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Cocaine- and Methamphetamine-Related Deaths in San Diego County (1987): Homicides and Accidental Overdoses

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ABSTRACT: Cocaine- and methamphetamine-related homicides and fatal accidental overdoses in San Diego County were studied retrospectively for the 1987 calendar year. Cocaine was involved in 66 cases (39 homicides, 27 accidental overdoses), methamphetamine in 32 cases (23 homicides, 9 accidental overdoses), and a combination of cocaine and methamphetamine in 10 cases (4 homicides, 6 accidental overdoses). The composite for cocaine-related deaths was a 30-year-old black man in whom was also found at least 1 other drug, usually ethanol or morphine. The composite for methamphetamine-related deaths was a 32-year-old Caucasian man who used methamphetamine with at least 1 other drug (usually ethanol). For cases involving both cocaine and methamphetamine, the composite was a 36-year-old Caucasian man in whom was also found at least 1 other drug, usually ethanol, codeine, or morphine. Mean tissue concentrations of cocaine and benzoylecgonine were significantly higher in accidental overdoses than in homicides except for cocaine concentrations in liver, which did not differ significantly between the two groups. For methamphetamine-related deaths there was no significant difference between mean tissue concentrations in accidental overdoses and in homicides. Cocaine or methamphetamine or both were involved in approximately one third of homicides in San Diego County in 1987, and when fatal accidental overdoses were included, cocaine was involved in twice as many cases as methamphetamine.

KEYWORDS: toxicology, cocaine, methamphetamine, death

Abuse of cocaine and methamphetamine has increased in epidemic proportions throughout the United States, and recent reports have suggested that such is certainly true in San Diego County [*1,2*]. Since comprehensive drug screening is routinely performed by the Office of the Coroner, County of San Diego, for suspected homicides and fatal accidental overdoses, records from these cases were studied in attempt to develop profiles of the typical cocaine- and methamphetamine-related homicide or fatal accidental overdose. The results of this study are presented here.

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Materials and Methods

Case Finding

All cases which were indicated as homicides (for example, gunshot wounds, stabbings, beatings) or accidental overdoses by the coroner's report (Office of the Coroner, County of San Diego) during the year 1987 and in which either cocaine, methamphetamine, or both were detected by drug screening were included in the study. Suicides (including intentional overdoses), deaths due to natural causes (for example, myocardial infarction), and deaths due to other causes such as motor vehicle accidents, drowning, hanging, asphyxiation, and electrocution were not included since drug analyses are not always performed in these instances. Demographic and ethnic information were gleaned from the investigative report while drug-screening data were obtained from the official report.

Analytical Methodology

Comprehensive drug screening was performed by the Toxicology Laboratory of the Office of the Coroner, County of San Diego. This screening included thin-layer chromatography [*3*] for basic drugs isolated from aqueous homogenates of liver prepared by a modification of the extraction method of Goldbaum and Domanski [*4*]. Urine, if available, was also analyzed by thin-layer chromatography [*3*]. Either radioimmunoassay (Abuscreen System for Amphetamines, Roche Diagnostic Systems, Division of Hoffmann-La Roche Inc., Montclair, NJ) or enzyme immunoassay (EMIT® d.a.u. Amphetamine Assay, Syva Co., Palo Alto, CA) was concurrently performed on all urine specimens to enhance detection of amphetamines (analytical sensitivity of 0.3 mg/L). Blood was routinely analyzed for alcohols by gas-liquid chromatography [*5*] and for barbiturates, benzoylecgonine, opiates, and phencyclidine by commercial radioimmunoassays (Abuscreen System) modified for postmortem blood. This approach resulted in an analytical sensitivity of 0.01 mg/L for benzoylecgonine screening. In all cases when urine was unavailable, blood was screened by gas-liquid chromatographic procedures [*6,7*]. Bile, if available, was analyzed for opiates by radioimmunoassay (Abuscreen System).

Drugs detected by these initial screening procedures were subsequently quantitated in blood and the respective tissues. Up to 3 Aug. 1987, unchanged cocaine was quantitated in blood, liver, brain, and urine by gas-liquid chromatography with a nitrogen-phosphorus detector [*8*]. The limit of detection of cocaine in fluids and tissue homogenates was 0.02 mg/L. After this date both cocaine and its metabolite, benzoylecgonine, were quantitated in only blood, liver, and brain by gas chromatography-mass spectrometry [*9*], the analytical sensitivity being 0.02 mg/L for both compounds in blood and tissue homogenates. Methamphetamine and its metabolite, amphetamine, were quantitated in blood, liver, and urine by gas-liquid chromatography [*6*] with the limit of detection being 0.02 mg/L for both compounds in fluids and tissue homogenates.

Because of the relative nonspecificity of immunoassays for the amphetamines, cases were excluded from the study if a positive immunoassay screen failed to be confirmed by subsequent quantitative analyses. In contrast, since the radioimmunoassay for benzoylecgonine is both quite specific and sensitive, all cases in which the immunoassay screen was positive were included in this study even if subsequent quantitative analyses failed to detect cocaine or benzoylecgonine or both. Finally, for purposes of this study gastric and urine drug concentrations were not included.

Statistics

The significance of the difference between means was evaluated using Student's t-test of significance. A value $P < 0.05$ was considered to be significant.

Results

During the 1987 calendar year, 66 cocaine-related deaths (39 homicides, 27 accidental overdoses), 32 methamphetamine-related deaths (23 homicides, 9 accidental overdoses), and 10 deaths involving both cocaine and methamphetamine (4 homicides, 6 accidental overdoses) were found by retrospective review of the records of the Coroner's Office, County of San Diego. Demographic and toxicological data are summarized in Tables 1, 2, and 3 for these populations, while the raw data from which these summaries were derived are presented in Tables 4, 5, and 6, respectively.

When mean tissue concentrations were compared for accidental overdoses versus homicides in the series of cocaine-related deaths, concentrations were, with one exception noted below, significantly higher in accidental overdoses than in homicides (mean ± SD): *blood* (cocaine, 1.02 ± 2.08 versus 0.08 ± 0.12 mg/L, $P < 0.05$; benzoylecgonine, 4.18 ± 4.76

TABLE 1—*Cocaine-related deaths in San Diego County (1987): homicides and accidental overdoses (summary).*

	Demographic Information		
	Males	Females	All Cases
A. Race:			
Black	21	4	25 (38%)
Hispanic	19	3	22 (33%)
Caucasian	16	2	18 (27%)
Filipino	1	0	1 (2%)
TOTAL	57 (86%)	9 (14%)	66 (100%)
B. Age (years):			
Mean	31	29	30
SD	7	8	7
Range	18-55	18-40	18-55
N	54[a]	8[b]	62
	Tissue Concentrations		
	Blood, mg/L	Liver, mg/kg	Brain, mg/kg
A. Cocaine:			
Mean	0.46	0.96	1.40
SD	1.40	4.59	3.55
Range	NMA[d]-7.39	NMA-33.34	NMA-16.01
N[c]	66	64	63
B. Benzoylecgonine metabolite:			
Mean	2.75	5.92	1.01
SD	4.06	11.59	1.29
Range	NMA-14.40	NMA-41.30	NMA-4.74
N[c]	25	25	23

Other Drugs Involved

A. Cases involving no other drugs = 21 (32%).
B. Cases involving other drugs in addition to cocaine = 45 (68%).
C. Other drugs detected (number of cases): ethanol (25 cases, mean 0.11%, SD 0.08%, range 0.03%-0.29% plus five additional cases in which putrefaction was present); morphine (21 cases); codeine (9 cases); opiates as a class (3 cases); amitriptyline with nortriptyline, butalbital, carbamazepine, desipramine, diphenhydramine, nordiazepam, phencyclidine, phenytoin, procaine (1 case each).

[a] Plus two cases of unknown age and one baby of five days.
[b] Plus one stillborn.
[c] Numbers are unequal as a result of lack of tissues or analyses or both in some cases.
[d] NMA = no measurable amount (see text).

TABLE 2—*Methamphetamine-related deaths in San Diego County (1987): homicides and accidental overdoses (summary).*

	Males	Females	All Cases
DEMOGRAPHIC INFORMATION			
A. Race:			
Caucasian	19	7	26 (81%)
Hispanic	3	0	3 (10%)
American Indian	2	0	2 (6%)
Black	1	0	1 (3%)
TOTAL	25 (78%)	7 (22%)	32 (100%)
B. Age (years):			
Mean	32	31	32
SD	9	8	8
Range	20-53	22-45	20-53
N	25	7	32

TISSUE CONCENTRATIONS	Blood, mg/L	Liver, mg/kg
A. Methamphetamine:		
Mean	0.90	4.06
SD	1.00	6.96
Range	0.02-3.05	0.13-35.96
N[a]	30	31
B. Amphetamine:		
Mean	0.13	0.70
SD	0.14	0.80
Range	NMA[b]-0.61	0.05-3.76
N[a]	29	30

OTHER DRUGS INVOLVED

A. Cases involving no other drugs = 11 (34%).
B. Cases involving other drugs in addition to methamphetamine = 21 (66%).
C. Other drugs detected (number of cases): ethanol (8 cases, mean 0.09%, SD 0.06%, range 0.03%-0.19% plus four additional cases in which putrefaction was present); ephedrine (6 cases); morphine (5 cases); codeine (3 cases); phencyclidine (2 cases); amitriptyline with nortriptyline, butalbital, caffeine, chlordiazepoxide, opiates as a class (1 case each).

[a]Numbers are unequal as a result of lack of tissues or analyses or both in some cases.
[b]NMA = no measurable amount.

versus 0.55 ± 0.50 mg/L, $P < 0.01$); *brain* (cocaine, 3.14 ± 5.22 versus 0.26 ± 0.34 mg/kg, $P < 0.01$; benzoylecgonine, 1.62 ± 1.53 versus 0.34 ± 0.39 mg/kg, $P < 0.02$); and *liver* (benzoylecgonine, 9.78 ± 14.52 versus 0.99 ± 0.76 mg/kg, $P < 0.05$). Mean concentrations of cocaine in liver, however, were not significantly different between accidental overdoses and homicides (2.27 ± 7.08 versus 0.01 ± 0.13 mg/kg). When respective mean tissue concentrations were similarly compared for accidental overdoses versus homicides in the series of methamphetamine-related deaths, no statistically significant differences were noted (mean ± SD): *blood* (methamphetamine, 0.66 ± 1.00 versus 0.98 ± 1.00 mg/L, $P > 0.10$; amphetamine, 0.08 ± 0.11 versus 0.16 ± 0.16 mg/L, $P > 0.10$) and *liver* (methamphetamine, 2.29 ± 3.83 versus 4.67 ± 7.73 mg/kg, $P > 0.10$; amphetamine, 0.37 ± 0.39 versus 0.80 ± 0.87 mg/kg, $P > 0.10$). Because of the small size of the mixed cocaine and methamphetamine series, such comparisons between accidental overdoses and homicides were not attempted.

TABLE 3—*Mixed cocaine/methamphetamine-related deaths in San Diego County (1987): homicides and accidental overdoses (summary).*

	DEMOGRAPHIC INFORMATION		
	Males	Females	All Cases
A. Race:			
Caucasian	6	2	8 (80%)
Black	1	1	2 (20%)
TOTAL	7 (70%)	3 (30%)	10 (100%)
B. Age (years):			
Mean	37	34	36
SD	10	11	10
Range	21-54	26-47	21-54
N	7	3	10
	TISSUE CONCENTRATIONS		
	Blood, mg/L	Liver, mg/kg	Brain, mg/kg
A. Cocaine:			
Mean	0.16	0.12	1.20
SD	0.33	0.24	2.37
Range	NMA[b]-0.97	NMA-0.72	NMA-7.20
N[a]	9	9	9
B. Benzoylecgonine metabolite:			
Mean	1.18	1.44	0.54
SD	1.48	1.74	0.71
Range	0.05-3.36	NMA-3.93	NMA-1.58
N	4	4	4
C. Methamphetamine:			
Mean	1.03	2.83	...
SD	2.30	5.20	...
Range	NMA-7.10	NMA-17.10	...
N[a]	9	10	...
D. Amphetamine metabolite:			
Mean	0.19	0.61	...
SD	0.41	1.12	...
Range	NMA-1.20	NMA-3.70	...
N	8	10	...

OTHER DRUGS INVOLVED

A. Cases involving no other drugs = 1 (10%).
B. Cases involving other drugs in addition to cocaine and methamphetamine = 9 (90%).
C. Other drugs detected (number of cases): ethanol (5 cases, mean 0.05%, SD 0.04%, range 0.01%-0.11% plus one additional case in which putrefaction was present); codeine (5 cases); morphine (5 cases); ephedrine (2 cases); acetaminophen, diazepam with nordiazepam (1 case each).

[a]Numbers are unequal as a result of lack of tissues or analyses or both in some cases.
[b]NMA = no measurable amount.

Discussion

Abuse of cocaine and methamphetamine has become a major problem in most large American cities, and San Diego is no exception [1,2]. The Office of the Coroner, County of San Diego, serves a population of approximately two million people, and drug screening is virtually always performed on victims of homicide and fatal accidental overdose. Consequently, it was thought that retrospective examination of the results of this screening might

TABLE 4—*Cocaine-related deaths in San Diego County (1987): homicides and accidental overdoses (raw data).*[a]

				Drug Concentrations			
Case	(Sex, Age)	Race	Mode of Death	Blood, mg/L	Liver, mg/kg	Brain, mg/kg	Other Drugs Involved
1	(M, 28)	C	AO	coc 5.45 BE NT	coc 1.14 BE NT	coc 14.10 BE NT	ethanol
2	(M, 25)	B	H	coc 0.01 BE NT	coc 0.02 BE NT	coc 0.12 BE NT	ethanol
3	(F, 27)	HS	H	coc 0.02 BE NT	coc 0.02 BE NT	coc 0.02 BE NT	ethanol
4	(M, 31)	B	H	coc NMA BE NT	coc NMA BE NT	coc 0.05 BE NT	ethanol, morphine
5	(M, 37)	HS	H	coc NMA BE NT	coc NMA BE NT	coc NMA BE NT	ethanol
6	(M, 26)	B	H	coc 0.03 BE NT	coc 0.02 BE NT	coc 0.10 BE NT	none
7	(M, 21)	B	H	coc NMA BE NT	coc NMA BE NT	coc NMA BE NT	none
8	(M, 26)	B	H	coc 0.07 BE NT	coc NMA BE NT	coc 0.21 BE NT	ethanol, desipramine
9	(M, 23)	B	H	coc NMA BE NT	coc NMA BE NT	coc NMA BE NT	none
10	(F, 27)	B	AO	coc NMA BE NT	coc NMA BE NT	coc 0.02 BE NT	codeine, morphine
11	(M, 29)	B	H	coc 0.09 BE NT	coc 0.06 BE NT	coc 0.13 BE NT	ethanol
12	(M, ?)	HS	H	coc 0.05 BE NT	coc 0.03 BE NT	coc 0.02 BE NT	ethanol
13	(M, 34)	HS	H	coc NMA BE NT	coc NMA BE NT	coc NMA BE NT	ethanol
14 (stillborn)	(F, 0)	B	AO	coc 0.04 BE NT	coc 0.11 BE NT	coc 0.10 BE NT	none
15	(M, 30)	B	H	coc 0.18 BE NT	coc 0.09 BE NT	coc 0.74 BE NT	none
16	(M, 35)	B	AO	coc 0.14 BE NT	coc 0.09 BE NT	coc 1.56 BE NT	none
17	(M, 24)	B	H	coc 0.42	coc 0.17	coc 0.40	none

				BE NT	BE NT	BE NT	
18	(M, 20)	HS	H	coc NMA	coc NMA	coc NMA	ethanol
				BE NT	BE NT	BE NT	
19	(M, 22)	C	AO	coc 1.10	coc 0.32	coc 14.50	none
				BE NT	BE NT	BE NT	
20	(M, 37)	C	AO	coc 0.13	coc 0.97	tissue NA	none
				BE NT	BE NT	tissue NA	
21	(M, 27)	C	AO	coc 0.11	coc 1.53	coc 2.15	ethanol (putrefaction)
				BE NT	BE NT	BE NT	
22	(M, 37)	B	H	coc NMA	coc NMA	coc NMA	none
				BE NT	BE NT	BE NT	
23	(F, 18)	B	H	coc 0.04	coc 0.02	coc 0.16	none
				BE NT	BE NT	BE NT	
24	(M, 30)	C	H	coc 0.03	tissue NA	coc 0.13	morphine
				BE NT	tissue NA	BE NT	
25	(F, 21)	C	H	coc 0.27	coc 0.14	coc 0.97	none
				BE NT	BE NT	BE NT	
26	(M, 33)	HS	H	coc 0.03	coc 0.04	coc 0.66	ethanol
				BE NT	BE NT	BE NT	
27	(M, 31)	HS	H	coc 0.50	coc 0.10	coc 0.94	ethanol, morphine
				BE NT	BE NT	BE NT	
28	(M, 39)	B	H	coc 0.04	coc 0.08	coc 0.43	ethanol
				BE NT	BE NT	BE NT	
29	(M, 31)	B	H	coc 0.03	coc 0.06	coc 0.18	ethanol, procaine
				BE NT	BE NT	BE NT	
30	(M, 31)	B	H	coc NMA	coc NMA	coc NMA	none
				BE NT	BE NT	BE NT	
31	(M, 19)	C	H	coc NMA	coc NMA	coc NMA	ethanol
				BE NT	BE NT	BE NT	
32	(F, 27)	B	H	coc 0.31	coc NMA	coc 0.86	none
				BE NT	BE NT	BE NT	
33	(M, 25)	HS	H	coc NMA	coc NMA	coc 0.74	phencyclidine
				BE NT	BE NT	BE NT	
34	(M, 35)	C	H	coc NMA	coc NMA	tissue NA	opiates as a class
				BE NT	BE NT	tissue NA	
35	(M, 42)	B	AO	coc 0.01	coc 0.02	coc 0.11	diphenhydramine, phenytoin,
				BE NT	BE NT	BE NT	carbamazepine
36	(M, 21)	B	AO	coc 0.02	tissue NA	coc 0.23	ethanol, morphine
				BE NT	tissue NA	BE NT	

TABLE 4—*Continued.*

Case	(Sex, Age)	Race	Mode of Death	Drug Concentrations: Blood, mg/L	Liver, mg/kg	Brain, mg/kg	Other Drugs Involved
37	(F, 40)	HS	H	coc NMA BE NT	coc 0.09 BE NT	coc 0.01 BE NT	ethanol
38	(M, 21)	HS	AO	coc 0.18 BE NT	coc 0.03 BE NT	coc 1.99 BE NT	morphine
39	(M, 44)	B	AO	coc 0.04 BE NT	coc 0.02 BE NT	coc 0.49 BE NT	ethanol, morphine
40	(M, 18)	HS	AO	coc 0.01 BE NT	coc 0.08 BE NT	coc NMA BE NT	ethanol, morphine
41	(M, 34)	C	AO	coc 0.17 BE NT	coc 0.02 BE NT	coc 0.73 BE NT	morphine
42	(M, 29)	HS	H	coc 0.08 BE 1.10	coc 0.07 BE 1.40	coc 0.32 BE 0.86	morphine
43	(M, 40)	HS	H	coc NMA BE 0.49	coc NMA BE 0.48	coc NMA BE 0.36	morphine
44	(M, 34)	C	AO	coc 0.64 BE 5.08	coc 0.13 BE 4.00	coc 6.33 BE 2.73	none
45	(M, 27)	F	H	coc 0.25 BE 0.63	coc 0.17 BE 1.36	coc 1.27 BE 0.19	codeine, morphine, amitriptyline, nortriptyline
46	(M, 32)	HS	H	coc NMA BE NMA	coc NMA BE NMA	coc NMA BE NMA	ethanol
47	(M, 35)	C	AO	coc NMA BE 0.37	coc 0.07 BE 0.53	coc 0.15 BE 0.18	ethanol (putrefaction), morphine
48	(M, 36)	B	AO	coc 0.06 BE 8.23	coc 0.06 BE 7.39	coc 0.04 BE 4.74	none
49	(M, 5 days)	HS	AO	coc NMA BE NMA	coc NMA BE NMA	coc NMA BE NMA	opiates as a class
50	(M, 31)	C	AO	coc 5.06 BE 9.52	coc 0.53 BE 15.80	tissue NA tissue NA	butalbital
51	(M, 55)	C	H	coc NMA BE NMA	coc NMA BE NMA	coc NMA BE NMA	none
52	(M, 40)	B	H	coc 0.05 BE 1.51	coc 0.20 BE 1.87	coc 0.15 BE 0.99	none
53	(M, 36)	C	AO	coc 0.08	coc 0.19	coc 0.16	ethanol (putrefaction), codeine,

				BE 1.52	BE 1.66	BE 0.76	morphine, nordiazepam
54	(M, 28)	HS	H	coc 0.08	coc 0.77	coc 0.29	morphine
				BE 0.35	BE 1.37	BE 0.20	
55	(M, 33)	B	AO	coc 1.54	coc 33.34	coc 10.97	none
				BE 7.46	BE 40.81	BE 2.81	
56	(M, 30)	HS	H	coc 0.10	coc 0.22	coc 0.20	ethanol, codeine, morphine
				BE 1.10	BE 2.15	BE 0.56	
57	(M, 18)	HS	H	coc 0.14	coc 0.11	coc 0.06	opiates as a class
				BE 0.33	BE 1.02	BE 0.10	
58	(M, 29)	HS	AO	coc 0.04	coc 0.06	coc 0.24	ethanol, codeine, morphine
				BE 0.04	BE 0.19	BE NT	
59	(M, 31)	C	AO	coc 5.11	coc 4.13	coc 7.82	ethanol (putrefaction)
				BE 10.90	BE 19.30	BE 3.30	
60	(M, ?)	HS	H	coc 0.12	coc 0.21	coc 0.62	none
				BE 0.53	BE 1.29	BE 0.84	
61	(M, 30)	HS	AO	coc 0.05	coc 0.10	coc 0.55	ethanol, codeine, morphine
				BE 1.26	BE 1.61	BE 0.44	
62	(F, 37)	C	H	coc NMA	coc NMA	coc NMA	none
				BE NMA	BE NMA	BE NMA	
63	(M, 31)	C	AO	coc NMA	coc NMA	coc 0.03	ethanol, codeine, morphine
				BE 0.21	BE 0.22	BE 0.13	
64	(M, 31)	C	AO	coc 0.04	coc 0.06	coc 0.14	ethanol (putrefaction), codeine,
				BE 2.87	BE 3.57	BE 1.72	morphine
65	(F, 35)	HS	AO	coc NMA	coc NMA	coc NMA	codeine, morphine
				BE 0.77	BE 0.62	BE 0.55	
66	(M, 26)	B	AO	coc 7.39	coc 15.96	coc 16.01	ethanol
				BE 14.40	BE 41.30	BE 2.09	

[a]Abbreviations used: Sex (M = male, F = female); Race (B = black, C = Caucasian, HS = Hispanic, F = Filipino); mode of death (AO = accidental overdose, H = homicide); and drug concentrations (coc = cocaine, BE = benzoylecgonine, NT = not tested, NMA = no measurable amount with quantitative assay, NA = not available).

TABLE 5—*Methamphetamine-related deaths in San Diego County (1987): homicides and accidental overdoses (raw data).*[a]

				Drug Concentrations			
Case	(Sex, Age)	Race	Mode of Death	Blood, mg/L	Liver, mg/kg	Brain, mg/kg	Other Drugs Involved
1	(M, 20)	C	H	met 0.25 amp 0.06	met 0.72 amp 0.21	tissue NA tissue NA	none
2	(M, 27)	C	H	met 0.64 amp 0.06	met 7.38 amp 1.21	tissue NA tissue NA	none
3	(F, 24)	C	H	met 0.81 amp 0.38	met 2.21 amp 1.07	met 1.90 amp 1.00	opiates as a class
4	(M, 32)	C	AO	met 0.02 amp NMA	tissue NA tissue NA	tissue NA tissue NA	ethanol, morphine
5	(M, 45)	C	H	tissue NA tissue NA	met 0.60 amp 0.44	met 0.29 amp 0.19	ethanol
6	(M, 37)	C	AO	met 0.08 amp NMA	met 0.17 amp 0.05	tissue NA tissue NA	ethanol, codeine, morphine, chlordiazepoxide
7	(M, 29)	B	H	met 1.88 amp 0.61	met 4.51 amp 1.43	tissue NA tissue NA	ephedrine
8	(F, 31)	C	H	met 0.25 amp 0.09	met 2.37 amp 0.87	tissue NA tissue NA	ephedrine
9	(M, 27)	C	H	met 0.92 amp 0.16	met 1.62 amp 0.31	tissue NA tissue NA	none
10	(M, 26)	C	H	met 0.21 amp 0.06	met 0.62 amp 0.21	tissue NA tissue NA	ethanol
11	(M, 43)	AI	H	met 0.49 amp 0.09	met 1.07 amp 0.19	tissue NA tissue NA	ephedrine
12	(M, 26)	HS	H	met 0.16 amp 0.03	met 0.45 amp 0.12	tissue NA tissue NA	ethanol, phencyclidine
13	(M, 31)	C	H	met 0.12 amp 0.06	met 0.87 amp 0.17	tissue NA tissue NA	ethanol
14	(F, 45)	C	AO	met 0.86 amp 0.10	met 1.75 amp 0.23	tissue NA tissue NA	ephedrine, codeine, morphine, butalbital, caffeine
15	(M, 26)	C	H	met 1.06 amp 0.10	met 4.18 amp 0.60	tissue NA tissue NA	none
16	(M, 35)	C	AO	met 0.33 amp 0.08	met 0.69 amp 0.27	tissue NA tissue NA	none
17	(F, 34)	C	H	met 2.82	met 9.82	tissue NA	ethanol (putrefaction)

				amp 0.36	amp 2.13	tissue NA	
18	(M, 32)	C	H	met 0.26	met 4.01	tissue NA	none
				amp 0.05	amp 1.02	tissue NA	
19	(M, 20)	HS	H	met 2.35	met 3.89	tissue NA	morphine
				amp 0.34	amp 0.55	tissue NA	
20	(M, 22)	AI	H	met 0.04	met 0.13	tissue NA	ethanol (putrefaction)
				amp NMA	amp 0.06	tissue NA	
21	(F, 22)	C	H	met 2.77	met 6.57	tissue NA	ethanol (putrefaction)
				amp INT	amp 1.70	tissue NA	
22	(F, 36)	C	H	met 0.34	met 1.23	tissue NA	none
				amp 0.02	amp 0.12	tissue NA	
23	(M, 28)	C	AO	met 0.06	met 0.30	tissue NA	codeine, morphine
				amp NMA	amp NMA	tissue NA	
24	(M, 36)	C	H	met 0.61	met 1.46	tissue NA	none
				amp 0.08	amp 0.17	tissue NA	
25	(M, 42)	C	AO	met 0.28	met 1.06	tissue NA	none
				amp 0.02	amp 0.10	tissue NA	
26	(M, 37)	C	H	met 0.27	met 1.42	tissue NA	none
				amp 0.09	amp 0.60	tissue NA	
27	(M, 44)	C	AO	met 0.56	met 0.52	tissue NA	ephedrine
				amp 0.09	amp 0.10	tissue NA	
28	(M, 53)	C	AO	tissue NA	met 2.25	tissue NA	ethanol (putrefaction),
				tissue NA	amp 0.78	tissue NA	amitriptyline, nortriptyline
29	(F, 23)	C	H	met 2.81	met 35.96	tissue NA	ephedrine
				amp 0.25	amp 3.76	tissue NA	
30	(M, 22)	HS	H	met 0.26	met 0.88	tissue NA	ethanol, phencyclidine
				amp 0.05	amp 0.15	tissue NA	
31	(M, 28)	C	H	met 2.37	met 15.40	tissue NA	ethanol
				amp 0.19	amp 1.38	tissue NA	
32	(M, 26)	C	AO	met 3.05	met 11.60	tissue NA	none
				amp 0.32	amp 1.06	tissue NA	

[a]Abbreviations used: Sex (M = male, F = female); Race (B = black, C = Caucasian, HS = Hispanic, AI = American Indian); mode of death (AO = accidental overdose, H = homicide); and drug concentrations (met = methamphetamine, amp = amphetamine, NA = not available, NMA = no measurable amount with *quantitative assay*, INT = *unable to quantify because of interfering substance*).

TABLE 6—*Mixed cocaine/methamphetamine-related deaths in San Diego County (1987): homicides and accidental overdoses (raw data).*[a]

				Drug Concentrations			
Case	(Sex, Age)	Race	Mode of Death	Blood, mg/L	Liver, mg/kg	Brain, mg/Kg	Other Drugs Involved
1	(M, 39)	C	AO	coc 0.97	coc 0.72	coc 7.20	ethanol
				BE NT	BE NT	BE NT	
				met 0.15	met 0.59	met NT	
				amp 0.03	amp 0.18	amp NT	
2	(F, 29)	C	AO	tissue NA	coc NMA	coc NT	none
				tissue NA	BE NT	BE NT	
				tissue NA	met 4.77	met 2.99	
				tissue NA	amp 0.72	amp 0.46	
3	(F, 26)	C	AO	coc NMA	coc NMA	coc NMA	codeine, morphine, ephedrine
				BE NT	BE NT	BE NT	
				met 1.01	met 2.07	met NT	
				amp 0.17	amp 0.39	amp NT	
4	(F, 47)	B	H	coc 0.03	coc NT	coc 0.19	ethanol
				BE NT	BE NT	BE NT	
				met 0.26	met 1.25	met NT	
				amp NMA	amp 0.08	amp NT	
5	(M, 21)	B	H	coc NMA	coc 0.04	coc 0.22	ethanol
				BE NT	BE NT	BE NT	
				met 0.03	met 0.30	met NT	
				amp NMA	amp 0.03	amp NT	
6	(M, 39)	C	H	coc NMA	coc NMA	coc 0.01	ethanol, ephedrine
				BE NT	BE NT	BE NT	
				met 7.10	met 17.10	met NT	
				amp 1.20	amp 3.70	amp NT	
7	(M, 33)	C	AO	coc 0.39	coc 0.28	coc 2.33	ethanol (putrefaction), codeine, morphine
				BE 3.36	BE 3.93	BE 1.58	
				met 0.23	met 0.45	met NT	
				amp 0.08	amp 0.11	amp NT	
8	(M, 33)	C	AO	coc NMA	coc NMA	coc NMA	ethanol, codeine, morphine, acetaminophen
				BE 0.05	BE 0.08	BE NMA	
				met 0.08	met 0.45	met NT	

				amp INT	amp 0.73	amp NT	
9	(M, 54)[b]	C	H	coc NMA	coc NMA	coc NMA	codeine, morphine
				BE 0.67	BE 0.57	BE 0.42	
				met NMA	met NMA	met NT	
				amp NMA	amp NMA	amp NT	
10	(M, 40)	C	AO	coc 0.07	coc NMA	coc 0.88	codeine, morphine, diazepam, nordiazepam
				BE 0.63	BE 1.25	BE 0.16	
				met 0.39	met 1.29	met NT	
				amp 0.04	amp 0.15	amp NT	

[a]Abbreviations used: Sex (M = male, F = female); Race (B = black, C = Caucasian); mode of death (AO = accidental overdose, H = homicide); and drug concentrations (coc = cocaine, BE = benzoylecgonine, met = methamphetamine, amp = amphetamine, NT = not tested, NA = not available, NMA = no measurable amount with quantitative assay, INT = unable to quantify because of interfering substance).

[b]Although neither methamphetamine nor amphetamine were present in measurable concentrations in blood or liver, both were detected in urine by gas-liquid chromatography and radioimmunoassay.

yield significant demographic and toxicologic information and might permit synthesis of the profile of the typical decedent in cocaine- and methamphetamine-related homicides and accidental overdoses.

Since it is retrospective, this study suffers from the usual problems associated with gleaning history from secondary sources (for example, family and friends), the inability of obtaining exactly the same tissues for toxicologic analysis in all cases, and the inability of knowing with certainty the time elapsed between drug ingestion and death. Despite these handicaps, certain important conclusions can be drawn from this study.

During the calendar year 1987 in San Diego County, 66 cocaine-related, 32 methamphetamine-related, and 10 mixed cocaine/methamphetamine-related homicides and fatal accidental overdoses occurred. Other cocaine- and methamphetamine-related deaths also occurred but were not included in this study since they were not homicides or fatal accidental overdoses.

The composite for cocaine-related cases was a 30-year-old black man in whom was also found at least 1 other drug, usually ethanol or morphine (Table 1). Most deaths were homicides. In our earlier study of nonfatal cocaine intoxications men and women of age 21 to 30 years were involved equally, and cocaine was found both alone and in combination with other drugs with equal frequency [*1*]. In that study, specific age and race were not elucidated.

In the present study of cocaine-related death, the mean age for males did not differ significantly from that for females. The mean age for the entire series also did not differ significantly from the mean age for mixed cocaine/methamphetamine-related deaths. As previously noted, mean tissue concentrations of cocaine and the benzoylecgonine metabolite were significantly higher following accidental overdose than following homicide except for cocaine in liver, presumably reflecting substantial depletion of hepatic cocaine by liver esterases [*9*]. However, mean concentrations did not differ significantly between cocaine-related deaths and mixed cocaine/methamphetamine-related deaths.

The composite for methamphetamine-related deaths was a 32-year-old Caucasian man who used methamphetamine with at least 1 other drug, usually ethanol (Table 2). Again, most deaths were homicides. In our earlier study of nonfatal methamphetamine intoxication, the average user was a 27-year-old Caucasian man who used methamphetamine either alone or in combination with other drugs with equal frequency [*2*].

In the present study of methamphetamine-related death, the mean age for males did not differ significantly from that for females. The mean age for the entire series also did not differ significantly either from that for cocaine-related deaths or from that for mixed cocaine/methamphetamine-related deaths. As previously noted, mean tissue concentrations of methamphetamine and the amphetamine metabolite were not significantly different between homicides and accidental overdoses. Mean tissue concentrations also did not differ significantly between methamphetamine-related deaths and mixed cocaine/methamphetamine-related deaths.

Finally, the composite for mixed cocaine/methamphetamine-related deaths was a 36-year-old Caucasian man in whom was also found at least 1 additional drug, usually ethanol, codeine, or morphine (Table 3). In this series, death was usually attributed to accidental overdose. The mean age for males did not differ significantly from that for females or, as previously discussed, from that for pure methamphetamine-related and cocaine-related cases. Because of the small population size for the mixed series, mean tissue concentrations were not compared between homicides and accidental overdoses. When compared with mean tissue concentrations for both pure cocaine-related and methamphetamine-related deaths, mean tissue concentrations, as noted above, for the mixed series did not differ significantly.

When compared with other reports of tissue concentrations associated with death [*9–14*], some of the concentrations in the present study (especially those for cocaine) appear to be low. However, it should be emphasized that most of the deaths in the entire study were homicides (66 of 108 total cases) rather than overdoses. Of the 42 cases believed to be fatal accidental overdoses, 31 were associated with at least 1 other drug (usually ethanol), so that death probably was the result of combined drug effect rather than of massive overdose of a single drug. Furthermore, in some cases substantial time had undoubtedly elapsed between drug ingestion and death, thereby permitting metabolism of the drugs. These variables, along with possible differences in the route of ingestion, may account for the wide variation in blood and tissue concentrations noted in the literature [*9-14*]. Finally, for cocaine-related deaths, the use of a sensitive and specific radioimmunoassay for benzoylecgonine in blood permitted its frequent detection during initial screening without measurable concentrations ("NMA," Tables 1 and 4) of either cocaine or benzoylecgonine during subsequent quantitation by less sensitive analytical methodology. Hence, the calculated mean concentrations were rendered lower by inclusion of these data. However, the data were included since the cases were still, after all, cocaine-related deaths. This situation did not occur with methamphetamine since, because of their relative nonspecificity, positive immunoassay screens without subsequent quantitative confirmation were not considered indicative of the presence of methamphetamine.

In summary, cocaine was involved in approximately one fifth and methamphetamine in about one eighth of homicides in San Diego County in 1987. When fatal accidental overdoses were considered together with homicides, cocaine was involved in twice as many cases as methamphetamine. Awareness of these facts should prompt forensic science laboratories to search carefully for both drugs when either of these two modes of death are involved, especially if the demographic profiles identified here are observed.

References

[*1*] Bailey, D. N., "Cocaine Detection During Toxicology Screening of a University Medical Center Patient Population," *Journal of Toxicology-Clinical Toxicology*, Vol. 25, Nos. 1 and 2, March/May 1987, pp. 71-79.

[*2*] Bailey, D. N., "Amphetamine Detection During Toxicology Screening of a University Medical Center Patient Population," *Journal of Toxicology-Clinical Toxicology*, Vol. 25, No. 5, Oct. 1987, pp. 399-409.

[*3*] Davidow, B., Petri, N. L., and Quame, B., "A Thin-Layer Chromatographic Procedure for Detecting Drug Abuse," *American Journal of Clinical Pathology*, Vol. 50, No. 6, Dec. 1968, pp. 714-719.

[*4*] Goldbaum, L. R. and Domanski, T. J., "An Approach to the Analysis of Biological Specimens for Basic Drugs," in *Progress in Chemical Toxicology*, Vol. 2, A. Stolman, Ed., Academic Press, New York, 1965, pp. 221-238.

[*5*] Jatlow, P. I. and Bailey, D. N., "Analytical Toxicology," in *Gradwohl's Clinical Laboratory Methods and Diagnosis*, Vol. 1, A. Sonnenwirth and L. Jarett, Eds., C. V. Mosby, St. Louis, MO, 1980, pp. 409-410.

[*6*] Foerster, E. H., Hatchett, D., and Garriott, J. C., "A Rapid, Comprehensive Screening Procedure for Basic Drugs in Blood or Tissues by Gas Chromatography," *Journal of Analytical Toxicology*, Vol. 2, No. 2, March/April 1978, pp. 50-55.

[*7*] Foerster, E. H. and Mason, M. R., "Preliminary Studies on the Use of *N*-Butyl Chloride as an Extractant in a Drug Screening Procedure," *Journal of Forensic Sciences*, Vol. 19, No. 1, Jan. 1974, pp. 155-162.

[*8*] Jatlow, P. I. and Bailey, D. N., "Gas-Chromatographic Analysis for Cocaine in Human Plasma, with Use of a Nitrogen Detector," *Clinical Chemistry*, Vol. 21, No. 13, Dec. 1975, pp. 1918-1921.

[*9*] Spiehler, V. R. and Reed, D., "Brain Concentrations of Cocaine and Benzoylecgonine in Fatal Cases," *Journal of Forensic Sciences*, Vol. 30, No. 4, Oct. 1985, pp. 1003-1011.

[*10*] Baselt, R. C., *Disposition of Toxic Drugs and Chemicals in Man*, Biomedical Publications, Davis, CA, 1982, pp. 193-198, 488-490.

[*11*] Finkle, B. S. and McCloskey, K. L., "The Forensic Toxicology of Cocaine (1971-1976)," *Journal of Forensic Sciences*, Vol. 23, No. 1, Jan. 1978, pp. 173-189.

[*12*] Wetli, C. V. and Wright, R. K., "Death Caused by Recreational Cocaine Use," *JAMA*, Vol. 241, No. 23, June 1979, pp. 2519-2522.

[13] Cravey, R. H. and Baselt, R. C., "Methamphetamine Poisoning," *Journal of Forensic Sciences*, Vol. 8, No. 1, Jan. 1968, pp. 118-120.
[14] Lundberg, G. D., Garriott, J. C., Reynolds, P. C., Cravey, R. H., and Shaw, R. F., "Cocaine-Related Death," *Journal of Forensic Sciences*, Vol. 22, No. 2, Feb. 1977, pp. 402-408.

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