



**Clinical  
Radiology**

The Royal College of Radiologists



**SCoR**

THE SOCIETY & COLLEGE  
OF RADIOGRAPHERS

# The radiological investigation of suspected physical abuse in children

## Methodology report

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A joint publication from The Royal College of Radiologists  
and The Society and College of Radiographers

Endorsed by the Royal College of Paediatrics and Child Health



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## Introduction

*The radiological investigation of suspected physical abuse in children* provides a complete revision of the *Standards for radiological investigation of non-accidental injury*, an intercollegiate report originally produced by The Royal College of Radiologists (RCR) and the Royal College of Paediatrics and Child Health (RCPCH) in 2008 and updated by the RCR and Society and College of Radiographers (SCoR). These standards have been adopted throughout the UK and have been formally adopted by the European Society of Paediatric Radiologists. The revised document incorporates evidence-based changes for the type of imaging conducted to detect occult injuries while minimising radiation exposure and patient distress.

The guidance was developed in partnership between the RCR, SCoR and key partners including representatives from the RCPCH, the Association of Paediatric Radiographers, the International Association of Forensic Radiographers and RCR lay representatives. In addition, the working party was grateful for input from Dr Owen Arthurs, National Institute of Health Research Clinician Scientist and Mr Matthew, Head of Radiology Physics, Medical Physics and Clinical Engineering at Nottingham University Hospitals NHS Trust, the British Society of Paediatric Radiology (BSPR) and the Society of Forensic Radiographers Patient Representatives (full acknowledgements can be found in the main document).

While this guidance assists the practice of healthcare professionals, it does not replace their knowledge and skills.

This document presents information on the methodology adopted by the RCR to update the guidance.

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## 1. Scope

### Remit

The RCR and SCoR updated the *Standards for radiological investigations of suspected non-accidental injury* and produced a new document entitled *The radiological investigation of suspected physical abuse in children*. The original scope is presented in Appendix 1.

### Population covered

Children with suspected physical abuse between the ages of zero and two years. The guidance can also be applied to children older than two years on a case-by-case basis.

### Target audience

This guidance is designed to assist paediatricians, radiologists, radiographers and nuclear medicine technologists who are requesting, performing or reporting on imaging in suspected physical abuse cases by taking them through the process in a logical and structured manner, setting out clear recommendations for each stage and providing exemplar forms and documentation. This guidance can be used by all paediatricians, both hospital and community-based, although a skeletal survey is likely to be undertaken in a hospital setting. Community paediatricians will have direct access to the hospital for this purpose.

### What this guidance covers

This guidance covers:

1. Which children should be imaged when physical abuse is suspected
2. Which imaging modalities should be used to maximise detection of occult injuries while limiting unnecessary radiation exposure
3. How the imaging should be performed, reported and communicated
4. When initial and follow-up imaging should be undertaken.

For the full list of clinical questions, see Appendix 2.

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## 2. Developers and conflicts of interest

A working group was appointed to oversee the guidance development process. The group carried out the systematic searches, critical appraisal and data extraction of papers. The RCR Professional Standards team co-ordinated the development of the guidance and provided methodological advice to the working group. The guidance was drafted in consultation with the working group. The guidance was not funded directly and was instead developed through time and efforts volunteered by the working group, the RCR and SCoR. The group met on nine occasions during the development of the guidance and in between meetings there was considerable exchange of views and comments on draft versions and associated issues. The working group were asked to declare all conflicts of interests, several members of the committee undertake medicolegal work in the field of investigation of suspected physical abuse in children outside their contracted NHS hours. This was considered not to conflict with the guidance development (see Appendix 3 for full details).

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3. **Aims and objectives** To review and update *Standards for radiological investigations of suspected non-accidental injury* and produce a new document entitled *The radiological investigation of suspected physical abuse in children*.
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4. **Developing the clinical questions** The clinical questions were developed by the working group and discussed at various meetings when the original document was produced in 2008. The clinical questions used for the systematic review can be found in Appendix 2.
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5. **Identifying the evidence** The review questions formed the starting point for systematic reviews of relevant evidence. A total of 21 review questions were identified. Two different research methodologies were undertaken to answer the clinical questions. For clinical questions 1–14 and 16–18, the results of previous systematic review were considered. These systematic reviews were conducted by Cardiff University under the Cardiff Child Protection Systematic Reviews (CORE-info) project and published online (information on their search strategies is available online at [www.core-info.cardiff.ac.uk/](http://www.core-info.cardiff.ac.uk/)). All searches were conducted on CORE databases, MEDLINE and Embase. Searches were limited by English language and there was no searching of grey literature. The search strategies, inclusion and exclusion criteria are presented in Appendix 4.
- For clinical questions 15 and 19–21, a literature review was undertaken to identify the relevant studies (see Appendix 4 for further information).
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6. **Reviewing and synthesising the evidence** The group carried out the systematic searches, critical appraisal and data extraction of papers. The articles were reviewed by the working party following the exact methodology employed by the CORE-info group and quality of evidence assessed with an adapted Critical Appraisal Skills Programme (CASP) tool.
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7. **Translation of evidence into recommendations** The guidance was drafted in consultation with the working group during face-to-face meetings throughout the development of the guidance and via email.
- Although the guidance report does not present an explicit link between the evidence and the recommendations, a list of included studies used to formulate the recommendations is included in Appendix 5.
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8. **Guidance consultation details** The document was sent for consultation among the RCPCH consultation panel and reached the relevant paediatric speciality groups. The document has been reviewed by the BSPR and SCoR representatives and, as part of the internal RCR approval process, the draft
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was considered by the RCR's Clinical Radiology Professional Support and Standards Board and the RCR's Clinical Radiology Faculty Board.

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9.  
Parent, carer and  
patient participation

The draft publication was considered by the UK Council of the Society of Radiographers on 10 May 2017. The RCR Clinical Radiology Professional Support and Standards Board and Clinical Radiology Faculty Board, both of which have lay members, considered the document and it was approved by the RCR on 23 June 2017. Lay organisations were not consulted separately.

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10.  
Guidance audit

An audit proforma is provided to assess adherence to key areas of the guidance. The proforma is included in the list of appendices within the guidance.

The proforma is also available at AuditLive ([www.rcr.ac.uk/auditlive](http://www.rcr.ac.uk/auditlive)), a section of the RCR website where other clinical radiology audit proforma can be found. AuditLive is a collection of audit templates providing a framework identifying best practice in key stages of the audit cycle, covering over 100 radiology topics.

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11.  
Guidance update

This guidance will be updated in line with standard RCR procedures; current practice is to review every four years. At that stage, the lead author will be consulted along with the partner organisations about the need and extent for any review and the way forward will be determined. Should new information or evidence come to light which impacts on the guidance before four years, the nature and extent of any changes would be considered, again in conjunction with the lead author and partner organisations.

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12.  
Editorial independence

The RCR and SCoR have funded this project, set-up the working party and identified its scope. The draft will ultimately need to be approved by both organisations and there may be issues and comments that need to be addressed before approval is granted. However, such issues will focus on the clarity and coherence of the recommendations. No undue influence has been brought to bear on the lead author or members of the working party undertaking the detailed work that underpins this guidance.

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13.  
Implementation

The guidance is hosted on the RCR website and the SCoR and the BSPR have a link to it so that individuals seeking the guidance via those websites will be able to access it.

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A link to the guidance will be placed in the relevant chapter in the Child Protection Companion on Paediatric Care Online platform of RCPCH.

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14.  
Resource implications

The working party was conscious of the need to avoid imposing unnecessary burdens on the service. While there may be some potential staffing implications arising from the recommendations, the working party believes these will be offset by the resulting rationalisation of processes and the saving in staff time and effort that this will achieve and has provided exemplar forms to assist services.

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## Appendix 1. Scope

### RCR/SCoR non-accidental injury working party scope

This appendix reflects the scope of the working party at the outset of the project.

#### Purpose/remit

To review and update the current joint RCR/RCPCH publication *Standards for radiological investigations of suspected non-accidental injury* and produce a new document entitled *The radiological investigation of suspected physical abuse in children*.

#### Objectives

- To undertake a full literature search and, based on the evidence identified, update the document to ensure that it is up to date and fit for purpose.
- To ensure the document is relevant across all UK countries and, where appropriate, seek advice from each of the devolved nations.
- The lead author should consider submitting an audit template, (if appropriate to the standard they have authored) to CR AuditLive either before or soon after the publication of the standard.

#### Membership

The membership of the working party will be drawn from the RCR, RCPCH and SCoR. It may be necessary during the development of this publication for the Chair of the working party to co-opt/appoint additional members as the group's work evolves. These may include representatives of other professional groups with whom the clinical radiology/paediatric specialty works in close association – for example, radiographers, medical physicists, medical oncologists or clinical nurse specialists. Nominations from the relevant professional body will need to be sought at this stage.

Additional input will be sought from the Royal College of Pathologists once the first draft of the document has been produced. Legal input will also be sought at the latter stages of the document development.

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## Appendix 2. List of clinical questions

The clinical questions used for the systematic review were:

1. Is full skeletal survey indicated in any child under two in whom abuse is suspected?
  2. Which children over two should have full skeletal survey to identify injury?
  3. Who should undergo follow-up skeletal imaging?
  4. What follow-up skeletal imaging should be performed?
  5. When should follow-up skeletal imaging be performed?
  6. Which siblings of a child with suspected physical abuse should undergo imaging?
  7. Which children with suspected physical abuse should undergo neuroimaging to identify occult injury?
  8. What is the neuroimaging modality of choice to image children in cases of suspected physical abuse?
  9. When should initial neuroimaging be performed?
  10. When should follow-up neuroimaging be performed?
  11. Which children should also have spinal imaging?
  12. When should spinal imaging be performed?
  13. How much of the spine should be imaged?
  14. Which children undergoing investigation for suspected physical abuse should have abdominal imaging?
  15. What is the role of cross-sectional imaging in the detection of musculoskeletal (MSK) injury in cases of suspected physical abuse?
  16. What is the role of ultrasound (US) in the detection of abusive fractures?
  17. What is the role of bone scanning in the cases of suspected physical abuse?
  18. Which features detected on magnetic resonance imaging (MRI) are associated with abusive head trauma?
  19. When should follow-up cranial MRI be performed to identify communications and inform prognosis and management?
  20. Which features of intra-cranial injury in children can be accurately dated on the basis of computed tomography (CT) and MRI differences?
  21. What is the best imaging modality to detect injury in the dead child?
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### Appendix 3. Declarations of interest

The agendas of all College board and committee meetings require members to be aware of conflicts of interest in respect of any items on the agenda. If this arises members are expected to speak to the chair prior to the meeting in order to agree how best to proceed. This is a formal item of business on each agenda and is recorded in the meeting minutes. No members of the working party declared any conflicts of interest.

Dr Geoff Debelle, Officer for Child Protection, RCPCH – Medicolegal work in this field.

Dr Neil Stoodley, Consultant Paediatric Neuroradiologist, Southmead Hospital, Bristol – Medicolegal work in this field.

Dr Kath Halliday, Consultant Paediatric Radiologist, Nottingham University Hospital – Medicolegal work in this field.

Dr Tim Jaspán, Consultant Paediatric Neuroradiologist, Nottingham University Hospital – Medicolegal work in this field.

Dr Amaka Offiah, Reader in Paediatric Musculoskeletal Imaging and Honorary Consultant Paediatric Radiologist, University of Sheffield – Medicolegal work in this field.

Ms Fatih Constantine, Lead Paediatric radiographer, Derriford Hospital, Plymouth – No declared interests.

Ms Sue Johnson, Professional Officer, SCoR – No declared interests.

Ms Christina Freeman, Professional Officer, SCoR – No declared interests.

Dr Katie Giles, Consultant Radiologist, Royal Cornwall Hospital Truro – No declared interests.

Professor Alison Kemp, Professor of Child Health, Cardiff University – No declared interests.

Dr Sabine Maguire, Senior Lecturer in Child Health, Cardiff University – No declared interests.

Mrs Katriona O'Hare, RCR Lay Representative – No declared interests.

Dr Ingrid Prosser, Consultant Paediatrician, Brecon Children's Centre, Powys – No declared interests.

Mrs Jacquie Vallis, Senior Lecturer in Forensic Radiography, Teeside University – No declared interests.

Mr David Christopher, Professional Standards Manager, RCR – No declared interests.

Mrs Kim Cyrus, Executive Officer Clinical Radiology, RCR – No declared interests.

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#### Appendix 4. Search strategy (including selection criteria)

For clinical questions 1–14 and 16–18 a systematic review that had been used and published on the Cardiff Child Protection Systematic Reviews (CORE-info) website and findings were used to answer the questions (note that the CORE-info reviews are now hosted on the RCPCH website ([www.rcpch.ac.uk/child-protection-evidence](http://www.rcpch.ac.uk/child-protection-evidence))).

#### Clinical questions related to fractures (1–5, 16, 17)

##### Search strategy

1. Child abuse.mp.
  2. child protection.mp.
  3. (battered child or shaken baby or battered baby).mp.
  4. 1 or 2 or 3
  5. (child: or infant: or baby or toddler:).mp.
  6. CHILD/
  7. CHILD, PRESCHOOL/
  8. 5 or 6 or 7
  9. non-accidental injur:.mp.
  10. (non-accidental trauma or nonaccidental trauma).mp.
  11. (non-accidental: and injur:).mp.
  12. soft tissue injur:.mp.
  13. physical abuse.mp.
  14. (or/9-13) and 8
  15. 4 or 14
  16. Fractures, Ununited/ or Radius Fractures/ or Fractures, Malunited/ or Tibial Fractures/ or Fractures, Bone/ or Rib Fractures/ or Femoral Neck Fractures/ or Femoral Fractures/ or Humeral Fractures/ or Shoulder Fractures/ or Fractures, Compression/ or Fractures, Cartilage/ or Hip Fractures/ or Intra-Articular Fractures/ or Fractures, Open/ or Fractures, Closed/ or Fractures, Comminuted/
  17. fractur:.mp.
  18. Fractures, Bone/
  19. rib fractur:.mp.
  20. (multiple skull fractur: or eggshell fractur: or skull fractur:).mp.
  21. femoral fractur:.mp.
  22. humeral fractur:.mp.
  23. pelvic fractur:.mp.
  24. (spiral fractur: or transverse fractur:).mp.
  25. metaphyseal fractur:.mp.
  26. (corner fractur: or bucket handle fractur:).mp.
  27. metaphyseal chip fractur:.mp.
  28. classic metaphyseal lesion:.mp.
  29. or/16-28
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30. (investigat: adj3 fract:).mp.
31. (radiolog: adj3 fractur:).mp.
32. (roentgen: adj3 fract:).mp.
33. skeletal survey.mp.
34. ((paediatric or pediatric) adj3 radiolog:).mp.
35. ((paediatric or pediatric) adj3 nuclear medicine).mp.
36. Tomography, X-Ray Computed/
37. Scintigraphy.mp.
38. (bone scan or X rays).mp.
39. skeletal survey.mp.
40. isotope bone scan:.mp.
41. or/30-40
42. healing.mp.
43. (timing adj3 healing).mp.
44. (pattern: adj3 fractur:).mp.
45. ((dating or date) adj3 fractur:).mp.
46. (ag: adj3 fractur:).mp.
47. or/42-46
48. 41 or 47
49. 15 and 29 and 48
50. 8 and 29 and 47
51. 49 or 50
52. limit 51 to yr="2014 -2015"

## Sources

Applied Social Sciences Index and Abstracts (ASSIA), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, Open SIGLE (System for Information on Grey Literature in Europe), Scopus, Social Care Online (previously Caredata), Web of Knowledge and relevant webpages – The Alberta Research Centre for Health Evidence (ARCHE) and Child Welfare Information Gateway (formerly National Clearinghouse on Child Abuse and Neglect). Hand searches in journals were undertaken in the *Journal of Child Abuse and Neglect* and *Child Abuse Review*. All searches were done in 2015.

## Inclusion and exclusion criteria

### Inclusion criteria were:

- Rank of abuse 1–3
- Comparative studies of children with fractures of rib, femur, skull or humerus
- Comparative AND non-comparative studies of other inflicted fracture types
- Primary research addressing how you can date fractures radiologically in children

- Children who had radiological investigations to identify bone fractures in suspected child abuse
- No clinical or radiological evidence of underlying bone disease.

**Exclusion criteria were:**

- Rank of abuse 4–5
- Relates to adults aged >18 years – either exclusively or where relevant data relating to children cannot be extracted
- Formal consensus/expert opinion/personal practice/review article
- Management of fractures
- Methodologically flawed papers.

**Clinical questions related to neurological imaging (questions 6–11 and 18)****Search strategy**

1. CHILD/
2. CHILD, PRESCHOOL/
3. (child: or infant: or toddler: or babies or baby).af.
4. or/1-3
5. ((non-accidental or nonaccidental) adj3 (trauma or injur:)).af.
6. ((non-abusive or nonabusive) adj3 (injur: or trauma)).af.
7. (non-accidental: and injur:).af.
8. soft tissue injur:..af.
9. physical abuse.af.
10. ((inflicted or noninflicted or non-inflicted) adj3 (brain injur: or cerebral injur: or head injur:)).af.
11. (inflicted traumatic head injur: or inflicted traumatic brain injur:).af.
12. (or/5-11) and 4
13. (child abuse or child maltreatment or child protection).af.
14. (battered child or shaken baby or battered baby).af.
15. (battered infant or shaken infant).af.
16. (Shak: Baby Syndrome or shak: impact syndrome).af.
17. Caffey-Kempe syndrome.af.
18. \*"Child Abuse"/di [Diagnosis]
19. infant traumatic stress syndrome.af.
20. parent-infant traumatic stress syndrome.af.
21. or/13-20
22. 12 or 21
23. abusive head trauma.af.
24. bleeding into brain.af.
25. blow to the head.af.

26. brain damage.af.
27. (brain haemorrhage: or brain hemorrhage:).af.
28. (brain swelling or cerebral edema).af.
29. cerebral injur.:af.
30. cervical spine injur.:af.
31. cervical spine neuropathology.af.
32. cranial injur.:af.
33. craniocerebral trauma.af.
34. diffuse axonal injur.:af.
35. extracranial CNS injur.:af.
36. extracranial Central Nervous System injur.:af.
37. central nervous system injur.:af.
38. (extradural haematoma or hematoma).af.
39. extradural haemorrhage.af.
40. haemorrhagic retinopathy.af.
41. (head injury: or head trauma).af.
42. impact injur.:af.
43. intracerebral bleeding.af.
44. (intracerebral haemorrhage or intracerebral hemorrhage).af.
45. (intracranial haemorrhage or intracranial hemorrhage).af.
46. intracranial injur.:af.
47. (intraventricular hematoma or intraventricular haematoma).af.
48. (multiple skull fracture: or eggshell fracture:).af.
49. exp Neck Injuries/
50. neck injur\*:af.
51. (neurological injur: adj3 child abuse).af.
52. neuropathology.af.
53. non-accidental head injur.:af.
54. (parenchymal contusion or laceration).af.
55. (retinal hemorrhage or retinal haemorrhage).af.
56. skull fracture:af.
57. (spinal cord injury adj3 radiologic abnormality).af.
58. spinal cord injur.:af.
59. (subdural haematoma or hematoma).af.
60. (subarachnoid hematoma or
61. (subdural haemorrhage or subdural hemorrhage).af.
62. (ventricular haemorrhage or ventricular hemorrhage).af.
63. whiplash impact syndrome.af.
64. whiplash injur.:af.

65. whiplash shaken infant.af.
66. infarction.af.
67. (hypoxic-ischemic injur: or hypoxic-ischaemic injur:).af.
68. (contusion: or contusional tear).af.
69. (hematoma or haematoma).af.
70. laceration:.af.
71. shearing injur:.af.
72. traumatic effusion:.af.
73. subdural hygroma.af.
74. hygroma.af.
75. interhemispheric.af.
76. parafalcine.af.
77. (brain or brainstem).af.
78. cerebral.af.
79. intraparenchymal.af.
80. sciwora.mp.
81. spinal cord injury without radiologic abnormality.af.
82. cervical lumbar.af.
83. thoracic lumbar sacral.af.
84. leptomeningeal cyst.af.
85. growing skull fracture.af.
86. (Extradural haemorrhag: or extradural hemorrhag: or extradural spinal haemorrhag: or extradural spinal hemorrhag:).af.
87. laminar necrosis.af.
88. encephalomalacia.af.
89. cerebral atrophy.af.
90. (craniocervical or hydrocephalus).af.
91. encephalopathy.af.
92. (intraparenchymal hemorrhag: or intraparenchymal haemorrhag:).af.
93. (Ha?morrhagic retinopathy adj3 retinal ha?emorrhag:).af.
94. cerebral venous thrombosis.mp.
95. diffuse axonal injur\*.tw.
96. spinal subdural.tw.
97. or/23-96
98. Computed tomography.af.
99. (CT or CAT scan:).af.
100. diagnostic imaging.af.
101. (magnetic resonance imaging or MRI).af.
102. neuroradiology.af.

103. neuroimaging.af.
104. plain films.af.
105. radiological imaging.af.
106. X-rays.af.
107. neurologic: imaging.af.
108. diffusion weighted imaging.af.
109. neurologic examination.af.
110. ultrasound scan:.af.
111. (Susceptibility Weighted Imaging or SWI).tw.
112. or/98-111
113. 22 and 97 and 112
114. 22 and 97
115. 12 and 97
116. 113 or 114 or 115
117. limit 116 to yr="2013 -2014"
118. management.mp.
119. Review.pt.
120. 118 or 119
121. 117 not 120

### Sources

ASSIA, CINAHL, Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, Scopus, Social Care Online, Web of Knowledge and hand searches on the *Journal of Child Abuse and Neglect* and *Child Abuse Review* and relevant webpages such as Child Brain Injury Trust (CBIT), International Society for Prevention of Child Abuse and Neglect (ISPCAN), Child Information Welfare Gateway and National Clearing Centre for Child Abuse and Neglect, Google Scholar and the National Center on Shaken Baby Syndrome.

### Inclusion and exclusion criteria

#### **Inclusion criteria were:**

- Rank of abuse 1–3
- If articles were answering the following questions:
  - What neuro-radiological investigations are indicated to identify abusive central neurological system (CNS) injury in children?
  - What are the neuro-radiological features of abusive CNS injury in children?
  - Can you date neuro-radiological CNS abnormalities?
  - What are the clinical features found in abusive head trauma in children?
  - What are the features (clinical +/- radiological, including fractures) of abusive spinal injuries in children? (may be comparative or non-comparative).



**Exclusion criteria were:**

- Formal consensus/expert opinion/personal practice/review article
- Rank of abuse is 4–5
- Relates to adults aged >18 years – either exclusively or where relevant data relating to children cannot be extracted
- Studies addressing outcome/sequelae of inflicted CNS injury, without details of presenting features
- Studies addressing management of abusive CNS injury, without details of presenting features
- Studies addressing exclusively accidental and/or organic CNS injury, post-mortem cases with no ante-morbid details, exclusively social/historical features
- Studies addressing exclusively fewer than five cases relating to neuro-radiological modality
- Studies addressing exclusively neuro-radiology investigations prior to the year 2000
- Methodologically flawed papers.

**Clinical questions related to spinal injuries (11–13)****Search strategy**

1. CHILD/
2. (paediatric or pediatric or neonate\*).af.
3. (child: or infant: or toddler: or babies or baby).af.
4. or/1-3
5. ((non-accidental or nonaccidental) adj3 (trauma or injur:)).af.
6. ((non-abusive or nonabusive) adj3 (injur: or trauma)).af.
7. (non-accidental: and injur:).af.
8. soft tissue injur:.af.
9. physical abuse.af.
10. ((inflicted or noninflicted or non-inflicted) adj3 (brain injur: or cerebral injur: or head injur:)).af.
11. (inflicted traumatic head injur: or inflicted traumatic brain injur:).af.
12. (maltreat\* or shaking).af.
13. (AHT or Abusive Head Trauma).af.
14. (or/5-13) and 4
15. (child abuse or child maltreatment or child protection).af.
16. (battered child or shaken baby or battered baby).af.
17. (battered infant or shaken infant).af.
18. (Shak: Baby Syndrome or shak: impact syndrome).af.
19. Caffey-Kempe syndrome.af.
20. \*\*"Child Abuse"/di [Diagnosis]
21. or/15-20

22. 14 or 21
23. extracranial CNS injur\*.af.
24. Craniocerebral Trauma/
25. cervical spine injur.:af.
26. cervical spine neuropathology.af.
27. diffuse axonal injur.:af.
28. extracranial CNS injur.:af.
29. (extradural haematoma or hematoma).af.
30. extradural haemorrhage.af.
31. exp Neck Injuries/
32. neck injur\*.af.
33. (parenchymal contusion or laceration).af.
34. spinal cord injur.:af.
35. (subdural haematoma or hemotoma).af.
36. (subarachnoid hematoma or subarachnoid haematoma).af.
37. (subdural haemorrhage or subdural hemorrhage).af.
38. whiplash impact syndrome.af.
39. whiplash injur.:af.
40. whiplash shaken infant.af.
41. infarction.af.
42. (hypoxic-ischemic injur: or hypoxic-ischaemic injur:).af.
43. (contusion: or contusional tear).af.
44. (hematoma or haematoma).af.
45. laceration.:af.
46. shearing injur.:af.
47. traumatic effusion.:af.
48. sciwora.mp.
49. spinal cord injury without radiologic abnormality.af.
50. thoracic lumbar sacral.af.
51. leptomenigeal cyst.af.
52. (Extradural haemorrhag: or extradural hemorrhag: or extradural spinal haemorrhag: or extradural spinal hemorrhag:).af.
53. (intraparenchymal hemorrhag: or intraparenchymal haemorrhag:).af.
54. diffuse axonal injur\*.tw.
55. spinal subdural.tw.
56. cervical.af.
57. exp Spinal Cord Injuries/
58. Spinal Injuries/
59. spinal cord trauma.af.

60. Spinal Cord Compression/
61. Cervical Vertebrae/
62. hyperflexion injur\*.af.
63. hyperextension injur\*.af.
64. or/23-6365. Fractur\*.af.
65. exp Fractures, Comminuted/
66. exp Fractures, Bone/
67. exp Fractures, Compression/
68. hangmans fractur\*.af.
69. Cervicomedullary injur\*.af.
70. (Atlanto-Axial Joint adj3 injur\*).af.
71. (fracture dislocation or crush fractur\*).af.
72. (or/65-72) and 64
73. (Spinal adj5 fract\*).af.
74. (Cervical adj5 fract\*).af.
75. (thoracic adj5 fract\*).af.
76. (lumbosacral adj5 fract\*).af.
77. (thoraco-lumbar adj5 fract\*).af.
78. (sacral adj5 fract\*).af.
79. (lumbar adj5 fract\*).af.
80. or/74-80
81. 73 or 81
82. skeletal survey.mp.
83. ((paediatric or pediatric) adj3 radiolog:).mp.
84. ((paediatric or pediatric) adj3 nuclear medicine).mp.
85. Scintigraphy.mp.
86. (bone scan or X rays).mp.
87. isotope bone scan:.mp.
88. (MRI or magnetic resonance imaging).af.
89. exp Tomography, X-Ray Computed/
90. (CT or CAT scan\*).af.
91. diagnostic imaging.af.
92. (neuroradiology or neuroimaging or neuro-imaging).af.
93. (radiological imag\* or neurologic\* imag\*).af.
94. diffusion weighted imaging.af.
95. \*\*Diffusion Magnetic Resonance Imaging\*\*/
96. (plain films or ultrasound scan\* or 3D reconstruction).af.
97. exp Ultrasonography/
98. (Susceptibility Weighted Imaging or SWI).tw.

99. neuro\* radiology.af.
100. neuro\* examination\*.af.
101. or/83-101
102. healing.mp.
103. (timing adj3 healing).mp.
104. ((dating or date or pattern\*) adj3 fractur\*).mp.
105. (ag: adj3 fractur\*).mp.
106. (ag\* adj3 fractur\*).mp.
107. ((dating or date or pattern\* or age or aging) adj3 fractur\*).mp.
108. (aging adj3 fracture).mp.
109. exp Aging/
110. exp Time Factors/
111. or/103-111
112. 102 or 112
113. 22 and 82 and 113
114. limit 114 to yr="20

### Sources

ASSIA, CINAHL, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, MEDLINE In-Process and Other Non-Indexed Citations, Scopus, Social Care Online, Web of Knowledge. Hand searches of the *Journal of Child Abuse and Neglect* and *Child Abuse Review*. Relevant webpages – The Alberta Research Centre for Health Evidence (ARCHE) and Child Welfare Information Gateway. All searches done up to 2015.

### Inclusion and exclusion criteria

#### **Inclusion criteria were:**

- Rank of abuse 1–3
- If articles were answering the following questions:
  - What neuro-radiological investigations are indicated to identify abusive spinal injury in children?
  - What are the neuro-radiological features of abusive spinal injury in children?
  - Can you date neuro-radiological spinal abnormalities?
  - What are the features (clinical +/- radiological, including fractures) of abusive spinal injuries in children? (may be comparative or non-comparative).

#### **Exclusion criteria were:**

- Rank of abuse is 4–5
- Relates to adults aged >18 years – either exclusively or where relevant data relating to children cannot be extracted
- Inadequate detail on precise brain/spinal injury

- Studies addressing outcome/sequelae of inflicted spinal injury without details of presenting features
- Studies addressing management of abusive spinal injury, without details of presenting features
- Studies addressing exclusively accidental and/or organic spinal injury, post-mortem cases with no ante-morbid details, exclusively social/historical features
- Studies addressing exclusively fewer than five cases relating to neuro-radiological modality
- Studies addressing exclusively neuro-radiology investigations prior to the year 2000
- Formal consensus/expert opinion/personal practice/review article
- Methodologically flawed papers.

### Clinical questions related to skeletal survey (questions 15, 19–21)

A literature review was undertaken to identify the relevant studies.

#### Search strategy

Search strategy for MEDLINE

1. Skeletal AND survey
2. Imaging OR image
3. Follow AND up
4. 1 OR 2 OR 3
5. Child AND abuse
6. 4 AND 5

Search strategy for EMBASE

1. Skeletal AND survey
2. Child AND abuse
3. Imaging OR image
4. Follow AND up
5. 1 AND 2
6. 2 AND 3
7. 2 AND 4
8. 5 OR 6 OR 7

#### Sources

MEDLINE and EMBASE 2011–2016.

#### Inclusion and exclusion criteria

##### Inclusion criteria were:

- Rank of abuse 1–3
- Studies were included if they addressed the following questions:

- Is full skeletal survey indicated in any child under two in whom abuse is suspected?
- Which children over two should have full skeletal survey to identify injury?
- Who should undergo follow-up skeletal imaging?
- What follow-up skeletal imaging should be performed?
- When should follow-up skeletal imaging be performed?
- Which siblings of a child with suspected physical abuse should undergo imaging?

**Exclusion criteria were:**

- Formal consensus/expert opinion/personal practice/review article
- Rank of abuse is 4–5
- Methodologically flawed papers
- Relates to adults aged >18 years – either exclusively or where relevant data relating to children cannot be extracted.

## Appendix 5. List of included studies

### Recommendation 1

See latest Fractures systematic review update accessible at the RCPCH, also:

1. Harper NS, Feldman KW, Sugar NF *et al.* Additional injuries in your infants with concern for abuse and apparently isolated bruises. *J Pediatr* 2014; **165**(2): 383–388.
2. Laskey AL, Holsti M, Runyan DK, Socolar RR. Occult head trauma in young suspected victims of physical abuse. *J Pediatr* 2004; **144**(6): 719–722.
3. Rubin DM, Christian CW, Bilianiuk LT, Zazyczny KA, Durbin DR. Occult head injury in high risk abused children. *Paediatrics* 2003; **111**(6Pt1): 1,382–1386.
4. Greenes DS, Schutzman SA. Occult intracranial injury in infants. *Ann Emerg Med* 1998; **32**(6): 680–686.

### Recommendation 2

5. National Institute for Health and Care Excellence. *Head injury: assessment and early management*. London: National Institute for Health and Care Excellence, 2014.
6. Kemp AM, Rajaram S, Mann M *et al.* What neuroimaging should be performed in children in whom inflicted brain injury (IBI) is suspected? A systematic review. *Clin Radiol* 2009; **64**(5): 473–483.

### Redommendation 3

No evidence available.

### Recommendation 4

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8. Lang CA, Cox MJ, Flores G. Maltreatment in multiple birth children. *Child Abuse Negl* 2013; **37**(12): 1109–1113.
9. Lindberg DM, Blood EA, Campbell KA *et al.* Predictors of screening and injury in contacts of physically abused children. *J Pediatr* 2013; **163**(3): 730–735.
10. Lindberg DM, Shapiro RA, Laskey AL *et al.* Prevalence of abusive injuries in siblings and household contacts of physically abused children. *Paediatrics* 2012; **130**(2): 193–201.
11. Lindberg DM, Berger RP, Reynolds MS *et al.* Yield of skeletal survey by age in children referred to abuse specialists. *J Pediatr* 2014; **164**(6): 1268–1273.

### Recommendation 5

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14. Hong TS, Reyes JA, Moineddin R *et al.* Value of post-mortem thoracic CT over radiography in imaging of pediatric rib fractures. *Pediatr Radiol* 2011; **41**(6): 736–748.

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16. Sanchez TR, Lee JS, Coulter KP, Seibert JA, Stein-Wexler R. CT of the chest in suspected child abuse using submillisievert radiation dose. *Pediatr Radiol* 2015; **45**(7): 1072–1076.

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18. The Health and Care Professions Council. *Standards of proficiency (Radiographers)*. London: The Health and Care Professions Council, 2013.
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20. The Department of Health. *Getting the right start: national service framework for children*. London: Department of Health, 2003.
21. Baroness Kennedy QC. *Sudden unexpected death in infancy: multi-agency guidelines for care and investigation, second edition*. London: The Royal College of Pathologists and The Royal College of Paediatrics and Child Health, 2016.
22. H M Government. *Working together to safeguard children*. London: H M Government, 2015.

### Recommendation 8

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### Recommendation 9

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### Recommendations 10 and 11

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### Recommendation 12

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31. Society and College of Radiographers. *The child and the law: roles and responsibilities of the radiographer*. London: Society and College of Radiographers, 2005.



32. Society and College of Radiographers. *Skeletal surveys for suspected NAI, SIDS and SUDI: guidance for radiographers*. London: Society and College of Radiographers, 2009.
33. Society and College of Radiographers. *Guidance for radiographers providing forensic radiography services*. London: Society and College of Radiographers, 2014.
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#### Recommendation 14

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#### Recommendation 15

38. Society and College of Radiographers. *Standards of radiographic practice for post-mortem cross-sectional imaging (PMC-SI)*. London: Society and College of Radiographers, 2015.
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### Recommendation 18

48. Society and College of Radiographers. *Skeletal surveys for suspected NAI, SIDS and SUDI: guidance for radiographers*. London: Society and College of Radiographers, 2009.

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### Recommendation 24

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No evidence available.

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No evidence available.

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No evidence available.

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