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PERSPECTIVES

Toxicology of Alcohol: The Role of Toxicologists in Social Host & Liquor Liability

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

INTRODUCTION

Commercial establishments where alcoholic beverages are served (e.g., bars, restaurants) and social hosts who serve alcohol in non-commercial settings may find themselves potentially liable for damage, injury, and/or death caused by alcohol-related accidents involving individuals they have served. Critical issues addressed by toxicologists often involve interpretation and/or estimation of blood alcohol concentration (BAC) levels, associated clinical effects, and degrees of intoxication.

This white paper outlines how toxicologists help resolve questions regarding liability in the alleged over-service of patrons or guests that has led to damage, injury, and/or death.

CLINICAL EFFECTS OF ALCOHOL

Alcohol consumption affects mental, cognitive, and other physical functions in a dose-related manner (e.g., more consumption is associated with greater effects). Toxicologists combine BACs with observed behavior to determine associated levels of impairment/intoxication.

It is generally accepted by toxicologists that the degree of physical and mental impairment from alcohol correlates with BAC. In general, higher BACs produce increased impairment and greater degrees of intoxication. For example, the typical effects of a 0.02% (or 0.02 g/dL) BAC include some loss of judgment, decline in visual function, and divided attention.[1] At a 0.08% BAC, which is the current national limit for legally driving while intoxicated in the United States,[2] typical effects include poor reaction time, balance, speech, vision, hearing, perception, and judgement.[3]

However, people who are chronic alcohol drinkers can develop a tolerance to the effects of alcohol and learn to compensate for impairment. Tolerance to alcohol means that alcohol produces less of an effect, including on behavior, than it would for non-tolerant individuals. These individuals may not exhibit gross signs or symptoms of impairment even when their BAC is above the legal limit, even though they are actually impaired. A person who consumes alcohol does not appear "intoxicated" merely because he or she has consumed alcohol. Rather, intoxicated behavior occurs when the quantity of alcohol the person consumed has exceeded the individual's tolerance for alcohol and produced mental, cognitive, or physical abnormalities. Whether an individual appears intoxicated depends on multiple factors other than alcohol consumption, including body weight, gender, race/ethnicity, the amount of food consumed before drinking, use of drugs or prescription medicines,[4] and social behavioral changes learned during multiple drinking episodes.[5]

INTERPRETATION OF ALCOHOL TEST RESULTS

When interpreting alcohol test results to determine how much alcohol was consumed by an individual at an earlier time, the toxicologist considers the quality of the sample collected and analysis method used.

The "gold standard" tissue sample collection for measuring BAC is a peripheral venous sample of blood or serum. Alternatively, a breathalyzer test is a non-invasive method to obtain an immediate result of the individual's breath alcohol concentration.[5] Interpretation of postmortem (i.e., collected after death) samples can be complex as discussed later in this paper. Forensic analyses for BAC analyze whole blood samples using gas chromatographic (GC) methods, which provide accurate and selective alcohol (i.e., ethanol) quantitation. In clinical settings (e.g., hospitals, emergency rooms), BAC is generally evaluated in serum or plasma samples using enzymatic methodologies with lesser accuracy but faster turnaround times (and lesser cost).[6] Due to the differences in the methodologies and the types of biological samples analyzed, BACs quantitated in clinical settings using enzymatic methodologies are

[1] U.S. Department of Transportation, National Highway Traffic Safety Administration. The ABCs of BAC: A guide to understanding blood alcohol concentration and alcohol impairment. NHTSA: Washington, D.C. Vol. DOT HS 809 844. July, 2016.
[2] National Highway Traffic Safety Administration. Digest of impaired driving and selected beverage control laws, 30th edition. Report No.: DOT HS 812 394, Washington, D.C.: U.S. Department of Transportation, June, 2017.
[3] Brick, J. and Carpenter, J.A. The identification of alcohol intoxication by police. Alcohol Clin Exp Res 25(6):850-855. 2001; Sullivan, J.B., Hauptman, M., et al. Lack of observable intoxication in humans with high plasma alcohol concentrations. J Forensic Sci 32(6):1660-1665. 1987; Urso, T., Gavaler, J.S., et al. Blood ethanol levels in sober alcohol users seen in an emergency room. Life Sci 28 (9):1053-1056. 1981; Wells, J.K., Greene, M.A., et al. Drinking drivers missed at sobriety checkpoints. J Stud Alcohol 58 (5):513-517. 1997.
[4] Caplan, Y.H. and Goldberger, B.A. Garriott's Medicolegal Aspects of Alcohol. 6th ed. Tucson, AZ: Lawyers & Judges Pub. 2014.
[5] Pizon, A.F., Becker, C.E., et al. The clinical significance of variations in ethanol toxicokinetics. J Med Toxicol 3(2):63-72. 2007.
[6] Barceloux, D.G. (2012). Medical Toxicology of Drug Abuse: Synthesized Chemicals and Psychoactive Plants. John Wiley & Sons, Inc., Hoboken, NJ. p. 400-401.

generally higher than the same samples quantitated using forensic GC analyses.[7] Toxicologists guide interpretation of results considering the various factors from the different assays.

The appropriateness of using BAC from postmortem samples to reflect BAC levels prior to death (i.e., antemortem) can be complex due to after-death redistribution and the potential for decomposition-related alcohol production. Each assessment to determine postmortem sample suitability (i.e., correlation to the concentration at time of death) is unique. One approach is to compare the postmortem BAC to alcohol concentrations measured in other biological fluid/tissue samples that are inherently less influenced by redistribution and decomposition-related issues (e.g., vitreous humor fluid of the eye, urine); correlation between the different assessments increases confidence that the postmortem BAC accurately reflects the antemortem level.[4]

An assessment for proper sample storage conditions may occur as improper storage may alter samples such that alcohol levels may no longer reflect an individual's BAC at the time of collection. For example, it is well known that loss of alcohol from biological specimens may result from evaporation and/or oxidation. Alcohol is volatile and will evaporate from blood samples if the specimen containers are not properly sealed, resulting in loss of alcohol by evaporation. Loss of alcohol can also result from oxidation of alcohol (ethanol) to acetaldehyde in stored biological specimens. Alcohol concentrations in biological specimens may increase when sterility is lost, as alcohol (ethanol) production can occur as a byproduct of biological growth. Under sterile conditions, the concentration of alcohol in blood specimens would not be expected to increase.[4]

BLOOD ALCOHOL CONCENTRATION CALCULATION

Toxicologists estimate BAC for individuals based on the known pharmacokinetics of alcohol (i.e., the time and dose-profile for how it absorbed, distributed, metabolized, and excreted) together with specific attributes of the individual and the drinking event under consideration. BAC assessments are generated to assess different parameters important for the evaluated issue, such as:

- Was the reported consumption profile and timing (e.g., what and when drinks were served and consumed) consistent with the measured BAC?
- How much alcohol would the individual have needed to consume to generate the measured BAC?
- Given the BAC was measured at a later timepoint, what was the individual's BAC when leaving the serving establishment and/or when the accident occurred?
- When assessing the BAC at the time of the accident (and if appropriate), what was the contribution of alcohol intake from the service event under consideration compared to additional alcohol consumed by the individual (either before arriving and/or after leaving the serving establishment)?

The tool toxicologists generally use for BAC extrapolations is the Widmark equation, named after the early 20th century seminal work conducted by the Swedish physician, E.M.P. Widmark.[8] The equation uses a set of variables to mathematically describe alcohol pharmacokinetics in the human body. Specifically, the equation incorporates a uniform distribution of alcohol (a one-compartment model) and a constant elimination/metabolism rate per unit time (zero-order elimination kinetics), together with human specific factors (e.g., body weight and distribution volume) and time-specific variables (e.g., time elapsed since drinking began, time of accident, and/or time of BAC measurement). The resulting equation describes BAC as a function of an individual's human factors together with the timing and amount of alcohol consumed.[9] Accuracy of estimates associated with the Widmark equation depends on the reliability of input parameters. Uncertainties arise with the number of assumptions made regarding an individual's body weight, the type and alcohol content of consumed beverages, and the individual's alcohol elimination/metabolism rate.

CONCLUSION

Social host liability issues generally hinge on the alleged over-service of guests subsequently involved in incidents

[7] Rainey, P.M. (1993). Relation between serum and whole-blood ethanol concentrations. Clin. Chem. 39 (11 Pt 1): 2288-2292.
[8] Gullberg, R.G. Estimating the Uncertainty Associated With Widmark's Equation as Commonly Applied in Forensic Toxicology. Forensic Sci Int 172 (1): 33-39. 2007.
[9] Jones, A.W. Evidence-based survey of the elimination rates of ethanol from blood with applications in forensic casework. Forensic Sci Int 200 (1-3): 1-20. 2010.

resulting in damage, injury, and/or death. Key issues in these matters hinge on the amount of alcohol served by the establishment, the resulting BAC of the consuming individual, and the associated clinical effects and degree of intoxication.

As described in this paper, J.S. Held toxicologists can address these issues and more, including assessments of sample validity and methodology; extrapolations of BAC to earlier timepoints; assessments to determine whether the service profile (i.e., what and when) correspond with the measured BAC; and, if appropriate, assessments to determine the contribution of alcohol from the service event under consideration to the BAC at the time of the accident.

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