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Research Article

Time of Death Relative to Alcohol Use: Application of Brain: blood Ratios and Gastric Ethanol

Abstract

A comparison of post-mortem toxicology results was made from victims in whom reasonable estimates of drinking were available to determine if blood, brain and gastric alcohol contents had combined forensic usefulness. When stomach alcohol is greater than 0.80% (v/v) and the brain:blood ratio is less than 0.80, it is likely the decedent died shortly after drinking, whereas when the stomach alcohol is less than 0.80% (v/v) and the brain:blood ratio is more than 1.0, it suggests that drinking was not recent and the victim was well into the post-absorption phase of drinking. Implications for medico-legal evaluations are discussed.

Introduction

Ethyl alcohol (alcohol) is the most commonly analyzed toxin in forensic laboratories, the drug most often found post-mortem, regardless of the cause of death and the drug most frequently reported in violent deaths [1,2]. Death from alcohol poisoning is commonly reported [2,3] and depending on the year of the study, alcohol intoxication is found in 40 percent of all highway fatalities, 47 percent of drowning deaths and up to 77 percent of fatal fall-down injuries in the United States [4].

Criminal investigation is often initiated in death cases in order to relate the degree of impairment just before a fatality to the ability to operate a vehicle, exercise good judgment, etc. Often, civil litigation requires that blood, other fluids or tissues obtained post-mortem be evaluated to further understand the pattern of drinking and intoxication prior to death. In such cases, the level of blood or brain alcohol in the decedent driver, pedestrian or other victims may be useful in understanding the role of alcohol as a contributing factor to a fatal event. Forensic evidence may also be important in dram-shop or social host liability litigation, where the estate of a decedent driver or passenger brings civil suit against a bar, alleging that the decedent was served while visibly intoxicated. In such cases, the interpretation of alcohol in blood, brain or other fluids or tissues may be useful in answering questions relating the effects of alcohol intoxication to behavior.

In fatal accidents, the collection of as much information as possible and the use of multiple collection sites for toxicological purposes are useful for a variety of reasons. For example, some sites may be compromised due to traumatic injuries, contamination or insufficient sample due to exsanguination. Alcohol may be measured in blood (the preferred tissue), brain, vitreous humor, stomach or even spleen or muscle. The relationship between different alcohol concentrations obtained from different anatomical sites varies as a function of bioavailability due to alcohol pharmacokinetics and differences in tissue water content. For example, alcohol entering the gastrointestinal system will initially be significantly higher than blood alcohol concentrations (BACs) because the concentration of beverage alcohol in a small compartment (e.g., stomach) is so much higher than alcohol that has been distributed in a comparatively large compartment of body water found in blood and other fluids. Dilution due to changes in available fluid volume in the stomach and blood, as well as factors such as metabolism and elimination as the alcohol passes through the liver will result in different alcohol concentrations between blood and stomach contents. Similarly, brain and BACs differ as a function of their respective water content and other factors.

In forensic examination, peripheral blood such as from the femoral artery is the preferred matrix for post-mortem alcohol analysis. Central sites, including heart and chest blood also seem acceptable under normal conditions [5,6], when post-mortem redistribution is unlikely and samples are not obtained from a "blind stick" [7]. There are many conditions in which post-mortem alcohol samples may be limited to fluids or tissues other than blood. There are also conditions wherein the blood sample may be compromised resulting in an unusually high alcohol concentration relative to other

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tissue. For example, if death was the result of major thoracic impact subsequent to an automobile collision, extensive hemorrhaging or lacerations (e.g., of the stomach or intestinal wall) may result. High gastrointestinal alcohol concentrations may then contaminate blood obtained from the chest cavity or unknown location near the heart, such as from a sample obtained by a blind puncture [7]. However, the brain or vitreous alcohol concentration would be relatively less affected in such a case. Similarly, a very high or low stomach alcohol concentration may raise questions about the interpretation of blood test results. Some toxicologists suggest that the presence of alcohol in the stomach in concentrations of more than 0.5% (v/v) may make the interpretation of blood alcohol level potentially difficult [8], presumably because in the absence of death, the BAC would have continued to increase. This would result in pharmacokinetic under estimates of alcohol use and intoxication. However, such conclusions should be eschewed absent evidence of a large amount of alcohol in the stomach or other confounding factors such as post-mortem redistribution or contamination.

Many investigators have studied the relationship between blood and brain alcohol but few studies have examined the effects of gastric alcohol and alcohol pharmacokinetics on this relationship. Backer (1980) [9] examined 60 autopsy cases and concluded that if the gastric alcohol concentration was more than 0.5% (v/v), the subject had most likely recently ingested alcohol and had not yet absorbed all the alcohol (i.e., pre-absorptive state). Similarly, if the stomach alcohol level was less than 0.5% (v/v), the subject most likely had not consumed alcohol recently and was in the post-absorptive state. Average brain:blood ratios from 37 human autopsies with stomach alcohol concentrations less than 0.5% (v/v) was 0.91. However, no bio behavioral data were included regarding prior acute drinking histories of these subjects. Drinking history information combined with toxicology data would allow better estimates to determine if the decedent was in the pre- or post-absorptive state. Such an investigation would offer a better understanding of the relationship between brain, blood and gastric alcohol and would be useful to the forensic examiner in interpreting post-mortem alcohol toxicology results.

The present preliminary investigation examines the relationship between brain:blood ratios and gastric alcohol from 23 human autopsy cases in which bio behavioral data were also available to make pharmacokinetic predictions. The purpose of this study is to determine if, absent subjective evidence about drinking, the relationship between blood, brain and stomach alcohol concentrations can be useful to infer if the subject was still absorbing alcohol at the time of death. Such information may be useful in interpreting a range of extrapolation estimates or other components of an investigation.

Methodology

Thirty-five fatal accident cases were reviewed that came primarily from New Jersey county prosecutors and other attorneys who submitted these records for evaluation in criminal or civil litigation. The thirty-five cases included 28 men (age 21-63) and 7 women (age 21-29).

Each case was examined for the following criteria for inclusion in this study: drinking history (e.g., time of first and last drink based on statements of surviving or other witnesses), time of fatal injury, objective chemical test results of blood, brain, vitreous humor and stomach alcohol, anthropometric data (age, weight, height and gender), and no autopsy evidence of trauma or sampling issues that might affect the validity of the alcohol test evidence. In New Jersey, whole blood and other tissue and fluid samples are routinely obtained at autopsy and subsequently analyzed by the State Medical Examiner's Office using headspace gas chromatography, an accurate and reliable analytical method.

Of the original 35 cases reviewed, 11 fatal cases were omitted because they did not meet more than one of the research criteria. Twenty-three cases included anthropometric data to calculate the total body water and estimate the volume of distribution (Watson, 1989), as well as blood, brain and stomach alcohol concentrations. In the cases where time of first and last drink were available, anterograde blood alcohol estimates were made using a non-linear pharmacokinetic model for absorption and distribution but applied zero-order Michaelis-Menton kinetics for alcohol elimination as previously described [10]. Except at very low BACs (below 0.02%), where first-order elimination kinetics may apply, this methodology results in accurate estimations of the maximum blood alcohol level and concentrations at various time points [10-13]. Based on published algorithms [10], 15 cases, subjects were determined to be in the pre-peak or post-peak elimination phase, whereas 8 cases, pharmacokinetic estimates placed the time of death at or close to the peak concentration.

After estimating whether the decedent was in the absorption or elimination phase of the blood alcohol curve based upon pharmacokinetic estimates and examining the corresponding stomach alcohol, a quasi-median split of stomach alcohol concentrations was made above and below stomach alcohol concentrations of 0.75% (v/v). This median split was considered conservative and deemed appropriate in terms of the distribution of the results, and minimization of a skewed data distribution.

Results

Table 1 illustrates the blood and brain alcohol concentrations, the brain:blood ratio, the stomach alcohol concentration and the predicted biological placement on the blood alcohol curve (before or after the peak BAC was reached) as discussed. It can be seen that these data represent decedents who, based upon their drinking history and stomach alcohol contents, in all probability had not yet reached their maximum BACs at the time of death and BACs were still increasing. In these cases the average stomach alcohol concentration was 1.08% (± 0.06 s.e.m.) and decedents had relatively high mean BAC of 0.230% (± 0.02 s.e.m.) at the time of their death. The mean brain:blood ratio was 0.778 ± (0.29 s.e.m.). No gender differences were observed.

Table 2 illustrates the blood and brain alcohol concentrations, the brain:blood ratios, the stomach alcohol concentration and

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the predicted biological placement on the blood alcohol curve (before or after peak). The mean brain:blood ratio was 0.975 (± 0.05 s.e.m.) and mean stomach alcohol of .342% (± 0.07 s.e.m.). It can be seen that these data represent decedents who, based upon their drinking history and stomach alcohol contents, in all probability were in the elimination phase of their blood alcohol curve. These decedents also had lower BACs (mean 0.199% ± 0.02) at the time of their death compared with victims for whom the BAC was estimated to be increasing (.23% ± 0.02).

A significant ratio by stomach alcohol interaction was present (F=25.14, P <0.011), pre- peak by post- peak interaction (F=7.1, p<0.011) and a significant three-way interaction was detected by ANOVA (F=75.54, p <0.0001) indicating a robust effect of absorption phases and matrixes.

Table 1: Matrix ratios pre-peak data split.

s	Blood (g%)	Brain (g%)	Brain:Blood	Stomach (g%)	Pre (<) Peak
1	0.200	0.152	0.760	0.776	<
2	0.154	0.126	0.818	0.825	=
3	0.177	0.158	0.890	0.844	<
4	0.308	0.221	0.718	0.865	<
5	0.372	0.346	0.930	1.02	<
6	0.060	0.050	0.833	1.07	=
7	0.235	0.194	0.826	1.14	<
8	0.230	0.185	0.804	1.17	<
9	0.232	0.169	0.728	1.23	<
10	0.171	0.106	0.620	1.29	<
11	0.325	0.274	0.843	1.30	=
12	0.300	0.169	0.563	1.45	<
mean	0.230	0.179	0.778	1.082	...
± s.d.	0.09	0.08	0.11	0.05	...
± s.e.m.	0.02	0.02	.03	0.06	...

"<" indicates alcohol still being absorbed (pre-peak), "=" indicates likely peak BAC at time of death.

Table 2: Matrix Ratios and Post-Peak Data Split.

s	Blood (g%)	Brain (g%)	Brain:Blood	Stomach (g%)	Post (>) Peak
1	0.130	0.146	1.123	0.057	=
2	0.058	0.065	1.121	0.077	>
3	0.163	0.156	0.957	0.133	=
4	0.158	0.195	1.234	0.242	>
5	0.284	0.294	1.035	0.243	<
6	0.189	0.175	0.926	0.285	>
7	0.038	0.037	0.974	0.342	=
8	0.207	0.141	0.681	0.498	=
9	0.153	0.156	1.020	0.510	>
10	0.239	0.216	0.904	0.685	>
11	0.201	0.151	0.750	0.687	=
mean	0.199	0.169	0.975	0.342	...
± s.d.	0.08	0.07	0.16	0.23	...
± s.e.m.	0.02	0.02	0.05	0.07	...

">" indicates alcohol mostly absorbed (post-peak), "<" indicates alcohol still being absorbed (pre-peak), "=" indicates likely peak BAC at time of death.

Discussion

These data revealed brain:blood ratios from 0.563 to 1.234, which is comparable to previously, reported ratios ranging from 0.65 to 1.24 [5]. The observed overall average brain:blood ratio of 0.87 is also reasonably consistent with the commonly reported brain:blood ratio of 0.80, [8] and 0.91 reported by Barker, et al. [9], but these ranges and averages do not account for BAC phase. Further examination of the data relative to BAC phase suggest that lower brain:blood ratios occurred when death most likely occurred prior to the peak BAC. Higher brain:blood ratios occurred when death occurred post-peak and when the decedent was in the elimination phase at the time of death. These findings are also consistent with higher stomach alcohol (>1%) in cases where alcohol was still being actively absorbed (i.e., pre-peak) or cases with lower stomach alcohol present post-peak, when all or most alcohol was absorbed. Overall, these results are consistent with the relative time required for alcohol to equilibrate in tissues based on their respective water content. In other words, the brain:blood alcohol ratio is slightly lower when alcohol is still being absorbed but increases as more alcohol reaches the brain.

These results, although preliminary, present useful implications for forensic examiners and researchers. We believe this is the first study to compare pharmacokinetic estimates whether death occurred on the ascending or descending limb of the blood alcohol curve with results with three different matrixes (blood, brain and gastric alcohol). In cases where the stomach alcohol is greater than 0.80% (v/v) and the brain:blood ratio is less than 0.80, it suggests that the decedent died shortly after drinking. Similarly, when the stomach alcohol is less than 0.80% (v/v) and the brain:blood ratio is more than 1.0, it suggests that drinking was not recent and the victim was on the descending limb of the blood alcohol phase.

We believe that the inter-relationship among blood, brain and gastric alcohol toxicology results may be useful in cases where diverse subjective reports about drinking exist or are not available. Although limited by the sample size, this study indicates the potential usefulness of and the need to collect post-mortem toxicology evidence from different anatomical sites and encourages further research in this area.

References

1. Baselt R, Cravey R (1980) Forensic Toxicology. In: Toxicology: The Basic Science of Poisons, Second Edition (Doull J, Klassen C, Amdur M eds.) MacMillan NY 663.

2. Garriott H, DiMaio V, Pelty C (1982) Death by poisoning: a ten-year survey of Dallas County. J Forensic Sci 868-879. Link: https://goo.gl/CCcKsN

3. Caplan Y, Ottinger W, Park J (1985) Drug and chemical related deaths: Incidences in the State of Maryland 1975-1980: 663. Link: https://goo.gl/ym3MZu

4. Brick J (2015) Alcohol Intoxication: Mode and Risk for Injury. In: Wiley Encyclopedia of Forensic Science. Jamieson A, Moenssens AA (eds). John Wiley: Chichester. Link: https://goo.gl/J7jVOK

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5. Caplan Y, Goldberger B (2008) Blood, urine and other fluid and tissue specimens for alcohol analyses. In Garriott's Medico Legal Aspects of Alcohol. 5th Edition. L&J Publishers 212. Link: https://goo.gl/vPN5Rq

6. Budd R (1988) Validity of post-mortem chest cavity blood ethanol determinations. J Chromatogr 449: 337-340. Link: https://goo.gl/dgvnlO

7. Coe J (1993) Chemical consideration- factors for evaluating postmortem biochemistry. In: Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation (3rd ed.), Charles C, Thomas Publisher, Springfield IL 50-70. Link: https://goo.gl/5dTaYw

8. Levine B (2010) Principles of Forensic Toxicology, American Association for Clinical Chemistry 178. Link: https://goo.gl/ErGBFk

9. Backer R, Pisano R, Sopher I (1980) The comparison of alcohol concentration in postmortem fluids and tissues. J Forensic Sci 25: 327-331. Link: https://goo.gl/E07ilz

10. Brick J (2006) Standardization of Alcohol Calculations in Research. Alcohol: Clin Exp Res 30: 1276-1287. Link: https://goo.gl/vT3LcP

11. Brick J, Adler J, Cocco K, Westrick E (1992) Alcohol Intoxication: Pharmacokinetic Prediction and Behavioral Analysis. In: Current Topics in Pharmacology 1: 57-67.

12. Mumenthaler M, Taylor J, Yesavage J (2000) Ethanol pharmacokinetics in white women: nonlinear model fitting versus zero-order elimination analyses. Alcohol Clin Exp Res 24: 1353-1362. Link: https://goo.gl/zlBNYX

13. Montgomery R, Reasor J (1992) Retrograde extrapolation of blood alcohol data: an applied approach. J Toxicol Environ Health 36: 281-292. Link: https://goo.gl/CKZ7Xq

Citation: Brick J (2016) Time of Death Relative to Alcohol Use: Application of Brain: blood Ratios and Gastric Ethanol. J Addict Med Ther Sci 2(1): 019-022. DOI: http://doi.org/10.17352/2455-3484.000016