

Abusive head trauma in children: Characteristic neuroimaging findings in two cases

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Abstract

Background: Abusive head trauma is one of the major causes of severe head injury in infants and is associated with significant morbidity and mortality. Shaking impact is the most common mechanism of trauma. Early recognition is crucial for timely intervention and prevention of further injury.

Cases: We present two cases of children with abusive head trauma. An abandoned 3-year-old female child presented with severe dehydration and emaciation. On examination, she had hypertonia of all limbs, with delayed developmental milestones. A clinical diagnosis of dyskinetic cerebral palsy was considered. Computed tomography (CT) and magnetic resonance imaging (MRI) revealed bilateral chronic gross subdural hemorrhages causing severe compression of cerebral parenchyma. Old hemorrhagic contusions with gliotic changes were noted in frontoparietal and temporal regions. A linear fracture was identified in right parietal bone extending into squamous part of right temporal bone.

2-month-old female child presented with an episode of seizures, with no history of trauma. CT of the brain demonstrated acute-on-subacute right subdural hemorrhage with a midline shift of 5.8 mm, along with few contusions in right parietal lobe.

Conclusion: These findings highlight that subdural hemorrhage, particularly in the absence of a relevant trauma history, is a strong indicator of abusive head trauma. This case series highlights the characteristic CT and MRI findings of abusive head trauma and highlights the crucial role of radiologists in recognizing imaging patterns suggestive of non-accidental injury, particularly when clinical history is absent or inconsistent.

Keywords: Abusive head trauma, subdural hemorrhage, pediatric neuroimaging, non-accidental injury, CT, MRI

Introduction

Abusive head trauma (AHT), previously referred to as non-accidental injury, battered baby syndrome, or shaken baby syndrome, is a severe form of child abuse resulting from inflicted injury to the head and brain [Pezeshki A et al., Chiesa A et al.] It is typically diagnosed based on the inconsistencies between clinical history provided by caregivers and the observed pattern of injuries, as well as the presence of injuries of varying ages. Radiologists play a crucial role in identifying these findings and raising suspicion for abuse [Nguyen A et al.].

Common imaging findings in abusive head trauma include subdural hemorrhage, retinal hemorrhage, rib fractures, cerebral atrophy, and ventriculomegaly. [Ewing-Cobbs L et al.,] Although abusive head trauma has been extensively described in pediatric literature, delayed diagnosis is common because clinical manifestations are often nonspecific and caregiver history may be misleading. Therefore, recognition of characteristic neuroimaging findings is essential.

In April 2009, American Academy of Pediatrics recommended the term 'abusive head trauma' for inflicted head injuries in children. [Christian CW]. They are associated with worse outcomes than seen in non-abusive head trauma, emphasizing the importance of early diagnosis, appropriate reporting, and timely intervention [Niederkrötenhaler T et al.,].

The diagnosis of abusive head trauma can be challenging, particularly in infants and young children, due to nonspecific clinical presentations such as vomiting, fever, irritability, and lethargy. [Jenny C et al.,].

Subdural hemorrhage is the most common and significant intracranial finding and is strongly associated with shaking-

type mechanisms of injury [Karibe H]. The presence of subdural hemorrhage, especially in the absence of a significant history of accidental trauma, warrants thorough evaluation for possible non-accidental injury [Hoskote A et al.,]. in this case report, we present two cases of abusive head trauma and highlight the characteristic imaging findings, emphasizing the role of radiology in early diagnosis and management.

Written informed consent was obtained from the patient for publication of this case report and accompanying images

Case Report 1

A 3-year-old female child was found abandoned and brought to the pediatric department. At admission, the child was severely dehydrated with a low-volume pulse. She was emaciated and had pallor.

On neurological examination, hypertonia of the upper limbs and hypotonia of the lower limbs were noted. Developmental milestones were not attained. A clinical diagnosis of dyskinetic cerebral palsy was considered.

Computed tomography (CT) and magnetic resonance imaging (MRI) of the brain revealed bilateral chronic gross subdural haemorrhages causing significant compression of the cerebral parenchyma. Cerebral and cerebellar atrophy were noted. Old haemorrhagic contusions with gliotic changes were seen in frontoparietal and temporal regions.

A linear fracture was identified in the right parietal bone extending into the squamous part of the right temporal bone laterally and coronal suture medially.

MR angiography demonstrated normal visualization of the P1 segment of the posterior cerebral artery, M1 segment of the middle cerebral artery, and anterior cerebral artery. Ophthalmological examination was unavailable.

Imaging findings were highly suggestive of chronic abusive head trauma, and the child was referred to child protection services for further evaluation.

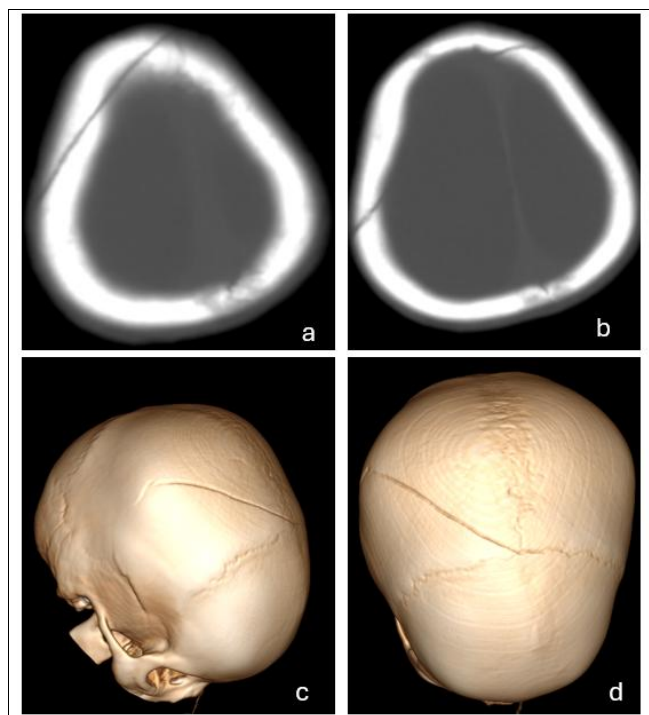


Fig 1: Axial non-contrast CT images in the bone window (a, b) and three-dimensional volume-rendered CT reconstructions (c, d) demonstrate a linear, non-depressed fracture involving the right parietal bone with extension into the squamous part of the right temporal bone and coronal suture

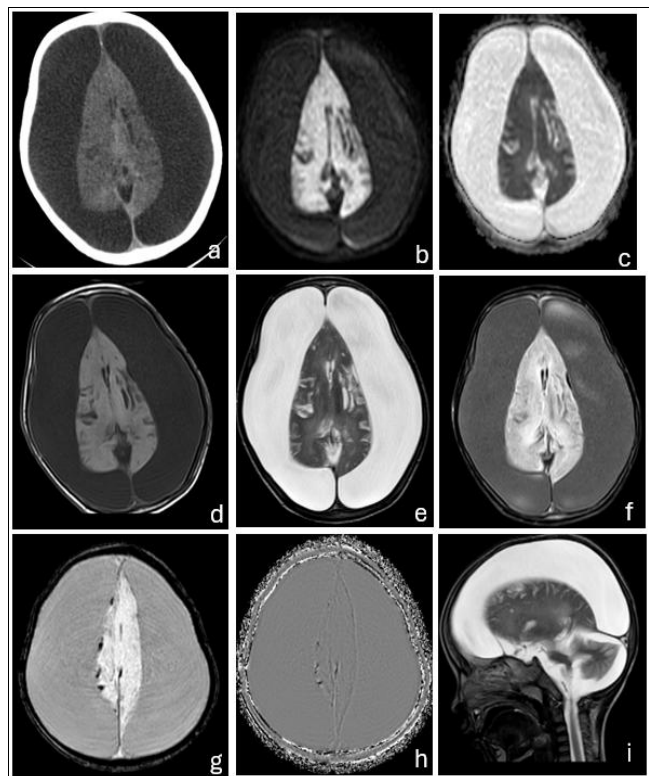


Fig 2: Axial non-contrast CT image (a), diffusion-weighted image (DWI) (b), apparent diffusion coefficient (ADC) map (c), T1-weighted image (d), T2-weighted image (e), fluid-attenuated inversion recovery (FLAIR) image (f), susceptibility-weighted image (SWI) (g), filtered phase image (h), and sagittal T2-weighted image (i) demonstrate large bilateral chronic subdural

hematomas producing marked mass effect with severe compression of the cerebral parenchyma. Multiple susceptibility blooming foci on SWI with corresponding signal changes on the filtered phase image are consistent with chronic blood products and hemosiderin deposition. Associated chronic hemorrhagic contusions and gliotic changes are also evident.

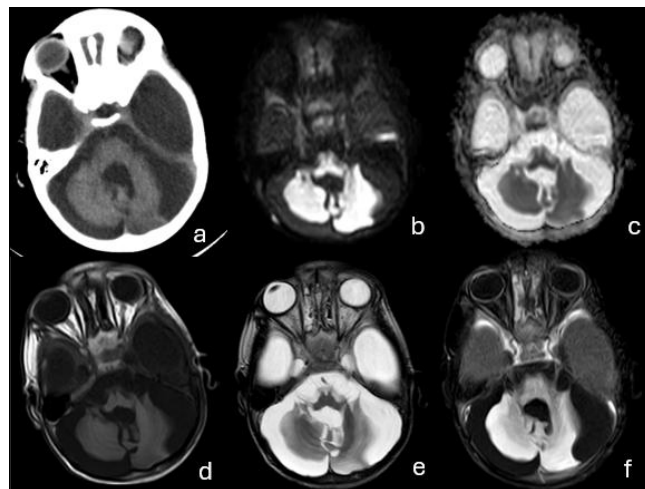


Fig 3: Axial non-contrast CT image (a), diffusion-weighted image (DWI) (b), apparent diffusion coefficient (ADC) map (c), T1-weighted image (d), T2-weighted image (e), and fluid-attenuated inversion recovery (FLAIR) image (f) demonstrate large bilateral chronic subdural hematomas producing marked mass effect with compression of the bilateral cerebellar hemispheres and dilatation of the fourth ventricle.

Case Report 2

A 2-month-old female child presented to the emergency department with seizures. There was no history of trauma. Non-contrast CT of the brain demonstrated acute-on-subacute right subdural hemorrhage causing mass effect, with effacement of the ipsilateral lateral ventricle and a midline shift of approximately 5.8 mm. Associated contusions were noted in the right parietal lobe. In the absence of a history of trauma, the imaging findings were highly suspicious for non-accidental injury. The patient subsequently underwent neurosurgical evaluation and managed conservatively.

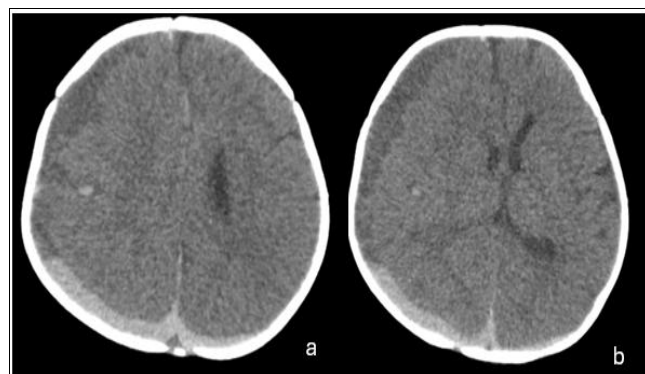


Fig 4: Axial non-contrast CT images of the brain (a, b) demonstrate an acute-on-subacute right frontoparietal subdural hematoma causing significant mass effect with effacement of the ipsilateral lateral ventricle and approximately 5.8 mm leftward midline shift.

The two cases illustrate the spectrum of abusive head trauma, ranging from chronic repeated injury with cerebral atrophy to acute presentation without a history of trauma.

Discussion

Abusive head trauma has been recognized for over a century. Tardieu first described caregiver-inflicted injuries in children in 1860 [Roche AJ et al.]. Caffey later linked chronic subdural hematomas with fractures and proposed the concept of shaking-related injury. [Caffey J al.]. Kempe subsequently introduced the term "battered child syndrome". Since then, the understanding of abusive head trauma has evolved, with subdural hemorrhage now recognized as its hallmark neuroimaging finding.

Several risk factors have been associated with abusive head trauma, including male gender, younger age of the child, young maternal age, lower socioeconomic status, and caregiver substance abuse [Narang S]. In our case series, both patients were female infants, with younger age being a significant contributing factor.

Normal crying of infants increases from birth and peaks at 6 to 8 weeks of age which coincides with the peak incidence of abusive head trauma. Additionally, children with disabilities are at increased risk of maltreatment [Hung KL]. In our study, one of the patients was a 2-month-old infant, corresponding to this vulnerable age group.

The underlying mechanism of injury in abusive head trauma is primarily related to repetitive acceleration-deceleration forces caused by shaking, leading to rapid flexion, extension, and rotation of the head. This results in tearing of bridging veins and subsequent subdural hemorrhage, along with parenchymal injury [Hung KL].

From a clinical perspective, infants and young children may present with a broad spectrum of manifestations, ranging from nonspecific features such as irritability, poor feeding, vomiting, macrocephaly, and developmental delay to severe manifestations including lethargy, respiratory compromise, apnea, and seizures [Narang S, Letson MM]. The presence of unexplained bruising should raise suspicion for non-accidental injury [Narang SK]. Clinicians should maintain a high index of suspicion, particularly in children younger than 2 years. In our cases, one child presented with seizures, while the other presented with failure to thrive and developmental delay.

The most common imaging findings in children with abusive head trauma are subdural hemorrhages. Certain patterns, including bilateral subdural hemorrhages, interhemispheric hemorrhage, and hemorrhages of varying ages (acute-on-chronic), are strongly suggestive of non-accidental injury [Narang S,]. In our case series, both patients demonstrated subdural hemorrhages, which is the most common intracranial finding in abusive head trauma. The first case showed bilateral chronic subdural hemorrhages with associated cerebral atrophy and skull fracture, suggesting repeated episodes of injury. The second case demonstrated acute-on-subacute subdural hemorrhage with mass effect, indicating recent trauma. These findings are consistent with previous studies highlighting the presence of hemorrhages of varying ages as an important indicator of non-accidental injury.

Other intracranial injuries like contusions, diffuse axonal injuries, lacerations or parenchymal hematoma may also be seen in abusive head injuries. In our cases, both patients demonstrated cerebral contusions. Skull fractures are another important associated finding, as seen in one of our patients.

The most common ocular imaging findings in children with abusive head trauma are retinal hemorrhages [Lopes NR].

Other ocular manifestations such as orbital or lid ecchymosis, subconjunctival hemorrhage, anisocoria, and disconjugate eye movements [Choudhary AK].

Differential diagnoses for subdural hemorrhage in children include accidental trauma, coagulation disorders, metabolic diseases, and birth-related intracranial hemorrhage. Therefore, a thorough clinical evaluation, laboratory investigations including coagulation profile, and detailed history are essential to exclude these conditions [Narang SK].

Radiological imaging is fundamental in the evaluation and diagnosis of abusive head trauma. CT is the preferred initial imaging modality for detecting acute hemorrhage and fractures, while MRI provides superior assessment of parenchymal injury. [Narang SK]. Advanced sequences such as susceptibility-weighted imaging (SWI) improve detection of prior hemorrhagic insults.

MRI, particularly diffusion-weighted imaging and susceptibility-weighted imaging, is superior to CT in detecting diffuse axonal injury, hypoxic-ischemic injury, and chronic hemorrhagic lesions.

A thorough clinical history is essential, particularly with regard to any history of shaking or inconsistent caregiver explanations [Christian CW]. Discrepancy between clinical history and imaging findings should raise strong suspicion for abusive head trauma [Choudhary AK].

In all suspected cases, laboratory evaluation including complete blood count and coagulation profile is necessary to exclude bleeding disorders. Additional tests such as platelet function studies, fibrinogen levels, D-dimer, and coagulation factor assays may be required in selected cases [Narang S].

A complete skeletal survey is recommended to identify associated fractures involving the skull, ribs, and long bones in all suspected cases of physical abuse [Maguire SA]. Ophthalmological evaluation is also essential to assess for retinal hemorrhages. Radiologists play a crucial role in early diagnosis by recognizing suspicious imaging patterns and correlating them with clinical findings. Prompt identification facilitates multidisciplinary intervention, including involvement of child protection services, thereby preventing further harm to the child.

Limitations

This report is limited by the small number of cases and lack of ophthalmologic and skeletal survey findings in one patient. Nevertheless, it illustrates the characteristic neuroimaging features that should alert radiologists to possible abusive head trauma.

Conclusion

Abusive head trauma should be considered whenever subdural hematoma is identified in infants or young children with an absent, inconsistent, or implausible history of trauma. Recognition of characteristic CT and MRI findings such as bilateral or mixed-age subdural hematomas, associated cerebral injury, and skull fractures should prompt consideration of abusive head trauma when the clinical history is absent, inconsistent, or implausible.

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