Injuries in infants who are not independently mobile. This age group rarely have accidental injuries
- An explanation that varies when described by the same or different parents/carers
- Multiple explanations that are proposed but do not explain the injury seen
- An inappropriate time delay in seeking appropriate medical assessment or treatment
- Inappropriate parent or carer response (e.g. unconcerned or aggressive)
- A history of inappropriate child response (e.g. didn't cry, felt no pain)
- Presence of multiple injuries
- Child or family known to children's social care or subject to Child Protection Plan
- Previous history of unusual injury/illness e.g. unexplained apnoea
- Repeated attendance with injuries that may be due to neglect or abuse.

9.2.3. **Taking a thorough history**

See Chapter 6.7.

9.2.4. A contemporaneous history must be carefully documented in terms of the timescale of the allegation and of events and circumstances leading up to the injury. Sufficient detail of the mechanism of injury should be collected to facilitate a decision as to whether the explanation given explains the injuries sustained.

9.3. Bruises

9.3.1. Bruising is the commonest injury in physical child abuse and distinguishing between unintentional and abusive injury is key[2].

9.3.2. As children acquire independent mobility they sustain bruises from every day knocks and falls.

9.3.3. **Unintentional bruising**

9.3.4. There is scientific evidence for the frequency and location of unintentional bruising. The pattern of unintentional bruising is strongly influenced by the child's level of independent

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mobility, with non-mobile infants least likely to sustain bruises. Unintentional bruises in pre-mobile infants are rare, with a prevalence of <1%[3].

9.3.5. Once children move independently, the prevalence of unintentional bruises increases. Bruising is found over the front of the body predominantly over bony prominences, the commonest site being the knees and shins[2].

9.3.6. In young mobile children, unintentional bruising to the head occurs predominantly in a 'T' shape across the forehead, nose, upper lip and chin[4].

9.3.7. Bilateral black eyes may follow blood tracking down from the forehead following an impact injury. This may involve the skin around the eyes but not the orbit. If this is unintentional, there should be a consistent account of a preceding incident (i.e. a memorable event).

9.3.8. **Abusive bruising**

9.3.9. Infants who have yet to acquire independent mobility (rolling/crawling) should not have bruises without a clear explanation.

9.3.10. All bruises that raise suspicion of physical abuse should be carefully assessed according to the developmental level of the child.

9.3.11. Abusive bruises are often located away from bony prominences and are found predominantly over soft tissue areas. Sites include the ear, neck, cheeks, buttocks, back, chest, abdomen, arms, hands and posterior thigh. However, no site is pathognomonic and a careful history must be taken in all cases.

9.3.12. Abusive bruises are often multiple and occur in clusters which may be 'defensive bruises'. These occur on the upper arm, to the outside of thigh, or on the trunk and adjacent extremity.

9.3.13. As with other injuries, any underlying medical condition that may predispose a child to easy bruising must be excluded.

9.3.14. Examples of alerting features suggestive of physical abuse are shown in Table 1.

Table 1. Alerting features that are suggestive of physical abuse[5]

- Bruising or petechiae, not caused by a medical condition such as a coagulation disorder
- Bruising in children who are not independently mobile
- Multiple bruising or bruises in clusters
- Bruises that are away from bony prominences
- Bruises to the face, eyes, ears, trunk, arms, buttocks and hands
- Bruises that carry the imprint of a hand, ligature or implement used

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9.3.15. **Specific patterns of abusive bruising:**

- Extravasation of blood: tracking of blood along tissue planes may distort the precise location of the original injury, e.g. blood from scrotal or penile bruising may track into the suprapubic area, resulting in a diffuse, triangular-shaped bruise, the apex being the original injury
- Petechial haemorrhages: petechiae in association with bruising are a strong predictor of abusive injury[6]
- Patterned injuries from positive or negative imprint: a bruise pattern commonly mimics the object used to create the impact[7] (e.g. imprint of a buckle of a belt, hairbrush or fingertip bruise or grip mark). Following a high-velocity injury, an unbruised negative image may be outlined by a fine rim of petechiae. At the margins of a high-velocity impact, capillaries can be stretched sufficiently to tear them. This may occur even when the force does not crush directly impacted vessels. Greater forces rupture the vessels that are directly impacted, creating a positive image bruise of the object used
- Bruises associated with sexual abuse include lower abdomen bruises, grip mark patterns around buttocks, top of the thighs, and genitalia.

9.3.16. **Ageing of bruises**

9.3.17. A bruise cannot be aged accurately from clinical assessment or from a photograph[8]. At this point in time, the practice of estimating the age of a bruise from its colour has no scientific basis and should be avoided in child protection proceedings. Terms such as ‘fresh’ or ‘old’ bruising should be avoided cannot.

9.3.18. While the existing studies are based on a small number of children, they do demonstrate that there is wide variation in intra and inter-observer variability in their accuracy of ageing bruises from their colour, both in-vivo and in photographs[8].

9.3.19. Different colours appear in the same bruise at the same time. In general, red/blue and purple colours are more commonly seen in bruises <48 hours old and yellow, brown and green bruises are more often seen in bruises over seven days. However, red/blue and purple can be identified in up to 30% of bruises older than seven days and yellow/brown or green can be seen in up to 23% of bruises less than 48 hours old. The observation that yellow bruising is not seen before 24 hours is based on only a small number of cases[9].

9.3.20. **Unintentional bruising in disabled children and young people**

9.3.21. Recent studies of bruising patterns in disabled children showed that the dorsum of the feet, thighs, arms, hands and trunk are sites of unintentional bruising. This is thought to be due to knocks during transfers or bumps from wheelchair users[10].

9.3.22. Bruising to the hands, arms and abdomen were significantly more common in disabled than able-bodied children[10,11].

9.3.23. Bruising increases with increasing independent mobility[10].

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9.3.24. **Differential diagnosis of bruising**

9.3.25. Bleeding disorders that may present with bruising:

- Defects in primary haemostasis (the formation of platelet plugs at the site of injury) result in bruises, petechiae and bleeding from mucosal membranes. Disorders include: Von Willebrand disease, Idiopathic Thrombocytopenic Purpura, inherited disorders of platelet function (e.g. storage pool disorder, Glanzmann's thrombasthenia)
- Defects in secondary haemostasis (coagulation factor cascade) results in bruising and bleeding in deeper tissues such as muscle, joints and internal cavities. Disorders include: coagulation disorders (e.g. Factor VIII deficiency, Factor XIII deficiency), vitamin K deficiency, drugs (Warfarin, Heparin).

9.3.26. Unusual bleeding out of proportion to the purported injury should be carefully assessed and investigated.

9.3.27. An abnormal result from a coagulation screen may not be associated with bleeding (e.g. Factor XII deficiency) and therefore may not be a sufficient explanation for the bruising seen[12].

9.3.28. Both physical abuse and bleeding disorders may co-exist[13] and the diagnoses are not mutually exclusive. Discussion between the paediatrician and an experienced paediatric haematologist is therefore very important.

9.3.29. Other conditions that mimic or present with bruises may include:

- Birth marks (Mongolian blue spots, capillary haemangioma, congenital melanocytic naevi)
- Vasculitic disorders
- Infection related (e.g. meningococcal septicaemia)
- Drug related (e.g. aspirin, nonsteroidal anti-inflammatory drugs (NSAIDs))
- Erythema Nodosum
- Henoch Schonlein Purpura
- Traumatic:
    - Cultural practices (e.g. coining, cupping lesions)
    - Self-inflicted injuries, including dermatitis artefacta
- Photosensitive dermatitis and contact dermatitis (either may leave a patterned mark that may be mistaken for the imprint of a weapon)
- Connective tissue disorders (e.g. Ehlers Danlos, hypermobility syndrome, scurvy)
- Malignancy (e.g. leukaemia)
- Striae.

9.3.30. Consider removable markings such as tattoos, crayons and felt-tip pens.

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9.3.31. **Assessment of bruises**

See Chapter 6

9.3.32. Differentiating 'normal' from 'abnormal' bruising requires careful documentation of history, examination and appropriate investigations[14].

9.3.33. History

- Past medical history should include questions to consider bleeding disorders:
    - Prolonged bleeding: ask about mode of delivery, any bruising or bleeding at birth or from the umbilical stump (a classic feature of factor XIII deficiency), haematoma after routine vitamin K injection, prolonged bleeding after Guthrieheel prick, trauma, or after surgery such as circumcision, tonsillectomy or tooth extraction
    - Frequent, prolonged and bilateral epistaxis, especially in the first two years of life
    - Gingival or mucocutaneous bleeding (suggesting a platelet abnormality or severe Von Willebrand disease)
    - Joint pain, swelling or reluctance to move a limb (suggestive of haemarthroses)
    - Menorrhagia
    - Poor wound healing, joint dislocations (suggestive of a connective tissue disease such as Ehlers-Danlos syndrome)

      NOTE: the absence of significant bleeding after surgical procedures largely excludes a clinically significant inherited bleeding disorder. A negative history does not exclude an important bleeding disorder[15]
- Drug history (e.g. aspirin, NSAIDs, Warfarin, Heparin)
- Family history of bleeding disorder:
    - It is insufficient only to ask if there is a family history of bleeding disorder; specifically ask about recurrent epistaxis, menorrhagia, bleeding following haemostatic challenge and in the perinatal period in family members
    - Haemophilia (30% may arise secondary to new mutations), Von Willebrand disease, platelet function defects
    - Consanguinity.

9.3.34. Examination specific to bruising (see Chapter 6):

- Number, distribution, site, colour, size, and pattern of bruises, petechiae and subcutaneous haematomata must be carefully recorded
- Top to toe examination including mouth (oral or gingival lesions), behind ears and buttocks
- Abnormal scars, skin elasticity, joint hypermobility
- Pallor, lymphadenopathy, hepatosplenomegaly.

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9.3.35. Documentation (see Chapter 16)

- Carefully and accurately describe and record cutaneous lesions, using body maps (see Appendix 20.1). Measure each lesion and its relationship to anatomical landmark, e.g. bony prominences
- Obtain clinical photographs. Note the date and time that photographs were taken (See Chapter 17)
- Consider alternative light sourcing (e.g. UV illumination[16]).

9.3.36. Investigation

- **Haematological investigations[17]**
    - Indications:
        - Any child with unusual bruising or bleeding out of proportion to the injury sustained, including infants with subdural and/or retinal haemorrhage
        - Investigations are generally not indicated when the only bruising is clearly the result of a slap or blow with an instrument
        - Any indications in the history or examination of a bleeding disorder.
    - Prior to taking the sample:
        - It is good practice to inform the haematology laboratory by prior discussion with haematologist to ensure efficient handling of the samples and advice on the most appropriate tests
        - Referral to a paediatric phlebotomist may be necessary so that the sample is taken and processed appropriately to minimise artefact
        - Ensure that a full drug history has been taken and communicated to the haematologist so the effect of the drug on the test result and clinical picture can be accurately evaluated. Check that the child has not been taking Warfarin, aspirin or NSAIDs during the previous two weeks.
    - Sample collection:
        - Atraumatic venepuncture where possible
        - Blood should not be taken with a vacuum system
        - Blood taken from a cannula or central line can be unreliable because of Heparin contamination
        - Avoid over or under filling specimen tube
        - Sufficient blood should be taken from a direct venepuncture to enable second line investigations to be done, where indicated, without recourse to a second venepuncture.
- **First line investigations** (age appropriate normal ranges should be used to evaluate results). If any of the initial investigations are abnormal, discuss the results with the haematologist in relation to the significance and further investigations.
    - Coagulation screen
        - Prothrombin time (PT); not International Normalised ratio (INR)
        - Activated partial thromboplastin time (aPTT)
        - Thrombin Time

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        - Fibrinogen (Clauss)
    - Full blood count and film (and mean platelet volume if thrombocytopenic)
    - Assays of Factor VIIIc, Von Willebrand factor (VWF antigen and VWF activity)
- **Second line investigations** (age appropriate normal ranges should be used to evaluate results). If there is ongoing concern about a coagulation disorder being the cause of the child's bleeding, or bruising and all first line investigations are normal, then rarer heritable causes of bleeding such as Factor XIII deficiency or a platelet function defect need to be considered in discussion with the haematologist. We would suggest:
    - In a child less than two years old:
        - Screen for Heritable severe disorders of platelet function (either by Closure Time using PFA-100 or by Flow Cytometry quantitation of platelet glycoproteins Ia, IIa/IIIb)
        - Factor XIII screen/assay
    - In a child > two years old:
        - Platelet aggregation
        - Factor XIII screen/assay.
- **NOTE:**
    - The above investigations are listed as 'first' and 'second' line, for guidance. Paediatricians need to work with their local haematologist to ensure an appropriate screen consistent with the following guidance to exclude a clotting disorder.
    - A Factor XIII assay (or screen) should be undertaken for a child of any age with an unexplained intracranial haemorrhage
    - Whereas it is reasonable to use normal PFA closure times to rule out a severe platelet defect in patients, a mildly abnormal closure time is difficult to interpret in infants and neonates. If the clinical suspicion of a platelet defect is high and severe platelet function disorders have been excluded, platelet aggregation tests are indicated
    - Consider PIVKA investigation (proteins induced by vitamin K deficiency or antagonist test) for prolonged coagulation in a neonate.

9.4. Bites

9.4.1. Human bites are always inflicted injuries. They are currently the only physically abusive injury where there is the potential to identify the perpetrator. This may be from dental characteristics or from salivary DNA[18]. Therefore, it is essential that paediatricians recognise a potential bite and refer to a forensic odontologist where available. Many human bites are not recognised as such and are dismissed as bruises. Any bruise with the shape of opposing curves should be treated as suspicious and the services of a forensic odontologist sought early in the investigation. The forensic odontologist will take dental impressions of any suspected perpetrators and make a comparison with the bite mark on the skin (this may also apply to children who are accused of causing the bite) and, if necessary, will present the evidence in court as an expert witness.

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9.4.2. Forensic odontologists can either directly examine the child or work from photographs (taken according to appropriate technique) (see Chapter 17). Access to forensic odontologists will vary across the UK and paediatricians should know how to contact them and have local protocols in place[19].

9.4.3. **Animal bites**

9.4.4. Domestic dogs have four prominent canine teeth that are considerably longer than the incisor teeth. Therefore, a dog bite consists of opposing pairs of triangular or rounded puncture wounds from the canine teeth. In addition, dog upper and lower dental arches are V-shaped.

9.4.5. **Human bites**

9.4.6. A human bite mark is a 2-5cm oval or circular mark (bruises, lacerations or scrapes from dragging of the teeth) made by two concave arcs, with or without associated bruising or petechiae[20]. Individual teeth marks may be visible. Upper teeth marks are larger than lower teeth marks. (See Figure 1).

9.4.7. So-called 'love bites' are suction marks caused by the mouth with or without teeth marks and can appear as petechial haemorrhages.

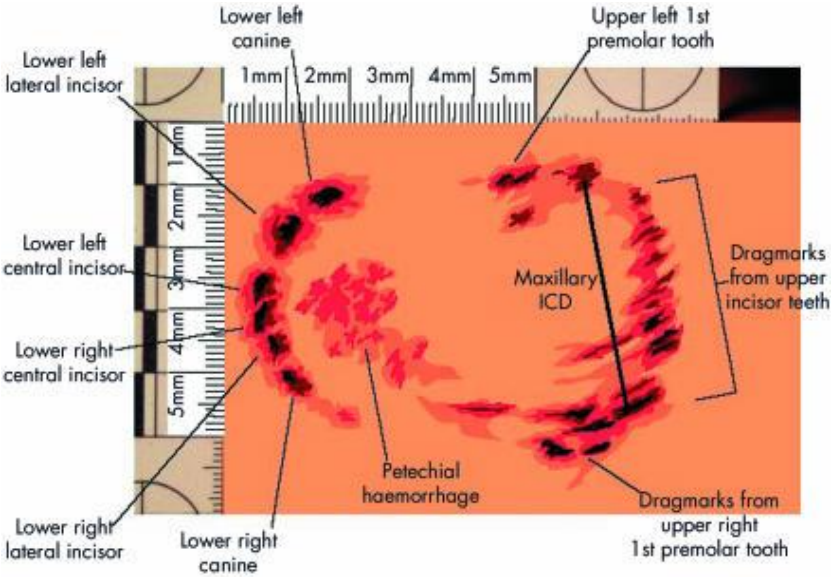

Figure 1. Diagram of human bite mark

9.4.8. **Adult or child bite?**

9.4.9. The differences between adult and child bites are subtle, and early referral to a forensic odontologist is recommended.

9.4.10. Traditionally, measurement of the inter-canine distance (ICD) of the bite has been used to distinguish between adult and child bites although this has not been scientifically validated.

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If the inter-canine distance is 3–4.5cms, the bite is more likely to be that of an adult (2.5–3.0cm being child or small adult).

9.4.11. The imprint of a child's deciduous teeth may be recognised in a bite with ICD of <2.5cm.

9.4.12. **Assessment**

9.4.13. Document and measure the bite mark:

- Contact forensic odontologist
- If the victim has not washed, swab skin over bite mark for DNA using double swab technique (wet swab followed by a dry swab[18]). A DNA sample from the victim (blood or buccal swab) should also be taken to allow interpretation of possible mixtures
- Photography: these should be taken by a professional medical photographer, the examining doctor with appropriate training and equipment or police photographer whenever possible, with advice from the forensic odontologists where possible (see Chapter 17).

9.5. Fractures

9.5.1. An estimated one third of children sustain a skeletal fracture before their 16th birthday[21,22]. Most are unintentional and sustained from falls or high velocity injuries.

9.5.2. Fractures have been recorded in up to one third of children who have suffered from physical abuse. The younger the child, the greater the likelihood of abuse. The majority of abused children with fractures are less than 18 months old; whereas most of accidental fractures occur in children over five years[23,24].

9.5.3. All fractures require appropriate explanation, and this must be consistent with the child's developmental age. Assessment of fractures in suspected physical abuse should involve paediatrics, paediatric radiology and paediatric orthopaedics wherever possible[1].

9.5.4. Abusive fractures are frequently occult; particularly rib, metaphyseal and vertebral fractures. A skeletal survey with follow up radiology or nuclear medicine bone scan, to the technical standards of the RCR radiological guidance, are recommended for all children under the age of two years who are undergoing clinical investigation for suspected physical abuse[1,25].

9.5.5. **Differential diagnosis of fractures**

9.5.6. The differential diagnosis of fractures includes:

- Unintentional injury
- Abusive injury
- Normal variant (e.g. when a bilateral physiological periosteal reaction is seen)
- Birth injury (e.g. clavicular fracture): a good obstetric history is important; these fractures usually heal within a few weeks. Calcification will be visible within 11–14 days[26]

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- Infection (e.g. osteomyelitis)
- Malignancy
- Caffey's disease (infantile cortical hyperostosis)
- Osteogenesis imperfecta (OI): the classification of this condition is becoming more complex; however, of the traditionally described four types of OI, type I is mild, type II is lethal, type III is severe with progressive bone deformities and type IV is intermediate between I and III. Types I and IV should be considered in the differential diagnosis as they may be difficult to differentiate from normal children[27]. Associated features include ligamentous laxity, blue sclerae, multiple Wormian bones and dentinogenesis imperfecta seen in varying combinations in each of the types. (see Table 2)
- Metabolic bone disease of prematurity: may be present in early infancy with gestational age <30 weeks, birth weight <1.25kg, with additional risk factors (e.g. prolonged total parenteral nutrition, delayed introduction of enteral feeds (>30 days), conjugated hyperbilirubinaemia, necrotising enterocolitis or gut resection, prolonged diuretics such as furosemide))
- Nutritional
    - Vitamin D deficiency (rickets): it is rare to see fractures in children born at term who have rickets, unless the bones show radiological evidence of rickets (see section 9.5.58)
    - Copper deficiency, vitamin C and vitamin A deficiency have been raised as possible diagnoses in the courts: the conditions are extremely rare, with historical rather than current day relevance
- Latrogenic (e.g. inter-osseous needle insertion in tibia), may appear as an acute fracture ormay cause periosteal reaction in the healing phase.

Table 2. The assessment of a child with occult fractures[27]

History	• Gestational age • Birth weight • Mode and detailed history of delivery • Maternal ethnicity, diet, sun exposure and health during pregnancy • Infant/child dietary history: Breast fed? Vitamin D supplementation • Neonatal history • Necrotising enterocolitis • Respiratory distress and chronic lung disease • Duration of parenteral nutrition • Cardio pulmonary resuscitation (method used and duration) • Conjugated hyperbilirubinaemia
Drug history	• Diuretics • Steroids
Developmental history	• Motor milestones

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Explanation for fractures	Apparent cause with details of mechanism of injury (See Chapter 6): • Place and time of incident • Activity of child prior to incident • Fall height • Surface of impact • Anatomical point of impact • How was child immediately after incident
Family history	• Family history for example of OI • Recurrent fractures with minor trauma, dislocations, hernia, early onset deafness, dentinogenesis imperfecta, late walking in siblings, osteoporosis in older family members (especially before the age of 50 years), eye disease (retinopathy, early blindness) • Rickets, vitamin D deficiency in siblings
Examination	Thorough physical examination to record associated bruising or injuries (easy bruising is reported in some cases of OI): • Brachycephaly/plagiocephaly/dolicocephaly • Large anterior fontanelle/sutural diastases without hydrocephalus • Craniotabes • Thickened wrists • Frontal bossing • Delayed fontanelle closure • Rosary • Harrison's sulcus • Blue sclerae • Translucent skin • Ligamentous laxity • Hernia(s) • Bowing deformity of limbs in weight bearing children • Dentinogenesis imperfect • Short stature

Investigations	Skeletal survey according to 2017 RCR radiological guidance[1] and BSPR standards:
	• Document
	  ○ Number, location, site and type of fractures
	  ○ Extent of fracture healing
	  ○ Presence or absence of signs of decreased bone density, rickets
	  ○ Or OI
	• CT scan according to RCR radiological guidance[1] if physical abuse suspected.
	
	Bone biochemistry:
	• Calcium and phosphate, alkaline phosphatase
	• Serum 25-hydroxyvitamin D
	• Parathyroid hormone

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9.5.7. **Multiple fractures**

9.5.8. Multiple fractures are more common in abused children[23,24].

9.5.9. If the bones look osteopenic, multiple fractures can be an indicator of significant bone disease.

9.5.10. **Humerus**

9.5.11. Any humeral fracture is more likely to be due to abuse than unintentional injury in a child under 18 months of age[28,29]. All humeral fractures in a non-mobile child are suspicious if there is no clear history of an accident.

9.5.12. Spiral fractures of the humerus are uncommon and are strongly associated with physical abuse[24,29,30].

9.5.13. Once the child is independently mobile a supra condylar fracture is most commonly due to unintentional injury[31].

9.5.14. **Ribs**

9.5.15. In the absence of underlying bone disease or major trauma (such as a road traffic accident), rib fractures in very young children are highly specific for abuse[32], and may be associated in some cases with abusive head trauma (AHT).

9.5.16. Abusive rib fractures are commonly multiple and may be bilateral or unilateral[33]. They often occur at the same location on adjacent ribs, most frequently affecting ribs 4– 12.

9.5.17. The commonest site for abusive rib fractures are posterior rib fractures. However anterior and lateral abusive rib fractures are also reported[32,34].

9.5.18. Fractures of the first rib have been reported in physical abuse[35].

9.5.19. Multiple anterior or costo-chondral rib fractures have rarely been described following cardio pulmonary resuscitation (CPR). Studies give an incidence of 0.5%-1.3% of children who have had CPR[36,37,38]. The majority of the acute fractures were discovered at autopsy; only a minority were evident on the post mortem skeletal survey.

9.5.20. If fractures are present on a chest X-ray after resuscitation the child must be investigated carefully to determine the likelihood that CPR or physical abuse is the cause. Acute rib fractures are often missed on the initial radiograph and only become detectable as they start to heal a few weeks later.

9.5.21. **Femur**

9.5.22. Femoral fractures in children who are not independently mobile are suspicious of abuse, regardless of type[39].

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9.5.23. Under the age of fifteen months, a spiral fracture is the commonest abusive femoral fracture[40]. Once a child is able to walk, they can sustain a spiral fracture from a fall while running[28].

9.5.24. A mid-diaphyseal fracture of the femur is the commonest presentation and can be found in unintentional and abusive injuries.

9.5.25. **Spinal fractures[41]**

9.5.26. Spinal injury is unusual in children. Most arise from sport or motor vehicle crash injuries in older children. Vertebral deformity is common in children with significant osteoporosis. Spinal crush fractures may be found in underlying bone disease as the endplates and anterior wall are prone to collapse, resulting in some characteristic appearances.

9.5.27. It is vital to identify spinal fractures early, as the child may require urgent surgery.

9.5.28. In physical abuse, cervical injuries are reported predominantly in infants (median age five months). A variety of injury types are seen throughout the cervical spine, involving the vertebrae with or without spinal cord involvement. These injuries are frequently accompanied by head injury. Symptoms and signs of these injuries may be masked by respiratory signs or impaired consciousness from the associated head injury.

9.5.29. In physical abuse, thoraco-lumbar injuries are seen in toddlers (median age 13 months). Fracture type included compression fractures or anterior dislocation of T12/L1–2. Mechanism of injury is thought to be hyperflexion or a direct blow, or forcibly thrusting the child on their bottom or feet. They have also been reported in association with spinal subdural haemorrhage and head injury.

9.5.30. Thoraco-lumbar fractures may present with lumbar kyphoscoliosis or thoraco lumbar swelling or focal neurology e.g. urinary retention.

9.5.31. **Metaphyseal fractures**

9.5.32. In the neonatal period, metaphyseal fractures can be related to birth injury, physiotherapy or casting of talipes. In the absence of these explanations physical abuse should be strongly considered in children under the age of two years[42,43,44,45].

9.5.33. Metaphyseal fractures are frequently occult and reported in any of the long bones.

9.5.34. Metaphyseal fractures will only be found if looked for carefully by radiologists with experience in the interpretation of skeletal surveys; coned views of the metaphyses should be considered in live children, and specimen radiography in post mortem cases.

9.5.35. Metaphyseal fractures are virtually never seen in OI.

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9.5.36. **Skull fractures**

9.5.37. Skull fractures are reported after head injury from a fall from a height and are reported with equal frequency in unintentional injury and physical abuse in infants under the age of a year[24,46]. In children >18 months, skull fractures are more commonly seen in unintentional injury[28].

9.5.38. A single linear parietal fracture is the commonest unintentional and abusive fracture[23,24,46]. It should be noted that biparietal fractures resulting from a single blow to the head have been reported following unintentional injury[47].

9.5.39. Other skull fractures are more uncommon and require a greater degree of force, which should be reflected in the history. Multiple or bilateral fractures and those that cross the suture line are of concern. In the absence of a plausible history of significant forceful injury physical abuse should be excluded[46].

9.5.40. **Investigations specific to fractures**

9.5.41. **Radiology[1,25]**

9.5.42. A full skeletal survey is recommended in all children less than two years of age where physical abuse is suspected. If a decision is made NOT to do a skeletal survey, the reasons for this decision should be carefully documented. Contemporaneous nuclear medicine bone scan or follow-up radiographs may reveal additional fractures not detectable on the first skeletal survey.

9.5.43. Skeletal imaging functions to:

- Detect and describe any fractures
- Estimate the age of any fractures 'in broad terms'[48]
- Check bones are normal and identify any underlying skeletal disorder (e.g. osteopenia, OI)
- Detect any other bony injury.

9.5.44. Skeletal survey should also be considered in:

- Severe inflicted injury in a child older than two years
- A child with localised pain, limp or reluctance to use limb where abuse is suspected
- A child with previous history of skeletal trauma and suspected of abuse
- A child with unexplained neurological presentation or suspected AHT
- A child dying in suspicious or unusual circumstances (request specimen radiography as part of post mortem to maximise detection of rib and metaphyseal fractures)
- A twin of an infant (or sibling less than two years) with signs of physical abuse. Consider screening siblings if there is any suspicion of abuse
- Older children with a disability and suspected physical abuse.

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9.5.45. **Skeletal survey**

9.5.46. Skeletal survey should be conducted to the technical standards recommended in the RCR radiological guidance[1]. Of particular note:

- Right and left oblique views of ribs should be included in a skeletal survey to maximise the detection of rib fractures[49]
- Lateral and AP views of the entire spine should be included
- AP and lateral coned views of elbows, wrists, knees and ankles should be considered when a fracture is suspected at these sites
- Despite the inclusion of a CT scan in the infant and the advent of a 3D head CT scan, a skull X-ray with AP, lateral and Townes views are recommended to firmly exclude skull fractures.

9.5.47. A single skeletal survey will miss fractures, particularly acute rib and metaphyseal fractures. A second radiological investigation (skeletal survey after 11-14 days or a contemporaneous nuclear medicine bone scan) is required particularly if skeletal survey is negative. Single skeletal survey or nuclear medicine bone scan alone will miss fractures[25]; however, both together are complementary and will increase the chances of identifying all fractures.

9.5.48. Functions of second radiological investigations:

- To check suspicious or unconfirmed findings on the initial survey, for example to confirm normal variants
- To look for additional injury, in particular rib fractures and metaphyseal fractures not visible on first survey as they were acute and difficult to visualise. A second skeletal survey has been found to provide additional information and may increase the yield of fractures by up to 27%[50]
- To give more information about the age of a fracture, as directed by the radiologist.

9.5.49. A contemporaneous Nucleotide Bone scan makes the assessment of the clinical evidence easier in the initial strategy meeting. A repeat skeletal survey is usually done after 10 days and may delay decisions and it may be hard getting patients back for the second skeletal survey.

9.5.50. Consider Computed Tomography (CT) head scan in infants to exclude intracranial injury. It is increasingly thought this should be part of a skeletal survey (see section 9.6).

9.5.51. Skeletal surveys should be reported by a radiologist who is trained and has experience in the field. Any abnormal findings should be communicated directly to the responsible paediatrician.

9.5.52. **Excluding other causes of skeletal fractures**

9.5.53. Section 9.5 identifies a list of other traumatic causes, abnormalities in bone collagen, mineralisation or rare conditions that should be considered in the differential diagnosis of unexplained fractures.

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9.5.54. Assessment of the child with unexplained fractures relies upon a careful history to exclude risk factors for other causes or associated conditions. Table 2 outlines recommended history, examination and investigations to consider when determining the cause of a skeletal fracture that does not have an obvious unintentional cause.

9.5.55. Parents/carers must be told that the investigation is to search for other injury or bone disease. The request card must indicate that abuse is being considered and it is good practice for the paediatrician to discuss the case with the radiologist. Whilst caution must be exerted when exposing a child to excessive radiation, if a child is at risk of harm, this must take precedence. Opinions about the relative risk of radiation versus missed diagnosis vary widely as do opinions regarding the relative risk of cancer and ionizing radiation.

9.5.56. A recent publication[51] and the American Academy of Pediatrics resource[52] aim to improve understanding of CT radiation and its potential risk in the development of cancer, which includes suggestions for an informed discussion with care givers. Radiologists will use optimal imaging protocols, employ parameters specific to imaging in early life, and adhere to the ALARA policy of 'As Low As Reasonably Achievable'; thus minimizing the risks to the child.

9.5.57. **Vitamin D deficiency**

9.5.58. Vitamin D deficiency or insufficiency is increasingly recognised in the UK. Black and ethnic minority groups, especially those of African Caribbean and South Asian origin and people with dark skin are particularly at risk. Vitamin D deficiency is associated with strict vegetarian diets, lack of dietary fibre, prolonged breastfeeding without vitamin D supplements and lack of exposure to sunlight. Other vulnerable paediatric patient groups include breast-fed (without vitamin D supplements), new-born babies and young infants of vitamin D deficient mothers, children with malabsorption, neonatal and neurodisability problems.

9.5.59. 'Low' vitamin D levels have been proposed as a cause of unexplained fractures in the court setting despite normal radiology. There is currently no scientific evidence base to support this hypothesis. The direct relationship between levels of Vitamin D and the risk of bone fractures is ill-understood. There is also a lack of evidence in children as to what levels of vitamin D constitute deficiency or insufficiency.

9.5.60. Advice from British Paediatric Adolescent Bone Group (BPABG)[53,54] is that vitamin D deficiency should be regarded as a plasma level of 25 hydroxyvitamin D of <25nmol/l (10ng/ml), vitamin D insufficiency being a level between 25 and 50nmol/l (10–20ng/ml) and vitamin D sufficiency as a level >50nmol/l. Furthermore, BPABG advise that in the context of unexplained fractures in infancy the level of 25 hydroxyvitamin D is not relevant to the causation of the fractures unless there is radiological evidence of rickets using conventional X-ray techniques and biochemical evidence of rickets, i.e. abnormal blood levels of calcium, phosphate, alkaline phosphatase or parathyroid hormone.

9.5.61. With these factors in mind, in the presence of a fracture where physical abuse is suspected, bone biochemistry tests should be strongly considered to include calcium, phosphate and

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alkaline phosphatase, vitamin D levels and para-thyroid hormone. If a child has low vitamin D levels and bone fracture suspicious of physical abuse, the case should be reviewed carefully and discussed with a senior colleague or named doctor; with reference to the full biochemical picture and skeletal survey together with a discussion of vitamin D supplementation.

9.5.62. **Genetic testing**

9.5.63. OI is a clinical diagnosis made on the basis of family history, history of repeated fractures, clinical examination, radiology and biochemistry. If after thorough assessment a diagnosis of OI cannot be excluded, the child should be referred to a paediatrician with specialist knowledge of bone metabolism, where genetic testing may be considered.

9.5.64. **Ageing fractures**

9.5.65. Estimating the age of a fracture can:

- Inform inconsistencies between the appearance of the fracture and the timing of an injury described
- Determine whether multiple fractures are of the same, or different, ages; thereby indicating one or more episodes of trauma.

9.5.66. Police and lawyers often seek detailed information about the timing of injuries to identify or exclude potential perpetrators in criminal and family court proceedings. The limited evidence suggests that radiologists are able to estimate the age of a fracture in broad time frames of acute (less than one week), recent (one to five weeks) and old (more than five weeks of age)[55,56]; based upon the signs of healing on a radiograph.

9.5.67. **Stairway injuries**

9.5.68. Falls down stairs are a recognised presentation to paediatric emergency departments (EDs) and often an explanation proposed by perpetrators of abuse. There is a recognised pattern of injury seen in children injured in stairway falls[57,58,59,60]:

- Single injuries predominate: injuries to more than one body part occur in 3-6%
- Over 70% of injuries are to the head and neck. Extremity injuries occur in around 30% but truncal injuries are uncommon, occurring in only 2–3%
- Injuries are usually soft tissue bruises, abrasions or lacerations
- Serious life-threatening injuries, such as abdominal trauma, rarely occur[61]
- When multiple, severe, truncal or proximal extremity injuries, such as a transverse femoral fracture, are noted in a child who reportedly fell downstairs, abuse should be suspected
- In unintentional stairway falls fractures to the distal limb (mainly tibial) predominate and are an uncommon occurrence in comparison to minor injuries to the head and neck. Undisplaced femoral fractures have been described whilst transverse fractures of femur were deemed suspicious[62].

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9.6. Abusive head trauma (AHT)

9.6.1. Differentiating AHT from another causes of brain injury is of the utmost importance to the welfare of the child and it is essential that the condition is correctly diagnosed. The condition has gone under several descriptors that have included non-accidental head injury and shaken baby syndrome. For consistency we have adopted the recent terminology and definition proposed by American Academy of Pediatrics, namely AHT; 'an inflicted injury to the head and its contents', in line with recent proposal by the Committee on Child Abuse and Neglect; American Academy of Pediatrics[63].

9.6.2. AHT is the commonest cause of death in physical child abuse. It is predominantly seen in children under the age of two; most commonly in those under six months of age. The mortality from AHT is up to 30%. Half of the survivors have residual disability of variable severity.

9.6.3. Infants with AHT present to hospital with a variety of symptoms. These range from poor feeding, lethargy, fits and respiratory difficulty to sudden death. In some cases, the absence of either a history or external signs of injury may delay diagnosis. Not all infants are acutely ill; others present for example with an increasing head circumference. Children with chronic subdural haemorrhage or effusions present a diagnostic problem because many lack a clear history of symptom-onset and corroborative findings are usually absent.

9.6.4. The diagnosis of AHT must be considered in any infant or young child who has an unexplained ALTE (Apparent Life-Threatening Event) or apnoeic episode. The paediatrician must maintain a low threshold for considering this diagnosis.

9.6.5. **Important features of AHT[64]**

9.6.6. It is widely accepted that AHT arises from severe repetitive rotational, acceleration-deceleration injury (from shaking) with or without additional impact, or impact alone.

9.6.7. Features associated with AHT include:

- Extra axial bleeding: subdural and subarachnoid haemorrhages (extradural haemorrhages are rarely seen in AHT and far more commonly seen in unintentional injury)[65]
- Subdural collections are often multiple, and common sites are over the convexity of the cerebral hemisphere, inter-hemispheric or in the posterior fossa. In the acute stage they are typically small and do not cause mass effect
- Brain injury – includes hypoxic ischaemic injury, cerebral oedema and parenchymal injury; which are likely to be responsible for the poor outcome in these children
- Retinal haemorrhages (RH) in one or more usually both eyes are reported in 70-80% of cases of AHT
- Bruising/abrasions, lacerations or swelling to the head; including scalp or face
- Skull fracture(s), usually with overlying haematoma if injury is recent
- Skeletal injury: rib or long bone fractures. There is a recognised association with cervical spinal injury

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- Bruising
- Apnoea and seizures
- Neck and cervical spinal cord injury.

9.6.8. **Differential diagnosis**

9.6.9. Other conditions associated with subdural haematoma (SDH), the most commonly seen intracranial injury in AHT, include:

- Non-intentional head injury: both subdural and RH may be associated with severe non-intentional injury (e.g. following high falls, crush injuries or motor vehicle crashes)
- Cranial malformations
- Metabolic disease: Galactosaemia, Glutaric aciduria type 1; the latter is nearly always accompanied by frontal lobe hypoplasia
- Hypernatraemia
- Birth trauma: SDH in asymptomatic infants generally resolves within 4 weeks[66]
- Bleeding disorders: both retinal haemorrhage and subdural haemorrhage can occur (e.g. haemophilia, haemorrhagic disease of the new-born, Factor XIII deficiency)
- Infection (e.g. subdural empyema, post meningitis effusion, sepsis).

9.6.10. **History**

See Chapter 6

9.6.11. In most cases of AHT there is either no history of trauma or, where a history of injury is given, it is of a minor nature that is inconsistent with the severity of the infant's condition, the developmental level of the child or the associated pattern of injuries seen.

9.6.12. **Examination**

9.6.13. The examination specific to AHT should:

- Assess the need for resuscitation and immediate clinical needs
- Look for and document any signs of external injury, including mouth, frenum, ears and scalp
- Check fontanelle and head circumference
- Think of further internal injury (e.g. intra-abdominal injury) (see section 9.8)
    - Ophthalmology examination (see section 9.7): always arrange for an examination by an experienced ophthalmologist as soon as possible in order to exclude eye injury, including retinal haemorrhage[67]. This will involve indirect ophthalmology and short-term dilatation of the pupils with imaging if possible. Imaging of the retina supports detailed documentation of retinal findings and provides a permanent record of retinal findings. Many ophthalmologists have access to RetCam imaging (a contact digital fundus camera providing a 1200/1300 field of view of the retina including the posterior pole and periphery) to record their findings.

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9.6.14. **Neuroimaging investigations**

9.6.15. Neuroimaging is the definitive diagnostic investigation and should be performed where AHT is suspected[68]. This includes infants or young children with:

- Unexplained sudden collapse
- Neurological symptoms or signs
- Enlarging head circumference
- Persistent uniform cerebrospinal fluid (CSF) bloodstaining
- Haemorrhagic retinopathy.

9.6.16. It is recommended that a CT head scan is included in the investigation of any infant under one year of age where there is evidence (signs or suspicion) of physical abuse, and should be considered in children up to the age of two years[1,69].

9.6.17. First line investigation in suspected AHT is a CT head scan due to its widespread availability and the fact that it can be performed without anaesthesia. When there are positive signs on CT a follow up magnetic resonance imaging (MRI) should be performed. MRI is a more sensitive method of detecting small intracranial collections, especially in areas less well seen on CT. Cerebral oedema and ischaemic changes are also well-demonstrated by diffusion-weighted MRI (Diffusion-Weighted Imaging (DWI)); enabling an opinion on prognosis.

9.6.18. DWI assists the ageing of an intra-cranial injury in the hands of a radiologist with expertise in paediatric neuroimaging.

9.6.19. In some centres with expertise in MRI, there is a move to offer MRI as the first line investigation. Head ultrasound is unreliable as a means of detecting or excluding SDH.

9.6.20. Where there is a high clinical suspicion of AHT the following has been suggested[1]:

- Day of presentation: head CT as soon as child stabilised after admission
- Day 1–2: skeletal survey including skull films if the child is well enough. If the child is too unwell then the survey should be done as soon as is possible without compromising the clinical condition of the child
- Day 3–4: If initial CT brain abnormal, perform a MRI of the head or, if not available, repeat CT headscan. The MRI should include the spine, to exclude coexisting injury to the spinal cord
- Follow up CT or MRI, where an earlier abnormality was detected. This may be required at around 10 days and possibly two to three months after the initial injury.

9.6.21. **Laboratory investigations**

9.6.22. Full blood count repeated after 24–48 hours may demonstrate a rapidly falling and low haemoglobin level.

9.6.23. Coagulation studies will exclude major bleeding disorders; secondary coagulation defects are often recorded in the seriously ill child (see section 9.3).

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9.6.24. Septic screen to exclude infection; subdural collections can be associated with meningitis.

9.6.25. Urine sample should be taken for toxicology screen.

9.6.26. If Glutaric aciduria is clinically suspected a metabolic specialist should be consulted to advise on appropriate investigations; fibroblast culture may be required from a skin biopsy.

9.7. Retinal findings in child abuse

9.7.1. The 2013 Royal College of Ophthalmologists (RCOphth)/RCPCH guidelines[67] provide an update of the latest evidence in relation to AHT and the eye, and set standards for ophthalmology assessments.

9.7.2. When RH are found in a child less than three years of age with intracranial injury, the probability that the child has sustained AHT is 71% (OR 3.504)[70].

9.7.3. It is important to establish the precise extent of any retinal haemorrhage, and whether additional retinal features are also present, such as retinoschisis and retinal folds.

9.7.4. **Retinal findings in AHT vs. unintentional trauma[70,71]**

9.7.5. RH can occur in up to 5% of children following accidental trauma, predominantly high-velocity injuries or crush injuries. However, there are clear differences between the pattern of RH found in AHT and accidental trauma, or non-AHT.

9.7.6. RH found in AHT are usually bilateral, numerous, extend to the periphery of the retina and are multi-layered, i.e. in the intraretinal, preretinal and subretinal layers. This is in direct contrast to RH found in unintentional trauma; which are predominantly unilateral, few in number and concentrated around the posterior pole.

9.7.7. Additional retinal features that have been strongly associated with AHT include perimacular retinal folds and retinoschisis. Their prevalence in unintentional head trauma is extremely difficult to ascertain, There are only isolated case reports, of severe crush injuries, where multiple, extensive, multi-layered RH were found in conjunction with the additional retinal features noted above[72,73].

9.7.8. **What other conditions can cause RH in young children?[74]**

9.7.9. Haematological disorders, such as leukaemia, thrombocytopenia and clotting disorders can all have RH as a manifestation[75].

9.7.10. Causes that overlap with abuse:

- Isolated case reports of RH in children with confirmed OI, fibromusculardysplasia, haemorrhagic disease of the new-born, protein C deficiency, methylmalonic aciduria with cobalamin deficiency, low fibrinogen levels, Hermansky Pudlak syndrome and spinal cord arteriovenous malformation.

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- Glutaric Aciduria (GA) is known to be associated with SDH, and RH have been described in a number of cases
- Cardiopulmonary resuscitation is a rare reported cause of RH in infancy; however, the haemorrhages are usually small and located in the posterior pole of the eye.
- RH in children who have had seizures are rare
- ALTE and coughing have not been associated with RH in children.

9.7.11. **Retinal haemorrhages (RH) in the new-born**

9.7.12. It is well recognised that up to 31% of new-borns may have RH, and this possibility is significantly increased if the birth was a vacuum or 'double instrumental' delivery (i.e. forceps and vacuum). They are predominantly bilateral, may be mild to severe, and are usually intraretinal and restricted to the posterior pole[76]. Unfortunately, there are only limited data on the length of time that such haemorrhages may persist, although there is clear agreement that 83% will have resolved by 10 days, and 97% by 42 days, with only single case reports of more severe individual foveal haemorrhages persisting to 58 days[77,78,79]. While SDH have been recorded following birth, there have not been any studies to date which have examined new-born infants for the co-existence of SDH and RH. However, it is important to note that the infants who have been found to have RH following delivery have been well and asymptomatic.

9.8. Abusive abdominal and visceral injuries

9.8.1. Abusive abdominal injury carries a significant mortality. It is therefore important for clinicians to be aware of the consequences of blunt abdominal trauma and other forms of visceral injury, and to consider investigations to identify injury even when history and physical signs are absent.

9.8.2. It is difficult to establish how common such injuries are, as a routine search for abdominal injuries does not always take place and large-scale studies are lacking. It is estimated that in the UK there is one case per million children per year across all ages, and two cases per million children per year in those aged less than five years, of such injuries[80].

9.8.3. Young children are particularly vulnerable to significant abdominal injury following a blow to the abdomen, due partly to their weak/less developed abdominal musculature and their diaphragm being more horizontal. The liver and spleen are more anterior and therefore less protected by ribs, which are themselves elastic and very compressible; potentially crushing solid organs below[81].

9.8.4. It is important to note that significant hepatic injury may present with few or no specific signs, and so clinical vigilance is key[82].

9.8.5. Clinicians should have a low threshold for investigating for occult abdominal trauma in children presenting with abdominal bruising, suspected inflicted head trauma or multiple soft tissue injuries.

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9.8.6. While every organ in the body has been injured due to abuse, certain injuries predominate:

- Small bowel injury (in particular duodenal)[81,83,84,85]
    - Duodenal injuries occur when the duodenum is compressed against the vertebral column. The resulting hematoma may cause partial or complete obstruction of the duodenal lumen.
    - The duodenum's location in the retroperitoneum affords it relative protection, hence the presence of injury indicates the transference of considerable blunt trauma to the abdomen. Vomiting, the most common symptom, often begins 24 to 48 hours after the time of the injury and is due to the progressive obstruction of the lumen. The likelihood of delayed onset of symptoms should be borne in mind when considering timing of the causative event
    - Diagnostic imaging should be discussed with paediatric radiology and surgical specialists and is likely to include contrast CT, contrast studies.
- Hepatic injury[83]
    - As the liver and spleen are highly vascular, hepatic and splenic injuries can cause fatal blood loss from either the parenchyma or the arteries and veins that supply them. Presentation may be with hypovolaemia, overlying abdominal tenderness and guarding. The clinician may be alerted to the possibility of blunt hepatic parenchymal injury by derangement of serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT).
- Pancreatic injury[83]
    - Symptoms from pancreatic injuries can result both directly from traumatic transection and from resultant pancreatitis. Vomiting and pain are the main symptoms, and onset can be over several days. This should be borne in mind when considering timing of the causative event.
    - Initial investigation is by measurement of serum pancreatic enzymes (e.g. lipase, amylase) according to local laboratory practice. Diagnostic imaging should be discussed with paediatric radiology and surgical specialists.
    - Those who present late may have pseudocyst formation, and present with epigastric pain, palpable abdominal mass, elevated lipase or amylase.

9.8.7. Children with abusive abdominal injuries tend to be younger than those with unintentional abdominal injuries; with the mean age ranging from 2.5—3.7 years in abused vs. 7.6—10.3 years among accidentally injured[80,84,86].

9.8.8. Likewise, children with abusive intra-thoracic injuries are predominantly aged less than five years[87,88,89,90,91,92].

9.8.9. While the full RCPCH Child Protection Evidence systematic review of abusive abdominal and visceral injuries did not identify any evidence to guide which children should be investigated for occult abdominal injury[93], the following Implications for Practice should be considered when assessing possible abusive abdominal injuries.

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Implications for Practice

- Many abdominal injuries, in particular hepatic injury, may be clinically occult and thus active consideration of blunt abdominal injury in children with suspected abuse is necessary.
- Abdominal injuries such as transection or laceration of the third/fourth part of the duodenum in children aged less than five years, particularly those less than two years old, who have not experienced a motor vehicle collision should prompt specific child protection investigations.
- In the child who has sustained a head injury or who is unconscious as a consequence of their abusive injuries, abdominal injuries must be considered during their investigation.
- Many children who have sustained abusive abdominal injury have evidence that there has been repeated blunt abdominal injury, although they have not come to attention with previous injuries. Thus, non-specific symptoms in young children with suspected abuse should prompt abdominal investigations[80].
- Contrast CT abdominal scan is the investigation of choice when abdominal and visceral injuries are suspected. The absence of bruising does not preclude the presence of significant abdominal injury; up to 80% of cases may have no bruising present[83]. The decision to undertake a CT abdominal scan must therefore be guided by the clinical presentation.
- There should be a low threshold for abdominal imaging in children of any age who present unconscious, and those found to have occult injury on skeletal survey and/or brain imaging.
- Research evaluating estimation of liver and pancreatic enzymes has been inconclusive, as significant abdominal injury has been found in children with normal serology. Serology cannot therefore be used to select those children requiring further investigation. Abdominal imaging should be undertaken for those with abnormal results and considered for those with normal results according to the clinical presentation.
- Infants less than six months of age with bruising but no other symptoms or signs of injury may still have occult abdominal injury[94].

9.9. Burns and scalds

9.9.1. Burns and scalds to children are common, with 70% of unintentional burns and scalds in childhood occurring in children under three years of age; the greatest prevalence is in toddlers between the age of 12 and 24 months, where 90% happen in the home. The majority of burns or scald injuries result from unintentional injury, which involves varying degrees of parental inattention. An estimated 10% are secondary to maltreatment with a ratio of neglect: physical abuse of 9:1[95].

9.9.2. Staff in EDs and children's burns units see the more severe injuries and their records and observations are vital to identify or exclude signs child abuse or neglect. Less severe injuries may present to GPs and health visitors.

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9.9.3. All childhood burns must be carefully assessed. The burn itself may be a result of neglect or an indicator of a neglectful household. Lack of supervision, failure to implement safety measures in the home, excessive unprotected exposure of children to the sun, failure to seek appropriate medical attention when required or lack of home first aid all contribute to a neglectful picture (see Chapter 11).

9.9.4. **Unintentional burns and scalds**

9.9.5. **Scalds[96]:** the commonest causes of thermal injury are scalds in approximately 60% of children. The most common single cause is the hot beverage. Toddlers are particularly at risk when they grasp cups and mugs of hot tea or coffee and pull the hot liquid down over themselves. Typically, they sustain a scald over their face, chest, or upper arm. The burn is deepest at the top of the scald where the hottest liquid comes into contact with the skin and becomes more superficial as the liquid cools as it runs down the body. Other common causes include water from kettles and hot food, especially in older children during food preparation. Rarer causal agents of unintentional scalds are the hot tap water or bath.

9.9.6. **Contact burns:** children suffer unintentional burns from irons, hair straighteners, oven doors or hobs. The children touch the hot objects, and 90% sustain burns to the fingers or palm of the hand. When a child touches a hot object they instinctively withdraw their hand thus limiting the extent of the burn. For this reason, the mechanism by which contact was maintained must be ascertained in anything other than minor contact burns. Deep contact burns are likely to occur only when enforced contact has taken place.

9.9.7. **Other causes**

- **Cigarette burns:** unintentional cigarette burns are rare but can occur when children brush up against a cigarette knocking the hot ash onto their skin
- **Flame burns:** are seen mostly in older children and teenagers involved in outdoor activities of high-risk behaviours. Agents include bonfires, barbeques, fireworks, aerosols and lighters
- **Radiation burns:** sunburn accounts for several hospital attendances and admissions every year in young children left unprotected in the sun. Despite age regulations, older children are seen with sunbed related burns.
- **Friction burns:** can occur from slides, skids on carpets and treadmill injuries
- **Chemical burns:** mostly involve household products and children under three years of age from a splash
- **Electrical burns:** are unusual and may be seen in older children who have touched electric cables.

9.9.8. **Abusive burns**

9.9.9. **Scalds** from physical abuse predominate in infants and toddlers:

- They most frequently involve immersion injury and have the appearance of stocking and glove scald with clearly demarcated edges
- Most frequently involve the buttocks and legs

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- Abusive scalds are frequently bilateral and symmetrical
- There may be central sparing of the buttocks where the child is held in contact with the bath surface that is cooler than the bathwater; similar sparing may be seen in the popliteal fossae.

9.9.10. **Contact burns[97]** are generally found anywhere on the body although rarely on the front of the hands or finger tips. The site often involves regions of the body that the child is unable to reach themselves (e.g. back or buttocks). The most frequent sites are the trunk, upper arm, thigh and back of the hand. Abusive contact burns are often multiple; in comparison to unintentional burns that are generally single. The injuries are classically clearly demarcated, of universal depth and can carry the shape of the implement used e.g. iron, fire grid, cooker hot plate, hot fork/spoon, grill of the hairdryer[98,99], cigarettes and cigarette lighters.

9.9.11. **Other burns**

- **Intentional cigarette burns:** are circular lesions of approximately 0.5cm diameter[97,100]. Appearance may vary from erythema, bullous lesion to a clearly demarcated circular burn with a deep central crater. They are frequently multiple and often located on the back of the hand. They heal to leave circular scars
- **Friction or carpet burns:** can be sustained on the trunk when a child is dragged across the floor
- Inflicted burns of **multiple causes** have been reported in case studies to include stun gun burns, flame and contact burns from cigarette lighters. These often generate skin injuries of an unusual appearance that may reflect the shape or nature of the agent used
- Microwave, **electrical burns** or incineration burns have been described
- **Chemical burns** from acid placed on the skin have also been reported. These can involve very atypical presentations such as chemical burns to the external auditory meatus[101].

9.9.12. **Differential diagnosis of burns and scalds**

9.9.13. Includes other skin pathology, especially infections. Staphylococcus aureus infection can cause 'the scalded skin syndrome', which resembles a scald and impetigo. An intentional burn may also become infected.

9.9.14. When burns are old or become infected they are difficult to differentiate from a primary infected lesion.

9.9.15. Precise ageing of injuries is also very difficult, although experienced staff in the care of burns can make an approximate estimate of the age of an injury in some cases.

9.9.16. **Examination**

9.9.17. Additional consideration should be given to the following:

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- The burn must be examined before it is dressed as long as this does not affect the optimal treatment of the child; or during dressing changes, to avoid unnecessary discomfort to the child.
- Detailed drawing of the burn including measurements, site, pattern on body map (consider position child was in at the time of injury).
- Depth of injury according to standard classification of depth in conjunction with surgical team (erythema, superficial, partial thickness and full thickness).
- Is there skin sparing and if so where? (e.g. soles/palms in immersion injury) Consider effects of clothes.
- Photograph the injuries with a scale in place providing close-up and distant views to enable the overall pattern to be appreciated (see Chapter 17).
- Assess child's development and ability to act in the way stated (e.g. can this child turn on a tap or climb into a bath?).
- Consider attending a home forensic visit with the police to give advice from a developmental paediatric perspective:
    - Examine appliance/heater alleged to have injured the child
    - Assess height of bath or sink, water depth and materials from which bath or sink are made of
    - Assess the likely temperature at the time of alleged injury
    - Assess the material alleged to have caused the injury (e.g. bleach)
    - Photograph injury scene and any appliances
    - Examine any clothing worn (consider keeping clothing)
    - Re-enact the event according to the parent/carer's description
    - N.B. scientific advice, manufacturer's data etc. may be required.
- A skeletal survey is recommended as for any child with suspected abuse according to RCR radiological guidance[1].

9.9.18. **Depth of burns and scalds**

9.9.19. The depth of burns depends on the temperature and duration of exposure to the heat source. This data is published for adults and it is estimated that it takes a quarter of the time to burn the skin of a child. It takes just one second for a child to sustain a full thickness skin burn at 60^{o}C[102].

9.10. Other abusive injuries

9.10.1. **Scratches, abrasions and lacerations** with no suitable explanation; and distribution similar to abusive bruising.

9.10.2. **Oral injuries:** examine the mouth in all cases. Injuries may include:

- Teeth: fractured, luxated, intruded or avulsed
- Lacerations and bruises to lips and tongue
- Torn labial frenum in an infant or toddler; although there is no current published evidence in the literature that an isolated torn labial frenum is diagnostic of physical abuse. If the child presents with this injury and it is not explained, physical abuse should be excluded as in any other situation of an unexplained or

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inadequately explained injury. It is now well-recognised that toddlers can sustain a torn frenum from a fall against a low table or on to the floor where they bang their face on the floor. The scientific literature certainly contains descriptions of children who have suffered from physical abuse and have a torn frenum as part of a wider picture of multiple serious abusive injuries[103]

- Palate/pharynx: burns from hot food, lacerations from cutlery/objects forced into mouth.

9.10.3. **Injuries to nails:** avulsed or broken, subungual haematoma, object pushed under nails.

9.10.4. **Injury to hair:** traumatic alopecia (distinguish from alopecia areata, self-inflicted hair loss, tinea capitis).

9.10.5. Marks from **tourniquets, ligatures**. Strangulation – associated with facial petechiae and sometimes external bruising to neck.

9.10.6. Injuries from **insertion of needles**: superficial needle marks, deep insertion into tissues or head in bizarre abuse (visible on X-ray).

9.10.7. **Injection** of material into skin (e.g. faeces to produce skin infection in fabricated or induced illness).

9.10.8. Deliberate **drowning** is often a difficult diagnosis and may depend on parent/carers admission. Accidental bath drowning typically occurs between eight and 24 months. Incidents outside this range, with previously normal development, should give rise to concern either for deliberate drowning or epilepsy (in older children)[104].

Further reading

- The Royal College of Radiologists, Royal College of Paediatrics and Child Health (2017) The radiological investigation of suspected physical abuse in children[1]
- The Royal College of Paediatrics and Child Health (RCPCH) Child Protection Evidence systematic reviews

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Update information

The following sections have been updated:

- **Section 9.8 (Abusive Abdominal and Visceral Injuries) in light of the updated RCPCH Child Protection Evidence systematic review: Visceral injuries**
  Date last updated: 2019
  Next review due: 2022

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