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Incidence of Cannabinoids in Medical Examiner Urine Specimens

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ABSTRACT: Cannabinoid use was studied in a nonspecific population of postmortem urine specimens in the State of Maryland. Of 500 sequential specimens screened for cannabinoids by enzyme multiplied immunoassay EMIT®, 63 (13%) were initially positive and 58 (12%) were confirmed positive (92%). It was observed that geographic location and race did not correlate with cannabinoid prevalence. Cannabinoid use was observed to be strongly age related, with peak use by the 21- to 25-year-old age group where 22% of the cases were positive. Use of cannabinoids was also closely linked to homicides, which represented nearly half of the positive cases but only 13% of the total cases. When comparing manner of death, the greatest percent of confirmed positives was seen in homicide (26%) and drug-related (17%) deaths. The incidence of cannabinoid use was found to be more than 3 times as great in drug-related (17%) as compared to natural deaths (5%). The percent of cannabinoid-positive cases from vehicle-related accidents was low (6%) and that from nonvehicle-related accidents somewhat higher (10%).

Other drugs appeared in cannabinoid-positive cases. Most prevalent was ethanol $N = 18$, followed by morphine (from heroin, $N = 11$), quinine $N = 11$, and cocaine $N = 11$. Phencyclidine (PCP) occurred twice and several other drugs were reported only once. Of the 25 homicide cases screened for drugs, 64% were positive for some drug including ethyl alcohol. Thus it appears that a high percentage of homicide cases are drug related. Males greatly outnumbered females (56:2) in positive cases, but the number of female specimens received was small.

KEYWORDS: pathology and biology, marijuana, urine, immunoassay, cannabinoids, EMIT®

The continuous use of marijuana has prompted studies of postmortem urine specimens to detect the presence of cannabinoids. The data reported have usually dealt with a specific subgrouping, rather than a general postmortem population. For example, the epidemiology of ethanol, marijuana, and other drugs in 600 drivers killed in single-vehicle crashes was reported by Mason and McBay [*1*]. In that study, 47 (8%) of 600 specimens screened positive for delta-9-tetrahydrocannabinol (THC). The facts that only blood was tested and that only a driving population was considered preclude using these results for comparative purposes in a general postmortem population. The study did find that cannabinoid users showed a tendency toward multiple drug use and were from younger age groups than other drivers. They noted no difference with regard to distribution by sex or ethanol use.

This study examines the prevalence of cannabinoids in a population of postmortem urine specimens. Five hundred medical examiner urine specimens received during a nine-month

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period in the State of Maryland were screened by enzyme multiplied immunoassay (EMIT®) for cannabinoids. Those determined to be positive using a 75.0-ng/mL cutoff concentration were then further analyzed by high-performance liquid chromatography (HPLC) with both ultraviolet (UV) and electrochemical (EC) detection and high-efficiency thin-layer chromatography (HETLC) using methods previously described [2]. Positive and negative cases were classified as to age, sex, race, geographic location, manner of death, and the presence or absence of ethyl alcohol and other drugs. The five hundred cases tested were also compared to the entire postmortem population for the period of the study (a total of two thousand and fifty-two cases).

Methods

Selection of Cases

All urine specimens submitted to the toxicology laboratory of the Office of the Chief Medical Examiner (OCME) were analyzed in successive order as they became available. All specimens were kept frozen. Only those specimens that were ready for disposal were tested. During the study period, some urine specimens were unavailable or were not originally submitted with the case. The population, then, is quite random and includes 500 urine specimens.

Determination of Cannabinoids

The 500 urine specimens were screened for cannabinoids by Syva EMIT using a 75.0-ng/mL cutoff concentration. All positive specimens were then confirmed by HPLC-UV, HPLC-EC, and HETLC according to methods previously reported [2]. For a case to be considered positive, all results by HPLC, HETLC, and EMIT must be in agreement. Any discrepancy required the case to be reported as an unconfirmed positive.

Determination of Other Drugs

Complete drug screens were performed only in cases in which such requests had been made by the medical examiners. Blood ethyl alcohol analysis was conducted in all cases. The analytical procedures employed were those currently in use in the toxicology department of the OCME which were designed to detect all major drugs of abuse.

Results

Of the 500 specimens screened by EMIT for cannabinoids, 63 (13%) were found to be positive. Later, 58 (92%) were confirmed positive by HPLC-UV, HPLC-EC, and HETLC. Of the 5 unconfirmed EMIT positives, 4 were negative by all confirming methods; 1 case was positive by EMIT and HETLC but negative by both HPLC methods. In all cases, positive or negative, both HPLC results were in agreement.

The confirmation rate of 92% was consistent with the previous study of Black et al. [3], also using a 75.0-ng/mL EMIT cutoff. The overall confirmed positive rate was 12% (58 out of 500). This compares favorably with a study by the National Institute on Drug Abuse (NIDA), where 5624 surveyed individuals (13%) claimed to have used marijuana within the last month [4]. The population questioned ranged from 12 to over 50 years of age.

The number of cases screened, the total number of confirmed positive cases, and the total number of cases received at the OCME during the course of the study within various age groups are presented in Table 1. The percent screened and the percent positive are also noted. The table shows that all age groups were included, with a somewhat greater emphasis

TABLE 1—*OCME-surveyed population by age: screened cases, confirmed cannabinoid positive cases, and total population for the period of the study.*

Age, years	Number Screened	Number Positive	Percent Positive	Number of Cases	Percent Screened
≤20	50	8	16	303	16
21–25	93	20	22	214	44
26–30	66	11	17	161	41
31–35	68	9	13	175	39
36–40	43	7	16	133	32
41–45	45	1	2	134	34
46–50	32	1	3	126	25
51–60	55	1	2	287	19
61–70	27	0	...	260	10
>70	21	0	...	259	8
Total	500	58	12	2052	24

on the drug-abuse-prone years. This is due to the fact that specimens from cases that were clearly nondrug-related; for example, some older adults, infants, and children were not submitted for testing.

Table 2 shows a breakdown of the 500 screened cases by age, sex, race, geographic location, manner of death, and presence or absence of ethyl alcohol and other drugs (the latter only if originally requested by the medical examiner for that case). A positive drug analysis was considered to be any trace of drug in any body fluid or tissue, quantifiable or not. The total number in each subclass is then given as well as the percent within that subclass as compared to the total number screened.

All cases received in the OCME for the period of the study (whether tested for cannabinoids or not) are presented in Table 3. As in Table 2, the total number in each subclass is reported as well as the percent within a subclass as compared to the total population.

Table 4 describes 58 confirmed positive cases. All cases are subdivided as before. Once again, the total number of confirmed positives in each subclass is given as well as the percent within a subclass as compared with the total confirmed positive population.

Table 5 compares the manner of death for the total cases screened and for those confirmed positive for cannabinoids. Of the 58 confirmed positive cases, 58 (100%) were screened for ethyl alcohol and 52 (90%) were screened for the other drugs in addition.

Table 6 shows the number of confirmed cases, positive or negative for ethyl alcohol or other drugs or some combination of these, for those 52 cases in which drug screens were performed, in addition to testing for ethyl alcohol. Of the cases *not* screened for drugs other than ethyl alcohol, 5 were negative for ethyl alcohol (2 were 20 years of age or younger, one between 26 and 30, and 1 between 31 and 35), and 1 was positive for ethyl alcohol and was in the 21- to 25-year-old age group.

Discussion

This study was performed using postmortem cases from the OCME in Baltimore, Maryland, which conducts medicolegal investigations under a medical examiner system. There is only 1 site at which autopsies are performed for the entire state, which includes all 23 counties and Baltimore, an independent city. While certain cases with no unusual history may be released by an appointed deputy medical examiner in his designated county, this is not the case for Baltimore City, where all cases are brought to the OCME. Consequently, it is not surprising that a greater number of deaths due to natural causes might be seen from Baltimore City as compared to the counties. However, since the population of interest here is

TABLE 2—*Comparison of 500 medical examiner urine specimens screened for cannabinoids by EMIT.*[a]

															Cannabinoids			Ethanol		Drug Screen[c]	
Age, years	N	M	F	B[b]	W	City	Cty	Hom	Sui	Veh	NVeh	D	Nat	U	Neg	Pos	Conf	Neg	Pos	Neg	Pos
≤20	50	40	10	16	34	18	32	11	10	22	5	0	2	0	41	9	8	30	20	38/40	2/40
21-25	93	79	14	42	51	35	58	31	12	5	5	6	7	2	73	20	20	49	44	63/88	25/88
26-30	66	58	8	28	38	29	37	16	9	12	4	13	10	2	54	12	11	33	33	32/59	27/59
31-35	68	54	14	36	32	36	32	16	8	13	3	15	10	3	57	11	9	29	39	28/58	30/58
36-40	43	34	9	22	21	15	28	9	6	6	7	3	9	3	36	7	7	24	19	25/39	14/39
41-45	45	31	14	19	26	15	30	10	6	7	0	4	18	0	43	2	1	25	20	22/28	6/28
46-50	32	28	4	12	20	14	18	2	2	9	2	1	16	0	31	1	1	20	12	10/14	4/14
51-60	55	48	7	13	42	18	37	3	5	10	10	4	23	0	54	1	1	30	20	15/24	9/24
61-70	27	22	5	9	18	13	14	0	5	4	1	0	16	1	27	0	0	20	7	7/9	2/9
>70	21	13	8	4	17	7	14	2	3	5	2	1	8	0	21	0	0	17	4	5/7	2/7
Total	500	407	93	201	299	200	300	100	66	118	39	47	119	11	437	63	58	277	233	245/366	321/366
% of Total	100	81	19	40	60	40	60	20	13	24	8	9	24	2	87	13	12	55	45	67	33

[a]Abbreviations: N = number, M = male, F = female, B = black, W = white, Cty = county, Hom = homicide, Sui = Suicide, Veh = vehicle-related accident, NVeh = nonvehicle-related accident, D = drug related, Nat = natural, U = undetermined, Neg = negative, Pos = positive and Conf = confirmed.

[b]Blacks and other non-Caucasians.

[c]Drug screen (excluding cannabinoids and ethyl alcohol) only reported if initially requested by the medical examiners.

TABLE 3—*Demographics of 2052 medical examiner cases encountered during a nine-month study.*[a]

Age, years	N	M	F	B[b]	W	City	Cty	Hom	Sui	Veh	NVeh	D	Nat	U
≤20	303	209	94	132	171	136	167	43	27	78	43	1	108	3
21–25	214	171	43	87	127	90	124	53	35	72	17	13	21	3
26–30	161	127	34	71	90	77	84	40	25	46	17	19	21	2
31–35	175	145	30	87	88	90	85	47	16	34	18	17	38	5
36–40	133	101	32	63	70	60	73	24	15	27	18	3	47	3
41–45	134	101	33	53	81	54	80	21	25	22	6	4	55	1
46–50	126	102	24	46	80	67	59	10	12	15	8	1	78	2
51–60	287	223	64	115	172	185	102	12	20	23	23	4	205	0
61–70	260	176	84	109	151	190	70	5	16	24	13	0	200	2
>70	259	147	112	97	162	165	94	9	16	29	24	1	176	4
Total	2052	1502	550	860	1192	1114	938	264	207	370	174	63	949	25
% of total	100	73	27	42	58	54	46	13	10	18	8	3	46	1
No. screened	500	407	93	201	299	200	300	100	66	118	39	47	119	11
% screened	24	27	16	23	25	18	32	38	32	32	22	75	12	44

[a]Abbreviations: N = number, M = male, F = female, B = black, W = white, Cty = county, Hom = homicide, Sui = suicide, Veh = vehicle-related accident, NVeh = nonvehicle-related accident, D = drug related, Nat = natural, and U = undetermined.

[b]Blacks and other non-Caucasians.

TABLE 4—*Comparison of 58 cannabinoid positive medical examiner urine specimens.*[a]

Age, years	N	M	F	B[b]	W	City	Cty	Hom	Sui	Veh	NVeh	D	Nat	U	Ethanol		Drug Screen[c]	
															Neg	Pos	Neg	Pos
≤20	8	7	1	5	3	7	1	5	2	1	0	0	0	0	6	2	5/6	1/6
21-25	20	20	0	11	9	11	9	10	0	5	0	3	2	0	10	10	9/19	10/19
26-30	11	10	1	6	5	6	5	4	2	1	2	1	1	0	7	4	5/10	5/10
31-35	9	9	0	4	5	4	5	3	2	0	0	2	2	0	5	4	2/8	6/8
36-40	7	7	0	6	1	4	3	3	0	0	1	2	0	1	5	2	2/7	5/7
41-45	1	1	0	0	1	0	1	0	0	0	0	0	1	0	1	0	1/1	0/1
46-50	1	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0/1	1/1
51-60	1	1	0	0	1	0	1	0	1	0	0	0	0	0	1	0	...	...
Total	58	56	2	33	25	33	25	26	6	8	3	8	6	1	36	22	25/52	27/52
% of total	100	97	3	57	43	57	43	45	10	14	5	14	10	2	62	38	48	52

[a]Abbreviations: N = number, M = male, F = female, B = black, W = white, Cty = county, Hom = homicide, Sui = suicide, Veh = vehicle-related accident, NVeh = nonvehicle-related accident, D = drug related, Nat = natural, U = undetermined, Neg = negative and Pos = positive.

[b]Blacks and other non-Caucasians.

[c]Drug screen (excluding cannabinoids and ethyl alcohol) only reported if initially requested by the medical examiners.

TABLE 5—*Incidence of cannabinoid use by manner of death.*

Manner	Number Screened	Number Positive	Percent Positive
Homicide	100	26	26
Suicide	66	6	9
Accident			
Veh.[a]	118	7	6
NVeh.[a]	39	4	10
Drug related	47	8	17
Natural	119	6	5
Undetermined	11	1	9
Total	500	58	12

[a]Veh = vehicle-related and NVeh = nonvehicle related.

TABLE 6—*Use of other drugs in cannabinoid-positive postmortem cases.*[a]

Age, years	Number			
	No. Drugs Detected	Ethanol Only Detected	Other Drugs With Ethanol	Other Drugs Without Ethanol
≤20	5	0	1	0
21-25	6	5	3	5
26-30	3	2	2	3
31-35	2	0	3	3
36-40	1	2	0	4
41-45	1	0	0	0
46-50	0	1	0	0
>50	0	0	0	0
Total	18	10	9	15
% of total	35	19	17	29

[a]Only those cases that were positive for cannabinoids and were screened for ethyl alcohol as well as other drugs are included.

generally a younger population, the fact that deaths in the Baltimore City population for the duration of the study might be slightly skewed toward natural causes does not appear significant.

Because of the nature of the population and the fact that the postmortem population tested may not represent the living population as a whole, the aim of this study was to provide insight into cannabinoid use in a general rather than statistically significant fashion.

Cannabinoid use is strongly age related. Of the cases positive for cannabinoids, 55 (95%) were 40 years of age or younger (Table 1). The highest incidence of cannabinoid use was seen in the 21- to 25-year-old age group, where 20 out of 93 cases screened (22%) were positive (Table 1). There is an age bias toward younger decendents because deaths in older age groups are generally natural, hence their prevalence in the medical examiners' population is reduced. Further, many such cases do not have urine specimens submitted to the laboratory; however, the rate of cannabinoid use within an age group should remain unaffected.

Several observations are noted in reviewing the breakdown of positive cases (Table 4). The overwhelming male predominance (97%) for confirmed positive cases may have been in part due to the relatively few female specimens received. In fact, for the duration of the study, 986 cases were received at the OCME whose age was 40 or less. Of these only 233 (24%) were

female (Table 3). During the same period, of 320 specimens screened for cannabinoids in people 40 or younger, 55 (17%) were females (Table 2). Thus the low incidence of cannabinoids in females in the postmortem study appears to be due not to a lack of having screened female urine specimens for cannabinoids, but perhaps to an overall much lower incidence for females, since of 93 female specimens screened, only 2 (2%) were confirmed positive, and of 55 female specimens screened from people 40 or younger, only 2 (4%) were confirmed positive.

Of all the positive cases, the percent from blacks (57%) and the City (57%) were only slightly higher than that of whites (43%) and the counties (43%). It would be erroneous to infer that all white cases came from the counties and all black cases from the City. Of importance, however, is the fact that the percent of black and City users only slightly exceeds that of white and county users. A similar trend was seen in the study by NIDA of individuals 18 years old and over [*4*]. Although no attempt was made to statistically compare antemortem and postmortem populations as a result of the variable nature of the 2 populations, it does not appear that a particular race or geographic location is a factor in cannabinoid use.

Of the 58 confirmed positive cases, 26 (45%) were from homicides (Table 4). This percentage is noteworthy when compared with the percentage of homicide cases (13%) for the total population for the same time period.

Cases screened and cannabinoid positive cases are classified by manner of death, as shown in Table 5. The total number of homicide cases screened ($N = 100$), when compared with the total number positive ($N = 26$), gives a 26% incidence rate for cannabinoids in all screened homicide cases. It should be noted that 93% of the screened homicide cases were 45 years old or younger and 96% of the confirmed positive homicide cases were 40 years old or younger. Thus the incidence of cannabinoids in homicide cases drops markedly after the age of 41, as it did in every other subclass. Further examination of Table 5 shows that after homicide cases, the greatest incidence of cannabinoids was found in cases where the death was drug related (17%). The incidence of cannabinoid use was much greater in drug-related deaths (17%) as compared to natural deaths (5%) (Table 5). Since a relatively higher proportion of natural deaths were not tested, no inference can be drawn from this observation.

Of 118 screened vehicle-related accident cases (including driver, occupant, and pedestrian-related fatalities), 7 (6%) were positive for cannabinoids, while about twice as many, 4 of 39 (10%) screened nonvehicle-related accident cases were positive (Table 5). Because of the limited number of cases, a breakdown of the type of accident could not be developed. Although the number of vehicle-related accidents was about 3 times greater than that of nonvehicle-related accidents (Table 3), the percent screened from each subgroup was quite close. The suggestion that cannabinoid use and vehicle-related accidents are not prominently related may be limited by the relatively small number of cases of this type studied.

The data exploring the incidence of other drugs in the specimens which tested positive for cannabinoids are shown in Table 6. Of the 58 confirmed positive cases, 52 (90%) were screened for other drugs in addition to ethyl alcohol. Only the 52 cases that were screened for ethyl alcohol as well as other drugs will be considered. Of those cases positive for ethyl alcohol, 9 (17%) were positive for ethyl alcohol and other drugs. Of those negative for ethyl alcohol, 18 (35%) were negative for all drugs and 15 (29%) were positive for 1 or more drugs.

These data show that a large number of cannabinoid users, 34 of 52 (65%), used 1 or more drugs (including alcohol) in addition to marijuana. Of the 24 cases that were positive for another drug, with or without ethanol, only 2 appeared to have had legitimate uses for the drug based upon the deceased's history. One was a patient whose cause of death was due to seizure disorders and who tested positive for phenobarbital at a subtherapeutic blood concentration, and the other was from lidocaine administration in the hospital to a homicide victim. A summary of the drugs and their incidence is shown in Table 7.

It is clear from this information that morphine (probably heroin identified as morphine)

TABLE 7—*Incidence of drugs in confirmed cannabinoid cases.*[a]

Drug	Occurrences
Amobarbital	1
Benzodiazepines	1
Chlorpromazine and metabolites	1
Cocaine and metabolites	11
Diazepam	1
Diphenhydramine	1
Ethanol	18
Lidocaine	1
Methadone and metabolites	1
Morphine	11
Nordiazepam	1
Phencyclidine	2
Phenobarbital	1
Quinidine and metabolites	1
Quinine and metabolites	11
Secobarbital	1

[a]Adds up to more than 24 (the number of cases positive for other drugs in addition to ethyl alcohol), as a result of multiple drug use.

($N = 11$), quinine ($N = 11$), and cocaine ($N = 11$) are the leading drugs abused with cannabinoids in addition to ethyl alcohol ($N = 18$). Any other drugs detected were seen only once, except PCP ($N = 2$). One study which surveyed the incidence of drugs in drug-related deaths reported that heroin/morphine was the most common drug detected. That study, however, did not include ethyl alcohol or cocaine in their data [5].

Another study by Caplan et al. [6] described the incidence of drug- and chemical-related deaths in Maryland over a six-year period, and treated narcotism deaths separately from all other drug- and chemical-related deaths. It was clear from examining their data as well that morphine was one of the most frequent drugs detected. Barbiturates and propoxyphene were the most prominent drugs seen in the nonnarcotic-related drug deaths. Cocaine was rarely detected (only 1.4% of the nonnarcotic-related drug deaths, and 2% of the narcotic-related drug deaths). This was a stark contrast to the results obtained in this study where cocaine and its metabolites were as equally prominent as morphine. However, the fact that this study was conducted between 1984 and 1985 and the study by Caplan et al. between 1975 and 1980 may also play a role since drugs and availability change with time.

From the suggestion that much of the population seemed to be using other drugs with cannabinoids, data were assembled to compare the manner of death with drug use in cannabinoid confirmed positive cases (Table 8). Once again, this table includes only the 52 out of 58 confirmed positive cases in which complete drug screens were performed in addition to ethyl alcohol determinations. There were as many homicide cases that were positive only for cannabinoids ($N = 9$), as for other drugs, excluding ethyl alcohol ($N = 9$). However, of the 25 homicide cases positive for cannabinoids that were also screened for other drugs, 16 (64%) were positive for some drug, including ethyl alcohol. Thus it seemed that a high proportion of homicide cases are drug-related, often with drugs in addition to cannabinoids. There were insufficient data to make any other generalizations relating to manner of death with multiple drug use except in the case of drug-related deaths (for example, narcotism) where, of course, one would expect additional drugs to be present.

TABLE 8—*Manner of death versus drug use in cannabinoid-positive postmortem cases.*[a]

Manner	Number			
	No Drugs Detected	Ethanol Only Detected	Other Drugs with Ethanol	Other Drugs without Ethanol
Homicide	9	7	4	5
Suicide	2	0	1	2
Accident				
Veh.[b]	2	3	0	1
NVeh.[b]	2	0	0	1
Drug related	0	0	3	5
Natural	3	0	1	1
Undetermined	0	0	0	0
Total	18	10	9	15
% of total	35	19	17	29

[a]Only those cases that were positive for cannabinoids and were screened for ethyl alcohol as well as other drugs are included.

[b]Veh = vehicle related and NVeh = nonvehicle related.

Conclusions

From the results obtained in this study, it is apparent that routine screening for cannabinoids in postmortem urine specimens would be worthwhile. Although urine test results cannot be pharmacologically reconciled, positive cannabinoid results contribute to the profile of an individual case. While routine screening may not be possible or practical for every case, specific types of deaths that show a particularly high association with cannabinoid use could be tested. These include homicide and drug-related deaths. In addition, screening for cannabinoids in all individuals between the age of 15 and 40 may be useful.

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