ARTICLE

Improved Documentation of Retinal Hemorrhages Using a Wide-Field Digital Ophthalmic Camera in Patients Who Experienced Abusive Head Trauma

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Objective: To describe the clinical use of a wide-field digital ophthalmic camera (RetCam 120; Massie Research Laboratories, Inc, Dublin, Calif) for the documentation of retinal hemorrhages in patients who experienced abusive head trauma.

Design: Case series.

Setting: Pediatric intensive care unit at a tertiary care center.

Participants: Children with suspected abusive head trauma.

Results: Eight children were studied during a 9-month period. The median age of the children was 2.25 months (range, 0.8-18.0 months). There were 4 male and 4 female patients. All patients had intracranial bleeding, documented by computed axial tomographic scans of the head. Of the 8 patients, 6 had bilateral retinal hemorrhages. All patients underwent a formal examination by a pediatric ophthalmologist (R.S. and others) using a wide-field digital ophthalmic camera. Three children died.

Conclusions: The wide-field digital ophthalmic camera allowed good visualization and produced high-quality photographic images, resulting in instant bedside documentation of retinal pathological features. The wide-field digital ophthalmic camera provides a new tool for the evaluation and precise documentation of retinal hemorrhages in suspected and confirmed cases of abusive head trauma.

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RETINAL hemorrhages are a common finding in patients who experience abusive head trauma, occurring in 50% to 90% of infants who were violently shaken.[1-6] Although some authorities[2-4] believe that retinal hemorrhages alone may not be diagnostic of shaken baby syndrome, their presence clearly reinforces the diagnosis when accompanied by intracranial injuries. Therefore, documentation of retinal hemorrhages is imperative to support the diagnosis of shaken baby syndrome. Traditionally, retinal hemorrhages are documented by freehand drawings, which can be time-consuming and may not accurately reflect retinal pathological features. While these drawings may give investigators and medical personnel an idea of the severity and number of the hemorrhages, they do not compare to actual retinal photographs.

Retinal photography using specialized handheld cameras improves bedside documentation of retinal hemorrhages, but requires special training and can be limited by the camera's field of view. Slit-lamp retinal cameras provide high-quality wide-field images, but require considerable patient cooperation and technical expertise and lack portability. Digital photography provides another alternative for documenting retinal pathological features. This technology has been incorporated into a wide-field digital ophthalmic camera (RetCam 120; Massie Research Laboratories, Inc, Dublin, Calif) capable of producing high-quality real-time images of the retina.

RESULTS

During a 9-month period, we examined 8 children (median age, 2.25 months; age range, 0.8-18.0 months) admitted to the pediatric intensive care unit. There were 4 male and 4 female patients. The primary admitting diagnosis, retinal findings, and computed tomographic scan results of the head are shown in the **Table**. A history of trauma was found in 4 patients: fall from a couch (n=2), dropping the child 105 cm to the floor (n=1), and

PARTICIPANTS AND METHODS

All children admitted to the pediatric intensive care unit at our institution with suspected abusive head trauma, including intracranial hemorrhages and/or retinal hemorrhages, were included in this study. Age, race, sex, presenting complaint, and survival data were recorded. Intracranial hemorrhages were documented by computed axial tomographic scans of the head. Retinal hemorrhages were documented by the attending intensivist at the time of admission. All children with suspected abusive head trauma underwent a formal ophthalmologic examination using a wide-field digital ophthalmic camera. This study was conducted with approval for human investigations by the institutional review board at Eastern Virginia Medical School, Norfolk.

a child's head hitting the sink (n=1). Of the 8 patients, 6 had bilateral preretinal and intraretinal hemorrhages by direct ophthalmic examination and 2 had no retinal hemorrhages. Subdural and/or subarachnoid bleeding was noted on computed tomographic images of the head in all patients. Four patients had skeletal injuries consistent with nonaccidental trauma. Two patients required cardiopulmonary resuscitation before admission to the pediatric intensive care unit. Seven patients underwent mechanical ventilation, and 6 had generalized seizures. The median length of stay in the pediatric intensive care unit was 4½ days (range, 2-9 days). The median total hospital stay was 8 days (range, 2-17 days).

All children underwent a formal ophthalmologic examination using a wide-field digital ophthalmic camera to confirm and document retinal hemorrhages. Examinations using the wide-field digital ophthalmic camera were performed by a pediatric ophthalmology attending physician (R.S. and others). The pupils were dilated using 0.2% cyclopentolate hydrochloride and 1% phenylephrine hydrochloride (Cyclomydril; Alcon Laboratories, Inc, Ft Worth, Tex) or 1% cyclopentolate hydrochloride (Cyclogyl; Alcon Laboratories, Inc) and anesthetized with 0.5% proparacaine hydrochloride (Alcon Laboratories, Inc) in 5 of the 8 patients studied. Three patients had fixed and dilated pupils. Hydroxypropyl methylcellulose (Goniosol; Ciba Vision Ophthalmics, Atlanta, Ga) was used in all patients to provide an interface between the image capture unit and the cornea. In 7 of the 8 patients, the retina was easily visualized. In 1 child, images appeared cloudy as a result of blood in the vitreous humor; however, the images obtained were of acceptable quality. Multiple photographs were obtained, allowing for selection of the best and elimination of inferior-quality and out-of-focus images.

At hospital discharge, 2 patients were released to foster care, 1 was institutionalized, and 2 were released to their mother. Three patients died. In 4 cases, the perpetrator confessed. Perpetrators were the father or male caretaker in 3 cases and the mother in 1.

COMMENT

Retinal hemorrhages are a common finding in patients who experience abusive head trauma and support the diagnosis of shaken baby syndrome.[1-4,7] Retinal hemorrhages caused by abuse can be unilateral or bilateral,[1,6,8,9] and result from rapid acceleration and deceleration and rotational forces as the child's head moves unsupported during the shaking event.[2-4,7]

Retinal hemorrhages associated with abusive head trauma are different than those associated with increased intracranial pressure, cardiopulmonary resuscitation, or childbirth.

With inflicted head injury, retinal hemorrhages tend to be multiple, tend to involve multiple retinal layers, and are distributed throughout the retina to the ora serrata.[10] With cardiopulmonary resuscitation, retinal hemorrhages tend to be small punctate hemorrhages, tend to be confined to the posterior pole of the retina, and tend to occur infrequently.[10,11] Retinal hemorrhages are a common finding in childbirth, occurring more frequently during vacuum-assisted deliveries, followed by spontaneous vaginal deliveries; they are infrequent with cesarean deliveries.[12,13] Direct compression to the globe and hemodynamic and rheologic changes during labor and delivery contribute to retinal hemorrhages during childbirth.[13] Most retinal hemorrhages associated with childbirth are intraretinal and typically resorb by the time the newborn is aged 7 to 10 days,[12,14] although they may persist up to 30 days.[13] Emerson and colleagues[13] found no preretinal hemorrhages or vitreous blood and only rare isolated subretinal hemorrhages in newborns with retinal hemorrhages, resulting in their conclusion that intraretinal hemorrhages in infants older than 1 month are unlikely to be related to birth trauma. Increased intracranial pressure can produce retinal hemorrhages, but these hemorrhages tend to be confined to the posterior pole and there are relatively few.[10] Last, traumatic retinoschisis in children has never been described in any entity other than shaken baby syndrome.[10] Clearly, accurate documentation of retinal hemorrhages is important for diagnosing shaken baby syndrome.

Traditionally, retinal hemorrhages were observed using a direct ophthalmoscope or a binocular indirect ophthalmoscope and documented by freehand drawings. Although these pictures provide a visual image used by investigators and medical personnel to document the number and severity of the retinal hemorrhages, photographs more accurately depict the type and extent of the hemorrhage and are not dependent on an artistic drawing.

A wide-field digital ophthalmic camera uses fiberoptic illumination to provide clear, high-resolution, real-time images. It provides a 120° field of view, producing images of the retina that can be stored and recalled in a portable and easy-to-use unit. The image capture unit is placed on the cornea over the dilated pupil, providing real-time images of the retina. These images are viewed on an external monitor, and the retina is photographed, providing instant documentation of retinal injuries (**Figure 1** and **Figure 2**). Digital images are stored, and medical record–ready photographs can be printed at the

Clinical Characteristics of the 8 Patients

Patient No./Sex	Admitting Diagnosis	Retinal Findings	Head CAT Scan Findings*	Bony Trauma	Outcome
1/F	Cardiac arrest	Bilateral preretinal, intraretinal, and subretinal hemorrhages	Frontal SD hematoma, SA and IP hemorrhages, and cerebral edema	Skull, humerus, tibia, and rib fractures	Died
2/F	Respiratory arrest	None	Bilateral SD hematoma and cerebral edema	Skull and rib fractures	Died
3/M	Vomiting	Bilateral preretinal, intraretinal, and subretinal hemorrhages	SA hemorrhage and cerebral edema	None	Died
4/M	Seizures	Bilateral preretinal, intraretinal, and subretinal hemorrhages	SA and SD hemorrhage	None	Survived
5/F	Respiratory arrest	Bilateral preretinal and intraretinal hemorrhages	SD hemorrhage	Scapula, humerus, femur, ilium, and rib fractures	Survived
6/M	Vomiting	Bilateral preretinal, intraretinal, and subretinal hemorrhages	Bilateral frontal SD hematoma and cerebral edema	None	Survived
7/M	Seizures	Bilateral preretinal and intraretinal hemorrhages	Bilateral SD hematoma	None	Survived
8/F	Seizures	None	SD hematoma	Skull, clavicle, and rib fractures	Survived

*CAT indicates computed axial tomographic; SD, subdural; SA, subarachnoid; and IP, intraparenchymal.

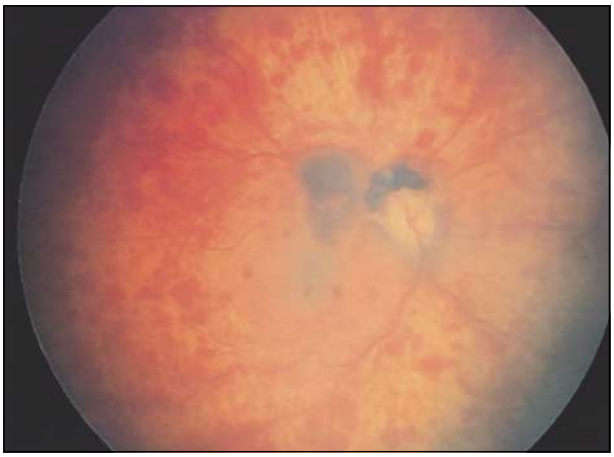

Figure 1. Image of the retina produced with a wide-field digital ophthalmic camera (RetCam 120; Massie Research Laboratories, Inc, Dublin, Calif), showing extensive intraretinal and preretinal hemorrhages throughout the periphery of the retina, with 1 large hemorrhage lateral to the optic nerve.

Figure 2. Image of the retina produced with a wide-field digital ophthalmic camera (RetCam 120; Massie Research Laboratories, Inc, Dublin, Calif), showing extensive retinal and preretinal hemorrhages throughout the periphery.

bedside with the patient's information imprinted on the photograph, including the time and date of the study. In addition, software allows for the electronic transfer of digital images to other physicians.

Photographs of the retina are obtained at the ophthalmic examination in some centers. This documentation typically depends on an ophthalmologist with special training in and equipment for photographing the retina. A wide-field digital ophthalmic camera requires minimal training and provides a much wider field of view compared with other more elaborate systems used to photograph the retina. This allows photographic documentation to occur at any time by physicians other than ophthalmologists and improves visualization of hemorrhages that are more peripheral. In addition, digital photographic images provide immediate and precise documentation of retinal hemorrhages, eliminating time-consuming freehand illustrations or photographic processing. The visual impact of photographic images allows multiple reviewers to independently review photographic documentation of retinal hemorrhages and may play a crucial role in the medicolegal aspects of abusive head trauma as well. Last, a wide-field digital ophthalmic camera is portable and easily transported to the bedside, allowing examination of the retina in even the most critically ill child.

A wide-field digital ophthalmic camera may prove to play an important role in the early diagnosis and intervention of abusive head trauma. Jenny and colleagues[15] noted that an incorrect diagnosis was made in one third of patients who experienced abusive head trauma; the delay resulted in further injury and death to some children. In addition, retinal hemorrhages were missed in almost 30% of abusive head trauma cases when examination of the retina was performed by a nonophthalmologist.[16] Use of a wide-field digital ophthalmic camera by nonophthalmologists is relatively easy and allows the fundus of most children to be viewed. Compared

What This Study Adds

Freehand drawings may not always reflect the extent of retinal hemorrhages in patients who have experienced abusive head trauma. Retinal photography using specialized handheld cameras improves bedside documentation of retinal hemorrhages, but requires special training and can be limited by the camera's field of view. Wide-field digital photography using a wide-field digital ophthalmic camera can improve bedside documentation of retinal pathological features in this select group of patients.

To our knowledge, this study is the first to describe the use of wide-field digital photography for documenting retinal hemorrhages in patients who have experienced abusive head trauma. The wide-field digital ophthalmic camera allowed good visualization and produced high-quality photographic images, resulting in instant bedside documentation of retinal pathological features. This technology improves efficiency and provides a new tool for the evaluation and precise documentation of retinal hemorrhages in suspected and confirmed cases of abusive head trauma.

with a direct ophthalmic examination using an ophthalmoscope, the wide field of view allows visualization of the retina to the ora serrata. This technology may prove useful by allowing rapid identification of retinal hemorrhages in suspected cases of abusive head trauma, allowing for earlier intervention.

A wide-field digital ophthalmic camera is also an ideal teaching tool, allowing students, residents, other allied health personnel, and investigators to instantly visualize retinal pathological features on a 43.2-cm monitor. Digital photographic images can be stored, permitting the creation of teaching files, and images can be reviewed and compared with previous examination results.

There are limitations to a wide-field digital ophthalmic camera. It is not a substitute for a formal ophthalmic examination. This diagnostic imaging tool should be used in collaboration with an ophthalmologist, ensuring that proper diagnosis and follow-up are obtained for children who have retinal pathological features. Image quality may be affected by blood in the vitreous humor and is dependent on patient cooperation. In our limited experience, image quality was somewhat affected by blood in the vitreous humor, but acceptable images were obtained. An examination using a wide-field digital ophthalmic camera may not be well tolerated by the awake or combative child; however, this examination would be no different than attempting to examine the eyes using an ophthalmoscope. In addition, it was not difficult to obtain images of children with an altered mental status even when they were not mechanically ventilated and heavily sedated. Imaging of a nondilated pupil is possible, but shadowing of the retina can limit the field of view and may result in image degradation. Printed images using the color printer have some image deterioration, and although the image quality is acceptable, there is no comparison with the resolution provided by the external monitor. Last, although expensive (approximately $64 000 with the color printer), a wide-field digital ophthalmic camera is versatile and can be used to image other retinal lesions besides those associated with abusive head trauma.

In summary, a wide-field digital ophthalmic camera is a unique camera that provides a new level of sophistication for the immediate documentation and evaluation of retinal pathological features in suspected cases of abusive head trauma.

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