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Clinical Reviews

RETINAL HEMORRHAGES AND SHAKEN BABY SYNDROME: AN EVIDENCE-BASED REVIEW

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☐ Abstract—Background: Among the causes of non-accidental head injury (NAHI), shaken baby syndrome (SBS) is difficult to diagnose and is associated with retinal hemorrhages (RH). Description: To identify findings and patterns of RH specific to SBS, a PubMed search using the keywords "shaken baby syndrome" or "child abuse" and "retinal hemorrhage" was conducted; 66 articles met the inclusion criteria. The published data address the utility of RH in three categories: 1) in diagnosing SBS; 2) as correlated to intracranial pathology; and 3) in prognosticating SBS. The present review aimed to summarize studies in a way that facilitates clinical decision-making. Results: Studies found a 53–80% incidence of RH with abusive head injury and a 0–10% incidence with proven severe accidental trauma. RHs are found bilaterally 62.5–100% of the time in SBS cases, and flame-shaped hemorrhages are the most common. The incidence of RH from convulsions, chest compressions, forceful vomiting, and severe persistent coughing in the absence of another condition known to cause RH is 0.7%, 0–2.3%, 0%, and 0%, respectively. Conclusion: SBS remains a difficult cause of NAHI to diagnose. Ophthalmologic examination can provide critical diagnostic and prognostic information in cases of suspected SBS. Child abuse should be highly suspect in children with RH and a parental explanation of accidental head injury, especially if the RHs are found to be bilateral, flame-shaped, or to extend through to all layers of the retina.

☐ Keywords—shaken baby syndrome; retinal hemorrhages; pediatric; child abuse

INTRODUCTION

Non-accidental head injury (NAHI) is a significant problem in young children and infants (1,2). It is estimated that one-fourth to one-half of all children under 24 months of age admitted to the hospital for head trauma are victims of abuse (3). Brain injuries in these children have been shown to permanently hinder neurological, behavioral, and cognitive development, resulting in motor deficits, visual deficits, epilepsy, speech and language abnormalities, or behavioral problems that may remain silent for up to 5 years after an episode of abuse (4). Due to the difficulty in categorizing head trauma as non-accidental outside of a parent confession, NAHI is often a diagnosis of exclusion. Three non-child-abuse-related situations where traumatic hemorrhage can be found are accidental head trauma, perinatal trauma, and cardiopulmonary resuscitation (CPR) (5–12).

Shaken baby syndrome (SBS) is one of the most difficult causes of NAHI to diagnose. External bruising has been shown to be absent in a significant minority (21%) of fatal non-accidental head injuries, and a history of previous maltreatment can be absent in up to 40% of

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cases (13,14). To this extent, the finding of retinal hemorrhage on ophthalmologic examination in a child with non-specific neurological symptoms can be very helpful in making the diagnosis of SBS (15).

SBS refers to a constellation of inflicted injuries mostly seen in young children, caused by violent shaking, and is typically characterized by subdural hematomas (SDH) and retinal hemorrhages (RH) (15). In a 10-year retrospective chart review of 364 cases of SBS from 11 pediatric tertiary care hospitals in Canada, the median age of SBS patients was 4.6 months (13). In our own review of two de-identified national inpatient admission databases that identified 1479 patients with SBS, the median age was 3.9 months. However, SBS has been diagnosed in children up to 8 years of age (16). In the aforementioned report, 19% of children died as a direct result of shaking, and only 22% of children who survived showed no signs of health or developmental impairment at discharge (13). Approximately 1400 cases of SBS are reported each year in the United States; however, this number is almost certainly an underestimate, as cases go unreported and physicians typically miss approximately one-third of cases (17,18). Sadly, a number of these children will be reinjured due to the delay in diagnosis (18,19).

To the best of our knowledge, no systematic review has been completed to answer the following question: in children younger than 3 years of age who are suspected victims of child abuse, what is the probability of SBS when RHs are found? This review aims to supplement the understanding of emergency care providers and clinicians who diagnose SBS by providing a comprehensive review of the published literature on RH and SBS. Additionally, demographic data from a large national database are presented to supplement the profile of these patients.

METHODS

Data that shed light on the issue of RH in SBS were extracted and reorganized into the following three categories: 1) diagnostic utility of RH in SBS; 2) correlative significance of RH to intracranial pathology; and 3) prognostic utility of RH in SBS. The following keyword phrases were used to search all English medical literature published on PubMed: "shaken baby syndrome" or "child abuse" and "retinal hemorrhage." All articles eligible for inclusion in this review contained 1) a discussion or analysis of non-accidental head trauma in the pediatric population, and 2) a discussion on RH. For purposes of this review, we defined SBS as a finding of SDH or RH in a child whom the investigators of the trials presumed to have been shaken. Although we excluded impact-associated abusive head trauma from our definition, trials that lumped together this group with SBS-associated abusive head trauma were in some cases included in this study, when pertinent studies investigating only SBS were not available.

Evidence in this review is rated as follows: class I is from prospective randomized controlled trials; class II is from observational studies, cohort studies, prevalence studies, and case control studies; class III is from clinical series, databases or registries, case reviews, case reports, and expert opinion (20). Recommendations in this review are rated as follows: level I is from a preponderance of class I data or strong class II data in areas where randomization may be very difficult; level II is from class II data or a preponderance of class III evidence; level III is generally supported by class III data (20).

Our initial literature search yielded 235 articles. Online titles of articles and abstracts were reviewed to screen for eligibility. After examining this information, 62 articles (reviews, case reports, and trials) that met our inclusion criteria remained. A thorough review of the citations contained in these 62 articles allowed us to add 32 articles to our pool. Once this review of citations had been completed, all review articles that did not present data (n = 22) were excluded from the review. From the full text of the 72 articles that remained, the following was extracted: objective, design, outcome measures, statistical analyses (if pertinent), and limitations. Final review of the extracted data narrowed the final set of articles that met inclusion criteria down to 64. An additional two articles were added to this pool as they were published after our initial search, but before final editing was complete (6,21).

To supplement this review, a retrospective analysis of a non-overlapping combination of the National Inpatient Sample (NIS) and Kids' Inpatient Database (KID) (1998–2003) was performed. Both databases have been developed as part of the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality. The NIS is an all-payer database that contains data on up to 8 million inpatient discharges from approximately 1000 hospitals across the United States each year. Hospitals are sampled to represent a 20% stratified sample of all community hospitals. Currently, data are available from 37 states (22). The KID contains a sample of pediatric (age 20 years or younger) discharges from all community, non-rehabilitation hospitals in states that participate in the HCUP. Unlike the NIS, which samples at the hospital level, the KID samples patient discharges that are then weighted to obtain national estimates. The sampling algorithm involves systematic random sampling to select 10% of uncomplicated in-hospital births and 80% of complicated in-hospital births as well as other selected pediatric cases. The KID contains information from up to 36 states (23). Information collected on patients in both databases included age at admission, gender, and race. Patients were included in the analysis if they had an International Classification of Diseases (ICD)-9 procedure code of 995.55 (shaken infant syndrome).

RESULTS

We present our results by answering clinical questions organized into the following three categories: 1) diagnostic utility of RH in SBS; 2) correlative significance of RH to intracranial pathology; 3) prognostic utility of RH in SBS.

Diagnostic Utility of RH in SBS

Can the finding of RH help to distinguish abusive from accidental head injury in infants? Our search yielded a total of 18 publications, of which eight are presented (five class II and three class III clinical studies), that sought to address this question (2,5,24–29). Seven studies were excluded because they did not include an accidental head injury group, one study was excluded because it grouped abuse occurring at all sites on the body together, and two studies were excluded due to insufficient power due to small sample size. Pierre-Kahn et al. compiled a prospective case series from January 1996 to September 2001 on 241 consecutive infants hospitalized for a SDH (26). Children were split into three categories corresponding to the degree of certainty that they were shaken: children presumed to have been shaken (group 1), children with signs of head trauma without a relevant history of trauma (group 2), and children with proven severe accidental trauma (group 3). Intraocular hemorrhage was seen in 77.5% of children in group 1, 20% of children in group 2, and no children in group 3, leading the author to conclude that intraocular hemorrhages are suggestive of SBS, but not specific for the syndrome (26).

In other studies, the intermediate category was removed and children were categorized as having been victims of either abuse or accident (2,24,25,27,28). Three prospective studies and two retrospective reviews conducted in this manner reported an incidence of RH of 53–80% in the NAHI group, compared with an incidence of 0–10% in the accidental group (2,24,25,27,28). One of these studies, a prospective analysis of 150 cases of head trauma collected over 3 years, calculated a sensitivity, specificity, positive predictive value, and negative predictive value for RH and child abuse of 75%, 93.2%, 89.4%, and 82.9%, respectively (2).

Further evidence that RH in accidental injury is exceedingly rare can be found in a study conducted by Johnson et al. that sought to determine the incidence of RH in known accidental circumstances (5). In this study, only two of 140 children with accidental injury sufficient to cause skull fracture or intracranial hemorrhage had RH. Those two children were victims of a side-impact motor vehicle accident (5).

A very common explanation given by perpetrators when their child presents at the hospital is that the patient fell a short distance. A retrospective review by Reece and Sege of 287 children with head injuries admitted to a children's hospital over a 5-year time span attempted to examine this question (29). They found that for falls of $<$ 4 feet, none of the children in the accidental group had RH, and 25% of the children in the abused category had RH (29). This led the author to conclude that "RHs are virtually never seen in short falls" (29).

What patterns for RH are specific to SBS? Four class II and three class III clinical studies were found that examined whether RHs from SBS are more commonly found unilaterally or bilaterally (15,24,26,30–33). Six of these studies found incidences of bilateral RH in children with presumed abusive head trauma from 40–100% (15,24, 26,30–32). This was supported by a review article by Levin published in June of 1990 that found an incidence range for bilateral RH of 58–100%, the broad range being attributed to differences in sample size and to some of the examinations being performed at the bedside, whereas others were performed at autopsy, giving greater freedom to explore the retina (33). This can be compared to an incidence of 1.5% for bilateral RH in hospitalized children younger than 2 years of age exposed to accidental head trauma (24).

Three class II and seven class III clinical articles were examined that commented on where in the retina to look when searching for RH in a child with suspected SBS (15,24,26,32–38). As evidenced by reviews, case reports, and trials, it is a commonly held belief that most RHs in abusive head injury concentrate on the posterior pole of the retina (26,32,33,35,36,38). However, it also has been noted that "the most common clinical eye examination visualizes only the posterior retina. Only indirect ophthalmic examination reveals the retinal periphery" (34). Kivlin et al. found that on clinical examination by direct ophthalmoscopy, 0% of 123 children with suspected abuse had RH on the peripheral retina near the ora serrata, whereas on autopsy, 77% had involvement there (15). Furthermore, according to Bechtel et al., the finding of a peripheral RH can be quite useful in helping to differentiate abusive vs. accidental head injury (24). They found peripheral RH in 27% of patients in the abusive head injury group and in 0% of patients in the accidental group (24). A report from the National Australian Conference on Shaken Baby Syndrome even went so far as to state that “only SBS (not accidental injury or disease) can result in a pattern of multiple hemorrhages distributed throughout the retina to the periphery” (37).

Although both severe and widespread RH and small and scattered RH have been found to be indicative of abusive head trauma, a class II clinical study was able to show a correlation between the amount of retina covered by RH and the likelihood that the mechanism was physical child abuse (39,40). In a study by Betz et al., RHs were found in at least one eye covering 19.2–73.2% of the entire retinal area in all seven cases of physical abuse (40). In only 2 of 24 children with severe non-inflicted head trauma (e.g., from falls, aircraft accidents, traffic accidents) were RH found. These were only located unilaterally and covered 1.18% and 3.33%, respectively, of the entire retinal area.

Three class II and three class III clinical studies were examined that support the assertion that RHs are found most commonly in the superficial layers of the retina, also known as the nerve fiber and ganglion cell layers (31,33,36,38–40). This correlates with the clinical prevalence of flame-shaped retinal hemorrhages, the most common form of RHs in SBS, which occur from blood in the nerve-fiber layer (36). In a retrospective study of the eyes of 12 infants who died with a clinical and pathologic diagnosis of SBS, RH was found in the superficial layers in at least one eye in 11 of the 12 infants and graded moderate or severe in 10 of those 11 (38). Riffenburgh and Sathyavagiswaran similarly found an extremely high incidence of RH in the superficial layers of the retina in the eyes of victims of child abuse (39). Out of 101 eyes examined by autopsy, 100 eyes had involvement of the superficial layers. Additionally, both Riffenburgh and Sathyavagiswaran and Rao et al. noted that in all of the eyes in which the deeper layers were involved, the superficial layers were more heavily involved, and no cases were found in which only the deeper layers were involved (31,39). When all layers of the retina are involved, Betz et al. found that physical abuse should be highly suspected (40). RH extending through to all layers was found in all seven cases of physical abuse and in 0 of 24 children with severe non-inflicted head trauma (40).

In addition to RH, vitreous hemorrhage, retrohyaloidal hemorrhages, premacular hemorrhages, preretinal hemorrhages, subretinal hemorrhages, retinal folds, dome-like hemorrhages, macular holes, and Roth spots without evidence of bacterial endocarditis all have been linked to abusive head trauma in children (15,24,26,30–33,35,36,38, 39,41–45).

Out of these additional forms of hemorrhage, vitreous hemorrhage probably has the most evidence linking it to child abuse. Two class II and three class III clinical studies found data supporting the assertion that although vitreous hemorrhage is a less common form of hemorrhage in SBS, it is not uncommonly found and it has an incidence of 10–14% when looked for on clinical examination (15,24,26,31,35,36). Furthermore, in the above-mentioned article by Bechtel et al., an incidence of 13% was found in the abusive head trauma group, whereas an incidence of 0% was found in the accidental group (24). Some evidence has now accumulated to suggest that the vitreous hemorrhage found in SBS may not be a primary injury, but rather may be due to RH progressively over time breaking through to the vitreous cavity (44). Four class III clinical studies reported that vitreous hemorrhage developed in infants after a delay of 2 days to weeks (32,33,35,44). Two additional class II studies found that every time a vitreous hemorrhage was found, it was associated with a RH, all of which were described by Pierre-Kahn et al. as being “large” (26,39). Two of the above-cited articles suggested that the typically delayed appearance of vitreous hemorrhages could help with estimating time of injury (33,35).

Four class II and seven class III clinical studies support the assertion that the finding of retrohyaloidal hemorrhages, premacular hemorrhages, preretinal hemorrhages, subretinal hemorrhages, dome-like hemorrhages, Roth spots without evidence of bacterial endocarditis, retinal folds, and macular holes can help one to make the diagnosis of SBS (15,24,26,30,31,33,38,41–43,45). The incidence of these other types of retinal damage in SBS has been estimated at: 47% for retrohyaloidal hemorrhages (hemorrhages beneath the envelope that encompasses the vitreous humor), 20% for premacular hemorrhages (hemorrhage between the macula and posterior vitreous face), 30–38% for preretinal hemorrhages (hemorrhages behind the internal limiting membrane and in front of the nerve fiber layer), 10% for subretinal hemorrhages (bleeding under the retina), 7% for dome-like hemorrhages (hemorrhages in the superficial layers causing the internal limiting membrane to bubble up), and 15% for Roth spots (white-centered retinal hemorrhages) (15,24,26,30). The incidence of retrohyaloidal hemorrhages, premacular hemorrhages, and preretinal hemorrhages in accidental head trauma was 0% (24,26). Additionally, retinal folds, a sign of retinal detachment, have been linked to death resulting from SBS. Munger et al. and Rao et al. found such folds in 5 of 12 and in 1 of 5 children presumed to have been fatally shaken, respectively (31,38,41). Macular holes in patients diagnosed with SBS are mentioned in only one article where they are associated with poor visual acuity outcome (45).

What diseases can mimic the RH seen in SBS? Our search yielded seven class III case reports and one class II observational study for infants with RH attributed to the following disease etiologies: osteogenesis imperfecta, Terson syndrome (intraocular bleeding associated with acute intracranial hemorrhage), homozygous protein C deficiency, glutaric aciduria type 1 (a rare autosomal recessive neurometabolic disorder), Hermansky-Pudlak Syndrome (an autosomal recessive condition characterized by albinism and platelet abnormalities), and hemorrhagic disease of the newborn (an acquired disorder of vitamin K deficiency) (46–53).

Can internally generated forceful body movements cause RH? Our review found three class II observational studies that sought to answer this question (21,54). Herr et al. conducted a descriptive study of 100 infants with a history of forceful vomiting from hypertrophic pyloric stenosis (54). All patients received a dilatated funduscopic examination and no RHs were identified in any of the cases. Goldman et al. looked at 100 consecutive children aged 3–24 months who were hospitalized for at least 3 days of coughing (21). In this study, no RHs were found in any of the children. Herr et al. followed 153 children younger than 24 months of age brought to the emergency department after a convulsive episode (54). After examining both eyes in all 153 children, only one eye was found to have a retinal hemorrhage.

Can CPR in children cause RH? Our search produced two prospective studies that addressed this relationship (9,55). In the first, Odom et al. found only one incidence of a small punctuate RH in 43 patients hospitalized for non-traumatic illnesses in intensive care and who received at least 1 min of chest compressions and survived long enough for a retinal examination (55). Similarly, Kanter found RH in only one patient out of 49 consecutive children who received chest compressions in whom child abuse was not suspected (9). It should be noted that in both studies, pre-arrest funduscopic examinations were not performed and it is therefore impossible to definitively determine the cause of the RH.

Can RH form from birth trauma and what is the typical time to resolution? Our literature search produced three studies with class II evidence that were fairly consistent in finding an incidence of RH of slightly > one-third and a time to resolution of < 1 week (6–8). Hughes et al. found RHs in 34% of 53 neonates examined 1 to 4 days after birth (6). Bergen et al. found RHs in 35% of 100 newborns and Levin et al. found RHs in 37.3% of 410 newborns examined within 24 h of delivery (7,8). Whereas Bergen et al. found a correlation between both mode of delivery and length of labor with the incidence of RH, Levin et al. found no such correlations. Both Bergen and Margolis and Levin et al. found that the majority of neonatal RHs resolved completely in 5–6 days, whereas Hughes et al. found that most RHs resolved completely by 3 to 9 days (6–8).

Can you date abuse by examination of RH? A class III study does not support the use of an ophthalmologic examination to estimate the interval between a traumatic event and presentation to medical personnel (56). In a retrospective study by McCabe and Donahue, the following times to resolution of RH for 20 patients who received follow-up were noted: 7 patients by 1 month, 5 patients by 2 months, 4 patients by 3 months, 2 patients by 4 months, 1 patient by 9 months, and 1 patient by 11 months (56).

Correlative Significance of RH to Intracranial Pathology

Can the presence or severity of RH be correlated with severity of intracranial trauma? Two class III clinical series were found that support using extent of eye hemorrhage as a rough estimate for severity of head trauma (57,58). In the first study, a forensic pathology study of eye and brain injuries in 23 consecutive children who died of non-accidental injury from 1988 through 1992, a very strong correlation between severity of central nervous system (CNS) trauma and both total eye trauma ($p < 0.0001$) and the degree of eye hemorrhage ($p < 0.0001$) was found (57). Green et al. also found RH in 12 of 16 children who died of CNS failure, compared with only 1 of 7 children without CNS death ($p < 0.02$) (57). In a second study of 75 children with apparent NAHI consistent with SBS, Morad et al. found a strong correlation between severity of cranial trauma and degree of RH ($p < 0.04$) (58). No association was found between anatomic site of RH and location of intracranial findings.

With what types of intracranial pathology are RHs associated? Four studies addressed this question. One study was excluded because it was a single case study and no statistically significant conclusions could be drawn. Although Morad et al. found no association between intracranial and retinal findings, two additional studies correlated RH with specific types of intracranial pathology (58–60). A retrospective case series of infants younger than 24 months of age with confirmed or suspected SBS correlated RH with parenchymal brain lesions (59). In this study, 1 of 8 infants without RH had a parenchymal brain lesion, compared with 17 of 18 infants with RH. In another study, 53 cases of NAHI in children underwent detailed neuropathologic study, which revealed a significant association between subdural bleeding and the presence of RH ($P < 0.001$) (60).

Prognostic Utility of RH in SBS

Can neurologic outcome be predicted by severity or presence of RH? The largest comprehensive series that includes both clinical and autopsy findings was a retrospective study of 123 children admitted to a children's hospital for SDH secondary to abuse from January 1987 through December 1998 (15). Ninety percent of the children had an ophthalmologic examination; 83% of those had RH. The presence of RH increased mortality by an odds ratio of 5.12 (15). There was a significant trend of increasing mortality with increasing severity of hemorrhage from no RH 10% mortality, to unilateral RH 23% mortality, to bilateral RH 38% mortality ($p < 0.012$). This study did not find an association between the presence of RH and visual outcome ($p > 0.05$) or neurological outcome ($p > 0.05$).

Five other studies, which had sample sizes of 5 to 23 children, found a similar correlation between severity of intraocular trauma and neurological outcome (61–65). In a study of 9 children with confirmed SBS and a normal head computed tomography scan on admission, severe RH, found in 5 children, was correlated with abnormal neurological outcome that included: developmental motor delay, ataxia, poor head control, seizure disorder, and swallowing difficulty (61). Bonnier et al. found severe disability in 9 of 12 children with retinal detachment or vitreous hemorrhage (considered a more severe finding than RH), compared with 5 of 11 patients with less severe or no ocular damage ($p = 0.04$) (62). Wilkinson et al. found a significant correlation between degree of retinal injury and initial neurologic injury ($p < 0.05$) and a borderline correlation between degree of retinal injury and late neurologic injury ($p > 0.05$) (63). Matthews and Das found that a dense vitreous hemorrhage in SBS is correlated with poor final visual outcome, even when accounting for corrective surgery (64). Lastly, in a study of 10 children diagnosed with SBS, Mills found a significant correlation between mortality and the presence of either perimacular retinal folds ($p < 0.05$) or peripheral retinoschisis ($p < 0.02$), a condition in which the retina splits into layers (65).

DISCUSSION

SBS remains among the most difficult causes of NAHI to diagnose. A lack of visible external injuries or no previous history of maltreatment in up to 40% of cases makes the ophthalmologic examination critical in the work-up of a child who is a suspected victim of abuse (13,14). Although the presence of RH does not confirm the diagnosis of SBS, the articles reviewed show that RHs are common in abused children and exceedingly rare in cases of accidental head injury. Although the data cannot remove any uncertainty about the precise etiology of injury in the absence of a witnessed inflicted head injury or confession by an alleged perpetrator, the sheer number of articles with consistent findings supports using RH as a physical examination finding consistent with SBS.

The correlation between hemorrhages in the deeper layers of the retina and SBS is founded on the idea that such hemorrhages originate in the superficial retinal layers and spread with increasing damage. It is speculated that greater trauma to the retina occurs during shaking due to a shearing effect that does not occur during typical accidental head trauma. Thus, when all layers of the retina are involved, physical abuse is often found.

Although RHs are one of the cardinal features of SBS, there are numerous potential causes of RH in children under the age of 3 years (46–53). Among these causes are a number of "zebra" diseases that can mimic the RH seen in SBS. Should a child fit into one of these clinical syndromes, clinical suspicion for SBS can be lowered. However, a history of forceful vomiting, persistent coughing, seizures, or prolonged chest compressions has not been shown to reproduce the RH seen in SBS. In 1972, Caffey speculated that the elevated intrathoracic venous pressure transmitted to the head during CPR could lead to eye damage (66). Since Caffey first hypothesized this mechanism of action, several case reports have come out attempting to link resuscitation attempts with RH (9–12). Data to date, though limited, do not support prolonged chest compressions as a potential cause of RH.

In addition to the above-mentioned difficulty in distinguishing between abusive and accidental head trauma, our ability to draw strong conclusions in certain areas was hindered by a lack of prospective studies and studies with small sample sizes. Due to the paucity of information available on certain topics that relate to SBS, several articles included in this analysis were retrospective reviews or analyses with small sample sizes: (1,13,15,27–29,38,56–62,64,65,67,68) and (4,31,38,40,57,62–65,69), respectively. This raises concerns that interpreter bias may be present, confounding variables may not have been identified, and study groups may not have been comparable, or that studies may have been underpowered to find true differences or causal relationships.

Another limitation of this analysis is the absence of the ophthalmologic examination from the repertoire of procedures performed regularly by most clinicians. It is well documented that when an ophthalmologic examination is performed by a physician unaccustomed to performing the examination, there is an increased incidence of false negatives (15,68). In a study by Morad et al., 72 children were examined first by a non-ophthalmologist and then by an ophthalmologist (68). Sixty-one patients had RH documented by the ophthalmologist, compared to only 28 by the non-ophthalmologist. The non-ophthalmologists indicated that they tried but were unable to examine the retina in 14 patients, whereas in an additional 26 patients, there was no documentation that a retinal examination was attempted. When the retinal examination was completed by the non-ophthalmologist, a correct diagnosis was made in 28 of 32 patients, or 87% of the time. In the remaining four children, the non-ophthalmologist incorrectly documented normal retinas when, in fact, RHs were present. Furthermore, none of the non-ophthalmologists noted the type, location, or number of hemorrhages or used pupil-dilatating drops, when these steps are standard and were performed by all the ophthalmologists in the study. Although some of the studies cited in this article employed a pediatric ophthalmologist, many of the studies relied on the ability of the first responder, who sometimes was not an ophthalmologist, to either screen for or diagnose RH (21,54–56).

CONCLUSION

This review forms the basis for the following level II recommendations: 1) child abuse should be highly suspected in children with RH and a parental explanation of accidental head injury, 2) the finding of bilateral RH should be considered a physical examination finding supporting the diagnosis of SBS, and 3) that the finding of flame-shaped retinal hemorrhages on clinical examination and the finding of RH in the superficial layers of the retina on autopsy, especially if the RH is found to extend through to all layers, should serve as evidence supporting the diagnosis of child abuse (2,5,15,24–33).

This review forms the basis for the following level III recommendations: 1) in cases of suspected SBS, indirect ophthalmic examination should be used to examine both the retinal periphery and the posterior pole, 2) clinical suspicion should be peaked when $>$ 20% of the retinal area is covered by RH, 3) the severity of intraocular damage should be used as a rough estimate for neurological prognosis, with higher severity being correlated to worse neurological outcome, 4) a history of forceful vomiting, persistent coughing, seizures, or prolonged chest compressions should not lessen clinical suspicion for child abuse in patients with RH, and 5) the extent of eye hemorrhage should be used as a rough estimate for severity of head trauma (9,15,24,26,32–40,55,57,58,61–65).

Additionally, although the literature on dating abuse by examination of RH is sparse, the wide range in resolution times of RH supports the idea that the appearance or lack of presence of RH on fundoscopic examination gives little information that can be used to date abuse (56).

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ARTICLE SUMMARY

1. Why is this topic important?

Shaken baby syndrome (SBS) is a common and underdiagnosed cause for permanent psychological and neurological morbidity in a completely defenseless population (infants).

2. What does this study attempt to show?

Retinal hemorrhage (RH) in an infant should reflexively prompt clinicians to rule out SBS even in the setting of a described accidental head injury, convulsions, chest compressions, forceful vomiting, or severe persistent coughing.

3. What are the key findings?

The incidence of RH with abusive head trauma is 53–80%, whereas the incidence of RH with proven severe accidental trauma, convulsions, chest compressions, forceful vomiting, and severe persistent vomiting found in five studies is 0–10%, 0.7%, 0–2.3%, 0%, and 0%, respectively.

4. How is patient care impacted?

SBS can be diagnosed earlier and should be missed less often, leading to less infant morbidity and mortality if clinicians better understand the implications of the disease's hallmark finding: retinal hemorrhages.