Ocular Findings at Autopsy of Child Abuse Victims

RALPH S. RIFFENBURGH, MD,[1] LAKSHMANAN SATHYAVAGISWARAN, MD[2]

Abstract: The incidence of retinal hemorrhage in child abuse victims was studied in cadavers of children that underwent autopsy in the Los Angeles County Coroner's office. One hundred ninety consecutive cases of childrens' eyes received at Doheny Eye Institute from 1985 to 1989 were included in the study. Retinal hemorrhage is the most common form of eye damage due to child abuse and is more likely to occur in infants who have been shaken than after blunt trauma to the head. Accordingly, retinal involvement is seen more frequently in younger children. The mechanism of retinal hemorrhage is unknown, but the authors' evidence suggests that it is not a direct result of submeningeal hemorrhage. The retinal hemorrhages are found most frequently in the bipolar and nerve fiber layers. They may be severe and widespread or small, scattered foci; both forms are indicative of abuse type injury. Any child who is comatose or who has other unexplained neurologic symptoms should have a thorough eye examination with the pupils dilated with emphasis on studies of the retina.
Ophthalmology 1991; 98:1519–1524

Over the past 30 years, the identification of victims of child abuse has developed from a rarity to one of our major public health problems. In 1946, Caffey[1] mentioned the presence of retinal hemorrhages in some children who had fractures of the long bones and subdural injuries, but, to our knowledge, the first report in the ophthalmic literature of ocular effects of child abuse was in 1964.[2]

Since then, numerous reports of various types of injuries resulting from child abuse have been published, and retinal hemorrhage appears to be one of the most common findings in these children. Caffey[3] reported retinal hemorrhages in several children who had been shaken and numerous studies subsequently demonstrated a relationship between retinal hemorrhages and the whiplash type of injury produced by shaking.[4–6]

As our training of emergency medical personnel has evolved, so has their awareness of child abuse and the need to look for the classic signs of old fractures, bruises, and other visible injuries of various ages. However, the "shaken baby" often does not show the classic stigmata of child abuse, and this produces a major problem in the recognition of cases of this type.

It is in cases of a child who has seizures or who is comatose with no obvious cause that a high index of suspicion is most important.[7] Evaluation of all infants and young children with such presentations should include computed tomography (CT) or magnetic resonance imaging (MRI) and careful examination of the retina with the pupils dilated. A CT scan can be extremely helpful, but is not universally dependable; the newer MRI examination may be more helpful in detecting hemorrhage in the central nervous system. Giangiacomo and associates[8] described five infants who had retinal hemorrhages associated with subdural hemorrhage. In three of these cases, the retinal hemorrhages preceded the subdural hemorrhage by days, and the subdural bleeding was identified only after repeated CT scans. The presence of retinal hemorrhages can thus be an important sign of subdural bleeding and should arouse suspicion of possible child abuse.

Jacobi[9] studied 41 infants who suffered head injuries due to child abuse. The shaken babies were younger (mean, 6 months) than were those with impact injury (mean, 13 months). Those with impact injury frequently died soon after the injury was inflicted, whereas the shaken infants tended to develop epilepsy subsequently, to be

Originally received: July 27, 1990.
Revision accepted: June 4, 1991.

[1] A. Ray Irvine, Jr. Ocular Pathology Laboratory, Doheny Eye Institute and Department of Ophthalmology, University of Southern California School of Medicine, Los Angeles.

[2] The Office of Chief Medical Examiner-Coroner, County of Los Angeles, Los Angeles.

Reprint requests to Ralph S. Riffenburgh, MD, Doheny Eye Institute, 1355 San Pablo St, Los Angeles, CA 90033.

Table 1. Head and Eye Findings at Autopsy

	Group 1 (n = 55)	Group 2 (n = 43)	Group 3 (n = 92)
Skull fracture	8	10	12
Cerebral submeningeal hemorrhage	29	32	10
Retinal hemorrhage	27	24	4

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).
Group 2 = children with possible, but not proven nonaccidental trauma.
Group 3 = children with no evidence of nonaccidental trauma.

Table 2. Other Findings in Group 1 Patients

	Patients with Retinal Hemorrhage (n = 27)	Patients with no Retinal Hemorrhage (n = 28)
History of abuse	10	7
Fractured ribs	4	8
Bruises, abrasions	18	15
Signs of sexual abuse	2	9
Fractured long bones	2	3
Old scars	5	1
Rupture of abdominal organs (liver, spleen, intestine)	1	9
Burns	1	2
Human bites	0	3
Ligature on neck/signs of strangulation	1	2

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).

Table 3. Cause of Death* in Group 3 Patients

Sudden infant death syndrome	44
Automobile accident	12
Drowning	8
Asphyxia	4
Fire	3
Choking	3
Pneumonia	3
Upper respiratory infection	3
Congenital defects	2
Aspiration of food	2
Enterocolitis	1
Seizure	1
Aspirin overdose	1
No cause of death determined	5

* Cause of death as determined by coroner's office.
Group 3 = children with no evidence of nonaccidental trauma.

Table 4. Presenting Sign at Initial Medical Contact

	Group 1 (n = 55)	Group 2 (n = 43)	Group 3 (n = 92)
Dead on arrival	19	12	37
Unresponsive/comatose	19	16	48
Seizure	0	2	2
Cardiac arrest	4	2	1
Lethargy	0	1	0
Meningitis	1	0	0
Disorientation	1	0	0
Vomiting	4	0	1
Inadequate history	7	10	3

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).
Group 2 = children with possible, but not proven nonaccidental trauma.
Group 3 = children with no evidence of nonaccidental trauma.

mentally retarded, and to suffer visual loss, including blindness.

Jacobi[9] suggests that retinal bleeding follows subarachnoid bleeding due to shearing of the bridging veins. Duhaime and associates,[10] however, tested with accelerometers and believe that shaking, in the absence of impact, does not produce the angular acceleration required for this injury. Rao and associates[11] hypothesized that retinal hemorrhage in shaken infants is related to concussion. Concussion is not always related to impact to the head itself. Whiplash injury can produce concussion by the wave of force being transmitted through the facial bones and orbit, which produces an impact on the globe. The retina is particularly vulnerable to injury as it slaps against the sclera. Gilkes and Mann[12] have suggested that the retinal hemorrhages may be related to either sudden increase in intracranial pressure (Terson syndrome) or to chest compression (Purtscher retinopathy) that occurs while the child is being shaken.

The majority of the reports of the shaken child syndrome have been of single or small numbers of cases that were seen clinically and in which retinal hemorrhages were noted. Rao and associates[11] studied 14 sets of eyes from possible child abuse victims who died. We have extended their study, and have reviewed and analyzed the pathologic findings in a larger sample of autopsy cases.

MATERIALS AND METHODS

It is the policy of the office of the Chief Medical Examiner–Coroner of Los Angeles County to remove the eyes in all cases of suspected nonaccidental trauma in children and to submit them to the pathology laboratory at the Doheny Eye Institute. In addition, in cases of infant death due to illness or proven accidental trauma, removal of the eyes is the option of the individual autopsy surgeon. In the period 1984 to 1990, 190 sets of such eyes were studied, including some of the 14 eyes previously reviewed by Rao and associates.[11] Specimens were dehydrated in a series of graded alcohol, fixed in formalin, embedded in paraffin, sectioned horizontally, and then stained with hematoxylin-eosin and with Prussian blue stain for iron.

Table 5. Association of Retinal Hemorrhage with Optic Nerve Submeningeal Hemorrhage

	Group 1	Group 2	Group 3
Retinal hemorrhage with optic nerve submeningeal hemorrhage	23	20	3
Retinal hemorrhage without optic nerve submeningeal hemorrhage	4	4	1
Optic nerve submeningeal hemorrhage without retinal hemorrhage	2	2	0

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).
Group 2 = children with possible, but not proven nonaccidental trauma.
Group 3 = children with no evidence of nonaccidental trauma.

Table 6. Association of Retinal Hemorrhage with Cerebral Submeningeal Hemorrhage

	Group 1	Group 2	Group 3
Retinal hemorrhage with cerebral submeningeal	21	20	3
Retinal hemorrhage without cerebral submeningeal	6	4	1
Cerebral submeningeal hemorrhage without retinal hemorrhage	8	10	0

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).
Group 2 = children with possible, but not proven nonaccidental trauma.
Group 3 = children with no evidence of nonaccidental trauma.

RESULTS

Based on review of the records, the cases were divided into three groups. Group 1 (55 cases) included children with a history of abuse or with definite evidence of nonaccidental trauma, such as multiple injuries, sexual assault, human bites, or ligature strangulation. Group 2 (43 cases) included questionable cases of child abuse: those with suspicious, unexplained trauma but inadequate hard evidence of nonaccidental trauma. Group 3 (92 cases) included all others, including cases of sudden infant death syndrome (SIDS), drowning, and automobile accidents.

The incidence of skull fracture, retinal hemorrhage, and submeningeal hemorrhage is shown in Table 1. Because subdural and subarachnoid hemorrhages are often coexistent, and because the report does not always distinguish between the two, we have included these under the broad term, submeningeal. It is apparent that the children in groups 1 and 2 sustained similar injuries. Table 2 shows the incidence in group 1 children (abused) of history of abuse and of other findings at autopsy in children with and without retinal hemorrhage. A history of abuse is very difficult to elicit in the absence of witnesses, as few child abusers will admit what actually happened, thus making the diagnosis dependent on the physical findings. Table 3 summarizes the causes of death in group 3 cases, those with no suggestion of nonaccidental trauma. Sudden infant death syndrome is by far the most common cause of death, making up almost half (44 of 92; 47.8%) of the cases.

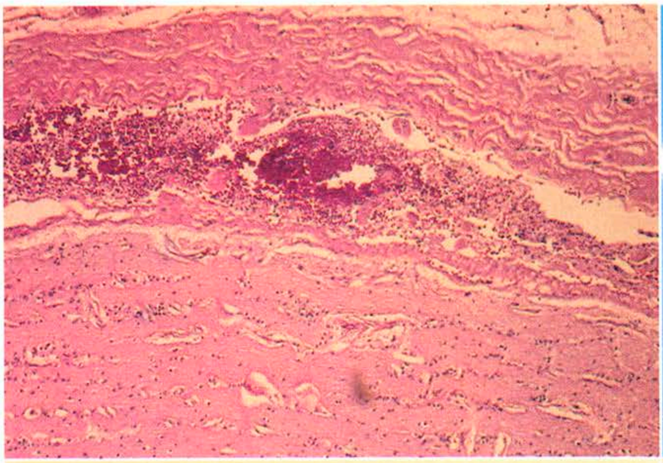
The presenting complaint or sign from the history obtained in the coroner's office from the hospital or paramedic or police reports is shown in Table 4. The terms unresponsive and comatose were used seemingly interchangeably in these reports; many of these children were actually dead on arrival but resuscitation was tried, usually by paramedics, to make sure that no chance of saving them was overlooked. The duration of the resuscitation attempts varied from a few minutes to one child with SIDS who was kept on life support for 8 months.

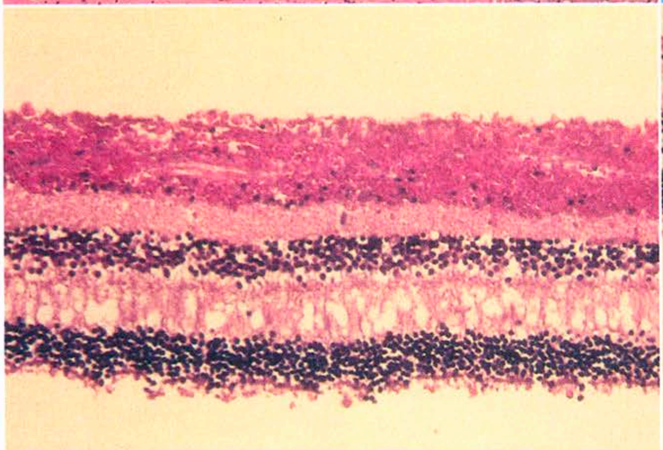
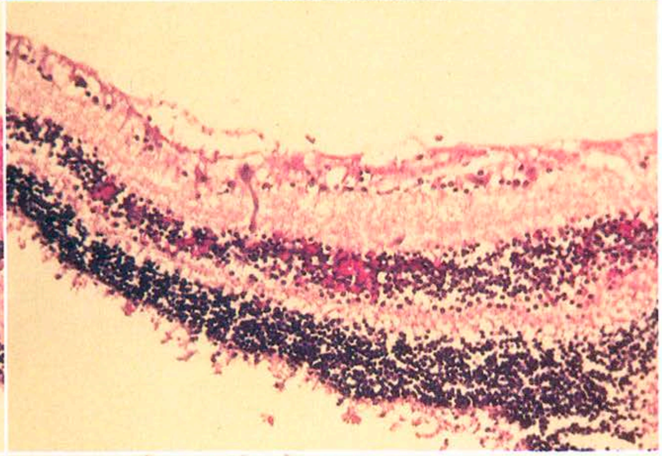
Table 5 shows the relationship of retinal hemorrhage to the presence of submeningeal hemorrhage in the optic nerve. Varying lengths of optic nerve were included in the specimens but submeningeal hemorrhage usually extends to the sclera and is thus easily identified (Fig 1). In the majority of cases, hemorrhage is found in each of these two areas, but either can occur without the other. Similarly, Table 6 presents the relationship of retinal hemorrhage to submeningeal hemorrhage within the cranial cavity. Again there is considerable correlation, but either can occur in the absence of the other.

There were only three cases in which retinal hemorrhage was found in one eye and not in the other. In each of these cases, the right eye was the one showing the hemorrhage. Variation in degree of involvement between the two eyes was not uncommon, with 20% of the bilateral cases showing a significant difference in the two eyes when the severity of hemorrhage was graded on a three-step basis.

The retinal hemorrhages varied from only sparse, localized hemorrhage in one layer of the retina to massive hemorrhage involving all layers and much of the retina with extension into the vitreous. Gross specimens of the latter type show the retina as it would appear when viewed through an ophthalmoscope (Fig 2). The retinal layer in which the hemorrhage was located was studied (Table 7); in some cases the hemorrhage was confined to the nerve fiber layer (Fig 3), while in others the hemorrhage was limited to the bipolar cell layer (Fig 4). Even in those eyes showing involvement of all layers of the retina (Fig 5), the internal layers were invariably more heavily involved than were the external layers. No cases were identified in which only the external layers were involved, indicating that such hemorrhages originate in the internal retinal layers. In 27% of the cases (15 of 55) the hemorrhage extended into the vitreous cavity. In only one case (group 1) was there evidence of old hemorrhage, as seen with iron stain; this case did not show evidence of recent hemorrhage.

Sex and racial distribution of the subjects was not remarkable, except that, again, the child abuse group was very similar to the questionable, nonaccidental trauma group (Table 8). There was a slight predominance of



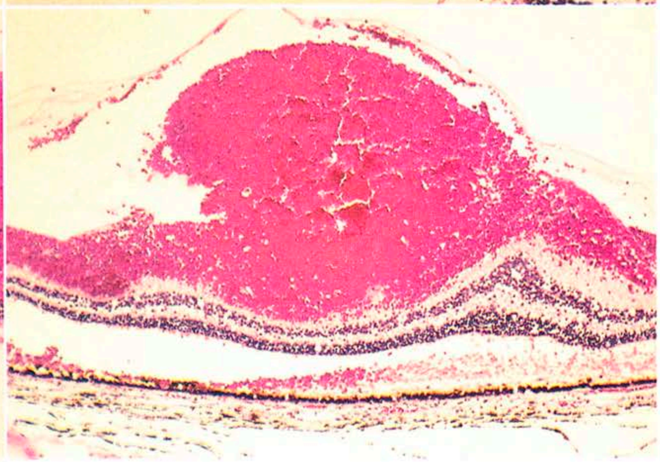
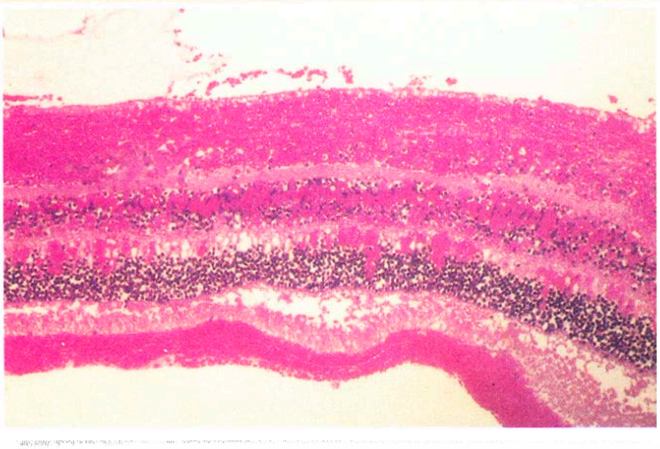



Fig 1. *Top left,* subdural hemorrhage in optic nerve (hematoxylin-eosin; original magnification, ×80). **Fig 2.** *Top right,* gross specimen shows diffuse retinal hemorrhages. **Fig 3.** *Second row left,* hemorrhage limited to the nerve fiber layer (hematoxylin-eosin; original magnification, ×200). **Fig 4.** *Second row right,* scattered hemorrhage limited to the bipolar cell layer (hematoxylin-eosin; original magnification, ×160). **Fig 5.** *Third row left,* extensive hemorrhage involves all layers of the retina (hematoxylin-eosin; original magnification, ×125). **Fig 6.** *Third row right,* a dome-shaped hemorrhagic lesion (hematoxylin-eosin; original magnification, ×80). **Fig 7.** *Bottom,* severe retinal hemorrhage with associated subretinal hemorrhage (hematoxylin-eosin; original magnification, ×80).

Table 7. Retinal Cell Layers Involved by Hemorrhage (n = 101*)

Nerve fiber	22
Bipolar cell	10
Both nerve fiber and bipolar cell	25
All layers	43

* Three patients had unilateral hemorrhage and 6 eyes had inadequate sections for this study.

Table 8. Sex and Race of Children in Study

	Group 1	Group 2	Group 3
Black girl	9	6	14
Black boy	9	8	9
White girl	14	8	21
White boy	12	8	16
Hispanic girl	5	3	9
Hispanic boy	6	3	12
Oriental girl	0	0	2
Oriental boy	0	1	1
Unknown	0	6	8

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).
Group 2 = children with possible, but not proven nonaccidental trauma.
Group 3 = children with no evidence of nonaccidental trauma.

males; the racial distribution shows a predominance of white and black children, fewer Hispanic children, and only three Asian children.

The age distribution shows that those children younger than 1 year of age had a higher incidence of retinal hemorrhage than did older children, with 70% of children younger than 1 year from groups 1 and 2 showing retinal hemorrhage versus 41% of those older than 1 year (Table 9). Group 3 children were not included in these analyses because of the large number of SIDS cases, which would bias the statistics.

Four of the children with retinal hemorrhage had a definite history of traumatic causation other than abuse to account for the hemorrhage. Two had sustained severe head injuries in auto accidents, 1 died 1 week after a difficult forceps delivery, and the fourth had had respiratory failure followed by resuscitation attempts, with resultant damaging chest compression (i.e., Purtscher retinopathy). Autopsy of this last case revealed enterocolitis as the cause of death.

DISCUSSION

The mechanism of the retinal bleeding in shaken infants has not been shown, although several theories have been advanced. The suggestion that the retinal hemorrhage is a direct result of submeningeal hemorrhage is not consistent with our identification of cases with retinal hemorrhage and no submeningeal bleeding and of other cases of submeningeal hemorrhage without retinal hemorrhage.

Table 9. Age of Autopsy Cases and Incidence of Retinal Hemorrhage

	Group 1	Group 2	Group 3
Total younger than 1 year	21	25	63
Younger than 1 year with hemorrhage	13	19	3
Total older than 1 year	34	12	21
Older than 1 year with hemorrhage	14	5	1
Unknown age	0	6	8
Percent younger than 1 year with hemorrhage	62	76	5
Percent older than 1 year with hemorrhage	41	42	5

Group 1 = children with a history or definite signs of nonaccidental trauma (abuse).
Group 2 = children with possible, but not proven nonaccidental trauma.
Group 3 = children with no evidence of nonaccidental trauma.

The cases reported by Giangiacomo and colleagues[8] in which the retinal hemorrhage was noted as much as 3 days before onset of submeningeal bleeding also strongly contradict this thesis.

Weedn and associates[13] have summarized the reports and mechanisms of the "shaken baby" syndrome in which the infant was shaken or given cardiopulmonary resuscitation to reinstitute respiration during apnea. Although this is not common, it did occur in one of our cases and must be considered before child abuse is diagnosed.

Greenwald and associates[14] reported splitting of the retina (retinoschisis) with formation of a large dome in the macular area. In a number of their cases, vitreous hemorrhages were not apparent until several days after the retinal injury.

All of our cases were studied for "dome-shaped lesions" in the macula. Several typical lesions were found, but only one was located in the macula. These lesions are caused by hemorrhage that elevates the internal limiting membrane; this in turn allows the blood to pool beneath the elevated membrane (Fig 6). All stages of dome development were found, from small puddles of blood beneath the internal limiting membrane, to those where the membrane had broken and the blood had accumulated under the vitreous face, to those in which the blood was infiltrating into the vitreous. It is our conclusion that these dome-shaped lesions do not represent a specific entity but, rather, reflect stages in the evolution of hemorrhage within the internal layers of the retina. If the hemorrhaging is profuse and prolonged, the accumulation of blood will elevate the internal limiting membrane, gradually leading to the dome-shaped appearance. If bleeding continues, the membrane will break and the blood will elevate the vitreous face; the vitreous face may then break, with resultant vitreous hemorrhage.

Similarly, with profuse bleeding, blood may be found between the retina and the retinal pigment epithelium, having broken through to the external side of the retina (Fig 7).

Our findings indicate that retinal hemorrhages are not pathognomonic of child abuse, and can be seen after head trauma due to various causes. However, this is a relatively rare occurrence and the presence of retinal hemorrhages in the absence of an obvious cause is evidence sufficient to warrant serious investigation into the cause of injury. Eisenbrey[4] has stated "unexplained retinal hemorrhages in children under three without external evidence of head injury should be considered diagnostic of child abuse until proven otherwise."

REFERENCES

1. Caffey J. Multiple fractures in the long bones of infants suffering from chronic subdural hematoma. AJR Am J Roentgenol 1946; 56:163–73.
2. Kiffney GT Jr. The eye of the "battered child". Arch Ophthalmol 1964; 72:231–3.
3. Caffey J. On the theory and practice of shaking infants: its potential residual effects of permanent brain damage and mental retardation. Am J Dis Child 1972; 124:161–9.
4. Eisenbrey AB. Retinal hemorrhage in the battered child. Childs Brain 1985; 5:40–4.
5. Ober RR. Hemorrhagic retinopathy in infancy: a clinicopathologic report. J Pediatr Ophthalmol Strabismus 1980; 17:17–20.
6. Spaide RF. Shaken baby syndrome: ocular and computed tomographic findings. J Clin Neuro Ophthalmol 1987; 7:108–11.
7. Carter JE, McCormick AQ. Whiplash shaking syndrome: retinal hemorrhages and computerized axial tomography of the brain. Child Abuse Negl 1983; 7:279–86.
8. Giangiacomo J, Khan JA, Levine C, Thompson VM. Sequential cranial computed tomography in infants with retinal hemorrhages. Ophthalmology 1988; 95:295–9.
9. Jacobi G. Schadensmuster schwerer M: Bhandlungen mit und ohne Todesfolge. Monatsschr Kinderheilkd 1986; 134:307–15.
10. Duhaime AC, Gennarelli TA, Thibault LE, et al. The shaken baby syndrome. A clinical, pathological, and biomechanical study. J Neurosurg 1987; 66:409–15.
11. Rao N, Smith RE, Choi JH, et al. Autopsy findings in the eyes of fourteen fatally abused children. Forensic Sci Int 1988; 39:293–9.
12. Gilkes MW, Mann TP. Fundi of battered babies. Lancet 1967; 2:468–9.
13. Weedn VW, Mansour AM, Nichols MM. Retinal hemorrhage in an infant after cardiopulmonary resuscitation. Am J Forensic Med Pathol 1990; 11:79–82.
14. Greenwald MJ, Weiss A, Oesterle CS, Friendly DS. Traumatic retinoschisis in battered babies. Ophthalmology 1986; 93:618–25.