

Standards for Radiological Investigations of Suspected Non-accidental Injury

March 2008



The Royal College of
Radiologists

Royal College of Paediatrics
and Child Health



Standards for Radiological Investigations of Suspected Non-accidental Injury

March 2008



**Intercollegiate Report from
The Royal College of Radiologists and
Royal College of Paediatrics and Child Health**

ISBN 978-1-906579-01-2

© 2008 Royal College of Paediatrics and Child Health

CONTENTS

Introduction	7
1. The role of the Colleges	9
2. The scale of the problem	10
3. What to do if non-accidental injury is suspected	11
4. Communication and consent	13
5. Indications for clinical imaging	14
6. The skeletal survey	15
7. Recommended procedures for (child protection) skeletal survey	16
7.1 Timing and radiology/radiography standards	16
7.2 When a child attends the radiology department	17
7.3 Radiographic principles.....	18
Table 1. The standard child protection skeletal survey for suspected non-accidental injury	20
8. Additional/supplementary imaging for suspected non-accidental skeletal injury	22
9. Follow-up radiographs	23
10. Scintigraphy (bone scans).....	25
10.1 The role of scintigraphy in NAI	25
10.2 Performing skeletal scintigraphy	25
11. Ultrasound.....	27
12. Magnetic resonance imaging and computed tomography scanning	28
13. Abdominal and thoracic injuries	29
14. Imaging techniques in head injury and other suspected neurological trauma	30
14.1 Role of imaging modalities MRI and CT	30
14.2 Indications for neuro-imaging.....	30
14.3 Multi-slice CT	31
14.4 MRI	31

15.	Schedule of neuro-imaging	33
	15.1 Acute presentation	33
	15.2 Day one.....	33
	15.3 Days three to five	33
	15.4 Three to six months	34
	15.5 Non-acute presentation.....	34
Table 2.	Imaging algorithm for suspected non-accidental head injury.....	35
16.	Imaging protocols in NAHI	36
	16.1 CT	36
	16.2 MRI: early.....	36
	16.3 Standard sequences.....	37
	16.4 MRI: late.....	37
17.	Image review systems.....	38
18.	The radiological opinion	40
19.	Radiology reports	41
	19.1 Background.....	41
	19.2 Clinical reports	42
	19.3 Legal reports	43
20.	Radiation safety.....	45
21.	Summary	47
22.	Recommendations	48
	22.1 Training	48
	22.2 Service delivery.....	50
23.	References	51

Foreword

Together with the Royal College of Paediatrics and Child Health, The Royal College of Radiologists has updated its guidance on working in child protection. This document brings together the latest guidance and recommendations on how to proceed in cases of suspected non-accidental injury and aims to ensure that all healthcare professionals involved within the field of child protection are suitably supported.

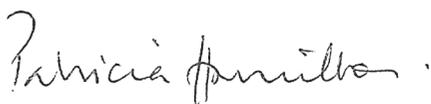
In order for radiologists to be more comfortable in this important role, appropriate training is vital. Therefore, the principles of child protection should become a critical component of training for all clinical radiologists, and the level of training should be tailored to the level of involvement of the individual radiologist in the imaging of children.

We hope the document will also be useful to other professions who work with children, giving them insight into the role played by the radiologist.

We would like to take this opportunity to thank those who have worked together to develop this document: Dr Paul Dubbins (Chair), Dr Chris Hobbs, Dr Jean Price, Dr Karl Johnson, Lady Margaret Wall, Dr Sabine Maguire, Dr Tim Jaspan, Dr Neil Stoodley, Dr Steve Chapman, Dr Alison Kemp and Dr Rosemary Arthur.



Professor Andy Adam FRCP FRCS
President
The Royal College of Radiologists



Dr Patricia Hamilton BSc MB FRCOG FRCP FRCPCH
President
Royal College of Paediatrics and Child Health

Editorial group

Dr Paul Dubbins (Chair)	Consultant Radiologist, Plymouth
Dr Jean Price	Consultant Paediatrician, Southampton
Dr Karl Johnson	Consultant Paediatric Radiologist, Birmingham
Dr Sabine Maguire	Senior Lecturer Child Health, Cardiff
Lady Margaret Wall	RCR Lay Representative
Dr Tim Jaspan	Consultant Neuro-Radiologist, Nottingham
Dr Chris Hobbs	Consultant Paediatrician, Leeds
Dr Neil Stoodley	Consultant Neuroradiologist, Bristol
Dr Steve Chapman	Consultant Paediatric Radiologist, Birmingham
Dr Alison Kemp	Reader in Child Health, Cardiff

Acknowledgements

We gratefully acknowledge the contribution of the following:

Dr Rosemary Arthur	Consultant Paediatric Radiologist, Leeds
--------------------	--

Introduction

Child protection should be everyone's responsibility. Paediatricians and radiologists have a particular responsibility to ensure child safety where there are concerns that a child may have suffered significant harm.

For most children parents, grandparents, family and friends are the guardians of safety and security. Sadly, for some children, these carers or others can be responsible for neglect or child abuse. There are many reasons for this but these are beyond the brief of this document. Similarly, during the course of normal activity, children will sustain accidental injury. Both groups of children require careful investigation which will include, in most cases, some form of clinical imaging.

The investigation of the injured child is stressful for all, especially when the child is suspected of suffering multiple injuries or when a pattern of injuries suggests that the child may have been abused.

The thorough investigation of children with suspected non-accidental injury (NAI) is critical to assure their safety. However, it is important to recognise that in many cases initial concerns are not borne out. It is essential that all children and their carers are managed sensitively throughout the process of investigation.

One of the consistent messages from enquiries into child death has been a lack of communication between professionals both within and between agencies charged with the care of children. The Laming Inquiry¹ identified shortcomings in services designed to safeguard child welfare, and highlighted that failure to intervene sufficiently early to protect a child at risk had been a theme of earlier reports. As a consequence, the Government made a commitment to reform children's services in order to ensure protection from neglect and harm. This commitment has formed the basis of new legislation.²⁻⁵

Implicit within this legislation is a new duty of care for professional staff and agencies to safeguard the health and to promote the welfare of children. For paediatricians and radiologists, this translates into a requirement to work together and with other healthcare professionals and agencies to prevent harm to children. This involves the establishment of clear lines of communication between all those involved in the care and protection of children.

It is essential that all healthcare professionals and their teams have access to advice and support from named and designated child protection professionals. It is also essential that paediatricians

and radiologists undertake regular training appropriate to their level of involvement in child protection.

For the child who may have suffered physical injury, imaging may be essential if patterns of trauma that are consistent with NAI are to be detected. The care and investigation should be delivered by senior professionals if high standards are to be achieved and maintained. For clinical radiology and paediatrics, this would usually be a consultant.

1. The role of the Colleges

- 1.1 The Royal College of Paediatrics and Child Health (RCPCH) and The Royal College of Radiologists (RCR) consider imaging of the injured child to be critical to the process of child protection. It is necessary to provide a framework, based on evidence, which supports the radiologist in contributing to child protection, provides education and training in all aspects of this work, stimulates recruitment and encourages best practice.
- 1.2 It is vital that confidence in the medical and allied professions is reaffirmed by ensuring that processes of investigation are standardised, robust and evidence based.
- 1.3 The advice given in this report is evidence based wherever possible or supported by widely held clinical opinion where the research evidence is not available. Where there is uncertainty, this will be acknowledged.
- 1.4 Throughout this report the paramount responsibility of all clinicians to the care and protection of the child will be stressed.⁶
- 1.5 The advice contained within this document provides detailed recommendations for the process of imaging, the timing of the initial investigations, the production of a report, and the timing and appropriateness of additional and follow-up investigations.
- 1.6 The role of the x-ray skeletal survey as well as other and more complex investigations will be discussed.
- 1.7 Many investigations that offer the potential to diagnose significant injury involve ionising radiation. These investigations will identify children who have been injured and those at risk of further injury or possibly death. This document contains an analysis of the risk/benefit of exposing children of all ages to diagnostic levels of radiation inherent in these investigations, based on the known dose levels and informed by extrapolated data from the Health Protection Agency – Radiation Protection Division (formerly the National Radiological Protection Board).

2. The scale of the problem

- 2.1 Research suggests that if all forms of injury in childhood are carefully analysed, then NAI is common.^{7, 8} Seven percent of children experienced serious physical abuse at the hands of their parents or carers during childhood. One percent of children experienced sexual abuse by a parent or carer and another three percent by another relative during childhood. Eleven percent of children experienced sexual abuse by people known but unrelated to them. Five percent of children experienced sexual abuse by an adult stranger or someone they had just met. Six percent of children experienced serious absence of care at home during childhood. Six percent of children experienced frequent and severe emotional maltreatment during childhood. Sixteen percent report serious maltreatment by their parents.
- 2.2 Up to 55% of fatally abused children have been seen within the previous month by a healthcare professional.⁹
- 2.3 The diagnosis can be missed if NAI is not considered, in which case the children are at a high risk of repeated abuse that may be fatal.¹⁰⁻¹²
- 2.4 The incidence of injury sufficient to cause fracture is variously reported as occurring in between 6% and 55% of physically abused children dependent on the age and nature of the population studied.¹³
- 2.5 The pre-mobile child is less prone to accidental injury, and the younger the child the more likely is the fracture to have been inflicted.¹⁴
- 2.6 Clinical studies have shown that children with disabilities are at increased risk of abuse.¹⁵ There should therefore be heightened awareness of the possibility of NAI in this group of children.
- 2.7 Severe injuries may include thoracic, abdominal and/or brain injury.
- 2.8 Non-accidental head injury (NAHI) with brain injury is a serious condition. Outcome studies¹⁰⁻¹² show an overall mortality of 20%, severe disability in 34% and mild disability in 25% of survivors.
- 2.9 Babies and toddlers are most susceptible to NAHI, resulting in significant brain injury. Epidemiologic studies suggest an annual population incidence of 36 per 100,000 in children less than six months of age, 14-24 per 100,000 in those under one year and 0.3-3.8 per 100,000 in one to two year olds.^{10, 16, 17}

3. What to do if non-accidental injury is suspected

- 3.1 Child protection is governed by a legislative framework that requires different agencies to work in concert but which identifies the responsibility of all.^{2,5}
- 3.2 It is essential that when a senior clinician (usually a paediatrician) has concerns about possible NAI and they require a radiological opinion that they convey their concerns clearly to the radiologist. If this concern is expressed via a telephone conversation, it should be recorded in the notes.
- 3.3 The possibility that a child has been injured non-accidentally should be clearly stated on the radiological request. Relevant information that **MUST** be identified in the request includes details of current clinical problems, mode of presentation and any relevant past medical, family or social history, whether this request is made conventionally as a handwritten request or electronically.
- 3.4 The development of Picture Archiving and Communications Systems (PACS) and Radiology Information Systems (RIS) is now well advanced. The original request cards should remain available for review, either manually archived or scanned into and stored electronically in the RIS.
- 3.5 These processes will ensure that the radiologist fully understands how to manage the child and family within the radiology department and also to assess how extensive their investigations may need to be.
- 3.6 It is also critical for the radiographer to be fully appraised of the clinical problem if he/she is to be able to manage the child and family effectively and to undertake the imaging study to the highest possible standard.
- 3.7 Once the radiologist has carried out his/her assessment and come to a conclusion, he/she should convey the findings verbally to the paediatrician at the earliest opportunity. This should be followed by a report in writing, which must be entered into the permanent patient record.
- 3.8 The results of such radiological investigations should be included in any report that is made to Social Services or the police. Both the paediatrician and the radiologist may be requested to provide a report for a case conference, police investigation or court hearing.

- 3.9 It is the responsibility of all clinicians to ensure that if abuse is suspected an appropriate referral to Social Services is made as soon as possible and usually within 24 hours.
- 3.10 For radiologists, this responsibility will usually be discharged by prompt communication of abnormal findings to the clinician caring for the child.^{13,14, 18, 19}
- 3.11 If the radiologist has continuing concerns about NAI and the continued safety of the child, in spite of assurances that a Social Services referral is not warranted, the radiologist has a continuing duty to the child. The radiologist must then seek advice from the named/ designated doctor for child protection within the Trust.
- 3.12 Some children will present with a serious life-threatening injury. In this situation the responsibility of the clinical team is to assess the critical injury in order to provide immediate treatment. This process may involve all of the imaging modalities, and the skeletal survey may be deferred until after the child has been stabilised.

4. Communication and consent

- 4.1 Good communication is vital if the child is to be properly and safely investigated. Effective team-working will afford optimum management of the child.
- 4.2 Good working relationships within and between the departments of paediatrics and clinical radiology are critical to good communication.
- 4.3 Communication between the paediatrician and the carer must include a careful and accurate presentation of the clinical concerns, a description of the imaging procedures that are being planned, an explanation of the reasons for the diagnostic pathway and an explanation of the risk/benefit of the procedures involved.
- 4.4 It is inappropriate that a full skeletal survey is performed without the knowledge of the child's referring paediatrician and carers.
- 4.5 The paediatrician will provide clinical information for the radiographer and radiologist in sufficient detail to allow the process of justification for the examination, according to the Ionising Radiation (Medical Exposure) Regulations 2000 IR(ME)R.²⁰ This will usually involve verbal as well as written communication and will record the level of concern.

5. Indications for clinical imaging

- 5.1 There are a number of clinical indicators from the presentation, history, examination findings and family background that may lead to a request for imaging designed to contribute to child protection.²¹⁻²⁶
- 5.2 If, during imaging for unrelated reasons, a fracture is detected that is inconsistent with the clinical history available, it is the duty of the reporting radiologist to discuss the findings with the clinician treating the child, at the earliest suitable opportunity, in order to establish if further investigations are warranted; for example, a rib fracture or fractures presenting on a chest x-ray performed for suspected chest infection.
- 5.3 It is not possible or appropriate to provide an extensive review of the clinical features of child abuse but it is important for the radiologist to be aware of the variety of presenting features that may generate a request for imaging as part of the process of child protection. This will have implications for training and continuing professional development of radiologists and paediatricians.

6. The skeletal survey

- 6.1 A skeletal survey is the standard initial imaging method for evaluation of children where NAI is one of the differential diagnoses.
- 6.2 In children under the age of two where physical abuse is suspected, a full skeletal survey should always be performed.
- 6.3 If it is decided not to perform a skeletal survey, the reasons for this should be detailed in the patient's notes.
- 6.4 In children over the age of two years, the decision to perform a skeletal survey will be guided by clinical and social history and physical findings.
- 6.5 A skeletal survey consists of a standard series of radiographic images that will visualise the entire skeleton.
- 6.6 The purpose of a skeletal survey is to allow the detection of occult bony injuries, obtain further information about a clinically suspected injury, aid in the dating of bone injuries and help in the diagnosis of any underlying skeletal disorder which may predispose to fractures.²⁷⁻²⁹
- 6.7 There is sound evidence that a skeletal survey has a high yield of revealing abusive fractures in children less than two years of age; older children will have to be discussed on a case-by-case basis.³⁰
- 6.8 A skeletal survey will be requested by a senior paediatrician as a result of review of the presentation and the clinical findings, and after discussion with the clinical radiologist.
- 6.9 The skeletal survey represents the first imaging investigation where child abuse is suspected, except where the clinical condition demands other urgent imaging or the presentation is with a head injury, in which case a computed tomography (CT) scan of the head will be undertaken first.
- 6.10 It is important that the skeletal survey is carried out to a high technical standard. The survey provides information that will inform patient management but may also be critical in the diagnosis of NAI.^{18,31,32}
- 6.11 The evidence obtained from a skeletal survey will be presented in multi-disciplinary meetings. It may also be used as part of court proceedings.

7. Recommended procedures for (child protection) skeletal survey

7.1 Timing and radiology/radiography standards

- 7.1.1 The high technical standards required for a skeletal survey place very significant demands on a department of clinical radiology.
- 7.1.2 Radiographers performing the skeletal survey should be trained in paediatric radiography techniques.
- 7.1.3 Appropriate training for radiographic staff must be available in all radiology departments where children are imaged.³³
- 7.1.4 Two radiographers working together should carry out the skeletal survey.
- 7.1.5 In addition there must be another professional who is responsible for the child's safety while in the radiology department. This would normally be a paediatric nurse or other healthcare professional from the paediatric department.
- 7.1.6 All the radiographic images should be reviewed for completeness and diagnostic quality by a consultant radiologist or senior experienced paediatric radiographer at the time the study is performed and prior to the child leaving the radiology department.
- 7.1.7 The radiologist responsible for supervising the investigation may not necessarily be the radiologist who ultimately reports the skeletal survey, although this would be best practice.
- 7.1.8 Ideally, the vast majority of skeletal surveys should be performed during normal working hours, when there is a full complement of radiographic and radiology staff.
- 7.1.9 However, the child may present during the evenings or at weekends. In these cases, the examination should be performed, wherever possible during the normal working day and usually within 24 hours of referral.
- 7.1.10 If a head injury is suspected, performing a complete skeletal survey should not delay obtaining a CT scan of the head, although x-rays of clinically apparent injuries would still be undertaken.

- 7.1.11 Exceptional circumstances, for example an unstable clinical condition, may delay the performance of the skeletal survey. Similarly, where the child remains an inpatient and when there are no child protection concerns about siblings within the home, it may be deferred for up to 72 hours.
- 7.1.12 It is recognised that for many hospitals this target will be difficult to achieve given the current shortage of specialist radiographic and radiologist expertise. Departments of clinical radiology must work with trust management to develop processes whereby these targets are met.
- 7.1.13 Although optimal conditions for performance of a skeletal survey prevail during normal working hours, the timing of the examination is important for a number of reasons:
- a) The investigation may not only influence the immediate clinical management but will inform the management of the whole family. For example, depending upon the clinical findings a normal examination may allow the child to go home; an abnormal skeletal survey may prevent a child being returned to a dangerous situation.
 - b) The early identification of features supporting a diagnosis of NAI will alert the child protection team and highlight the need for multidisciplinary assessment.
 - c) If the case is brought before the courts any delay in investigation could afford an opportunity for the allegation that the injury may have occurred while the child was in hospital.

7.2 When the child attends the radiology department

- 7.2.1 The radiology department should liaise with the staff caring for the child about the most appropriate appointment time for the survey to be performed.
- 7.2.2 If analgesia is thought to be clinically necessary, then this should be administered in appropriate dose prior to commencement of the skeletal survey.
- 7.2.3 The child should be clearly identified with an appropriate hospital identification label or by the professional accompanying them.
- 7.2.4 Correct identity must be confirmed by two radiographers.

- 7.2.5 The welfare and wellbeing of a child during imaging investigations are best served by allowing the carers to accompany the child (as long as this has not been prohibited earlier by appropriate agencies). This approach applies during a skeletal survey as for any other investigation. However, if there are concerns about either the safety of the child, or adequacy of examination it may be appropriate for the child to be accompanied only by a member of the paediatric or nursing staff. Occasionally it may be necessary to provide security support.
- 7.2.6 After the skeletal survey is completed the child should be returned for ongoing care to the referring clinician.
- 7.2.7 It is not appropriate for the child, parents, carers or social workers to wait for the report of the examination in the radiology department.

7.3 Radiographic principles

- 7.3.1 The skeletal survey should be performed in accordance with the principles of high-quality diagnostic radiography. These include proper technical factors, positioning, correct exposure factors for the child's age and weight, and appropriate restraining methods.
- 7.3.2 All the radiographs should have the correct patient name, side marker, date and time of examination clearly visible. All these factors should form part of the radiographic image and must not be added at a later date. Where the time and date are recorded automatically during the exposure it is important to ensure that this is appropriately set to GMT or BST.
- 7.3.3 The name of the radiographer(s) performing the survey must be recorded.
- 7.3.4 Further radiographic projections may be required after subsequent clinical information is available or review of the original films.
- 7.3.5 The supervising radiologist is responsible for any additional radiographic projections that are required either at the time of the original survey (or subsequently) and their justification under IR(ME)R.
- 7.3.6 Each anatomical area should be imaged with a separate exposure to optimise image quality.

- 7.3.7 X-rays should be exposed to show soft tissue as well as bone detail.
- 7.3.8 The radiographic images that should be routinely obtained in all cases are shown in Table 1.^{13, 18, 19,34-39}
- 7.3.9 A single film ‘babygram’ must not be performed.
- 7.3.10 Right and left oblique views of the ribs should be included in all skeletal surveys. Oblique views improve the sensitivity and specificity of the survey in detecting rib fractures with increased diagnostic accuracy of about 9%.⁴⁰
- 7.3.11 Wherever possible the limbs must be straight and radiographs of each extremity should be at least in the frontal projection.
- 7.3.12 The hands and feet should have separate exposures in addition to those for the limbs.
- 7.3.13 Skull x-rays should be obtained even if a CT brain scan is being performed or is planned, as some skull fractures can be missed on CT.^{41, 42}
- 7.3.14 Two skull views are standard for the skeletal survey but an additional Townes view should be performed if clinically indicated.
- 7.3.15 If, on review of the images, any overlying articles or pieces of clothing (such as identification bracelets, religious jewellery etc) are seen to be obscuring part of the skeleton, repeat radiographs should be taken after having moved or removed these items.
- 7.3.16 If clinical signs suggest a focal injury (for example, soft tissue swelling or tenderness) then two radiographic projections at 90° should be obtained. This is standard radiographic practice for all cases of trauma.
- 7.3.17 Complete views of the whole leg should be obtained in small children with femoral fractures before Gallows traction is applied. If this is not practical the lower limb should be x-rayed at a later date, after the traction has been removed.

Table 1. The standard child protection skeletal survey for suspected non-accidental injury

Skull <ul style="list-style-type: none">• Anterior posterior (AP), lateral, and Townes view (the latter if clinically indicated).• Skull x-rays should be taken with the skeletal survey even if a CT scan has been or will be performed.
Chest <ul style="list-style-type: none">• AP including the clavicles.• Oblique views of both of the sides of the chest to show ribs ('left and right oblique').
Abdomen <ul style="list-style-type: none">• AP of abdomen including the pelvis and hips.
Spine <ul style="list-style-type: none">• Lateral: this may require separate exposures of the cervical, thoracic and thoracolumbar regions.• If the whole of the spine is not seen in the AP projection on the chest and abdominal radiographs then additional views will be required.• AP views of the cervical spine are rarely diagnostic at this age and should only be performed at the discretion of the radiologist.
Limbs <ul style="list-style-type: none">• AP of both upper arms• AP both forearms• AP both femurs• AP both lower legs• PA of hands• DP of feet

Supplementary views

AP and lateral coned views taken tangentially to the metaphyses of the elbows, wrist, knees and ankles are particularly helpful, especially where these regions are not well seen on the full length views of the limb. These views may demonstrate metaphyseal injuries in greater detail and in other cases may help to confirm, with greater certainty, the absence of any radiological abnormality.

Where an abnormality is suspected these views should be supplemented by:

- Lateral views of any suspected shaft fracture.
- AP and lateral coned views of the elbows, wrist, knees and ankles, when a fracture is suspected at these sites.

These may demonstrate metaphyseal injuries in greater detail than AP views of the limbs alone.

8. Additional/supplementary imaging for suspected non-accidental skeletal injury

- 8.1 Most children in whom radiological imaging is required for suspected physical abuse will be examined by a skeletal survey. There are, however, other complementary investigations that may contribute to the diagnosis.
- 8.2 Radiologists, in consultation with their clinical colleagues, will determine the role of other imaging modalities in contributing to the diagnosis; the radiologist being responsible for their justification under IR(ME)R.
- 8.3 The most appropriate method of detection of occult injury, considering the logistics of care and follow-up, will be determined.
- 8.4 The choice of additional imaging modality will depend on availability of appropriate imaging technology and expertise, as well as the clinical and imaging findings of the original skeletal survey.
- 8.5 Further imaging will be required:
- a) When there are equivocal findings on the skeletal survey.
 - b) Where the skeletal survey is negative but there remain ongoing clinical child protection concerns.

9. Follow-up radiographs

- 9.1 Follow-up radiographs may be of significant value in cases of suspected NAI providing in some cases confirmatory evidence and in others contributing to the exclusion of the diagnosis.⁴³⁻⁴⁵
- 9.2 Follow-up radiographs have been shown to be of value in improving the detection of rib and metaphyseal fractures with detection rates improved by up to 27% (although the studies attesting to these enhanced sensitivities did not use oblique rib views on the original skeletal survey).⁴³⁻⁴⁵
- 9.3 In cases where there is ongoing clinical concern, there is evidence that a repeat skeletal survey may detect occult fractures not seen on the initial skeletal survey. A full skeletal survey should be repeated with the exception of the skull.
- 9.4 In cases where there are equivocal findings of possible fractures on the initial radiographs, repeat views of these areas may be of benefit in determining whether or not a fracture is present on the basis of demonstrating features of bone healing. This practice remains common for all types of injury in children although there are no specific research data to support the practice in NAI.
- 9.5 Timing of follow-up radiographs is important in order to detect additional fractures and to contribute to the dating of injury. It is recommended that they are obtained eleven to fourteen days after the original skeletal survey to achieve optimum detection of evidence of healing.
- 9.6 The repeat skeletal survey should be performed two weeks after the initial survey.
- 9.7 Potential drawbacks of a policy of repeat skeletal survey are as follows:
- a) Delay in reaching a firm diagnosis in some cases.
 - b) Failure to manage the child and the family appropriately as a consequence of the delay.
 - c) It may be difficult to determine where the child should be cared for in the interval before the follow-up imaging is performed.

- d) Non-attendance for follow-up imaging. Departments of clinical radiology must develop robust mechanisms to inform the designated doctor or nurse of the failure to attend.

10. Scintigraphy (bone scans)

10.1 The role of scintigraphy in NAI

10.1.1 In addition to the indications for further imaging described in section 9, there are situations where a bone scan is the supplementary imaging modality of choice.

10.1.2 For example, this may be the preferred option where a follow-up skeletal survey in eleven to fourteen days is not a viable option, either because concerns about child safety remain during the interval, or where failure to attend for repeat skeletal survey is felt to be likely.

10.1.3 The roles of radiographic skeletal surveys and bone scans are complementary. If both are done, more skeletal injuries may be identified than with either in isolation.⁴⁶⁻⁵¹

10.1.4 Bone scans are sensitive in the detection of fractures and in some cases will detect bone injury, either invisible or difficult to identify on the initial skeletal survey, as a bone scan may become positive within seven hours of a bone injury.⁵¹

10.1.5 Conversely, a bone scan is not as sensitive as a radiographic skeletal survey in detecting metaphyseal or skull fractures and may also add less to the detection of rib fractures if oblique radiographs are routinely used in the initial skeletal survey.

10.1.6 Any positive lesions identified on the bone scan still require confirmatory x-rays, as the specificity of bone scans is limited. The bone scan may be abnormal in infection, and malignancy, as well as trauma. Furthermore, bone scans alone cannot assist in the dating of fractures.

10.1.7 If the bone scan and skeletal survey are performed and are negative, there would only be an indication for a repeat skeletal survey in exceptional circumstances.

10.2 Performing skeletal scintigraphy

10.2.1 There are a number of criteria that are essential for high-quality skeletal scintigraphy.

10.2.2 Many departments in the UK have limited experience in bone scanning in children.

- 10.2.3 Consequently, if the department is not performing bone scans in children on a regular basis, bone scanning should not form part of the investigation of the injured child.
- 10.2.4 Performance of bone scintigraphy should follow the guidelines produced by the Paediatric Committee of the European Association of Nuclear Medicine (PCEANM).⁵²

11. Ultrasound

- 11.1 There are case reports of the use of ultrasound in detecting subperiosteal haemorrhage in occult rib fractures and around fractures prior to any radiographically visible subperiosteal new bone formation.⁵³⁻⁵⁵
- 11.2 However, the use of ultrasound in the investigation of bone injury has not been validated in child protection and it cannot be advocated as a primary tool for the investigation of bone injury.

12. Magnetic resonance imaging and computed tomography scanning

- 12.1 As with ultrasound the precise role of magnetic resonance imaging (MRI) in investigating children with suspected non-accidental bone injury has not been clearly defined.⁵⁴
- 12.2 MRI has a major role, supplementary to CT, in the investigation of suspected brain injury (see section 14).
- 12.3 CT has the same role in the evaluation of non-accidental bone injury as in those injuries occurring accidentally, serving to define the extent and severity of complex fractures or those not optimally demonstrated with plain radiographic techniques. This is particularly the case in spinal fractures, those involving the bony pelvis and complex fractures involving the joints.
- 12.4 CT and MRI have a major role in the evaluation of soft tissue injury either in association with bone injury or in isolation.

13. Abdominal and thoracic injuries

- 13.1 Children who have been abused may suffer other forms of injury, including trauma to the chest and abdomen.
- 13.2 The overriding clinical responsibility is the diagnosis and treatment of the presenting clinical injury.
- 13.3 The investigation of thoracic and abdominal injuries in suspected NAI should be no different from the imaging used for accidental trauma.
- 13.4 Contrast enhanced CT is the imaging modality of choice for both the abdomen and chest, although the whole gamut of cross-sectional imaging may be employed in certain circumstances.⁵⁶⁻⁶⁰ If a head CT is being undertaken at the same time, this should be performed prior to the chest and abdomen and prior to the administration of contrast.
- 13.5 In some circumstances, ultrasound may be used to evaluate the abdomen as an adjunct to CT.⁵⁵

14. Imaging techniques in head injury and other suspected neurological trauma

14.1 Role of imaging modalities MRI and CT

14.1.1 The evaluation of suspected head injury in early life has evolved rapidly over the past three decades.

14.1.2 CT has become central to neuro-imaging and the development of multislice scanning has further enhanced the importance and efficacy of this modality.

14.1.3 CT scanning is highly sensitive and specific for the detection of acute intracranial haemorrhage (such as subdural haematoma, subarachnoid and intraventricular haemorrhage and haemorrhagic contusions)⁶¹⁻⁶³ as well as secondary parenchymal low density changes (for example, cerebral oedema, ischaemia and infarction).⁶⁴

14.1.4 MRI has superior ability to define parenchymal injury in the acute phase.^{65,66} MRI also enables more accurate mapping and detection of subacute and chronic intracranial haemorrhage.^{67,68}

14.1.5 The combined use of CT and MRI enables more accurate detection, localisation and characterisation of any intracranial injury as well as the monitoring of the frequent pattern of cascade of secondary brain injury.

14.1.6 The sequence of imaging will depend on the nature of clinical presentation, the clinical status of the child, the presence of other life threatening injury and the availability of neuro-imaging techniques.

14.2 Indications for neuro-imaging

14.2.1 There are clear clinical features that suggest that neurological injury may have occurred, but in addition there are certain groups of children in whom evidence suggests that neurological injury is more likely. Thus neuro-imaging should be undertaken in the following groups:

- a) Any child who presents with evidence of physical abuse with encephalopathic features or focal neurological signs or haemorrhagic retinopathy.

b) Any child under the age of one where there is evidence of physical abuse.^{17,69-72}

14.2.2 The reasoning for the decision whether or not to proceed to neuro-imaging must be documented in the notes.

14.3 Multi-slice CT

14.3.1 Multi-slice CT scanners are now widely available, and enable quick and effective first line evaluation of infants and young children. Not infrequently, these children will be haemodynamically unstable and require resuscitative measures that in general preclude MRI as the first line investigation.

14.3.2 CT is of proven value for the detection of acute intracranial haemorrhage. It can reliably diagnose sequelae of NAHI that may require urgent surgical attention; for example, subdural haematoma with mass effect or large contusions.

14.3.3 CT is, however, not as sensitive as MRI for detecting subtle parenchymal abnormalities, the full extent of intra-axial and extra-axial haemorrhage and the secondary ischaemic changes that may develop in NAHI.

14.4 MRI

14.4.1 MRI can be less reliable than CT for identifying hyper-acute intracranial haemorrhage, but becomes increasingly sensitive for detecting sub-acute haemorrhage and is therefore used where appropriate from days three to five.⁷³

14.4.2 Pulse sequences tailored for the detection of acute haemorrhage (for example, T2* gradient echo) increase the sensitivity of MRI for the detection and evaluation of acute trauma.

14.4.3 The full extent of subdural haematomas (SDH) is best evaluated by MRI. Small SDHs not seen on CT, particularly when adjacent to the calvarium or in the posterior fossa, may also be identified.

14.4.4 Evolving ischaemic brain injury is more effectively and accurately evaluated, particularly in conjunction with diffusion weighted imaging (DWI). Use of DWI will detect a significantly greater incidence of brain injury compared with conventional MRI sequences.^{65,66}

- 14.4.5 Evolving secondary brain damage is best assessed seven to ten days after the acute injury. Early parenchymal abnormalities on CT or MRI due to reversible or irreversible ischaemia may become more clearly identified. Haemorrhagic laminar cortical necrosis may develop seven to ten days after the injury. Scanning at this stage will also evaluate whether there is any expansion of subdural collections or early development of hydrocephalus.
- 14.4.6 Late sequela of brain injury are also best evaluated by MRI. These include:
- a) Enlarging, chronic subdural haematomas/effusions
 - b) Hydrocephalus
 - c) Leptomeningeal cyst which may be associated with brain parenchymal injury, dural defect and brain herniation
- 14.4.7 Spinal injury (cervical or thoracolumbar) has been recorded in physical abuse. However, as yet there is insufficient evidence to justify routine spinal imaging. Spinal imaging should be undertaken if there are clinical or imaging findings which would suggest spinal injury.

15. Schedule of neuro-imaging

15.1 Acute presentation

The precise timing of investigations will be influenced not only by clinical need and clinical judgement, but also by the specific circumstances in each individual case. The schedule of scanning provided below is aimed at optimising the diagnostic and forensic information and serves as a guideline.^{74, 75}

15.2 Day one

- a) Cranial CT. This must be undertaken as soon as the child is stabilised following admission. If normal, and there are no neurological symptoms either at presentation or subsequently, no further neuroradiological imaging is required.
- b) Therapeutic tapping of subdural haematomas may be required and can provide important forensic information (such as the nature of the fluid and its appearance, which may assist in ageing of the blood). Except in extreme circumstances, subdural tapping should be postponed until CT has been acquired.

15.3 Days three to five

- a) If the initial cranial CT is abnormal or if the child has neurological abnormalities in the presence of an apparently normal or equivocal CT, cranial MRI should be performed.
- b) If MRI is not available on site, advice should be sought from the regional paediatric or neurosciences centre and consideration given to transferring the child there for MRI and further management.
- c) If the initial CT and/or MRI is normal and/or the neurological abnormalities are resolving, no further neuroradiological investigation is required. Further investigation is essential in the presence of an abnormal MRI and/or CT. In the event that the original neuro-imaging is normal, but ongoing neurological symptoms persist, consideration of further neuro-imaging should be discussed.

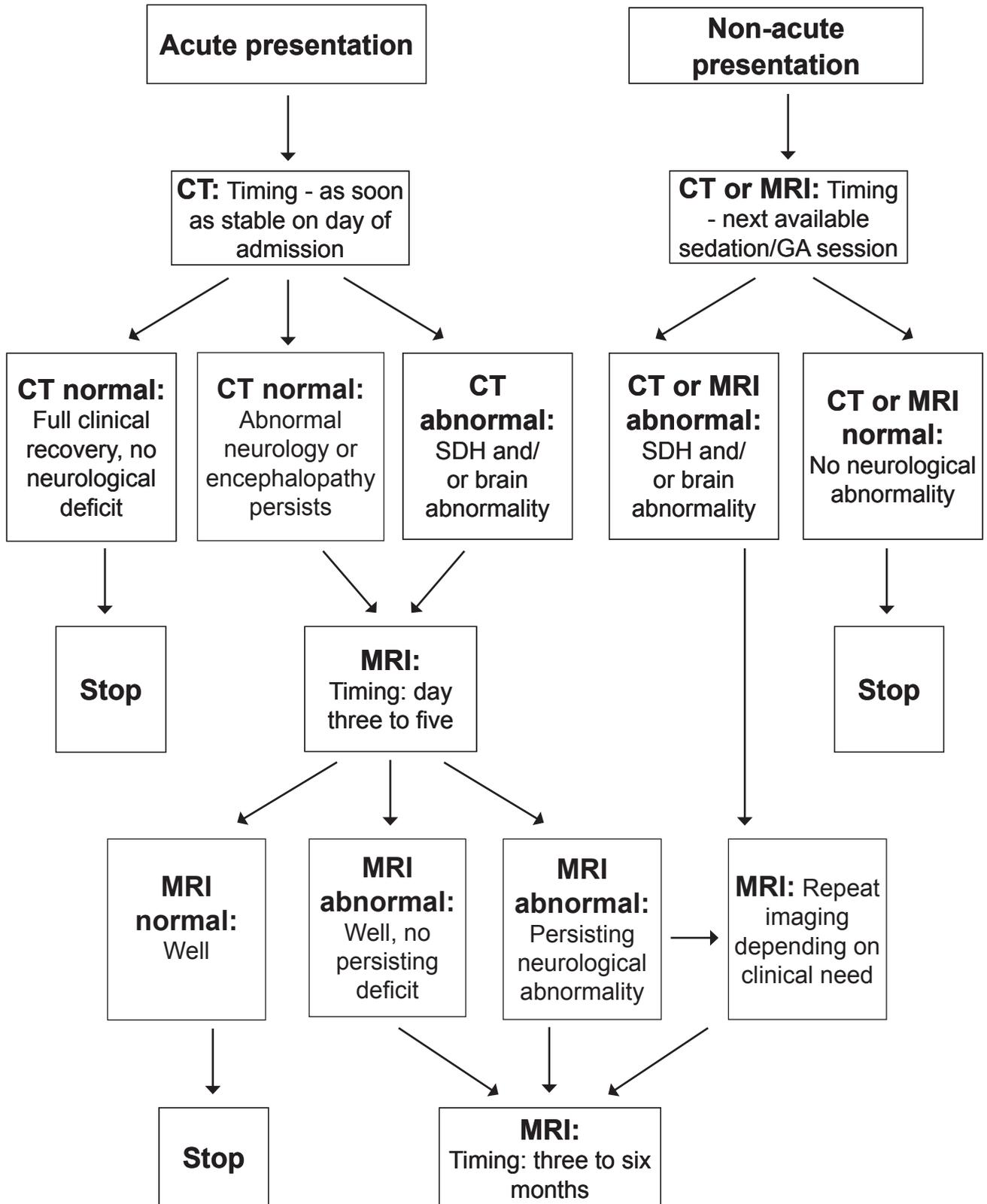
15.4 Three to six months

- a) If early imaging demonstrated brain injury or there is persisting neurological abnormality, MRI examination should be obtained as it may provide prognostic information to assist in the future management of the child.^{65,66}
- b) The examination at this stage may not require a full set of sequences (see 16.3).

15.5 Non-acute presentation

- a) MRI is the modality of choice as it is better able to evaluate the status of any brain injury as well as the nature and extent of any extra-axial fluid.

Table 2. Imaging algorithm for suspected non-accidental head injury



16. Imaging protocols in NAHI

16.1 CT

- 16.1.1 Axial scanning must be undertaken from the base of the brain to the vertex.
- 16.1.2 Slice thickness should be 5mm or less throughout the brain.
- 16.1.3 Images must be reviewed on both soft tissue and bone window settings, with intermediate settings if necessary in the presence of equivocal extra-axial haematomas over the brain surface.
- 16.1.4 The soft tissue settings should be optimised for a neonate or young infant, ideally set at a window of approximately 80HU and a level of 30-40HU.
- 16.1.5 Contrast administration is seldom necessary.

16.2 MRI: early

Children under two to three months of age can be imaged in a knee surface coil, which gives a greater signal-to-noise ratio because of the proximity to the coil. Older infants are generally imaged in a head coil. Under twelve months of age, when the myelin is not fully formed and the brain has a higher water content, it is helpful to increase the TR of T2-weighted sequences. This produces greater contrast between grey and white matter. Diffusion weighted imaging must be undertaken routinely to detect the secondary ischaemic sequelae of NAHI which may be occult on routine sequences.

16.3 Standard sequences

All brain imaging should be performed using a slice thickness of 5mm or less.

Axial:	Dual echo SE (under one year of age). Dual echo FSE (over one year of age). T2* gradient echo (or EPI susceptibility sequence). Diffusion weighted imaging (DWI).
Coronal:	T1 SE and FLAIR or T2 FSE.
Sagittal:	T1 SE.
Spine:	All spine imaging should employ slice thickness of 3mm. Sagittal T1 and T2. Axial T1 and T2 sequences should be performed through any abnormal region that is identified on the sagittal sequences. If the appropriate coil is available, the whole spine should be examined.

16.4 MRI: late

Axial:	Dual echo SE (under one year of age). Dual echo FSE (over one year of age).
Coronal:	T1 SE and T2 FSE.
Sagittal:	T1 SE.

17. Image review systems

- 17.1 The National Programme for Information Technology has undertaken a programme to ensure that all departments will be 'filmless' by the end of 2009. Consequently all images will be reviewed in soft copy on computer workstations.
- 17.2 All images will then be produced utilising digital/computed radiography systems.
- 17.3 It is recognised that digital radiographs have a lower spatial resolution than conventional systems. However, digital radiographs allow better contrast resolution and manipulation when imaged as soft copy as compared to conventional systems.⁷⁶⁻⁷⁸
- 17.4 There has been a limited amount of research into the optimum image acquisition system, but early studies suggested that rib and metaphyseal fractures might be missed with digital radiography.⁷⁹ There is no study that has validated the use of digital imaging in the investigation of clinical NAI cases.
- 17.5 More recent evidence suggests that digital radiography is now of a similar standard to conventional film/screen combinations in detecting rib fractures on post mortem radiographs.⁷⁶ However, the systems evaluated were direct digital systems, rather than computed radiography systems, which are more commonly used in the UK.
- 17.6 Given that all image acquisition and review systems will become digital with the roll-out of PACS through Connecting for Health, it is vital that the images that are obtained are acquired and reviewed under optimum conditions.
- 17.7 The digital system must be optimised to the highest resolution possible, optimising exposure factors to produce the highest quality digital images.⁸⁰
- 17.8 High-resolution cassettes and CR systems should be used if available.
- 17.9 There should be regular quality assurance testing of all the digital equipment.
- 17.10 The detectors should exhibit good quantum efficiency, low electronic noise levels and good detective quantum efficiency in the clinically relevant range of spatial frequencies.

- 17.11 Monitors should be of at least three megapixel resolution, and of high luminescence.
- 17.12 Reporting of the skeletal survey should be on soft copy to allow image manipulation.
- 17.13 The reporting environment should be optimised for ambient light, ergonomics and minimum noise level.

18. The radiological opinion

- 18.1 Reporting on the radiology of NAI is within the core competence of all paediatric radiologists, both those working in specialist centres and those undertaking paediatric radiology as a special interest within a general department.
- 18.2 It is inevitable that more senior members of staff will have more experience than those recently appointed. This experience should be available to colleagues to ensure continuity of care of possibly abused children.
- 18.3 The radiological opinion will generally be sought from radiologists who have experience of generic paediatric trauma as well as that associated with abuse.
- 18.4 The initial report will usually be obtained from a consultant radiologist but may be issued by a senior specialist registrar (SpR), although in the latter case the SpR must be supervised by a consultant who must also countersign the report.
- 18.5 It is incumbent on all departments who x-ray children to provide at least an initial report in cases where NAI is suspected.
- 18.6 The radiologist should state his/her level of confidence in the report. For example, indicate it is provisional, that it is not within his/her area of expertise, and that a second opinion is being sought, and state from where this is requested.
- 18.7 Consideration should be given to developing local and regional networks to facilitate a second opinion.
- 18.8 Development of such networks would allow the review of the expert report and images by the local radiologists. This will increase and develop expertise on a wider basis.
- 18.9 In providing an opinion the radiologist should be aware that the information derived from imaging will contribute to diagnosis but that the management of the child depends upon the contribution of information from all members of the clinical and wider child protection team.

19. Radiology reports

19.1 Background

- 19.1.1 Radiological reports in relation to suspected NAI may be required for different situations. These may include:
- a) A standard radiological report on the imaging as required by the referring clinician. This forms part of the case record.
 - b) A report which may be required for multi-disciplinary assessment.
 - c) A report for legal proceedings. This may be requested as a factual report of the process of the investigation(s), or it may be requested in order to provide expert opinion to the court.
- 19.1.2 A report may also be commissioned by one of the parties involved in the proceedings. This is usually commissioned from an independent clinician/radiologist who has no prior connection with the investigation; however, this expert opinion may in fact be sought from the ‘treating’ clinician/radiologist who has the necessary degree of expertise and who feels competent and confident to provide an objective opinion.
- 19.1.3 A report may be required in criminal proceedings and commissioned by the police and the Crown Prosecution Service or the legal team for the defendant.
- 19.1.4 Where a report is required for legal proceedings, a letter of instruction setting out the requirements for the report should be sent as part of the request for the report.
- 19.1.5 At all times the radiologist should be mindful that he or she is a witness to the court and not an advocate for either side. It is their duty to detail the facts, pass opinion on those areas within their expertise and decline to comment on areas outside their competence.⁸¹

19.2 Clinical reports

- 19.2.1 The radiology report is the basis of communication between radiologists and other clinicians. Clear generic guidance for the construct and structure of the report is provided by The Royal College of Radiologists.⁸²⁻⁸⁶
- 19.2.2 The report must contain certain critical data including;
- a) Date.
 - b) Nature of imaging modality.
 - c) For x-rays; the views performed, and the number of films (for a child protection skeletal survey it will suffice to state “performed according to the standard imaging protocol” – RCR/BSPR/RCPCH).
 - d) For CT, the nature of acquisition, use of contrast.
 - e) For scintigraphy, the nature of the radiopharmaceutical and administered activity as well as the views.
 - f) For MRI, the sequences and imaging planes employed.
- 19.2.3 It is important to indicate that a report refers to a series of images/investigations where this is the case.
- 19.2.4 The report should be clear and detail each identified abnormality.
- 19.2.5 The report should include a comment about radiological bone density and any evidence of generalised bone abnormality. It should be acknowledged that radiographs do not provide a quantitative assessment of bone density.
- 19.2.6 Where there are fractures, it should state clearly whether or not there is evidence of healing.
- 19.2.7 On the basis of the above observations, a judgement must be made and recorded on whether there are fractures of more than one age.

- 19.2.8 The report should reflect a consideration of all the findings, recognising that visibility of injuries may vary on different views.
- 19.2.9 Avoidance of ambiguous language and technical jargon is critical to ensure the correct interpretation of the findings by other professionals involved in the protection of the child.
- 19.2.10 The differential diagnosis of the imaging findings must be carefully considered and detailed in the report, before reaching a conclusion that the radiological findings suggest NAI. In considering differential diagnoses the radiologist should liaise with the paediatrician to seek supportive clinical evidence.
- 19.2.11 The report should finish with a clear conclusion and a summary of the justification for the opinion.
- 19.2.12 The report should be transmitted verbally to the referring clinician and confirmed in writing.
- 19.2.13 Joint review of the imaging between radiologist and clinician is strongly recommended. The diagnosis of NAI is dependant on the combination of clinical, investigative and social findings.

19.3 Legal reports

- 19.3.1 The radiologist who was clinically involved is legally required, on request, to provide a factual report for the court in relation to family proceedings or to the police in relation to possible criminal proceedings.
- 19.3.2 If the clinician/radiologist involved in the clinical care of the patient/child is asked to prepare a report for the Court, this is likely to be required to furnish the court with an account of the factual events surrounding the admission, the investigation, the diagnosis, and the treatment. In some instances, the radiologist may be further asked to provide an ‘expert’ opinion. The radiologist in these circumstances should carefully evaluate whether he/she feels competent and confident to do so – objectively and expertly. A clear statement of the level of confidence and expertise should always be given.

19.3.3 Generally expert opinions for court hearings are sought from independent experts; but this should not deter the appropriately qualified treating clinician from offering expert opinion when it is requested, and when the clinician feels confident and competent to give such opinion

19.3.4 Any report provided for the courts demands a particular formal structure:

- a) All legal reports should start with name, position and qualifications of the radiologist/healthcare professional.
- b) In both family and criminal proceedings, a declaration of the independence of the radiologist and acknowledgement of the duty to the court will be required.
- c) This should be followed by a summary of instructions from the legal team acting on behalf of the court.
- d) The details of the radiological investigations undertaken should be presented in chronological order with the findings and conclusions.
- e) This will be then followed by answers to the questions as detailed in the letter of instruction.

19.3.5 Expert reports should be laid out similarly but will include opinions within the expertise of the expert. Where these are without your expertise, this should be stated. Further information about the preparation, structure and submission of a legal report is available usually from the instructing solicitor.

19.3.6 It is recommended that expert witnesses follow closely the advice provided by the RCR,⁸¹ RCPCH²¹ and by other bodies.⁸⁵

20. Radiation safety

- 20.1 The responsibilities for radiation protection are clearly established under the legislative framework of IR(ME)R (2000).²⁰ These regulations identify duty-holders: the referrer, the operator and the practitioner who have specific roles and responsibilities for ensuring radiation safety for all diagnostic imaging.
- 20.2 Most imaging procedures involve a relatively low dose when compared to background radiation. A chest x-ray, for example represents an exposure equivalent to three days of background radiation.
- 20.3 A skeletal survey, involving several exposures may equate to four to eight months of background radiation, when adequate shielding is used.
- 20.4 A CT examination of the head in a child may involve a radiation dose of about ten months of background radiation. CT of the abdomen involves a significantly higher dose, perhaps equivalent to as much as four to five years, although this may be reduced by optimising parameters for paediatric imaging.
- 20.5 Estimating the risk associated with diagnostic radiation is extremely complex. Different organs exhibit different sensitivities to radiation. The infant and young child appears more sensitive than the adult. The infant brain, for example appears to be twice as sensitive as the adult brain.
- 20.6 The risk of induced cancer is used as a measure of excess risk. For example, the risk of a fatal childhood cancer is 1 in 1,300, while the lifetime risk of fatal cancer is one in three. Calculation of the mean exposure incurred during a CT of the brain suggests that the excess risk is 1 in 4,250 for a newborn, 1 in 4,750 for a one year old and 1 in 6,500 for a five year old. In other words, the excess risk of developing a fatal childhood cancer for an infant between zero and one year of age is approximately one-third of the natural risk and one-fifth for a child of five years.⁸⁶⁻⁸⁸
- 20.7 Although this represents a small increased risk it is important that the paediatrician and the radiologist balance risk against the clinical indication for imaging. Clearly, where the safety of the child is at risk, the potential benefit of establishing a diagnosis outweighs the small excess risk attributable to the radiation. The radiologist, the practitioner as defined by IR(ME)R, must discharge the responsibility of justification of exposure in all cases.

- 20.8 It is important to present information about the risk/benefit of radiation to the parents/ carers in order to ensure that proper consent is achieved. The explanation of the need for a skeletal survey, a head CT or other imaging involving ionising radiation is the responsibility of the referring clinician who must be able to present the information in a way that is clearly understood by the parents.
- 20.9 In presenting information to the patient and their carer(s) it is important to recognise the hierarchy of clinical responsibility. The primary role of imaging investigations is to evaluate the presence or absence of injury in order to better care for the child, although the findings on imaging may be used for evidential and forensic purposes.
- 20.10 If consent is declined, the paediatrician, in concert with the child protection team and the radiologist, must determine whether there are overriding concerns which mandate the institution of a skeletal survey or cross-sectional imaging.²¹

21. Summary

- 21.1 There is a legal duty on all doctors to initiate child protection procedures if they suspect a child is being abused. Failure to do so may lead to serious injury or death of the child. In instituting these procedures, the doctor must in all cases undertake a risk-benefit assessment which will be based on a review of all the available information. For the radiologist, this will include the clinical information provided and findings from imaging investigations already performed. Formal justification of any further imaging must be undertaken, taking into account issues of radiation protection and an assessment of the continued safety of the child. This will usually be informed by discussion with other professionals and agencies involved in the care of the child and the family.
- 21.2 The diagnosis of NAI is complex: the clinical radiologist will contribute to this, but the diagnosis will ultimately depend upon evidence collected from all the agencies involved in the care of the child.
- 21.3 The recognition of the more subtle injuries requires experience of the radiological features of paediatric trauma - both accidental and non-accidental.
- 21.4 High-quality imaging, undertaken according to this detailed guidance, is essential for the recognition of injury which contributes to the diagnosis of NAI.
- 21.5 Image interpretation and reporting of skeletal surveys for child protection should be a core skill for all paediatric radiologists and general radiologists with a special interest in paediatrics.
- 21.6 Radiological evidence is often crucial to the diagnosis and it is better if a single radiologist within a team of radiologists coordinates this. This will require, in many institutions, the development of a robust team where all imaging (skeletal, organ and neurological) is reviewed before an overview is provided for the clinician.
- 21.7 There is a need to ensure adequate training for general and paediatric radiologists in child protection. This includes an understanding of the clinical features of physical child abuse, modes of presentation, selection of imaging modalities, imaging interpretation, preparation of legal reports, and working with other agencies and with the courts.

22. Recommendations

22.1 Training

22.1.1 The importance of multi-agency working in child protection must be stressed.

22.1.2 Child protection should be a mandatory part of training for all clinical radiologists. The level of training should be appropriate for the degree of involvement of the radiologist in imaging children.

22.1.3 Radiologists may be responsible for imaging children in the following circumstances:

- a) Reporting images from A&E.
- b) Reviewing plain films from out patients, primary care or the wards.
- c) As neuroradiologists.
- d) As specialist radiologists in musculoskeletal, genitourinary (GU), gastrointestinal (GI) imaging and so on.
- e) As radiologists with a special interest in paediatric imaging.
- f) As specialist paediatric radiologists.

22.1.4 The RCR should develop an educational programme in concert with the British Society of Paediatric Radiology and the RCPCH to support this aim. The programme should include:

- a) The legal framework of child protection and the duties of a doctor within this framework.
- b) The modes of presentation of non accidental injury and the complex jigsaw that underpins the diagnosis.
- c) The methods of investigation of NAI and their relative sensitivities.

- d) The radiological findings in NAI. The differential diagnosis and the specificity of different patterns of injury.
 - e) The structure and function of child protection teams.
 - f) The importance of communication and methods of referral of suspected NAI.
 - g) The preparation of a formal report to inform multidisciplinary review and for the courts.
 - h) The duties of a doctor in preparing evidence for the Court both as a witness of fact and as an expert.
- 22.1.5 The RCR should determine the exact curriculum content and determine what are the core requirements and what should be in the realm of specialist practice.
- 22.1.6 The Royal Colleges should work in concert with the Family Justice Council (FJC), the courts and with the Chief Medical Officer (CMO) to develop a system of medical expert witness teams including radiologists for the interpretation of imaging in cases of suspected NAI. These would be constituted of experts in the field of paediatric radiology and neuroradiology, but with less experienced radiologists attending in a similar way to Barrister pupils.
- 22.1.7 This would enable less experienced radiologists to develop skills and contribute to succession planning for expert witnesses.
- 22.1.8 This represents an opportunity to develop a consistent standard of expert advice, the opportunity for robust peer review and, where appropriate the provision of a consensus view for the courts.
- 22.1.9 It must remain possible for there to be a challenge to the consensus view but it is expected that this would then become the exception.

22.2 Service delivery

- 22.2.1 The Royal Colleges should work with hospital trusts and with service commissioners to develop local networks for imaging in child protection. It is important if consistently high standards of care are to be maintained that there is loco-regional development of links between local radiology leads for imaging in child abuse and regional/national experts.
- 22.2.2 Such arrangements must be recognised by a contractual relationship between trusts and commissioners.
- 22.2.3 *The job plan.* It is essential that child protection work undertaken by clinical radiologists is recognised and remunerated within their job plan. It may be, however, that some of this work, particularly for expert review may be performed outside the contractual hours and separately remunerated.
- 22.2.4 It is widely recognised within the profession that recruitment into paediatric radiology has been affected, not only by an aversion to the process of litigation but also increasingly by an increased risk (real and perceived) of potential referral to the General Medical Council (GMC). Currently it is possible for this to be consequent upon a complaint made by a parent or carer upset by the outcome of civil or criminal court proceedings.
- 22.2.5 The Royal Colleges should work with the FJC, the courts, the GMC and the CMO to develop guidance on the processes of referral to the GMC via the courts for allegations of malpractice. It is important that doctors are not deterred from practising in the field of child protection for fear of inappropriate referral to the GMC.

References

1. TSO. The Victoria Climbié Enquiry. Report of an Inquiry by Lord Laming. London: The Stationery Office, 2003.
2. TSO. Every Child Matters. Department for Education and Skills and the Home Office. London: The Stationery Office, 2003.
3. TSO. Children Act 2004. Department for Education and Skills and the Home Office. London: The Stationery Office, 2004.
4. TSO. Standards for Better Health. Department for Education and Skills and the Home Office. London: The Stationery Office, 2004.
5. HM Government. Working together to Safeguard Children. Department of Health. London: The Stationery Office, 2006.
6. Barker J, Hodes D. Child in Mind. Oxford: Taylor and Francis, 2004.
7. Cawson P, Wattam C, Brooker S, Kelly G. Child Maltreatment in the United Kingdom. A study of the prevalence of child abuse and neglect. London: NSPCC, 2000.
8. Creighton SJ, Noyes P. Child abuse Trends in England and Wales 1983-1987. London: NSPCC, 1989.
9. Lucas DR, Wezner KC, Milner JS, McCanne TR, Harris IN, Monroe-Posey C, & Nelson JP. Victim, perpetrator, family and incident characteristics of infant and child homicide in the United States air force. *Child Abuse and Neglect* 2002; 26: 167-186.
10. Hobbs C, Childs AM, Wynne J, Livingston J, Seal A. Subdural haematoma and effusion in infancy: an epidemiological study. *Arch Dis Child* 2005; 90(9): 925-955.
11. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA* 1999; 281(7): 621-626.
12. Minns R, Brown K. Shaking and other non-accidental head injuries in children. Cambridge: MacKeith Press, 2006.
13. Merten DF, Radkowski MA, Leonidas JC. The abused child, a radiological reappraisal. *Radiology* 1983; 146(2): 37-81.
14. Leventhal JM, Thomas SA, Rosenfield NS, Markowitz RI. Fractures in Young Children. Distinguishing child abuse from unintentional injuries. *Am J Dis Child* 1993; 147(1): 87-92.
15. Sullivan PM, Knutson JF. Maltreatment and disabilities: a population-based epidemiological study. *Child Abuse and Negl* 2000; 24(10): 1257-1273.
16. Barlow KM, Minns RA. Annual incidence of shaken impact syndrome in young children. *Lancet* 2000; 356(9241): 1571-1572.
17. Jayawant S, Rawlinson A, Gibbon F, Price J, Schulte J, Sharples P, Sibert JR, Kemp AM. Subdural haemorrhages in infants: population based study. *BMJ* 1998; 317(7172): 1558-1561.

18. Belfer RA, Klein BL, Orr L. Use of the skeletal survey in the evaluation of child maltreatment. *Am J Emerg Med* 2001; 19(2): 122-124.
19. Ellerstein NS, Norris KJ. Value of radiologic skeletal survey in assessment of abused children. *Pediatrics* 1984; 74(6): 1075-1078.
20. Health and Safety Legislation. Statutory Instrument 2000 No. 1059 The Ionising Radiation (Medical Exposure) Regulations 2000. <http://legislation.hmso.gov.uk/si/si20001059.htm>
21. RCPCH. Child Protection Companion. London: Royal College of Paediatrics & Child Health, 2006.
22. Hobbs CJ, Hanks HGI, Wynne JM. Child Abuse and Neglect: A Clinician's Handbook. London: Churchill Livingstone, 1998.
23. Greenes DS, Schutzman SA. Occult intracranial injury in infants. *Ann Emerg Med* 1998; 32(6): 680-686.
24. Kemp AM, Stoodley N, Copley C, Coles L, Kemp KW. Apnoea and brain swelling in non-accidental head injury. *Arch Dis Child* 2003; 88(6): 472-476.
25. King WJ, MacKay M, Sirnik A. Canadian Shaken Baby Study Group. Shaken baby syndrome in Canada: clinical characteristics and outcomes of hospital cases. *CMAJ* 2003; 168(2): 155-159.
26. David TJ, Levin AV. Retinal Haemorrhage and Child Abuse in Recent Advances in Paediatrics. London: Royal Society of Medicine Press, 2000:155-219.
27. Kogutt MS, Swischuk LE, Fagan CJ. Patterns of injury and significance of uncommon fractures in the battered child syndrome. *Am J Roentgenol Radium Ther Nucl Med* 1974; 121(1): 143-149.
28. Loder RT, Bookout C. Fracture patterns in battered children. *J Orthop Trauma* 1991; 5(4): 428-433.
29. Martille L, Cattaneo C, Dorandeu A, Baccino E. A multicentre and prospective study of suspected cases of child abuse. *Int J Legal Med* 2006; 120(2): 73-78.
30. Kemp AM, Butler A, Morris S, Mann M, Kemp KW, Rolfe K, Sibert JR, Maguire S. Which radiological investigations should be performed to identify fractures in suspected child abuse? *Clin Radiol* 2006; 61(9): 723-736.
31. Taitz J, Moran K, O'Meara M. Long bone fractures in children under 3 years of age: is abuse being missed in Emergency Department presentations? *J Paediatr Child Health* 2004; 40(4): 170-174.
32. Worlock P, Stower M, Barbor P. Patterns of fractures in accidental and non-accidental injury in children: a comparative study. *BMJ (Clin Res Ed)* 1986; 293(6539): 100-102.
33. ScoR. The Child and the Law: The roles and responsibilities of the Radiographer. London: The Society and College of Radiographers, 2005.
34. Diamond P, Hansen CM, Christofersen MR. Child abuse presenting as a thoracolumbar spinal fracture dislocation: a case report. *Pediatr Emerg Care* 1994; 10(2): 83-86.

35. Dickson RA, Leatherman KD. Spinal injuries in child abuse: case report. *J Trauma* 1978; 18(12): 811-812.
36. Rooks VJ, Sisler C, Burton B. Cervical spine injury in child abuse: report of two cases. *Pediatr Radiol* 1998; 28(3): 193-195.
37. Ablin DS, Greenspan A, Reinhart MA. Pelvic injuries in child abuse. *Pediatr Radiol* 1992; 22(6): 454-457.
38. Hechter S, Huyer D, Manson D. Sternal fractures as a manifestation of abusive injury in children. *Pediatr Radiol* 2002; 32(12): 902-906.
39. Nimkin K, Spevak MR, Kleinman PK. Fractures of the hands and feet in child abuse: imaging and pathologic features. *Radiology*; 203(1): 23-26.
40. Ingram JD, Connell J, Hay TC, Strain JD, Mackenzie T. Oblique radiographs of the chest in non-accidental trauma. *Emerg Rad* 2000; 7: 42-46.
41. Cohen RA, Kaufman RA, Myers PA, Towbin RB. Cranial computed tomography in the abused child with head injury. *Am J Roentgenol* 1986; 146(1): 97-102.
42. Tsai FY, Zee CS, Apthorp JS, Dixon GH. Computed tomography in child abuse head trauma. *J Comput Tomogr* 1980; 4(4): 27-86.
43. Kleinman PK, Nimkin K, Spevak MR, Rayder SM, Madansky DL, Shelton YA, Patterson MM. Follow-up skeletal surveys in suspected child abuse. *Am J Roentgenol* 1996; 167(4): 893-896.
44. Zimmerman S, Makoroff K, Care M, Thomas A, Shapiro R. Utility of follow-up skeletal surveys in suspected child physical abuse evaluations. *Child Abuse Negl* 2005; 29(10): 1073-1074.
45. www.core_info.cf.ac.uk
46. Haase GM, Oritz VN, Sfakianakis GN, Morse TS. The value of radionuclide bone scanning in the early recognition of deliberate child abuse. *J Trauma* 1980; 20(10): 873-875.
47. Jaudes PK. Comparison of radiography and radionuclide bone scanning in the detection of child abuse. *Pediatrics* 1984; 73(2): 166-168.
48. Kleinhans E, Kentrup H, Alzen G, Skopnik H, Bull U. [A false negative bone scintigram in a biparietal skull fracture in a case of a Battered Child Syndrome]. *Nuklearmedizin* 1993; 32(4): 206-207.
49. Pickett WJ, Faleski EJ, Chacko A, Jarrett RV. Comparison of radiographic and radionuclide skeletal surveys in battered children. *South Med J* 1983; 76(2): 207-212.
50. Mandelstam S, Cook D, Fitzgerald M, Ditchfield MR. Complementary use of radiological skeletal survey and bone scintigraphy in detection of bony injuries in suspected child abuse. *Arch Dis Child* 2003; 88(5): 387-390.
51. Sty JR, Starshak RJ. The role of bone scintigraphy in the evaluation of the suspected abused child. *Radiology* 1983; 146(2): 369-375.

52. Hahn K, Fischer S, Colarinha P, et al. Guidelines for bone scintigraphy in children. *Eur J Nucl Med.* 2001; 28(3): BP42-47.
53. Markowitz RI, Hubbard AM, Harty MP, Bellah RD, Kessler A, Meyer JS. Sonography of the knee in normal and abused infants. *Pediatr Radiol* 1993; 23(4): 264-267.
54. Nimkin K, Kleinman PK, Teegar S, Spevak MR. Distal humeral physeal injuries in child abuse: MR imaging and ultrasonography findings. *Pediatr Radiol* 1995; 25(7): 562-565.
55. Smeets AJ, Robben SG, Meradji M. Sonographically detected costo-chondral dislocation in an abused child. A new sonographic sign to the radiological spectrum of child abuse. *Pediatr Radiol* 1990; 20(7): 566-567.
56. Partan G, Pamberger P, Blab E, Hruby W Common tasks and problems in paediatric trauma radiology. *Eur J Radiol* 2003; 48(1): 103-124.
57. Taylor GA, Eich MR. Abdominal CT in children with neurologic impairment following blunt trauma. Abdominal CT in comatose children. *Ann Surg* 1989; 210(2): 229-233.
58. Roshkow JE, Haller JO, Hotson GC, Sclafani SJ, Mezzacappa PM, Rachlin S. Imaging evaluation of children after falls from a height: review of 45 cases. *Radiology* 1990; 175(2): 359-363.
59. Taylor GA, Kaufman RA, Sivit CJ. Active haemorrhage in children after thoracoabdominal trauma: clinical and CT features. *AJR Am J Roentgenol* 1994; 162(2): 401-404.
60. Coppola V, Verrengia D, Coppola M, Fiorillo R, Alfinito M, Vallone G. Computed tomography in injuries to the respiratory system in children. The Correlation with adults. *Radiol Med (Torino)* 1997; 94(5): 468-476.
61. American Academy of Pediatrics: Committee on Child Abuse and Neglect. Shaken Baby Syndrome: rotational cranial injuries - technical report. *Pediatrics* 2001; 108(1): 206-210.
62. Zimmerman RA, Bilaniuk LT, Bruce D, Schut L, Uzzell B, Goldberg HI. Computed tomography of craniocerebral injury in the abused child. *Radiology* 1979; 130(3): 687-690.
63. Schutzman SA, Barnes P, Duhaime AC, et al. Evaluation and management of children younger than two years old with apparently minor head trauma: proposed guidelines. *Pediatrics* 2001; 107(5): 983-993.
64. Johnson DL, Boal D, Baule R. Role of apnea in non-accidental head injury. *Pediatr Neurosurg* 1995; 23(6): 305-310.
65. Biousse V, Suh Dy, Newman NJ, et al. Diffusion-weighted magnetic resonance imaging in shaken baby syndrome. *Am J Ophthalmol* 2002; 133(2): 249-255.
66. Suh DY, Davis PC, Hopkins KL, Fajman NN, Mapstone TB. Non-accidental pediatric head injury: diffusion weighted imaging findings. *Neurosurgery* 2001; 49(2): 309-318.
67. Liang L, Korogi Y, Sugahara T, et al. Detection of intracranial hemorrhage with susceptibility-weighted MR sequences. *AJNR Am J Neuroradiol* 1999; 20(8): 1527-1534.
68. Noguchi K, Ogawa T, Seto H, et al. Subacute and chronic subarachnoid hemorrhage diagnosis with fluid-attenuated inversion-recovery MR imaging. *Radiology* 1997; 203(1): 257-262.

69. Rubin D, Christian CW, et al. Occult head injury in high risk abused children. *Pediatrics* 2003; 111(6 Pt 1): 1382-1386.
70. Feldman KW, Bethel R, Shugerman RP, et al. The cause of infant and toddler subdural hemorrhage: a prospective study. *Pediatrics* 2001; 108(3): 636-646.
71. Duhaime AC, Alario AJ, Lewander WJ, et al. Head injury in very young children: mechanisms, injury types and ophthalmological findings in 100 hospitalised patients younger than 2 years of age. *Pediatrics* 1992; 90(2 Pt 1): 179-185.
72. Alexander R, Sato Y, Smith W, Bennett T. Incidence of impact trauma with cranial injuries ascribed to shaking. *AM J Dis Child* 1990; 144(6): 724-726.
73. Datta S, Stoodley N, Jayawant S, Renowden S, Kemp A. Neuroradiological aspects of subdural haemorrhage. *Arch Dis Child* 2005; 90(9): 947-951.
74. Jaspan T, Griffiths PD, McConachie NS, Punt JA. Neuroimaging for non-accidental head injury in childhood: a proposed protocol. *Clin Radiol* 2003; 58(1): 44-53.
75. Kemp AM. Investigating subdural haemorrhage in infants. *Arch Dis Child* 2002; 86(2): 98-102.
76. Kleinman PK, O'Connor B, Nimkin K, et al. Detection of rib fractures in an abused infant using digital radiography: a laboratory study. *Pediatr Radiol* 2002; 32(12): 896-901.
77. Piraino DW, Davros WJ, Lieber M, et al. Selenium-based digital radiography versus conventional film-screen radiography of the hands and feet: a subjective comparison. *AJR Am J Roentgenol* 1999; 172(1): 177-184.
78. Youmans DC, Don S, Hildebolt C, et al. Skeletal surveys for child abuse: comparison of interpretation using digitized images and screen-film radiographs. *AJR Am J Roentgenol* 1998; 171(5): 1415-1419.
79. Garmer M, Hennigs SP, Jager HJ, et al. Digital radiography versus conventional radiography in chest imaging: diagnostic performance of a large-area silicon flat-panel detector in a clinical CT-controlled study. *AJR Am J Roentgenol* 2000; 174(1): 75-80.
80. Offiah, AC, Grehan J, Hall CM, Todd-Pokropek A. Optimal Exposure parameters for Digital Radiography of the infant skull: a pilot study. *Clinical Radiology* 2005; 60(11): 1195-1204.
81. The Royal College of Radiologists. Providing expert advice to the Court: advice to Members and Fellows. London: The Royal College of Radiologists, 2005.
82. The Royal College of Radiologists. Good Practice Guide for Clinical Radiologists. London: The Royal College of Radiologists, 1999.
83. The Royal College of Radiologists. Risk Management in Clinical Radiology. London: The Royal College of Radiologists, 2002.
84. The Royal College of Radiologists. Standards for the Reporting and Interpretation of Imaging Investigations. London: The Royal College of Radiologists, 2006.

85. Department of Health. *Bearing Good Witness: Proposals for reforming the delivery of medical expert advice in family law cases – A report by the Chief Medical Officer*. London: Department of Health, 2006
86. ImPACT. CT Patient Dosimetry Calculator, version 0.99. www.impactscan.org, 2005.
87. Khursheed A, Hillier MC, Shrimpton PC, Wall BF. Influence of patient age on normalized effective doses calculated for CT examinations. *Br J Radiol* 2002; 75(898): 819-830.
88. National Radiological Protection Board. *Board Statement on Diagnostic Medical Exposures to Ionising Radiation during Pregnancy and Estimates of Late Radiation Risks to the UK population*. London: National Radiological Protection Board, 1993.

Royal College of Paediatrics and Child Health

5-11 Theobalds Road, London WC1X 8SH

Telephone: 020 7092 6000

The Royal College of Paediatrics and Child Health (RCPCH)
is a registered charity in England and Wales (1057744)
and in Scotland (SC038299)

ISBN 978-1-906579-01-2