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Status of Alcohol Absorption in Drinking Drivers Killed in Traffic Accidents*

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ABSTRACT: One issue which constantly confronts the forensic toxicologist in drinking driver cases is the relationship between the breath or blood alcohol concentration (AC) of the driver at the time of an event such as a traffic stop or an accident and the AC measured at a time subsequent to the event. In theory, the AC can be rising, on a plateau or declining at the time of the event. Several studies have indicated that the overwhelming majority of drinking drivers are on a plateau or are post-absorptive at the time of the event. In this study, driver fatality cases investigated by the Office of the Chief Medical Examiner, State of Maryland during a three-year period were reviewed. Included in this study were cases positive for alcohol in the blood at a cutoff of 0.01 g/dL and death occurring within 15 min of the accident. In fact, many of these deaths were instantaneous or near instantaneous based on the injuries documented by the medical examiner at autopsy. The blood and urine were analyzed for alcohol by head-space gas chromatography and urine AC to blood AC ratios were calculated. A total of 129 cases were included in this study. Eleven of the 129 cases (8.5%) had urine to blood AC ratio less than 1.0. It is likely that these individuals were in the absorptive phase at the time that the accident occurred. Thirty-two cases had a urine to blood AC ratio between 1.0 and 1.2 inclusive. In these cases, the subject could be viewed as in the plateau phase of the blood AC versus time curve. The remaining 86 cases had a urine to blood AC ratio greater than 1.2. This suggests that these individuals were in the post-absorptive state at the time of the accident. The information acquired from this study provides additional evidence to support the notion that the vast majority of individuals are not in the absorptive phase at the time of a traffic stop or an accident.

KEYWORDS: forensic science, alcohol, absorption status, postmortem, forensic toxicology

In driving under the influence (DUI) or driving while intoxicated (DWI) cases, the test for alcohol, either in the blood or breath, is usually the most compelling evidence against the accused. In fact, almost all states in the United States have adopted "per se" statutes whereby the result of the alcohol test becomes sufficient to convict the driver of the offense, depending on the result of the test and the limit or limits of alcohol concentration established by the state law. Therefore, challenging the admissibility, reliability or meaning of the alcohol test becomes an important component in defending an individual charged with DUI or DWI.

One common defense argument used in support of individuals charged with DUI or DWI is the "rising alcohol defense." This defense is basically that the alcohol concentration was below the legal limit at the time of the offense but above the legal limit when the breath test was performed or when the blood specimen was collected (1). This defense may be challenged if documentation of a drinking history is available and suggests that alcohol absorption between the arrest and the test is unreasonable. However, a history of the accused drinking history is often unavailable or unreliable. States such as Maryland have attempted to circumvent this problem in their law by specifying specimen collection within a certain time of arrest and by defining alcohol related infractions based on the alcohol concentration at the time of the test.

In the scientific literature, several approaches have been used to study actual drivers and the likelihood that a driver is in the absorptive phase at the time of a traffic stop. These approaches fall into three groups: 1) collection of two consecutive blood specimens; 2) simultaneous collection of blood and urine specimens; and, 3) collection of multiple breath specimens. For example, Neuteboom and Jones (2) studied 2354 drunk drivers from the Netherlands where two successive blood specimens were collected. The time between the collection of specimens varied from less than 10 min to greater than 40 min. They found that the blood alcohol concentration (BAC) of the second specimen was greater than the BAC of the first specimen in 2% of the cases. In another study, Jones (3) measured the alcohol concentrations of two urine specimens collected approximately 60 min apart and a capillary blood specimen collected between the two voids. Using the criteria that for the initial urine specimen, a ratio of the urine alcohol concentration (UAC) to BAC less than unity implied absorptive status, he found that 3.5% of the drivers were in the absorptive state. Gullberg and McElroy (4) compared breath alcohol concentrations obtained from a roadside preliminary breath testing device with an evidential breath testing device used within 2 h of the arrest. A small, but significant decrease was observed between the two tests. They concluded that there was no evidence that individuals were in the ascending portion of the BAC versus time curve at the time of the traffic stop.

Another approach that can be taken is to study driver fatalities where death occurred within a very short period of time after the accident. In many driver fatalities, injuries may be documented that indicate that death occurred instantaneously or within minutes of the accident. By measuring the UAC to BAC ratio for these cases, one is able to get an indication of the driver's absorptive status essentially at the time of driving. The following is a compilation of such cases investigated by the Office of the Chief Medical Examiner (OCME), State of Maryland.

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Experimental

Specimen Acquisition

Specimens were obtained from cases investigated by the OCME. Autopsies were performed within 24 h after death. Once received by OCME, the body was stored in a refrigerator until the autopsy was performed. All determinations of the cause and manner of death were made by medical examiners following investigation, autopsy and toxicological analysis. Included in this study were cases positive for alcohol in the heart blood at a cutoff of 0.01 g/dL and death occurring within 15 min of the accident. Cases where significant therapeutic intervention was documented were excluded.

Heart blood specimens were collected directly from the heart and placed into plastic containers without preservatives. The containers were filled as much as possible. Peripheral blood specimens were collected from the subclavian or femoral veins. Urine was obtained directly from the bladder. Specimens were stored at 4°C between receipt into the laboratory and specimen analysis. Analysis occurred within 48 h of receipt.

Ethanol Analysis

Ethanol was quantitated by head-space gas chromatography. The procedure and instrument conditions have been published previously (5).

Calculation of Urine to Blood Ratios

Blood and urine concentrations were rounded off to two decimal places. The concentration ratio was calculated using these rounded off values.

Results

A total of 129 cases were included in this study. Table 1 provides the BAC, UAC and UAC to BAC ratios for these cases. The average BAC was 0.16 g/dL. The mean UAC to BAC ratio was 1.38; this is consistent with previously reported average UAC to BAC ratios of about 1.3 (6). The standard deviation is 0.41. This variation is also expected and verifies the uncertainty in predicting a BAC from a randomly collected urine specimen.

TABLE 1—*Blood alcohol concentrations (BAC), urine alcohol concentrations (UAC) and UAC to BAC ratios (RATIO) in the 129 cases studied.*

No.	BAC (g/dL)	UAC (g/dL)	Ratio	No.	BAC (g/dL)	UAC (g/dL)	Ratio	No.	BAC (g/dL)	UAC (g/dL)	Ratio
1	0.02	0.02	1	44	0.13	0.31	2.38	87	0.2	0.26	1.3
2	0.02	0.02	1	45	0.13	0.2	1.53	88	0.2	0.26	1.3
3	0.02	0.03	1.5	46	0.13	0.27	2.08	89	0.2	0.3	1.5
4	0.03	0.07	2.33	47	0.13	0.25	1.92	90	0.2	0.2	1
5	0.03	0.04	1.33	48	0.13	0.08	0.62	91	0.21	0.31	1.48
6	0.03	0.04	1.33	49	0.13	0.2	1.54	92	0.21	0.25	1.19
7	0.03	0.07	2.33	50	0.13	0.15	1.15	93	0.21	0.23	1.1
8	0.03	0.03	1	51	0.14	0.18	1.29	94	0.21	0.32	1.52
9	0.03	0.05	1.67	52	0.14	0.2	1.43	95	0.21	0.25	1.19
10	0.03	0.11	3.67	53	0.14	0.25	1.79	96	0.21	0.25	1.19
11	0.05	0.06	1.2	54	0.14	0.21	1.5	97	0.21	0.31	1.48
12	0.05	0.07	1.4	55	0.14	0.19	1.36	98	0.21	0.28	1.33
13	0.05	0.13	2.6	56	0.14	0.18	1.29	99	0.21	0.37	1.76
14	0.05	0.07	1.4	57	0.14	0.23	1.64	100	0.21	0.31	1.48
15	0.06	0.09	1.5	58	0.14	0.18	1.29	101	0.22	0.23	1.05
16	0.06	0.07	1.17	59	0.15	0.2	1.33	102	0.22	0.29	1.32
17	0.07	0.08	1.14	60	0.15	0.19	1.27	103	0.22	0.33	1.5
18	0.07	0.05	0.71	61	0.15	0.2	1.33	104	0.22	0.29	1.32
19	0.08	0.11	1.38	62	0.15	0.18	1.2	105	0.22	0.26	1.18
20	0.08	0.16	2	63	0.15	0.23	1.53	106	0.22	0.25	1.14
21	0.08	0.17	2.13	64	0.15	0.28	1.87	107	0.22	0.2	0.91
22	0.09	0.15	1.67	65	0.15	0.18	1.2	108	0.22	0.36	1.64
23	0.09	0.07	0.78	66	0.15	0.2	1.33	109	0.23	0.26	1.13
24	0.09	0.25	2.78	67	0.16	0.24	1.5	110	0.23	0.3	1.3
25	0.09	0.03	0.33	68	0.16	0.18	1.12	111	0.23	0.31	1.35
26	0.09	0.08	0.89	69	0.16	0.28	1.75	112	0.24	0.29	1.21
27	0.09	0.12	1.33	70	0.16	0.22	1.38	113	0.24	0.29	1.21
28	0.1	0.11	1.1	71	0.16	0.26	1.63	114	0.24	0.23	0.96
29	0.1	0.17	1.7	72	0.17	0.26	1.52	115	0.25	0.3	1.2
30	0.1	0.18	1.8	73	0.17	0.21	1.24	116	0.25	0.21	0.84
31	0.11	0.16	1.45	74	0.17	0.22	1.29	117	0.25	0.31	1.24
32	0.11	0.17	1.55	75	0.18	0.17	0.94	118	0.25	0.25	1
33	0.11	0.19	1.72	76	0.18	0.23	1.28	119	0.25	0.31	1.24
34	0.11	0.23	2.09	77	0.18	0.22	1.22	120	0.25	0.29	1.16
35	0.11	0.17	1.55	78	0.18	0.26	1.44	121	0.25	0.29	1.16
36	0.11	0.17	1.55	79	0.18	0.17	0.94	122	0.26	0.31	1.19
37	0.11	0.18	1.64	80	0.19	0.2	1.05	123	0.27	0.35	1.3
38	0.12	0.17	1.42	81	0.19	0.29	1.53	124	0.28	0.38	1.36
39	0.12	0.15	1.25	82	0.19	0.17	0.89	125	0.31	0.31	1
40	0.12	0.15	1.25	83	0.2	0.26	1.3	126	0.31	0.37	1.19
41	0.12	0.12	1	84	0.2	0.3	1.5	127	0.33	0.39	1.18
42	0.13	0.16	1.23	85	0.2	0.22	1.1	128	0.34	0.41	1.21
43	0.13	0.18	1.38	86	0.2	0.25	1.25	129	0.35	0.38	1.09

Eleven of the 129 cases (8.5%) had a UAC to BAC ratio less than 1.0. It is likely that these individuals were in the absorptive phase at the time that the accident occurred. Seven of the 11 blood specimens had concentrations greater than 0.13 g/dL; the other 4 blood specimens had concentrations less than 0.10 g/dL. Thirty-two cases had a UAC to BAC ratio between 1.0 and 1.2 inclusive. In these cases, the subject could be viewed as in the plateau phase of the BAC versus time curve. The plateau phase refers to the intermediate period when absorption is still occurring, but at a diminished rate, such that any increase in BAC due to absorption is being offset by elimination. The remaining 86 cases had a UAC to BAC ratio greater than 1.2. This suggests that these individuals were in the post-absorptive state at the time of the accident.

Discussion

The data from this study are useful because they represent a measure of alcohol concentrations in closer proximity to a particular event than is not ordinarily possible with living subjects. Since ethanol absorption and elimination stop at death, and since death occurred within minutes of the accident in these cases, the measurement of postmortem blood and urine alcohol concentrations provides strong indications of the individual's alcohol absorption status at the time of the accident. The information acquired from this study provides additional evidence to support the notion that the vast majority of individuals are not in the absorptive phase at the time of a traffic stop or an accident.

One point in the calculation of the urine to blood alcohol concentration ratios should be noted. The alcohol concentrations were rounded to two decimal places prior to calculation of the ratios. This could have a significant effect on the calculated ratio at lower alcohol concentrations, especially below 0.05 g/dL. In this study, 14 of the 129 cases (11%) had a blood alcohol concentration at or below 0.05 g/dL.

In order for these data to have applicability to living individuals, it is necessary to address potential differences between postmortem and antemortem blood. For those individuals who have worked with both types of specimens, many of these differences are obvious. For example, the hematocrit of blood is maintained within a tight range during life. A blood specimen drawn from a living person will have the same hematocrit regardless of the site of collection. However, when an individual dies, blood components may separate or redistribute according to body position such that the blood specimen obtained from the heart region may be pericardial fluid that is closer to serum than to whole blood. Since alcohol distributes to a greater extent into serum than red blood cells (6), a postmortem blood specimen consisting mainly of serum will have a higher alcohol concentration than a postmortem specimen collected from the same body that is predominantly red blood cells.

To address this issue, the blood results obtained in this study were compared to blood results obtained from living drivers suspected of DUI or DWI in the State of Maryland. Maryland law requires the collection of a breath specimen in these cases except under the following conditions: the subject is unconscious; the subject requires medical attention; or, an evidential breath testing instrument is unavailable. When a blood specimen is collected, it is analyzed by the Maryland State Police Crime Laboratory using the same method, calibrators and controls that are used by the OCME. Over the same three year period that the present study was performed, 1954 blood specimens were analyzed for ethanol; the average BAC was 0.17 g/dL as compared to an average BAC of 0.16 g/dL in the present study. Furthermore, a similar frequency distribution of BACs were observed with both sets of data. These facts clearly indicate that the two sets of data are similar.

One other potential factor relating to postmortem blood is the potential for postmortem redistribution such that alcohol concentrations of blood specimens collected at different sites are not necessarily the same (7,8). One mechanism for this to occur is through postmortem diffusion of ethanol from the stomach into the heart blood (9). This issue was addressed by measuring the BAC of a peripheral blood site, either the subclavian or femoral vein. The average peripheral BAC in the presented cases was 0.15 g/dL and the average peripheral BAC to heart BAC ratio was 1.02. Even if the heart BACs were artificially elevated, the UAC to BAC ratios would be reduced and would indicate that more cases would be in the absorptive state.

One other factor that must be considered in any interpretation of postmortem BAC is the potential for alcohol formation after death. After death, microorganisms present in the body are able to convert sugars and other endogenous substances to alcohol (10). This alcohol may be produced either in the intact body after death or in vitro after the specimen is collected. The likelihood of any in vitro formation of alcohol in a specimen from living individuals is remote provided the specimen is collected in fluoridated tubes, sealed and stored properly (11). Similar collection and storage procedures are recommended for postmortem specimens.

It is unlikely that postmortem alcohol formation was a factor in any cases in the presented study. Cases were included in this study only if the time of the accident and the time of death were documented. Autopsies were performed within 24 h after death. However, body recovery and transport to OCME occurred in a much shorter period of time. Once received by OCME, the body was stored in a refrigerator until the autopsy was performed. Moreover, all urine specimens in these cases were positive for alcohol. Postmortem alcohol formation in blood is often indicated if the urine specimen is negative for alcohol, since urine is a specimen more resistant to the putrefactive process. Even if scenarios involving a combination of drinking and postmortem alcohol formation occurred, a higher BAC to UAC ratio would occur, implying that the individual was more likely in the absorptive phase at death.

Based on the above study, the following conclusions can be offered: 1) less than 10% of ethanol drinking drivers were in the absorptive phase at the time of their fatal accident; 2) over 90% of ethanol drinking drivers were in the plateau or post-absorptive phases at the time of their fatal accident; 3) these data are consistent with studies from living individuals which indicate that only a small number of drivers are in the absorptive phase at the time of a particular event; and 4) these data are consistent with alcohol concentrations found in living drivers in Maryland.

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