Shaken Baby Syndrome

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Purpose: To examine the comprehensive ophthalmologic experience with the shaken baby syndrome at one medical center, including clinical findings, autopsy findings, and the outcome of survivors.

Design: Retrospective, noncomparative case series.

Participants: One hundred twenty-three children admitted from January 1987 through December 1998 for subdural hematomas of the brain secondary to abuse were included.

Methods: Clinical features of eye examinations of the patients during their admission and after discharge and histopathologic observations for patients who died were retrieved from medical records and statistically analyzed.

Main Outcome Measures: Visual response and pupillary response on initial examination, fundus findings, final vision, neurologic outcome of survivors, and death.

Results: Ninety percent of the patients had ophthalmologic assessments. Retinal hemorrhages were detected in 83% of the examined children. The retinal hemorrhages were bilateral in 85% of affected children and varied in type and location. Nonophthalmologists missed the hemorrhages in 29% of affected patients. Poor visual response, poor pupillary response, and retinal hemorrhage correlated strongly with the demise of the child. One child who died had pigmented retinal scars from previous abuse, a condition not previously observed histopathologically to our knowledge. One fifth of the survivors had poor vision, largely the result of cerebral visual impairment. Severe neurologic impairment correlated highly with loss of vision.

Conclusions: Shaken baby syndrome causes devastating injury to the brain and thus to vision. Retinal hemorrhages are extremely common, but vision loss is most often the result of brain injury. The patient's visual reaction and pupillary response on presentation showed a high correlation with survival. Good initial visual reaction was highly correlated with good final vision and neurologic outcome.

According to the literature, when retinal hemorrhages are found in young children, the likelihood that abuse occurred is very high. Nonophthalmologists' difficulty in detecting retinal hemorrhages may be an important limiting factor in identifying shaken babies so they can be protected from further abuse. *Ophthalmology 2000; 107:1246–1254 © 2000 by the American Academy of Ophthalmology.*

The shaken baby syndrome (SBS) is characterized by subdural hematoma of the brain, occult bone fractures, and retinal hemorrhages (RH) in children usually less than 3 years old. One third of the identified patients die acutely and many survivors have significant neurologic handicaps.[1] Hypoxia and ischemia resulting from apnea may be the major causes of brain injury, rather than shearing or impact.[2] Many children are abused repeatedly.[3]

Violent shaking alone can cause these injuries,[3] but many carefully examined infants also show signs of impact injury to the head, ranging from skull fractures to subtle soft tissue bruises.[4,5] Some authors prefer the term *shaken-impact syndrome* to SBS.[6] Characteristically, the exact types of injuries inflicted are hidden by the perpetrators.

Research on the biomechanics of brain injury has not included studies of the retina.[7,8] Two theories on the cause of RH in SBS continue to be debated in the literature.[9–13] The first postulates venous obstruction in the retina from increased intracranial pressure due to cerebral edema and subdural hemorrhage. Sudden increases in chest or head pressure may be contributing factors as well.[14,15] The second theory postulates that traction of the vitreous on the retina during the acceleration and deceleration of shaking and impact causes circular retinal folds and hemorrhagic retinoschisis cavities, as well as smaller hemorrhages.

Shaken babies frequently present with irritability, lethargy, and vomiting and are commonly believed to have gastroenteritis or other infection because the history of injury is withheld. The external signs of head injury are rarely obvious enough to prompt the ordering of computerized tomography (CT) imaging without this history. Thus SBS can go undetected. The physical finding of RH is extremely helpful to emergency room physicians because of the high correlation of RH with subdural hematoma.[16,17] The patient's evaluation then turns abruptly from a working diagnosis of gastroenteritis toward one of head trauma. The

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child then has a chance of being protected from further abuse.[18,19]

More recent clinical series of SBS patients have had relatively small numbers of patients and have emphasized particular features such as retinoschisis,[9,20] circular retinal folds,[9,13,21] and vitreous hemorrhage.[22,23] The largest ophthalmologic series have consisted of consecutive autopsy cases.[24,25] We present here our comprehensive experience with SBS, including the acute clinical findings of the entire population, the visual outcome of the survivors, and the histopathologic findings of the deceased patients.

Methods

Study Setting

The Childrens' Hospital of Wisconsin serves as a trauma center for a population of approximately 1.8 million people. The Child Advocacy Center of the hospital receives 2000 referrals each year to evaluate children for possible abuse.

Patient Selection

Patients were evaluated retrospectively from the authors' personal records and the hospital's database, according to discharge diagnoses of child maltreatment syndrome, retinal hemorrhage, and SBS, in an effort to have as complete a series as possible. Institutional Review Board approval was obtained for the database search.

All children less than 3 years of age who experienced subdural hematomas from abuse and were admitted to this hospital from January 1987 through December 1998 for their initial evaluation were included. The occurrence of SBS was determined by Child Advocacy physicians based on the presence of subdural hematomas, characteristic bone injuries, and the absence of a history of compatible accidental trauma. Several patients were excluded because they had small subdural hemorrhages that were only adjacent to their skull fracture, indicating a single impact injury rather than shaking. Two abused children with RH were excluded because they were more than 3 years of age. Two patients identified by discharge diagnosis were excluded because their hospital charts were not available.

Eight patients had been included in a previous report on brain trauma,[26] and 71 patients were included in a report on the perpetrators of the abuse, explanations of injury, and skeletal injuries.[27]

Examinations

Initial Evaluations. The extent of the eye examinations by ophthalmologists was dictated by the medical stability of the patients. The examinations included an assessment of visual acuity, pupillary response, motility and alignment, and anterior segment and fundus evaluations. Fundus photography was obtained in some patients, largely for forensic documentation.

Many patients were treated for seizures and paralyzed for endotracheal intubation. Because the medications used could influence visual reaction, as well as pupillary size and reaction,[28] the assessment of these findings was derived from the patient record made before the use of such medications. The earliest Glasgow Coma Score or modified Children's Coma Score in the chart was noted.[29]

Subsequent Clinical Examinations. Inpatients were seen at approximately weekly intervals. Outpatient follow-up occurred at variable intervals. Visual acuity, visual fields, and fundus abnormalities were noted. For those patients not examined by ophthalmologists, visual function was ascertained from the records of pediatricians, neurosurgeons, and developmental specialists. Neurologic functioning was determined by review of outpatient charts.

Histopathologic Examinations. The globes of 27 deceased patients were removed by the personnel of the Medical Examiner's Office. Some early specimens had vitreous aspiration for chemistry testing. The globes were fixed in a 10% buffered formalin solution and sectioned horizontally to include the pupil and optic nerve. They were examined grossly and microscopically, including staining for hemosiderin.

Data Analysis. Data obtained from review of the patients' records were analyzed and statistical analysis was applied if the data were sufficient.[30] SAS statistical software (SAS Institute, Inc., Cary, NC) was used.

Table 1. Patient Characteristics

Total	123
Males	71 (58%)
Age ≤ 6 mos	74 (60%)
Previous developmental delays	7 (6%)
Previous social service intervention with the family	6 (5%)

Results

Patient Characteristics

One hundred twenty-three patients were included in the study (Table 1). Race distribution for this series is compared with that of the hospital's total patient population in Figure 1A, B.

Five patients were brought in for treatment weeks to months after their injury because of increasing head size noted on a medical encounter. The remainder had acute neurologic deterioration.

Previous Medical Encounters

Thirty-five patients (28%) had a previous medical encounter within 6 weeks of their admission for brain injury. Retrospectively, one third of these encounters occurred because of abuse that was not recognized. Four of the 35 children died and five lost their vision because of the subsequent abuse.

Evaluations

Initial Visual Response. Only one third of the patients were visually alert at their first medical encounter (Fig 2).

Motility and Alignment. Bilateral sixth nerve pareses were found acutely in one patient. As obtundation cleared, one other patient was found to have a unilateral complete third nerve palsy and four patients were found to have horizontal gaze pareses.

Anterior Segment. No anterior segment abnormalities were found clinically. One patient examined only at autopsy had old bilateral angle recessions.

Fundus Examination. Ninety-five patients had a dilated funduscopic examination by an attending ophthalmologist, a resident ophthalmologist, or both (Table 2). There were postmortem examinations on an additional 16 patients for whom an ophthalmology consultation had not been requested, yielding a 90% ophthalmologic assessment of this population.

Retinal hemorrhages were the most common ocular finding,

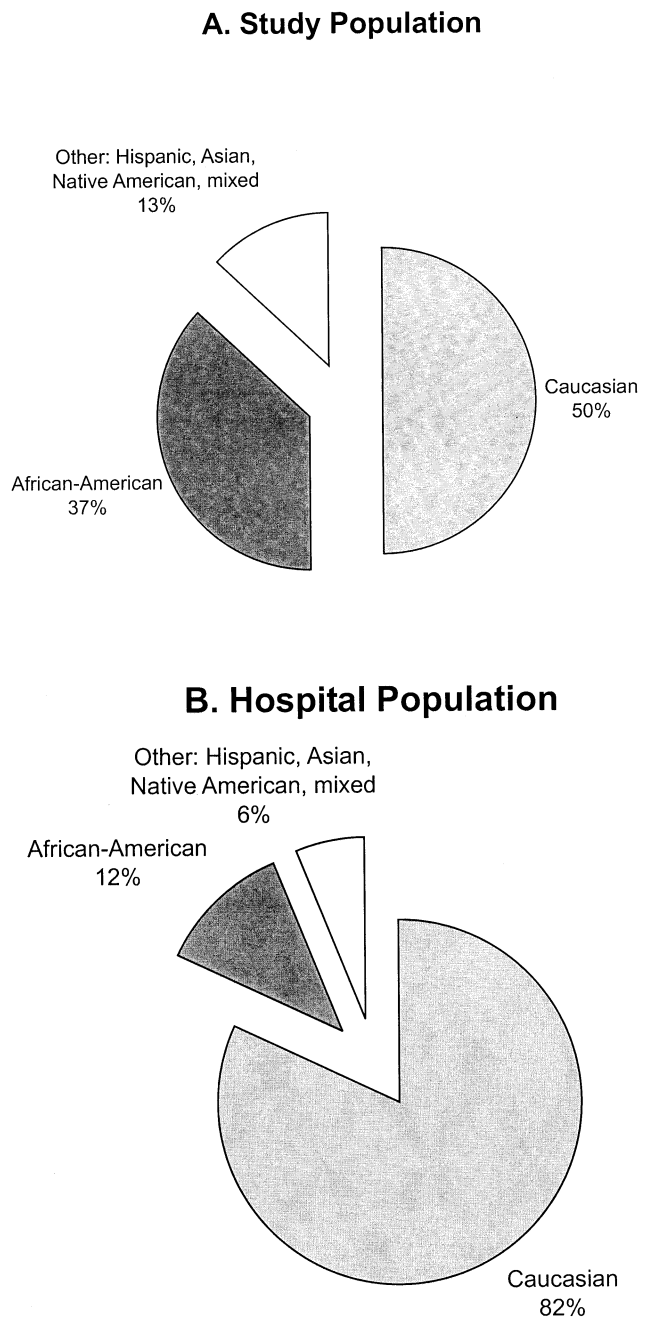

Figure 1. A, B, comparison of race distribution in the study population versus the hospital population.

detected in 79% of the entire group and 83% of the 111 patients who had an ophthalmologic assessment (Table 2). Other characteristics of these hemorrhages, noted by ophthalmologists or pathologists and supplemented by review of any photographs, are given in Table 3. Most patients had many intraretinal and preretinal hemorrhages bilaterally. The small number of unilaterally affected patients had fewer and less extensive hemorrhages. One patient had only one RH in one eye. One patient required a vitrectomy for a nonclearing vitreous hemorrhage. Retinal hemorrhages occurred significantly more often in the older patients (logistic regression model, $P < 0.0063$; Table 4).

In the patient with bilateral angle recessions mentioned above, multiple areas of retinal scarring with atrophy of the outer retinal layers and the retinal pigment epithelium were found bilaterally. Focal hemosiderin staining, indicating resolved hemorrhage, was found elsewhere in her retinas. Another patient without acknowledged previous episodes of injury had focal iron staining scattered throughout the retina bilaterally. Three patients had intrascleral hemorrhage.

Although many patients had cerebral edema, optic disc edema was observed in only four of the 95 clinical evaluations and four of the 16 autopsy examinations where an ophthalmology consultation had not been performed. Perimacular circular folds were found in only seven patients in the entire series (6%), and retinal edema and exudates were also rare. One choroidal rupture was found clinically without other signs of direct trauma.

Nonophthalmologist Examinations. For 111 patients, the nonophthalmologists' eye findings could be compared with the ophthalmology consultation or autopsy report. In 29% of the patients with RH on ophthalmologic evaluation, the hemorrhage had not been detected by any nonophthalmologists involved in the child's care. There was one patient with a false-positive report.

Other Evaluations. In 25 of the 27 autopsy cases, subdural hemorrhages, subarachnoid hemorrhages, or both were found around both optic nerves on gross and microscopic examination, including three eyes of two patients who had no RH. The CT scans of 18 of these patients included views of the optic nerves, but no corresponding abnormalities could be identified.

Impact injuries included skull fractures in 20 patients, visible bruising of the head in 36 patients, and bruising of the eyelids or periorbital region in 20 patients. Sixty-eight patients had no record of any impact injury to the head or eyes; however, standardized prospective evaluations for impact injuries were not performed.

Hospital Course

Visual attentiveness improved markedly in 10 patients who had poor vision before sedation over periods of time ranging from 12 hours to 4 weeks. Nine of these patients improved to normal for their age. In eight other patients, it could not be determined if the initial unresponsiveness was the result of being in a sedated or postictal state; all improved in less than 2 weeks.

Small splinter hemorrhages were observed to have disappeared in 3 to 7 days in two patients clinically, and small dot hemorrhages had disappeared in one eye of another patient during the 11 days before death. Large preretinal hemorrhages slowly shrank in size over several weeks in four patients. Resolution of hemorrhages was not specifically studied.

Outcome

Death. Thirty-six patients (29%) died of their head injuries. Two died after discharge from the hospital, one from a chronic vegetative state and the other from enlarging subdural hematoma. Lack of visual response (Fig 2) and poor pupillary response (Fig 3) proved to be strongly associated with demise (Fisher's exact test, $P < 0.0001$ for both). Most of the seven patients who had circular retinal folds died. Patients who had seizures were far less likely to die than those without seizures (Fisher's exact test, $P < 0.00001$).

Retinal hemorrhages also correlated with death. For the 110 patients examined by ophthalmologists shortly after their injury, the presence of any RH increased the chance of dying by 5.12 (odds ratio). There was a significant trend for an increasing chance of dying with severity of hemorrhage from no hemorrhage (10%) to unilateral hemorrhage (23%) to bilateral hemorrhage (38%; Mantel-Haenszel chi-square test, $P < 0.012$).

The patient's age, race, and prematurity did not correlate with death. The coma score did not add significantly to a prediction of

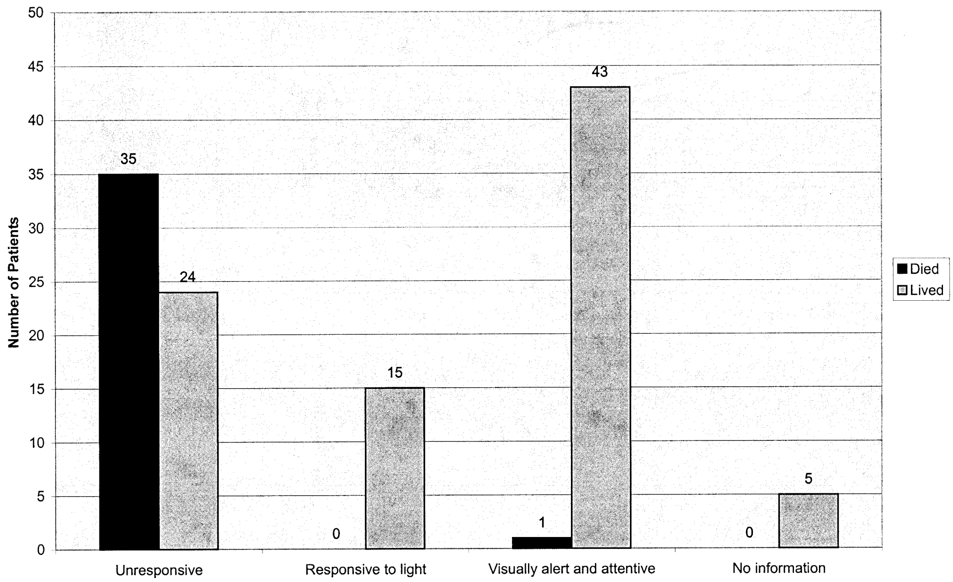

Figure 2. Initial visual reaction and survival.

death when pupillary and visual response were first considered in a multiple regression analysis.

Survivors' Visual Outcome. Visual outcome at the last outpatient visit could be assessed from the records of 68 of the 87 survivors (78%). Follow-up periods ranged from 1 month to 7 years, with a mean follow-up of 21 months. Sixty percent were evaluated by an ophthalmologist. Because the other patients were evaluated by nonophthalmologists, outcomes were broadly defined (Table 5). More than half of the patients were known to see well at their last outpatient visit, whereas one fifth had some visual impairment. Patients whose initial vision was light perception or better were much more likely to see well at their last visit (Fisher's exact test, $P < 0.00001$). Survivors who had not had seizures were also more likely to see well (Fisher's exact test, $P < 0.0041$). Age of the patient, race, prematurity, bruising of the eye or head, skull fracture, pupillary reaction, and presence of RH did not help to predict the visual outcome (logistic regression analysis for age, Fisher's exact test for the other variables, $P > 0.05$).

Cerebral visual impairment resulting from bilateral brain injury posterior to the optic chiasm was the most common cause of bilateral visual impairment (Table 6). Neuroimaging of the head performed at least 6 months after the injury was available for 14 patients with bilaterally poor vision. In two patients, unilateral encephalomalacia corresponded to their homonymous hemianopsia. Seven patients had diffuse bilateral encephalomalacia of the entire cerebral cortex, whereas two had bilateral isolated areas of encephalomalacia, including the occipital lobes. Three patients had bilateral isolated occipital lobe injuries.

In four patients with optic atrophy, retinal scarring, or high myopia, good reactivity of the pupils despite very poor vision was interpreted as indicating that cerebral visual impairment was also part of the cause of the poor vision. The acute fundus appearance in the highly myopic patient was not known. He did not have vision problems before the injury, and there were no findings suggestive of retinopathy of prematurity or vitreous hemorrhage.

Survivors' Neurologic Outcome. Findings are summarized in Table 7. Follow-up ranged from 1 month to 5 years with an average of 26 months. Four of the severely impaired children had been known to be developmentally delayed before their injuries.

Because vision loss was often the result of cerebral visual impairment, it is not surprising that poor visual outcome and severe neurologic outcome were highly correlated (Fisher's exact test, $P = 0.0005$; Table 7). Good initial visual reaction predicted a good neurologic outcome (Fisher's exact test, $P < 0.041$). Age of the patient, race, pupillary response, the presence or bilaterality of RH, seizures, prematurity, bruising, and skull fracture did not

Table 2. Retinal Hemorrhages

Found by	Bilateral	Unilateral	No Hemorrhages	Totals
Ophthalmologist	65	11	19	95
Pathologist only	14	2		16
Nonophthalmologists	5		7	12
Totals	84	13	26	123
Percent	68%	11%	21%	

Table 3. Characteristics of Retinal Hemorrhage

	Clinical Examinations (96 Patients)	Autopsy Examinations (27 Pairs of Eyes)
Bilateral	68%	89%
Unilateral	11%	8%
None	20%	4%
Asymmetric bilateral involvement	6%	17%
Posterior pole most heavily affected	24%	8%
Peripheral retina near ora serrata affected	0%	77%
Dome-like hemorrhages under ILM, any size	7%	15%
White-centered hemorrhages	19%	58%
Preretinal hemorrhage	38%	42%
Subretinal hemorrhage	10%	38%
Vitreous hemorrhage	14%	63%

ILM = internal limiting membrane.

Eleven patients were examined by both ophthalmologists and the pathologist.

Table 4. Retinal Hemorrhages and Age

Age Group (mos)	No. Patients	Any RH	Unilateral RH	None	No Information	Percent with Any RH
0–6	77	51	5	17	9	66
7–12	22	18	5	2	2	82
13–24	17	15	1	1	1	88
25–36	7	7	2	0	0	100

RH = retinal hemorrhage.

correlate with neurologic outcome (logistic regression analysis for age, Fisher's exact test for other variables, $P > 0.05$).

Discussion

This large series of shaken baby syndrome patients is similar to previously reported general series, and thus is likely to be representative of this population.[1,31] The patients were very young and almost one third died.[32,33] One fourth of the patients had factors that make babies more difficult to rear, including prematurity, chronic medical problems, and developmental delay. There was a majority of males for both the patients and the perpetrators.[1,27] Multiple episodes of trauma were evident from the ages of the brain and bone injuries in many patients. Retrospectively, some of our patients had a previous medical encounter where abuse was not recognized.[1,19] Previous and subsequent investigation by social service and court agencies was known. The greater percentage of minority patients may reflect where they obtain emergency care or may indicate a higher suspicion for shaken baby syndrome in medical encounters with minority families, as in other reports.[1,19,34]

The occult nature of SBS means that milder cases could escape clinical detection.[1,19] Even for children who die, there is not always enough forensic evidence to make a definitive diagnosis of homicide. Thus an accurate denominator for SBS studies remains unknown. The limitations of retrospective studies apply to this and many studies of SBS. Data are gleaned from the records of different observers, rather than being gathered from the patient in a standardized manner. However, even for prospective studies, there will be clinical limitations as to the timing and detail of ocular examination that can be tolerated by these fragile patients. Follow-up examinations are often difficult to achieve because of the patients' social situations.

Despite the above limitations, this large series provides data on the occurrence of ocular abnormalities. Retinal hemorrhages are extremely common, occurring in 83% of examined patients. Previous studies, some with RH as an inclusion criterion, have shown an incidence of 50% to 100%.[8,11,19,25,35–38] Most of our patients had bilateral RH, but some had minimal or no hemorrhage, confirming that SBS is not ruled out in the latter circumstance.[39,40]

This comprehensive series showed an increase in the occurrence of RH with the age of the patient (Table 4), unlike previous autopsy series.[24,25] The reasons for this are not clear. Vitreoretinal adherence would still be strong in the older patients. The younger patients did not appear to have greater delays in recognition, which could have allowed the hemorrhages to resolve. The greater force required to shake a larger child may contribute to RH, but a corresponding increase in mortality was not found. Furthermore, there were many fewer older patients for statistical analysis.

Different types of RH were often seen in these patients. Dome-shaped hemorrhages under the internal limiting membrane were not common. They were recognized clinically most often in the macular area, but were found in any area of the retina on histopathologic examination, as reported previously.[39,41] Circular retinal folds were rare. Evidence of vitreous traction on the retina at the apex of

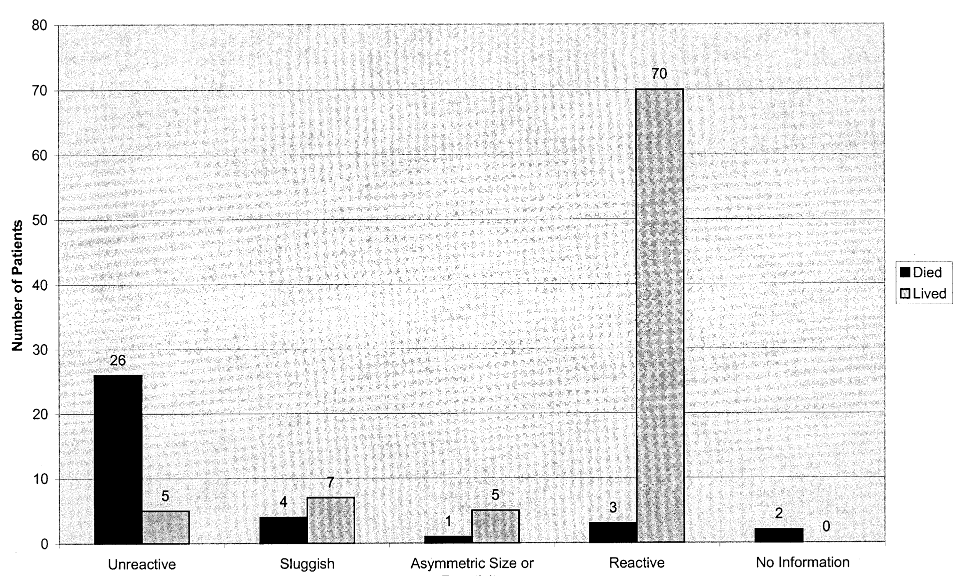

Figure 3. Initial pupillary response and survival.

Table 5. Final Vision versus Initial Vision

	Final Vision in 87 Survivors				
Initial Vision	*Good*	*Poor*	*Poor in One Eye*	*Good at Discharge, No Follow-up*	*No Information*
Fixates and follows	29	1		9	
Light perception	9	1			2
Unreactive	6	10		2	3
No information	5	5	2	1	2
Totals	49 (56%)	17 (20%)	2 (2%)	12 (14%)	7 (8%)

Good = ≥20/40 acuity, attentive to objects more than 10 feet away, or fixates on small objects.

Poor = Inattention to faces, light perception, no light perception, ≤20/200 Teller acuity after 2 years old, or homonymous hemianopsia.

Table 7. Neurologic Outcome at Last Follow-up

	Neurologic Outcome			
Visual Outcome	*Good*	*Mildly Impaired*	*Severely Impaired*	*No Information*
Good	18	4	10	11
Poor		1	13	5
Poor in one eye			2	
No information	4	3	1	15
Totals (%)	22 (25%)	8 (9%)	26 (30%)	31 (36%)

Visual outcome: good = 20/40 acuity, attentive to objects more than 10 feet away, or fixates on small objects; poor = inattention to faces, light perception, no light perception, 20/200 Teller acuity after 2 years old, or homonymous hemianopsia.

Neurologic outcome: good = normal for age; mild = attention deficit disorder or mild speech delay; severe = hemiparesis, ataxia, severe developmental delay.

circular retinal folds and at the edge of dome-shaped hemorrhages was found, as reported previously.[9,11–13] Dense vitreous hemorrhage was very rare.

In the autopsy portion of this study, most eyes had diffuse RH with no predominant location, whereas other series noted a predilection for different retinal areas.[12,25] Here, as found by Rao et al,[42] hemorrhages were noted at all levels of the retina, rather than in particular layers.[41,43] Optic nerve sheath hemorrhage was extremely common, as in other series.[24,25,42,44,45] However, intrascleral hemorrhage was rare compared with other series.[4,25,43,46]

The exclusion of patients who had only impact injuries may account for the lower frequency of direct impact injuries to the globe in this study.[47–50] The autopsy case with peripheral retinal scars appears to be similar to the clinical reports of French[51,52] and English patients[53] who had signs of impact trauma. The angle recessions in our case add further evidence that impact injury is the cause of these lesions. To our knowledge, this is the first histopathologic study of this entity.

There were differences in the findings of autopsy and clinical examinations in this series. The greater severity of injury in patients who died could explain the greater frequency of severe RH and papilledema noted here and elsewhere.[42,54–56] However, the differing circumstances and goals for the clinical and autopsy examinations may also explain some of the differences. Retinal hemorrhages were noted most often clinically in the posterior pole of the fundus, similar to Levin's report[56], whereas in the autopsy portion, most patients had diffuse RH. These fragile patients rarely had scleral depression. The mere presence of any retinal hemorrhage is adequate to raise the concern of SBS. The extent or type of the hemorrhage is less clinically important.

Table 6. Cause of Vision Loss

Bilateral (19 patients)	
CVI alone	11
CVI + optic atrophy	1
CVI + retinal injury	2
CVI + high myopia	1
Retinal injury and HH	1
HH alone	3
Unilateral (2 patients)	
Retinal/optic nerve injury and strabismic amblyopia	1
Strabismic amblyopia	1

CVI = cerebral visual impairment; HH = homonymous hemianopsia.

Asymmetry of RH was noted more often in this autopsy series than clinically.[41,55] This observation is easier to make when both eyes can be seen simultaneously. Other observations such as white-centered hemorrhages and dome-like hemorrhages, although possibly related to more severe injury, may relate to the longer time available for study of the eyes in the pathology laboratory. Also, obscuration of fundus detail by vitreous hemorrhage may be a greater problem for clinical examination than for postmortem examination. Finally, specific avoidance of lengthy, detailed radiology evaluations in these moribund patients may explain why the optic nerve sheath hemorrhage seen at autopsy was not found radiologically.

This large study also provides information on the frequency and cause of vision loss in SBS. One fifth of the survivors were known to have visual impairment, most often the result of brain injury. More of our patients had global bilateral hemispheric injury rather than isolated occipital lobe damage.[37] Unilateral injury causing homonymous hemianopsia was less common.[37,57–59] In previous reports of patients, cerebral visual impairment, ocular causes, and no mention of a cause occurred approximately equally.[20,31–33,36,37,40,47,50,54,58,60–68] Combined cerebral and ocular reasons were mentioned infrequently.[37,56,58–60,67]

In this series, retinal disorders were apparent more often in the patients with unilateral vision loss. Other patients with less apparent bilateral retinal injury could have been missed because electroretinography was not performed.[20,67] The lack of therapeutic benefit of this testing has precluded its acceptance by patients' families.

That visual outcome appeared good in 56% of survivors in the present series, and probably good in the 14% without follow-up because they saw well at discharge (Table 5), is encouraging news for this grim condition, commonly stated to cause blindness.[6,33,65]

This series also demonstrates the prognostic value of a number of ocular findings. The patient's initial vision and pupillary response have been featured infrequently in ophthalmology series.[9] Visual response is part of the Glasgow Coma Score used by intensive care physicians.[69] However, fixed and dilated pupils correlated better with death here and elsewhere[29] than did the coma score. Mills[9] found a significant relationship between no visual response and death in his patients, but not for unreactive pupils. These signs may be missed by ophthalmologists because they often examine the patients after they have received sedation or seizure medications, or after the patients have deteriorated neurologically.

The presence and bilaterality of RH also gave a worse prognosis for survival in the present series, associations less clear in smaller series. Lack of RH may indicate less severe injury to the child or simply survival of an episode of abuse remote enough in time that the hemorrhages had resolved. Our five patients who were brought in for treatment late with large heads but no hemorrhages may represent the latter possibility.

More than half of the patients who had circular folds died, a higher percentage than for the entire series, but similar to Mills' study.[9] However, because this was a rare finding, occurring in only 6% of this large series, it was a less useful predictor.[8,33,35,40,64,70]

For survivors, both good initial and final vision were correlated with a good neurologic outcome, associations not previously noted to our knowledge.

The importance of fundus examinations in detecting abused infants has been stressed in the literature,[71,72] but finding RH is difficult for nonophthalmologists.[40,62,73] This series was not planned as a study of the abilities of nonophthalmologists, but it does show actual experience with a set of patients who often had signs of brain dysfunction and were more likely to have RH. It is encouraging how many patients had ophthalmologic consultations, although these were often at the prompting of the Child Advocacy Center, so a suspicion of abuse was already present. We are not aware of a study in which all infants admitted for irritability, lethargy, or "rule out sepsis" had dilated funduscopic examinations. Hopefully the yield of such a survey would be low; but for the patients found, lives could be saved if further abuse could be prevented.

Basic funduscopy, as well as careful neurologic examinations, may have been discouraged by the availability of CT or magnetic resonance imaging scans. However, the presence of RH is a strong predictor of abnormal scans, making it easier to decide which patients should be scanned.[16] In a few cases, RHs were found, but the initial CT scans were judged to be normal.[74,75] Subsequent CT scans or magnetic resonance imaging scans showed subdural hematoma, confirming the diagnostic value of RH. It should be noted, however, that CT scans can be read incorrectly as well, causing SBS to be missed.[19]

Ophthalmologists at this hospital sometimes listed a long differential diagnosis for the RH and, like pediatricians and radiologists before them,[76] appeared reluctant to suggest abuse. The most likely causes for RH in an infant are birth, abuse, severe coagulopathy, severe accidental trauma, and infection, with other causes being much less likely.[1,8,11,16,25,77] If the child is more than 3 weeks old and did not have a traumatic birth, the first cause is eliminated. Because abuse is life threatening for a young child, and because RH correlates highly with subdural hematoma from various causes, a CT scan should be seriously considered for any child with RH.[16,78]

Hemophilia, von Willebrand's disease, and vitamin K deficiency are the coagulopathies in which mild trauma can cause intracranial bleeding.[79–81] This bleeding can be life threatening in these children, so scanning should be performed. These disorders can be ruled out with hematologic testing.[82]

Accidental trauma rarely causes RH, and the trauma is usually severe.[11,83,84] A vague history that changes on requestioning or is inconsistent with the age of the patient or extent of the injury should be an alert for abuse for any physician. Ophthalmologists are the first physicians to see abused children approximately 4% of the time.[49] Meningitis causes RH rarely; negative cultures point away from this diagnosis.[40,85] Finally, cardiopulmonary resuscitation causes RH very rarely.[86,87]

Unfortunately, there are no clinical ocular findings that are pathognomonic for SBS. Findings such as circular retinal folds and dome-shaped hemorrhages, originally thought to be most characteristic of abuse, have been shown to occur in other conditions.[10,32,87–94] Retinal hemorrhages also cannot be accurately dated to aid police investigations in identifying the perpetrator.

Ophthalmologists can do more for SBS patients than document their RH for forensic purposes. Follow-up is necessary for patients with large dome-shaped hemorrhages because they can break into the vitreous and linger for months in these visually immature patients. Vitrectomy should be considered for these patients, particularly if the electroretinogram response is good.[20,22,23,67,95] Management of amblyopia and correction of refractive errors can help maximize remaining vision.[56] For those children whose vision cannot be improved, referral to early intervention programs can be helpful.

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