Forensic Science International 254 (2015) 80–86

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Duration of detection of methamphetamine in hair after abstinence

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ARTICLE INFO

Article history:
Received 23 April 2015
Received in revised form 22 June 2015
Accepted 29 June 2015
Available online 10 July 2015

Keywords:
Methamphetamine
Yaba
Hair analysis
Prospective sampling
Duration of detection
Abstinence

ABSTRACT

Researchers in the field of hair analysis have known for at least two decades that test results for many chemical compounds remain positive for a considerable period of time after subjects have reported cessation of use. These findings were generally based on small sample populations or individual case studies. Within the last decade, hair analyses of larger populations have investigated the phenomenon of residual positives in abstinent individuals in order to determine the period of time required for various compounds to present negative hair test results at internationally accepted cutoff levels. Such data has primarily been used to establish guidelines for retesting former abusers of illicit drugs in order to evaluate claims of abstinence. To date, research has focused on cocaine and opiates. The present study is the first to examine the duration of detection of methamphetamine (MA) and its metabolite amphetamine (AP) in the hair of chronic MA users who recently ceased their consumption of the drug. The study population ($n = 63$) consisted of inpatients at a hospital drug rehabilitation program in Chiang Mai, Thailand. Drug taking behavior was collected by personal interview at the time of enrollment. Subjects provided hair samples at approximately monthly intervals for MA and AP analysis by gas chromatography–mass spectrometry at 0.2 ng/mg cutoff levels. The correlation of baseline MA and AP concentrations in hair at the beginning of abstinence with corresponding duration of detection indicated great individual variability for the rate of clearance of MA and AP from hair. In regard to duration of detection, the majority of chronic MA users remained MA positive for up to about 90 days of reported abstinence, but by 120 days, the detection rate had fallen to about 16%. All subjects tested negative for MA after 153 days of abstinence. For AP, the limit of the duration of detection was reached at 106 days. With the adoption of a margin of safety to compensate for outlier individual variability, the present study affirmed that hair analysis of chronic MA abusers should test negative for MA after 6 months of claimed abstinence.

1. Introduction

The analysis of chemical compounds in hair has become an accepted and valuable tool for researchers in several disciplines. Because hair analysis usually provides a much wider window of detection than the analysis of other biological matrices, the technique has played a significant role in the identification of chronic drug abuse for clinical, judicial and forensic purposes [1,2]. Human scalp hair typically grows at the rate of about 1 cm per month. By analyzing sequential 1 cm segments of hair strands cut close to the scalp, researchers can create approximate calendars of drug use, where segments located proximal to the scalp represent recent drug-taking behavior and more distal segments represent more remote behavior [3,4].

Hair analysis to detect illicit drug use in a general population will yield a much greater number of negative results than positive results. Therefore, it might be said that greater analytical effort has gone into the detection of abstinence than into the detection of use. However, in the terminology of drug abuse research, "abstinence" does not mean merely refraining from drug taking in the first place. Rather, it means the cessation of active use followed by prolonged and ultimately permanent disuse. When abstinence is studied in these terms, it is usually in the context of monitoring a chronic drug abuser's compliance with rehabilitation requirements, as mandated by legal or medical authorities [5,6]. Since the beginning of the twenty-first century, methamphetamine (MA) has been the most widely abused illicit drug in Thailand [7]. Typically, the drug

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http://dx.doi.org/10.1016/j.forsciint.2015.06.030
0379-0738/

is ingested by smoking an illegally manufactured tablet known in the Thai language as "yaba" (crazy drug), which contains approximately 10–20% MA and 50–70% caffeine. To a lesser extent, MA is also consumed in the form of crystalline methamphetamine, known locally as "ice" [7]. The Thai penal code deals severely with those who are convicted of possessing and/or consuming MA-containing substances, but the Narcotics Addict Rehabilitation Act of 2002 allows the appropriate authorities to place MA users into compulsory rehabilitation programs before proceeding with criminal prosecution [8,9]. If an individual's compliance with program requirements satisfactorily passes medical and legal review, the individual can rejoin society without penalty. MA users can also voluntarily enter such programs to receive treatment. Abstinence is monitored both during and after rehabilitation by periodic drug testing by urinalysis.

Urinalysis has several drawbacks for monitoring MA abstinence, the most serious being the technique's narrow window of detection (typically 1–3 days), which offers recidivists many opportunities for circumventing detection. But the verification of abstinence by hair analysis also has difficulties. Prior research concerning drug use has established that a considerable period of time can elapse before the cessation of consumption is substantiated by negative hair test results [10]. As there was little information concerning the clearance of drugs from hair after the discontinuance of use [11], these residual positives mainly served as cautionary flags for the interpretation of hair test results [3,10,12]. The findings themselves were derived from the hair analyses of only a few individuals [10,11,13–16]. Recently, two investigations have applied segmental hair analysis to larger populations in order to study more systematically the declining concentrations of residual positives [17,18]. This work has targeted opiates and cocaine. There has been no corresponding study of methamphetamine (MA), despite its widespread abuse [14]. The primary objective of the present study is to use validated quantitative analysis protocols in order to determine the duration of detection of MA and its metabolite amphetamine (AP) in the hair of chronic MA users at the beginning of abstinence. An associated objective is to establish time-frame guidelines for retesting former MA users in order to evaluate more clearly claims of abstinence.

2. Methods and materials

2.1. Subjects

The results of this study are based on analyses of biological samples provided by in-patients at a MA rehabilitation program at Chiang Mai Thanyarak Hospital. The study enlisted only subjects who admitted repeatedly using MA during a 90-day period prior to enrollment. This information, along with other drug-taking data, was elicited by means of a personal interview with a single trained researcher who was responsible for conducting all of the study's interviews according to the same format. The study enrolled a total of 81 subjects, but it retained only those enrollees who were willing and capable of providing the required urine and hair specimens and who satisfactorily followed the hospital's treatment protocols. Duration of treatment, and therefore duration of participation in the study, ranged from 62 days to 105 days. The final number of subjects was 63. Sixty were in treatment by legal mandate; three by voluntary self-admission. Test results from those who were eventually excluded from the study were discarded. All enrollees received modest monetary payments after furnishing each hair sample. The 63 subjects who comprised the final sample received an additional lump-sum payment at the end of their participation for having furnished the required number of urine samples. This study's objectives and procedures were reviewed and approved by a Research Ethics Committee of the Faculty of Medicine of Chiang Mai University, as recorded in Document Number 193/2555. All enrollees gave written informed consent concerning their participation.

2.2. Chemicals and reagents

Methamphetamine hydrochloride (MA·HCl, 99.42% purity), and amphetamine hydrochloride (AP·HCl, 99.84% purity) were purchased from Lipomed (Arlesheim, Switzerland). Lipomed also supplied pentadeuterated methamphetamine hydrochloride (MA-d_5·HCl, 99.04% purity), which was used as an internal standard in the hair analysis protocol. Derivatizing reagents for hair analysis were heptafluorobutyric chloride (HFBCl, 98% purity) and heptafluorobutyric anhydride (HFBA, 99% purity). Both were purchased from Sigma–Aldrich (St. Louis, MO, USA). Phenethylamine (99% purity), which was used as an internal standard in the urinalysis protocol, came from Fluka (Buchs, Switerland). Potassium carbonate (K_2CO_3, AR grade) was acquired from Fisher Scientific (Loughborough, Leicestershire, UK). Sodium hydroxide (NaOH, ACS grade) and acetone (AR grade) were obtained from Merck (Darmstadt, Germany).

2.3. Hair samples

The collection of hair specimens served two analytical functions. The first was to permit the quantification of baseline MA concentrations that reflected actual consumption patterns of chronic users at the beginning of abstinence, which was defined as the date of "last reported use". The second was to permit the comparison of MA concentrations over time after the last reported use. In both cases, the hair sampling rationale was based on the findings of previous research that scalp hair, despite some individual variation, typically grows at a rate of about 1 cm per month [4]. A single trained researcher followed the same protocol for collecting all hair specimens used in the study. Hair was cut close to the scalp from the vertex posterior region, with root ends marked, and kept in a clean plastic bag.

As determined by the interview process, 47 of the study's 63 participants reported that they had stopped using MA 11–30 days before the first collection of hair, which occurred on the same day as enrollment in the study. For this group, the 1 cm segment most proximal to the scalp was judged to represent active MA consumption before abstinence. The quantification of MA from these samples provided a baseline of initial concentration for comparison with MA values derived from 1 cm segments of "new growth" hair subsequently collected from the same individuals in the same fashion at approximately monthly intervals until the subjects exited from the study. Because 16 of the study's participants reported that they had last used MA more than 30 days prior to enrollment, the most proximal 1 cm segment of hair collected during their first hair cutting was judged not to represent active drug taking behavior. These hair segments, as well as the 1 cm segments of new growth hair subsequently collected at approximately monthly intervals, provided MA values that reflected a lengthening period of abstinence. For purposes of linguistic convenience, we have described the hair collection schedule as "approximately monthly." But for purposes of comparing MA concentrations over time, we tracked MA values in terms of intervals enumerated in days. These intervals were calculated by adding the number of days between hair cuttings to the number of days since the last reported use of MA.

2.4. Hair analysis

Quantitative hair analysis for MA and AP followed a previously published validated protocol involving solid-phase microextraction