

## **EANS/UEMS European examination in neurosurgery**

Variants of questions with answers (compilation - Vyacheslav S. Botev, Department of Neurology and Neurosurgery, Ivano-Frankivsk National Medical University)

### **NON-ACCIDENTAL INJURY IN THE PEDIATRIC**

The presence of skull fractures or intracranial hemorrhage, particularly in children younger than the age of 2 years, in the absence of known trauma to explain such injuries, should raise the suspicion of child abuse (non-accidental trauma). There are more than 3 million reported cases of child abuse each year, and close head injury is among the leading causes of morbidity and death in these children. Approximately 10% of neurologic developmental delays can be attributed to non-accidental trauma. Brain injury may be the result of direct trauma, aggressive shaking, or strangulation or suffocation. There is often little or no evidence of external trauma.

#### **Questions**

1. What is the most common cause of traumatic mortality in infants?
2. Is there a recognizable pattern of physical and behavioral signs and symptoms that warrant consideration of child abuse?
3. Why are the terms *inflicted injury* and *nonaccidental injury* used instead of terms like *shaken-baby syndrome*?
4. What makes recognizing child abuse patients difficult upon presentation?
5. What are some signs that can be associated with inflicted head injury?
6. What findings indicate a more severe acute injury syndrome?
7. What is the estimated risk of suffering inflicted neurotrauma?
8. True or false: At least 24% of children <2 years old who are hospitalized for head injury have suffered nonaccidental trauma.
9. True or false: Most inflicted neurotrauma cases occur in children >2 years of age.
10. What are the risk factors for inflicted injury?
11. What are the most frequent perpetrators of inflicted child injury?

12. What are the two most common histories given by caregivers when children present with nonaccidental head trauma?
13. What are some signs and symptoms to look for when there is no reported history of trauma?
14. How is the best and most helpful history acquired?
15. What are the important questions to ask in a suspected child abuse case after the initial history of trauma is given?
16. Retinal hemorrhages are present in what percentage of children with inflicted neurotrauma?
17. What type of retinal hemorrhages is associated with major traumatic forces in accidental or nonaccidental injuries (i.e., cannot be attributed to low-height falls)?
18. What combination of findings can only be attributed to inflicted injury and not to any other known illness or condition?
19. What is the most common type of intracranial injury reported in the context of inflicted mechanisms?
20. What is “big black brain?”
21. MRI is useful for identifying which lesions resulting from child abuse?
22. True or false: CT scans are more likely to diagnose skull fractures than are skull films.
23. Skull fractures are observed in what percentage of children who have sustained child abuse?
24. In what other areas can skeletal injuries occur in inflicted head trauma patients?
25. What type of skeletal survey should be done?
26. What other study may be useful in identifying subtle injuries not seen by plain films?
27. Are all patterned bruises indicative of abuse?
28. In what ways can head injuries be classified?
29. What are the downsides of using the GCS in children?

30. Why should a history of a fall from a low height together with an acute subdural hematoma prompt consideration of inflicted trauma as the source of the injury?
31. What study, often cited by defense experts in inflicted injury cases, showcased an exception to the above statement?
32. How do falls from playground equipment differ from falls from the same height described in histories given in many inflicted injury scenarios?
33. In young adults, do most acute subdural hematomas need contact in order for large enough forces to be generated to rupture cortical bridging veins?
34. True or false: Overall, low-height falls (such as from a couch <1m tall) can cause skull fractures and epidural hematomas but inadequately account for acute subdural hematomas, brain swelling, and death.
35. How should acute brain injury from inflicted trauma be managed?
36. Should any special considerations be made?
37. What are the three categories that the medical team uses for describing the level of suspicion for inflicted injury?
38. What is one problem that a neurosurgeon participating in a civil or criminal proceeding can encounter?
39. What is a safe statement under such circumstances if the injury syndrome is not consistent with obvious inflicted injury (healing skeletal fractures, acute subdural hematoma, severe bilateral retinal hemorrhages)?
40. What is important for the neurosurgeon to offer in inflicted injury cases?
41. What study has the highest sensitivity and specificity for diagnosing a suspected skull fracture?
42. A 6-month-old boy is brought to the ED for new onset of seizures. You note retinal hemorrhages. A CT scan of the brain is read as normal. What is your conclusion?
43. True or false: Nonabusive head trauma may result in retinal hemorrhage.
44. True or false: In a comparison between inflicted head trauma and noninflicted head trauma, the neurologic findings are similar.
45. A 10-month-old baby is brought to the ED, essentially dead on arrival. No marks, bruises, or ecchymoses are found on the child's body, and there is no

history of illness. Is sudden infant death syndrome (SIDS) the most likely diagnosis?

46. What four types of retinal hemorrhages are associated with abuse?
47. What are the classic CT findings in shaken baby syndrome?
48. Which specific fractures have a high probability of being caused by child abuse?
49. Which specific fractures have a low specificity for abuse?
50. Which of the following is *least* suggestive of child abuse?

- A. Acute and healing long-bone fractures
- B. Interhemispheric subdural hematoma
- C. Parietal skull fracture
- D. Retinal hemorrhages
- E. Tentorial subdural hematoma

51. If a child is in the ER under age 10 with trauma

- a. one must think \_\_\_\_\_, which will be true in **child abuse**
- b. \_\_\_\_\_% of cases. **10%**
- c. Examine \_\_\_\_\_ for \_\_\_\_\_. **retina; hemorrhages**

52. Answer the following regarding child abuse:

- a. True or false. There are pathognomonic findings in child abuse. **false**
- b. Suspicious findings are
  - i. r \_\_\_\_\_ h \_\_\_\_\_ **retinal hemorrhage**
  - ii. b \_\_\_\_\_ c \_\_\_\_\_ s \_\_\_\_\_ **bilateral chronic subdural**  
h \_\_\_\_\_ **hematomas**
  - iii. s \_\_\_\_\_ f \_\_\_\_\_ **skull fractures**

53. Retinal hemorrhage in a baby is pathognomonic of

- s \_\_\_\_\_ / i \_\_\_\_\_ b \_\_\_\_\_ **shaken/impact baby**
- s \_\_\_\_\_. **syndrome**

## Answers

1. What is the most common cause of traumatic mortality in infants?

Inflicted injury.

2. Is there a recognizable pattern of physical and behavioral signs and symptoms that warrant consideration of child abuse?

Yes; in the mid-1900s John Kempe proposed the battered-child syndrome and John Caffey came up with the shaken-baby syndrome.

3. Why are the terms *inflicted injury* and *nonaccidental injury* used instead of terms like *shaken-baby syndrome*?

Because the diverse injuries that children present with stem from a diverse range of mechanistic causes and usually not from a single specific cause (as the term *shaken-baby syndrome* implies).

4. What makes recognizing child abuse patients difficult upon presentation?

Withholding of the true history of present illness and nonspecific symptoms.

5. What are some signs that can be associated with inflicted head injury?

- Single acute neurological events
- Acute or healing skeletal trauma
- Chronic subdural hemorrhages
- Retinal hemorrhages
- Bruising
- Signs of physical neglect

6. What findings indicate a more severe acute injury syndrome?

Apnea and hypoxia.

7. What is the estimated risk of suffering inflicted neurotrauma?

1 in 4065 by age 1.

8. True or false: At least 24% of children <2 years old who are hospitalized for head injury have suffered nonaccidental trauma.

True.

9. True or false: Most inflicted neurotrauma cases occur in children >2 years of age.

False; the mean age of children inflicted with neurotrauma is <1 year of age.

**10.** What are the risk factors for inflicted injury?

- Young parents
- Low socioeconomic status
- Socially unstable households
- Single parents
- Infant prematurity
- Parents or caregivers were subjected to abuse when they were children
- Parents or caregivers have psychiatric or substance abuse histories

**11.** What are the most frequent perpetrators of inflicted child injury?

Most commonly, child abuse is perpetrated by a close relative, usually the parent. Girls are abused more often than boys are, and one parent is usually the “active perpetrator” and the other parent is the “passive perpetrator.”

- Fathers (37%)
- Mothers’ boyfriends (20.5%)
- Female babysitters (17.3%)
- Mothers (12.6%)

Strangers are rarely involved in child abuse.

**12.** What are the two most common histories given by caregivers when children present with nonaccidental head trauma?

History of trivial blunt trauma (usually a fall from a short height, like from a bed) and no history of trauma.

**13.** What are some signs and symptoms to look for when there is no reported history of trauma?

- Difficulty with feeding or vomiting
- Lethargy
- Irritability
- Abnormal movements
- Seizures
- Apnea
- Unresponsiveness

The clinical features most commonly associated with inflicted brain injury in infants include apnea (93%), retinal hemorrhage (71%), and rib fractures (73%).

Also remember that where you find one type of abuse, you are likely to find another type (child abuse, spousal abuse, or elder abuse).

**14.** How is the best and most helpful history acquired?

At the initial meeting, with the neurosurgeon emphasizing the goals of understanding what happened to the child, anticipating the nature of the possible injuries, customizing evaluation and management, and anticipating possible delayed complications.

**15.** What are the important questions to ask in a suspected child abuse case after the initial history of trauma is given?

- Exactly what happened?
- What time did it occur?
- Who was there?
- How high was the fall/drop/trajectory?
- What kind of surface and where on the body did the baby hit?
- What position was he/she in?
- Who saw it happen?
- If there were no witnesses, who heard it/arrived at the scene?
- What did the baby look like and do?
- For how long?
- What happened next?

**16.** Retinal hemorrhages are present in what percentage of children with inflicted neurotrauma?

65 to 95% (best seen with mydriatics).

**17.** What type of retinal hemorrhages is associated with major traumatic forces in accidental or nonaccidental injuries (i.e., cannot be attributed to low-height falls)?

Severe, bilateral retinal hemorrhages.

**18.** What combination of findings can only be attributed to inflicted injury and not to any other known illness or condition?

- Acute subdural hemorrhage
- Healing skeletal injuries
- Healing skeletal injuries
- Severe bilateral retinal hemorrhages (especially with retinal folds or detachments)

19. What is the most common type of intracranial injury reported in the context of inflicted mechanisms?

Acute subdural hematoma.

20. What is “big black brain?”

Extensive hypodensity covering an entire hemisphere or both supratentorial compartments evident on CT, seen in infants and young children (age-dependent response). Attributed to any potential overwhelming combination of brain insults (hypotension, hypercarbia, seizure, hypoxia). Its mortality approximates 67%.

21. MRI is useful for identifying which lesions resulting from child abuse?

Small subdural hemorrhages and parenchymal contusions that do not show up on CT and extra-axial CSF collections from hemorrhagic subdural collections.

22. True or false: CT scans are more likely to diagnose skull fractures than are skull films.

False; skull films are more likely to diagnose skull fractures than are CT scans.

23. Skull fractures are observed in what percentage of children who have sustained child abuse?

25 to 75%.

24. In what other areas can skeletal injuries occur in inflicted head trauma patients?

Ribs, long bones, and spine.

25. What type of skeletal survey should be done?

A full skeletal survey.

26. What other study may be useful in identifying subtle injuries not seen by plain films?

Radioisotope bone scan.

27. Are all patterned bruises indicative of abuse?

No; they can be the result of some folk remedies, like coin rubbing.

28. In what ways can head injuries be classified?

- Type: where and what



- Mechanism: impact and inertial events (e.g., translational or rotational/angular forces)
- Severity: Glasgow Coma Scale (GCS), for use 6 hours after traumatic injury and after resuscitation.

29. What are the downsides of using the GCS in children?

- Cannot be applied to infants and preverbal children
- Sensitive to influence by sedative and paralytic agents and intubation

30. Why should a history of a fall from a low height together with an acute subdural hematoma prompt consideration of inflicted trauma as the source of the injury?

Because numerous studies have demonstrated that, aside from epidural hematomas, falls from low heights (<1m) in children do not result in life-threatening brain injuries.

31. What study, often cited by defense experts in inflicted injury cases, showcased an exception to the above statement?

Plunkett's study that found subdural hematoma with brain swelling as the most common intracranial pathology (sometimes accompanied by retinal hemorrhages) in children falling 2 to 10 feet (60cm to 3m) from playground equipment.

32. How do falls from playground equipment differ from falls from the same height described in histories given in many inflicted injury scenarios?

Playground falls usually occur in older children and involve initial velocity (swings, seesaws, etc.) in addition to free fall acceleration, and thus the traumatic force inflicted on the head may be greater.

33. In young adults, do most acute subdural hematomas need contact in order for large enough forces to be generated to rupture cortical bridging veins?

Yes.

34. True or false: Overall, low-height falls (such as from a couch <1m tall) can cause skull fractures and epidural hematomas but inadequately account for acute subdural hematomas, brain swelling, and death.

True.

35. How should acute brain injury from inflicted trauma be managed?

The same as for acute brain injury from any other source.

36. Should any special considerations be made?

- Anticonvulsants, because seizures are common even though they may be subtle and not clinically evident
- Evacuation of hemorrhages with significant mass effect
- Dural slits for allowance of blood extrusion in the setting of excessive brain swelling
- Decompressive craniectomy when indicated.

37. What are the three categories that the medical team uses for describing the level of suspicion for inflicted injury?

- Consistent with accidental trauma
- Suspicious but not presumptive (indeterminate)
- Presumptive for inflicted injury

38. What is one problem that a neurosurgeon participating in a civil or criminal proceeding can encounter?

Being pressured into stating if the cause of injury was abuse or not because the legal system is inclined toward a more black-and-white specification.

39. What is a safe statement under such circumstances if the injury syndrome is not consistent with obvious inflicted injury (healing skeletal fractures, acute subdural hematoma, severe bilateral retinal hemorrhages)?

“It may have been, but we can’t tell for sure.”

40. What is important for the neurosurgeon to offer in inflicted injury cases?

Objectivity, compassion, and prevention efforts.

41. What study has the highest sensitivity and specificity for diagnosing a suspected skull fracture?

A skull radiograph best shows a skull fracture, although a CT scan of the head often reveals a fracture. If the fracture line is horizontal, it may be missed by the horizontal cuts of the CT scan.

42. A 6-month-old boy is brought to the ED for new onset of seizures. You note retinal hemorrhages. A CT scan of the brain is read as normal. What is your conclusion?

CT may not pick up all central nervous system (CNS) injuries. Your next step is to order an MRI scan. MRI may detect small punctate hemorrhages or subdural collections that are isodense on CT. A new onset of seizures and retinal hemorrhages has a high probability of being caused by child abuse.

**43.** True or false: Nonabusive head trauma may result in retinal hemorrhage.

True. Other causes of trauma may be associated with retinal hemorrhage, but with much lower frequency than shaking. If retinal hemorrhages are present with no history of trauma, suspect an incorrect or hidden history.

**44.** True or false: In a comparison between inflicted head trauma and noninflicted head trauma, the neurologic findings are similar.

False. Children with inflicted head trauma have more severe head injury, which requires more ED management and longer hospital stays and is associated with poorer outcomes.

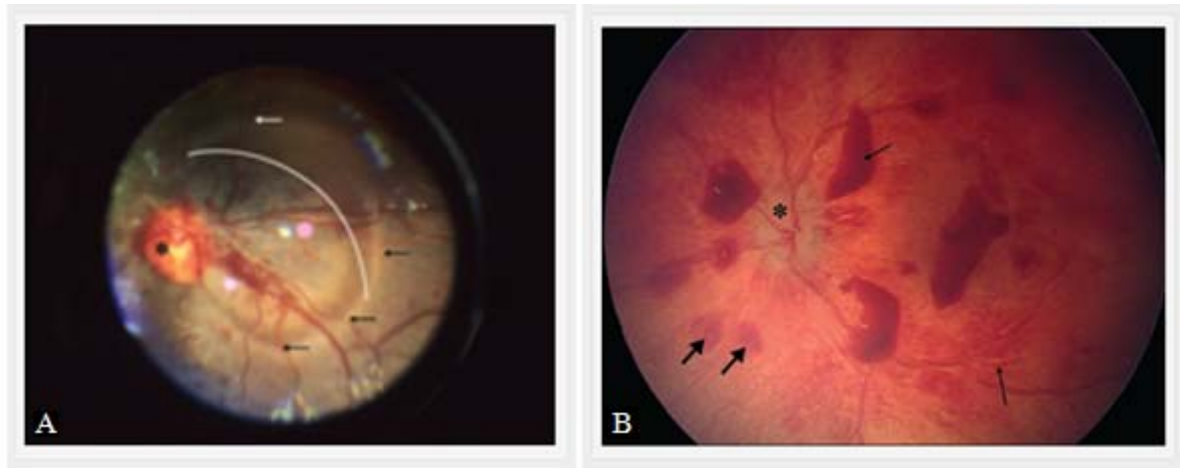
**45.** A 10-month-old baby is brought to the ED, essentially dead on arrival. No marks, bruises, or ecchymoses are found on the child's body, and there is no history of illness. Is sudden infant death syndrome (SIDS) the most likely diagnosis?

Most cases of SIDS occur at ages 2 to 5 months. Once a child is older than 6 months, you should be highly skeptical. Accurate diagnosis of SIDS requires a complete autopsy and death scene investigation.

**46.** What four types of retinal hemorrhages are associated with abuse?

1. Simple flame hemorrhage
2. Dot-and-blot hemorrhage
3. Surface hemorrhage, obscuring vessels
4. Retinoschisis

The retina is a multilayered organ lining the inside of the eye, extending from the optic nerve to behind the iris. The anterior (peripheral) retinal edge is the ora serrata. Retina around the optic nerve is the peripapillary retina. The posterior pole includes the optic nerve disc, macula (generally defined as posterior retina extending out to temporal vascular arcades), fovea (center of macula), and peripapillary region (A). Four vortex veins mark the posterior edge of peripheral retina. The area between the posterior pole and peripheral retina is the midperipheral retina (B). One can describe patterns of distribution (eg, perivascular).



(A). Traumatic macular retinoschisis of an infant with abusive head trauma. Photograph shows the posterior pole including the optic nerve (asterisk) and hypopigmented circumferential retinal fold (arrows). The hump in the vessel created by the fold can be seen where the vessels cross. The arc highlights the 3-dimensional appreciation of the elevated internal limiting membrane of the retina creating a domed cavity involving the macula. There is no blood within the cavity in this child.

(B). Posterior pole of the left eye and extending into the midperiphery of the retina (at edges of image) of an infant with abusive head trauma. Image shows optic nerve (asterisk), a preretinal hemorrhage (note how it lies over a retinal vessel) (short arrows), and flame hemorrhage with characteristic linear appearance (long arrows).

Retinal hemorrhage (RH) can also be counted. When the number becomes too high to easily count, terms such as confluent, too numerous to count, or rough estimates of number (eg, 50-100) should be used. One should avoid terms such as mild, moderate, severe, or extensive. What may seem severe to someone who has never seen an RH may actually be mild to someone with more experience.

When bleeding occurs in front of the retinal layers, the hemorrhage is described as preretinal or subhyaloid (underneath the hyaloid [ie, vitreous gel]; B). Intraretinal RH encompasses any bleeding within retinal layers. If bleeding is within the superficial nerve fiber layer, it has a flame or splinter appearance (B), whereas hemorrhage into the deeper layers appear to be and are called dot or blot hemorrhage (B). Blot hemorrhages are relatively larger than dot hemorrhages but without objective criteria for this distinction. Bleeding under the retina is subretinal.

Retinal hemorrhages occur in approximately 85% of abusive head trauma (AHT) cases. More than 75% have bilateral RH. In approximately two-thirds, RHs are too numerous to count, involving multiple retinal layers and covering nearly the entire retinal surface. Retinal hemorrhages from accidental causes rarely reach the periphery, are usually confined to the posterior pole, and are few. Severity of the RH correlates positively with severity of the intracranial trauma.

47. What are the classic CT findings in shaken baby syndrome?

The classic findings are subdural hemorrhage, particularly in the intrahemispheric fissure; injury to the frontal or occipital lobe; loss of gray-white matter differentiation; and basal ganglia injury. Evidence of old CNS injury is another alerting sign.

48. Which specific fractures have a high probability of being caused by child abuse?

Rib fractures, metaphyseal chip fractures, spine and scapula fractures, and complex skull fractures.

49. Which specific fractures have a low specificity for abuse?

Linear skull fractures, clavicle fractures, single-bone transverse fractures, and spiral fractures of the tibia (toddler's fracture).

50. C. Parietal skull fracture.

Of the choices listed, an isolated parietal skull fracture (C) is the *least* suggestive of child abuse, or nonaccidental trauma. Acute and healing long bone fractures (A), retinal hemorrhages (D), and the presence of subdural hematomas (B and E) should be treated as nonaccidental trauma until proven otherwise. When associated with abuse, skull fractures tend to be multiple or complex, depressed, and nonparietal.

## Pearls

- Inflicted injury is the most common cause of traumatic mortality in infants.
- The most common constellation of findings in children with inflicted head injury includes subdural hemorrhages with or without scalp contusion, skull fracture, retinal hemorrhage, and skeletal injury.
- Because children may present with a variety of injury types resulting from a variety of mechanistic causes, the terms inflicted injury and nonaccidental injury are preferable to those implying a specific single mechanism (such as shaken baby syndrome).
- The most common history is no history of trauma (infant presenting because of symptoms such as lethargy or seizures) or a history of a short-height free fall.
- Infants may present with varying levels of consciousness, ranging from normal to comatose. An infant who does not cry or grimace in response to painful stimulation can be considered to have cortical impairment.
- Apnea and seizures are common, and seizures may be subclinical.
- Infants who present with unresponsiveness and whose imaging shows bilateral hemispheric hypodensity have high morbidity rates and uniformly poor outcomes. Infants with lesser degrees of injury have variable outcomes. Early hemicraniectomy has gained increasing use in children with the unilateral form of severe brain swelling associated with subdural hematoma.



## Nonaccidental versus accidental trauma in children

### **Skull fracture**

Skull fractures unusual in accidental trauma.

A combination of old and new skull fractures, or fractures that are multiple, complex, bilateral, or that cross sutures: suspicious of nonaccidental head injury (NAHI).

If fractures occur, they are typically linear (both in trauma and NAHI).

Stellate, depressed, diastatic (>1 mm width) and/or comminuted fractures more common in NAHI.

Direct impact can cause ping-pong fracture with indenting of the membranous calvarial bone.

X-rays are the gold standard for identification of skull fractures; computed tomography (CT) may miss linear fracture but is the study of choice for underlying intracranial lesions.

### **Intracranial hemorrhage**

Acute subdural hemorrhage, particularly at multiple locations, should raise suspicion for NAHI.

MRI recommended in all patients with suspected NAHI (combination of CT and MRI increases accuracy).

Subarachnoid hemorrhage (SAH) seen in nearly all serious head trauma; SAH seen in interpeduncular cisterns and sylvian fissures.

SAH in the setting of NAHI seen in the sulci along the falx or as focal hyperdense clots within the cerebral hemispheric sulci.

Acute subdural hemorrhage due to accidental trauma is rare.

Epidural hematomas rare and usually venous in origin.

Cortical contusions may be seen in both accidental and NAHI.

### **Cerebral edema/infarct**

Cerebral edema in NAHI usually diffuse. Infarction in NAHI tends to be multifocal or involving multiple lobes.

Infants with edema may also develop watershed infarct, usually between the anterior and middle cerebral artery territories.

Multifocal SDH in combination with diffuse ischemic change is highly suspicious of NAHI.

Strangulation is associated with cerebral infarcts from compression carotid artery in the neck.

Retinal hemorrhages seen funduscopically are classic of NAHI but are rarely seen on imaging.

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