Abusive head trauma and the eye in infancy

A child suspected of having an abusive head trauma (AHT) is referred by paediatricians to an ophthalmologist for evaluation. The incidence of abusive head injury in children is highest in infancy and less frequently seen in children over 3 years of age. Retinal haemorrhages (RHs) have a high positive predictive rate for abusive head injury. In the presence of head injury without any plausible medical explanation the description of the retinal findings help in distinguishing between abusive injury and other causes. It is incumbent on the ophthalmologist to be familiar with the clinical presentation, the differential diagnosis, and controversies associated with attributing the presence or absence of retinal findings to abusive head injury in children.

The guidance was developed by a guideline working party (GWP) from the Royal College of Ophthalmologists (RCO) and the Royal College of Paediatrics and Child Health (RCPCH). It brings together previous publications of the RCO^{1–3} and an update of the literature since these publications.

The publication is a summary of the updates of the full version of the document, with its appendices available on the websites of the RCO (www.rcophth.ac.uk) and the RCPCH (www.rcpch.ac.uk).

Methods

A total of 5823 abstracts were scanned for relevancy covering the period between 2000 to 2011. A total of 657 abstracts were reviewed and a total of 294 full papers are referenced in the document.

Results

The guidance is presented under a number of clinically relevant questions developed by the GWP. It is divided into four main chapters:

- Aetiological factors and experimental models
- Clinical features and pathology
- Differential diagnosis and confounding conditions
- Guidance for the ophthalmologist

The guidance includes a standardised proforma for documenting retinal findings.

Aetiological factors and experimental models

(1) What forces are needed to produce retinal haemorrhages and other signs of intraocular trauma in infants without direct ocular injury?

The forces involved in producing retinal haemorrhages in abusive head trauma are not known. Information on the forces involved is extrapolated from observational and experimental studies using computational and animal models

(2) Is additional impact necessary for the production of very severe ocular injury?

Retinal haemorrhages may be seen without any associated evidence of direct impact to the head.

(3) Can normal handling (such as vigorous play) cause retinal and intracranial haemorrhages?

On the basis of a few case series and case studies, there is anecdotal evidence that retinal haemorrhages can occur in healthy children less than two years old during handling accidents and accidents during play. It is to be noted, however, that in all these studies where retinal haemorrhages have been reported in association with the accidental injury significant head injury coexists. These retinal haemorrhages are likely to be few, small and unilateral. More severe haemorrhages in these circumstances should initiate concerns of there being an underlying medical condition or the possibility of prior non-accidental injury even in fully independently witnessed accidents.

(4) What are the postulated mechanisms of retinal haemorrhages in abusive and non-abusive head trauma?

The possible mechanisms for retinal haemorrhages (RHs) in abusive head trauma include: external forces on blood vessel walls (shaking or impact); internal forces of raised intravascular pressure (pulsed or maintained); biomechanical properties of blood vessel walls, though this is not known, and abnormalities of the blood (in various pathologies).

Evidence is indirect, and the mechanisms may well be mixed in most cases. There are some pointers towards the likely predominant mechanism in certain circumstances: external forces, and confessed shaking injury, with/without impact very often associated with numerous, bilateral RHs. Shaking may indicate potential vitreous traction with external forces and additional internal forces. In accidental impact trauma RHs are only associated with severe, high-velocity injuries.

Head crush injury (abrupt severe elevation intravascular pressure) can produce severe RHs; however, the severity of RHs does not correlate with periods of raised intracranial or intrathoracic pressure.

(5) Does hypoxia give rise to the clinical picture of Shaken baby syndrome?

Hypoxia resulting from apnoea or associated with choking or respiratory arrest during vomiting has not been shown to cause the clinical picture of AHT. Retinal hypoperfusion/ischemia as a result of non-accidental injury may lead to the development of preretinal fibrovascular proliferation and tractional retinal detachment.

(6) What are the current computer and biomechanical models of AHT?

A perfect biofidelic model of an infant does not exist and hence the forces required to produce ocular injury that are calculated on current models will be imprecise. Data from recent computational models using finite element analysis suggest that shear forces are exerted maximally at the posterior retina. The precise force required to produce the ocular features of abusive head trauma is not known.

(7) Are there any suitable animal models of AHT?

There is no satisfactory primate or non-primate models reported that replicate retinal injury seen in children with abusive head trauma.

Clinical features and pathology

(8) Are retinal haemorrhages in child abuse more common in infants than in older children?

Retinal injury in AHT is commonly reported in children under three years of age. The highest prevalence is seen in infancy, though case studies of older children have been reported.

(9) What is the usual site and extent of retinal haemorrhages in child abuse?

RHs may be unilateral and asymmetrical, but they are often reported as severe, multi-layered and bilateral.

(10) Are any ocular fundus findings pathognomonic of child abuse?

There are no fundus findings pathognomonic of child abuse though multi-layered retinal haemorrhages that are bilateral involving the posterior pole and periphery may be highly suggestive of it.

(11) Are unilateral retinal haemorrhages compatible with child abuse?

While retinal haemorrhages are more commonly bilateral in cases of abusive head trauma, cases with unilateral haemorrhages do occur. They also occur in accidental head trauma and in other pathologies. When they occur in association with unilateral intracranial haemorrhage, they are often but not exclusively ipsilateral.

(12) Can intraocular haemorrhage increase after injury? Progressive increasing severity of RH in AHT has not been reported.

(13) Is it possible to determine from an examination of the retina the time at which an injury occurred or whether there have been haemorrhages at more than one time?

Direct evidence from cases of AHT and indirect evidence from birth studies; give similar timings for clearance of confluent intraretinal bleeding noted clinically. The majority of birth-related retinal haemorrhages clear within two weeks, though some intraretinal haemorrhages may persist up to 58 days. Histopathologically the presence of haemosiderin in the retina may represent a haemorrhage, which has occurred between 2 days and 16.8 months prior to examination.

(14) Are there any retinal findings without intracranial findings or encephalopathy?

RHs are relatively rare in the absence of encephalopathy or intracranial bleeding in AHT. CT imaging is relatively insensitive in picking up small subdural haemorrhages and very thin film subdural bleeding. MRI is thus used as a definitive method in CT scan to increase the diagnostic yield. However, it appears that in some severely injured children, early CT and MR imaging may indicate an absence of intracranial haemorrhage but reveal extensive cerebral oedema. Marked cerebral oedema may prevent intracranial blood accumulation and may in fact be a marker of more severe head injury.

(15) Are retinal haemorrhages secondary to intracranial bleeding?

Current evidence demonstrates that intraocular bleeding secondary to intracranial haemorrhage from intracranial pathology or accidental trauma is rare in young children. Retinal findings, however, may closely resemble those seen in AHT. Cases where intraocular and intracranial haemorrhage are seen together include those with clear evidence of a ruptured aneurysm, severe accidental head injury, epidural haemorrhage and neurosurgical intervention. The severity of the ocular findings being directly related to the severity of the intracranial event with an acute, sharp rise in intracranial

cranial pressure playing a role in the mechanism of retinal haemorrhages.

(16) Is intracranial damage always accompanied by retinal haemorrhages in AHT?

There is clear evidence that retinal haemorrhage is found in approximately two-thirds of intracranial injury caused by abusive head trauma.

(17) What is the optic nerve and orbital pathology seen in AHT?

Optic nerve sheath haemorrhages are common in AHT, however they may also be seen in cases of accidental head injury. The only study which specifically examined orbital tissues in detail found that bleeding into orbital fat and especially the extraocular muscles and posterior orbit may be of significance in distinguishing AHT from accidental injury, but more work is required to confirm this. Scleral haemorrhage at the junction between the optic nerve and sclera is common in AHT, and is seen in association with ONSH and RH, but the number of studies documenting this finding is small.

Differential diagnosis and confounding conditions

(18) Can accidental injury cause retinal haemorrhages?

RHs are rare in accidental injury. Though the majority of reports suggest that these RHs are mainly mild in severity and predominantly unilateral, few in number either pre or intra retinal and located to the posterior pole, a pattern of bilateral extensive multi-layered RHs extending from the posterior pole to the periphery, associated with retinoschisis and retinal folds have been the subject of a few recent case reports and autopsy series with predominantly severe crush head injury.

(19) What other conditions of childhood may have retinal haemorrhages?

Leukaemia, haemorrhagic disease of the newborn, sickle Cell retinopathy, ECMO treatment, retinopathy of prematurity, galactosemia, Henoch-Schonlein purpura, thrombocytopaenic purpura, maternal ingestion of cocaine, meningitis, intracranial vascular malformation, optic disc drusen, tuberous sclerosis, X linked retinoschisis, severe papilloedema, intraocular surgery, severe hypertension, homocystinuria, glutaric aciduria, osteogenesis imperfecta, osteoporosis pseudoglioma syndrome, incontinentia pigmenti, central retinal vein occlusion, prematurity, Infections and septicaemia, cerebral malaria, fibromuscular dysplasia, prematurity, Terson's syndrome, asphyxia.

(20) For how long can birth related retinal haemorrhages persist?

RHs are common in newborn babies; they are more prevalent in assisted births and least common after elective caesarean sections. They may range from few to widespread bilateral RHs. They largely resolve within two weeks though dense foveal intraretinal RH may persist for months.

(21) Can bleeding diathesis or blood dyscrasia cause retinal haemorrhages similar to those seen in child abuse?

Bleeding diathesis should be excluded in all suspected cases of AHT with RHs.

(22) Can seizures alone cause retinal haemorrhages as seen in cases of child abuse?

Retinal haemorrhages are rarely caused by seizures alone. If RHs are found in a child with convulsions, this finding should prompt a search for another cause.

(23) Can cardio-pulmonary resuscitation (CPR) cause retinal haemorrhages?

CPR is very unlikely to cause retinal haemorrhages, even if carried out by unskilled individuals. A caveat could be added to exclude very premature children on the basis of the case report.

(24) Can prolonged vomiting, gagging cause retinal haemorrhages?

RHs appear to be very rare (if they occur at all) as a result of Valsalva manoeuvre in young children.

(25) Is an apparent life threatening event associated with retinal haemorrhages?

ALTE has not been reported to be associated with RHs.

(26) Are vaccinations associated with retinal haemorrhages?

The association of RH and vaccinations has not been reported in children.

(27) Do high cervical injuries from any other source give rise to retinal haemorrhages?

Studies describe a mechanism of injury, which may involve the cervical cord but do not prove that high cervical injury alone can give rise to retinal bleeding.

(28) Can short distance falls cause retinal haemorrhage?

Short distance falls are unlikely to cause retina haemorrhages if the injury is not severe. In rare cases accidental falls, especially those associated with SDH may be associated with RHs, but these tend to be unilateral, localised and superficial.

(29) Do retinal haemorrhages similar to AHT occur with raised intracranial pressure?

Experimental and clinical data demonstrate that an acute dramatic rise in intracranial pressure (ICP) may produce unilateral or bilateral retinal haemorrhages in infants that resemble those reportedly caused by abusive head trauma.

(30) What are the ocular findings in crush injury?

Few to widespread RHs have been reported in crush injuries to the infant head.

Guidance for the ophthalmologist

(1) Which methods are useful in imaging the retina in AHT?

Imaging of the retina in abusive head trauma supports detailed documentation of retinal findings and provides a permanent record of retinal findings. Use of the OCT helps in elucidating the vitreoretinal relationships in AHT.

(2) Procedures for the ophthalmologist and documentation.

When child maltreatment is suspected the ophthalmologist is advised what procedures need to be in place to safeguard the victim. The presenting features of a child suspected of abusive injury

and neglect are listed. The procedures for the ophthalmologist when dealing with child maltreatment are presented with guidance on seeking the advice from child protection teams and social care services, in addition to advice on the ocular examination and standardised documentation.

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