Detection of Misreported Drug Use in Forensic Populations: An Overview of Hair Analysis

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Criminal and civil forensic evaluations are frequently complicated by misreported (denied or exaggerated) substance abuse. This article provides an introduction to the use of radioimmunoassay of hair (RIAH). RIAH with gas chromatography/mass spectrometry confirmation is superior to the more commonly employed urinalysis in its (1) wider window of detection, (2) ability to provide a chronology of substance abuse, and (3) resistance to countermeasures. The potential implications of the RIAH procedure to retrospective and prospective forensic evaluations are discussed.

A critical dimension of forensic evaluation is the accurate appraisal of antecedents and determinants of psychiatric impairment. Particularly problematic are efforts to assess substance abuse and its potential role in both criminal and civil cases.[1] Many criminal defendants are unwilling to divulge the nature and extent of their substance abuse, fearing additional drug-related charges and generally more punitive sentencing.[2] Similar concerns surface in civil cases in which socially appropriate conduct is expected in family matters[3] (e.g., child custody, competency to parent) and official duties[4, 5] (e.g., fitness for duty of police officers). Moreover, claimants in disability cases (e.g., personal injury and workers' compensation) are likely to deny use of unprescribed drugs, which might suggest an alternative explanation for their purported impairment.

Most forensic assessments rely heavily on the self-reporting of criminal and civil defendants. In both criminal and civil cases, evaluated persons may have strong motivations to distort reports of their drug usage. In this article, we begin with a concise review of traditional assessment methods for the detection of misreported drug use. We follow this review with a description of hair analysis, including a summary of its methodology and clinical utility. We conclude with a discussion of and preliminary guidelines for its forensic applications.

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Traditional Assessment Methods

Forensic psychiatrists and psychologists rely predominantly on self-report information of substance abuse in the majority of psycholegal cases. Histories of acknowledged substance abuse are combined with other clinical data in rendering diagnoses and expert opinions.[6] Although unstructured accounts are probably the most commonly used by clinicians, standardized measures of substance abuse are also available. Perhaps the most frequently employed measures are the Michigan Alcoholism Screening Test (MAST)[7] and the Drug Alcohol Screening Test (DAST).[8] Both measures have a high degree of face validity and assume that evaluated persons will be honest and forthright. Not surprisingly, research on the MAST[9] has convincingly demonstrated that patients can easily deny substance abuse. Diagnostic interviews, such as the Diagnostic Interview Schedule (DIS)[10] and Structured Clinical Interview for DSM-III-R Diagnosis (SCID),[11] include extensive inquiries regarding drug use and associated symptoms. While not formally tested, the denial or minimization of substance abuse is also likely to occur on these structured interviews. One advantage of diagnostic interviews is the standardization of clinical inquiries and documentation of drug-related symptoms[12] that enable clinicians to make systematic comparisons of reported drug use across time.

Collateral sources of substance abuse data are often available but rarely include disinterested parties. For example, family members may have a strong vested interest in the outcome of most forensic evaluations. They may collude with a personal injury claimant in the denial of substance abuse. Conversely, they may exaggerate the drug use of a criminal defendant with whom there are longstanding conflicts. The extent to which collateral accounts of substance abuse are distorted remains uninvestigated. Interestingly, early data on reported alcohol abuse suggested that patients may be more forthcoming if they expect that collateral interviews will be employed.[13] While we certainly recommend the use of informant interviews, neither consistency nor inconsistency across sources can be considered conclusive evidence. Forensic experts sometimes can obtain relatively objective data on substance abuse from records of prior convictions and documented treatment, although such information typically provides an incomplete history.

Several psychometric methods have been widely employed to assess denied substance abuse. For example, special scales on the MMPI and MMPI-2 are often touted in the assessment of unacknowledged substance abuse. Elevations on the MacAndrew (MAC) alcoholism scale[14] sometimes have been used to assess unreported alcohol and drug abuse, although the MAC scale is likely to miss the majority of substance abusers. At present, elevations on the MAC scale are conceptualized as evidence of "addiction-proneness"[15]; the vagueness of this construct and its inefficiency with known substance abusers has led Gottesman and Prescott[16] to conclude that the MAC should not be used in the clinical deter-

mination of substance abuse. Moreover, Greene[17] expressed caution about using it with nonwhite ethnic groups and for classifying substance abusers in both medical and psychiatric settings. More recently, efforts have been devoted to the development of an Addiction Potential Scale,[15] but its use in the detection of unreported drug abuse has yet to be fully investigated.

Miller[18] developed the Substance Abuse Subtle Screening Inventory (SASSI) to address ubiquitous problems of denial and minimization among chemically dependent populations. Currently, the SASSI is used extensively in correctional settings, particularly probation and parole. The original validation studies suggested initial promise for the SASSI in detecting previously unreported drug abuse, which ranged from 73 to 92 percent of chemically dependent adults. Unfortunately, no cross-validational research has been published in the last decade on the detection of unreported drug use. Therefore, the SASSI should best be conceptualized as a useful but preliminary screen.

Clinicians have sought to circumvent the above described problems with interview-based and psychometric data by implementing laboratory procedures for the detection of substance abuse. The most common assay technique is urinalysis. Frequently, drug screens are performed using radioimmunoassay methods; this technique is used to assess the presence/absence of recently ingested drugs.[19] This technique is based on a competition for binding sites *in vitro* between radiolabeled drug and drug in a sample (e.g., urine, hair). Once binding has occurred, radioactivity is measured and sample amounts of the drug are calculated via a standard curve (i.e., amount of drugs expected by the level of radioactivity) generated in the assay procedure. Drug-positive urine samples are usually reevaluated via the more sensitive gas chromatography/mass spectrometry (GC/MS) for confirmation of results.[20] These techniques, in combination, allow researchers to isolate and identify a drug based on its chemical characteristics. Urinalysis in combination with GC/MS is the definitive standard in drug testing.[20]

Despite its widespread use, urinalysis as a measure of unreported drug use is constrained by several limitations:

1. Urinalysis has a narrow window of detection (36 to 72 hours), because many drugs are rapidly excreted.[19–22] Thus, if urine samples are tested to monitor illicit drug use, random sampling is critical. Even with random sampling, some frequent drug users will likely avoid detection.[23]

2. One countermeasure, described in the literature, is the use of "flushing" to minimize detection. According to Baumgartner *et al.*,[19] excessive fluid intake prior to urinalysis sampling can result in a false-negative drug test. Other techniques resulting in false-negatives include temporary abstinence and manipulation or substitution of urine samples.

3. False-positive results may be obtained due to ingestion of poppy seeds, laboratory error, or inadvertent ingestion of "laced" substances.[24]

4. The intrusiveness of monitoring the collection of urine samples may deter cli-

nicians from making direct observations. Additionally, urine specimens require special handling and may pose a potential health risk to those collecting and assaying samples.[21]

Hair Analysis

The radioimmunoassay of hair (RIAH) allows investigators to determine current (within a week) and past drug use based on well established evidence that growing hair absorbs drugs and their metabolites from the bloodstream. As the hair grows in the follicle, the drug and/or its metabolites become permanently embedded in the core of the hair shaft[21] at levels proportional to amounts ingested. Therefore, laboratories can not only establish the presence of specific drugs, but can also determine the extent of abuse. In addition, the hair provides a chronology of abuse. Since scalp hair grows at a relatively stable rate (approximately .5 inch every 30 days), laboratories are able to estimate patterns of drug use by the relative position of positive results along the hair shaft.[20] Indeed, a longitudinal history of an individual's drug use is limited only by the length of the hair sample. Moreover, drug deposits are stable; for example, they cannot be washed out.[25] Of historical interest, RIAH methods detected opiates taken 167 years ago by the Victorian poet, John Keats, which was consistent with his documented use of laudanum as a palliative treatment during the end stages of tuberculosis.[20]

A sample of 60 hairs (20 milligrams) is typically recommended for assaying using RIAH procedures. Although most researchers use hair taken from the scalp,[25] other types of body hair may also be used.[26] The RIAH procedure is composed of three basic steps: decontamination of the hair sample; dissolution of the sample and extraction of the drug and/or metabolites; and RIAH assay for presence of drug. Decontamination of the hair sample is necessary, as it prevents false-positives resulting from passive contamination (e.g., smoke). As part of the laboratory procedure, the hair sample is washed extensively before extraction.[24] Most researchers chemically digest the hair sample before the analytical process, typically by dissolving it in a strong acid or base solution.[27] Extraction may be obtained using one of several techniques, including solvent-based extraction, acid-base extraction, or antibody extraction. Unfortunately, these different dissolution and extraction procedures may not yield uniform results; therefore, comparisons across studies may be difficult.[19] Following extraction, the sample is assayed via RIAH for presence of drug or drug metabolites. As with urinalysis, drug-positive samples are confirmed using GC/MS procedures.

RIAH can be used with a broad range of prescription and street drugs. At the present time, research has demonstrated its efficacy with cocaine, phencyclidine (PCP), opiates, marijuana, diazepam, nicotine, and methamphetamine.[19, 22, 28–30] Animal models have demonstrated near-perfect linear relationships between amounts of drug (e.g., heroin, cocaine, PCP) injected and amounts found in hair samples,[19] and have distinguished between drug-free and drug-using periods based on segments of hair assayed.[22]

With humans, experimental designs using many drugs are constrained by legal and ethical concerns, although a few studies have reported results using experimental methodologies. For example, Baumgartner *et al.*[19] reported a linear relationship between administered amounts of digoxin in serum and in hair. Nakahara *et al.*[31] used laboratory-controlled procedures to test RIAH detection of methoxyphenamine (MOP, a model compound of methamphetamine). Subjects were administered MOP once a day for seven days. All hair samples were drug-positive, and the ratio of drug levels in corresponding sections closely correlated with the ratio of drug dosages. Additional criterion-related validity has been established by comparing RIAH results with self-report data and urinalysis. As in many areas of forensic psychiatry, "ground truth" can never be absolutely established, but these studies consistently have demonstrated increased detection levels with RIAH. In studies comparing results of RIAH and urinalysis for detection of drug use, RIAH is more sensitive and results in more drug-positive samples.[32–34] For example, Martinez *et al.*[32] reported 55 percent of samples testing drug-positive using RIAH, compared with only 4.3 percent using urinalysis. Berka and Baumgartner[33] reported that RIAH is more sensitive than urinalysis in tests for previous use of cocaine (420% increase in positive samples), PCP (270% increase), and opiates (180% increase). The results were equally impressive when determining drug use in a one-year surveillance period, with an increase in drug-positive samples of 430 percent for cocaine and 500 percent for PCP, using RIAH compared with urinalysis.

RIAH's increased sensitivity is due, at least in part, to its wide window for detection, especially in low to moderate drug users. One alternative explanation, which RIAH is prone to false-positives, is obviated by confirmation of all drug-positive samples using GC/MS procedures. For example, Mieczkowski and colleagues[34] reported 28.5 percent more drug-positive samples using RIAH compared with urinalysis; in every case, GC/MS confirmed the findings of the RIAH. In a study by Martinez *et al.*,[32] not only were RIAH findings supported by subsequent GC/MS for the presence of drug, but also the four samples shown to have the highest amounts of drug by RIAH were similarily found to have the highest amounts by GC/MS. Given the consistency between RIAH and GC/MS confirmation in numerous studies, investigators have concluded that the RIAH has far greater sensitivity than urinalysis in detecting unreported drug use. Moreover, these studies indicate a superb specificity with no reported false-positives.

RIAH has also been used to assess prenatal drug exposure. Marques *et al.*[35] reported that amounts of crack cocaine found in infants' hair reflected maternal use during the last trimester. Traces of morphine have also been measured in hair collected from neonates whose mothers were admitted heroin users.[30] RIAH of infants' hair in suspected cases of maternal drug use is probably a more valid assessment technique of prenatal exposure than maternal self-report.[36]

Countermeasures are unlikely to be ef-

fective with RIAH. Repeated washings have no apparent effect on drug traces stored in the core of the hair fiber. While use of hair treatments (e.g., dyeing, perming) may alter amounts of drug detected, Baumgartner *et al.*[19] reported that these treatments do not affect hair samples to the extent that users escape detection. As noted previously, in cases of short hair or shaved heads, samples can be taken from other parts of the body.

The RIAH offers several advantages over urine testing. First, the sampling method for RIAH is superior, including its comparative ease of collection, the stability of hair samples (i.e., not susceptible to countermeasures), and the availability of multiple samples should retesting be warranted. Second, RIAH is effective in the detection of a wider range of drugs. Third, hair is easy to handle and bears no risk of disease transmission. Fourth, RIAH allows for a longitudinal determination of whether drug use is increasing or decreasing and distinguishes among heavy, moderate, and light users.[20–22]

Some experts believe RIAH should be used only in conjunction with urinalysis and GC/MS, although RIAH results by themselves have been admitted into evidence in several court cases in the United States[37] and Europe[38] in both criminal (e.g., denied drug use in a homicide) and civil (e.g., reinstatement of an employee dismissed for alleged substance abuse) matters. Several issues remain to be resolved concerning the use of RIAH by itself. Foremost among them is the standardization of RIAH procedures.[34] In other words, although laboratories consistently produce highly significant results, concerns have been raised about the lack of generally accepted standards for decontamination and extraction techniques as well as cut-off values for drug detection. Moreover, while many researchers agree that proper washing of the hair samples removes external contamination from crack cocaine or marijuana smoke,[19, 25] not all investigators concur.[39] Some researchers have argued that drugs may enter hair in a variety of ways other than simple diffusion from the bloodstream and that a better understanding of the mechanisms through which hair incorporates drugs is critical to evaluating RIAH results.[40]

Discussion

The purpose of this article is a critical review of hair analysis and a discussion of its potential relevance in forensic psychiatric evaluations. An important caveat to the subsequent discussion is that the authors' knowledge of hair analysis is scholarly rather than practice-based. Our intent is to provide a thoughtful overview and to encourage future contributions on practice-related issues regarding its integration into forensic consultations and its legal admissibility in courts.

The chief advantage of hair analysis is its ability to address different time perspectives. As noted in Table 1, forensic psychiatrists and psychologists are frequently asked to address both retrospective and prospective issues. Retrospectively, experts are asked to address criminal responsibility and professional liability in which the concern is the use of drugs and their potential effects on behav-

Table 1
Forensic Assessment of Suspected Drug Abuse: Multiple Time Perspectives

Time Perspective	Representative Forensic Cases	Forensic Questions
Retrospective/cross-sectional	Insanity and professional liability	At a specific period in the past, was the behavior (criminal or professional) affected by substance abuse?
Retrospective/longitudinal	Personal injury and capacity to parent	Is there an ongoing pattern of substance abuse that complicates treatment or compromises functioning?
Current/cross-sectional	Competency to stand trial and competency to consent	Is current behavior affected by drug abuse?
Prospective/longitudinal	Dangerousness, sentencing, and fitness for duty	Based on past and current patterns of substance abuse, what predictions can be made about future likelihood of continued abuse? What behavioral correlates for this abuse have been observed?

ior. As observed by Moeller *et al.*,[38] criminal defendants may either deny drug use where it is suspected or, conversely, claim drug use as a mitigating factor. In these circumstances, the critical issue is drug ingestion during a discrete time period (i.e., cross-sectional). While RIAH is unable to specify a particular day or even week, the procedure can provide information about discrete periods of time in the past. For example, if the defendant denied drug use during the weeks before the alleged crime, the RIAH will be able to address the truthfulness of these statements. Moreover, if the defendant claims heavy drug use, then hair analysis should be able to provide corroboration.

Forensic experts are often asked to address retrospectively patterns of behavior rather than specific time periods. For example, the RIAH can be employed to evaluate parents who are suspected of drug abuse and involved in proceedings for the termination of parental rights. Likewise, personal injury cases typically involve not only the immediate and long-term effects of the injury but also the response to treatment. Forensic experts are often placed in the unenviable role of ruling out other causes for sustained disability and lack of recovery. In cases of suspected drug use, the RIAH with GC/MS confirmation might assist us in understanding the reasons for nonrecovery. In a recent disability evaluation without the benefit of RIAH with GC/MS confirmation, the second author suspected but was unable to confirm that the

purported depression was really a cover for cocaine abuse.

Forensic experts are rarely asked by the courts to address issues involving immediate drug use. Even with such issues as competency to stand trial and competency to consent to treatment, the concept of "current" is typically not limited to the last 24 hours. If such circumstances do arise, urinalysis provides the most effective measure, since RIAH is less precise and requires approximately one week before structural changes occur in the hair shaft. Of course, psychiatrists and psychologists benefit greatly from urinalysis data collected at the time of the offense, but are rarely involved in requesting this procedure at the time of apprehension.

Forensic experts are often asked to render predictive conclusions regarding a person's dangerousness, fitness for duty, or capacity to benefit from treatment and remain in the community (i.e., sentencing). From past and current patterns of substance abuse, clinicians are afforded by RIAH an unparalleled opportunity to consider several relevant questions: Is the *level* of drug use either increasing of decreasing? Are the *amounts* of drug use either increasing of decreasing? Are criminal or other problematic behaviors associated in the past with certain *patterns* of drug use? Use of these data should enable forensic experts to make more specific predictions for substance abusers.

A commentary by Visher,[41] on behalf of the National Institute of Justice, reported wide acceptability among judges in the District of Columbia for a pretrial testing program based on hair analysis. Moreover, Berka and Baumgartner[33] indicated that the RIAH had been accepted as admissible evidence in more than 50 criminal and civil cases. They quote, without legal citation, from an opinion by Judge Jack B. Weinstein: "Extensive scientific writings on RIAH hair analysis establish both its reliability and its acceptance in the field of forensic toxicology when used to determining cocaine use" (p 54). They conclude that the RIAH with GC/MS confirmation met the Federal Rules of Evidence, Section 702. As discussed by Zonana,[42] the Supreme Court has recently held[43] that Section 702 has superseded the Frye test in deciding the admissibility of expert evidence. Certainly, the previously cited empirical data would support the conclusion that the RIAH is based on accepted scientific and technical knowledge.

One consideration in evaluating the probative/prejudicial nature of RIAH is its potential for biasing experts and the courts with extralegal factors. For example, the reporting of positive findings on the RIAH in an insanity case might improperly influence the experts or the jurors. Intrusions into privacy by RIAH have been raised in its workplace applications,[44, 45] although not in forensic cases. Still, forensic experts should have a clear understanding of the specific purposes for using RIAH in a particular legal case for at least two reasons. First, the types of RIAH requested will vary with the time perspective (retrospective, current, or prospective). Second, unnecessary investigations will be minimized if the specific purposes of the RIAH are known.

Most scientific limitations of RIAH

can be resolved with further research. Standardization of assay procedures across laboratories and a concomitant implementation of standard cutoff values for the presence of drugs are achievable goals. Without this standardization, the RIAH does not presently on its own give definitive proof of drug use, but instead must be employed in conjunction with the GC/MS. Further investigations of the specific mechanism for drug incorporation would enhance our understanding of the RIAH procedure.

In summary, forensic experts may wish to consider the RIAH with GC/MS confirmation as a useful laboratory procedure for their consultations to the courts. The RIAH is particularly valuable in forensic cases that involve an extended time perspective, because of its unique ability to chronologize substance abuse. Moreover, the RIAH with GC/MS confirmation provides an accurate appraisal of commonly abused drugs and delineates general categorization for the level of substance abuse.

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