

Original Paper

The Unspoken Shaken Baby Lie Detector Algorithm—An
Analysis of Diagnostic Procedures in Cases of Allegedly
Abusive Head Trauma without External Signs of Trauma

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Abstract

Various algorithms have been developed for diagnosis of Abusive Head Trauma (AHT); however, there is no explicit algorithm for the 1/3 of alleged AHT cases which present with findings restricted to subdural and retinal hemorrhages, with or without encephalopathy—i.e., isolated triad cases. Moreover, such cases have been lumped together with AHT cases with external sign of trauma and all diagnosed as AHT despite those we are focusing on lack signs of trauma. It is therefore relevant to analyze how this diagnosis can be reached in the absence of unequivocal trauma.

Our analysis indicates that with respect to isolated triad cases, a two-step algorithm seems to be in use—but unspoken. The first step concerns a ruling out diagnostic process and the second step addresses the veracity of the caregivers' narrative. Both steps are based on the traditional AHT mechanism theories and ten tacitly applied auxiliary hypotheses which are, however, questionable or incorrect. If the traditional AHT mechanism theories and necessary auxiliary hypotheses are not valid, then neither is the two-step algorithm.

Accordingly, we propose that in alleged AHT cases with no external signs of trauma, the two-step algorithm—here referred to as the unspoken shaken baby lie detector algorithm—should be abandoned.

Keywords

Philosophy of medicine, scientific controversies, shaken baby syndrome, hidden lie detector algorithm, social consequences

1. Background

It has been claimed that Abusive Head Trauma (AHT) is solely a medical, evidence-based diagnosis (Choudhary et al., 2018, Choudhary et al., 2019) and not a legal determination of the intent of the perpetrator—in spite of the word “abusive” (Choudhary et al., 2018). Child Abuse Pediatricians (CAPs) might rule out possible differential diagnoses of other conditions, apart from shaking, which present with Subdural Hemorrhage (SDH), Retinal Hemorrhages (RH) and symptoms of encephalopathy—referred to as the triad. Triad findings might be identified with and without external signs of trauma. But an assessment of the caregiver’s account of events is also often included. A typical question is whether the (initial) narrative is commensurate with the alleged signs of trauma (Hettler & Greenes, 2003; Hymel et al., 2020). If a caregiver states that nothing has happened and the infant in addition to the triad exhibits a number of external signs of trauma—e.g., bruises, fractures—these signs might indicate that the caregiver is hiding something and not telling the truth. However, when an infant displays the triad without external signs of trauma, the caregiver is often suspected of having shaken the baby, regardless of the caregiver’s narrative. But how is it possible to conclude that a child without accepted signs of trauma has been physically abused? Research has been undertaken in order to provide CAPs and Child Protection Teams (CPTs) with guidelines for the diagnosis of AHT (Hettler & Greenes, 2003; Hymel et al., 2020; Duhaime et al., 1992; Chadwick, 1997; Reece & Sege, 2000; Reece, 2008; De Leeuw et al., 2013). Algorithms and criteria have been developed and a special clinical tool, for predicting AHT, has also been presented (Cowley et al., 2018).

Triad cases *without* external signs of trauma comprise around 1/3 of all alleged AHT cases (Lynøe & Eriksson, 2018) with a peak age of 4-8 weeks (Parks, Sugeman, Xu, & Coronado, 2012; Parks, Kegler, Annett, & Mercy, 2012). It is noticeable the peak age is similar to other conditions such as Sudden Infant Death Syndrome (SIDS) and Brief Resolved Unexplained Event (BRUE) and it has been suggested that the latter condition might cause both SIDS and alleged AHT cases without external signs of trauma (Lynøe & Eriksson, 2020).

Based on a biomechanical study and certain criteria, Duhaime et al. presented an integrated algorithm in which they stated that isolated subdural and subarachnoid bleedings were *suspicious* for inflicted injury if the caregiver provided *no history* (Duhaime et al., 1992). Moreover, these authors stated that the presence of isolated subdural and subarachnoid bleedings was *presumptive* for inflicted injury if the caregiver *changed history* or if the story was *developmentally incompatible* (Duhaime et al., 1992). This algorithm has obviously had a huge impact on how concerned CAPs and child protection teams have diagnosed AHT, and was also used by Reece et al. when evaluating criteria for diagnosing AHT (Reece & Sege, 2000; Reece, 2008). The same algorithm was applied by Hettler et al. (Hettler & Greenes, 2003) and recently by Hymel et al. (Hymel et al., 2020) to estimate the validity of the caregiver’s initial story in predicting shaking. Furthermore, the presence or lack of a lucid interval was used when de Leeuw et al. (De Leeuw et al., 2013) determined whether or not the caregiver’s story was

false. Apart from these studies however, a more comprehensive algorithm for diagnosing isolated triad cases as AHT has never been openly presented.

In the subsequent section we aim to identify *the unspoken shaken baby algorithm* for identifying isolated triad cases as allegedly AHT cases. The medico-legal prediction tool we present comprises a two-step algorithm: (i) the clinical *rule out diagnostic process* with its five auxiliary hypotheses; (ii) a process to determine whether or not the caregiver is lying, which presupposes five additional auxiliary hypotheses.

The reasons for referring to an *unspoken shaken baby lie detector algorithm* are twofold: (i) It is unspoken regarding triad cases *without* external signs of trauma because isolated triad cases have been obfuscated when lumped together with triad cases *with* external signs of trauma; and (ii) it is unspoken because the necessary auxiliary hypotheses have not previously been openly presented. The validity of all ten auxiliary hypotheses will be examined in the *Discussion* section.

1.1 The Unspoken Shaken Baby Lie Detector Algorithm

A fictive but typical case: A caregiver presents at the emergency department with a 2 month-old infant suffering from encephalopathy (e.g., lethargy) but without external signs of trauma. The caregiver states that the infant was crying before it became lethargic and eventually lost consciousness. On the basis of the encephalopathy symptoms, the pediatrician will probably first rule out sepsis, stroke, hypoglycemia, meningitis, and increased intracranial pressure (Reynolds, Marikar, & Roland, 2018) as the cause, and subsequently orders a CT and/or MRI scan of the infant's head. The scan indicates the presence of a thin bilateral subdural hemorrhage (SDH) but nothing else. The infant is later referred for examination by an ophthalmologist, who finds bilateral retinal hemorrhages (RHs). The infant is then referred to a Child Protection Team (CPT) and the social services are alerted. Under optimal conditions, the CPT initiates clinical examinations in order to rule out certain differential diagnoses or conditions that might be associated with the triad findings without external signs of trauma. These include, i.a., coagulation disorders, infectious diseases, metabolic diseases and malignancies such as leukemia (Elinder et al., 2018) (Figure 1).

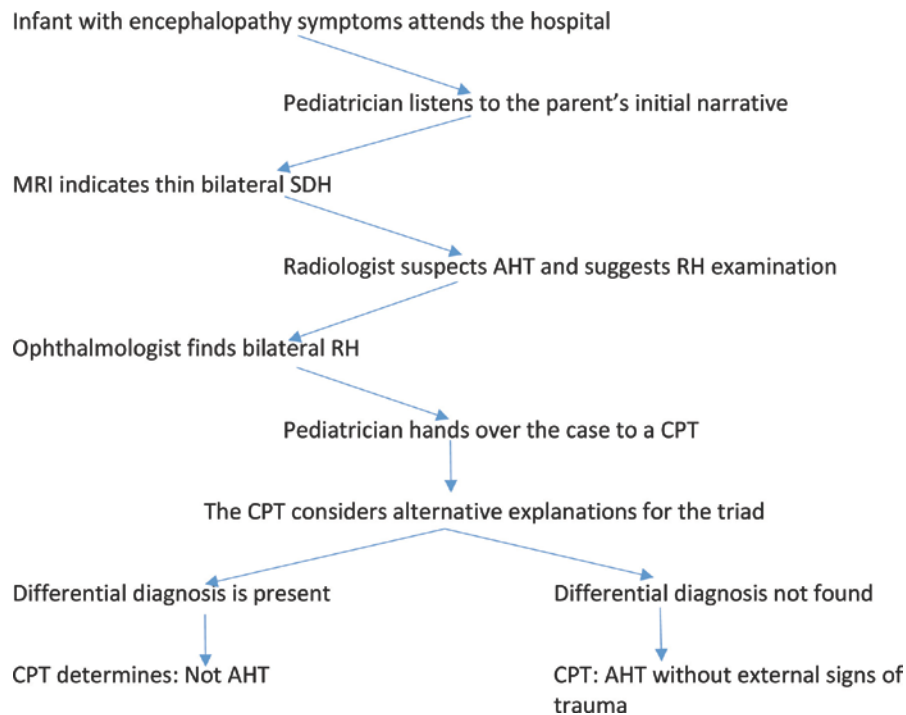


Figure 1. The First Steps of the Algorithm, the Clinical Examination Procedure in the Presented Case. SDH=Subdural Hemorrhage, AHT=Abusive Head Trauma, RH=Retinal Hemorrhage, CPT=Child Protection Team

But conditions which refer to re-bleeds after a birth related SDH, brain swelling due to hypoxia, venous sinus thrombosis, benign extra-axial fluid of infancy and minor trauma are not “acceptable” differential diagnoses (Jenny, 2014).

If, however, the “accepted” differential diagnoses are ruled out, it is time for the next step: evaluating the initial account given by the caregiver. If the CPT rules out all “acceptable” explanations—explanations which also can cause isolated triad findings—it is by default concluded that the only possible explanation remaining is violent shaking. This reasoning presupposes, however, the validity of the five subsequent auxiliary hypotheses (I-V):

- I. Unknown explanations do not exist and differential diagnoses which today are not accepted by all will never be accepted in the future.
- II. The position that, in the absence of another “acceptable” explanation, the infant *must* have been shaken violently presupposes that there is no controversy, and there will never be any controversy, regarding what explanations are “acceptable” and what is not.
- III. The isolated triad cannot develop spontaneously or after a minor trauma, e.g., a short fall.
- IV. Violent shaking always results in the development of the triad.

V. If shaking does not generate forces sufficient to explain the isolated triad, it is assumed that the infant's head has also been slammed against a soft surface.

Provided these five unspoken auxiliary hypotheses are valid, it might be possible to claim that infants with the isolated triad *must* have been shaken violently (Hymel, 2020; Duhaime, 1992).

The next step is to assess the caregiver's account of events. However, in order to make this step function, five additional unspoken auxiliary hypotheses are needed to determine that the caregiver is lying (VI-X):

VI. Since the encephalopathy symptoms are supposed to occur promptly after shaking it leaves no room for a lucid interval.

VII. An infant's crying triggers violent shaking.

VIII. False confessions do not occur, accordingly when a person confesses that he/she has shaken a baby this is always correct and so is a subsequent conviction.

IX. Any adult is capable of shaking an infant violently, i.e., this kind of abuse is not limited to families with a history of, e.g., abuse, psychopathology or domestic violence.

X. If the caregiver tells that he/she did shake the baby, but only *after* the baby became unconscious—as an action of resuscitating—this is “not acceptable” and the caregiver must lie.

The initial account of events by the caregiver in the fictive case presented above was that at first the infant was crying, became lethargic after a while and eventually unconscious. The caregiver's description indicates that the encephalopathy symptoms developed successively. According to the traditional AHT mechanism theories (Duhaime et al., 1992), the symptoms are, however, supposed to appear promptly; thus the caregiver's narrative is apparently not correct. If the caregiver instead states that he/she actually shook the baby, but only in an attempt at resuscitation *after* it became unconscious, then the caregiver has changed the account of events. The CAP concludes that this story is “not acceptable” for two reasons: (i) the assumed cause cannot appear *after* its effects, i.e., after the encephalopathy symptoms; (ii) the fact that the caregiver changed the narrative is suspicious in itself (Hettler & Greenes, 2003; Hymel et al., 2020). “No history” or “changing the initial history” has actually been used as a *positive predictive value* for diagnosing AHT (Hettler & Greenes, 2003; Hymel et al., 2020). Most caregivers actually do not have a narrative when they present at the hospital with the infant, indicating that they do not know the cause of the infant's symptoms in these cases *without* (external) signs of trauma (Choudhary et al., 2018).

The next question is: How did the caregiver react to the infant's crying? It is generally assumed that the infant's crying might trigger violent shaking (Barr, 2014): hence crying might indicate that the infant was actually shaken. Accordingly, if the caregiver denies having shaken the infant, this is interpreted as a lie (Figure 2).

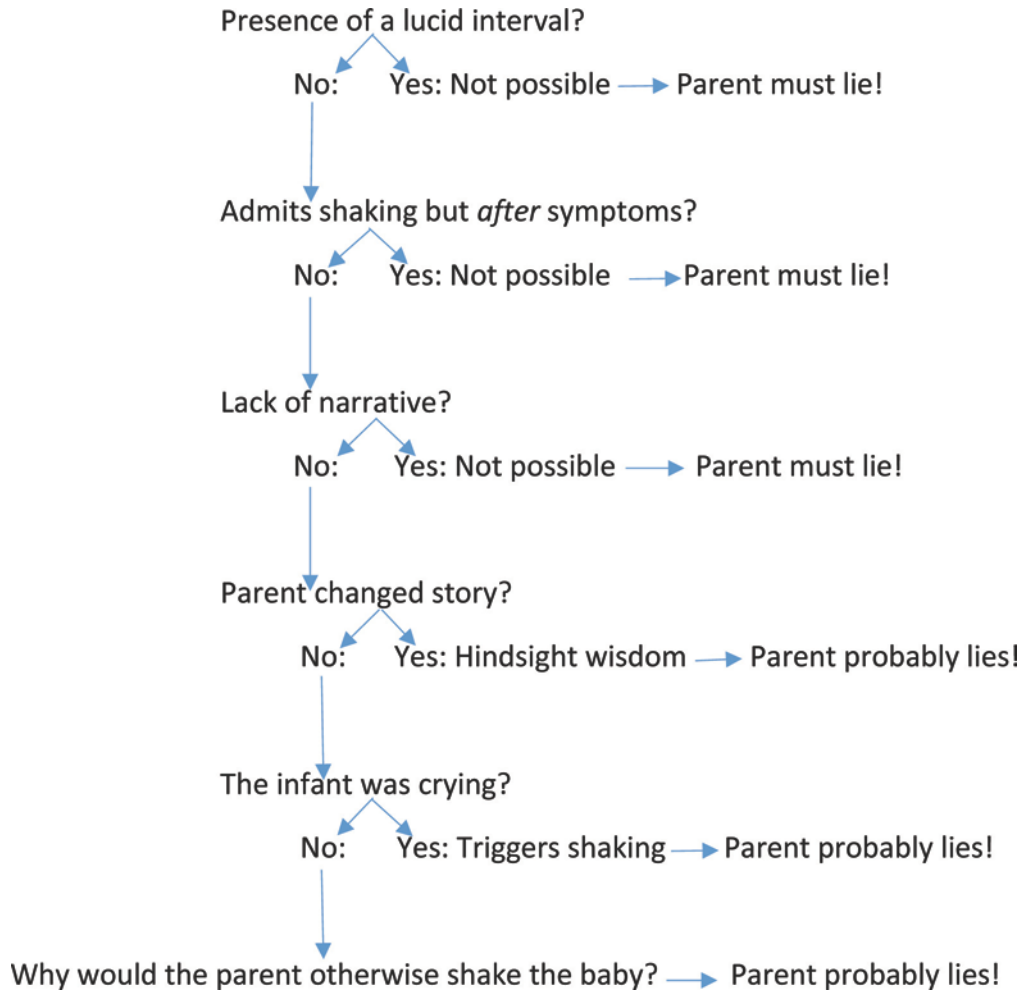


Figure 2. The Shaken Baby Lie Detector Algorithm. This Algorithm Will Solely Determine Whether or not the Parent/Caregiver Is Actually Lying—the Algorithm Cannot Be Used to Determine If He/She Is Telling the Truth; Hence the Algorithm Functions as a Medico-Legal Tool to Confirm Lies

Depending on the caregiver's account of events, the order of the different topics might vary, but as illustrated, the outcome is that the caregiver is considered to be lying unless he/she (falsely?) confesses to having shaken the infant violently.

2. Discussion

As can be seen from the second step of the unspoken shaken baby lie detector algorithm (Figure 2), there are several apparently strong arguments indicating that the caregiver *must* be lying. When applying this lie detector algorithm to the fictive case above, the caregiver has no chance of being considered trustworthy unless he/she confesses to having shaken the infant violently in order to stop the infant's crying. The auxiliary hypothesis (VII) that crying trigger violent shaking (and/or that shaking

leads to the triad symptoms) might be questioned since a preventive program teaching caregivers how to manage an infant's crying did not decrease the incidence of alleged AHT cases (Zolotor et al., 2015; Lynøe & Eriksson, n.d.).

A slow and successive development of symptoms (a "lucid interval") makes the caregiver's account of events theoretically impossible (De Leeuw et al., 2013) and similarly if the caregiver confesses to having shaken the infant but only *after* the onset of symptoms. Hence, if this reasoning is applied, it confirms that the caregiver must be lying. Moreover, if the reasoning is combined with the caregiver's initial narrative that the baby had been crying before becoming lethargic and eventually unconscious, the conclusion becomes even more certain: the baby *must* have been shaken violently and one of the caregivers must be the perpetrator (De Leeuw et al., 2013).

It has been claimed repeatedly that it is a myth that the triad is used in clinical practice as sole and sufficient evidence of AHT. If it were untrue that the concerned pediatricians use the triad when determining AHT in cases without external signs of trauma, such cases would never be handed over to a CPT or if so, the CPT would determine that such cases are not caused by abuse. Obviously, this is not what happens in real life—isolated triad cases account for approximately 1/3 of all alleged AHT cases (Lynøe & Eriksson, 2018), and repeatedly appear in court trials in several countries such as, e.g., Australia, Canada, France, Japan, Norway, and US (Wester, 2019; Lynøe et al., 2019). In Australia the presence of the isolated triad has recently been described as a "smoking gun" (Brook, 2019).

The question is, however, how valid are the traditional AHT mechanism theories and the applied auxiliary hypotheses? If these mechanism theories and auxiliary hypotheses are not valid or even false, what are the implications for the unspoken shaken baby lie detector algorithm?

2.1 Are the Mechanism Theories and The Associated Auxiliary Hypotheses Valid?

Even though proponents of the traditional AHT mechanism theories claim that "there is no scientific controversy within the AHT research area" (Choudhary et al., 2018), several new mechanism theories have been suggested—clearly illustrating that a scientific controversy actually exists. The first alternative theory was presented during 2001-2004 by Geddes and co-workers (Geddes, Hackshaw, Vowles, Nickols, & Whitwell, 2001; Geddes, Vowles, Hackshaw, Nickols, Scott, & Whitwell, 2001; Geddes & Whitwell, 2004). Their theory questioned the prevailing theory about the mechanism underlying the encephalopathy symptoms. The point of departure was the microscopic examination of the brains of 37 fatal cases—median age 2.4 months (Geddes, Vowles, Hackshaw, Nickols, Scott, & Whitwell, 2001). Of those, 28 presented no nerve fiber disruption, instead they displayed hypoxia. Only two infants who also had impacts (multiple skull fractures) had brain damage with torn nerve fibers. Twelve of the 28 infants had no external signs of trauma or other impacts—only the triad was identified in these cases. The authors suggested that the encephalopathy of the infants with isolated triad findings were due to *hypoxic* brain damage followed by brain edema and increased intracranial pressure, and the SDH and RH were secondary to this cascade of events (Geddes, Hackshaw, Vowles, Nickols, & Whitwell, 2001; Geddes, Vowles, Hackshaw, Nickols, Scott, & Whitwell, 2001; Geddes &

Whitwell, 2004). Hypoxia, brain edema and increased intracranial pressure might develop over hours or days: hence this mechanism theory encompasses the possibility of the existence of a lucid interval between the allegedly traumatic shaking and the onset of symptoms. This has consequences for both the first and the second step of the presented lie detector algorithm and the actual auxiliary hypotheses. Firstly, the mechanism theory that the encephalopathy symptoms are due to disrupted nerve fibers seems to be incorrect in triad cases without external signs of trauma. Secondly, the assumption that the encephalopathy symptoms occur immediately after the alleged traumatic shaking (De Leeuw et al., 2013) also seems to be incorrect in isolated triad cases.

Later, Geddes' research group suggested that hypoxia is not necessarily attributable to trauma, but might develop more or less spontaneously and accordingly have natural or physiological causes such as, e.g., gastroesophageal reflux (Geddes & Whitwell, 2004). If this is correct it also has implications for the unspoken shaken baby lie detector algorithm, due to the immaturity of the infant's brain (Lynøe & Eriksson, 2020). In triad cases without external signs of trauma a caregiver might be telling the truth when he/she maintains that nothing happened before the infant displayed symptoms of encephalopathy and eventually became unconscious. After all, the absence of external signs of trauma cannot automatically be regarded as proof of physical trauma! Similarly, the caregiver might also be truthful if admitting that he/she did shake the infant, but only as an attempt at resuscitation *after* the infant became unconscious.

Although Geddes' hypoxia theory has been heavily criticized by proponents of the traditional AHT mechanism theories (Choudhary et al., 2018; Jenny, 2014; Punt et al., 2004; Richards et al., 2006), authors of a comparison analysis found the hypoxia theory was much more plausible than the traditional AHT mechanism theories (Acres & Morris, 2014). Moreover, other authors have actually corroborated Geddes' hypoxia theory (Kemp et al., 2003; Oehmichen, Schleiss, Pedal, Saturnus, Gerling, Meissner, 2008; Cohen & Scheimberg, 2009; Cohen, Sprigg, Whitby, 2010; Scheimberg et al., 2013).

The traditional AHT mechanism theories has also been shown to suffer from several scientific inconsistencies, paradoxical phenomena and anomalies, indicating several types of scientific crises (Lynøe, Juth, & Eriksson, 2019). Although apparently supported by a huge number of observational studies, the great majority of these studies is based on circular reasoning and hence suffers from high risk of bias (Elinder et al., 2018; Lynøe & Eriksson, 2018). Accordingly, these studies do not corroborate the traditional AHT mechanism theories.

The ten above-mentioned auxiliary hypotheses might also be questioned:

Ad I. The claim that only certain "acceptable" differential diagnoses need to be ruled out—meaning that new theories and diagnoses will not be developed and what we accept as true today can never be changed—does not conform with the history and development of medical science (Johansson & Lynøe, 2008). Hence, if AHT proponents claim to have found the final truth they have embraced an

unscientific approach to medical research (Johansson & Lynøe, 2008). This auxiliary hypothesis is simply incorrect.

Ad II. The auxiliary hypothesis that in the absence of an alternative “acceptable” explanation the infant *must* have been shaken violently can also be questioned because it will result in a discussion of what constitutes “acceptable” explanations in isolated triad cases (Acres & Morris, 2014). In an ongoing scientific controversy it is very difficult to tell which of the competing theories should prevail without being biased, and this auxiliary hypothesis is currently neither correct nor incorrect.

Ad III. The auxiliary hypothesis that the triad cannot develop spontaneously or after minor trauma has been questioned by competing theories but also by a witnessed fall from low height (e.g., Gardner, 2007). The auxiliary hypothesis seems to be more incorrect than correct.

Ad IV. The auxiliary hypothesis that the triad *must* be due to violent shaking has also been questioned in epidemiological, biomechanical and other studies (Elinder et al., 2018; Acres & Morris, 2014; Duhaime, 1988; Duhaime, Gennarelli, Thibault, Bruce, Margulies, & Wiser, 1987). This auxiliary hypothesis seems to be merely incorrect.

Ad V. The auxiliary hypothesis that infants with isolated triad findings who were subjected to only limited shaking forces must also have been slammed into a soft surface is contradicted by biomechanical studies [Duhaime, 1988; Duhaime, Gennarelli, Thibault, Bruce, Margulies, & Wiser, 1987; Findley et al., 2012], and the auxiliary hypothesis should accordingly be considered as incorrect.

Ad VI. The auxiliary hypothesis that there is no “lucid interval” between alleged shaking and the encephalopathy symptoms might be correct in some triad cases *with* external signs of trauma, but in cases *without* external signs of trauma it must be questioned as no physical trauma has been proven. If in such cases a better explanation is hypoxia (Geddes, Hackshaw, Vowles, Nickols, & Whitwell, 2001; Geddes, Vowles, Hackshaw, Nickols, Scott, & Whitwell, 2001; Geddes & Whitwell, 2004; Acres, & Morris, 2014; Kemp, Stoodley, Cobley, Coles, & Kemp, 2003; Oehmichen, Schleiss, Pedal, Saternus, Gerling, Meissner, 2008; Cohen & Scheimberg, 2009; Cohen, Sprigg, Whitby, 2010; Scheimberg et al., 2013), the onset time of symptoms can vary between hours and days. This auxiliary hypothesis is questionable due to the current scientific controversy.

Ad VII. The auxiliary hypothesis that it is the baby’s crying that triggers violent shaking has probably been based on caregivers who have confessed to having shaken the baby (Biron & Shelton, 2005; Adamsbaum, Grabar, Mejean, & Rey-Salmon, 2008). If this were correct, prevention program studies in how caregivers should behave if their baby cries would have had an effect, but this is not the case (Zolotor et al., 2015; Lynøe & Eriksson, n.d.). This auxiliary hypothesis also depends on the correctness of the subsequent auxiliary hypothesis:

Ad VIII. Confessions are always true, meaning that false confessions will never occur. It is well known, however, that both police-induced confessions and plea bargain procedures bring about false confessions (Lynøe, Juth, & Eriksson, 2019; Beaulieu, Jiang, Zheng, Rajabali, & Pike, 2019; Court of Appeal for Nedre Norrland (Sweden), 2015). This auxiliary hypothesis is clearly incorrect.

Ad IX. The auxiliary hypothesis that *all* caregivers are able to shake a baby violently—independent of socioeconomic background—has been contradicted by studies in which suspects have been identified (Beaulieu, Jiang, Zheng, Rajabali, & Pike, 2019; Ghahreman, Bhasin, Chaseling, Andrews, & Lang, 2005) and is accordingly incorrect.

Ad X. Apparently it seems reasonable to claim that a caregiver must lie if he/she tells that he/she did shake the baby but only *after* it became unconscious—an effect cannot appear before its cause. But this is correct only if violent shaking is supposed to be the one and only possible cause for the appearance of the isolated triad. If the hypoxia theory is correct and hypoxia has been caused by, e.g., gastroesophageal reflux (Niederkrötenhaler, Xu, Parks, & Sugerman, 2013) and the subsequent cascade of hypoxia, brain swelling and increased intracranial pressure has caused the subdural and retinal hemorrhages, the caretaker might have told the truth. Hence, also this auxiliary hypothesis is questionable.

The examination of the ten tacitly assumed auxiliary hypotheses indicates that some are contradicted or incorrect, others are questionable due to the current scientific controversy, but none is unequivocally correct. Further, the traditional AHT theories have been shown to suffer from different and disturbing inconsistencies, paradoxical phenomena and anomalies (Lynøe, Juth, & Eriksson, 2019). Accordingly, it seems reasonable to conclude that if the system of established AHT mechanism theories and the associated auxiliary hypotheses on which the unspoken shaken baby lie detector algorithm is based is incorrect or questionable, the algorithm must also be regarded as incorrect and questionable. The algorithm should accordingly be abandoned as a diagnostic tool in triad cases without external signs of trauma.

3. Conclusion

Although it might be tempting for a CPT to use a -declared or unspoken- lie detector algorithm when diagnosing isolated triad cases as AHT cases, this is highly problematic.

As the traditional AHT mechanism theories and associated auxiliary hypotheses on which the unspoken shaken baby lie detector algorithm is based is not valid, the algorithm is seriously undermined. Accordingly, concerned physicians should abstain from applying this unspoken algorithm in triad cases without external signs of trauma.

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