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Original communication

Diagnostic yield of hair and urine toxicology testing in potential child abuse cases

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ABSTRACT

Detection of drugs in a child may be the first objective finding that can be reported in cases of suspected child abuse. Hair and urine toxicology testing, when performed as part of the initial clinical evaluation for suspected child abuse or maltreatment, may serve to facilitate the identification of at-risk children. Furthermore, significant environmental exposure to a drug (considered by law to constitute child abuse in some states) may be identified by toxicology testing of unwashed hair specimens. In order to determine the clinical utility of hair and urine toxicology testing in this population we performed a retrospective chart review on all children for whom hair toxicology testing was ordered at our academic medical center between January 2004 and April 2014. The medical records of 616 children aged 0–17.5 years were reviewed for injury history, previous medication and illicit drug use by caregiver(s), urine drug screen result (if performed), hair toxicology result, medication list, and outcome of any child abuse evaluation. Hair toxicology testing was positive for at least one compound in 106 cases (17.2%), with unexplained drugs in 82 cases (13.3%). Of these, there were 48 cases in which multiple compounds (including combination of parent drugs and/or metabolites within the same drug class) were identified in the sample of one patient. The compounds most frequently identified in the hair of our study population included cocaine, benzoylecgonine, native (unmetabolized) tetrahydrocannabinol, and methamphetamine. There were 68 instances in which a parent drug was identified in the hair without any of its potential metabolites, suggesting environmental exposure. Among the 82 cases in which hair toxicology testing was positive for unexplained drugs, a change in clinical outcome was noted in 71 cases (86.5%). Urine drug screens (UDS) were performed in 457 of the 616 reviewed cases. Of these, over 95% of positive UDS results could be explained by iatrogenic drug administration. There were no cases in which a urine drug screen alone altered the outcome of a case. In summary, hair toxicology testing proved clinically useful in the evaluation of a child for suspected abuse; in contrast, urine drug testing showed low clinical yield.

1. Introduction

Child abuse, defined as neglect, physical abuse, psychological maltreatment, and sexual abuse, continues to be a significant problem in the United States and other countries. The United States Department of Health and Human Services reported 678,810 substantiated cases of child abuse in 2012, of which 1593 were ultimately fatal.[1] Non-medical drug use by a parent or other caregiver is one of several well-recognized risk factors for child maltreatment.[2,3] The risk of harm to a child substantially increases while caregivers are intoxicated, experiencing symptoms of drug withdrawal, or engaging in activities related to drug acquisition. In addition, children may be exposed to drugs by passive (environmental) exposure, accidental ingestion, or intentional drug administration. Environments in which drugs such as methamphetamine are being illegally manufactured potentially expose the child to drugs, drug precursors, hazardous chemicals and their by-products, and other safety dangers such as fires.

Detection of drugs in a child may be the first objective finding that can be reported in cases of suspected child abuse. In the United States, healthcare providers are required to notify child protective services when a drug-exposed child is identified per the Child

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Abuse Prevention and Treatment Act.[2] However, there are currently no state or federal protocols that delineate which children to test for drug exposure, what specimens (e.g., urine, blood, hair, etc.) to use for toxicology testing, and which specific drugs and drug metabolites to assay. This results in variability in testing protocols across localities.

Hair toxicology has been shown to detect both passive and systemic drug exposure in neonates, children, and adults, with a time detection window of up to several months.[3–17] On average, 85% of the hairs on the human scalp are in the anagen phase, the metabolically most active phase of hair growth. It is generally thought that the majority of drug incorporation into the hair shafts takes place in this phase. Drugs are believed to incorporate into hair by multiple routes including the blood supply, sebum, sweat, and external contamination.[18] It takes approximately 7–10 days for growing hair to reach the surface of the scalp at which time it may be trimmed and submitted for testing.[7,9,15] Some hair toxicology analyses are designed for enhanced detection of environmental exposure.

The delay between systemic drug exposure and detection in the hair provides the possible advantage of a decreased probability of detection (and potential misinterpretation) of recently administered iatrogenic medications (e.g., opiates and benzodiazepines in the acute medical management of an injured child). In addition, drug exposure may be detected even if there is delay in presentation of the child for medical services, as can commonly occur in abuse scenarios. Processing of unwashed hair may detect passive drug exposure to the child, which may provide evidence of an unsafe environment even if there is no systemic exposure. The potential downside of hair testing is that recent non-medical drug exposures (e.g., accidental ingestion by child) may be missed by hair toxicology analysis. Also, the amount of hair needed for toxicology analysis may preclude testing in some children (especially infants) with sparse hair.[7,9,15,17,19,20]

Urine is a common specimen for toxicology studies but has a shorter detection window compared to hair.[21–23] Many drugs and drug metabolites are detectable only within several days to one week from last exposure. Some drugs such as tetrahydrocannabinol (THC; from cannabis) or long-acting sedative-hypnotics (e.g. diazepam, phenobarbital) may be detected in urine more than one week after exposure. Urine drug testing may pick up iatrogenic medications, a common occurrence when children present for emergency medical care and receive sedative-hypnotics, opioid analgesics, or other medications prior to urine collection.

Few studies have evaluated the usefulness of hair toxicology as a component of child abuse evaluation.[3,8,10–14,16,24–27] In particular, there is limited data on what compounds are detected in the hair, how hair and urine toxicology results compare, and what impact toxicology testing has on the outcome of suspected child abuse cases.

In order to evaluate the utility of toxicology testing in the setting of possible child abuse, we performed a retrospective chart review of suspected child abuse cases from January 2004 to April 2014 in which hair toxicology testing was performed. The setting was an academic medical center in the state of Iowa (University of Iowa Hospitals and Clinics, UIHC). Per Iowa state legal code, a child in need of assistance by a government agency (such as Child Protective Services) may include a child in whose body there is an illegal drug present, or whose caregiver manufactures or possesses particular drugs (e.g, methamphetamine or synthetic precursors) in the presence of a child.[28] In the timeframe of retrospective analysis, child abuse evaluations at UIHC often included toxicology testing on hair and urine from the child in order to determine whether the child had ingested or been environmentally exposed to illicit drugs or prescription medications.

2. Materials and methods

2.1. Retrospective chart review

A retrospective chart review was performed on cases in which children (defined as age less than 18 years old at time of medical evaluation) had hair toxicology testing ordered at UIHC between January 1, 2004 and April 13, 2014 as part of a suspected child abuse evaluation. Drug testing was ordered by licensed provider based on clinical protocol and was not influenced by this or other research protocols.

The electronic medical records were reviewed for patient demographics, injury or suspected abuse history (including that which prompted a toxicology evaluation), previous and current illicit and prescription drug use by parent(s) or other caregiver(s), hair toxicology results, urine drug testing results (if performed), patient medications, and outcome of any child abuse evaluation. Potential outcomes included filing of abuse report or supplement abuse report to Child Protective Services (Department of Human Services within Iowa), involvement and/or investigation by Child Protective Services, or other change in patient care as a direct result of positive toxicology findings.

2.2. Hair toxicology analysis

Hair toxicology analysis was referred to a commercial reference laboratory (United States Drug Testing Laboratories, Inc., Des Plaines, IL, USA). The specific hair toxicology analysis was the Childguard® test, a protocol designed to detect environmental (passive) drug exposure in addition to systemic exposure. Initial screening of hair samples was performed on extracts of unwashed hair by enzyme-linked immunoassay. Confirmation of positive screens was performed by gas chromatography/mass spectrometry (GC/MS) or liquid chromatography/tandem mass spectrometry (LC/MS/MS). A panel for five drug classes was performed, which allowed for detection of amphetamines [including amphetamine, methamphetamine, 3,4-methylenedioxyamphetamine (MDA), 3,4-methylenedioxy-*N*-methamphetamine (MDEA), and 3,4-methylenedioxy-*N*-ethylamphetamine (MDMA, 'ecstasy')], cannabinoids [including unmetabolized ('native') THC and 11-nor-9-carboxy-Δ^9-tetrahydrocannabinol ('carboxy-THC')], cocaine (including cocaine, benzoylecgonine, norcocaine, and cocaethylene), opiates [including codeine, hydrocodone, hydromorphone, morphine, 6-monoacetylmorphine (6-MAM; metabolite of heroin diagnostic of heroin use), oxycodone, and oxymorphone], and phencyclidine. Drug identification was considered positive only if confirmed by GC/MS or LC/MS/MS analysis.

2.3. Urine drug testing

Urine drug screening (UDS) was performed using homogeneous immunoassays (Roche Diagnostics, Indianapolis, IN, USA) by the UIHC core clinical laboratory. The routine UDS panel at UIHC changed during the course of the period of retrospective study. The screening test panel at the beginning of retrospective study (January 1, 2004) included amphetamines, barbiturates, benzodiazepines, cocaine metabolite (benzoylecgonine), opiates, phencyclidine, THC, and tricyclic antidepressants. Screening tests for phencyclidine and tricyclic antidepressants were removed from the routine drug of abuse panel in 2009. THC and barbiturates were removed from the screening panel in 2010; however, an in-house screening assay for THC was still available after 2010 as a separate order. A screening test for oxycodone/oxymorphone was added to the routine drug of abuse screening panel in 2010. Confirmation