Child Protection Evidence
Systematic review on Visceral Injuries

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Summary

This review, last updated in May 2014, includes visceral injuries not encompassed within the other reviews, apart from ear nose and throat injuries, which are the subject of an ongoing review. Whilst almost every organ of the body has been reported as having been injured, the literature predominantly addresses abdominal injuries. Abdominal injuries are a significant cause of morbidity and mortality amongst abused children\textsuperscript{1,2}. The challenge for clinicians is to recognise when such injuries have occurred, as many symptoms are non-specific and occur predominantly in pre-school children\textsuperscript{3}.

There is a disappointing lack of new literature in this area, but further details of intra-thoracic injuries and the potential role of liver enzymes to identify occult abdominal injury continue to be explored. The review aims to answer two clinical questions:

- What are the features of visceral injuries occurring as a consequence of physical abuse?
- What is the value of non-radiological investigations in detecting abusive abdominal injury?

Key findings:

- Many abdominal injuries, in particular hepatic injury, may be clinically occult and thus active consideration of blunt abdominal injury in children with suspected abuse is necessary
- Abdominal injuries such as transection or laceration of the third / fourth part of the duodenum in children aged less than five years, particularly those less than two years old, who have not experienced a motor vehicle collision should prompt specific child protection investigations
- In the child sustaining head injury or who is unconscious as a consequence of their abusive injuries, abdominal injuries must be considered during their investigation
- Many children sustaining abusive abdominal injury have evidence that there has been repeated blunt abdominal injury, although they have not come to attention with previous injuries. Thus, non-specific symptoms in young children with suspected abuse should prompt abdominal investigations
- While a positive serology test may warrant further investigation, those with negative serology may also have significant intra-abdominal injury
- Infants less than 6 months of age with an isolated bruise may still have occult abdominal injury
Background

This systematic review evaluates the scientific literature on abusive and non-abusive visceral injuries in children published up until May 2014 and reflects the findings of eligible studies. The review aims to answer two clinical questions:

- What are the features of visceral injuries occurring as a consequence of physical abuse?
- What is the value of non-radiological investigations in detecting abusive abdominal injury?

Methodology

A literature search was performed using a number of databases for all original articles and conference abstracts published since May 2014. Supplementary search techniques were used to identify further relevant references. See Appendix 1 for full methodology including search strategy and inclusion criteria.

Potentially relevant studies underwent full text screening and critical appraisal. To ensure consistency, ranking was used to indicate the level of confidence that abuse had taken place and also for study types.

Findings of clinical question 1
What are the features of visceral injuries occurring as a consequence of physical abuse?

- Of 196 studies reviewed from the international literature, 90 articles addressed this question.1-91
- These studies included fatal and non-fatal abuse. Where the term “abdominal injury” is used this alludes to blunt abdominal injury
- Age: 0 – 16 years
- Gender: Two studies analysed the results by gender and found no difference between the abused and non-abused children.25,77

Influence of ethnicity and socio-economic group

These aspects were not addressed by the included studies.
1.1 Abdominal injuries

Comparative Studies

- Of the six comparative studies\textsuperscript{1,3,9,77,88}, four addressed blunt abdominal injuries\textsuperscript{1,9,77,88}:
  - All studies identified abused children with abdominal injury as significantly younger than accidentally injured children, with the mean age across the three studies for abused children all being less than three years\textsuperscript{1,9,77,88}
  - The commonest cause of accidental injury was motor vehicle collision\textsuperscript{1,9,77,88}
  - Where given, the mean age of the accidentally injured group was greater than seven years\textsuperscript{1,9,77,88}
  - No child less than four years of age sustained an accidental duodenal injury from a fall\textsuperscript{3,9}
  - No child less than two sustained a duodenal injury from any accidental mechanism\textsuperscript{77}
  - Co-existent injuries were common amongst the abused cohort (including fractures, head injury, burns, bites and oral injury\textsuperscript{1,9,88})

- Two exclusively addressed duodenal injuries\textsuperscript{3,77}:
  - Duodenal injuries are rare in childhood, accounting for 0.3\% of abdominal trauma\textsuperscript{3}, accounting for 1.5/1000 trauma admissions in children less than five years old\textsuperscript{77}
  - The commonest accidental mechanism of injury was motor vehicle collision\textsuperscript{3,77}
  - Abused children with duodenal injury were significantly younger (mean age 2.25 ± 0.7 years) than accidentally injured children (mean age 7.6 ± 4.4 years\textsuperscript{3}), no child less than two years of age sustained an accidental duodenal injury\textsuperscript{77}
  - Only 1/8 abused children had bruising to the upper abdomen\textsuperscript{3}
  - Abused children were more likely to experience transections than non-abused (35\% vs 17\%) \textsuperscript{(76)}, although perforation was equally likely in another study\textsuperscript{3}

- One exclusively addressed pancreatic injury\textsuperscript{47}:
  - Abuse was the third commonest cause of pancreatic injury, with motor vehicle collisions being the predominant cause
  - Mortality for pancreatic injury was low overall, however 4/10 abused children died
  - Co-existent injury was present in the fatal cases

Solid organ injuries

- 24 studies predominantly described details of hepatic injury\textsuperscript{1,5,7,9,10,15,16,19,21,32,39,41,44-46,48,51,55,57,61,62,72,80,88}

- Children were aged three weeks to eight years (where age is given)\textsuperscript{1,5,7,9,10,15,16,19,21,32,39,41,44-46,48,51,55,57,61,62,72,80,88}
The hepatic injuries included lacerations, contusions, subcapsular haematomas and complete transection of the liver.\(^1,5,7,9,10,15,16,19,21,32,39,41,44-46,48,51,55,57,61,62,72,80,88\)

Co-existent injury included bruising, rib fractures, head injuries, additional abdominal trauma, intra-thoracic trauma and bites.\(^1,5,7,9,10,15,16,19,21,32,39,41,44-46,48,51,55,57,61,62,72,80,88\)

Bruising to the abdomen was recorded in 26 / 37 cases.\(^7,10,16,20,22,32,39,41,44-46,48,51,57,61,62,72\)

**Splenic injury**

Less frequently recorded.\(^1,9,17,46,62,88\)

- Amongst the comparative studies, one study did not report any abusive splenic injuries\(^1\)
- Whilst two studies noted them to be equally prevalent amongst abusively and accidentally injured children.\(^9,88\)
- Where described, the majority of children presented with haemodynamic shock, although presence or absence of abdominal bruising was rarely noted (one case of multiple abdominal organ injury recorded abdominal bruising).\(^88\)
- Details of co-existent injuries were not uniformly available. Where noted, they included other abdominal injuries.\(^1,9,17,46,62,88\)

**Pancreatic injuries**

Predominantly addressed in 10 studies.\(^19,39,46,47,51,60-62,66,75\)

One comparative study noted that motor vehicle collisions were the commonest cause of accidental injury. A third of patients died and abuse was the second commonest aetiology amongst fatal cases.\(^47\)

- The pancreatic trauma included transection of the head of the pancreas, acute necrotising pancreatitis, chronic pancreatitis and pseudocyst formation.\(^19,39,46,47,51,60-62,66,75\)
- Complications of pancreatic injury included pseudocyst formation.\(^39,52,60,62,66\)
- An important late manifestation included osteolytic lesions causing pain and limitation of movement. These predominantly affect long bones, phalanges, tarsals and metatarsals, and may be accompanied by fever.\(^60,75\)
- Many children with pancreatic injury had co-existent additional abdominal injuries and other injuries including burns, fractures, head injury and bruising.\(^19,39,46,47,51,60-62,66,75\)
Renal trauma

Predominantly addressed in three studies: 
- It was the primary injury described in a four month old infant presenting with collapse due to sepsis. It was noted that the left kidney was infarcted in addition to splenic infarction and co-existent fractures.
- Seven further cases of renal trauma were described in conjunction with other abdominal injuries.
- One case of renal vascular injury to an ectopic kidney is also reported.

Other solid organ injuries

- Three studies recorded additional solid organ injuries, including adrenal haematoma and adrenal laceration, including almost complete transection in one case.
- Bruising to the abdomen / trunk was present in all cases, and multiple co-existent injuries were also present, including further abdominal injury, head injury, fractures and oral injury.

Hollow organ injuries

- Overall, hollow organ injuries were recorded as frequently as solid organ injuries, however duodenal injuries occurred more commonly than expected.
- Comparative studies highlighted the rarity of duodenal injury in accidental trauma and its relative frequency in abused children.
  - Duodenal injury did not occur as a consequence of falls in any child less than four years of age.
  - Features of duodenal injury recorded in both comparative and non-comparative studies include intra-mural haematoma (with or without bowel obstruction), complete transection, subserosal haematoma, perforation or inflammation.
  - The commonest duodenal injury involved a transection or perforation between the third and fourth part of the duodenum.
  - Where age was detailed, the children ranged from one week of age to five years of age and a single case of a severely disabled thirteen year old child with an intra-mural haematoma of the second part of the duodenum.
  - Many children presented with an acute abdomen, although some cases did not come to attention for some days after the onset of symptoms.
Co-existent injuries were frequently present, predominantly other abdominal injuries, but also fractures, head injury, and burns. Needle insertions piercing abdominal viscera.

An eight week old infant is described with multiple needle insertions in the abdomen, including penetration of the rectum. In addition, an 11 year old child is described with multiple needle insertions in the abdomen and one in the lower chest, including perforation of the caecum and liver.

**Gastric rupture**

A single case of gastric rupture was recorded in a two year old child, occurring due to a forceful blow to the abdomen, straight after a feed.

**Bladder injuries**

Bladder rupture was the primary injury in six studies, in children aged four months to six years. Rupture to the dome of the bladder occurred in all instances and the children presented variably with collapsed abdominal symptoms, haematuria, reduced urinary output and vomiting.

These highlight the potential mechanism as being a direct blow to a full bladder leading to an acute rise in intravesical pressure.

Four out of the six children had no additional co-existent injuries other than bruising.

**Colonic injuries**

Colonic injuries are described in four studies, representing 100 abused children of whom four sustained large bowel injuries, all of which were in conjunction with other injuries.

The injuries recorded included colonic contusions, rectal perforation, serosal tears of the colon, pneumatosis intestinalis and meso-colonic tear.

**Further abdominal injuries**

Trauma to the abdominal lymphatics presenting as chylous ascites was recorded in a group of children aged 10 weeks - two and a half years. Increasing abdominal distension was the commonest presentation although one child presented with a chyle filled hernia.

Co-existent injuries included fractures, burns, bruising, faltering growth, additional abdominal injuries and head injury.
1.2 Intra-thoracic injuries

- One comparative study\textsuperscript{25} of intra-thoracic injuries in children with rib fractures aged less than three years highlighted that:
  - Abused children were more likely to be aged less than six months, whereas the majority of the accidentally injured children were aged one to three.
  - There was a correlation between the number of rib fractures and the extent of intra-thoracic injuries in the accidentally injured children but not the abused children.

Cardiac and vascular injuries

- Direct cardiac trauma were described in children aged nine weeks to five years\textsuperscript{21,24,27,49,69}:
  - Half of the children died as a consequence of their injury\textsuperscript{21,24,27}.
  - Injuries included traumatic ventriculoseptal defects\textsuperscript{21,49,69}, laceration and intimal tears of the right atrium\textsuperscript{24,27}, transmural laceration of the apex of the left ventricle\textsuperscript{1} and traumatic right ventricular aneurysm\textsuperscript{69}.
  - Co-existent injuries included abdominal injuries, fractures, and head injury.

- A single case described intra-cardiac needle insertion by the parent\textsuperscript{76}.

- Vascular injuries included two injuries to the abdominal aorta\textsuperscript{54,70}:
  - One occurred as a consequence of a kick to the abdomen, resulting in a large pseudo-aneurysm presenting four months after the assault\textsuperscript{70}.
  - The second case was a fatal acute traumatic transection of the abdominal aorta in association with complete fracture-dislocation of the lumbar spine. This case was thought to be due to a hyperextension injury to the spine\textsuperscript{54}.

Pulmonary trauma

- Children aged three weeks to 18 months have been described with pulmonary contusions or subpleural contusions\textsuperscript{29,32,34,59,72}:
  - Co-existent injuries included multiple rib fractures, head injury, bruising and abdominal injuries\textsuperscript{29,32,34,59,72}.
  - The children presented with respiratory difficulty or collapse and pneumothorax in one case\textsuperscript{29}.

- In a comparative study of abused and non-abused children less than three years with rib fractures and intra-thoracic injuries:
  - Pneumothoraces, pulmonary contusion and pulmonary laceration were more common in abused than non-abused children.
  - Pleural effusion occurred equally in both groups (Darling).
  - There was no difference between groups in relation to co-existent intra-cranial or intra-abdominal injury.
• One case recorded needle insertion into the neck, mediastinum, and left forearm. The mediastinal needle lay close to the great vessels\textsuperscript{62}

**Pharyngeal and oesophageal trauma**

• Pharyngeal and oesophageal trauma were predominantly addressed in 10 studies\textsuperscript{4,8,37,52,56,62,66,68,82,84}:
  
  o Injuries to the posterior pharynx included tear, and occasionally complication by retropharyngeal pouch or abscess formation\textsuperscript{8,37,52,62,66,84}
  
  o The children presented with subcutaneous emphysema, oral bleeding or drooling, respiratory distress or difficulty swallowing\textsuperscript{8,37,52,62,66,84}
  
• Injuries to the oesophagus included laceration and perforation\textsuperscript{4,56,82}:
  
  o These children were aged 0–9 months and all presented with irritability, poor feeding, respiratory distress or increasing swelling of the neck and chest with subcutaneous emphysema\textsuperscript{4,56,82}

**Chylothorax**

• Trauma to the thoracic duct leading to chylothorax is recorded in children aged 6–18 months\textsuperscript{6,33,38,40}:
  
  o Children presented with increasing respiratory distress\textsuperscript{6,33,38,40}
  
  o All children had co-existent rib fractures, and other fractures\textsuperscript{6,33,38,40}
  
  o In addition bruising, subdural haematoma and corneal abrasions were noted in one case\textsuperscript{6}

1.3 Implications for practice

• Many abdominal injuries, in particular hepatic injury, may be clinically occult and thus active consideration of blunt abdominal injury in children with suspected abuse is necessary

• Abdominal injuries such as transection or laceration of the third / fourth part of the duodenum in children aged less than five years, particularly those less than two years old, who have not experienced a motor vehicle collision should prompt specific child protection investigations

• In the child sustaining head injury or who is unconscious as a consequence of their abusive injuries, abdominal injuries must be considered during their investigation

• Many children sustaining abusive abdominal injury have evidence that there has been repeated blunt abdominal injury, although they have not come to attention with previous injuries. Thus, non-specific symptoms in young children with suspected abuse should prompt abdominal investigations

• Absence of bruising does not preclude the presence of significant abdominal injury as up to 80% of cases may have no bruising present\textsuperscript{1,3,92,93}
1.4 Research implications

- Only one study to date has determined the incidence of abdominal injury due to child abuse (UK data)\(^9\) and this study excluded children who died as a consequence of abuse or accidental trauma. There is a need for large scale epidemiological data to determine the prevalence and incidence of abusive abdominal injury.
- It is disappointing that of 90 included studies in this review, only seven were comparative studies. There is an urgent need for large scale case control studies of abdominal injuries to delineate the distinguishing characteristics of abusive and accidental injury.

1.5 Limitations of review findings

- Only 7 / 90 included studies were comparative and none were case control, thus limiting definition of distinguishing features between abusive and accidental injury.
- Due to the large number of highly selected case studies / series, meta-analysis was not possible.
- Many large scale studies of blunt abdominal injury had to be excluded as it was not clear whether or not abuse had been considered as a possible aetiology, or where this was mentioned there was inadequate confirmation of abuse.
- Case studies / series afford considerable clinical detail of the included cases, however the generalisability of these findings is limited.
- Only 20 / 90 included studies were published in the last 10 years.

Findings of clinical question 2
What is the value of non-radiological investigations in detecting abusive abdominal injury?

- Of 196 studies reviewed from the international literature, 5 articles addressed this question\(^{20,66,55,94,95}\)
- Age: 0 -12 years
- Gender: results were not analysed by gender

Influence of ethnicity and socio-economic group
These aspects were not addressed by the included studies.
2.1 Serological tests

- Four diagnostic test studies addressed the value of serological markers in identifying occult abdominal injury.\(^{20, 55, 94, 95}\)
- The optimal study design would include all children undergoing a "gold standard" investigation such as an abdominal computerised tomography (CT) scan. Two studies did not do this, thus limiting the value of their findings (1, 4), one did but only 19.4% underwent definitive testing.\(^{95}\)
- A prospective study of 49 children less than 12 years of age presenting with suspected physical abuse underwent testing with liver transaminases, lactate dehydrogenase (LDH), alkaline phosphatase and amylase. 4 / 49 had elevated transaminases / LDH, three of whom had liver laceration. No child with negative serology underwent imaging.\(^{1}\)
- A prospective multi-centre study of 1,676 children with suspected abuse aged less than five years screening with transaminases. Not all children presenting underwent serology, and it is not clear how children were selected for testing. 259 children had elevated transaminases of whom 138 underwent "gold standard" testing. 41 / 138 had identifiable abdominal injury. A cut off of 80 IU/L was deemed “positive” and based on this the sensitivity of testing was 77% with a specificity of 82%.\(^{55}\)
- A retrospective review investigated 2,890 children aged less than ten years whose siblings were evaluated for abuse:
  - 53.2% underwent serological testing, although criteria for performing screening were not specified. 310 children had elevated transaminases of whom two thirds underwent definitive testing and 29.3% of whom had an intra-abdominal injury. It is of note that 13.7% of those with negative transaminases who underwent definitive testing also had an intra-abdominal injury.\(^{95}\)
  - A secondary analysis of this data explored the level of positive serology in infants less than 6 months of age presenting with an isolated bruise. 92/146 (63%) underwent serology, of whom 14 had elevated enzymes, 12 of whom underwent CT. 4/15 children overall undergoing CT had a liver laceration or contusion, it is not clear whether these children had elevated enzymes or not.\(^{94}\)
- A study of the value of CT imaging of 84 abused children aged less than five years of age compared positive CT imaging to positive serology:\(^{46}\)
  - 56 children underwent serology\(^{46}\)
  - 21 / 27 children with abdominal injury had elevated transaminases while 19 / 29 with normal abdominal CT also had elevated serology\(^{46}\)
  - Elevated amylase or lipase found in 14 / 28 children with abdominal injury and 2 / 14 with a normal CT\(^{46}\)
2.2 Implications for practice

- While a positive serology test may warrant further investigation, those with negative serology may also have significant intra-abdominal injury.
- Infants less than 6 months of age with an isolated bruise may still have occult abdominal injury.

2.3 Research implications

- Future studies should be prospective studies of children presenting with suspected abuse, all of whom undergo serological testing with precisely defined cut-offs, and abdominal CT would be the imaging of choice to delineate abdominal injuries.
- It would be optimal for children with negative investigations to undergo imaging to truly define specificity and sensitivity, however it is recognised that the radiation involved may pose ethical dilemmas.

2.4 Limitations of review findings

- Only four diagnostic test studies have been conducted, not all children with positive serology underwent diagnostic imaging, and in no case did all children with negative investigations undergo “gold standard” testing.
- Where clinicians elected to perform or not perform serology, the reasons for this were not given for all cases.

Other useful resources

The review identified a number of interesting findings that were outside of the inclusion criteria. These are as follows:

Clinical question 1

Visceral consequences of injury

- Rhabdomyolysis has been described as a consequence of severe physical abuse with multiple extensive bruises, and has resulted in renal failure\(^{96,97}\).
- Commotio cordis has been described where the assault on the child involves a direct blow to the chest resulting in ventricular dysrhythmia and subsequent death. Significantly, no pathological abnormality was found in the heart on autopsy and in only one case were co-existent rib fractures present (in this child the perpetrator also admitted to severe squeezing of the chest)\(^{98-100}\).
Vulnerability of infants to abdominal injury

- Young children are susceptible to injury due to a less muscular, thin abdominal wall, the diaphragm being more horizontal and the liver and spleen more anterior, thus less protected by ribs. As the ribs themselves are elastic and more compressible, direct trauma to the chest may crush solid organs below\(^{101}\)

Epidemiology

- While the following studies did not meet our inclusion criteria for rank of abuse, they provide a population estimate of:
  - The prevalence of abusive abdominal trauma in children in the USA\(^{102-104}\)
  - The proportion of children with fatal abuse with abdominal injury in the UK\(^{2}\)

Trauma service involvement

- Given the prevalence of poly-trauma amongst abused infants and children, prompt trauma service evaluation would be of value\(^{105}\)

Clinical question 2

Optimal radiological investigation of suspected abdominal injury is a CT scan of the abdomen\(^{106}\) with or without contrast\(^{107}\)

A plain abdominal film may indicate perforation, and ultrasound (U/S) is non-invasive and easily accessible. However, either of these investigations may miss significant injury\(^{105,107-111}\)

A Cochrane review concluded there is no evidence in using U/S in preference to CT scan for blunt abdominal injury as its sensitivity is too low for definitive identification of injury\(^{112}\)

Related publications

Publications arising from visceral injuries review
References


116. Health Evidence Bulletins Wales: A systematic approach to identifying the evidence. Project Methodology 5. Available from  
http://hebw.cf.ac.uk/projectmethod/Project%20Methodology%205.pdf (last accessed
Appendix 1 – Methodology

We performed an all-language literature search of original articles, their references and conference abstracts published since 1950. The initial search strategy was developed across OVID Medline databases using keywords and Medical Subject Headings (MeSH headings) and was modified appropriately to search the remaining bibliographic databases. The search sensitivity was augmented by the use of a range of supplementary ‘snowballing’ techniques including consultation with subject experts and relevant organisations, and hand searching selected websites, non-indexed journals and the references of all full-text articles.

Identified articles, once scanned for duplicates and relevancy, were transferred to a purpose-built Microsoft Access database to coordinate the review and collate critical appraisal data. Where applicable, authors were contacted for primary data and additional information. Translations were obtained, when necessary. Relevant studies were scanned for eligibility by the lead researcher; those that met our inclusion criteria were reviewed.

Standardised data extraction and critical appraisal forms were based on criteria defined by the National Health Service’s Centre for Reviews and Dissemination (Centre for Reviews and Dissemination 2009). We also used a selection of systematic review advisory articles to develop our critical appraisal forms.113-116 Articles were independently reviewed by two reviewers. A third review was undertaken to resolve disagreement between the initial reviewers when determining either the evidence type of the article or whether the study met the inclusion criteria. Decisions related to inclusion and exclusion criteria were guided by Cardiff Child Protection Systematic Reviews, who laid out the basic parameters for selecting the studies.

Our panel of reviewers included paediatricians, paediatric surgeons, radiologists, pathologists, information specialists and designated and named doctors in child protection. All reviewers underwent standardised critical appraisal training, based on the CRD critical appraisal standards113, and this was supported by a dedicated electronic critical appraisal module.

Inclusion criteria

We included high quality case series/studies, where abuse had been confirmed. To minimise circularity in relation to confirmation of abuse, we included only those studies where the rank of abuse was 1 or 2. In order to address the role of non-radiological investigations in detecting abusive abdominal injury, we accepted studies with a lower rank of abuse (4-5) for this question, in order to determine if occult injuries were present.
See evidence sheets and critical appraisal forms for each year's update.

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children aged 0 to &lt; 18 years</td>
<td>Studies with mixed child and adult subjects, where the children’s data could not be extracted</td>
</tr>
<tr>
<td>Alive or deceased on presentation</td>
<td>Inadequate clinical detail of included cases</td>
</tr>
<tr>
<td>Injury confirmed by one or more of the following:</td>
<td>studies including a mixture of abusive and accidental injuries, where the details of these two groups could not be extracted</td>
</tr>
<tr>
<td>Contrast studies</td>
<td>studies exclusively addressing the outcome / management of visceral injuries</td>
</tr>
<tr>
<td>Computed tomography (CT) scanning, with or without contrast</td>
<td>studies of sexual abuse, thus all ano-genital / rectal injuries</td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
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<tr>
<td>Post mortem examination</td>
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</tr>
</tbody>
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**Ranking of abuse**

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Criteria used to define abuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Abuse confirmed at case conference or civil, family or criminal court proceedings or admitted by perpetrator or independently witnessed</td>
</tr>
<tr>
<td>2</td>
<td>Abuse confirmed by stated criteria including multidisciplinary assessment</td>
</tr>
<tr>
<td>3</td>
<td>Diagnosis of abuse defined by stated criteria</td>
</tr>
<tr>
<td>4</td>
<td>Abuse stated as occurring, but no supporting detail given as to how it was determined</td>
</tr>
<tr>
<td>5</td>
<td>Abuse stated simply as 'suspected', no details on whether it was confirmed or not</td>
</tr>
</tbody>
</table>

**Search strategy**

The below table presents the search terms used in the 2014 Medline database search for visceral injuries, truncation and wildcard characters were adapted to the different databases where necessary.

| 1. exp Child Abuse/                          | 76. renal fracture.af.                                        |
| 2. child abuse.af.                           | 77. "Kidney"/in [Injuries]                                   |
| 3. (child protection or child maltreatment).af. | 78. "Aortic Rupture"/                                        |
| 4. (battered child or shaken baby or battered baby).af. | 79. renal contusion:.af.                                  |
|                                               | 80. "Renal Artery"/in [Injuries]                              |
5. exp Shaken Baby Syndrome/
6. exp Battered child Syndrome/
7. or/1-6
8. (child: or infant: or baby or toddler:).ti,ab.
9. child/ or Infant/ or Child, Preschool/
10. 8 or 9
11. inflicted injur:.af.
12. non-accidental injur*.af.
13. non-accidental trauma*.af.
14. (non-accidental: and injur*).ti,ab.
15. soft tissue injur*.af.
16. (physical abuse or physical punishment).af.
17. assault.mp.
18. (or/11-17) and 10
19. 7 or 18
21. Tomography, X-Ray Computed/
22. (MRI or Magnetic resonance imaging).af.
23. plain film.af.
24. ultrasound scan.af.
25. CT scan.af.
26. CTA scan.af.
27. Radiography, Abdominal/
29. Contrast-enhanced ultrasound.af.
30. barium meal.af.
32. angiogram.af.
33. Tomography, Spiral Computed/
34. intravenous pyelogram.af.
35. upper GI series.af.
36. lower GI series.af.
37. (esophagram or oesophagram).af.
38. 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37
39. Intestinal Perforation/
40. duodenal perforation.af.

81. subcapsular h?ematoma.af.
82. hepatic laceration:.af.
83. Lacerations/
84. contusion.af. or Contusions/
85. rectal injur:.af.
86. **“Rectum”/in [Injuries]
87. Peritonitis/
88. peritoneal fluid.af.
89. perinephric collection.af.
90. Transaminases/
91. Foreign Bodies/
92. gamma-Glutamyltransferase/ or GGT.af.
93. Intestine, Small/
94. Amyloid/
95. liver enzymes.af.
96. “Spleen”/in [Injuries]
97. Thoracic Injuries/
98. thoracic trauma.af.
99. mesenteric.af.
100. duodenal h?ematoma.af.
101. Wounds, Nonpenetrating/
102. *Intestines/in [Injuries]
103. hepatic fracture:.af.
104. hepatic hematoma.af.
105. Amylases/
106. Alanine Transaminase/ or ALT.af.
107. Aspartate transaminase/ or AST.af.
108. Aortic trauma.af.
109. Cardiac laceration:.af.
110. Cardiac perforation.af.
111. “Heart Injuries”/
112. gastric perforation.af.
113. gastric laceration:.af.
114. gluteal.mp.
115. (Haemorrhage: or hemorrhage:).af.
116. ileal injur:.af.
117. lung laceration:.af.
118. Mediastinal trauma:.af.
| 41. | Splenic Rupture/ |
| 42. | Rupture, Spontaneous/ |
| 43. | oesophageal tear*.af. |
| 44. | oesophageal laceration*.af. |
| 45. | Cardiac Tamponade/ |
| 46. | pericardial tamponade.af. |
| 47. | bladder rupture:.af. |
| 48. | kidney rupture:.af. |
| 49. | pancreas rupture:.af. |
| 50. | Rupture/ |
| 51. | Abdominal Injuries/ |
| 52. | liver injur:.af. |
| 54. | intestinal injur:.af. |
| 55. | colonic injur:.af. |
| 56. | Visceral injur:.af. |
| 57. | Esophageal Perforation/ |
| 58. | thorax injur:.af. |
| 59. | bladder perforation.af. |
| 60. | bowel perforation.af. |
| 61. | esophageal laceration:.af. |
| 62. | Heart Rupture/ |
| 63. | Pancreatic Pseudocyst/ |
| 64. | Hematoma/ |
| 65. | Hematemesis/ |
| 67. | vascular injur:.af. |
| 68. | pharyngeal.af. |
| 69. | Hematoma/ |
| 70. | h?ematoma.af. |
| 71. | oesophageal injur:.af. |
| 72. | bowel injur:.af. |
| 73. | jejunal injur:.af. |
| 74. | Jejunum/ |
| 75. | renal laceration:.af. |
| 119. | Pulmonary contusion:.af. |
| 120. | Pulmonary laceration:.af. |
| 121. | Ascites/ |
| 122. | Chylos Ascites/ |
| 123. | Hematuria/ |
| 125. | Lipase/ |
| 126. | mesentary.af. |
| 127. | viscus.af. |
| 128. | Viscera/ |
| 129. | osteolytic lesions.af. |
| 130. | chylothorax.af. |
| 131. | Heart Septal Defects, Ventricular/ |
| 132. | chylothorax/ |
| 133. | cervical soft tissue lesion*.af. |
| 134. | ((cardiac or ileal or liver or kidney or colonic or spleen or duoden* or oesophagus or esophageal or abdominal or lung or pancrea* or viscera or bowel or intestine) adj3 (rupture or trauma or tear)).mp. |
| 135. | ((spleen or pelvic or duodenal) adj3 (lacerat* or injur*)).af. |
| 137. | Gastrointestinal Tract.mp. |
| 138. | occult abdominal injur*.mp. |
| 139. | Subcapsular h?ematoma.af. |
| 140. | lymphatic chylous ascites.mp. |
| 141. | Chylous Ascites/ |
| 142. | Alkaline Phosphatase/ |
| 143. | ALK Phos.mp. |
| 144. | or/39-143 |
| 145. | 19 and 38 and 144 |
| 146. | 19 and 144 |
| 147. | 145 or 146 |
| 148. | limit 147 to (humans and yr="2013 - Current") |
Thirteen databases were searched together with hand searching of particular journals and websites. A complete list of the resources searched can be found below.

<table>
<thead>
<tr>
<th>Databases</th>
<th>Time period searched</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSIA (Applied Social Sciences Index and Abstracts)</td>
<td>1987 – 2014</td>
</tr>
<tr>
<td>Child Data</td>
<td>1958 – 2009†</td>
</tr>
<tr>
<td>CINAHL (Cumulative Index to Nursing and Allied Health Literature)</td>
<td>1982 – 2014</td>
</tr>
<tr>
<td>Cochrane Library (formerly All EBM Reviews - Cochrane DSR, ACP Journal</td>
<td>1996–2014</td>
</tr>
<tr>
<td>Club, DARE, and CCTR)</td>
<td></td>
</tr>
<tr>
<td>EMBASE</td>
<td>1980 – 2014</td>
</tr>
<tr>
<td>MEDLINE</td>
<td>1950 – 2014</td>
</tr>
<tr>
<td>MEDLINE In-Process and Other Non-Indexed Citations</td>
<td>1951-2014</td>
</tr>
<tr>
<td>Open SIGLE (System for Information on Grey Literature in Europe)</td>
<td>1980 – 2005†</td>
</tr>
<tr>
<td>Pubmed e publications</td>
<td>2014</td>
</tr>
<tr>
<td>Scopus</td>
<td>1960-2014</td>
</tr>
<tr>
<td>Web of Knowledge – ISI Science Citation Index</td>
<td>1981 – 2014</td>
</tr>
<tr>
<td>Web of Knowledge – ISI Social Science Citation Index</td>
<td>1981 – 2014</td>
</tr>
</tbody>
</table>

| ceased indexing |
| institutional access terminated |

<table>
<thead>
<tr>
<th>Journals ‘hand searched’</th>
<th>Time period searched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Abuse and Neglect</td>
<td>1977 – 2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Websites searched</th>
<th>Date accessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Association for the Study and Prevention of Child Abuse and Neglect (BASPCAN)</td>
<td>May 2014</td>
</tr>
<tr>
<td>British Society of paediatric Radiology</td>
<td>May 2014</td>
</tr>
<tr>
<td>Child Abuse Professional Network (CAPnet)</td>
<td>May 2014</td>
</tr>
<tr>
<td>Child Welfare Information Gateway (formerly National Clearinghouse on Child Abuse and Neglect)</td>
<td>May 2014</td>
</tr>
</tbody>
</table>
Pre-review screening and critical appraisal

Papers found in the database and hand searches underwent three rounds of screening before they were included in this update. The first round was a title screen where papers that obviously did not meet the inclusion criteria were excluded. The second was an abstract screen where papers that did not meet the inclusion criteria based on the information provided in the abstract were excluded. In this round the pre-review screening form was completed for each paper. These first two stages were carried out by clinical experts. Finally a full text screen with a critical appraisal was carried out by members of the clinical expert sub-committee. Critical appraisal forms were completed for each of the papers reviewed at this stage. Examples of the pre-review screening and critical appraisal forms used in previous reviews are available on request (clinical.standards@rcpch.ac.uk).