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Site-Dependent Postmortem Changes in Blood Cocaine Concentrations

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ABSTRACT: When a forensic toxicologist interprets postmortem blood cocaine findings he usually must make assumptions regarding perimortem drug concentrations. In-vitro studies have shown that cocaine rapidly hydrolyzes in unpreserved blood, particularly at elevated temperatures. However, other studies have demonstrated site-dependent postmortem release of some drugs from tissue stores accompanied by increases in drug concentrations in the blood. This study was undertaken to investigate whether blood cocaine concentrations change in the body during the postmortem interval and, if so, to measure the direction and magnitude of the changes.

In medical examiner cases in which scene investigation suggested that the deceased was a cocaine user, blood samples were collected as soon after death as possible. At autopsy, a second set of samples was collected. Analysis of paired samples by gas chromatography/mass spectrometry (GC/MS) revealed dramatic differences in the cocaine concentration. The magnitude and direction of the change appears to be site dependent. Usually, but not invariably, cocaine concentration in subclavian vein blood decreases while that in heart, aorta, and femoral vein blood increases during the interval between death and autopsy.

The findings emphasize the danger inherent in attempting to estimate the concentration of cocaine in blood at the time of death from postmortem data.

KEYWORDS: toxicology, cocaine, postmortem interval, postmortem change, drug abuse

In the interpretation of postmortem toxicology reports, a toxicologist or a pathologist makes assumptions about the relationship between the measured concentration of substances in autopsy specimens and the concentration that existed at the time of death. The assumed perimortem concentration is then compared with values reported in the literature to arrive at conclusions about the substance's effect on the deceased.

In the case of cocaine, police and attorneys often want to know if the deceased was under the drug's influence when a fatal incident such as a motor vehicle accident or a homicide occurred. Studies in humans have shown the range of blood concentrations associated with behavioral effects [*1–6*]. Therefore, if one can estimate the antemortem

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blood cocaine concentration from the postmortem toxicology findings, it may be possible to determine whether the deceased was under the influence at the time of death.

In-vitro experiments have demonstrated that cocaine is hydrolyzed rapidly in blood by esterases [*6–13*] and that it also hydrolyzes spontaneously at physiological pH [*6,8–13*]. The former process, but not the latter, is inhibited by cholinesterase inhibitors and the fluoride ion. Refrigeration retards both processes, while freezing blood samples containing sodium fluoride can preserve the cocaine for extended periods of time.

Based solely upon in-vitro studies, one would expect cocaine in the blood to hydrolyze extensively between the time of death and the time when the autopsy blood specimen is taken. Even allowing for the inhibitory effect of postmortem acidification of the blood by the products of glycolysis, the cocaine concentration in postmortem blood would be lower than the perimortem concentration if hydrolysis is the only process acting on cocaine.

Many drugs are sequestered within tissues during life and are released into the blood in the postmortem interval [*14–23*] in a process known as postmortem release. This can cause dramatic elevations of drug concentration in postmortem blood taken from some visceral sites, such as the heart and aorta, whereas the drug concentration in blood from other sites, such as the femoral vein, changes to a lesser degree. If cocaine is subject to postmortem release, this process would partially or completely compensate for losses caused by hydrolysis. The net effect of the two processes might be to cause the blood cocaine concentration to increase, decrease, or remain unchanged. This study was undertaken in an attempt to determine whether blood cocaine concentrations change during the interval between death and autopsy and, if so, to determine the direction and magnitude of the changes. If a trend could be identified, it might assist with interpretation of cocaine concentrations in autopsy blood and therefore guide the pathologist in selecting sites for sampling blood in cases where cocaine use is suspected.

Materials and Methods

Experimental Design

Specimens analyzed in this study were obtained from cases investigated by the Dade County Medical Examiner Department. When circumstances suggested that the deceased was under the influence of cocaine, blood samples were collected as soon as possible after death. Those samples collected during the death scene investigation by the pathologist were called scene blood samples. They were placed in gray-top vacuum tubes (B-D Vacutainer 10 mL) containing sodium fluoride and potassium oxalate and were immediately refrigerated in insulated containers for transport to the Medical Examiner Department where they were stored in a refrigerator at 0°C until they were analyzed.

At autopsy, additional blood samples were collected from multiple vascular sites. These autopsy samples usually included samples from the same sites where the scene bloods had been collected. They were likewise placed in tubes with sodium fluoride and potassium oxalate and were refrigerated as soon as the autopsy was finished. All samples were labeled with the Medical Examiner case number, date and time collected, and sampling site.

Each case was screened for volatiles and acidic, basic and neutral drugs and confirmed for cocaine and benzoylecgonine by a combination of immunoassay [enzyme multiplied immunoassay (EMIT) or TD_x], thin-layer chromatography (ToxiLab), and gas chromatography.

The gas chromatographic analysis made use of an *n*-butyl chloride extraction with cyclizine as the internal standard. Extracts were analyzed on a Hewlett-Packard Model 5880 gas chromatograph equipped with an autosampler. The gas chromatograph was

fitted with dual 30-m, 0.25-mm inside diameter, capillary columns (DB-1 and DB-17, J + W) from a single injection port and dual nitrogen-phosphorus detectors.

Cocaine Quantification

The quantitative analyses of all blood samples for cocaine and benzoylecgonine were performed as soon as possible after the presence of cocaine was confirmed. All samples from each case were analyzed in a single batch and results for each sample were reported as the mean of duplicate analyses.

Reagents and Standards

All inorganic reagents were reagent grade. Solvents were high purity or high-performance liquid chromatography (HPLC) grade. The derivatization reagent consisted of a 1:1 mixture of dimethylformamide di-*n*-propylacetal (Aldrich) and anhydrous dimethylformamide (DMF) (Aldrich, Gold Label). Cocaine and benzoylecgonine reference materials purchased from Alltech-Applied Science were used to prepare stock standards of 1.0 mg/mL in anhydrous dimethylformamide. For each batch of samples, the stock solutions were diluted to yield working stock solutions that were added to blood to yield calibrators containing both cocaine and benzoylecgonine at 0.125, 0.25, 0.50, 1.00, 5.00, and 10.00 mg/L. Deuterated (D_3) cocaine and benzoylecgonine internal standards were obtained from Radian Corp. (100 μg/mL) in DMF. These solutions were used to prepare a working internal standard containing 10 μg/mL of each substance.

Extraction Procedure

In a 15-mL disposable culture tube, 1.0 mL of sample (unknown, control, blank blood, or calibrator) was mixed with 50 μL of working internal standard, 2.0 mL 1*M* phosphate buffer at pH 7.0, and 1 Coors 5-J scoop (approximately 1.0 g) of sodium chloride crystals. The mixture was vortexed and then centrifuged for 5 min at 3000 rpm. The supernatant was poured into an Analytichem International CE-1003 extraction column and allowed to absorb until 3 min after the last of the sample had entered the packing. Each column was eluted twice with 6 mL of chloroform/dry isopropanol (9:1). The second volume of solvent was added 3 min after the first had completely entered the packing. The eluate was collected in 15-mL screw-capped culture tubes and then evaporated to dryness at 65°C under a gentle stream of nitrogen.

Derivatization

The residue from evaporation of the extract was dissolved in 100 μL of derivatizing reagent and the tube was capped tightly. The mixture was gently refluxed over a flame for 30 s and allowed to cool. Then 1.0 mL of 0.5*N* sulfuric acid was added, and the tube was vortexed. The acidic solution was washed with 3 mL of toluene/heptane/isoamyl alcohol (76:20:4) by vortexing for 10 s, followed by centrifuging. The organic phase was discarded and the aqueous phase was adjusted to a pH greater than 8 by adding 0.5 mL of 1*N* sodium hydroxide (NaOH) and 2.0 mL of 50% dibasic potassium phosphate (K_2HPO_4). The aqueous phase was then extracted with 3 mL of toluene/heptane/isoamyl alcohol (76:20:4) on a rotating extractor for 10 min and centrifuged. The organic phase was transferred to a 15-mL disposable conical culture tube (Kimble, No. 73785) and evaporated to dryness under nitrogen at 65°C. The residue was reconstituted in 50 μL of chloroform and 1.0 μL was injected into the gas chromatograph/mass spectrometer.

The extracts were analyzed in a Finnigan Model 4510 gas chromatograph/mass spec-

trometer equipped with a 15-m fused silica capillary column, with a 0.25-mm inside diameter and a 0.25-mm film thickness (DB-5 or DB-17, J + W). Injections were done in the splitless mode, and the column temperature was programed from 50 to 300°C at 25 degrees per minute. The mass spectrometer was operated in the electron impact mode with multiple ion monitoring. The ions monitored were 82, 182, and 303 for cocaine, 306 for deuterated cocaine, 82, 210, and 331 for propylbenzoylecgonine, and 334 for the deuterated derivative. Each ion was monitored for 100 ms for a total scan time of 0.7 s.

Calculations

The ratios of peak areas 303/306 and 331/334 were determined for cocaine and propylbenzoylecgonine standards, respectively, and standard curves were determined for the area ratio versus the concentration of each analyte. Then area ratios for the unknowns were used to calculate the corresponding analyte concentrations. The procedure has a linear range of 0.02 to 10.0 mg/L and a coefficient of variation of 6.9% for cocaine and 7.2% for benzoylecgonine.

Results

Case No. 1: Cocaine-Excited Delirium

A 45-year-old Hispanic male was taken into custody at 8:15 a.m. after being observed running through yards and acting erratically. When placed in a police car, he attempted to kick out the windows. Upon removal he collapsed and stopped breathing. Fire rescue arrived and found him unconscious, in respiratory arrest, cyanotic, and in bradycardia. Within 1 min he went into full cardiac arrest. He was intubated and defibrillated twice unsuccessfully, then placed on a thumper and taken to a local hospital. When he arrived at 8:50 a.m. he was without pulse or blood pressure, with pupils fixed and dilated. He did not respond to further resuscitative efforts and was pronounced dead at 9:00 a.m. A scene sample was drawn from the femoral vein at 9:10 a.m. His rectal temperature was 104.7°F (40.4°C).

The cocaine concentration in this perimortem femoral vein blood sample was 1.1 mg/L (Table 1). By the time of autopsy (24 h later) the cocaine concentration at that site was 1.7 mg/L (54% higher), while a specimen from the aorta was 3.5 mg/L. The benzoylecgonine concentrations also were higher, but by a smaller amount.

Case No. 2: Cocaine-Excited Delirium

A 22-year-old black male, nude and carrying a machete, broke into a house and attacked the man and woman who lived there. The homeowner and a neighbor attempted to restrain him. When police arrived and took him into custody, the man stopped breathing. Fire rescue was called and pronounced the victim dead.

TABLE 1—*Scene versus autopsy cocaine and benzoylecgonine concentrations: Case 1—cocaine-excited delirium.*

Blood Source	Cocaine, mg/L	Benzoylecgonine, mg/L	Postmortem Interval, h
Femoral (scene)	1.1	6.2	0.17
Iliac (autopsy)	1.7	6.4	24
Aorta (autopsy)	3.5	7.5	24

Table 2 shows the cocaine and benzoylecgonine concentrations in paired scene and autopsy samples from the subclavian and femoral veins. In addition, vitreous humor was sampled from one eye when the body was received in the morgue and the second eye was sampled during the autopsy.

This case clearly shows the divergence of cocaine concentration in venous blood from two sites during the 20-h period between the scene sampling and the autopsy. In subclavian blood, the concentrations of both cocaine and benzoylecgonine were lower by 48% and 24%, respectively. However, the concentrations of both those analytes were higher in femoral blood. The observed 250% increase in the vitreous humor cocaine is in agreement with the findings reported by Beno and Kriewall [*24*].

Case No. 3: Cocaine Intoxication

The victim, a 19-year-old white female, was found in the bathtub with her face in the water. Fire rescue was called and pronounced her dead. The only significant trauma consisted of minor bruises near her right eye and on her legs. In addition to cocaine, she had acetaminophen, 58.4 mg/L in serum, and diphenhydramine, 1.1 mg/L, in whole blood, taken from the aorta.

Samples in this case included only femoral blood from the scene and aorta blood from the autopsy (Table 3). However, the cocaine concentration in the autopsy sample was nearly three times as high as that in the scene blood. The same trend is seen with the benzoylecgonine, which had a higher concentration in the autopsy blood than in the scene sample.

TABLE 2—*Scene versus autopsy cocaine and benzoylecgonine concentrations. Case 2—cocaine-excited delirium.*[a]

Specimen Source	Cocaine, mg/L	Benzoylecgonine, mg/L
Subclavian blood		
Scene	2.3	3.7
Autopsy	1.2	2.8
Femoral blood		
Scene	1.8	3.6
Autopsy	3.9	8.1
Vitreous humor		
Scene	1.0	1.1
Autopsy	3.5	1.7

[a]The scene-to-autopsy interval was 20 h (18 h for vitreous humor).

TABLE 3—*Scene versus autopsy cocaine and benzoylecgonine concentrations: Case 3—cocaine intoxication.*

Blood Source	Cocaine, mg/L	Benzoylecgonine, mg/L	Postmortem Interval, h
Femoral vein (scene)	1.41	7.45	2.5f[a]
Aorta (autopsy)	4.12	9.03	13.0

[a]f indicates the time found when the exact time of death is unknown.

Case No. 4: Cocaine Intoxication

A 24-year-old white female was taken by a male to a motel where they drank approximately four beers and sniffed some cocaine. Approximately 30 min later she began convulsing. Fire rescue was called and found her dead. In addition to cocaine she had a blood ethanol concentration of 0.18%, and cocaethylene was detected but not quantified in her blood.

As in the preceding case, only femoral vein blood collected at the scene and aorta blood from the autopsy were submitted for analysis. In this case, the aorta blood cocaine concentration was twice as high as that in the femoral vein blood collected 23 h earlier (Table 4). The benzoylecgonine concentration was also greater in the autopsy blood than in the scene blood.

Case No. 5: Suicide by Gunshot Wound

The victim, a 27-year-old white male committed suicide by a gunshot wound to the right temple. Drug paraphernalia, along with injection sites on both arms, indicated that he had been using cocaine intravenously.

Both subclavian vein blood and heart blood (by percutaneous cardiac puncture) were collected at the scene, and femoral vein blood and a second heart blood sample were obtained during the autopsy. Both cocaine and benzoylecgonine levels were elevated in autopsy specimens relative to their concentration in the scene specimens (Table 5). No other drugs were detected.

Case No. 6: Polydrug Overdose

The deceased was a 20-year-old white female prostitute. She was found dead on the floor of her apartment by her boyfriend. He stated that she was a heavy user of "crack" cocaine.

TABLE 4—*Scene versus autopsy cocaine and benzoylecgonine concentrations: Case 4—cocaine intoxication.*

Blood Source	Cocaine, mg/L	Benzoylecgonine, mg/L	Postmortem Interval, h
Femoral vein (scene)	3.13	2.14	2.5f[a]
Aorta (autopsy)	6.34	3.24	23.0

[a]f indicates the time found when the exact time of death is unknown.

TABLE 5—*Scene versus autopsy cocaine and benzoylecgonine concentrations: Case 5—gunshot suicide.*

Blood Source	Cocaine, mg/L	Benzoylecgonine, mg/L	Postmortem Interval, h
Subclavian vein (scene)	0.44	4.10	1.75f[a]
Heart (scene)	0.36	4.70	1.75f
Femoral vein (autopsy)	0.60	5.50	21.5
Heart (autopsy)	0.48	5.20	21.5

[a]f indicates the time found when the exact time of death is unknown.

In addition to the cocaine findings presented below, she had amobarbital (aorta blood, 10.9 mg/L; gastric contents, 54 mg total), secobarbital (aorta blood, 8.1 mg/L; gastric contents, 70 mg total), and nordiazepam (aorta blood, 0.16 mg/L).

A sample of blood from the femoral vein taken at the scene 2.7 h after the body was discovered contained 0.29 mg/L cocaine and 5.49 mg/L benzoylecgonine. Seven hours later, at the autopsy, a second femoral vein blood sample and an aorta blood sample were collected. They contained 0.38 and 0.44 mg/L of cocaine and 5.39 and 5.25 mg/L of benzoylecgonine, respectively (Table 6). There does not appear to be any difference in the benzoylecgonine concentrations between the scene and autopsy samples [that is, there was a less than 4.6% difference between the largest and smallest, with a method coefficient of variation (CV) of 7.2%]. However, there appears to be an increase in the cocaine concentration between the scene and the autopsy samples.

Case No. 7: Acute Cocaine Intoxication

A 17-year-old Latin female checked into a hotel with a male companion. Approximately 1½ h later an unidentified male asked the night clerk to call fire rescue, who found her dead with no visible trauma. Besides the cocaine results reported below, only alcohol, 0.01% in aorta blood, was detected.

A subclavian vein blood sample was collected at the scene 2.25 h after death and both subclavian vein and aorta blood were obtained at autopsy. The results of cocaine and benzoylecgonine analyses are shown in Table 7. The concentrations of both analytes are substantially higher in both autopsy samples than in the scene sample. The interval between the scene and the autopsy was 4.5 h.

Summary Data for Multiple Cases by Sampling Site

Table 8 compares cocaine concentrations in scene (percutaneous cardiac aspiration) and autopsy samples of heart blood from six cases, including Case 5 above. In three

TABLE 6—*Scene versus autopsy cocaine and benzoylecgonine concentrations: Case 6—polydrug overdose.*

Blood Source	Cocaine, mg/L	Benzoylecgonine, mg/L	Postmortem Interval, h
Femoral vein (scene)	0.29	5.49	2.7f[a]
Femoral vein (autopsy)	0.38	5.39	7.0
Aorta (autopsy)	0.44	5.25	7.0

[a]f indicates the time found when the exact time of death is unknown.

TABLE 7—*Scene versus autopsy cocaine and benzoylecgonine concentrations: Case 7—cocaine intoxification.*

Blood Source	Cocaine, mg/L	Benzoylecgonine, mg/L	Postmortem Interval, h
Subclavian vein (scene)	2.98	4.21	2.25
Subclavian vein (autopsy)	3.04	6.88	6.75
Aorta (autopsy)	5.21	6.25	6.75

TABLE 8—*Postmortem changes in cocaine concentration in heart blood (six cases).*

Scene Blood, mg/L	Interval 1[a]	Autopsy Blood, mg/L	Interval 2[b]
0.36	1.7	0.48	20
0.12	3.0	0.45	12
0.69	4.1	2.3	5
2.5	6.8	2.4	13.5
1.7	3.0	1.7	5.5
2.8	3.0	3.0	20

[a]Interval 1 = time (hours) between death or when found and blood drawn at the scene.
[b]Interval 2 = time (hours) between blood drawn at the scene and autopsy.

cases, the cocaine concentration was 33 to 275% higher in the autopsy specimens collected after intervals ranging from 5 to 20 h from the scene sampling. In the last three cases, the concentration remained essentially unchanged after intervals of 5.5 to 20 h. The percentage of difference was independent of the interval.

Table 9 shows scene and autopsy femoral vein blood cocaine concentrations from six cases, including data from Cases 1, 2, and 6. In the first five of these cases, the cocaine concentration appeared to increase by amounts varying from 22.5 to 117% of the scene blood concentration during intervals ranging from 4.1 to 25 h. The last case shown has the lowest initial cocaine concentration, and it appeared to decrease by 40% over 21 h. Again, neither the magnitude nor the direction of change was related to the interval between samples.

The differences in subclavian blood cocaine concentration between the scene and the autopsy are shown in Table 10. Data from Cases 2 and 7 are included. In contrast to findings for the other sites, three of the four cases had a cocaine concentration lower by 15 to 48% in autopsy blood collected after intervals ranging from 7 to 20 h. Moreover, in these three cases, the percentage difference is roughly proportional to the interval,

TABLE 9—*Postmortem changes in cocaine concentration in femoral blood (six cases).*

Scene Blood, mg/L	Interval 1[a]	Autopsy Blood, mg/L	Interval 2[b]
3.1	2.5	3.8	20.5
1.8	6.3	3.9	20
0.29	2.7	0.38	4.1
4.1	2.6	5.2	24.5
1.1	0.17	1.7	25
0.1	2.7	0.06	21

[a]Interval 1 = time (hours) between death or when found and blood drawn at the scene.
[b]Interval 2 = time (hours) between blood drawn at the scene and autopsy.

TABLE 10—*Postmortem changes in cocaine concentration in subclavian blood (four cases).*

Scene Blood, mg/L	Interval 1[a]	Autopsy Blood, mg/L	Interval 2[b]
0.45	6.2	0.31	18
0.13	4.5	0.11	7
2.3	6.3	1.2	20
3.0	2.1	5.0	5

[a]Interval 1 = time (hours) between death or when found and blood drawn at the scene.
[b]Interval 2 = time (hours) between blood drawn at the scene and autopsy.

ranging from 1.7 to 2.4% per hour. The fourth case deviated from the other three in both direction and magnitude in that the cocaine concentration was 67% higher after 5 h. This case had the shortest interval between the scene and the autopsy as well as the shortest postmortem interval.

Discussion

The data presented above suggest that blood cocaine concentrations change significantly during the interval between death and autopsy. Furthermore, the direction of the change appears to be dependent upon the site from which the blood is sampled.

This study does not rule out the possibility that the differences might have been caused by actual variations in cocaine concentration in blood at different sites in the body at the time of death. Such a condition might occur during the phase of absorption and distribution when blood leaving the site of absorption may have a higher concentration of drug than blood at some distant site in the body at the same time. However, it is unlikely that all of the subjects in this study were absorbing cocaine when they died. Although the volume of distribution of cocaine is small compared with that of some other drugs, such as the tricyclic antidepressants, it is still much larger than the volume of blood or even the total body water. This implies that cocaine accumulates in some tissues, and postmortem distribution studies often show higher concentrations in the brain and liver than in the blood. Thus a depot exists from which cocaine can be released into blood during the postmortem interval. Furthermore, postmortem release is the only reasonable explanation for the increase of cocaine concentration in vitreous humor observed by Beno and Kriewall [*24*] and in this study, when the two eyes were sampled at different times. It is improbable that such large differences existed prior to death. In view of the above, we contend that the observed differences in cocaine concentration are caused by the net effects of a combination of postmortem release and hydrolysis.

In blood from the subclavian vein, the trend appears to be for the cocaine concentration to decrease. The reason for the increase in one case is unclear. Apparently, in subclavian blood hydrolysis plays a predominant role, as predicted from in-vitro studies. The spontaneous hydrolysis of cocaine to benzoylecgonine is inhibited in acidic solutions. One would expect the pH of the postmortem blood samples to be acidic because of the glycolytic production of lactic and pyruvic acids; this was borne out by measurements that showed a pH in the range of 5.9 to 6.8 in 18 samples from all sites used in this study. The observation that the benzoylecgonine concentration in subclavian blood decreased in Case 2 suggests that the action of esterases on the carbomethoxy group, rather than spontaneous hydrolysis, was responsible for the decline.

The apparent postmortem increase in cocaine concentration frequently seen in blood from the heart, aorta, and femoral vein indicates that postmortem release of cocaine in those sites can be sufficient to overwhelm the effect of hydrolysis. However, a postmortem increase in cocaine concentration in heart blood and femoral vein blood was not invariably observed.

In 50% of the heart blood cases the cocaine concentration remained essentially unchanged in the postmortem interval, the amount hydrolyzed being approximately equal to the amount released. For the most part, these represent the cases with the highest cocaine concentrations, suggesting that with acute fatal intoxication there is insufficient time for accumulation of the drug in the heart or lungs before death. The three cases where postmortem increase occurred were two homicides and one suicide, in which the victims were heavy cocaine abusers. Their deaths probably followed cocaine binges.

The apparent postmortem increase in cocaine concentration in femoral vein blood is surprising in view of reports that femoral blood is less influenced by postmortem release of drugs than heart or aorta blood [*23*]. The source of the cocaine appearing in the

femoral blood over time is unknown. The femoral vein returns the blood from the leg just as the subclavian vein returns blood from the arm. If hydrolysis predominates over release in subclavian blood, one would expect the same to be true of femoral blood. However, the opposite is observed. It is possible that the second sample taken from the femoral vein represents blood that had moved to that site from the iliac vein and inferior vena cava after the first sample was removed. Thus, the second sample may be more representative of "visceral" than peripheral blood. The only case in which the femoral blood cocaine concentration decreased is the one with the lowest initial concentration. This may represent a point near the end of cocaine elimination in which the depot remaining for release is negligible, or the total amount consumed may have been too small to allow a significant accumulation in the tissues.

The obvious difficulty of obtaining blood from the aorta at the scene precluded investigation of paired samples from that site. However, a scene sample from any site is likely to be more representative of the perimortem state than a sample collected hours later. If that is a correct assumption, then Cases 1, 3, 4, 6, and 7 show a clear trend for aorta blood (Table 11). In all cases, the cocaine concentration was higher in aorta blood than in samples collected at the scene, the difference varying from 52 to 218% of the concentration in the scene sample. This apparent elevation may be caused by release from the heart or lungs, accompanied by postmortem movement of blood from those sites to the aorta. A less likely explanation to account for such a large magnitude of change would be that the aorta has an extremely high affinity for cocaine.

The single pair of vitreous humor samples analyzed in this study is insufficient to permit conclusions to be drawn from these data alone. They are presented here because they illustrate the point, thoroughly covered by Beno and Kriewall [*24*], that vitreous humor is not a better specimen than blood for quantitative cocaine analysis.

In view of the variability in blood cocaine concentration with the sampling site and postmortem interval, it would appear that postmortem blood is not a particularly useful specimen for estimating the exact concentration existing at the time of death. If the change in cocaine concentration begins immediately after death, the sooner the blood samples are collected, the more nearly they will reflect perimortem conditions. Therefore, when cocaine use by a decedent is suspected it is desirable to collect blood specimens for toxicological examination as early as possible in the death investigation process.

A second approach might be to measure brain cocaine concentrations. As reported by Spiehler and Reed [*25*], the brain is a better matrix than blood for cocaine analysis because the parent drug is more stable in that lipid-rich environment. Therefore, brain cocaine concentrations measured in autopsy specimens should be representative of the perimortem drug concentration in that organ.

The experimental administration of cocaine to human subjects has generated data relating the blood or plasma cocaine concentration to subjective and behavioral effects. For obvious reasons, no data are available relating brain cocaine concentrations to behavioral effects in humans. For purposes of interpretation, it is desirable to establish a

TABLE 11—*Summary data—scene blood versus aorta blood.*

Case No.	Scene Concentration, mg/L	Scene Site	Aorta Concentration, mg/L	Difference, %
1	1.1	femoral vein	3.5	218
3	1.4	femoral vein	4.1	193
4	3.1	femoral vein	6.3	103
6	0.29	femoral vein	0.44	52
7	3.0	subclavian vein	5.2	73

relationship between the cocaine concentration in the postmortem brain and that in properly preserved perimortem blood. Spiehler and Reed [*25*] presented data for two cases but did not report whether the antemortem blood samples were properly preserved. More data are needed. The perimortem blood/brain cocaine concentration relationship is currently being investigated at the Dade County Medical Examiner Department.

The findings reported here emphasize the danger inherent in attempting to draw conclusions regarding the concentration of cocaine existing at the time of death from postmortem data.

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