BMJ Best Practice

Abusive head trauma in infants and young children

Straight to the point of care

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Summary

Abusive head trauma in infants and young children is diagnosed when there is unexplained injury to the skull, brain, and/or spinal cord with no other medical explanation for their clinical presentation.

Frequently, there are other associated findings such as widespread retinal haemorrhaging, unexplained bruising, fractures and/or abdominal trauma. These additional findings are not necessary to make the diagnosis of abusive head trauma.

The clinical presentation and degree of injury occur on a spectrum from mild to severe. Management is supportive, with intervention to stop seizures and reduce intracranial pressure if needed.

Around 10% of victims die from their injuries.

Most surviving victims are at high risk of permanent neurological damage, vision loss, and pervasive cognitive deficits and behavioural issues ranging from moderate to severe.

Children with inflicted brain injury have worse neurocognitive outcome than those with accidental head trauma.

In many cases repeated injury has occurred, as documented by the finding of old injuries such as fractures and previous head injury.

Definition

Abusive head trauma refers to the constellation of cranial, spinal cord, and brain injuries that result from deliberately inflicted injury in infants and children.[1] The term includes injuries caused by shaking and by direct trauma to the head.

Abusive head trauma may be associated with other forms of physical abuse that may result in bruising, fractures, or abdominal injury in addition to brain injury.[1] [2]

Epidemiology

Incidence is highest in the first year of age, where reported figures range from 14.7 to 39.8 per 100,000 infants.[3] [4] [5] [6] [7] These numbers are likely to be underestimated due to missed diagnoses, erroneous coding by hospitals, and milder injuries that do not present for medical care. According to the American Academy of Pediatrics, estimated incidence is at 32 to 38 cases per 100,000 in the first year, and fatal in nearly one quarter of those cases.[1]

An analysis of national data in Taiwan from 2006 to 2015 found that the incidence of abusive head trauma was nearly 10-fold or 20-fold higher in infants <1 year (20.0 per 100,000), than in children aged 1 to 2 years (2.1 per 100,000) and 3 to 5 years (1.2 per 100,000).[7]

One comparative study in New Zealand found a marked increase in referrals for abusive head trauma in children <15 years old from 1991 to 2010, with 88 records identified in the first decade, compared with 257 in the second. The majority of children were aged <2 years.[8]

The global incidence of abusive head trauma is difficult to elicit. Identification and diagnosis of child abuse and inflicted head injury varies drastically from country to country, often due to cultural views of what constitutes child abuse. Shaking is a common form of discipline, however, with worldwide incidence ranging from 2.6% to as high as 36% in some settings.[9]

Approximately 10% of infants die from their injuries.[10]

There is no documented ethnicity predominance.[11]

Boys sustain abusive head trauma more often than girls.[7] [10]

Incidence varies by age. Cases are reported from 2 to 3 weeks of age, peak at 9 to 12 weeks, and decline to lower, stable levels by 29 to 32 weeks of age.[10] [12] Cases may continue to occur until approximately age 3 years.[13]

Aetiology

Abusive head trauma occurs when an infant is violently shaken, causing back and forth, and rotational movement of the head. The injuries seen can result from a fairly short period (5-10 seconds to <1 minute) of shaking alone.[14] [15] Children may also sustain abusive head trauma subsequent to inflicted blunt force trauma to the head or an inflicted crushing injury.

It is hypothesised that crying is the most common trigger to the shaking of an infant. Studies of perpetrator confessions support this hypothesis, revealing that crying is the most common antecedent to the loss of control and violent shaking of a child.[12] [14] [16]

Pathophysiology

Infants are especially susceptible to abusive head trauma due to their large head-to-body ratio, their weak neck muscles, the relative lack of myelination of nerves when compared with older children, and the disparity in size between victim and perpetrator.

Violent shaking subjects an infant's brain to repetitive, rotational force. This triggers a cascade of events leading to cranial and ophthalmological pathology.

Subdural haemorrhage is a common finding and occurs from direct trauma, or bleeding from bridging vessels that are torn when the brain moves inside the skull. The arachnoid may also tear, leading to leakage of cerebrospinal fluid into the subdural spaces, causing the appearance of mixed-density subdural haemorrhage on computed tomography (CT) or magnetic resonance imaging (MRI).[17]

Neuronal damage occurs from blunt force trauma (described as an acceleration-deceleration injury), shearing injuries, and secondary damage from excitatory amines, which are released by dying brain cells. There is loss of cerebral autoregulation and disruption of ionic homeostasis.[18] In many cases, it is felt that damage to the craniocervical junction leads to apnoea and hypoxic brain injury.[18] Brain tissue injury often occurs at the junction of areas of differing density (such as the grey-white junction), and infants who are shaken appear to have greater injury depth than those with accidental injury.[19]

The forces that result from blunt force trauma are much higher than forces from shaking alone; thus, some clinicians believe that in children with severe brain injury there was likely not only shaking, but also direct head trauma.

Ophthalmological findings, which may be present in cases of violent shaking, are hypothesised to result from vitreo-retinal traction that can lead to numerous multi-layer, widespread retinal haemorrhages that may be bilateral or, in some cases, unilateral. There may also be retinoschisis (splitting of the layers of the retina), optic nerve sheath haemorrhage (observed at post-mortem examination), and vitreous or conjunctival haemorrhage.[20]

Abusive injury can lead to scalp and skull injury, including visible or subcutaneous bruising of the scalp, neck muscle haemorrhage, and skull fracture.[1]

In addition, some infants may have bruising, fractures, or intra-abdominal injury related to concomitant physical abuse. Rib fractures from squeezing of the chest and metaphyseal corner fractures of the long bones from trauma are common, but not necessary to make the diagnosis.

Case history

Case history #1

A previously well 2-month-old male infant presents to the accident and emergency department with a seizure and difficulty breathing. His father reports that he put the child down for a nap and then discovered him having a seizure 1 hour later. He called his wife at work to ask her what he should do, and she told him to call the emergency services. When the paramedics arrived they found the infant to be pale and bradycardic. They instituted basic life support and gave lorazepam to control the seizures. In the accident and emergency department, the child requires further antiseizure medications. Examination is unremarkable except for brisk reflexes and a paediatric Glasgow Coma Scale of 10 (or V on the AVPU [alert, voice, pain, unresponsive] scale). Bilateral multilayer retinal haemorrhages are seen on fundus examination. Skeletal survey reveals multiple rib fractures and several classic metaphyseal fractures.

THEORY

Other presentations

Abusive head trauma may present in a variety of ways, and diagnosis can be delayed due to an incomplete history from the carer.

Mild inflicted traumatic brain injury from shaking can present with increasing head circumference noted by a primary care physician, or with mild symptoms such as vomiting, sleepiness, or irritability with no underlying illness. Patients may also present with much more obvious signs of brain injury such as apnoea or seizure.

Abusive head trauma may be mistaken for accidental head trauma, or meningitis/encephalitis or other causes of cerebral oedema.

Severe abusive head trauma can result in death almost immediately, and presentation may initially be confused with sudden infant death syndrome until a post-mortem examination is performed.

Some infants may present to medical care for a non-related medical complaint and have a work-up that incidentally identifies signs of inflicted injury.

Approach

The diagnosis of abusive head trauma requires that medical personnel be vigilant for signs of abuse when evaluating infants or children with signs of scalp, skull, or brain injury. Thorough history taking and a very careful medical examination are imperative. The presence of unexplained external head trauma, skull fracture, subdural bleeding, clinical signs of brain injury, and retinal haemorrhage or retinoschisis, is highly suggestive of abusive head trauma.

Hospital social work and child protection team staff should be involved as soon as the possibility of inflicted injury is apparent.[1] [22]

Any underlying metabolic disorder, clinically significant bleeding disorder, or infection should be excluded. Medical evaluation may involve testing for osteogenesis imperfecta, congenital clotting abnormalities, or glutaric aciduria type I.[31] [32] [33] [34]

History

The carer's history is generally inconsistent with the medical findings.

Carers may offer either no history of trauma or a history of minor trauma that in no way could lead to scalp or skull injury or the degree of brain injury that is present.[35] Typically, perpetrators have a period of time when they are alone with the infant, and they may describe an event that a child is developmentally incapable of (such as a 2-month-old infant crawling to the edge of a surface and falling). It is common for the history given by the perpetrators to change as they are interviewed by sequential medical providers.

There may also be a delay in seeking treatment; it is not uncommon for a carer who has injured an infant to call a non-offending parent at work and attempt other measures to wake up an infant before seeking emergency medical treatment.

Symptoms of apnoea, seizure, vomiting, and loss of muscle tone were all documented in a study of perpetrator confessions, with symptoms apparent immediately after shaking in 91% of cases.[12] [14] [16] Child maltreatment may be further suspected if a child has repeated life-threatening events, the onset is witnessed only by one parent or carer, and a medical explanation has not been identified.[22]

There may be an intercurrent illness or recent vaccinations leading to fever, which may make diagnosis more difficult, as the infant's symptoms of irritability or vomiting may be confused with viral infection or meningitis. Additionally, symptoms vary depending on the degree of injury, and milder injury may present with gradually developing symptoms.[1]

A significant number of infants have history or previous medical evaluations that in retrospect are likely to represent previous episodes of injury.[24] If medical providers do not have a high degree of suspicion, they may misdiagnose symptoms of mild injury as gastroenteritis, colic, meningitis, or pyloric stenosis. Radiologists who are not trained in paediatric radiology may misread subtle findings that are indicative of abusive trauma.

Some infants with mild injury may not be brought to medical attention and may recover on their own. These infants may present with an increasing head circumference noted by a primary care physician. Non-offending parents may be completely unaware that abuse is taking place. Infants may be brought to

medical care for a non-related medical complaint such as respiratory distress, and have an evaluation that incidentally identifies signs of inflicted injury, such as rib fractures on a chest radiograph.

Abusive head trauma occurs in families from all socio-economic backgrounds; however, one study found that diagnosis is more likely to be missed in white children of married parents.[24]

Other points in the history that may suggest child maltreatment include known risk factors such as parental/carer drug or alcohol misuse, parental or carer mental illness, and a history of violent offending or previous child maltreatment within the family.[10] [22]

Physical examination

Physical examination commonly does not reveal any external signs of injury. The fontanelle may be full or tense, and there may be a documented change in head circumference. Oral injuries are uncommon, but the finding of mucosal injury or torn labial or lingual frenulum is of concern.[36] Abusive long-bone fractures may be detected on physical examination; however, many abusive fractures such as the posterior rib fracture and classic metaphyseal lesion (corner fracture) usually have no overlying bruising or swelling.[35]

Skin findings including bites or bruising may be present. Bruising of the torso, ears and neck, or any bruising in a child younger than 4 months, should raise concern for inflicted injury.[37] Anogenital signs or symptoms without an appropriate explanation should raise the concern of child maltreatment.[22]

Bruising on the ear of a 10-month-old infant

Reproduced with permission from Backhouse L et al. Unexplained bruising: a developing story. BMJ Case Rep. 2018 May 14;2018:bcr2017222793

Torn labial frenulum with associated bruising in a neonate

Reproduced with permission from Gurung H et al. Labial frenum tear from instrumental delivery. Arch Dis Child. 2015 Aug;100(8):773

Neurological presentation

Varies depending on the degree of injury; however, some clinical signs of brain injury are usually present. Neurological signs may include irritability, vomiting, brisk or asymmetrical reflexes, poor muscle tone, seizures, or coma.

Paediatric Glasgow Coma Scale

The paediatric Glasgow Coma Scale comprises three assessments: eye, verbal, and motor responses. The lowest possible value is 3 (deep coma or death), while the highest is 15 (fully awake and aware person).

- Best eye response (E):
    1. No eye opening
    2. Eye opening to pain
    3. Eye opening to speech
    4. Eyes opening spontaneously
- Best verbal response (V):
    1. No verbal response
    2. Infant moans to pain
    3. Infant cries to pain
    4. Infant is irritable and continually cries

5. Infant coos or babbles (normal activity)

- Best motor response (M):

1. No motor response
2. Extension to pain (decerebrate response)
3. Abnormal flexion to pain for an infant (decorticate response)
4. Infant withdraws from pain
5. Infant withdraws from touch
6. Infant moves spontaneously or purposefully

The use of the paediatric Glasgow Coma Scale, rather than the AVPU (alert, voice, pain, unresponsive) scale, is advised by the UK National Institute of Health and Care Excellence (NICE) in the evaluation of paediatric head injury.[38]

NICE suggests that child maltreatment is likely if a child has an intracranial injury in the absence of major confirmed accidental trauma or known medical cause, in one or more of the following circumstances:[22]

- The explanation is absent or unsuitable
- The child is aged under 3 years
- There are also
  - Retinal haemorrhages or
  - Rib or long-bone fractures or
  - Other associated inflicted injuries
- There are multiple subdural haemorrhages, with or without subarachnoid haemorrhage, with or without hypoxic damage to the brain.

Retinal examination

Retinal and vitreous haemorrhages and traumatic retinoschisis are characteristic of violent shaking leading to abusive head trauma.[1] [39] Retinal haemorrhage can also be seen with crush injuries to the skull, although usually to a lesser degree.

Ophthalmology should be consulted to perform a dilated retinal examination if the child is clinically stable.[39] It may be necessary to delay this examination if the child's clinical status is guarded. Retinal haemorrhage can be transient: ophthalmological consultation should preferably take place within 24 hours after the child presents for medical care.[39]

Widespread, multi-layer retinal haemorrhages are believed to occur with abusive shaking when the vitreous humour, which is adherent to the retina, is set into motion, causing shearing forces on the retina and splitting of the layers of the retina. Retinal haemorrhage may be unilateral or bilateral. However, in 15% to 25% of cases there is no evidence of retinal haemorrhage.[13] [40]

Retinal haemorrhages in abusive head trauma are usually widespread and multi-layered, as seen in this image

From the personal collection of Alice Newton, MD; used with permission

Cranial imaging

Cranial imaging is indicated when there is a clear suspicion of inflicted traumatic brain injury and in cases where more general abuse is suspected.[41] In infants <6 months who have findings of other physical abuse injuries, head imaging should always be obtained.

Imaging should be performed as soon as possible, both for diagnosis and treatment of the patient, and for the protection of other children who are cared for in the same setting where abuse took place (e.g., siblings).

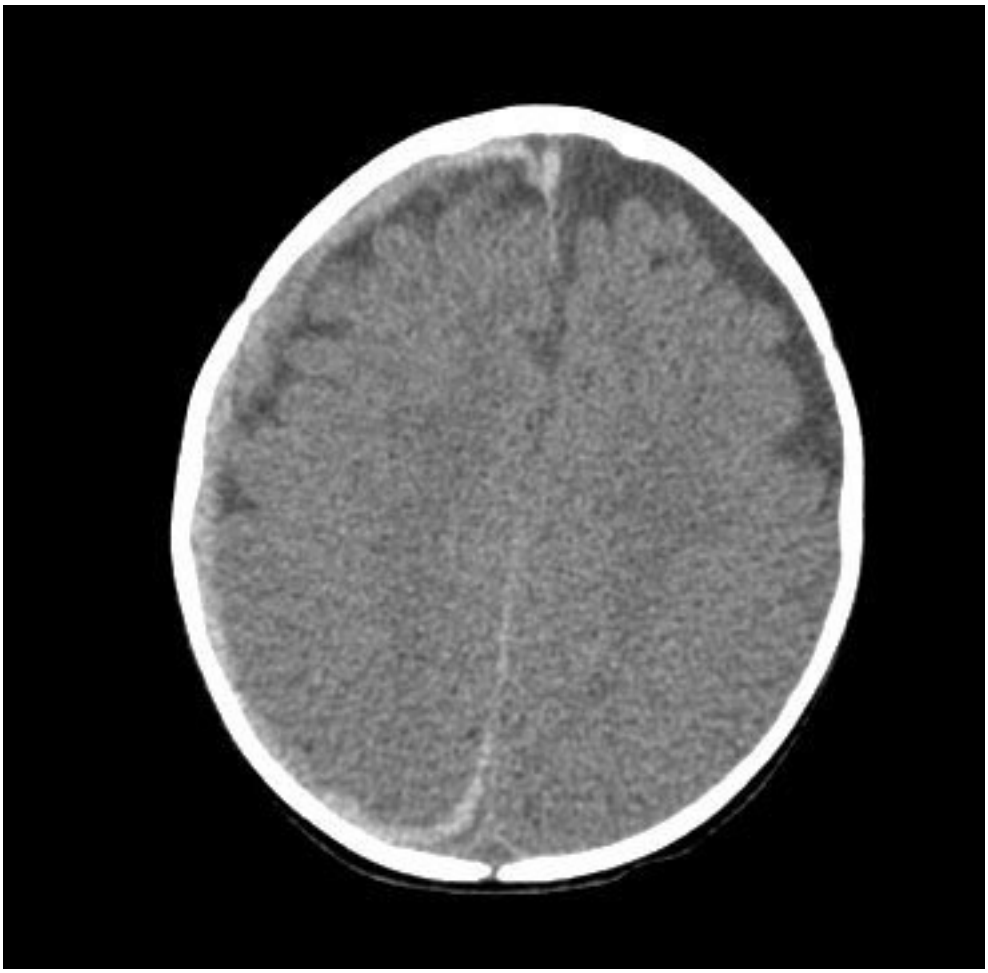
A computed tomography (CT) scan of the brain is usually the first study performed because of speed and availability. Further imaging with magnetic resonance imaging (MRI) is indicated if inflicted traumatic brain injury is diagnosed by CT or if there is a high suspicion of abusive head injury with a negative CT.[41] [42]

MRI may identify subdural collections, cortical contusions, ischaemia, intraparenchymal haemorrhage, and shearing injuries.[42]

Cranial ultrasound is not sensitive enough for routine diagnostic use.[42] In cases of unexplained increasing head circumference or in very unstable patients, cranial ultrasound can be helpful to detect subdural haemorrhage and to identify subarachnoid or subdural fluid collection. Cranial ultrasound, however, may not identify small subdural collections. High resolution ultrasound may be used to monitor lesions identified on CT or MRI.

In the UK, NICE advises performing a CT scan within 1 hour of identifying a number of risk factors, including any suspicion of non-accidental injury.[38] Depending on the presentation, a CT scan of the cervical spine or an MRI of the spine may also be required to exclude spinal injury.

A neurosurgical consult is generally required in most cases of inflicted brain injury, especially when there are signs or symptoms of raised intracranial pressure such as irritability, vomiting, and a tense fontanelle, or radiological evidence.

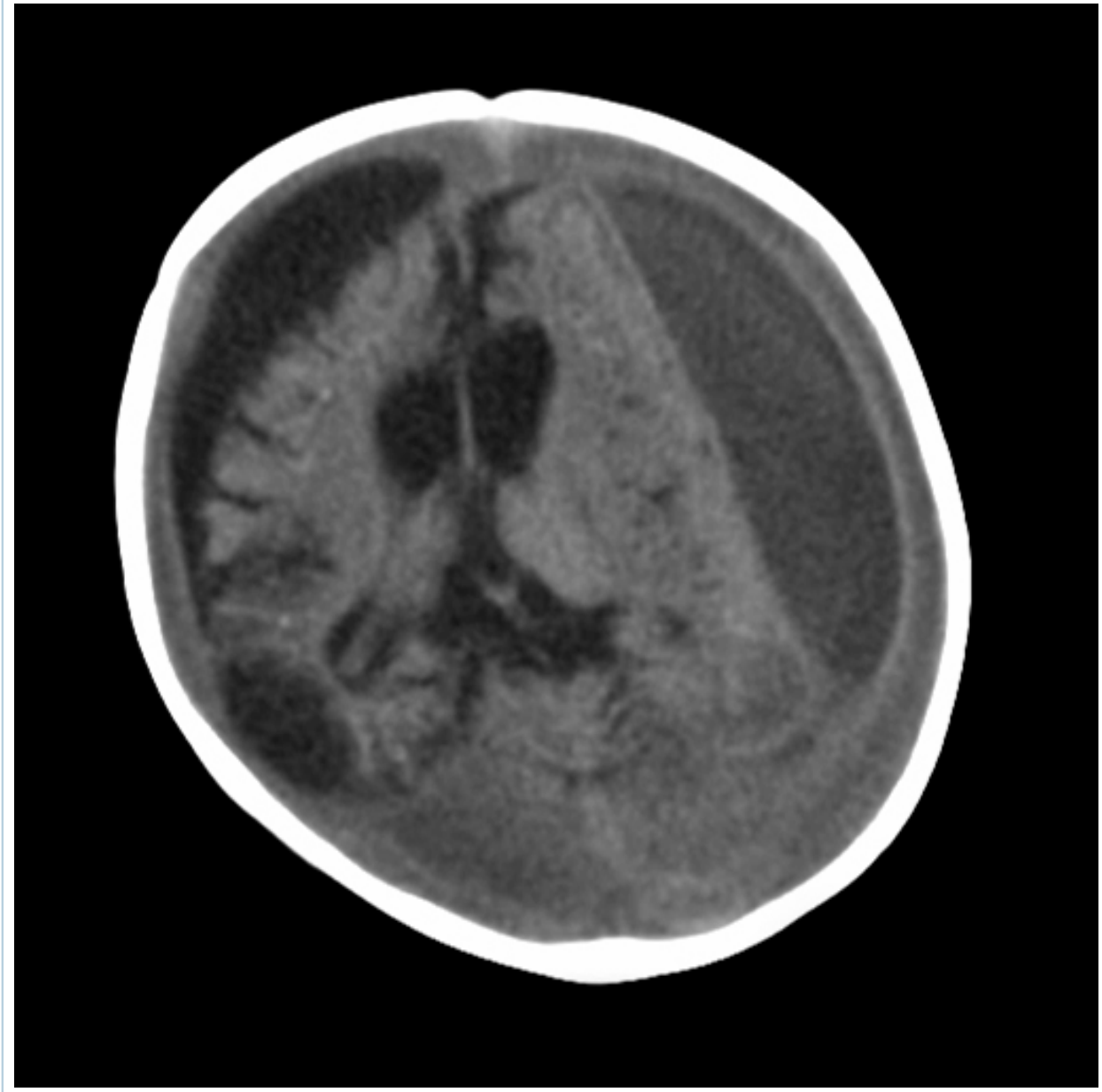


CT scan revealing subdural haemorrhage extending over the right convexity and in the intrahemispheric region, as well as enlargement of the extra-axial fluid spaces

From the personal collection of Alice Newton, MD; used with permission

CT findings in fatal abusive head trauma often reveal significant brain oedema with loss of grey-white differentiation and effacement of the ventricles. Subdural blood is often difficult to appreciate in such cases

From the personal collection of Alice Newton, MD; used with permission



MRI depicting subdural hygromas surrounding severe brain atrophy from abusive head trauma. This child was initially erroneously diagnosed with meningitis

From the personal collection of Alice Newton, MD; used with permission

Skeletal imaging

A full skeletal survey is indicated in every case of suspected physical abuse in children <2 years of age and may be performed in children up to age 3 or 4 years in select cases. If at all possible, the study should be performed at a centre where a paediatric radiologist can review the images. A follow-up skeletal survey, 2 weeks later, may identify subtle or acute injuries that may not have been visualised on the initial survey. A complete repeat survey is usually appropriate, although a limited view follow up could also be considered.[43] Complementary imaging may be indicated depending on the findings of the skeletal survey. These include CT/MRI for brain analysis and nuclear scintigraphy and/or extremity CT for a focal area of concern.[43]

Initial laboratory tests

Initial laboratory tests should include a full blood count, blood culture (if fever is present), liver function tests to assess for abdominal injury, and coagulation studies including prothrombin time, von Willebrand's testing, and fibrinogen.[31]

Urine should be tested for infection if fever is present, and for glutaric aciduria type I. Although many countries test for this disorder in their newborn screen, it is possible for the initial test to be negative. Glutaric aciduria is generally associated with a positive family history (autosomal recessive), macrocephaly, motor delay, and learning difficulties, but these signs and symptoms may not yet be present in a young infant.[32] [44] [45] It is also often helpful to send urine for toxicology testing to rule out exposure to illegal substances that may be in the home.

Other investigations

If clinical signs suggest meningitis or encephalitis, lumbar puncture should be ordered unless contraindicated. In the case of traumatic brain injury, the cerebrospinal fluid shows an abundance of red blood cells and normal glucose, and may reveal xanthochromia if injury occurred at least 8 to 12 hours before presentation.

If unexplained fractures are present, testing for serum 1,25-dihydroxy vitamin D, calcium, phosphate, and magnesium levels should be performed to rule out metabolic dysfunction, such as rickets. Testing for osteogenesis imperfecta is often performed even in the absence of suspicious clinical history or physical findings. Generally, this is done via blood testing for known DNA mutations associated with osteogenesis imperfecta, although in select cases skin biopsy (with testing of collagen levels produced by fibroblast cultures) is used as well.[33] [46]

Given the potential legal repercussions of abusive injury, it is very important to rule out any differential diagnoses, however unlikely. Consultation with a geneticist or haematologist may be indicated.

Any unexplained infant death must have a post-mortem examination to determine possible traumatic, infectious, or other medical causes before the diagnosis of sudden infant death syndrome is made.

Legal considerations

It is important to consult with a hospital child protection team and social work services as soon as possible when a case of potential child abuse is identified.[1] [22]

Child protection services will assess risk of re-injury of the patient, and risk to other children with the same carer. After assessing family and other carers, child protection services may remove children from exposure to the offending carer.

Additionally, most cases of inflicted brain injury will be referred to the police or the relevant authorities for criminal investigation.

History and exam

Key diagnostic factors

presence of risk factors (common)

- Key risk factors include: age <1 year, peak of normal crying curve, and presence of a male carer.

age <3 years (common)

- The incidence of abusive head injury in children is highest in infancy and occurs less frequently in children age >3 years.[13]

altered mental status: irritability/lethargy/coma (common)

- Neurological sign indicative of brain injury. Clinically suggests raised intracranial pressure.

clinical findings inconsistent with carer history (common)

- The carer's history is generally inconsistent with the medical findings. It is common for carers to offer either no history of trauma or a history of minor trauma that in no way could lead to scalp or skull injury or the degree of brain injury that is present.[35]

retinal/vitreal haemorrhages or retinoschisis (common)

- Highly associated with inflicted brain injury.[39] [47]
- Examination should always be performed by an ophthalmologist, who should complete a dilated retinal examination if the child is clinically stable.[39] It may be necessary to delay this examination if the child's clinical status is guarded. Retinal haemorrhage can be transient: ophthalmological consultation should preferably take place within 24 hours after the child presents for medical care.[39]

Retinal haemorrhages in abusive head trauma are usually widespread and multi-layered, as seen in this image

From the personal collection of Alice Newton, MD; used with permission

apnoea (common)

- Apnoea is strongly associated with abusive head trauma.
- In a child age <3 years with intracranial injury and apnoea, the positive predictive value for abusive head trauma is 93%.[42] The mechanism may be related to brainstem trauma.[35] [47]

Other diagnostic factors

no known history of trauma (common)

- There is usually either no history of trauma or a history of minor trauma that is disproportionate to the degree of brain injury that is present.[35]

seizure (common)

- May be apparent immediately after brain injury or as neurological sequelae develop.[48]

vomiting (common)

- May be apparent immediately after brain injury or as neurological sequelae develop. Clinically suggests raised intracranial pressure.

loss of muscle tone (common)

- May be apparent immediately after brain injury or as neurological sequelae develop.

brisk or asymmetrical reflexes (common)

- Neurological sign indicative of brain injury.

unexplained bruising (common)

- Bruising of the torso, ears and neck, or any bruising in a child younger than 4 months, should raise concern for inflicted injury.[37]

increasing head circumference (uncommon)

- A small subset of cases are discovered when a primary care physician notes a change in head circumference percentile.

bulging fontanelle (uncommon)

- The fontanelle may be full or tense, and there may be a documented change in head circumference. Clinically suggests raised intracranial pressure.

long-bone fractures (uncommon)

- Abusive long-bone fractures may be detected on physical examination.[35] However, many abusive fractures such as posterior rib fractures and classic metaphyseal lesions (corner fractures) have no overlying bruising or swelling.

mucosal injury or torn labial/lingual frenulum (uncommon)

- Oral injuries are uncommon, but the finding of mucosal injury or torn labial or lingual frenulum is of concern.[36]

Torn labial frenulum with associated bruising in a neonate

Reproduced with permission from Gurung H et al. Labial frenum tear from instrumental delivery. Arch Dis Child. 2015 Aug;100(8):773

anogenital signs and symptoms (uncommon)

- Unexplained anogenital signs (bruising, venous congestion, laceration, tears, fissures, dilated anus, or persistent discharge or bleeding) is suspicious for inflicted injury.[22]

Risk factors

Strong

age <1 year

- Cases of abusive head trauma are reported from 2 to 3 weeks of age, peak at 9 to 12 weeks, and decline to lower, stable levels by 29 to 32 weeks of age.[10] [12]

peak of normal crying curve

- The association between crying and shaking has been documented by several studies of perpetrator confessions.[12] [14] [16] The normal peak of infant crying is convergent with the peak age at which shaken baby syndrome is diagnosed.[12]

male carer

- The most frequent perpetrator is the infant's father, stepfather, or mother's boyfriend.[10]

Weak

unrelated adult household member

- There is a 47.6-fold increased risk of death in infants residing in a household with adults unrelated to that infant, compared with households where the adults are the infant's biological parents.[21]

male sex

- Most studies show a slightly greater predominance of male victims. This may be due to social stereotypes of male infants as babies who should not cry, and who are tougher and less vulnerable to rough handling.[18]

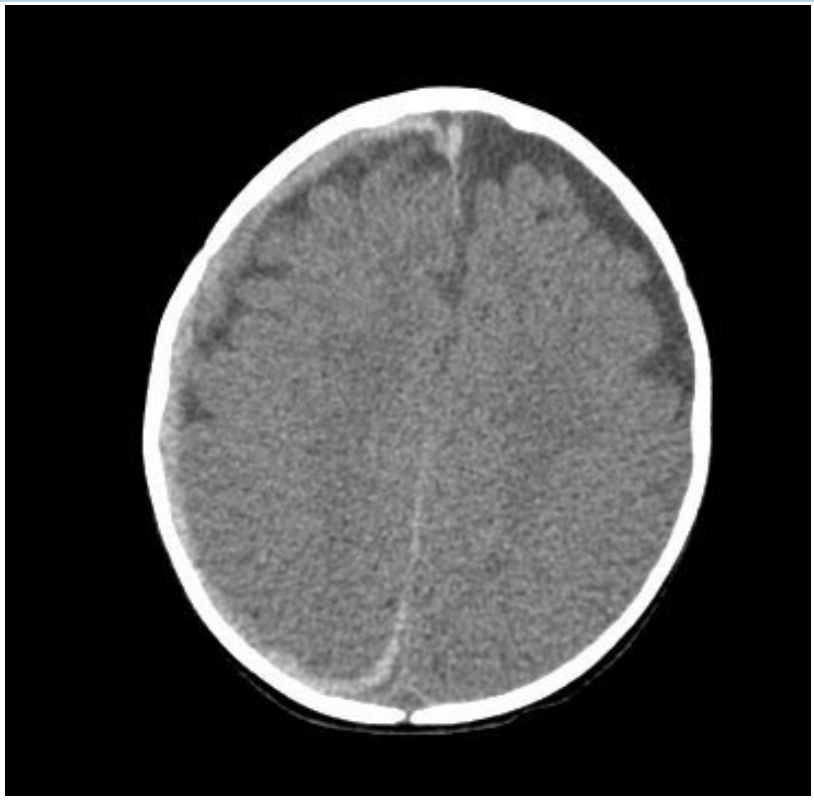
socio-economic stressors

- Multiple social and economic stressors may contribute to a carer's inability to cope with infant crying. These factors include carer history of child abuse, carer substance abuse, domestic violence, young/single parent status, mental illness, poverty, a history of violent offending, or previous child maltreatment within the family.[10] [22] [23]
- The burden of these factors may make an otherwise suitable carer respond with violence to an infant whom they may perceive as adding to their burden. However, abusive head trauma occurs in families from all socio-economic backgrounds. One study found that diagnosis is more likely to be missed in white children of married parents.[24]

Investigations

1st test to order

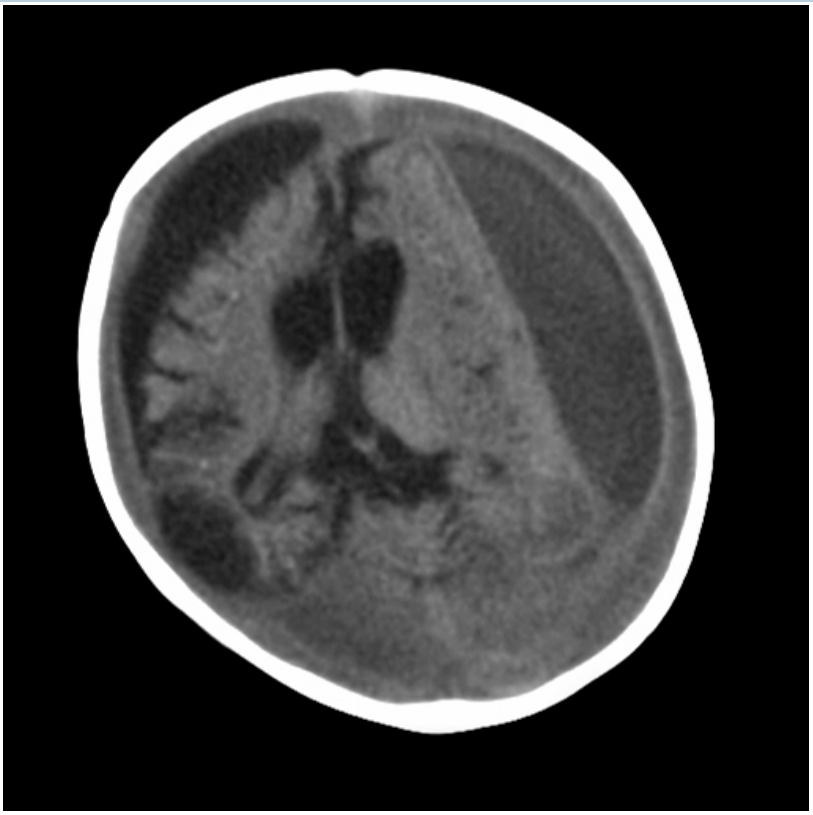
Test	Result
cranial CT scan • Cranial imaging should be performed as soon as possible in cases of suspected abusive head trauma in order to make the diagnosis and identify injuries that require surgical intervention.[1] [41] • A CT scan of the brain is usually the first study performed because of speed and availability. In a small number of patients, subdural haemorrhage may not be present, either because it is not large enough to be apparent on CT or because the presence of significant brain oedema may tamponade the blood before it can accumulate.[49] [50] • In all cases of suspected abusive head trauma, 3-dimensional reconstruction should be performed to rule out skull fracture. • Further imaging with MRI is indicated if inflicted traumatic brain injury is diagnosed by CT or if there is a high suspicion of abusive head injury with a negative CT.[41] [42]	**subdural fluid collection, midline shift, skull fracture**



CT scan revealing subdural haemorrhage extending over the right convexity and in the intrahemispheric region, as well as enlargement of the extra-axial fluid spaces
From the personal collection of Alice Newton, MD; used with permission

Test	Result
 *CT findings in fatal abusive head trauma often reveal significant brain oedema with loss of grey-white differentiation and effacement of the ventricles. Subdural blood is often difficult to appreciate in such cases* *From the personal collection of Alice Newton, MD; used with permission*	
FBC • Subdural bleeding from inflicted traumatic brain injury may result in a drop in haematocrit (Hct) and, rarely, infants may require blood transfusion. • The greatest number of inflicted brain injury cases occurs when children are at a physiological nadir of their Hct, so determining the aetiology of a low Hct is complicated and may not be directly attributable to intracranial blood loss. • The WBC count may be elevated due to demargination of WBCs after trauma, and may not be indicative of infection.	**variable; Hct may be low, WBC count may be elevated**
liver function tests • There are commonly no external signs of abusive abdominal trauma, and elevated liver function tests may be the only clue to the presence of abdominal injury.[51] • Abusive abdominal injury may include hollow viscus perforation, blunt liver or splenic trauma, bowel wall haematoma, and renal, adrenal, or pancreatic contusion.	**elevated if abdominal injury present**

Test	Result
toxicology screen • The presence of a positive toxicology screen (for illicit drugs such as cocaine and marijuana) may reflect passive exposure in the home. • Care should be used in interpreting testing, as a positive test for benzodiazepines and opiates may be related to drugs used during resuscitation.	**variable**
prothrombin time (PT)/activated PTT/fibrinogen/von Willebrand's testing • Coagulation studies should be performed along with thorough history taking to rule out any pre-existing bleeding disorders.[31] • However, it must be noted that PT prolongation and activated coagulation may result from parenchymal brain damage, especially in more severely injured children.[52]	**normal; may be abnormal in severe cases**
urinalysis • Urine should be tested for infection if fever is present and for glutaric aciduria type I if clinically indicated: for example, positive family history (autosomal recessive); macrocephaly; motor delay; and learning difficulties.[32] [44] [45]	**usually normal; dipstick positive for leukocytes, nitrates, and blood suggest infection; increased levels of glutaric, glutaconic, and 3-hydroxyglutaric acids suggests glutaric aciduria type I**
cerebrospinal fluid analysis • If clinical signs suggest meningitis or encephalitis, lumbar puncture should be ordered unless contraindicated. • In the case of trauma, the cerebrospinal fluid shows an abundance of red blood cells and normal glucose, and may reveal xanthochromia if injury occurred at least 8 to 12 hours before presentation.	**elevated WBC count if infection present; elevated red blood cell count or xanthochromia in cases of trauma**
cranial MRI • MRI may include T1- and T2-weighted sequences, gadolinium-enhanced imaging, proton density or fluid-attenuated inversion-recovery (FLAIR) imaging, diffusion-weighted imaging, and gradient echo T2-W sequences. In select cases, MR angiogram or venogram may also be included to rule out the possibility of aneurysm or intracranial venous thrombosis.[53] • MRI study is complementary to CT, and should be performed in all diagnosed cases of inflicted traumatic brain injury, as it can help to discern between subarachnoid and subdural bleeding, and help further determine degree of brain injury, allowing prognostication. MRI is also indicated if high suspicion of abusive head injury persists subsequent to negative CT.[41] [42] • MRI may identify subdural collections, cortical contusions, ischaemia, intraparenchymal haemorrhage, and shearing injuries.[42] • The presence of mixed-density subdural haemorrhage does not necessarily indicate old and new injury, as this finding may occur with 'hyperacute' bleeding or mixing of blood with cerebrospinal fluid when a tear in the arachnoid membrane occurs.	**subdural collections, cortical contusions, ischaemia, intraparenchymal haemorrhage, and shearing injuries**

Test	Result
 *MRI depicting subdural hygromas surrounding severe brain atrophy from abusive head trauma. This child was initially erroneously diagnosed with meningitis* *From the personal collection of Alice Newton, MD; used with permission*	

Other tests to consider

Test	Result
spinal MRI • May be considered to assess for concurrent spinal injuries.[1]	**ligamentous injuries or spinal subdural haemorrhage**
cranial ultrasound • Cranial ultrasound is not sensitive enough for routine diagnostic use.[42] • In cases of unexplained increasing head circumference or in very unstable patients, cranial ultrasound can be helpful to detect subdural haemorrhage and to identify subarachnoid or subdural fluid collection. Cranial ultrasound, however, may not identify small subdural collections. High resolution ultrasound may be used to monitor lesions identified on CT or MRI.	**subdural fluid collection**
skeletal survey • Skeletal survey of hands, feet, long bones, skull, spine, and ribs (including oblique ribs) should be performed in children <2 years to detect occult fractures.[1] Multiple views of the axial and appendicular skeleton are required. • In cases of diagnosed abuse, a follow-up skeletal survey in 2 weeks is often performed to diagnose any fractures that may not have been identified on initial study. A complete repeat survey is usually appropriate, although a limited view follow-up could also be considered.[43]	**variable; unexplained fractures including skull fractures, long-bone fractures, rib fractures, and classic metaphyseal lesions**
complementary imaging • Complementary imaging may be indicated depending on the findings of the skeletal survey. These include CT/MRI for brain analysis and nuclear scintigraphy and/or extremity CT for a focal area of concern.[43] • Bone scintigraphy can be helpful in identifying rib and long-bone fractures, but it does not help to identify the classic metaphyseal lesions.	**variable; unexplained fractures**
blood culture • Should be obtained as part of the routine work-up of a febrile illness.	**bacteraemia may be present**
serum calcium • Normal values are 2.25 to 2.70 mmol/L (9.0 to 10.8 mg/dL); as low as 1.90 mmol/L (7.6 mg/dL) in neonatal period. • It is important to exclude other underlying medical conditions that could cause the symptoms: for example, calcium may be decreased in hypocalcaemic rickets.	**normal values for age**
serum 1,25-dihydroxy vitamin D levels (calcidiol) • Normal values are 41.6 to 169.0 picomols/L (16 to 65 picograms/mL); may be higher in pre-term babies. • It is important to exclude other underlying medical conditions that could cause the symptoms: for example, vitamin D levels can be normal or increased in hypocalcaemic rickets; they are usually normal or slightly increased in hypophosphataemic forms of rickets.	**normal values for age**

Test	Result
serum inorganic phosphorus • Normal values vary with age; neonatal period: 1.45 to 2.91 mmol/L (4.5 to 9.0 mg/dL); adolescence: 0.87 to 1.45 mmol/L (2.7 to 4.5 mg/dL). • It is important to exclude other underlying medical conditions that could cause the symptoms: for example, phosphate may be decreased in hypocalcaemic and hypophosphataemic rickets.	**normal values for age**
serum parathyroid hormone (PTH) • Normal values vary with age and method. • It is important to exclude other underlying medical conditions that could cause the symptoms: for example, high serum PTH levels with hypocalcaemic rickets and normal PTH levels with hypophosphataemic rickets.	**normal values for age**
serum alkaline phosphatase • High alkaline phosphatase may represent a high bone turnover state; may be elevated if skeletal fractures are present. • Alkaline phosphatase is also elevated in rickets and in osteogenesis imperfecta.	**elevated**
skin biopsy/fibroblast culture • If osteogenesis imperfecta is considered a possible differential diagnosis, skin biopsy or blood sample should be obtained, allowing testing for mutation of COL1A1 and COL1A2 genes. Additionally, a collagen synthesis assay may show quantitative or qualitative differences in collagen in patients with osteogenesis imperfecta.	**normal; abnormal collagen synthesis if osteogenesis imperfecta**
post-mortem examination • Any unexplained infant death must have a post-mortem examination to determine possible traumatic, infectious, or other medical causes before the diagnosis of sudden infant death syndrome is made. • A review of the medical records and investigation of the scene of death is also required.[54]	**subdural haemorrhage, brain oedema, retinal or optic nerve sheath haemorrhage, unexplained fractures**

Differentials

Condition	Differentiating signs / symptoms	Differentiating tests
Accidental head trauma	• History of trauma: in infants, significant trauma such as a serious fall or motor vehicle accident will usually be witnessed and documented by police or paramedics. • Physical examination will usually reveal bruising related to a fall, although in some cases scalp bruising may be deep and therefore not visible externally. • Ophthalmological examination is usually completely negative, although in crush injuries or instances where the eye received a direct blow there may be a small number of retinal haemorrhages.	• CT head: although skull fracture and subdural haemorrhage may be present, it is rare for accidental household falls to result in significant brain injury.
Birth trauma	• If a birth-related haemorrhage is severe enough to cause symptoms, this will occur in the newborn period. The new onset of symptoms and signs of inflicted traumatic brain injury in a child who was asymptomatic at birth is not consistent with birth-related subdural haemorrhage. • Retinal haemorrhages are seen in 30% to 50% of births, are generally few in number, and present in the intraretinal layer. They can be bilateral and widespread; most resolve within 1 or 2 weeks, and the remainder are gone in 6 to 8 weeks.[40] [55] [56] Widespread retinal haemorrhages after 6 to 8 weeks of age are of concern for abusive head trauma.	• Distinguishing between inflicted injury and birth trauma is based on historical factors of the birth as well as the current presentation of injury.
Central nervous system infection: meningitis and encephalitis	• Fever and clinical signs of meningism. • Generally, parents give history of progressively worsening illness.	• Lumbar puncture and cerebrospinal fluid analysis: increased number of WBCs, visualisation of bacteria on microscopy, low glucose, high protein, positive culture

Condition	Differentiating signs / symptoms	Differentiating tests
		for organism, positive serology for viruses.
Subdural bleeding into benign enlargement of the subarachnoid space (BESS)	• Pre-existing condition of BESS may predispose infants to the occurrence of subdural bleeding with minor trauma. • Usually asymptomatic, absence of retinal haemorrhages; no other signs of abuse.	• Cranial imaging: enlargement of subarachnoid space with subdural bleeding that is often unilateral, not space-occupying, or associated with signs of brain oedema or injury such as contusion, diffuse axonal injury, or tissue shearing.
Glutaric aciduria type I	• Positive family history (autosomal recessive), classic radiological findings on brain imaging, macrocephaly, motor delay, and learning difficulties are usually present.[32] [44] [45] Retinal haemorrhages may be present in the setting of glutaric aciduria type I. • A genetics/metabolism team should be consulted if there is any possibility of glutaric aciduria type I.[32]	• CT head: frontotemporal brain atrophy, subdural fluid collections that sometimes contain blood. • Urine screen: increased levels of glutaric, glutaconic, and 3-hydroxyglutaric acids.
Osteogenesis imperfecta	• Positive family history (autosomal dominant), history of fractures after minor trauma, discoloration of the sclera to a blue-grey colour (types 1 and 3), poor muscle tone.	• DNA analysis from blood testing confirms mutations associated with osteogenesis imperfecta. Quantitative or qualitative differences in collagen detected after skin biopsy and fibroblast culture. • Mutation analysis of COL1A1 and COL1A2 genes from fibroblast RNA may also be performed.
Rickets	• Nutritional insufficiency or deficiency of vitamin D is common if children are breastfed without vitamin D supplementation; however, radiological findings of rickets are rare. • Bone deformities of the forearms and posterior bowing of the distal tibia can occur in infants.	• Typically low calcium and vitamin D levels in hypocalcaemic rickets, in association with elevated parathyroid hormone and findings of osteopenia and widened metaphyses on x-ray.

Condition	Differentiating signs / symptoms	Differentiating tests
Vitamin K deficiency	• Haemorrhagic disease of the newborn due to vitamin K deficiency can be clinically indistinguishable from shaken baby syndrome. • History of lack of administration of vitamin K at birth; drugs taken by mother including warfarin and certain anticonvulsants or antibiotics; or the presence of other medical conditions (intractable diarrhoea, alpha-1 antitrypsin deficiency, hepatitis or biliary atresia, cystic fibrosis, or the use of antibiotics) that result in poor absorption of oral vitamin K.[57]	• Prolonged prothrombin time and activated partial prothrombin time.
Sudden infant death syndrome	• Clinical absence of retinal haemorrhage and skeletal injury.	• Autopsy negative for other causes of death.
Intracranial venous thrombosis	• Superior sagittal venous thrombosis is a rare but serious disease in infants. This may result from dehydration, infection, coagulation disorders, or other medical disorders. • It is important to note that cases of abusive head trauma may result in localised thrombosis in the bridging veins, so it is helpful to have the input of neuroradiology and neurology about whether the venous thrombosis is a result of trauma or a cause of the clinical presentation.	• CT or MRI with venogram is often the most helpful study. Haematology may be consulted to assess for coagulation defects.

Approach

Treatment of infants with abusive head trauma is dependent on the type of injury. In severe cases, management focuses on supportive care because brain damage and other injuries sustained from abuse are generally irreversible.[38][58] Care needs to be coordinated across a variety of teams.

Emergency treatment

The infant's airway, breathing, circulation, and cervical spine control should be assessed and stabilised immediately.[59] An important goal of stabilisation is to avoid secondary injury to the traumatised brain from hypoxia, hypotension, or raised intracranial pressure.[58]

Cardiopulmonary resuscitation, supplemental oxygen, and tracheal intubation may be necessary. Glucose should be administered to correct hypoglycaemia. Benzodiazepines may be required to treat persistent seizures.[60] Attempts should be made to reduce intracranial pressure with medical or surgical intervention.[61]

Severely injured infants may have haematological abnormalities (e.g., anaemia or coagulopathies), which could require blood transfusion or replacement of coagulation factors (e.g., with fresh frozen plasma or platelet transfusion).[62]

Urgent treatment of other abusive injuries such as intra-abdominal injury or unstable fractures may also be necessary.

Interdisciplinary management

Commonly, management of abusive head trauma requires involvement of social workers, child protection team physicians, radiologists, neurosurgeons or neurologists, ophthalmologists, and possibly orthopaedic surgeons.

Evaluation of differential diagnosis may also require the input of geneticists, metabolic experts, and haematologists.

Child protection/legal issues

It is important to consult with the hospital child protection team and social work services as soon as possible when a case of potential child abuse is identified.[1] [22]

If there are other children in the home, child protection services will assess the risk of re-injury of the patient, and risk to other children with the same carer. After assessing the family and other carers, child protection services may remove children from exposure to the offending carer. Additionally, the majority of cases of abusive head trauma will be referred to the police or the relevant authorities for criminal investigation.

The accurate diagnosis of abuse is important to protect the patient and other children from ongoing abuse, and to avoid accusations of abuse in cases where medical findings may be explained by underlying medical disorders (e.g., coagulation defects, metabolic disease, or infection).

Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute (summary)		
all patients		
	1st	supportive care
	plus	child protection services and social work evaluation
with apnoea or bradycardic arrest	plus	CPR per protocol
with seizure	plus	anticonvulsive therapy
with increased intracranial pressure (ICP) ± cerebral oedema	plus	neurosurgery consultation ± ICP monitoring ± ICP-lowering regimen
with subdural haemorrhage	plus	observation ± surgery
with fever or other signs of sepsis	plus	antibiotics
with anaemia	plus	blood transfusion
with coagulopathy	plus	correction of coagulopathy
with associated injury and signs of physical abuse	plus	sub-specialty consultation/referral

Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute

all patients

1st **supportive care**

» Patients often require supportive care to maintain their cardiovascular status. Interventions may include oxygen via a mask or endotracheal tube and infusions of intravenous fluids. Blood glucose levels should also be monitored.

plus **child protection services and social work evaluation**

Treatment recommended for ALL patients in selected patient group

» It is important to consult with a hospital child protection team and social work services as soon as possible when a case of potential child abuse is identified.[1] [22] If there are other children in the home, child protection services may remove those children from exposure to the offending carer. Local policy should be referred to when informing legal authorities.

» The accurate diagnosis of abuse is important to protect the patient and other children from ongoing abuse, and to avoid accusations of abuse in cases where medical findings may be explained by underlying medical disorders (e.g., coagulation defects, metabolic disease, or infection).

» Medical evaluation may involve testing for osteogenesis imperfecta or glutaric aciduria type I.[32] [33] [34]

with apnoea or bradycardic arrest

plus **CPR per protocol**

Treatment recommended for ALL patients in selected patient group

» Medical providers are directed to treatment recommendations for both basic and advanced paediatric life support.[59] [63] [64]

» In patients with severe cardiorespiratory compromise, CPR may be indicated.

with seizure

plus **anticonvulsive therapy**

Treatment recommended for ALL patients in selected patient group

MANAGEMENT

Acute

» Basic guidelines are followed for stabilisation of infants with unexplained seizures.[65]

» For patients with hypoglycaemia, intravenous glucose should be administered as soon as possible.[60]

» If the seizures persist beyond 5 minutes then a benzodiazepine is recommended.[60]

» An alternative anticonvulsant may be required if the seizures continue despite benzodiazepine administration. In refractory cases, induction of a coma may be required.[60]

with increased intracranial pressure (ICP) ± cerebral oedema — **plus** — **neurosurgery consultation ± ICP monitoring ± ICP-lowering regimen**

Treatment recommended for ALL patients in selected patient group

» Raised ICP is clinically suggested by irritability, vomiting, and tense fontanelles. International consensus statements on the management of increased ICP should be followed.[61] [66]

» Patients with paediatric Glasgow Coma Scale scores of ≤8 may need to have ICP monitoring. Monitoring can be done by ventriculostomy, subarachnoid bolt, or intraparenchymal ICP monitor.[61]

» Primary options that can be used to lower ICP include raising the head of the bed to 30°, or using the reverse Trendelenburg position if spinal instability or injury is present. Analgesics and sedation can be useful, as pain and agitation can increase the ICP.[61]

» When ventricular access is available, cerebrospinal fluid drainage should be considered.[61]

» Secondary treatment options to lower ICP include neurosurgery and/or medical options - including barbiturate infusion, late moderate hypothermia, induced hyperventilation, and higher levels of hyperosmolar therapy.[61]

» If hypotension is a contributory factor, vasopressors may be beneficial.

with subdural haemorrhage — **plus** — **observation ± surgery**

Treatment recommended for ALL patients in selected patient group

» While acute, small, non-expansile haematomas may not warrant acute surgical intervention, they may be associated with other intracranial haematomas requiring either

Acute

increased intracranial pressure management or surgical evacuation. In a small group of patients, small subdural haematomas may cause significant cerebral oedema and neurological deterioration. For this reason, clinical symptoms and signs, in conjunction with size, influence the management of subdural haematomas.

» Surgery is indicated for an acute subdural haematoma that is expanding and/or causing neurological signs and symptoms. The decision of what type of surgery to perform depends on the radiographic appearance of the haematoma and the surgeon's preference.

» Surgical options include burr hole craniotomy, where at least 2 burr holes are made and the clot is irrigated out using saline irrigation and suction; trauma craniotomy, which involves standard frontotemporoparietal craniotomy, durotomy and removal of the clot; and hemicraniectomy, which involves a large frontotemporoparietal craniotomy, durotomy, and removal of the clot without replacement of the bone flap.

» Hemicraniectomy and duraplasty is frequently performed when there is considerable cerebral swelling and/or other intraparenchymal lesions.

with fever or other signs of sepsis **plus** **antibiotics**

Treatment recommended for ALL patients in selected patient group

» Appropriate antibiotic administration typically precedes identification of a specific pathogen.

» When choosing empirical therapy, the suspected source of infection or causative organism, local resistance patterns, and the patient's immune status need to be considered.

» Once culture and sensitivity results are known, antibiotics should be adjusted if required. See Sepsis in Children (Treatment algorithm)

with anaemia **plus** **blood transfusion**

Treatment recommended for ALL patients in selected patient group

» Red cell transfusions should be given to ameliorate cardiovascular or respiratory symptoms, for severe anaemia (Hb <100 g/L [10 g/dL]), or for clinical signs of cardiovascular instability such as tachycardia.[67]

with coagulopathy **plus** **correction of coagulopathy**

Treatment recommended for ALL patients in selected patient group

Acute

		» Many patients with severe head injury present in a state of disseminated intravascular coagulopathy and require normalisation of their coagulation profile. All patients should have serial prothrombin time (PT), activated partial thromboplastin time (aPTT), international normalised ratio, platelet and fibrinogen levels. » Correction of coagulopathy can include fresh frozen plasma for abnormal bleeding function (aPTT, PT, fibrinogen) and platelets for severe thrombocytopenia.[62]
with associated injury and signs of physical abuse	**plus**	**sub-specialty consultation/referral** Treatment recommended for ALL patients in selected patient group » It is critical to involve the ophthalmology service in the evaluation of retinal haemorrhages.[13] » Emergency evaluation is required in those with skull fracture, with urgent referral to a neurosurgeon. » If skeletal trauma is evident, stabilisation of spinal injury and/or associated fractures with immediate orthopaedic consultation is necessary in accordance with trauma guidelines.[68] » Emergency evaluation is required in those with signs of abdominal injury, with urgent referral to a paediatric surgeon.

Primary prevention

Parents

- Education in hospital at infant's birth, ongoing education from paediatricians and other family support settings, home visits from visiting nurse or home visitors, parental stress hotlines, parenting groups and other social supports, as well as support from child protection services (with possible transfer of custody to foster care).[25] [26] [27] [28] [National Center on Shaken Baby Syndrome] (http://www.dontshake.org/index.php)

Public

- Legislation supporting community and in-hospital education, public service campaigns, 'Don't shake the baby' cards, flyers, billboard displays, provision of adequate daycare services and other family supports in communities.[29] [30]

Family and formal daycare settings

- Education of staff about the consequences of shaking, checking of references, active and ongoing supervision, open and frequent communication between parents and staff, unannounced visits.

Secondary prevention

It is important to consult with a hospital child protection team and social work services as soon as possible when a case of potential child abuse is suspected or identified.[1] [22]

Child protection services will assess the risk of re-injury of the patient, and risk to other children with the same carer. After doing so, child protection services may remove the patient and other children from exposure to the offending carer.

Additionally, most cases of abusive head trauma will be referred to the police or the relevant authorities for criminal investigation.

FOLLOW UP

Monitoring

Monitoring

Patients require ongoing close medical monitoring after discharge from hospital. Some patients who survive require placement in a rehabilitation facility before discharge home.

Seizure medication must be monitored by neurology service, with appropriate drug levels taken at preordained intervals. Nutrition must be followed, especially if placement of a feeding tube was required. Ophthalmological injury may require ongoing intervention such as vitrectomy for dense vitreous haemorrhage or treatment of glaucoma related to increased intraocular pressure. Orthopaedic injuries may require serial casting or surgical correction.

Children with developmental delay will benefit from early and aggressive physical and occupational therapy, and may require ongoing work with developmental specialists as they enter the school setting. Specialist input by ophthalmology and audiological physicians may also be required, as well as input from mental health teams for patients and families as the legal processes surrounding the diagnosis of abuse move forward.

Complications

Complications	Timeframe	Likelihood
visual impairment/blindness	**short term**	**medium**
Occurs as a result of retinal haemorrhage. May require ongoing intervention such as vitrectomy for dense vitreous haemorrhage or treatment of glaucoma related to increased intraocular pressure. Ophthalmological consultation is necessary.		
developmental delay	**long term**	**high**
Various neurological deficits may result from the cranial trauma or its sequelae, including increased intracranial pressure. Children who are victims of abusive head injury from shaking are at greater risk of permanent neurocognitive delay than those with accidental head injury. Some of this may be due to familial characteristics, as outcome seems to be better for children from higher socio-economic backgrounds.[70] Recovery is variable; ongoing evaluation and treatment by developmental paediatrician, and home- and school-based services, is required.		
severe faltering growth	**long term**	**medium**
Occurs as a result of cranial trauma. A gastrostomy feeding tube (nasogastric or surgically placed) may be necessary.		
cerebral palsy	**long term**	**medium**
May develop as a result of cranial trauma. Consultation with neurologist and specialist services may be necessary. Contractures secondary to cerebral palsy may require orthopaedic consultation and possible surgical intervention.		
chronic seizure disorder	**variable**	**medium**
There is a moderate risk of associated post-traumatic epilepsy. Anticonvulsive therapy and/or consultation with a neurologist may be necessary.		
hydrocephalus	**variable**	**low**
Can occur as a result of cranial trauma. Placement of a ventricular shunt may be required.		
hearing loss	**variable**	**low**
Can occur as a result of cranial trauma. Consultation with an audiologist/otolaryngologist is necessary.		

FOLLOW UP

Prognosis

Around 10% of infants with abusive head trauma from shaking and/or violent slamming die from their injuries acutely.[10] Paediatric Glasgow Coma Scale score ≤5 at presentation, cerebral oedema, retinal haemorrhage, and intraparenchymal haemorrhage are associated with increased mortality.[69]

Most infants who survive sustain some permanent damage ranging from mild learning or behavioural disabilities to chronic seizures, learning difficulties, cerebral palsy, ventilator dependence, and other neurological sequelae (loss of vision and loss of hearing). The degree of brain injury and dysfunction on initial presentation correlates directly with outcome.

Diagnostic guidelines

United Kingdom

Child maltreatment: when to suspect maltreatment in under 18s (https://www.nice.org.uk/guidance/cg89)

Published by: National Institute for Health and Care Excellence **Last published:** 2017

North America

Evaluating for suspected child abuse: conditions that predispose to bleeding (https://publications.aap.org/pediatrics/article/150/4/e2022059277/189508/Evaluating-for-Suspected-Child-Abuse-Conditions?searchresult=1)

Published by: American Academy of Pediatrics section on Hematology/Oncology; American Society of Pediatric Hematology and Onclology; American Academy of Pediatrics Council on Child Abuse and Neglect **Last published:** 2022

Abusive head trauma in infants and children (https://pediatrics.aappublications.org/content/145/4/e20200203)

Published by: American Academy of Pediatrics **Last published:** 2020

ACR appropriateness criteria: suspected physical abuse - child (https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria)

Published by: American College of Radiology **Last published:** 2016

Multidisciplinary guidelines on the identification, investigation and management of suspected abusive head trauma (http://www.cps.ca/en/documents/authors-auteurs/child-and-youth-maltreatment-section)

Published by: Canadian Paediatric Society **Last published:** 2007

Treatment guidelines

Europe

European Resuscitation Council guidelines 2021: paediatric life support (https://cprguidelines.eu)

Published by: European Resuscitation Council **Last published:** 2021

International

Summary from the basic life support; advanced life support; pediatric life support; neonatal life support; education, implementation, and teams; and first aid task forces (https://www.ahajournals.org/doi/10.1161/CIR.0000000000001179)

Published by: International Consensus Group on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science **Last published:** 2023

Pediatric life support 2022 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations (https://publications.aap.org/pediatrics/article-abstract/151/2/e2022060463/189896/2022-International-Consensus-on-Cardiopulmonary)

Published by: International Consensus Group on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science **Last published:** 2023

Management of pediatric severe traumatic brain injury: 2019 consensus and guidelines-based algorithm for first and second tier therapies (https://journals.lww.com/pccmjournal/Fulltext/2019/03000/Management_of_Pediatric_Severe_Traumatic_Brain.8.aspx)

Published by: Society of Critical Care Medicine; World Federation of Pediatric Intensive and Critical Care Societies **Last published:** 2019

North America

Multidisciplinary guidelines on the identification, investigation and management of suspected abusive head trauma (http://www.cps.ca/en/documents/authors-auteurs/child-and-youth-maltreatment-section)

Published by: Canadian Paediatric Society **Last published:** 2007

Online resources

1. National Center on Shaken Baby Syndrome (http://www.dontshake.org/index.php) *(external link)*

Key articles

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- National Institute for Health and Care Excellence. Child maltreatment: when to suspect maltreatment in under 18s. October 2017 [internet publication]. Full text (https://www.nice.org.uk/guidance/cg89)
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Images

Figure 1: Bruising on the ear of a 10-month-old infant

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Figure 2: Torn labial frenulum with associated bruising in a neonate

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Figure 3: Retinal haemorrhages in abusive head trauma are usually widespread and multi-layered, as seen in this image

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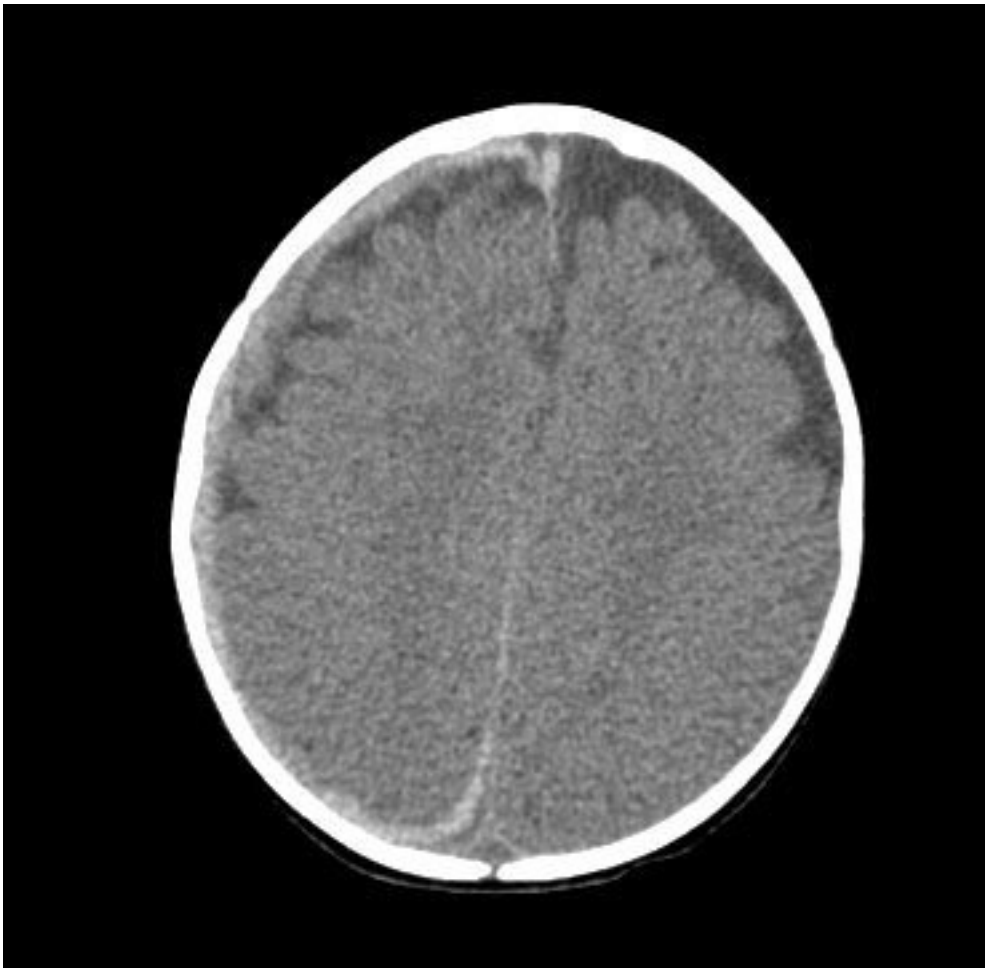

Figure 4: CT scan revealing subdural haemorrhage extending over the right convexity and in the intrahemispheric region, as well as enlargement of the extra-axial fluid spaces

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Figure 5: CT findings in fatal abusive head trauma often reveal significant brain oedema with loss of grey-white differentiation and effacement of the ventricles. Subdural blood is often difficult to appreciate in such cases

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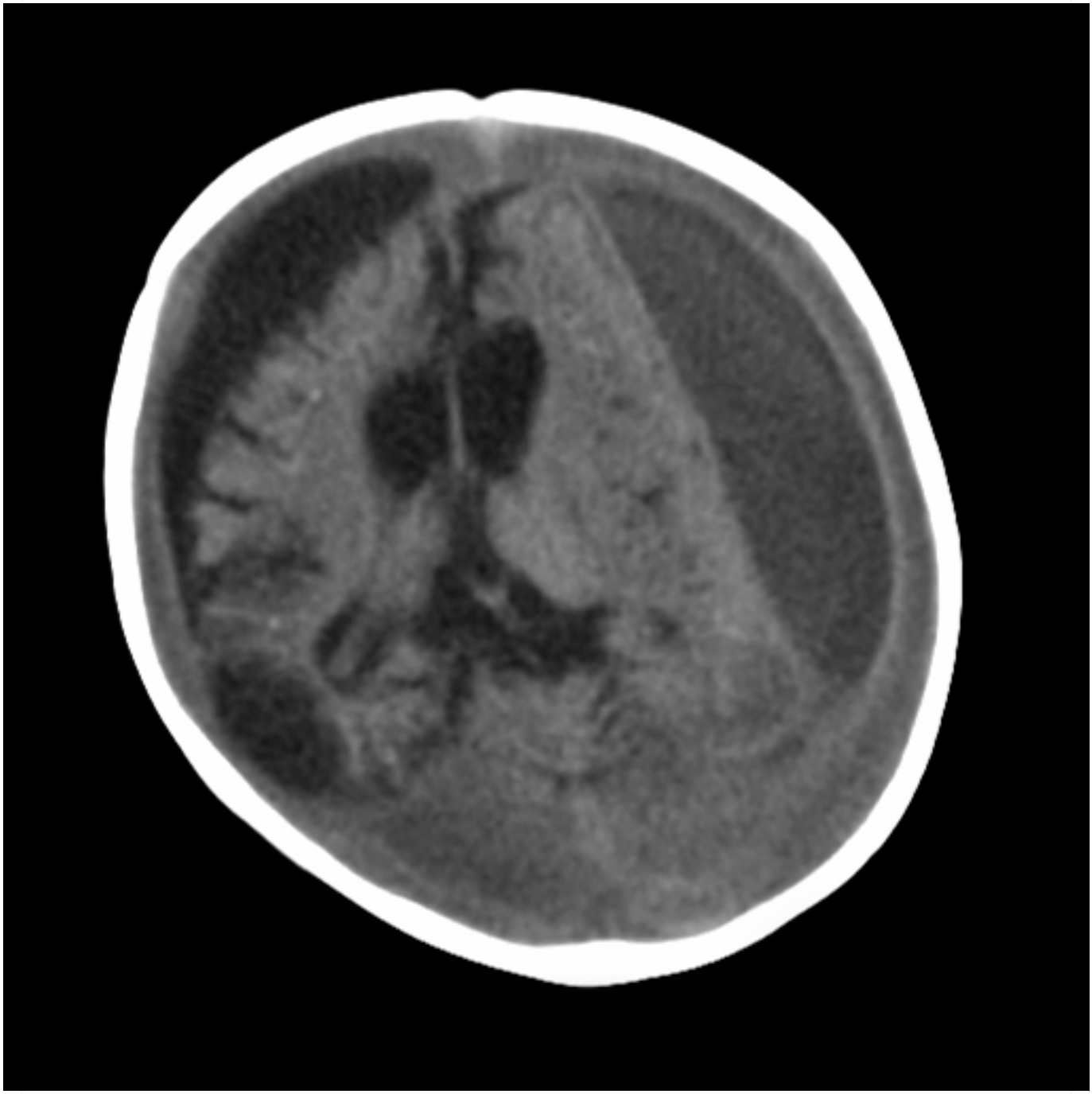

Figure 6: MRI depicting subdural hygromas surrounding severe brain atrophy from abusive head trauma. This child was initially erroneously diagnosed with meningitis

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Figure 1 – BMJ Best Practice Numeral Style

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