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# The natural history of retinal hemorrhage in pediatric head trauma

Gil Binenbaum, MD, MSCE<sup>a,b</sup>, Wendy Chen, MD, PhD<sup>c</sup>, Jiayan Huang, MS<sup>b</sup>, Gui-shuang Ying, PhD<sup>b</sup>, and Brian J. Forbes, MD, PhD<sup>a</sup>

<sup>a</sup>Division of Ophthalmology, The Children's Hospital of Philadelphia, Philadelphia <sup>b</sup>Scheie Eye Institute, Department of Ophthalmology, Perelman School of Medicine at the University of Pennsylvania, Philadelphia <sup>c</sup>Division of Ophthalmology, Alpert Medical School at Brown University, Providence, Rhode Island

#### **Abstract**

**BACKGROUND**—Ophthalmologists are commonly asked to interpret appearance of retinal hemorrhages (RH) in children with suspected traumatic head injury. We sought to determine the natural history of RH in young children with head trauma and to identify patterns suggestive of chronicity in order to help establish timing of suspected traumatic injury.

**METHODS**—The medical records of children <2 years of age with abusive or accidental head trauma and RH on initial fundus examination who had 1 or more follow-up examination were retrospectively reviewed. Types of RH (intraretinal, preretinal) were noted; intraretinal hemorrhage (IRH) severity was graded as mild (0–10), moderate (10–20), or severe (>20, too numerous to count [TNTC]).

**RESULTS**—A total of 91 eyes of 52 children were studied. All eyes had IRH (62 eyes with TNTC). In all but one eye, IRH resolved to none or mild within 1–2 weeks. TNTC IRH did not persist beyond a few days. The longest an isolated IRH persisted was 32 days. Preretinal hemorrhage (PRH) was present in 68 eyes, persisting 5–111 days. On initial examination, 25% of eyes had only IRH, 75% both PRH and IRH; no eyes had only PRH. At 2 weeks, 3% had only IRH, 18% both, and 45% only PRH. In no eyes did RH worsen.

**CONCLUSIONS**—IRH clears rapidly, whereas PRH may persist for many weeks. The presence of TNTC IRHs indicates that trauma occurred within a few days prior to examination, whereas the presence of PRH with no or few IRHs suggests days to weeks since trauma. To accurately identify these patterns, eye examinations should be completed as soon as possible after admission, preferably within 24–48 hours.

Retinal hemorrhage (RH) is an important diagnostic sign of inflicted head trauma in infants and young children. <sup>1–9</sup> Ophthalmologists are often asked to interpret the appearance of RH

Correspondence: Gil Binenbaum, MD, MSCE, Children's Hospital of Philadelphia, 34th Street and Civic Center Blvd., 9-MAIN, Philadelphia, PA 19104 (binenbaum@email.chop.edu).

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in an effort to provide clues about the timing of a suspected injury. The diagnostic specificity of the severity, location, and type of RH for inflicted versus accidental injury are well established, 1,2,5–11 but there are limited published data to guide an assessment of injury timing based on RH findings. The time to resolution of birth-trauma related RH has been reported, with intraretinal hemorrhage (IRH) clearing much faster than preretinal hemorrhage (PRH), 12,13 but the overall patterns of RH at varying postnatal ages following birth have not been explicitly described. Further, the time course and patterns of resolution of RH in pediatric head trauma have not been formally investigated. A reported case of abusive head trauma has suggested the potential for limited progression of RH during the initial 24 hours of medical care, 14 but this possibility has not been formally evaluated. The purpose of this study was to determine the natural history of RH in infants and young children with suspected abusive or accidental head trauma and to identify patterns of RH that might suggest chronicity or aid in establishing the timing of a suspected traumatic injury.

## **Subjects and Methods**

The medical records of children <2 years of age diagnosed with either abusive or accidental head trauma at the Children's Hospital of Philadelphia between 2001 and 2009 were retrospectively reviewed to identify patients with RH in one or both eyes on initial ophthalmological examination who had one or more subsequent inpatient or outpatient eye examinations. The diagnosis of head trauma was made by a multidisciplinary team, including child abuse physicians. Children were excluded if the initial eye examination occurred more than 72 hours from the time of presentation to a hospital, whether it was the primary study hospital or a referring hospital in the case of children who transferred from another facility. The study was approved by the institutional review board of the Children's Hospital of Philadelphia and was carried out in compliance the US Health Insurance Portability and Accountability Act of 1996. Informed consent was waived for this retrospective study.

All funduscopic examinations were performed by a pediatric ophthalmologist using an indirect ophthalmoscope through pharmacologically or pathologically dilated pupils. The following data were abstracted from the clinical notes of the ophthalmologists for each eye examination: the pattern of type(s) of RH, which was recorded as intraretinal only, preretinal only, or both intra- and pre-retinal; the severity or number of IRH, which was categorized as none, mild (<10 hemorrhages), moderate (10–20 hemorrhages), or severe (>20 hemorrhages, which in most cases was "too numerous to count" [TNTC]); and the presence or absence of other ocular findings, such as retinal folds and optic disk swelling. The ophthalmologists' documentation was sufficiently consistent across all subjects with regard to the type and number of RHs to permit classification of the written descriptions into the categories described above. However, subretinal hemorrhage was inconsistently reported at the initial examination and often only noted after the clearing of more superficial hemorrhages; therefore, subretinal hemorrhage was not included in the analysis. PRH severity or number also was not analyzed, because it was not recorded in the medical record in a standardized fashion by the ophthalmologists, and the severity of PRH is not simply represented by the number of hemorrhages, as is the case with IRH. For example, the retinal surface area

covered by PRHs may be similar for an eye with a few large PRHs and an eye with numerous small PRHs.

The patterns of type of RH, severity/number of intraretinal hemorrhage, resolution of IRH, resolution of PRH, and progression of RH were analyzed over time using simple descriptive statistics. To facilitate these analyses, examinations were grouped into windows of time surrounding the following time points after the initial examination: 1 week, 2 weeks, 3 weeks, 4 weeks, 6 weeks, 2 months, 3 months, and 4 months. For example, "1 week" visits included examinations performed 5–9 days from the initial examination, which was considered day 0. The longest times that an individual IRH or PRH persisted were determined in the actual number of days from the initial examination.

All descriptive analyses were performed by eye as opposed to by subject. Eyes that did not have RH at the baseline examination or that had vitreous hemorrhage (1 patient) prohibiting adequate visualization of the retina at the baseline examination were excluded. An a priori decision was made to combine the data from eyes of children with accidental and inflicted head trauma for analysis, because there was no biological reason to hypothesize that the resolution of RH should vary with the type of head trauma. Post hoc analysis revealed that the patterns of RH resolution described below did not differ between eyes of children with abusive head trauma and children with accidental head trauma. Continuous variables are reported below as mean with standard deviation. All analyses were performed using SAS statistical software version 9.2 (SAS Inc, Cary, NC).

#### Results

A total of 91 eyes of 52 children were included: 45 children had abusive head trauma; 7 children had accidental head trauma. Mean subject age was  $6.7 \pm 7.7$  months. Twelve eyes were excluded because they did not have any RH on initial examination; 1 eye was excluded because it had large amounts of vitreous hemorrhage obscuring the underlying retina. The number of eyes examined in each time window were 91 at presentation, 32 at 1 week, 34 at 2 weeks, 28 at 3 weeks, 14 at 4 weeks, 50 at 6 weeks, 20 at 2 months, 20 at 3 months, and 18 at 4 months.

All 91 eyes had IRHs at presentation, and in 62 eyes (68%) these hemorrhages were TNTC. Sixty-eight eyes (75%) had PRH as well at the time of initial examination. Therefore, at presentation, 25% of eyes had only IRH, 75% of eyes had both types present, and no eyes had only PRH. The pattern of only PRH was first seen at the 1-week examination, and the proportion of eyes with this pattern increased with each successive examination, as the IRHs cleared faster than PRHs (Figures 1 and 2). Of eyes examined at 1 week, 3% had only IRH, 55% had both types present, and 17% had only PRH. Of eyes examined at 2 weeks, 4% had only IRH, 21% had both types, and 54% had only PRH.

With regard to the number of IRHs, TNTC IRHs were present only on initial examination and were not seen at subsequent examinations in any children in our study (Figure 3). Additional findings at baseline included a hemorrhagic macular cyst in 19 eyes (21%), retinal fold in 10 eyes (11%), vitreous hemorrhage in 11 eyes (12%), and optic disk swelling

in 6 eyes (7%). At the 1-week follow-up, all examined eyes had either no or mild IRH. At the 2-week examination, 1 eye, which had not been examined at 1 week, had moderate IRH, and all remaining eyes had no or mild IRH. The latest an isolated single IRH persisted was 32 days. The longest an isolated PRH persisted was 111 days. In no eyes did RHs progress or increase in number.

### **Discussion**

We examined the natural history of RH in infants and young children with head trauma and found identifiable patterns that are informative with regard to injury timing. In eyes with hemorrhage, IRH was uniformly present on initial examination and was in many but not all cases accompanied by PRH. IRHs resolved rapidly, with large numbers of hemorrhages, even TNTC, resolving over a few days. By 2 weeks, either all IRHs had resolved or there were less than 10–20 hemorrhages. PRHs resolved more slowly. Therefore, at 1 week after presentation, a pattern developed of PRH unaccompanied by IRH first. Although it is not possible to precisely date RHs, inferences can be drawn based on these patterns. If PRHs are seen with no or very few IRHs, the injury is unlikely to have occurred recently but rather happened at least a few days to a week or more prior to the examination. Conversely, if TNTC IRHs are observed, the injury occurred within the past few days, as such hemorrhages do not persist out to a week. If 10–20 intra-RH are present, the injury may have occurred as recently as the past day but not more than about 2 weeks before.

These observations are consistent with studies of birth-trauma-related RHs. <sup>12,13</sup> This literature shows that the majority of IRHs clear in the first 2 weeks of life, whereas PRHs do so more slowly, sometimes over weeks. In our study, the longest a single IRH persisted was 32 days. In their birth-related RH study, Hughes and colleagues <sup>12</sup> reported a single, dense IRH that persisted to 58 days. Importantly, in both cases only isolated, individual dense intra-RH persisted this long, and all other IRHs had cleared by 2–3 weeks of age. Therefore, numerous or multiple grouped IRHs present in an infant past the age of 4 weeks are not consistent with birth trauma, and another etiology should be sought.

The rapid resolution of IRHs and resultant quickly changing patterns of RH type and number highlight the importance of a timely dilated fundus examination by an ophthalmologist. Increasing severity of RH has been strongly associated with increasing specificity for abusive versus accidental traumatic injuries, and the ability to obtain this diagnostic information may decrease if the RH pattern changes over time. 1,5,10–14 Therefore, we recommend that examinations be performed as soon as possible, preferably within 24–48 hours, after presentation to the hospital. If the pupils are not traumatically dilated and cannot be dilated pharmacologically, an undilated pupillary examination should still be attempted and the results documented with a description of any limitations posed by the small pupils. However, whenever possible pharmacological dilation of pupils should be performed.

In no eyes in our study did the number of RHs increase over time. The possibility of progression of RHs was documented in a case reported by Gilles and colleagues<sup>14</sup> as part of a case series of infants with head trauma. This child progressed from unilateral to bilateral RHs during the first 24 hours after admission; however, only 3 peripapillary IRHs had

appeared by the second examination. There have been no further reports of RH progression beyond 24 hours or progression more than the appearance of the few peripapillary IRHs observed in this case. Therefore, based on the available literature and our own findings, we believe that RHs do not progress in severity to a significant degree after initial presentation, with the exception of a PRH extending into the vitreous.

There are limitations to our study. First, IRHs were graded retrospectively, and therefore the grading schema and analyses were limited by what data could be reliably ascertained from the medical records. However, the consistency of documentation across providers was considered in the analysis plan and conclusions. For example, IRH, PRH, and vitreous hemorrhage were consistently documented, while subretinal hemorrhage was not; thus subretinal hemorrhage was not included within the analysis. Similarly, the number of hemorrhages were sufficiently consistently described with ranges (eg, <5, 5–10, etc) or simple descriptors (eg, few, too numerous to count) to classify the number of RHs into mild, moderate, and severe categories. The study conclusions then were made general enough using these categories in order to not overstep the limitations inherent in coding the examinations retrospectively in this way. Therefore, these limitations do not change our study results.

Second, follow-up fundus examinations were not performed at predefined intervals but rather scheduled according to the judgment of the treating ophthalmologist. Therefore, not all eyes had examinations at each time point. In addition, it was necessary to group together multiple days around a central time point for analysis purposes; for example, the 1-week time point included examinations occurring on days 5 through 9 after presentation. These limitations are unlikely to have influenced our purposefully general conclusions regarding the interpretation of hemorrhage patterns, which are consistent with the large amount of available birth-related RH data. 12,13

Finally, the abusive head trauma event was assumed to have occurred shortly before presentation to medical care. This assumption is reasonable, because symptom (eg, altered mental status) onset is thought to closely or immediately follow injury, and, again, our findings strongly match the natural history of RH due to birth, the timing of which is obviously known. Indeed, the agreement between the birth-trauma RH literature and the current study further supports the supposition that injury timing can be inferred from the patterns of RH observed in children with head trauma.

We found informative patterns about the natural history of RH in young children with head trauma. In eyes with RH, IRHs are uniformly present at presentation and resolve quickly, leaving a pattern increasingly dominated by PRH over the following weeks, because PRHs clear more slowly. The severity of RH due to head trauma did not worsen significantly over time. In general, the presence of numerous IRHs indicates that head trauma has occurred within the past few days, while the absence of IRH in the presence of PRH suggests more chronicity. Retinal examination by an ophthalmologist should be performed as soon as possible after admission to the hospital, preferably within 24–48 hours, in order to accurately document the types, locations, and number of hemorrhage before the pattern changes.

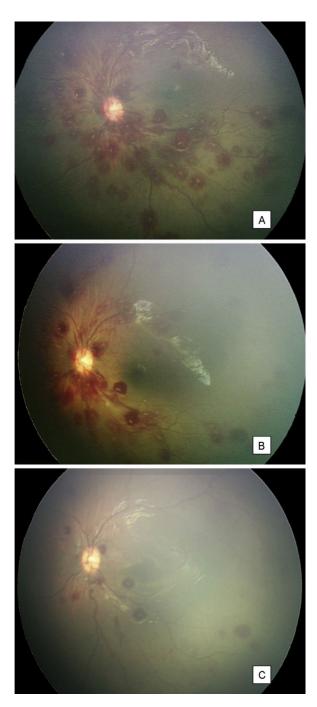
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**FIG 1.** Fundus photographs of the left eye of a child with abusive head trauma. At presentation (A) numerous intraretinal hemorrhages (IRHs) and few preretinal hemorrhages (PRHs) are present. On examination 2 days after (B) and 6 days after presentation (C), numerous IRHs have cleared, leaving mostly PRHs.

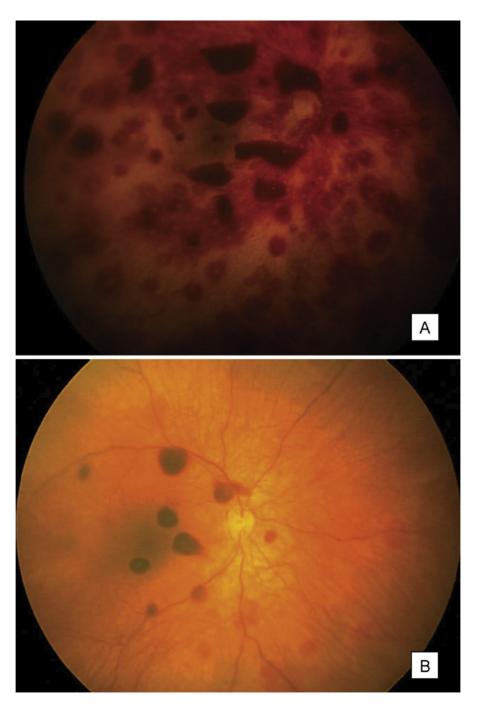


FIG 2. Fundus photographs of the left eye of a child with abusive head trauma not enrolled in the study. At presentation (A), enumerable IRHs and few PRHs are present. At examination 14 days later (B), numerous IRHs have cleared, leaving primarily PRHs.

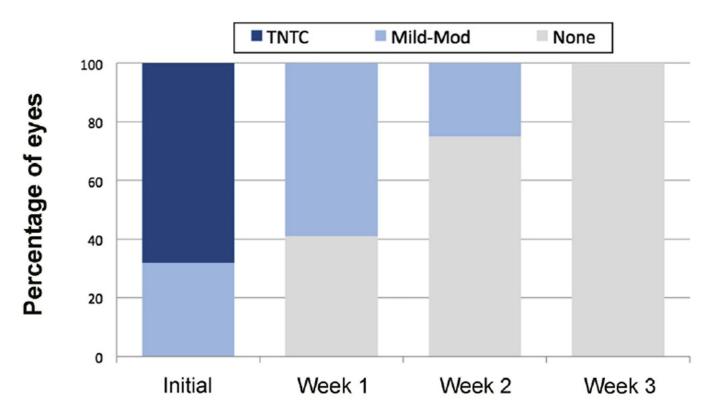


FIG 3. Number of intraretinal hemorrhages present at initial examination and at subsequent weekly time points. *TNTC*, too-numerous-to-count IRHs; *Mild-mod*, mild to moderate number of IRHs (1–20 hemorrhages).