CASE REPORT

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Evidence of Polydrug Use Using Hair Analysis: A Fatal Case Involving Heroin, Cocaine, Cannabis, Chloroform, Thiopental and Ketamine

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ABSTRACT: A case is presented involving a young woman on several illicit drugs (heroin, cocaine and cannabis) as well as two medications and a solvent used for their anesthetic and narcotic properties: thiopental, ketamine and chloroform. This complex drug use was supported by hair analysis over a 10.5 cm segment of the hair taken at autopsy. The average measured concentrations in hair were: thiopental = 5.3 ng/mg, pentobarbital = 10.0 ng/mg, ketamine = 11.3 ng/mg norketamine = 1.0 ng/mg, diazepam = 1.2 ng/mg, nordiazepam = 0.1 ng/mg, 6-acetylmorphine = 4.4 ng/mg, morphine = 3.4 ng/mg, codeine = 1.2 ng/mg, cocaine = 5.5 ng/mg, benzoylecgonine = 1.5 ng/mg and methylecgonine ester = 1.0 ng/mg. While the ketamine/norketamine ratio is consistent with that already reported on drug detection in hair, the thiopental/pentobarbital ratio seems to be inverted.

KEYWORDS: forensic science—substance abuse, death, hair, thiopental, pentobarbital, ketamine, norketamine, gas chromatography-mass spectrometry, high-performance liquid chromatography, photodiode array ultraviolet detection, solid phase extraction

Drug users have developed addictions to pharmaceutical medicine with increasing frequency. One case we studied recently involved a young woman on several illicit drugs (heroin, cocaine, and cannabis); two medications used in anesthesia (thiopental, and ketamine); as well as a solvent which induces narcosis: chloroform. An analysis of her hair revealed regular use of the two pharmaceutical anesthetics. This case recorded for the first time the detection and the analysis of thiopental, pentobarbital, ketamine, and norketamine in hair samples.

Methods

The technique used in the analysis of these substances has been previously published elsewhere (1). It utilizes, after decontamination and grinding of the hair, a double incubation (acid and neutral environment), followed by a twin solid phase extraction on a C_{18} cartridge. The buffers used are 0.1 N hydrochloric acid and 0.2 M sodium bicarbonate with 10% methanol. The specific eluants are composed of ammoniated methanol and methanol acidified with acetic acid. The different separation and identification methods utilize both gas chromatography-mass spectrometry (GC-MS) and high performance liquid chromatography coupled to photodiode array UV detection (HPLC-PDA) (2).

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Case Report

A young woman between 25 and 30 years old was pulled by firefighters from a burning public restroom. The victim died a few minutes later. After the fire, on-scene investigators found a spoon, syringes and needles, as well as a homemade pipe used to smoke crack. On the victim's clothes paramedics note the strong odor of a chorine solvent. The autopsy revealed that the blood and the brain have a crimson color and that the bronchial tubes are obstructed by residue from black smoke. Samples are taken of the blood, urine, and hair for detailed toxicological analysis.

Results

Blood and Urine

The complete toxicological analysis of the blood reveal the following toxins: codeine = 13 ng/mL, morphine = 420 ng/mL,

TABLE 1—*Drug quantitation in hair of the deceased woman.*

Name of the Compounds	Segment 1 (3.5 cm) Amount in ng/mg	Segment 2 (3.5 cm) Amount in ng/mg	Segment 3 (3.5 cm) Amount in ng/mg
Thiopental*	4.85	3.65	7.44
Pentobarbital*	7.38	17.06	5.68
Ketamine**	17.26	8.56	8.17
Norketamine**	2.07	0.33	0.57
Diazepam**	1.02	1.40	1.25
Nordazepam**	0.07	0.16	0.11

*Quantitation was achieved by HPLC-PDA at λ = 285 nm for thiopental and λ = 215 nm for pentobarbital

**Quantitation was realized by GC-MS using the following ions m/z = 180, 166, 256, and 242 for ketamine, norketamine, diazepam, and nordazepam respectively.

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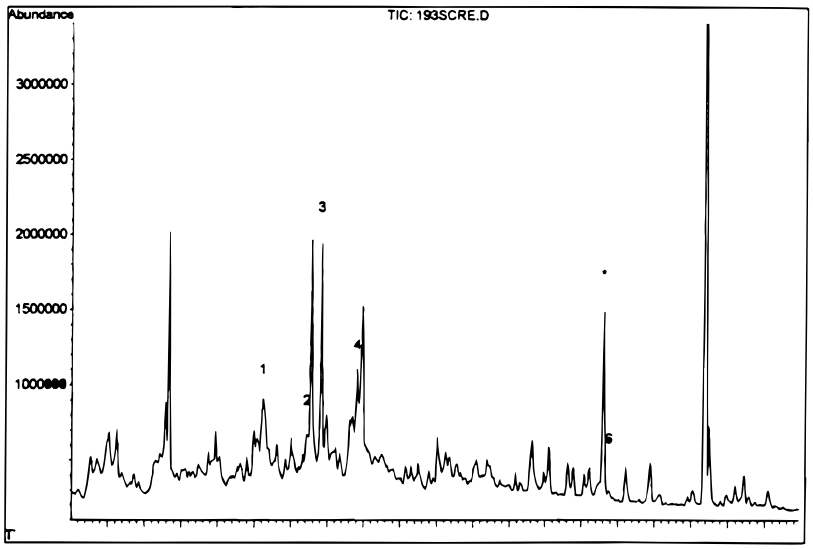
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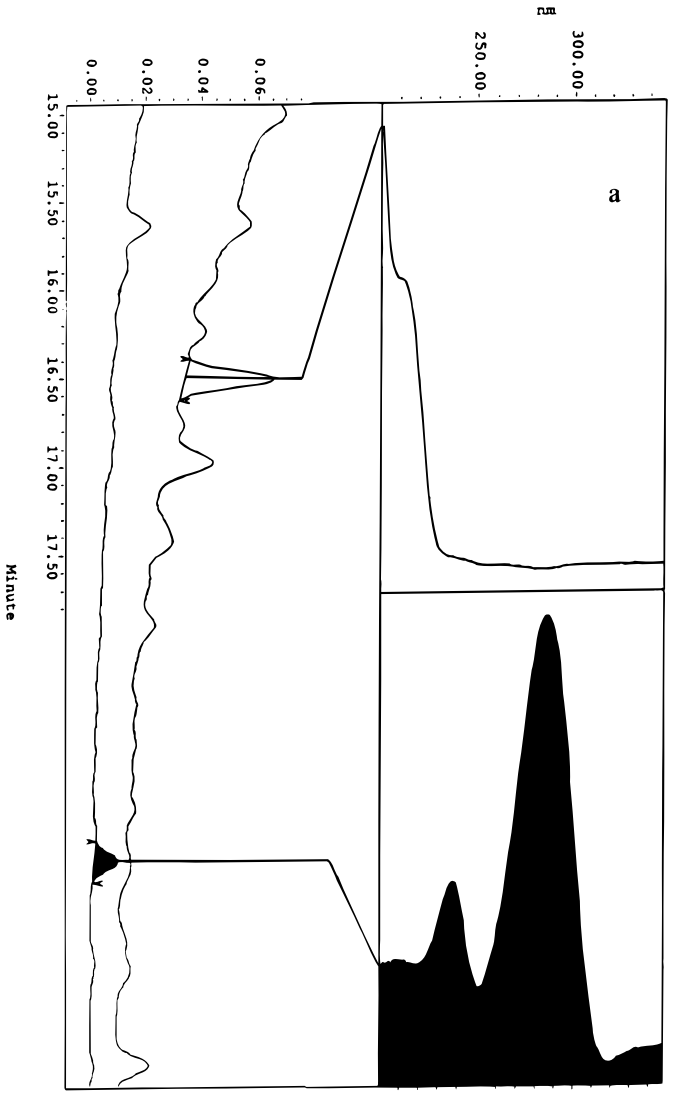

FIG. 1—*Chromatogram of the pooled extracts of 75 mg of powdered hair using acidic and basic solid-phase extraction. (a) Total Ion Chromatogram collected from 44 to 450 a.m.u. (b) full scan mass spectrum of norketamine and (c) full scan mass spectrum of ketamine. Conditions were the following: Apparatus was a 5890 series II plus gas chromatograph from Hewlett Packard (Les Ulis, France) a HP 7673 automatic injector and equipped with the 5972 mass selective detector. Analytical column was a CP SIL 8 CB, 25 m length, i.d. 0.25 mm (0.25 μm film thickness) from Chrompack (Les Ulis, France). Helium was used as the carrier gas at a flow of 1.3 mL/min in the constant flow mode (i.e., 60 KPa at 50°C). The temperature of the detector was 300°C. Splitless injection (2 μL) was done at 280°C. The initial oven temperature was 50°C for 2 min and was increased to 310°C at 15°C/min and held for 4.67 min. The chromatographic run time was 24 min.*

*Identified peaks were: 1 = pentobarbital (quantitation realized by HPLC-PDA, see below), 2 = norketamine (0.57 ng/mg), 3 = ketamine (8.17 ng/mg), 4 = thiopental (see below), 5 = diazepam (1.25 ng/mg), 6 = nordazepam (0.11 ng/mg), * = internal standard.*

cocaine = 576 ng/mL, methylecgonine ester = 780 ng/mg, anhydroecgonine ester = 120 ng/mL, diazepam = 0.07 μg/mL, nordiazepam = 0.20 μg/mL, thiopental = 1.97 μg/mL, pentobarbital = 2.64 μg/mL, ketamine = 1.40 μg/mL, chloroform = 30.7 μg/mL, and carboxyhemoglobin = 55%.

The urine was also subjected to drug analysis in a first step consisting of a general drug screening. Immunochemical assays as well as GC-MS, HPLC-PDA and Head Space-GC-MS techniques revealed the presence of all the previously enumerated drugs together with the presence of 6-acetylmorphine, benzoylecgonine, norketamine and oxazepam. Additionally found in the urine was Δ9-THCCOOH at a concentration of 48 ng/mL. The official cause of death, as determined by the coroner, was intoxication by CO vapors.

Hair

The victim's identity being unknown, it was important to know whether or not she was a habitual user of pharmaceutical products.

hair as a function of three criteria: affinity to melatonin, liposolubility, and the pH level. The isoelectric pH of hair being 3.8 (7); we can thus easily understand why acid does not migrate readily into the hair. Fortunately, this is very often compensated for by very high active plasma concentrations of these products in relation to active concentrations of basic compounds.

Diazepam was recorded at relatively low levels (approximately 1 ng/mg). Nordiazepam, being more polar than diazepam, was detected in very small amounts in spite of its relatively long half-life. Oxazepam was not detected by the present method.

Barbiturates

Testing for thiopental in the hair sample of the deceased revealed an average level of 5.3 ng/mg. An acidic medication with a pK of 8.0, thiopental possesses an average half-life of about 9 hours in blood (8). In spite of thiopental's very strong liposolubility, this short-acting barbiturate does not easily pass through the membranes. This would certainly explain its relatively low levels in relation to active plasma concentrations. On the other hand, pentobarbital, with an almost equivalent pK level of 7.6, has an average half-life of about 27 hours (9). Just slightly less liposoluble than its original product, the average level found in the hair sample is 10.0 ng/mg, around twice as much as the thiopental level (Figs. 1 and 2). A review of the literature, as well as our own experience, would allow us to conclude that the original product is always at a higher concentration in hair than its metabolites. The case of thiopental is unique, however, as we have found, for the first time, an inverse relationship between original product/metabolite. The high lipophilia of pentobarbital together with a favorable blood kinetic could certainly explain this finding.

However, by studying each result, the tendency is not systematic. As a matter of fact we observe an inversion of the previous ratio on the third segment of the hair. Therefore, interpretation is very difficult. It seems that unlike the other products (opiates, cocaine . . .) thiopental's main metabolite accumulates strongly into the hair. This may produce a ratio parent drug/metabolite higher than 1. Unfortunately, we cannot disprove the hypothesis of a co-consumption of thiopental and pentobarbital by the deceased.

Ketamine

Ketamine, an anesthesia inducer, has been abused often by drug-users. It produces hallucinations, and it has been named by users "Special K" (10,11). Ketamine and its principal metabolite, norketamine, were found at average levels of 14.0 and 1.0 ng/mg, approximately 7–12% norketamine compared to its original product, a rather typical ratio in hair sample analysis.

Conclusion

We have found compelling evidence for multiple drug addiction by the deceased. The data were collected through analysis of hair segments taken from the individual which indicate addiction to heroin, cocaine, cannabis, as well as ingestion of two very powerful hypnotic, anesthesia inducers: thiopental and ketamine. Norketamine and pentobarbital, metabolites from the previous two, respectively, were detected and measured in the hair. While the ratio norketamine/ketamine is in line with what has been found in other analytes, it seems that it is inverted as to thiopental and pentobarbital. Naturally, we cannot disregard the possibility of a concomitant ingestion of pentobarbital, but this could not be supported by analysis or by police investigation.

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