Cocaine Contamination of United States Paper Currency

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Abstract

The exchange of illicit cocaine for money by drug dealers is an everyday occurrence in cities in the United States. There is ample opportunity during the exchange, storage, and use of cocaine for paper currency to become contaminated. Because currency is exchanged frequently, it is likely that contaminated currency would be found in common use. We examined ten single dollar bills from several cities in the United States for the presence of cocaine. Individual bills were extracted with methanol (10 mL). Cocaine was purified from the methanol extract by solid-phase extraction (SPE). The SPE extract was analyzed by gas chromatography–mass spectrometry (GC–MS). Standard curves were constructed with new, uncirculated currency. Cocaine was identified qualitatively by full scan and quantitated by selected ion monitoring. Cocaine was present in 79% of the currency samples analyzed in amounts above 0.1 µg and in 54% of the currency in amounts above 1.0 µg. Contamination was widespread and was found in currency from all sites examined. Cocaine amounts were highly variable and ranged from nanogram to milligram amounts. The highest amount of cocaine detected on a single one-dollar bill was 1327 µg. These results indicated that cocaine contamination of currency is widespread throughout the United States and is likely to be primarily a result of cross-contamination from other contaminated currency and from contaminated money-counting machines.

Introduction

Estimates of illicit cocaine available for consumption in the United States during 1993 range from 243 to 340 metric tons (1). The packaging, distribution, sale, and use of this immense drug supply by dealers and users undoubtedly causes local environmental contamination. Articles of clothing, personal belongings, households, and even public areas are likely to become contaminated from contact with the drug. Concern has been expressed that casual contact with contaminated items might transfer cocaine to the hands of uninvolved individuals. ElSohly (2) evaluated whether individuals who handled cocaine contaminated money would test positive by urinalysis. Two one-dollar bills were immersed in dry, powdered cocaine, and then shaken free of loose cocaine. One individual then handled the money several times during the course of the day. Analysis of urine samples collected over a period of approximately 24 h after handling the contaminated money revealed that the individual excreted a maximum of 72 ng/mL of benzoylecgonine 12.5 h after handling had occurred. It was concluded that casual handling of articles contaminated with cocaine would not result in a positive urine test at a cutoff concentration of 300 ng/mL of benzoylecgonine.

The sale of illicit cocaine is often associated with the exchange of large sums of money, which may become contaminated. Indeed, the presence of cocaine on money is often interpreted as evidence of drug trafficking and is used in court proceedings (3). Cocaine contamination of paper currency is believed to be widespread based on anecdotal reports, but only a few studies have documented the presence of cocaine on money (3,4). We examined circulated paper currency ($1 denominations) collected from 14 cities in the United States for the presence of cocaine and related analytes in an attempt to determine the extent of contamination.

Materials and methods

Chemicals, reagents, and materials

Cocaine hydrochloride was obtained from Mallinckrodt, Inc. (St. Louis, MO). Benzoylecgonine tetrahydrate, norcocaine, and ecgonine methyl ester hydrochloride were obtained from the National Institute on Drug Abuse (Rockville, MD). Cocaethylene and norcocaethylene fumarate were obtained from Research Triangle Institute (Research Triangle Park, NC). Anhydroecgonine methyl ester oxalate and ecgonine ethyl ester were obtained from the Addiction Research Center, National Institute on Drug Abuse (Baltimore, MD). Deuterated analogues of cocaine, benzoylecgonine, cocaethylene, and ecgonine methyl ester were obtained from Sigma Chemical Co. (St. Louis, MO).

N,O-bis(trimethylsilyl)trifluoroacetamide (BSTFA) with 1% trimethylchlorosilane (TMCS) was obtained from Pierce

Chemical Co. (Rockford, IL). All organic solvents were HPLC grade and chemicals were reagent grade. Acetate buffer (pH 4.0 ± 0.1) was prepared with 2.0M sodium acetate and 2.0M acetic acid. The elution solvent, methylene chloride–isopropanol–concentrated aqueous ammonium hydroxide (80:20:2, v/v/v), was prepared daily. Extraction columns, CLEAN SCREEN® (ZCDAU020), and the vacuum manifold system (VMF024GL) were purchased from United Chemical Technologies (Bristol, PA).

Instrumentation

Analyses were performed on a Hewlett-Packard (Wilmington, DE) 5890A gas chromatograph with an autosampler (HP7673A) interfaced with a Hewlett-Packard 5970B mass selective detector (MSD). A split–splitless capillary inlet system and a HP-1 fused-silica capillary column (12 m × 0.2-mm i.d., 0.33-µm film thickness) were used for cocaine analyses.

Collection of United States paper currency

Paper currency ($1 denominations) was collected in 14 cities in the United States and was in general circulation at the time of collection. The money was placed in plastic freezer bags and shipped to the Addiction Research Center for analysis. Uncirculated and uncut currency was purchased from the United States Treasury Department, Washington, D.C., for use as drug-free control currency.

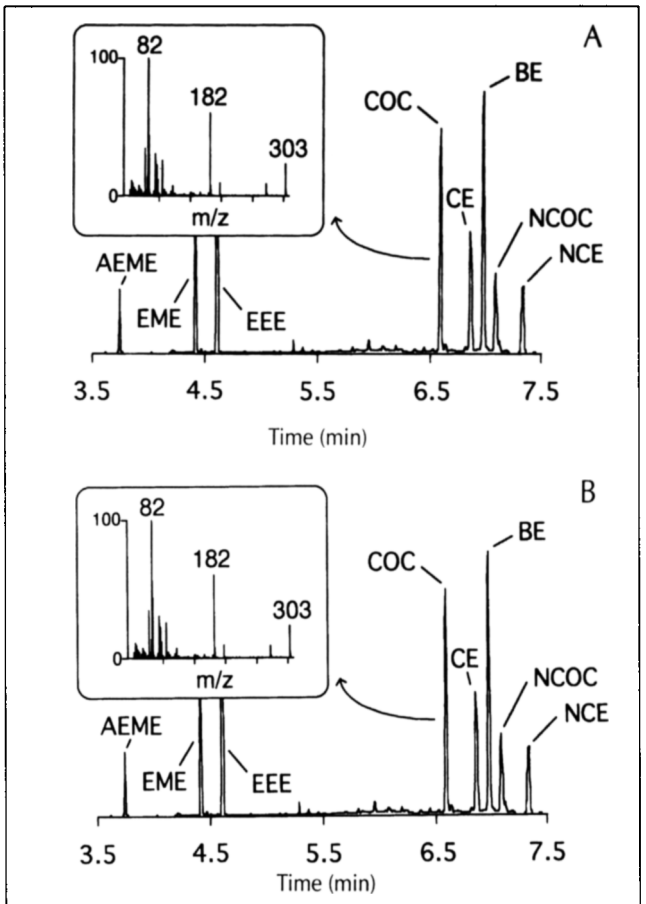

Figure 1. Total ion current recordings of extracts from uncirculated currency with added cocaine standards (A) and circulated United States currency ($1 denomination from Spanish Fort, AL) (B). Insets represent the mass spectrum of cocaine obtained in each run. Cocaine content in the Spanish Fort, AL currency was 70.2 µg/bill and benzoylecgonine was 3.6 µg/bill. Cocaine standards were added to uncirculated currency in amounts from 250-500 ng. Analytes are identified as follows: AEME = anhydroecgonine methyl ester; EME = ecgonine methyl ester; EEE = ecgonine ethyl ester; COC = cocaine; CE = cocaethylene; BE = benzoylecgonine; NCOC = norcocaine; NCE = norcocaethylene.

Extraction and analysis of currency

Single currency bills were placed in 15-mL centrifuge tubes and extracted with 10 mL methanol. The tubes were capped, agitated for 2 min, and allowed to stand at room temperature for 1 h. Aliquots (1-mL) were removed and treated with deuterated internal standards (500 ng each). Samples were extracted by solid-phase extraction (SPE) followed by gas chromatography–mass spectrometry (GC–MS) over analysis according to a published procedure (5). Briefly, the procedure consisted of addition of sodium acetate buffer (3 mL, 2M, pH 4.0) to each sample, followed by mixing. Samples were filtered through 4-mL fritted filters, and the eluent was decanted onto preconditioned SPE columns. The columns were washed with deionized water (1 × 2 mL) and 0.1 M HCl (1 × 1.5 mL) and aspirated to dryness for 2 min. Methanol was added (2 × 1 mL) and the cartridges were again aspirated to dryness for 2 m. The analytes were eluted into clean tubes with elution solvent (6 × 1 mL). Extracts were evaporated to dryness at ambient temperature under nitrogen and reconstituted in 20 µL acetonitrile. The samples were transferred to autosampler vials (0.1-mL) and derivatizing reagent (20 µL BSTFA with 1% TMCS) was added. The vials were sealed and heated at 60°C for 30 min. One microliter was injected for GC–MS analysis. The samples were analyzed in the scan mode for identification purposes and in the selected ion monitoring mode for quantitation. Cocaine was measured in currency extracts by internal standardization and comparison of responses to standard curves constructed with unused, drug-free currency. Standard curves were run in duplicate with each batch of currency and contained cocaine, ecgonine methyl ester, and benzoylecgonine in amounts of 0, 12.5, 25, 50, 100, 250, and 500 ng and anhydroecgonine methyl ester, ecgonine ethyl ester, cocaethylene, norcocaine, and norcocaethylene in amounts of 0, 6.25, 12.5, 25, 50, 125, and 250 ng. Duplicate control samples were also analyzed with each batch. Control samples were prepared with drug-free currency and contained cocaine and benzoylecgonine at two amounts (100 ng and 500 ng per extract).

Results

Cocaine was extracted from currency bills and identified by GC–MS operating in the full scan mode. Additional derivatives and metabolites of cocaine were included in the analysis to determine if they were also present on money. Figure 1A illustrates the response of cocaine analogues (500 ng/250 ng) extracted from a single uncirculated currency bill (without internal standard). The inset contains the mass spectrum of standard cocaine at a retention time of 6.6 min that was obtained in the same run. Figure 1B illustrates the response from an extract of a single piece of circulated currency collected in Spanish Fort, AL.

Cocaine was identified by comparison of the mass spectrum of the peak with a retention time of 6.6 min (see inset) with that of the cocaine standard. The characteristic ions of cocaine at *m/z* 303, 182, and 82 provided unequivocal evidence of the identity of cocaine in this currency. The currency extract (Figure 1B) also contained traces of benzoylecgonine (retention time, 7.1 min) that was identified by mass spectral comparison. Quantitative analysis of the Spanish Fort, AL, currency illustrated in Figure 1 provided an estimate of the total amount of cocaine and benzoylecgonine present. There was a total of 70.2 µg cocaine and 3.6 µg benzoylecgonine present in the single piece of currency. Benzoylecgonine was identified in 17% (N = 136) of the currency bills analyzed. No other cocaine constituents were detected in the analyses.

Quantitation of cocaine and benzoylecgonine in individual bills was accomplished by GC–MS operating in the selected ion monitoring mode. Currency extracts were treated with deuterated internal standards (500 ng) and extracted by SPE, derivatized and analyzed together with calibration standards and control samples that contained known amounts of cocaine analytes. Calibration curves were linear across the range from 0 to 500 ng of cocaine extracted from unused currency. Correlation coefficients were typically greater than 0.99. Between-run coefficients of variation were less than 5% for control samples containing 100 and 500 ng of cocaine. The limit of quantitation was arbitrarily selected as 12.5 ng, the lowest point on the calibration curve. Recovery of cocaine from currency was evaluated by extracting currency that had been previously extracted. A mean amount of 20.5 µg of cocaine was present in the first extract (N = 5 individual pieces of currency) and a mean amount of 2.3 µg was present in the second extract. Correction for the residual cocaine left by the first extraction solvent (1 mL of the first solvent was retained by the paper currency) indicated that greater than 95% of cocaine present was removed in the first extract. Analysis of all extracts of uncirculated currency were negative for cocaine and analytes.

Cocaine was present in 79% of the currency bills in amounts above 0.1 µg and in 54% of the currency bills in amounts above 1.0 µg. Contamination was widespread and was found in currency from all collection sites. Cocaine amounts were highly variable and ranged from nanogram to milligram amounts (Table I). The highest amount was 1327 µg found on a single bill from Portsmouth, OH. This bill also contained the highest amount of benzoylecgonine (146.6 µg). Generally, benzoylecgonine was present in amounts not exceeding one-tenth that measured for cocaine.

Table I. Cocaine concentrations in United States Paper Currency ($1 denominations) from Selected Cities

City	Number positive (>0.1 µg/bill)	Number positive (>1.0 µg/bill)	Mean amount (µg/bill)	Range (µg/bill)
Baltimore, MD	9	9	75.7	0–597.0
Miami, FL	3*	2*	2.5	0–13.1
Chicago, IL	7	4	0.7	0–2.2
Honolulu, HI	10	5	3.0	0.2–9.9
Kansas City, KS	9	8	6.3	0–24.3
Las Vegas, NV	9	5	3.9	0–13.9
Los Angeles, CA	9	6	3.9	0–11.4
Minneapolis, MN	8	6	63.8	0–559.8
Spanish Fort, AL	9	7	9.0	0–70.3
Ft. Wayne, IN	9	6	3.8	0–16.6
Pittsburgh, PA	4	1	0.4	0–2.6
Yellowstone, WY	5	2	1.9	0–14.5
Whitefish, MT	7	4	0.9	0–3.0
Portsmouth, OH	10	9	136.9	0.5–1327.0

* N = 10 for all collection points except Miami, FL, where N = 6

Discussion

This study demonstrated that $1 denominations of circulated United States paper currency are highly contaminated with cocaine. With the exception of benzoylecgonine, a hydrolysis product of cocaine, other derivatives of cocaine were not present. The absence of anhydroecgonine methyl ester would seem to indicate that "crack" cocaine vapor was not the source of contamination because this pyrolysis product is produced when cocaine is smoked (6). Cocaine was detected in individual bills from all collection sites. No obvious trend in amount or frequency of contamination was observed for different geographical areas. Currency from less populous areas (e.g., Whitefish, MT and Yellowstone, WY) tended to have lower amounts, but highly populous areas like Chicago, IL, also had low cocaine content compared with some areas. The small number of bills collected at each site and the nonrandom method of collection precluded generalizations regarding geographical area.

The cause of the widespread cocaine contamination of paper currency ($1 denominations) is unclear. It seems highly unlikely that the majority of all one-dollar bills in circulation have been involved in illicit drug sales and drug exchanges. It is possible that currency becomes contaminated from contact with previously contaminated currency and with money counting machines in financial institutions. If this is the case, contamination would begin as soon as uncirculated currency is introduced into circulation. Contamination could even occur during handling and processing prior to general circulation. The average lifespan of a one-dollar bill in the United States is approximately 12 months. During this period, many exchanges between individuals and financial institutions occur. These exchanges would provide ample opportunity for cross contamination from other currency.

The results from this study suggest that the presence of cocaine in amounts up to 1 mg per bill does not signify that the currency was involved in a drug transaction. Once contaminated, currency is likely to remain contaminated during the remainder of its circulation. Cocaine binding studies with tritium-labeled cocaine in our laboratory have shown that the paper matrix of one-

dollar bills has the capacity to bind cocaine in a specific, reversible manner not unlike biological binding sites (unreported data). The high binding affinity and capacity of United States paper currency for cocaine may explain why cocaine is retained on currency. Although the ubiquity of cocaine on money lessens its value as a marker for illegal drug transactions, other tests for cocaine may be performed.

Aaron and Lewis (4) suggested an alternate test could be performed by law enforcement to determine if specific bills were used in cocaine transactions. They placed circulated currency inside polyester envelopes and shook them to remove loose cocaine powder. The interior of the envelope was washed with methanol and analyzed by GC–MS. The presence of cocaine in the envelope was considered corroborative evidence that the money had been involved in the sale or use of cocaine. They also tested normal, circulated currency in denominations of $10 to $100. No cocaine was found in the methanol washes of the envelopes following shaking; consequently, it was suggested that the test would distinguish "drug transaction" currency from normal, circulated currency. It is noteworthy, however, that further analysis of methanol washes of the normal, circulated currency also revealed the presence of cocaine. As a result of that study and findings from the current experiments, it can be concluded that cocaine is present as a contaminant in a majority of all circulated United States paper currency.

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