Accepted Manuscript

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PII: S0379-0738(17)30145-7
DOI: http://dx.doi.org/doi:10.1016/j.forsciint.2017.04.008
Reference: FSI 8821

To appear in: *FSI*

Received date: 23-11-2016
Revised date: 4-4-2017
Accepted date: 10-4-2017

Please cite this article as: Supot Puanglumyai, Suree Lekawanvijit, The importance of optic nerve sheath hemorrhage as a postmortem finding in cases of fatal abusive head trauma: a 13-year study in a tertiary hospital, Forensic Science Internationalhttp://dx.doi.org/10.1016/j.forsciint.2017.04.008

The importance of optic nerve sheath hemorrhage as a postmortem finding in cases of fatal abusive head trauma: a 13-year study in a tertiary hospital

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Highlights

- Important role of postmortem optic nerve examination in identifying fatal abusive head trauma
- Optic nerve sheath hemorrhage (ONSH) is easily identified at autopsy with high accuracy.
- High diagnostic performance of combined ONSH and subdural hemorrhage in fatal abusive head trauma
- ONSH should be included as a major criterion for postmortem identification of abusive head trauma.

The importance of optic nerve sheath hemorrhage as a postmortem finding in cases of fatal abusive head trauma: a 13-year study in a tertiary hospital

Abstract

Fatal abusive head trauma is a major cause of death in children and toddlers who suffer from cruel physical abuse. Postmortem differentiation of fatal abusive head trauma from accidental head trauma can be a complicated process. This consecutive case series study aimed to determine the role of subdural optic nerve sheath hemorrhage (ONSH) in 70 autopsy cases of children ≤ 3 years old in making this differentiation. The study took place over a 13 year period (between August 1st 2003 and July 31st 2016) at a tertiary hospital in Thailand. Eleven cases were diagnosed with fatal abusive head trauma and 10 were identified as being accidental closed head trauma cases. Bilateral retinal hemorrhage was noted in antemortem medical records in every hospitalized abusive head trauma case (n=10). Upon autopsy, ONSH was observed in all 11 fatal cases of abusive head trauma (bilateral=10 and unilateral=1) but not in any cases of accidental head trauma (0/5). Subdural hemorrhage was found in 10 out of 11 abusive head trauma victims but not in any of the 10 with accidental head trauma. Other postmortem findings in abusive head trauma included subarachnoid hemorrhage (5/11), marked brain swelling (3/11), skull fracture (4/11) and brain contusion (1/11). This study suggests that ONSH, together with subdural hemorrhage, plays an essential role in an accurate postmortem diagnosis of fatal abusive head trauma. Therefore, an ocular investigation should be performed in all autopsy cases where child abuse is suspected and where there is no reliable history/witnesses, confession or antemortem ophthalmologic examination.

Key words: Optic nerve sheath hemorrhage; Abusive head trauma; Child abuse; Autopsy; Postmortem investigation

Introduction

Physical child abuse is a major cause of death in infants and toddlers. Up to 80% of fatal child abuse cases are due to abusive head trauma.[1-3] The mechanism of injury in cases of abusive head trauma may result from severe rotational and translational acceleration due to vigorous shaking (non-contact force), direct impact (contact force), or a combination of both.[2,4] Generally, an initial given history in correlation with the mechanism of injury is usually inadequate and not reliable in most cases of child abuse. Thus, the diagnostic process of abusive head trauma can be very difficult when differentiating from accidental head trauma especially in cases with combined rotational acceleration and direct impact force. In non-fatal abusive head trauma cases, the investigation is usually carried out by a collaborative team of child abuse pediatricians and other specialists, such as ophthalmologists, radiologists, neurosurgeons, psychologists, nurse practitioners, certified social workers and attorneys while forensic pathologists play an important role in fatal cases.

In suspected cases of child abuse, clinical diagnosis of abusive head trauma is generally based on a classic triad of findings: diffuse axonal injury (presenting with coma or death), subdural hemorrhage and/or subarachnoid hemorrhage and intraocular hemorrhage. However, in recent years there has been considerable debate over the efficacy of the triad in accurately identifying a child who suffers from vigorous shaking. Although presence of the triad has been accepted by a majority of physicians as a diagnostic criteria for abusive head trauma or shaken baby syndrome in children without a history of motor vehicle collision[5], there is also a wide range of other medical conditions presenting with the triad, for example, birth difficulties, coagulopathy, infections, metabolic disorders, severe hypoxia and seizures.[6] Recently, there is a systematic review based on 30 selected publications from the original search of 3773 that aimed to determine the diagnostic accuracy of the triad in detecting shaken baby syndrome.[7] The authors concluded that there was limited scientific evidence demonstrating the association between the triad or its individual components and traumatic shaking, and that there is insufficient scientific evidence to assess the diagnostic accuracy of the triad to identify traumatic shaking.[7] All the information mentioned above has raised serious concerns about the diagnostic tools that have been generally acceptable for establishing a diagnosis of abusive head trauma.

On the other hand, several studies [8-18] have described ocular findings in cases of child abuse, including intraocular lesions (retinal hemorrhage, circumferential retinal folds with macular schisis, peripheral circumferential retinal folds, peripheral retinoschisis and peripapillary scleral hemorrhage, intrascleral hemorrhage and vitreous hemorrhage) and optic nerve sheath hemorrhage (ONSH). Postmortem ocular and orbital examination in two studies [10,17] suggested that the orbital or optic nerve injury is more common in shaken baby syndrome than in cases of accidental head trauma. A systematic review [4] also demonstrated that ONSH is significantly more indicative of abusive head trauma than other causes of pediatric death.

However, at present there are still no standard criteria for postmortem diagnosis of abusive head trauma. The purpose of this report is to examine whether in cases of suspected child abuse ONSH has a role in postmortem determination of abusive head trauma.

Materials and methods

This is a consecutive case series study of ONSH in fatal abusive head trauma cases. All pediatric medicolegal related deaths aged under 3 years during a 13 year period (August 1st 2003 – July 31st 2016) from the Department of Forensic Medicine, Chonburi Hospital, Ministry of Public Health, Thailand were included in the study.

The data was collected from autopsy reports, as well as from medical records in fatal cases which were admitted to the pediatric intensive care unit. Abusive head trauma cases were identified based on autopsy findings and clinical summary (by a multidisciplinary child protection team in cases being hospitalized before death) by having at least 2 of the following: 1) intracranial hemorrhage, 2) retinal hemorrhage, 3) marked brain swelling on neuroimaging or at autopsy, 4) inadequate history to explain the degree of head injury, and 5) confessions/reliable witnesses or child abuse being confirmed in legal proceedings.

Cases with fatal child abuse without severe brain parenchyma loss due to direct impact and fatal accidental closed head trauma were also retrieved based on the recorded cause of death, manner of death and legal findings as well as antemortem medical records and history, if applicable.

Demographic data and forensic postmortem examination, in particular any ocular investigation enabling the identification of ONSH, were carefully reviewed. ONSH was confirmed by either gross examination (Figure 1) or histologic sections (Figure 2).

Dissection technique for orbital exenteration was performed as described elsewhere.[10] Briefly, after removal of the brain, the orbital roof was then completely removed without injuries to the underlying periosteum using small cartilage cutters, small scissors or rongeur. The periosteum was separated by using blunt dissection from the orbital walls. 360-degree conjunctival peritomy was performed by using small scissors and forceps then carefully dissect around the globe between undermining Tenon fascia and the sclera. The optic nerve was then exposed by carefully dissect surrounding tissue for an *in situ* examination. In most cases, ONSH was easily observed (Figure 1, upper panels). However, in cases with minimal ONSH placing an instrument (such as non-traumatic forceps/clamps) under the optic nerve then moving back and forth was helpful to identify ONSH as blood was squeezed and pooled on both lateral sided of the optic nerve (Figure 1, lower panels). This technique also confirmed unilateral ONSH (Figure 1, right lower panel) or an absence of ONSH (Figure 3)

After removing the globe and orbital contents en bloc along with the canalicular optic nerve, the en bloc was fixed in 10% neutral buffered formalin for 48-72 hours. A 3 mm thick tissue slice cut through mid-horizontal plane of the orbit and the optic nerve in an anteroposterior direction was processed for histopathology. Hematoxylin and eosin stained sections (4 µm thick) were assessed under a light microscope (Figure 2). ONSH was diagnosed when numerous extravasated red blood cells were observed in the optic nerve sheath, usually most prominent in subdural space (see Figure 2, lower panel).

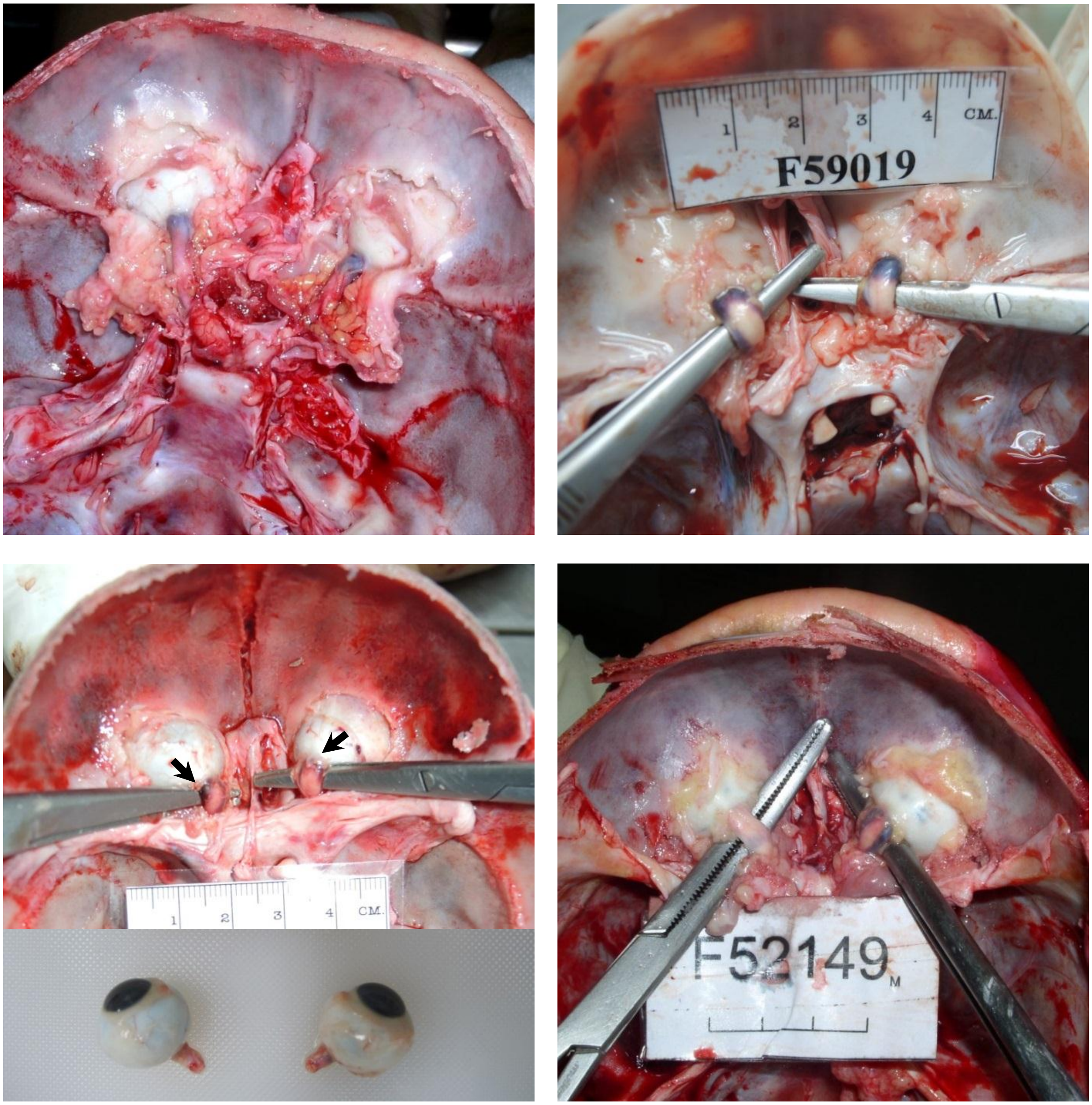

Figure 1 Subdural optic nerve sheath hemorrhage (ONSH) in cases of fatal abusive head trauma. Upper panel (cases #1 and #5 in Table 1) demonstrates bilateral ONSH that is clearly evident after brain removal. ONSH in AHT typically initiates from the attaching point to the eyeball (left lower panel, arrows), extends distally and does not connect to the intracranial subdural/subarachnoid hemorrhage. A careful *in situ* examination is crucially required in cases with minimal ONSH which is more difficult to evaluate in removed specimens (left lower panel, inset). Unilateral ONSH is observed in case #3 (Table 1) (right lower panel).

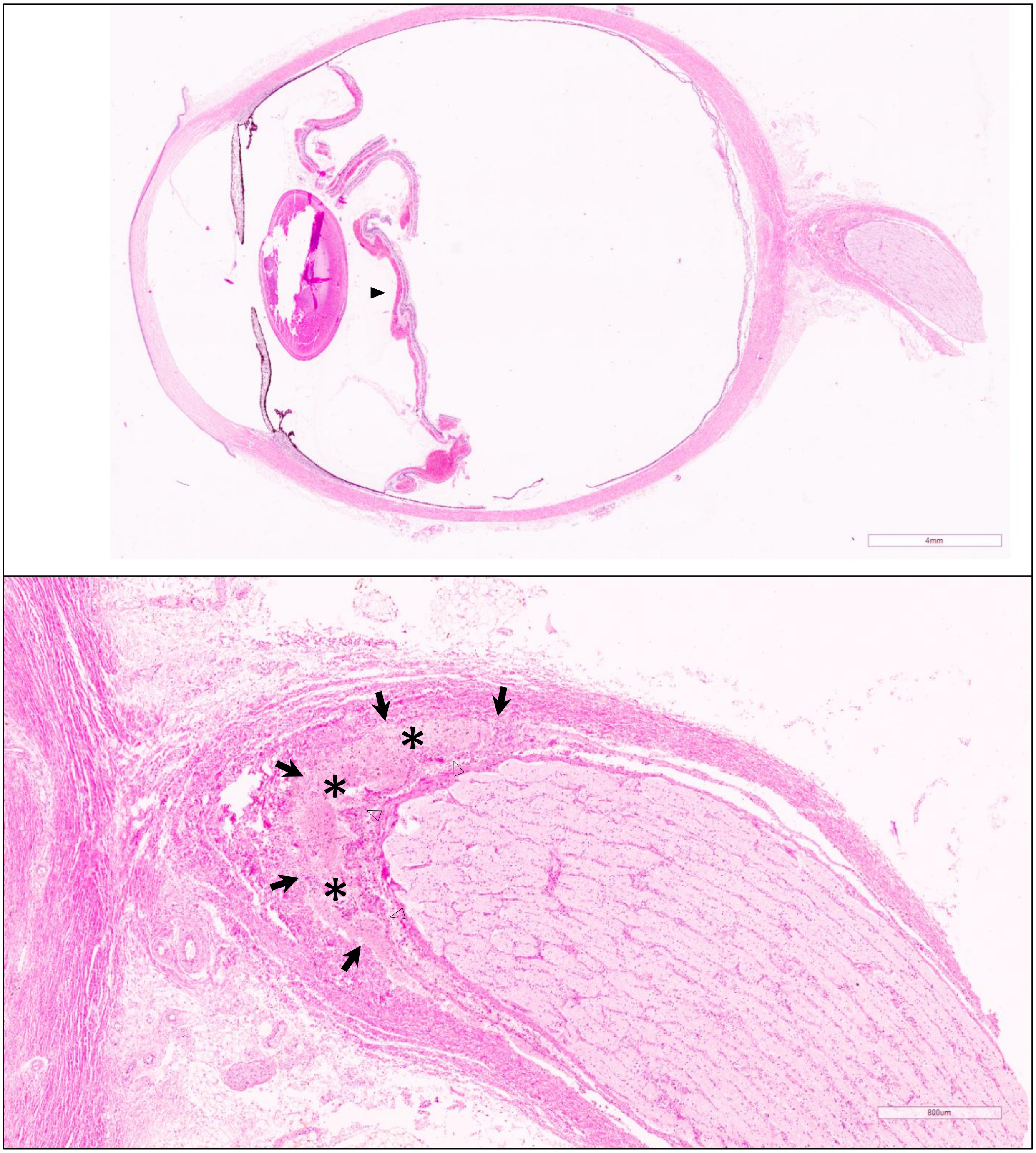

Figure 2 Histology of subdural optic nerve sheath hemorrhage (ONSH). Upper panel shows a sagittal section through the eyeball and retrobulbar portion of the optic nerve. Lower panel: Numerous extravasated red blood cells (asterisks) between the dura (arrows outlining the innermost surface) and arachnoid (open arrowheads) maters represent subdural ONSH. Note: retinal hemorrhage is observed in this case (arrowhead, upper panel) (case #11 in Table 1). Hematoxylin and eosin stain.

Results

Between 2003 and 2016, forensic postmortem examinations were performed on 70 young children aged 3 years or under. Sixteen (22.9%) suffered fatal child abuse and 54 (77.1%) died of other causes, including accidental head trauma (10), accidental blunt abdominal trauma (1), sudden infant death syndrome (22), congenital heart and pulmonary anomalies (12), asphyxia (5), drowning (2) and pneumonia (2).

Of the 16 fatal child abusive cases, 11 (68.8%) were abusive head trauma. Table 1 summarizes the demographic characteristics, autopsy findings and available antemortem clinical examination data of the 11 fatal AHT victims. The mean victim age was 12.1 months old (range, 1-24 months). Six (54.5%) were female. No initial history of accidental trauma was found in 9 (81.8%) victims while a history of a short-height fall was recorded in 2 (18.2%) victims. External signs of blunt head injury such as scalp contusion or skull fractures were found in 8 (72.7%) victims. An antemortem eye examination performed by ophthalmologists and/or pediatricians found retinal hemorrhage in all hospitalized victims (n=10). Upon autopsy, ONSH was found in every abusive head trauma case (10 were bilateral and 1 was unilateral) without obvious proximal injury such as base of skull or orbital fracture. The ONSH observed in all AHT victims initially affected the immediate retrobulbar part of the optic nerve and did not connect to intracranial subdural/subarachnoid hemorrhage (Figures 1). Other intracranial injuries included subdural hemorrhage (10/11), subarachnoid hemorrhage (5/11) and marked brain swelling (3/11).

The causes of death in the other 5 abusive cases which did not meet the criteria for diagnosis of abusive head trauma were manual strangulation (1), blunt chest and abdominal injury (1), and blunt abdominal injury (3) as shown in Table 2. The mean victim age was 21.5 months old (range, 0.5-36 months). For case #1, the records showed that there had been a direct impact head injury resulting in a skull fracture and subarachnoid hemorrhage without subdural hemorrhage and marked brain swelling but data concerning the optic nerve examination was not available in this case.

Table 3 summarizes the demographic characteristics, autopsy findings and available antemortem clinical examination data of the 10 accidental closed head trauma victims. The mean victim age was 12.45 months old (range, 0.5-36 months). Two (20.0%) were female. Although optic nerve examination was only performed in 5 cases, ONSH was absent (Figure 3).

Table 1 Demographic data, history, clinical and autopsy findings of fatal abusive head trauma cases

Case	Age	Sex	Trauma history	Antemortem clinical examination		Autopsy findings					Time between incident/admission and death
				RH	Others	SDH	SAH	Marked brain swelling	ONSH	Others	
1	5 mo	F	None	Yes, bilateral	-Scalp contusion	Yes	Yes	No	Yes, bilateral	-Scalp contusion	5 d
2	15 mo	F	Short-height fall (60 cm)	Yes, bilateral	-Scalp contusion -Multiple-stage contusions of body -Bilateral pneumothorax	Yes	No	Yes	Yes, bilateral	-Scalp contusion -Multiple-stage contusions of body	6 d
3	5 mo	M	Short-height fall (100 cm)	Yes, bilateral	-Scalp contusion	Yes	No	No	Yes, unilateral	-Scalp contusion -Skull fracture -Cerebellar contusion	3 d
4	7 mo	F	None	Yes, bilateral	-Unusual scar at left axilla -Bilateral pneumothorax	Yes	Yes	No	Yes, bilateral	-Scar at left axilla	5 d
5	24 mo	M	None	Yes, bilateral	-Scalp contusion -Multiple-stage contusions of body	Yes	No	No	Yes, bilateral	-Scalp contusion -Multiple-stage contusions of body -Goat pepper in stomach	1 d
6	1 mo	M	None	Yes, bilateral	-Contusion at lip	Yes	Yes	No	Yes, bilateral	-Contusion at lip -Vitreous hemorrhage	1 d
7	24 mo	F	None	Yes, bilateral	-Scalp contusion -Multiple contusions of body	Yes	No	No	Yes, bilateral	-Scalp contusion -Multiple contusions of body	15 d
8	8 mo	F	None	Yes, bilateral	-Second degree burn of left hand	No	No	Yes	Yes, bilateral	-Skull fracture	3 d
9	1 mo	M	None	Yes, bilateral	-	Yes	No	Yes	Yes, bilateral	-None	3 d
10	1 mo	M	None	Yes, bilateral	-Scalp contusion	Yes	Yes	No	Yes, bilateral	-Scalp contusion -Skull fracture	6 d
11	3 mo	F	None	n/a*	n/a*	Yes	Yes	No	Yes, bilateral	-Scalp contusion -Skull fracture -Retinal hemorrhage	n/a

F, female; mo, month; M, male; n/a, no data available; n/a*, no data available due to no antemortem hospitalization; ONSH, optic nerve sheath hemorrhage; RH, retinal hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

Table 2 Demographic data, history, clinical and autopsy findings of the other 5 fatal abusive trauma cases

Case	Age	Sex	Trauma history	Antemortem clinical examination		Autopsy findings				
				RH	Others	SDH	SAH	Marked brain swelling	ONSH	Others
1	16 days	M	Physical assault	n/a*	n/a*	No	Yes	No	n/a	-Scalp contusion -Subconjunctival hemorrhage -Skull fracture -Strap muscle contusion of neck
2	23 mo	M	None	n/a*	n/a*	No	No	No	No	-Contusion at chest and abdomen -Ruptured right atrium -Massive hemoperitoneum
3	36 mo	F	Physical and sexual abuse	n/a*	n/a*	No	No	No	n/a	-Multiple abrasions of head and body -Contusion of both labia majora and minora -New tear of hymen and anus -Massive hemoperitoneum
4	24 mo	M	Physical assault	n/a*	n/a*	No	No	No	n/a	-Peritonitis -Colon injury
5	24 mo	F	None	n/a*	n/a*	No	No	No	n/a	-Multiple contusion of chest and body -Massive hemoperitoneum

F, female; mo, month; M, male; n/a, no data available; n/a*, no data available due to no antemortem hospitalization; ONSH, optic nerve sheath hemorrhage; RH, retinal hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

Table 3 Demographic data, history, clinical and autopsy findings of accidental head trauma cases

Case	Age	Sex	Trauma history	Antemortem clinical examination		Autopsy findings				
				RH	Others	SDH	SAH	Marked brain swelling	ONSH	Others
1	16 mo	M	Short-height fall (30cm)	n/a*	n/a*	No	No	No	n/a	-Contusion on head -Skull fracture -Epidural hemorrhage
2	16days	M	Short-height fall (60cm)	n/a*	n/a*	No	Yes	No	n/a	-Contusion on head -Skull fracture
3	12 mo	M	Short-height fall (50cm)	n/a*	n/a*	No	Yes	No	No	-Contusion on head -Skull fracture
4	10 mo	M	Short-height fall (100cm)	n/a*	n/a*	No	No	Yes	No	-Contusion on head -Scalp contusion -Massive retrohemoperitoneum -Fracture and dislocation of lumbar spine (L3-L4)
5	1 mo	F	Car accident	n/a*	n/a*	No	No	Yes	n/a	-Scalp contusion -Skull fracture
6	4 mo	M	Car accident	n/a*	n/a*	No	No	No	n/a	-Scalp contusion -Depressed skull fracture -Intracerebral hemorrhage
7	12 mo	M	Pedestrian accident	n/a*	n/a*	No	No	Yes	No	-Multiple abrasions on body -Scalp contusion -Massive hemoperitoneum
8	10 mo	M	Motorcycle accident	n/a*	n/a*	No	No	No	n/a	-Scalp contusion -Skull fracture -Brain laceration
9	23 mo	F	Motorcycle accident	n/a*	n/a*	No	No	Yes	No	-Large scalp contusion
10	36 mo	M	Crush injury due to Ferris wheel	n/a*	n/a*	No	No	Yes	No	-Scalp contusion -Skull fracture -Transverse fracture base of skull at the middle cranial fossa

F, female; mo, month; M, male; n/a, no data available; n/a*, no data available due to no antemortem hospitalization; ONSH, optic nerve sheath hemorrhage; RH, retinal hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage.

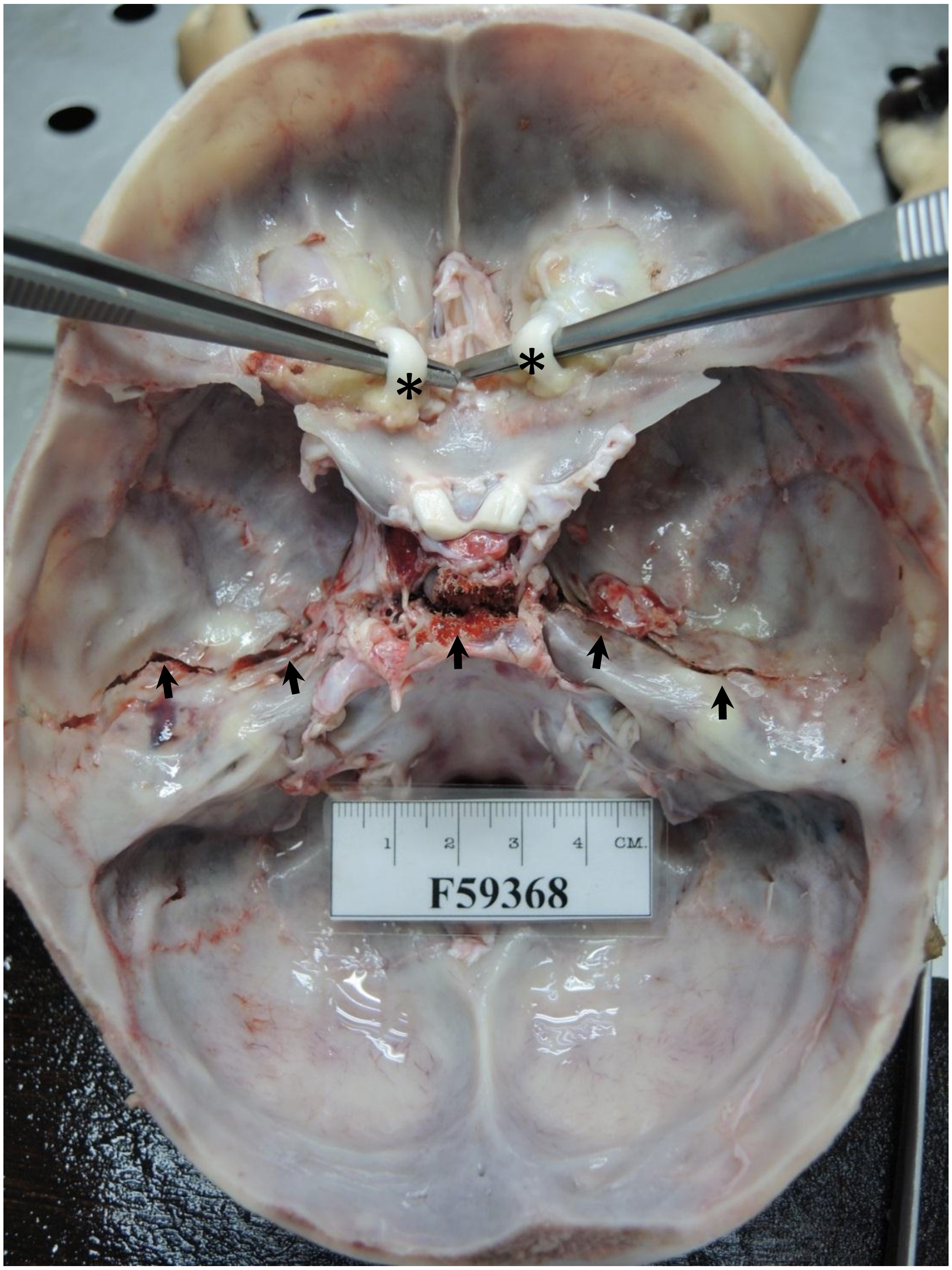

Figure 3 Unremarkable optic nerve in a case of accidental head trauma. Representative images of accidental head trauma (case #10 in Table 3) show a transverse fracture line at the base of the skull (arrows). Both optic nerves are unremarkable (asterisks).

Discussion

Lambert et al[19] first defined the presence of ONSH in cases of child abuse. The present study has demonstrated ONSH in all 11 fatal abusive head trauma cases but not in the accidental head trauma cases or in the other 5 abusive victims. The reported prevalence of ONSH in child abuse varies from 40% to 100%.[1,8,10,16,20] Wygnanski-Jaffe et al. showed significantly higher prevalence in abusive than accidental head injuries (78% vs 39%, n=18 for each group).[10] A systematic review reported that ONSH has a sensitivity and specificity of 72% and 71%, respectively, for enabling a clear diagnosis of abusive head trauma.[4] Among ocular findings, ONSH has been demonstrated to have a higher correlation with child abuse (odds ratio = 32.5, $P<0.001$) than does an intraocular hemorrhage (odds ratio = 18.9, $P<0.001$).[17]

However the pathogenesis of ONSH in abusive head trauma victims is poorly understood. The possible explanation may be that the optic nerve is longer than the distance from the apex of the orbit to the back of the globe. This allows rotational and translational acceleration movements of the globe in the orbital cavity when a child is vigorously shaken. Globe movement transfers shear forces to the optic nerve and potentially causes stretching of the bridging veins. Lambert et al[19] also suggested that a sudden increase in intracranial pressure may lead to dilatation of the optic nerve sheath with tearing of the bridging veins thereby contributing to subdural ONSH. The immediate retrobulbar portion of the optic nerve which attaches to the globe appears to be the point of highest tension. This may explain why ONSH most commonly originates from this area as observed in the present study as well as in a previous study.[21]

Cases of abusive head trauma may be classified into three groups depending on the mechanical force: contact injury, non-contact injury and a combination of both. Contact injury happens when the head knocks or is knocked by an object, while non-contact injuries are caused by rotational and translational acceleration of the head. Contact forces cause injuries at the site of impact and may result in scalp contusion or laceration, skull fracture, subarachnoid hemorrhage and epidural hemorrhage. However, an absence of scalp contusions does not indicate that there is no direct impact because a young child's scalp is very elastic and may recoil on impact.[2] Non-contact forces in abusive head trauma are mostly due to violent backwards and forwards shaking that largely generates translational (or linear) acceleration, responsible for compressive forces to damage the brain. However, rotational acceleration usually occurs simultaneously as there is an axial rotation of the child's head on the neck. Rotational forces with the same magnitude as compressive forces of translational acceleration potentially cause more severe brain injury[22], as well as stretching of the bridging veins in subdural space.[23] The typical findings in abusive head trauma due to pure non-contact forces include diffuse axonal injury, subdural hemorrhage and intraocular hemorrhage, normally without significant skull/orbital fracture. Compared with abusive head trauma caused by contact injury, intraocular hemorrhage is more common in abusive head trauma caused by non-contact injury.[24] In the present study, a combination of contact and non-contact injury appears to be the most common causes of abusive head trauma in young children. All cases, except case #9 in Table 1, had findings indicative of both non-contact injury (such as retinal hemorrhage and ONSH) and contact injury (scalp/skull injury and/or subarachnoid hemorrhage).

Previous publications of autopsy series [10,17] suggest that ONSH may have a role in enabling forensic pathologists to identify abusive head trauma in cases of suspected child abuse, despite varied prevalences. The present study found ONSH in all abusive head trauma victims, suggesting a high sensitivity (100%) of ONSH, either bilateral or unilateral, in postmortem diagnosis of abusive head trauma. Of note, ONSH is more easily determined in *in situ* examination rather than in enucleated specimens especially where there is a minimal lesion (Figure 1, left lower panel). ONSH is also more readily detected at autopsy, compared with other intraocular hemorrhages such as retinal hemorrhage that usually need time for tissue processing before a final histological evaluation.

Several studies [10,20,25-29] demonstrated other causes of ONSH, such as accidental head trauma due to motor vehicle accidents, toppled televisions and stairway falls. However direct blunt trauma to the head and orbital area in these causes were much more severe than in fatal abusive head trauma and reasonably explained the presence of ONSH. For example, in one case of pediatric head injuries, which were caused by a toppled television, the autopsy showed widely-displaced skull fractures extending from the right parietal bone to the left parietal bone and including a transverse fracture at the base of skull at the middle of the cranial fossa.[25] In general, ONSH appears to be specific to abusive head trauma when the mechanism of injury is rotational acceleration of the head. This is most commonly caused by vigorous shaking. However, in cases of fatal abusive head trauma resulting from isolated direct contact or a combination of mechanisms where the degree of blunt head injury is very severe, ONSH or even the conventional triad of subdural hemorrhage, intraocular hemorrhage and diffuse axonal injury may be unable to differentiate abusive from accidental head trauma without information from scene investigations, reliable third party witnesses, other concomitant postmortem findings or confession. Although, in the present study, ONSH was not evident in the other 9 causes including: accidental head trauma (n=5); blunt thoracoabdominal injury from physical abuse (n=1); sudden infant death syndrome (n=1); congenital heart disorder (n=1) and asphyxia (n=1), the specificity of ONSH cannot be determined due to a too small number of evaluated cases.

Often, the clinical history from caretakers is inconsistent with the obvious injuries in cases of fatal child abuse. Low level falls or no history of trauma are the most common initial histories given in abusive head trauma cases.[30] It is noteworthy that a history of a lucid interval is likely false in abusive shaken-impact head trauma because non-contact forces from violent head shaking usually lead to immediate and persistent diffuse brain injury.[24,31] In the present study, 81.8% of all abusive head trauma cases did not have any history of trauma provided by the caretakers and the remaining 2 cases only had a history of short height falls. Short falls have been demonstrated to rarely cause subdural hemorrhage, retinal hemorrhage or death.[32,33] Without a history or confession in cases suspected abusive head trauma, presence of other injuries in abusive head trauma cases including multi-stage contusions, burns, pneumothorax and unusual scars are very helpful in enabling the establishment of an accurate diagnosis.

In conclusion, the history of trauma from the caretakers may not be reliable in cases where infants and young children are suspected of having abusive injuries. It is vitally important when assessing a child presenting with trauma to include the possibility that the injuries may not be accidental. However an intense debate over the accuracy of the ‘generally acceptable’ diagnostic criteria for abusive head trauma, which is particularly crucial for non-fatal cases with regard to the subsequent management, is still inconclusive. In fatal cases a complete postmortem examination, including an ocular evaluation, should be performed by an experienced forensic pathologist in all cases of sudden unexplained infant death or suspected physical child abuse, especially in non-hospitalized cases without an antemortem clinical investigation. A complete ocular examination may be particularly helpful in identifying abusive head trauma cases with minimal external physical injury that could help other children in the family.

Acknowledgements

This work was supported by The Chonburi Research Center (Chonburi Hospital); Faculty Research Fund (Faculty of Medicine, Chiang Mai University) and The Ananda Mahidol Foundation.

The authors thank Assistant Professor Dhunyawat Treenate for his useful suggestions in the completion of the manuscript.

Figure legends

Figure 1 Subdural optic nerve sheath hemorrhage (ONSH) in cases of fatal abusive head trauma. Upper panel (cases #1 and #5 in Table 1) demonstrates bilateral ONSH that is clearly evident after brain removal. ONSH in AHT typically initiates from the attaching point to the eyeball (left lower panel, arrows), extends distally and does not connect to the intracranial subdural/subarachnoid hemorrhage. A careful *in situ* examination is crucially required in cases with minimal ONSH which is more difficult to evaluate in removed specimens (left lower panel, inset). Unilateral ONSH is observed in case #3 (Table 1) (right lower panel).

Figure 2 Histology of subdural optic nerve sheath hemorrhage (ONSH). Upper panel shows a sagittal section through the eyeball and retrobulbar portion of the optic nerve. Lower panel: Numerous extravasated red blood cells (asterisks) between the dura (arrows outlining the innermost surface) and arachnoid (open arrowheads) maters represent subdural ONSH. Note: retinal hemorrhage is observed in this case (arrowhead, upper panel) (case #11 in Table 1). Hematoxylin and eosin stain.

Figure 3 Unremarkable optic nerve in a case of accidental head trauma. Representative images of accidental head trauma (case #10 in Table 3) show a transverse fracture line at the base of the skull (arrows). Both optic nerves are unremarkable (asterisks).

Conflict of interest

None

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