

Ocular findings in the evaluation of abusive head trauma in children

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Abstract:

PURPOSE: Abusive head trauma (AHT) is a form of child physical abuse that can result in major ocular injuries. This study describes the clinical presentation and ocular manifestations of infants diagnosed with AHT in a tertiary care center in Saudi Arabia.

METHODS: This is an observational, retrospective, cross-sectional study from 2015 to 2022 conducted at King Abdullah Specialized Children's Hospital (KASCH) in Riyadh, Saudi Arabia. Inclusion criteria include infants <2 years of age, diagnosed with AHT that had an eye examination as part of the evaluation.

RESULTS: A total of 25 (50 eyes) cases of AHT had an eye examination documented in the electronic patients' records. The majority were males 19 (76%), and <6 months of age 10 (40%). About half of the children were healthy 13 (52%), and 12 (48%) had underlying physical illness. All patients had computed tomography scans. Subdural bleeding was noted in 22 (88%), 1 (4%) had epidural, and 4 (16%) had subarachnoid bleed. External ocular signs were noted in 8 (32%) patients only, including raccoon eyes, periorbital bruises, subconjunctival hemorrhage, and nonfixating eyes. Fundus findings were bilateral in 18 (72%), unilateral in 2 (8%), and normal in 5 (20%). In those with findings, the majority of 34 (68%) eyes had multiple retinal hemorrhages, 4 (8%) had vitreous hemorrhages, 2 (4%) retinal detachments, and 1 (2%) retinoschisis.

CONCLUSION: Fundus examination is an important part of the comprehensive examination of children with suspected AHT; the majority of patients had an abnormal fundus examination with the tendency of bilateral findings.

Keywords:

Abusive head trauma, child abuse, retinal hemorrhage, Saudi Arabia, shaken baby syndrome

INTRODUCTION

Abusive head trauma (AHT) is an injury to the skull and intracranial structures of a newborn or child younger than 5 years due to violent shaking or abrupt impact.^[1] Accidental and inflicted pediatric head trauma is a major contributing factor to morbidity and mortality.^[2,3] The majority of physical abuse deaths in children under the age of 5 years are caused by AHT, with mortality rates ranging from 11% to 36%.^[4] Even for those who are fortunate enough to survive, it is estimated that up to 80% of children may experience developmental delay as a result of head trauma or will lose their eyesight as a result of cortical visual impairment.^[5,6]

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There are various risk factors for AHT, including particular behaviors and circumstances involving the child, the family, and the caregiver.^[7] One risk factor at the child's level is infantile colic or inconsolable crying.^[7,8] Infant crying is greatest during 6–8 weeks of age; hence, AHT is highest at this period.^[9] Another risk factor for abuse is the child's disability or children with underlying diseases who are difficult to care for.^[10] At the level of family dynamics, the lack of prenatal care, poor education level, low socioeconomic status, families with one parent, and young parents are all risk factors.^[11–13]

Following head trauma, the child may present with a range of symptoms from nonspecific symptoms that need only supportively care to severe life-threatening presentation requiring immediate care.^[14] The initial clinical signs

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of AHT may range from subtle signs such as decreased interaction, poor feeding, vomiting, and lethargy, to severe such as apnea, respiratory distress, loss of consciousness, or seizures.^[1]

Given the social, psychological, and legal implications, an accurate diagnosis of AHT can be difficult and contentious. The American Academy of Pediatrics has issued a policy statement that highly supports investigations that involve, rigorous medical history taking, physical examinations, and diagnostic tests.^[15] For a comprehensive diagnosis, a multidisciplinary team that includes neurology, radiology, ophthalmology, and other specialties may be required. Child protective services and police enforcement may also be involved in the situation.

The eye is vulnerable to damage in AHT due to its anatomical placement. Child physical abuse can result in either direct or indirect ocular injuries.^[6] Childhood vision impairment can have a significant long-term impact on everyday functioning and psychological well-being.^[16] Retinal hemorrhages (RHs) are the most prevalent manifestations, occurring in about 75% of children who have suffered AHT and are assumed to be secondary to the repetitive acceleration-deceleration forces of the head in the setting of the weak neck muscles, with or without severe impact force on the head.^[17] RHs which are multiple, multilayered, and spread to the peripheral retina are characteristic of AHT.^[18,19] RH was observed in 78% of AHT versus 5% of nonabusive head trauma (nAHT).^[20]

Research on child abuse in general and AHT in particular is limited in Saudi Arabia. The first case series of child physical abuse with a description of AHT from Saudi Arabia was reported in the literature in 1994.^[21] In a recent study from Saudi Arabia, AHT ranged from 2.4 to 5.3 per million population.^[22] In another report from Riyadh, Saudi Arabia looking at the characteristics of nonaccidental fractures in abused children, skull fractures, and AHT were the most common sites of fractures in 40%.^[23] Despite the recognition of child abuse and neglect and many studies in the field in the last 30 years, the true scope of the problem of AHT and its ocular characteristics in Saudi Arabia remained unknown in the absence of accurate and reliable statistics. Few population-based epidemiological studies enabled us to estimate the frequency and identify the risk factors of AHT; however, there is little knowledge on the accompanying characteristics such as RH, making it an area that needs further exploration. Therefore, this study aimed to describe the ocular manifestations of AHT cases in a tertiary care center in Saudi Arabia.

METHODS

This is a descriptive, observational, retrospective cross-sectional study that was conducted at King Abdullah Specialist Children's Hospital (KASCH) in Riyadh, Saudi Arabia from 2015 to 2022. This tertiary care center serves a steady number of National Guard military personnel, civilians, and dependents. The research was approved by the Institutional Review Board at King Abdullah International

Medical Research Center. No consent form was required as patients' charts were reviewed.

All suspected AHT cases in children <2 years of age presented to KASCH and had eye examinations were included in the study. The included cases were evaluated and confirmed for AHT suspicion by the Suspected Child Abuse and Neglect (SCAN) team. The SCAN team is a consultation-based, multidisciplinary service at KASCH, the members of the team evaluate all cases of child abuse and neglect who present to the emergency room or outpatient or are referred for further diagnosis and evaluation. The SCAN team keeps records of evaluated cases with the diagnosis of child maltreatment in a hospital electronic system.

Patients' electronic medical records were reviewed, and data were collected, entered in an Excel sheet, and stored in a password-protected computer.

The study variables were collected and organized into three main sections: the first section included patients' demographical data, including age, gender, nationality, social background, mother's age (younger than 20 years was considered a young mother), patients' comorbidities, imaging modality, brain hemorrhage type, and laterality. The second part evaluated the characteristics of the trauma, time from injury to the presentation (>12 h was considered delayed), and the event as well as signs and symptoms at the time of diagnosis. The third part included information about the eye involvement such as fundus examination findings and follow-up findings and outcomes.

Data presentation and statistical analysis

After collecting the patient's data, they were checked for completeness and any missing information. Then, the collected data were entered and coded into Microsoft Excel. For categorical variables, they were described using frequencies and percentages.

RESULTS

A total of 25 cases, 50 eyes of AHT were included in the study. More than half of the patients were male 19 (76%), and 6 (24%) were female. The majority of children were <1 year old 19 (76%), whereas only 6 (24%) were between 1 and 2 years old. Regarding the social risk factors, the most common was a family history of domestic violence (DV) 9 (36%). About half of the children were previously healthy 13 (52%), and 12 (48%) had underlying physical illnesses such as prematurity, developmental delay, and cerebral palsy. Patients' demographics are shown in Table 1.

The most common clinical presentation at the time of the diagnosis was drowsiness/loss of consciousness/hypoactivity in 20 (80%) patients, followed by seizures/abnormal movements 13 (52%), cutaneous signs including facial and body bruises 11 (44%). Moreover, 8 (32%) had eye signs including raccoon eyes, periorbital bruises, subconjunctival hemorrhage, and nonfixating eyes. Five (20%) had cardiovascular symptoms including hypotension and bradycardia [Figure 1].

Table 2 shows the mechanism of injury and presentation as reported by caregivers. Falls were the most commonly reported mechanism of trauma in 17 (68%), only 2 (8%) of the children were thrown or shaken, and 6 (24%) had no history of trauma. Moreover, 12 (48%) of the children presented late (above 12 h

Table 1: Demographic characteristics of the 25 children diagnosed with abusive head trauma

Demographics	n (%)
Gender	
Male	19 (76)
Female	6 (24)
Age	
<6 months	10 (40)
6–12 months	9 (36)
>1 year	6 (24)
Nationality	
Saudi	21 (84)
Non-Saudi	4 (16)
Social risk factors	
Maternal chronic/mental illness	4 (16)
Divorced parent/single parent	4 (16)
History of domestic violence	9 (36)
Polygamy	2 (8)
Young mother (<20 years)	3 (12)
Co-morbidities	
Healthy Child	13 (52)
Underlying physical illness	12 (48)
Imaging modality	
CT	25 (100)
MRI	12 (48)
Intracranial hemorrhage type	
Subdural	22 (88)
Epidural	1 (4)
Subarachnoid	4 (16)
Intracranial hemorrhage laterality	
Unilateral	8 (32)
Bilateral	15 (60)

CT: Computed tomography, MRI: Magnetic resonance imaging

from trauma) to the emergency room, and 4 (16%) patients had undergone cardiopulmonary resuscitation (CPR) in the hospital.

Table 3 demonstrates the fundus examination findings in 50 eyes of 25 patients. Out of the 25 AHT cases that were included in our study, 5 (20%) patients had normal fundus examination findings upon examination, 2 (8%) had unilateral findings, and the majority, 18 (72%) had bilateral findings. Of the 50 fundus examinations, 12 (24%) showed normal eyes and 4 (8%) showed vitreous hemorrhage, whereas the most common finding was RH extending to the ora serrata accounting for 37 (68%). Upon the follow-up over 1 year from the event, 4 (16%) patients showed normal follow-up fundus examinations. In addition, 9 (36%) had long-term sequela that affected the sight such as optic nerve atrophy in 2 (8%), nystagmus in 2 (8%), strabismus in 2 (8%), amblyopia in 1 (4%), traumatic 6th nerve palsy in 1 (4%), and macular pucker in 1 (4%). Furthermore, 7 (28%) patients were lost to follow-up.

Figure 2 shows illustration of different fundus findings.

DISCUSSION

Child abuse is associated with handicaps in development across multiple domains,^[24] with mental health problems being among the most pronounced sequelae of child abuse and neglect.^[25] Our study aimed to investigate the ocular manifestations of an abused child as well as the clinical presentation and fundal examination findings. We examined a total of 25 cases of AHT. Notably, our findings revealed that AHT is more common in male infants where more than three-quarters of the patients were males (76%). Our study aligns with a common trend seen in some previous research, studies from the literature have indicated a tendency for males to be more frequently affected by AHT.^[22] This trend could be attributed to various factors, including the disposition of male children to display behaviors that may render them more vulnerable to both

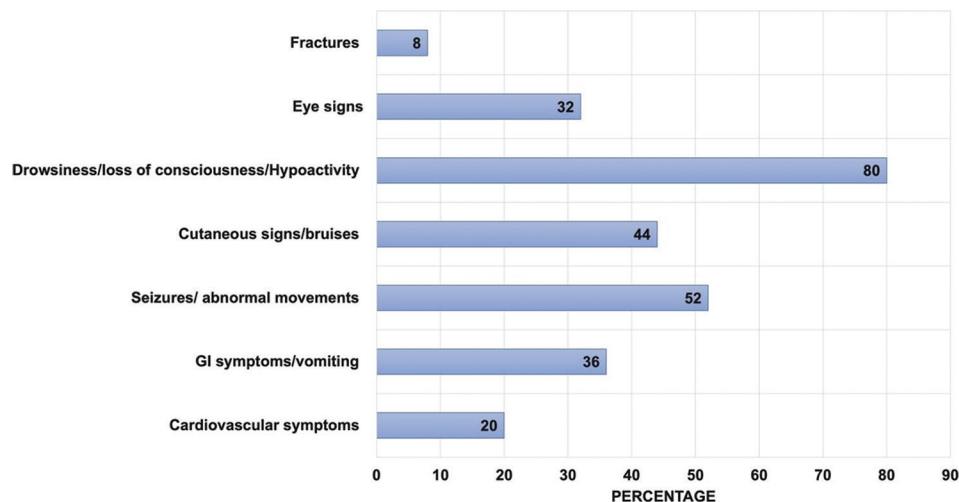


Figure 1: Presenting signs and symptoms at the time of the diagnosis

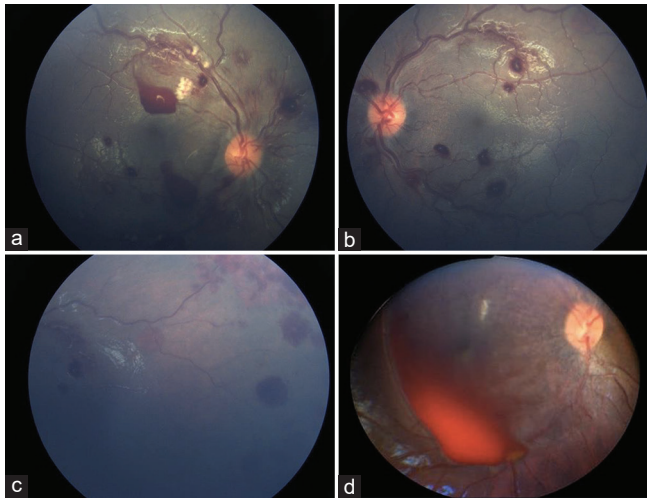


Figure 2: Illustrations of different fundus findings. (a) right eye, (b) left eye. Multiple multilayer retinal hemorrhages (RH) and RH with faint centers are seen in the fundus examination of a child with suspected abusive head trauma. (c) The periphery of the left eye shows the extension of RH, (d) hypopigmented folds of retinoschisis cavity in another child that became more evident 2 weeks after the attack

accidents and, unfortunately, punitive measures that escalate to child abuse.^[26] Furthermore, child physical abuse cases, including AHT, have shown a greater prevalence in males, in studies conducted in Saudi Arabia.^[22] This observation is also consistent with the broader body of research in the region on different types of child maltreatment.^[27] A study was conducted at the Forensic Medicine Center of the Ministry of Health in Riyadh, Saudi Arabia between 2015 and 2016. A total of 385 sexual assault cases were included in the study. The majority of the cases were boys (72.1%).^[28]

Our study identified and recorded various social risk factors of child abuse; among them, DV was reported as the most common social risk factor in 9 (36%). This family dysfunction and violence may transcend to the child where the abuser usually is a close relative or parent. This is similar to the findings of studies carried out in Jamaica, where parental violence is the most commonly reported risk factor associated with child abuse.^[29] Children living in families with DV are more prone to physical abuse either directly or indirectly and subsequently to AHT and RHs.^[30]

The clinical presentations of AHT exhibited significant variability among the cases during admission. Drowsiness and loss of consciousness were the most commonly reported symptoms, mirroring the findings of other studies.^[31] Importantly, it is worth noting that the signs and symptoms of AHT can range from mild to severe, as evidenced by the percentage of cases in our study that required resuscitation. This variation in clinical presentation underscores the complexity of identifying and diagnosing AHT cases. In some instances, the early signs may resemble common childhood illnesses or accidental head injuries, making it challenging for health-care professionals to promptly recognize and differentiate AHT

Table 2: Characteristics of the trauma event reported on the abusive head trauma children

	n (%)
Previous visit to ER	
Yes	12 (48)
No	13 (52)
Trauma type according to history	
Falls	17 (68)
The baby was thrown or shaken	2 (8)
No history of trauma	6 (24)
Delay in presentation (>12 h)	
Yes	12 (48)
No	10 (40)
Unknown (time was not noted)	3 (12)
CPR performed on presentation to the hospital	
Yes	4 (16)
No	21 (84)

CPR: Cardiopulmonary resuscitation, ER: Emergency room

Table 3: Fundus examination findings in 50 eyes of 25 patients

	n (%)
Patients with affected eye	
Unilateral	2 (8)
Bilateral	18 (72)
Normal eye examination	5 (20)
Fundus examination findings	
Normal	12 (24)
Retinal hemorrhage	34 (68)
Vitreous hemorrhage	4 (8)
Commotio retinae	1 (2)
Retinal detachment	2 (4)
Cotton wool spots	1 (2)
Peripapillary hemorrhage	1 (2)
Retinal edema	1 (2)
Pale/abnormal optic nerve	3 (6)
Retinoschisis	2 (4)
Level of hemorrhage	
Preretinal	12 (24)
Intraretinal	21 (42)
Multilayered	10 (20)
Follow-up examination	
Optic nerve atrophy	2 (8)
Nystagmus	2 (8)
Strabismus	2 (8)
Amblyopia	1 (4)
Traumatic sixth nerve palsy	1 (4)
Macular pucker	1 (4)
Lost follow-up	7 (28)

from other conditions. Therefore, medical practitioners must maintain a high level of suspicion and vigilance when dealing with cases of head trauma in children.

Considering the reported etiology of AHT, falls were the most commonly reported mechanism of trauma 17 (68%), which is also consistent with previous studies.^[32] About 12 (48%) of the children presented late to the emergency room, this is attributed

to the fact that the abusers tend to keep the case discrete in order not to be accused,^[33] which would eventually lead to catastrophic complications, as our results reported that 4 (16%) patients were abused and delayed presentation to the level they had to undergo cardiac resuscitation (CPR) at the hospital.

We conducted fundus examinations on all our patients, highlighting the importance of eye examinations in AHT cases, on 50 eyes belonging to 25 patients with suspected AHT. The findings revealed a range of ocular abnormalities. Notably, 20% of the patients had normal fundus examination findings, and 80% had abnormal eye examinations, suggesting that not all AHT cases exhibit visible ocular abnormalities upon examination. This underscores the importance of comprehensive eye assessments, even in the absence of apparent symptoms.^[34]

In the literature, the majority of AHT cases, 83%, exhibited bilateral findings in their fundus examinations. This high prevalence of bilateral findings suggests that ocular abnormalities in AHT cases frequently affect both eyes,^[20] further emphasizing the need for thorough examinations of both eyes.^[35] A study done in 2019 used susceptibility-weighted imaging in MRI, which is highly suited to identify various forms of intracranial hemorrhage and RH in AHT. Out of 26 AHT cases, RH was identified in the right eye (42.8%) and in the left eye (38.1%).^[36] A systematic review reported the retinal signs that distinguish AHT from nAHT and found that RHs were bilateral in 83% of AHT compared with 8.3% in nAHT.^[20]

In our study, 68% of the AHT cases exhibited RH as the most common ocular finding. This prevalence aligns with findings from previous research,^[37] where 47 out of 77 children who died as a result of suspected child abuse had RHs. Notably, these hemorrhages were more frequently observed in cases where the child was subjected to shaking or swinging rather than severe direct head trauma, emphasizing the importance of considering the mechanism of injury in AHT cases.^[38]

Regarding follow-up examinations, the presence of optic nerve atrophy in 8% of the cases suggests a significant impact on the optic nerve, possibly indicating severe injury or compression during AHT. Nystagmus observed in 8% could be the result of anterior visual pathway damage occurring in the 1st year of life. The occurrence of strabismus in 8% of the cases underscores the vulnerability of ocular alignment in children subjected to AHT. The identification of amblyopia in 4% of the cases implies a risk of impaired visual development, potentially resulting from reduced visual input during the critical period of visual maturation. Traumatic 6th nerve palsy, present in 4% of the cases, indicates damage to the sixth cranial nerve, leading to impaired eye movement control. The discovery of macular pucker in 4% of the cases suggests a potential impact on the central vision due to the formation of scar tissue on the macula.

In addition, 8% of our cases exhibited optic nerve atrophy. This suggests that certain AHT cases may experience lasting

damage to the optic nerve, potentially leading to visual impairments.^[39] In general, visual potential in children who have suffered severe head trauma can be impacted by retinal scar from retinoschisis and hemorrhage, optic nerve atrophy, and cortical visual impairment, with the latter being the most common cause of visual impairment.^[40]

A study reported the rates of vision loss and ocular findings outcome after AHT with RHs over 5 years of follow-up.^[41] At the last follow-up, 46% of 96 children had abnormal vision for their age in at least one eye. Ocular results included strabismus (43%), amblyopia (40%), and cortical visual impairment (19%). This shows that in children with AHT with RHs, there is an increased risk of long-term visual impairment and ophthalmologic morbidities.^[41]

It is noteworthy that 24% of the patients were not re-examined due to being lost to follow-up, which may affect the outcome findings. This highlights a challenge in studying AHT cases, where some individuals may not receive ongoing medical care or assessments. Understanding the reasons for patients being lost to follow-up is essential for improving the continuity of care for AHT survivors, thus emphasizing the importance of follow-up examinations.^[42]

A limited number of Saudi studies were published in this scope; hence, this study is considered a valuable base for evidence. This study highlighted an important issue which aids to pave the way as the base for further studies in this aspect. Nonetheless, the study was not without limitations. It was limited by a small sample size; therefore, it may be difficult to generalize the findings to the total community. A bigger sample size of patients would have improved the statistical significance of the results. In addition, poor follow-up was seen in 28% of the cases, which may affect the clinical judgment on the actual visual outcome. This is a retrospective assessment of a registry database that does not provide complete AHT information. Furthermore, the retrospective data acquired were limited to the quality of documentation in the medical record, which depends on clinical circumstances and eye examination findings which could pose a limitation on the findings in some patients. In addition, effects and psychosocial abnormalities were not investigated in our study. These topics could be explored in future studies.

CONCLUSION

More than half of the patients had bilateral eye findings, and RH was the most common finding during fundal examination. A proportion had long-term complications such as optic nerve atrophy and strabismus indicating a poor outcome of eye sights in AHT in Saudi Arabia. The results not only contribute to our understanding of AHT but also underscore the need for continued research and comprehensive care strategies to address the varying needs of AHT survivors, especially concerning their ocular health. Further efforts to strengthen child protection services in Saudi Arabia are recommended.

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Conflicts of interest

There are no conflicts of interest.

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