Child Protection Evidence
Systematic review on Retinal Findings

Published: March 2015
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Summary

This systematic review evaluates the scientific literature on abusive and non-abusive retinal findings in children with a head injury published up until January 2015 and reflects the findings of eligible studies. The review aims to answer the following clinical questions:

- Identify discriminating features relating to the retinal haemorrhage findings in abusive head trauma and other traumatic and non-traumatic conditions in childhood
- Determine the prevalence of retinal haemorrhages in conditions proposed as confounders amongst abusive head trauma (AHT) cases i.e. seizure, cough, apparent life-threatening events (ALTE), cardiopulmonary resuscitation (CPR)
- Characterise the retinal findings in newborn infants to assist those assessing babies aged less than three months of age who may present with suspected head trauma and retinal abnormalities

Key findings:

- There have been no new studies in 2014 to add to the meta-analysis of studies detailing retinal findings in children less than three years with a head injury. The current meta-analysis highlights the association between retinal haemorrhage and abusive head trauma (odds ratio of 15.31, 95% CI 18.78-25.74). New studies relating to retinal haemorrhages in other disease states and newborn infants have been added. Increasing emphasis has been placed on the detailed pattern of retinal findings and whether these characteristics may aid in distinguishing abusive head trauma from other aetiologies. Ophthalmologists may also encounter children with direct trauma to the eye as a direct consequence of abuse and a recent review highlights the characteristics that may assist in identifying these injuries. To date there are however no large scale comparison studies involving eye injuries due to abuse versus those due to accidental injury
- With the increased use of MRI, recent studies highlight the correlation between intracranial features and retinal haemorrhages. There are still no studies to date which set out to determine the evolution of retinal haemorrhages to enable dating of these injuries
Background

This systematic review evaluates the scientific literature on abusive and non-abusive retinal injuries in children with a head injury published up until January 2015 and reflects the findings of eligible studies. The review aims to answer the following clinical questions:

1. What differences are found between abusive head trauma retinal findings versus non-abusive head trauma retinal findings? (only include children < 11 years or where median age falls within this age range)

2. What are the differential diagnoses of retinal haemorrhages in children with clinical features associated with child abuse? (only include children < 11 years or where median age falls within this age range)

3. Retinal haemorrhages in newborn infants:
   a) What are the retinal findings in newborn infants?
   b) What are the obstetric correlates to retinal haemorrhages in the newborn?
   c) What is the evolution of newborn retinal haemorrhages?

4. Can you date retinal findings in children? (only include children < 11 years)*

5. Which features or characteristics of eye injury are present in child maltreatment, neglect and fabricated or induced illness? (only include children < 11 years or where median age falls within this age range)

Methodology

A literature search was performed a number of databases for all original articles and conference abstracts published since 1950. 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 differences are found between abusive head trauma retinal findings versus non-abusive head trauma retinal findings?

- Of 376 studies reviewed from the international literature, 71 articles addressed this issue. Add four new studies.
- These 71 articles all met our inclusion criteria, quality standards for ophthalmological examination and ranking of abuse requirements.
- **Age:**
  - Children included in the majority of comparative studies were aged less than three years old. Two studies included children up to the age of 17 years.
  - Non-comparative AHT cases included older abused children aged three to eight years old. Non-comparative nAHT cases included children up to age 14 years.
- **Gender:**
  - One comparative study showed no significant difference in gender distribution between AHT and nAHT cases.
  - There was a greater preponderance of males among the accidental group than among the inflicted injury group in one study.
- **Multilevel logistic regression analysis:** the probability of abuse when a child aged less than three years is found to have retinal haemorrhages: odds ratio (OR) 15.31 (confidence interval (CI) 7.84, 29.89).
- Among the recent studies, one includes a detailed examination of a subset of the data from previous studies.

Influence of ethnicity and socio-economic group
Not addressed by the included studies

### 1.1 Retinal findings

Retinal findings were recorded in relation to laterality, number and extent of haemorrhages and layers of the retina involved, as follows:
Laterality of retinal haemorrhages

- Comparative data showed the majority of abusive head trauma (AHT) cases were bilateral\(^8,14,32,50,62\) in contrast to non-abusive head trauma (nAHT) where 0-8% of cases were bilateral\(^8,22,50,60\).
- Studies detailing accidental trauma include:
  - Isolated case reports of bilateral retinal haemorrhages following severe crush injury or high fall\(^4,39,50,59\).

Number of retinal haemorrhages

- Comparative data identified that the majority of AHT cases had larger numbers of retinal haemorrhages in comparison to the accidental cases\(^8,14,22,50,62,63\).
- Among the non-comparative literature\(^24,28,43,44,69\) four case reports of non-abusive injury recorded cases with multiple retinal haemorrhages\(^24,28,43,69\) of which three were crush injuries\(^28,43,69\).

Extent of retinal haemorrhages

- Few comparative studies recorded the extent of retinal haemorrhages; of those that did\(^8,50,60,62,64,66\) the majority of AHT extended to the ora serrata, while very few nAHT cases did\(^50,59,64,66\).
- Amongst the non-comparative nAHT studies, retinal haemorrhages were limited to the posterior pole in the majority\(^26,28,44,61\).

Retinal layer

- Devising a summary of the retinal layer most involved was hampered by authors’ varying terminology.
- Among comparative studies, intraretinal haemorrhages predominated in both AHT and nAHT; except in one study which showed intraretinal haemorrhages to be more common in AHT\(^50\): subretinal haemorrhages were only (or more commonly\(^50\)) recorded in AHT; preretinal haemorrhages were more common among AHT\(^8,14,22,32,50,55,62,64,66\). A recent study of witnessed accidents versus confessed abuse noted more flame-shaped haemorrhages amongst nAHT\(^63\).
- In one comparative study, only the abuse cases exhibited retinal haemorrhages, all of which were multilayered including preretinal and intraretinal and subhyaloid\(^59\).
- In one non-comparative nAHT study detailing the layer, 4/7 cases were multi-layered with the precise layer not defined\(^4\).
- From non-comparative nAHT literature, intraretinal haemorrhage remained the commonest location but with preretinal noted\(^23,28,39,43,52,61,69\).
Additional retinal features

- Numerous additional retinal features were recorded\(^3,5-9,12-19,21-44,46-58,60-62,64-71\)
- Of note, schisis cavities were recorded in up to ten-times as many AHT cases\(^49-51,57,63,69\) as nAHT cases\(^5,35,38,45-48,50,60,69,71\)
- Retinal folds are more common amongst AHT cases\(^5,35,38,45,48,50,60,69,71\) than nAHT cases\(^39,43,69\)
- Vitreous haemorrhages are more common amongst AHT cases\(^5,8,13-16,18,25,26,30,37,40,41,46-50,68\) than nAHT cases\(^18,43,50\)
- Two cases of subhyaloid haemorrhage were recorded in AHT cases. One required surgery, the other had cleared by two months\(^29\)
- Few cases of epiretinal membrane\(^21\), retinal tears\(^40,42,46,70\) and macular hole\(^6,46\) were recorded and these were exclusively amongst AHT cases

Retinal findings amongst perpetrator admitted AHT cases

- One comparative study addressed retinal findings amongst perpetrator admitted AHT and independently witnessed nAHT\(^63\), two other studies were non-comparative AHT cases\(^10,45\)
- In the comparative study 84% of AHT cases had retinal haemorrhages versus 17% of nAHT. Amongst those, 56.8% of AHT had severe retinal haemorrhages versus 2.27% of nAHT\(^63\)
- The majority of cases included bilateral, multiple retinal haemorrhages\(^10,45\). It was notable however that despite perpetrator admitted injury, 3/17 cases were unilateral while 2/17 had less than five retinal haemorrhages per eye\(^45\)

Neuroradiological features amongst children with retinal haemorrhages

- Amongst comparative studies, where the detail is available, all cases had abnormalities on neuroimaging\(^8,14,22,50,55,59,62,64,66,67\) apart from in one study\(^7\) where all AHT had abnormalities but 2/16 nAHT did not
- Of note amongst nAHT cases, two studies\(^23,61\) noted retinal haemorrhages in conjunction with some children with extradural haemorrhages, although in one case these were only noted post-surgery\(^23\), the remaining cases underwent surgery but it is unclear as to whether the retinal examination was conducted pre or post-operatively\(^61\)
- Nine cases\(^26,33,67,73\) had neurological symptoms but no identifiable abnormalities on initial imaging. However, subsequent imaging in 3/9 cases became abnormal, five did not undergo repeat imaging, and one with severe neurological symptoms had normal imaging repeated on three occasions
- There appears to be a correlation between severity of retinal haemorrhage and hypoxic ischaemic injury\(^2,50\)

Please note that the six cases from\(^73\) are the same as those in the included study by the same author\(^53\)(as confirmed by author correspondence) but described in more detail.
1.2 Coexistent features

- Amongst studies recording fractures:
  - skull fractures occurred predominantly amongst non-abusive head trauma (nAHT) cases as opposed to abusive head trauma (AHT) cases (AHT comparative\(^8,59,64,66\)) (AHT non-comparative\(^5,12,16,27,30,32,34,47,56,60,69\)) (nAHT comparative \(^8,22,59,64,66\)) (nAHT non-comparative\(^4,17,23,28,39,43,44,52,61,69\))
  - rib fractures were recorded exclusively in AHT (AHT comparative\(^2,8,14,64,66\)) (AHT non-comparative\(^2,5,16,18,33,36,51,53,54,56,68,71\))
  - long bone were far more frequent amongst AHT than nAHT cases (AHT comparative\(^2,8,14,64,66\)) (AHT non-comparative\(^5,6,13,16,18,30,34,36,47,51,53,54,56,63,67,68\)) (nAHT comparative\(^2,63,64,66\))
  - multiple fractures were far more frequent amongst AHT than nAHT cases (AHT comparative\(^8,64,66\)) (AHT non-comparative\(^5,16,18,32,34,36,51,53,54,56,66\)) (nAHT comparative\(^64,66\))

- One case of a three year old with perpetrator admitted shaking had interhemispheric subdural haemorrhage and cerebral oedema with no co-existent fractures\(^10\)
- Other clinical features included clavicle fracture\(^51\), corneal abrasion\(^67\), bruising\(^2,9,33\) bites and perineal injuries\(^51\), and visceral injuries\(^2\)

1.3 Implications for practice

- Fundal examination must be conducted by an ophthalmologist with papillary dilatation and use of indirect ophthalmoscopy in order to ensure that haemorrhages to the periphery are accurately noted
- Retinal haemorrhages are a rare finding in accidental trauma and are predominantly associated with high impact head injury or crush injury
- It is recommended that children undergoing ophthalmological examination for suspected abuse have standardised recording of all retinal findings

1.4 Research implications

- Future studies should incorporate standardised recording of all retinal features, noting their presence or absence in all cases
- Further studies of the putative association between extradural haemorrhage and retinal haemorrhage would be of value
- Prospective studies of children less than two years of age undergoing CPR to determine any association with retinal haemorrhages would be of value

Variable standards of ophthalmological examination led to many studies being excluded
Amongst included studies, a wide range of terminology and classification systems regarding extent and severity of retinal haemorrhages hampered meta-analysis.

A lack of standardised neuroimaging and timing to retinal examination contributed to heterogeneity between studies.

Findings of clinical question 2
What are the differential diagnoses of retinal haemorrhages in children with clinical features associated with child abuse?

Within this review, we were interested in retinal findings in children who were not subjected to physical trauma but where either they had a condition whose features may mimic child abuse, or a condition which has been proposed to cause retinal haemorrhages (only included children < 11 years or where median age falls within this age range).

- Of 376 studies reviewed from the international literature, 30 articles addressed this issue.
- Age:
  - The children’s ages ranged from birth to 15.8 years
  - The majority of children were aged less than 18 months
  - Older children were reported in two studies

Influence of ethnicity and socio-economic group
Not addressed by the included studies.

Clinical overlap with abuse
- Studies were only included if the children had one or more of the features considered to be associated with child abuse, as follows: fractures, bruising, intracranial bleeding
- Please note that pre-existing known bleeding disorders were excluded from this review – see inclusion/exclusion criteria
RH were found in the following conditions:

- **Metabolic conditions**
  - Glutaric aciduria\(^\text{84,88}\)
  - Methylmalonic aciduria with homocysteinuria (Cobalamin C deficiency) \(^\text{83,99}\)
  - Congential disorder of glycosylation Type 1A\(^\text{93}\)

- **Osteogenesis imperfecta\(^\text{85}\)**

- **Haematological conditions:**
  - Platelet function defect (Hermansky-Pudlak syndrome)\(^\text{97}\)
  - Protein C deficiency\(^\text{77,87}\)
  - Low fibrinogen levels\(^\text{90}\)
  - Haemorrhagic disease of the newborn (cardiopulmonary resuscitation also performed)\(^\text{101}\)

- **Vascular abnormalities:**
  - Fibromuscular dysplasia\(^\text{82}\)
  - Spinal cord arteriovenous malformation\(^\text{78}\)
  - Cerebral aneurysm (two cases)\(^\text{4,74}\), arteriovenous malformation (two cases)\(^\text{4,95}\)

- **Intracranial abnormalities:**
  - Case of external hydrocephalous*\(^\text{94}\)

  *Correspondence with author confirmed the standard of ophthalmological examination met the inclusion criteria

**Features of abuse**

- All of the children in the included studies had an intracranial haemorrhage\(^\text{4,56,76-78,82-85,88,90,93-95,97,99,101}\)
- Nine had co-existent bruising where recorded\(^\text{77,85,87,90,93,101}\)
- The three cases with osteogenesis imperfecta also had fractures present\(^\text{85}\)

**Retinal haemorrhage findings**

- Retinal haemorrhages found were bilateral in 13/21 cases\(^\text{4,76-78,82-85,90,93-95,97,99,101}\)
- They were located in the posterior pole in 8/12 (where location recorded)\(^\text{76,84,85,88,93-95,97,99}\)
- They were predominantly intraretinal (13/14 – where recorded)\(^\text{78,82-85,88,90,97,99,101}\) or subhyaloid\(^\text{95,95}\)
- Only seven cases had multiple or extensive retinal haemorrhages\(^\text{82,84,85,93-95,101}\) and in only three studies\(^\text{4,82,94}\) were they in more than one layer, as has been recorded in abusive head trauma
- In one case of cerebral artery aneurysm with intracranial haemorrhage an examination nine days after admission and postoperatively demonstrated extensive pre-retinal and intra-retinal haemorrhages in one eye\(^\text{76}\)
Subhyaloid haemorrhages in the child suffering from external hydrocephalus cleared within six months\(^9^4\)

**Conditions in which retinal haemorrhages are proposed to occur**

**Seizures:**

- Five studies examined children with seizures, reflecting 397 children\(^7^9,9^1,9^6,9^8,1^0^0\)
- 235 cases had febrile seizures; the remaining cases included epilepsy, metabolic disease, infection or CVA\(^7^9,9^1,9^6,9^8,1^0^0\)
- Retinal haemorrhages were only recorded in two cases\(^9^1,9^6\)
  - Mei-Zahav et al\(^9^1\); an infant with generalised seizure and no other risk factors who had flame-shaped haemorrhages in the posterior pole unilaterally
  - Rubin et al\(^9^6\); single case report of an infant with hyponatremia and prolonged seizure who had multiple retinal haemorrhages in the posterior poles bilaterally

**Apparent life-threatening events**

- 292 cases in children aged less than two years old were examined\(^5^6,7^5,8^0\)
- No retinal haemorrhages were found in any children examined

**Prolonged coughing**

- 135 cases in children aged less than two years old were examined\(^8^1,8^6\)
- No retinal haemorrhages were found in any children examined

**Cardiopulmonary resuscitation**

- A single study\(^9^2\) met our inclusion criteria: 43 children were examined following resuscitation
- One infant was noted to have bilateral, numerous, punctuate haemorrhages. However, this child also had one hour of open chest cardiac massage with deranged clotting and platelet counts\(^9^2\)

**Retinal haemorrhages of children in the intensive care unit**

- Two studies have examined children admitted to the intensive care unit for the prevalence of retinal haemorrhages\(^7^4,8^9\)
- One study included children aged six weeks to six years, excluding penetrating eye trauma and abusive head trauma\(^7^4\). 24 out of 159 children (15.1%) had retinal haemorrhages and 12 out of the 24 had unilateral retinal haemorrhages, with 11 having the haemorrhages restricted to Zone 1. Severity of bleeding was mild to moderate in 75% of children. There were seven cases of trauma, of which two were road traffic accidents and one was a crush injury. The remaining cases had leukaemia, sepsis, or intra-cerebral abnormalities
The second study examined all children who were intubated in the intensive care unit, aged 0-4 years. Those with retinopathy of prematurity, retinoblastoma, retinal trauma, or previous retinal haemorrhages were excluded. Excluding four cases with abusive head trauma, 2 out of 81 children had retinal haemorrhages, one of whom had sustained a crush injury and one cardiac arrest and CPR. Both of these cases had bi-lateral mild to moderate retinal haemorrhages. The child with a crush injury had multi-layered retinal haemorrhages. The infant undergoing cardiopulmonary resuscitation who died of hypoxic ischemic encephalopathy had mild haemorrhages in the retinal layer, exclusively in the posterior pole. Correspondence with the author confirmed that abuse had been excluded by the child abuse team in this case.

2.1 Implications for practice

- While bleeding disorders are recognised causes of retinal haemorrhages in children, this review has identified a small number of conditions which may also need to be considered when assessing such children.
- No evidence has been found for the putative association between apparent life-threatening events / prolonged cough and retinal haemorrhages.
- There is no evidence, to date, to substantiate cardiopulmonary resuscitation as a cause of retinal haemorrhages, although further large-scale studies are warranted.
- Retinal haemorrhages have been noted in a very small number of cases with seizures, although one of these cases had co-existent risk factors.
- Recent studies of critically ill children have identified very rare associations with retinal haemorrhage in this population.

2.2 Research implications

- None of the conditions in which retinal haemorrhages were noted have been examined in a large-scale epidemiological study, thus the true prevalence of retinal haemorrhages in these cases cannot be determined. It would be particularly beneficial for such studies to be conducted on children with osteogenesis imperfecta and the metabolic disorders identified.
- Further studies of children undergoing cardiopulmonary resuscitation, preferably with ophthalmological exam pre- and post-cardiopulmonary resuscitation, are warranted.

2.3 Limitations of review findings

- The most significant limitation is that the cases reported are all isolated case reports and thus the true prevalence of retinal haemorrhages in these conditions cannot be determined.
• Given that retinal haemorrhages were likely to be a rare association with, cough and cardiopulmonary resuscitation, larger scale studies would have been preferable to explore these associations

**Findings of clinical question 3**

**Retinal haemorrhages in newborn infants**

Given the significance of retinal haemorrhages when they are identified in young infants, an important differential diagnosis are retinal findings as a consequence of birth. Thus this review aimed to answer the following questions:

1. What are the retinal findings in newborn infants?
2. What are the obstetric correlates to retinal haemorrhages in the newborn?
3. What is the evolution of newborn retinal haemorrhages?

We undertook a separate newborn-specific literature search of international literature (search terms used); of these, 15 articles addressed this issue\(^{102-116}\)

**Influence of ethnicity and socio-economic group**

Not addressed by the included studies

**Retinal haemorrhages recorded following different modes of delivery**

• Retinal haemorrhages were recorded in 26% (range 21.4% – 40%) of infants following spontaneous vaginal delivery\(^{102-105,107-109,116}\)

• Retinal haemorrhages were more common in instrumental deliveries\(^{102-104,107-111,114-116}\)

• The strongest association was found with vacuum delivery\(^{103,104,107,109,110,114-116}\) or a failed vacuum delivery followed by a forceps delivery (aka double instrumental delivery)\(^{103,104,109,116}\)

• Infants delivered by caesarean section were less likely to develop retinal haemorrhages than those delivered by spontaneous vaginal delivery\(^{102-105,107-109,111-113,116}\), apart from those undergoing an emergency second-stage caesarean section after failed instrumental delivery\(^{103,104,115}\)

• Only four infants underwent elective caesarean section\(^{109}\) (no retinal haemorrhages recorded)

• Eight Hispanic infants born via Caesarean delivery (no detail re: elective or otherwise) were examined and none had retinal haemorrhages\(^{106}\). Two of eight had sub-retinal fluid identified by optical coherence tomography

**Other obstetric correlates**

Data relating to the duration of the second stage of labour, or the expulsive phase, were conflicting as to its association with retinal haemorrhages\(^{107,108,112}\)
Retinal features
- There was a lack of standardisation in the recording of retinal features among included studies

Severity
- Where severity of retinal haemorrhages was noted the findings varied, with mild, moderate and severe retinal haemorrhages being recorded 103,105,107,109-116

Size of retinal haemorrhages
- Size of retinal haemorrhages was recorded in seven studies and the majority were found to be small105,109,111-115

Layer
- Six studies recorded the layer in which haemorrhages occurred102,105,107,109,111,116 which were intraretinal for all cases apart from a single subretinal haemorrhage107

Laterality
- Five studies reported the laterality of the haemorrhages102,107-109,111, which were more commonly bilateral but with 22-48% occurring unilaterally

Location
- Haemorrhages were predominantly found in the posterior pole104,105,107-111,116 with two studies recording haemorrhages to the periphery107,111

Outcome
- Three studies conducted follow-up examinations and noted that the majority resolved within two weeks, with 97% resolved by 42 days107,109,111. In two subjects haemorrhages were still present at 31 and 58 days, respectively109

Additional findings
- One study examined the role of handheld spectral-domain optical coherence tomography (SD-OCT). They noted the presence of bilateral subfoveal fluid in six infants. Follow up SD-OCT at one month of age showed resolution in 2/3 infants, and resolution in the remaining case by two months105
- A further study of 20 Hispanic infants utilising OCT noted 10% had sub-retinal fluid and 10% had cystoid macular oedema106

3.1 Research implications
- The included studies are of a high quality and address this subject comprehensively. However, further studies documenting the rate of resolution of haemorrhages would be of benefit
• While there is a clear association between a vacuum or double instrumental delivery and retinal haemorrhages, it is impossible to discern how much of this relationship relies on the pressures applied to the infant skull, and how much is a consequence of the obstructed labour requiring instrumental intervention.

• While subdural haemorrhages have been recorded as a consequence of delivery, it is unfortunate that no study has been conducted examining the coexistence of subdural haemorrhages and retinal haemorrhages in the newborn.

• There is a need for an internationally agreed recording of retinal haemorrhages in children.

3.2 Implications for practice

• When examining an infant less than 42 days of age with suspected abuse in whom retinal haemorrhages are found, consideration should be given to whether these are a consequence of delivery.

• The vast majority of retinal haemorrhages occurring as a consequence of birth are resolved by two weeks of age.

• The mode of delivery most commonly associated with retinal haemorrhages is a vacuum delivery, either on its own or following failed forceps.

• Infants delivered by caesarean section rarely develop retinal haemorrhages.

3.3 Limitations of review findings

• Few authors recorded the layer, extent and severity of retinal haemorrhages in sufficient detail to determine if the pattern recorded in abusive head trauma is ever found in the newborn.

Findings of clinical question 4
Can you date retinal findings in children

To date, there have been no studies that specifically set out to address this question (only including children < 11 years).
Findings of clinical question 5
Which features or characteristics of eye injury are present in child maltreatment, neglect and fabricated or induced illness?

• As part of our retinal findings review, we sought to answer the question: which features or characteristics of eye injury are present in child maltreatment, neglect and fabricated or induced illness?
• This review aimed to identify direct trauma to the eye as a consequence of abuse, whereby studies ranked 1-2 for confirmation of abuse were included and a higher rank of eye examination(1-2) were also included
• Of 48 studies reviewed from the international literature, four articles addressed this issue
• These four articles all met our inclusion criteria, quality standards for ophthalmological examination and ranking of abuse requirements

Globe rupture
• Two infants aged 9 and 14 months are reported with unilateral traumatic globe rupture. Each infant had coexistent injuries including bruising and/or fractures
• Each had subconjunctival haemorrhages in association with the globe rupture, 100% hyphema and chemosis
• One of the two infants had presented one week earlier, with her eye examined, and discharged without a child abuse evaluation

Subconjunctival haemorrhages
• Two studies reported sixteen children presenting with subconjunctival haemorrhages. All of these were aged 1-68 months
• Twelve of the sixteen presented due to the subconjunctival haemorrhages, eight of the sixteen were bilateral
• Co-existent injuries were identified in fourteen out of sixteen children. These injuries included fractures, burns, bruises, abusive head trauma
• Its notable that in two of three cases of infants less than 5 months of age who presented with subconjunctival haemorrhages, abuse was not recognised during these assessments and the infants re-presented some weeks later

Traumatic hyphema
• A series of seven children aged 4-14 years presented with hyphema ranging from 5-14% as a consequence of being struck in the eye with a belt.\textsuperscript{117}
• Coexistent facial and trunk bruising was also reported in one case, but no details given relating to further assessment for fractures or other injuries

4.1 Implications for practice
• This small series of cases highlights the significance of subconjunctival haemorrhages in infants as a potential presenting sign for physical abuse
• Ophthalmologists examining children with trauma to the eye should consider physical abuse within the differential, even in older children where hyphema was reported as a consequence of being struck by a belt

4.2 Research implications
• There is clearly a need for comparative studies describing features of eye injuries as a consequence of physical abuse in comparison to those resulting from accidental injury
• A prospective study of infants presenting with subconjunctival haemorrhages to determine the likelihood of coexisting injuries would be of value
• When eye injuries as a consequence of abuse are being reported, full details of coexistent investigations and injuries will make an important contribution

4.3 Limitations of review findings
• This review was limited by small case series/studies
• No comparative literature is available at present
• Authors did not consistently report what investigations were undertaken to identify other injuries
• A number of larger studies were excluded due to a lack of clear confirmation of abuse among the children reported
• When eye injuries as a consequence of abuse are being reported, full details of coexistent investigations and injuries will make an important contribution

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

Clinical question 1

Retinal Imaging
• The use of RetCam imaging to record retinal findings facilitates accurate quantification of the retinal features present and the opportunity for further opinions\textsuperscript{60,121,122}.

• There is a recorded instance of RetCam potentially contributing to retinal haemorrhage in the newborn\textsuperscript{123}; however, in a recent prospective study of 50 eyes in 25 children 60 minutes after a retcam examination for retinopathy of prematurity, none had developed retinal haemorrhage\textsuperscript{124}.

• MRI scan of the brain may include images of the eye. If this involves GRET2 sequences\textsuperscript{125}, or the use of susceptibility weighted imaging\textsuperscript{126} it may reveal retinal haemorrhages.

• Hand-held spectral domain optical coherence tomography, with\textsuperscript{127} or without\textsuperscript{128} electroretinography may be of value in defining retinal features.

Subconjunctival haemorrhages

• These are thought to occur in infants with prolonged coughing or haematological disorders. Two studies report their presence in child abuse\textsuperscript{118,120}. There have been no large-scale studies of this association.

Examination and recording of retinal findings

• Recent studies have evaluated tools to improve the standardised recording of retinal findings in suspected abusive head trauma\textsuperscript{129-133}.

• In a study of 72 children undergoing examination by ophthalmologists and non-ophthalmologists, non-ophthalmologists were correct in their findings in 44\% of cases; they had no false-positives but retinal haemorrhages were present in the 13\% of cases they missed\textsuperscript{134}. This highlights the importance of an appropriate examination technique.

Indications for ophthalmological examination in suspected abuse

• An assessment of the value of retinal examination in children with suspected abuse but no intracranial injury\textsuperscript{135}. 

Updated UK national guidance

- This relates to the ophthalmological examination and assessment of children with suspected physical abuse, including a standardised examination pro forma based on our validated reporting tool\textsuperscript{136,137}

Pathophysiology of Retinal Haemorrhages

- A finite element infant eye model indicates that shaking could generate sufficient force to cause retinal haemorrhage\textsuperscript{137}

Clinical question 2

- Retinal haemorrhages have been described in adults in association with extreme hypoxia\textsuperscript{138,139}
- Retinal haemorrhages have been described in children with profound anaemia\textsuperscript{140}
- A fatal case of a child aged almost two years with a subarachnoid haemorrhage secondary to vertebral artery dissection and co-existent retinal haemorrhages is described. The mechanism was attributed to a fall, witnessed by the father\textsuperscript{141}
- There is now updated UK national guidance relating to the ophthalmological examination and assessment of children with suspected physical abuse, including a standardised examination pro forma based on our validated reporting tool\textsuperscript{136,137}
- A further study exploring the relationship between CPR and retinal haemorrhages unfortunately could not be included as pre-CPR examinations were not conducted in the majority, and there was no mention of exclusion of AHT in the case with retinal haemorrhage\textsuperscript{142}

Clinical question 4

- A Cochrane review has been published which addresses the neonatal outcomes of instrumental delivery\textsuperscript{143}
- A retrospective study examining the prevalence of intracranial haemorrhage in newborn infants. No child underwent ophthalmological examination\textsuperscript{144}
- A further study which did not meet the quality standards for inclusion due to a lack of detail identified that of 123 infants, 1 infant had a retinal haemorrhage persisting to two months\textsuperscript{145}

Clinical question 5

- Recurrent conjunctivitis in a 5 month old infant with multiple hospital attendances was ultimately found to be caused by FII\textsuperscript{146}
Related publications

Publications arising from retinal findings review


References


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[https://www.ncbi.nlm.nih.gov/pmc/articles/PMC381329/pdf/bmj32800754.pdf](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC381329/pdf/bmj32800754.pdf)

[https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1771945/pdf/bio08800155.pdf](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1771945/pdf/bio08800155.pdf)


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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.

Standardised data extraction and critical appraisal forms were based on criteria defined by the National Health Service’s Centre for Reviews and Dissemination 147. We also used a selection of systematic review advisory articles to develop our critical appraisal forms 148-152. 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, ophthalmologists, pathologists, neonatologists and designated and named doctors in child protection. All reviewers underwent standardised critical appraisal training, based on the CRD critical appraisal standards 3, and this was supported by a dedicated electronic critical appraisal module.

Inclusion criteria

Clinical question 1: ‘what differences are found between abusive head trauma retina findings versus non-abusive head trauma retinal findings?’

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studies of children aged 0 to &lt;11 years</td>
<td>Consensus statements or personal practice studies</td>
</tr>
<tr>
<td>Abusive head trauma (AHT) – ranking of abuse of 1-2</td>
<td>AHT – ranking of abuse within study of 3-5 or mixed ranking where cases ranked 1-2 could not be extracted</td>
</tr>
<tr>
<td>Non-abusive head trauma – non-abusive aetiology confirmed (abuse excluded / accident confirmed)</td>
<td>Study exclusively addresses retinal findings in association with:</td>
</tr>
<tr>
<td></td>
<td>• prior ophthalmic surgery</td>
</tr>
<tr>
<td></td>
<td>• solid mass lesions of the eye (e.g. retinoblastoma) or brain</td>
</tr>
<tr>
<td></td>
<td>• post mortem examination alone (i.e. where eyes not examined in life)</td>
</tr>
<tr>
<td></td>
<td>• medical causes of retinal haemorrhage (RH)</td>
</tr>
<tr>
<td></td>
<td>• RH found in the immediate postnatal period</td>
</tr>
</tbody>
</table>
- blunt trauma to the eye

Ophthalmic examination performed by an ophthalmologist

Ophthalmic examination performed by non-ophthalmologist

Comparative studies

Non-comparative studies

Ophthalmic findings described with reference to severity, location and laterality

Clinical question 2: ‘What are the differential diagnoses of retinal haemorrhages in children with clinical features associated with child abuse?’

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;15 years old examined while alive</td>
<td>Adult data or mixed child and adult data where child data could not be extrapolated</td>
</tr>
<tr>
<td>Medical diagnosis confirmed</td>
<td>Organic disease stated but not explicitly confirmed by clinical test or by characteristic clinical profile</td>
</tr>
<tr>
<td>Ophthalmic examination performed by an ophthalmologist</td>
<td>Major trauma</td>
</tr>
<tr>
<td>Details of retinal haemorrhages (RH) found, to include at least one of: layer, location or severity recorded</td>
<td>Solid mass lesion of the eye, retinopathy of prematurity or diabetes mellitus, newborn RH</td>
</tr>
<tr>
<td>RH as the primary ophthalmological finding</td>
<td>Ophthalmic surgery prior to RH detection</td>
</tr>
<tr>
<td>Children with proposed confounding condition (seizures, acute life threatening event, cough, cardiopulmonary resuscitation, hypoxia, osteogenesis imperfecta, immunisations, Vitamin D deficiency) examined for presence of RH</td>
<td>Known coagulopathy or severe anaemia diagnosed prior to presentation with RH</td>
</tr>
</tbody>
</table>

  - Post-mortem studies
  - Vitreous haemorrhage precluding visualisation of the retina
  - RH as a consequence of birth

Criteria used to address ‘retinal haemorrhages in newborn infants:

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ophthalmic examination performed by an ophthalmologist within 120 hours (5 days) of birth, and prior to discharge from obstetric unit</td>
<td>Infants not examined prior to discharge from hospital</td>
</tr>
<tr>
<td>Ophthalmic examination with the pupils dilated using the indirect ophthalmoscope</td>
<td>Cases with confirmed or suspected child abuse</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Ophthalmic examination conducted using a ‘RetCam’ where the images were reviewed by an ophthalmologist</td>
<td>Preterm infants born prior to 32 weeks gestation</td>
</tr>
<tr>
<td>Studies conducted within Organisation for Economic Co-operation and Development (OECD) countries to attain greatest consistency in obstetric practices</td>
<td>Birth weight of less than 1500g of any gestation</td>
</tr>
<tr>
<td></td>
<td>Infants who have undergone ophthalmic surgery</td>
</tr>
<tr>
<td></td>
<td>Post-mortem studies</td>
</tr>
<tr>
<td></td>
<td>Infants with congenital eye conditions and/or established organic eye disease including Retinopathy of Prematurity (ROP)</td>
</tr>
<tr>
<td></td>
<td>Studies in which the presence of vitreous hemorrhages obscures the fundal view</td>
</tr>
<tr>
<td></td>
<td>Studies in which the ophthalmologic examination has been carried out by anyone other than an ophthalmologist, regardless of their training</td>
</tr>
<tr>
<td></td>
<td>Infants who have sustained blunt trauma to the eye(s)</td>
</tr>
<tr>
<td></td>
<td>Animal studies</td>
</tr>
</tbody>
</table>

### Ranking of abuse

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Criteria used to define abuse</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>Abuse confirmed at case conference or civil or criminal court proceedings or admitted by perpetrator or independently witnessed</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Abuse confirmed by stated criteria including multidisciplinary assessment (social services / law enforcement / medical)</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Abuse defined by stated criteria</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Abuse stated but no supporting detail given</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Suspected abuse</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Confirmation of active exclusion of abuse from non-abused group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>By multi-disciplinary assessment and child protection clinical investigation or forensic recreation of the scene</td>
</tr>
<tr>
<td><strong>B1</strong></td>
<td>By checking either the child abuse register or records of previous abuse</td>
</tr>
</tbody>
</table>
By confirmation of organic disease or witnessed accidental causes

Stated but no detail given

No attempt made

### Ranking: Confirmation of accidental/unintentional traumatic causes of retinal findings

<table>
<thead>
<tr>
<th>Rank</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Witnessed trauma</td>
</tr>
<tr>
<td>B</td>
<td>Consistent account of accident by either two (or more) individuals or the same individual over time</td>
</tr>
<tr>
<td>C</td>
<td>Accidental cause stated</td>
</tr>
<tr>
<td>D</td>
<td>No detail given</td>
</tr>
</tbody>
</table>

### Ranking: Confirmation of medical causes of retinal findings

<table>
<thead>
<tr>
<th>Rank</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Diagnostic test confirmed organic cause</td>
</tr>
<tr>
<td>B</td>
<td>Diagnosis confirmed from clinical profile</td>
</tr>
<tr>
<td>C</td>
<td>Stated diagnosis but no detail given</td>
</tr>
<tr>
<td>D</td>
<td>No detail of aetiology</td>
</tr>
</tbody>
</table>

### Quality standards for ophthalmological examination

Ranking used for clinical questions 1 and 2:

- The optimal standard was studies in which all children had been examined by an ophthalmologist, using indirect ophthalmoscopy and pupillary dilatation (+/- additional retinal imaging) with detailed recording of the retinal findings relating to retinal haemorrhage (laterality, layers of retina involved, number and extent – from optic disc to peripheral retina – of haemorrhages) and additional features (e.g. retinoschisis)
- However, this detailed description was not always available and the minimum accepted standard was examination undertaken by an ophthalmologist since it is well recognised that non-ophthalmologists may miss retinal haemorrhages and additional findings are unlikely to have been documented in detail

Ranking used for clinical question 3:
1. Examined by ophthalmologist, dilated pupil examination AND indirect ophthalmoscopy clearly documented

2. Examined by ophthalmologist, with use of ‘RetCam’ (making the assumption that the baby’s pupils were dilated)

3. Examined by ophthalmologist, EITHER dilated pupil examination documented without mention of examination method, OR indirect ophthalmoscopy documented without mention of pupil status

4. Examined by ophthalmologist, no details regarding pupil dilatation or use of indirect ophthalmoscopy, and only if detailed documentation of retinal hemorrhages is included

5. Mixed Ranking

**Ranking of evidence by study type**

| T1 | Randomised control trial (RCT) |
| T2 | Controlled trial (CT) |
| T3 | Controlled before-and-after intervention study (CBA) |
| O1 | Cohort study / longitudinal study |
| O2 | Case-control study |
| O3 | Cross-sectional |
| O4 | Study using qualitative methods only |
| O5 | Case series |
| O6 | Case study |
| X  | Formal consensus or other professional (expert) opinion (automatic exclusion) |

**Search strategy**

The below tables presents the search terms used in the 2015 Medline database search for retinal findings. Truncation and wildcard characters were adapted to the different databases where necessary.

**What differences are found between abusive head trauma retinal findings versus non-abusive head trauma retinal findings?**

<p>| 1. Infant/ or Infant, Newborn/ | 40. ha?morrhagic retinoschisis.mp. |</p>
<table>
<thead>
<tr>
<th>2. (child$ or toddler$ or neonate$ or baby or infant$).mp.</th>
<th>41. (Intraocular ha$morrhage$ or Intraretinal ha$morrhage$).mp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. babies.mp.</td>
<td>43. (Multiple small punctate haemorrhage$ or Multiple small punctate hemorrhage$).mp.</td>
</tr>
<tr>
<td>5. child/</td>
<td>44. multilayer retinal h$emorrhage$.mp.</td>
</tr>
<tr>
<td>6. or/1-5</td>
<td>45. pale-centered hemorrhage$.mp.</td>
</tr>
<tr>
<td>7. ((non-abusive or nonabusive) adj3 (injur: or trauma)).mp.</td>
<td>46. Pale-centered retinal hemorrhage$.mp.</td>
</tr>
<tr>
<td>8. ((non-accidental or nonaccidental) adj3 (trauma or injur$)).mp.</td>
<td>47. (Preretinal haemorrhage$ or Preretinal hemorrhage$).mp.</td>
</tr>
<tr>
<td>10. physical abuse.mp.</td>
<td>49. (foveal haemorrhage$ or foveal hemorrhage$).mp.</td>
</tr>
<tr>
<td>11. abusive head trauma.mp.</td>
<td>50. *Retina/</td>
</tr>
<tr>
<td>13. (or/7-13) and 6</td>
<td>52. (Retinal detachment adj5 (haemorrhag$ or hemorrhag$)).mp.</td>
</tr>
<tr>
<td>14. (child abuse or child maltreatment or child protection).mp.</td>
<td>53. Retinal exudates.mp.</td>
</tr>
<tr>
<td>15. (battered child$ or shaken baby or battered baby).mp.</td>
<td>54. Retinal fold$.mp.</td>
</tr>
<tr>
<td>16. (battered infant$ or shaken infant$).mp.</td>
<td>55. Retinal hemorrhage/</td>
</tr>
<tr>
<td>17. (Shak$ Baby Syndrome or shak$ impact syndrome).mp.</td>
<td>56. (retinal haemorrhage$ or retinal hemorrhage$).mp.</td>
</tr>
<tr>
<td>18. (intracranial injur* adj3 abuse).tw.</td>
<td>57. retinal injur$.mp.</td>
</tr>
<tr>
<td>19. non-accidental head injur*.tw.</td>
<td>58. ruptured retinal capillary$.mp.</td>
</tr>
<tr>
<td>20. non?accidental head injur*.tw.</td>
<td>59. (Splinter haemorrhage$ or Splinter hemorrhage$).mp.</td>
</tr>
<tr>
<td>21. NAHI.tw.</td>
<td>60. (Subhyaloid haemorrhage$ or Subhyaloid hemorrhage$).mp.</td>
</tr>
<tr>
<td>22. exp Child Abuse/</td>
<td>61. (Subhyaloid macular hemorrhage$ or Subhyaloid macular haemorrhage$).mp.</td>
</tr>
<tr>
<td>23. or/14-22</td>
<td>62. (Subretinal hemorrhage$ or Subretinal haemorrhage$).mp.</td>
</tr>
<tr>
<td>24. 13 or 23</td>
<td>63. (Unilateral retinal haemorrhage$ or Unilateral retinal hemorrhage$).mp.</td>
</tr>
<tr>
<td>25. (Bilateral retinal haemorrhag$ or Bilateral retinal hemorrhage$).mp.</td>
<td>64. (Vitreous haemorrhage$ adj5 retina$).mp.</td>
</tr>
<tr>
<td>26. (Blot retinal haemorrhage$ or Blot retinal hemorrhage$).mp.</td>
<td></td>
</tr>
<tr>
<td>27. Disc oedema.mp.</td>
<td></td>
</tr>
<tr>
<td>28. (Dot retinal hemorrhage$ or Dot retinal</td>
<td></td>
</tr>
</tbody>
</table>


What are the differential diagnoses of retinal haemorrhages in children with clinical features associated with child abuse?

1. Infant/ or Infant, Newborn/
2. (child$ or toddler$ or neonate$ or baby or infant$).mp.
3. Child, Preschool/
4. babies.mp.
5. child/
6. or/1-5
7. (Bilateral retinal haemorrhag$ or Bilateral retinal hemorrhage$).mp.
8. (Blot retinal haemorrhag$ or Blot retinal hemorrhage$).mp.
9. Posterior pole.mp.
10. (fundal adj 5 Posterior pole finding).mp.
11. (Haemorrhagic retinopathy or Hemorrhagic retinopathy).mp.
12. ((Haemorrhag$ or Hemorrhag$) adj5 retin$).mp.
13. Retinoschisis/
14. retinoschisis.mp.
15. (Extramacular dot hemorrhag$ or Extramacular dot haemorrhag$).mp.
16. (eye hemorrhag$ or eye haemorrhag$).mp.
17. (Flame shaped hemorrhag$ or Flame shaped haemorrhag$).mp.
18. (Flame hemorrhag$ or Flame haemorrhag$).mp.
19. (eye hemorrhag$ or eye haemorrhag$).mp.
20. (Flame shaped hemorrhag$ or Flame shaped haemorrhag$).mp.
22. (fundal adj 5 Posterior pole finding).mp.
23. (Haemorrhagic retinopathy or Hemorrhagic retinopathy).mp.
24. ((Haemorrhag$ or Hemorrhag$) adj5 retin$).mp.
25. Retinoschisis/
26. retinoschisis.mp.
27. (Extramacular dot hemorrhag$ or Extramacular dot haemorrhag$).mp.
28. (eye hemorrhag$ or eye haemorrhag$).mp.
29. (Flame shaped hemorrhag$ or Flame shaped haemorrhag$).mp.
30. (Flame hemorrhag$ or Flame haemorrhag$).mp.
31. Posterior pole.mp.
32. (fundal adj 5 Posterior pole finding).mp.
33. (Haemorrhagic retinopathy or Hemorrhagic retinopathy).mp.
34. ((Haemorrhag$ or Hemorrhag$) adj5 retin$).mp.
35. Retinoschisis/
36. retinoschisis.mp.
37. Haemorrhagic retinopathy.mp.
38. Retinoschisis/
39. retinoschisis.mp.
40. (Extramacular dot hemorrhag$ or Extramacular dot haemorrhag$).mp.
41. (eye hemorrhag$ or eye haemorrhag$).mp.
42. (Flame shaped hemorrhag$ or Flame shaped haemorrhag$).mp.
43. (Subretinal hemorrhag$ or Subretinal haemorrhag$).mp.
44. (Unilateral retinal haemorrhag$ or Unilateral retinal hemorrhag$).mp.
45. (Vitreous hemorrhag$ adj5 retina$).mp.
46. (Vitreous hemorrhag$ adj5 retina$).mp.
47. punctate hemorrhag$ or punctate hemorrhage.mp.
48. foveal hemorrhag$ or foveal hemorrhage.mp.
49. retinal capillar$.mp.
50. intraretinal h?emorrhag$.mp.
51. (Preretinal h?emorrhag$ or pre-retinal hemorrhag$).mp.
52. Vitreoretinal traction.mp.
53. or/25-71
54. 72 and 74
55. (rat: or mouse or mice or hamster: or animal: or dog: or cat: or rabbit: or bovine or sheep).mp.
56. (lamb or woodpecker or pig or porcine).mp.
57. Animals/
58. animal stud$.mp.
59. "Review"/
60. or/74-78
61. 73 not 79
62. limit 80 to yr="2013 -Current"
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10.</td>
<td>(Dot retinal hemorrhage$ or Dot retinal haemorrhage$).mp.</td>
</tr>
<tr>
<td>11.</td>
<td>(Extramacular dot hemorrhage$ or Extramacular dot haemorrhage$).mp.</td>
</tr>
<tr>
<td>12.</td>
<td>(Flame shaped hemorrhage$ or Flame shaped haemorrhage$).mp.</td>
</tr>
<tr>
<td>13.</td>
<td>(Flame hemorrhage$ or Flame haemorrhage$).mp.</td>
</tr>
<tr>
<td>14.</td>
<td>Posterior pole.mp.</td>
</tr>
<tr>
<td>15.</td>
<td>(fundal adj 5 Posterior pole finding).mp.</td>
</tr>
<tr>
<td>16.</td>
<td>(Haemorrhagic retinopathy or Hemorrhagic retinopathy).mp.</td>
</tr>
<tr>
<td>17.</td>
<td>((Haemorrhag$ or Hemorrhag$) adj5 retin$).mp.</td>
</tr>
<tr>
<td>19.</td>
<td>(optic nerve haemorrhage* or optic nerve hemorrhage*).mp.</td>
</tr>
<tr>
<td>20.</td>
<td>Retinoschisis/</td>
</tr>
<tr>
<td>21.</td>
<td>retinoschisis.mp.</td>
</tr>
<tr>
<td>22.</td>
<td>haemorrhagic retinoschisis.mp.</td>
</tr>
<tr>
<td>23.</td>
<td>(Intraocular haemorrhage$ or Intraretinal haemorrhage$).mp.</td>
</tr>
<tr>
<td>24.</td>
<td>epiretinal membrane.mp.</td>
</tr>
<tr>
<td>25.</td>
<td>(Multiple small punctate haemorrhage$ or Multiple small punctate hemorrhage$).mp.</td>
</tr>
<tr>
<td>26.</td>
<td>pale-centered hemorrhage$.mp.</td>
</tr>
<tr>
<td>27.</td>
<td>Pale-centered retinal hemorrhage$.mp.</td>
</tr>
<tr>
<td>28.</td>
<td>(Papilledema or papilloedema).mp.</td>
</tr>
<tr>
<td>29.</td>
<td>(Preretinal haemorrhage$ or Preretinal hemorrhage$).mp.</td>
</tr>
<tr>
<td>30.</td>
<td>(Residual foveal haemorrhage$ or Residual foveal hemorrhage$).mp.</td>
</tr>
<tr>
<td>31.</td>
<td>(foveal haemorrhage$ or foveal hemorrhage$).mp.</td>
</tr>
<tr>
<td>32.</td>
<td>*Retina/</td>
</tr>
<tr>
<td>33.</td>
<td>(Retinal detachment adj5 (haemorrhag$ or h?emorrhag$).mp.</td>
</tr>
<tr>
<td>52.</td>
<td>or/7-51</td>
</tr>
<tr>
<td>53.</td>
<td>Purtscher retinopathy.mp.</td>
</tr>
<tr>
<td>54.</td>
<td>Terson Syndrome.mp.</td>
</tr>
<tr>
<td>55.</td>
<td>Immunization/</td>
</tr>
<tr>
<td>56.</td>
<td>Vaccination/</td>
</tr>
<tr>
<td>57.</td>
<td>Vaccines/</td>
</tr>
<tr>
<td>58.</td>
<td>(immunisation or vaccin$).mp.</td>
</tr>
<tr>
<td>59.</td>
<td>exp Cardiopulmonary Resuscitation/</td>
</tr>
<tr>
<td>60.</td>
<td>(cardio-pulmonary resuscitation or cardiopulmonary resuscitation).mp.</td>
</tr>
<tr>
<td>61.</td>
<td>CPR.mp.</td>
</tr>
<tr>
<td>62.</td>
<td>heart massage.mp.</td>
</tr>
<tr>
<td>63.</td>
<td>cardiac massage.mp.</td>
</tr>
<tr>
<td>64.</td>
<td>Resuscit$.mp.</td>
</tr>
<tr>
<td>65.</td>
<td>exp Vitamin D/</td>
</tr>
<tr>
<td>66.</td>
<td>vitamin d.mp.</td>
</tr>
<tr>
<td>67.</td>
<td>Apparent Life-Threatening Events.mp.</td>
</tr>
<tr>
<td>68.</td>
<td>ALTE.mp.</td>
</tr>
<tr>
<td>69.</td>
<td>exp Seizures/</td>
</tr>
<tr>
<td>70.</td>
<td>seizure$.mp.</td>
</tr>
<tr>
<td>71.</td>
<td>exp Cough/</td>
</tr>
<tr>
<td>72.</td>
<td>cough*.mp.</td>
</tr>
<tr>
<td>73.</td>
<td>Hypoxia.mp.</td>
</tr>
<tr>
<td>74.</td>
<td>Apnoea.mp.</td>
</tr>
<tr>
<td>75.</td>
<td>Apnea/</td>
</tr>
<tr>
<td>76.</td>
<td>Anoxia/</td>
</tr>
<tr>
<td>77.</td>
<td>exp Valsalva Maneuver/</td>
</tr>
<tr>
<td>78.</td>
<td>valsalva retinopathy.mp.</td>
</tr>
<tr>
<td>79.</td>
<td>Valsalva Maneuver$.mp.</td>
</tr>
<tr>
<td>80.</td>
<td>or/53-79</td>
</tr>
</tbody>
</table>
hemorrhag$)).mp.
34. Retinal exudates.mp.
35. Retinal fold$.mp.
36. Retinal hemorrhage/
37. (retinal haemorrhage$ or retinal hemorrhage$).mp.
38. retinal injur$.mp.
39. ruptured retinal capillar$.mp.
40. (Splinter haemorrhage$ or Splinter hemorrhage$).mp.
41. (Subhyaloid haemorrhage$ or Subhyaloid hemorrhage$).mp.
42. (Subhyaloid macular hemorrhage$ or Subhyaloid macular haemorrhage$).mp.

Retinal haemorrhages in newborn infants

1. exp Infant, Newborn/
2. exp Infant/
3. (infant* or newborn* or baby or babies or neonate*).mp.
4. or/1-3
5. exp Choroid Hemorrhage/
6. exp Retinal Hemorrhage/
7. exp Vitreous Hemorrhage/
8. exp Retinal Detachment/
9. exp Retina/
10. (h?emorrhage* adj3 retin*).ti,ab.
11. ((retina* or eye) adj3 detachment).mp.
12. multilayer retinal h?emorrhage.mp.
13. Eye Hemorrhage/
39. "assisted vaginal deliver*".mp.
40. "mechanical vaginal deliver*".mp.
41. "spontaneous vertex deliver*".mp.
42. ((induction or extraction or suction or ventouse or prolonged or forcep* or cesarean) adj3 (deliver* or birth)).mp.
43. normal vaginal delivery.mp.
44. ("midcavity forceps" or "obstetric forceps" or "wrigleys forceps" or "outlet forceps").mp.
45. ("low cavity forceps" or "neville barnes forceps" or "kielland forceps" or "ferguson forceps").mp.
46. (prolonged labo?r or second stage of labo?r).mp.
47. ("delayed delivery" or "delayed second stage" or "failed forceps").mp.
48. failed ventouse.mp.
49. "Kiwi Omnicup".mp.
50. "polyethylene vacuum cup".mp.
Which features or characteristics of eye injury are present in child maltreatment, neglect and fabricated or induced illness?

1. Infant/ or Infant, Newborn/

24. Orbit/
Fifteen 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>All EBM Reviews – Cochrane DSR, ACP Journal Club, DARE, and CCTR</td>
<td>1996 – 2010*</td>
</tr>
<tr>
<td>ASSIA (Applied Social Sciences Index and Abstracts)</td>
<td>1987 – 2012†</td>
</tr>
<tr>
<td>Child Data</td>
<td>1958 – 2009*</td>
</tr>
</tbody>
</table>
## Child Protection Evidence – Systematic review on Retinal Findings

<table>
<thead>
<tr>
<th>Database / Source</th>
<th>Time period searched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochrane Central Register of Controlled Trials (CENTRAL)</td>
<td>2010 – 2014</td>
</tr>
<tr>
<td><strong>CINAHL</strong> <em>(Cumulative Index to Nursing and Allied Health Literature)</em></td>
<td>1982 – 2014</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 Grey</td>
<td>2010 – 2012</td>
</tr>
<tr>
<td>Open SIGLE <em>(System for Information on Grey Literature in Europe)</em></td>
<td>1980 – 2005*</td>
</tr>
<tr>
<td>Pubmed <em>(Epub ahead of print)</em></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>
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</table>

* ceased indexing  
† institutional access terminated  
‡ no yield so ceased searching

### Journals ‘hand searched’

<table>
<thead>
<tr>
<th>Journal</th>
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<tbody>
<tr>
<td>Child Abuse and Neglect</td>
<td>1977 – 2014</td>
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</table>

### Websites searched

<table>
<thead>
<tr>
<th>Website</th>
<th>Date accessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>The National Center on Shaken Baby Syndrome <em>(NCSBS)</em></td>
<td>9 January 2015</td>
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## Retinal haemorrhages in newborn infants

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<td>1970 – 2014</td>
</tr>
<tr>
<td>Cochrane Library</td>
<td>1970 – 2014</td>
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<tr>
<td>EMBASE</td>
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<td>Scopus</td>
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<tr>
<td>Web of Knowledge – Conference Proceedings Citation Index- Social Science &amp; Humanities</td>
<td>1970 – 2014</td>
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<tr>
<td>Journal of the American Association for Pediatric Ophthalmology and Strabismus</td>
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### Which features or characteristics of eye injury are present in child maltreatment, neglect and fabricated or induced illness?

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</tr>
<tr>
<td>MEDLINE</td>
<td>1946 – 2015</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).