Criminal Law

Alcohol-Related Offenses: Retrograde Extrapolation After Wager

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The end of the millennium saw significant activity in both the Michigan Legislature and Supreme Court concerning drinking and driving. The Legislature enacted substantial changes in both the drunk driving and driving while license suspended sections of the Motor Vehicle Code.[1] It eliminated distinctions between categories of offenses for enhanced punishment purposes in the Operating Under the Influence of Liquor (OUIL) provisions, and increased overall punishment in both sets of provisions. Of equal significance, is the Michigan Supreme Court opinion in *People v Wager*,[2] which eliminated the "bright line" two-hour-and-fifteen-minute rule for the admissibility of breath/blood/urine tests that had obtained a foothold in the Court of Appeals, ultimately rejecting the notion that any bright line rule should exist.[3]

A greater number of drunk driving trials in Michigan will be the likely result of the Legislature's actions in expanding the categories of offenses in the definition of "prior offenses" and in increasing punishments. Because of the Supreme Court's pronouncement that the effect of a delay of a chemical test goes to its weight, not its admissibility as evidence, both the defense and the prosecution will frequently need expert testimony on toxicology. Even when a party does not require a toxicologist, effective cross-examination of an opposing expert will require an understanding of the concepts at the foundation of such evidence. This article highlights the areas of chemical testing and toxicology that are frequently factors in assessing the weight to be given a particular result. Renewed legislative toughness and wider discretion for trial judges will combine to create a field fertile for novel and creative arguments. In a typical fact pattern, the driver of an automobile or snowmobile that has crashed is injured or flees the scene and two hours or more will often elapse before police can obtain a chemical sample. Consequently, the results of the sample will raise the question of whether the driver was over the legal limit at the time of the accident; the lower the alcohol result and/or the longer the delay, the more serious the issue.

Although the proponent of the evidence bears the burden of proof, opposing counsel should not rest easily, as the trial judge's ruling on admissibility is now clearly discretionary. Counsel should assume that test results will be admitted. A full understanding of the concepts of toxicology will provide the necessary foundation from which to argue that the bodily alcohol content at the time of the accident was within a particular range.

Because the focus of this article relates to the scientific concepts of toxicology, the basic legal principles involved in qualifying a witness as an expert and the appropriate standards for opinion testimony are only briefly addressed. The practitioner is presumed to be familiar with the basic requirement for, and factors to be considered in, the admission of chemical test evidence.

LEGAL CONCEPTS

Qualification as an Expert

Three criteria must be satisfied before expert testimony will be admitted: (1) the expert must be qualified; (2) the evidence must provide the trier of fact with a better understanding of the evidence or assist in determining a fact in issue; and (3) the evidence must be from a recognized discipline.[4] Whether a witness is an expert is a determination within the discretion of the trial court and will not be disturbed on appeal absent an abuse of discretion.[5] Michigan allows a liberal grant of witness qualification, and the rule is not applied narrowly.[6] The qualifications of each party's experts do not have to be equal, this type of consideration going to the weight of the evidence not its admissibility; instead, the inquiry is "whether [the expert's] knowledge of the subject matter is such that [the] opinion will most likely assist the trier of fact in arriving at the truth"[7]

Admissibility of Opinion Testimony

For many years, the admissibility of scientific evidence in Michigan has been controlled by the decisions in *Frye v United States*[8] and *People v Davis*,[9] which held that the evidence be subject to "general acceptance" in the recognized community. In *Daubert v Merrell Dow Pharmaceuticals, Inc*,[10] the U.S. Supreme Court modified the requirement, holding that the "general acceptance" criterion is only a factor for consideration among many others that courts may use in deciding whether to admit such evidence.[11] The *Daubert* Court then detailed the considerations in determining admissibility, holding that the court must first examine whether the reasoning or methodology underlying testimony is scientifically valid and can be applied to the facts at issue.[12] A key consideration for a determination of whether the evidence constitutes scientific knowledge that will assist the trier of fact is whether the evidence can be and has been tested.[13] Also significant to a determination of admissibility is whether the theory or technique has been subjected to peer review and publication, although publication is not a *sine qua non* of admissibility.[14]

In *Nelson v American Sterilizer Co*,[15] a post-*Daubert* Michigan Court of Appeals examined the phrase "recognized scientific knowledge" without mentioning the *Frye-Davis* test. The court gave the word "recognized" its plain and ordinary meaning: a general acknowledgment of the existence, validity, authority, or genuineness of a fact, claim, or concept. Under this definition, "knowledge" can be recognized by a scientific community without necessarily being generally accepted by that community.

SCIENTIFIC PRINCIPLES OF RETROGRADE EXTRAPOLATION

Retrograde extrapolation, in and of itself, is a deceptively simple process of multiplication: the elimination rate of alcohol (beta slope) multiplied by the time period in question. Unfortunately, the simplicity stops with the definition, and expert testimony becomes necessary to explain the results of extrapolation, its limits, and the weight it should be given by the trier of fact.

The difficulties with extrapolation arise from the variability in the human response to alcohol (ethanol). This difficulty is exacerbated by the difficulties in measuring the effects of alcohol on the human body and of human enzymes on alcohol. Fortunately, while the effects on an individual may vary from one drinking episode to the next, and effects may vary in individuals, the values in a large population follow a normal distribution that is capable of being tested statistically. The normal distribution also allows for most variables to be controlled individually to determine their statistical significance.

Scientists apply scientific principles of toxicology, metabolism, physiology, pharmacology, and biology in assessing the validity of claims made in research papers. Advanced training or education in scientific research and statistical analysis also assists scientists in determining whether the conclusions of previous researchers are trustworthy. It is this specific combination of education, training, and experience that will undoubtedly assist the trier of fact in

determining a defendant's blood alcohol level (actually blood alcohol concentration, abbreviated as BAC) at the time he or she was operating a vehicle.

The last half of the 20th Century saw substantial research into the concepts underlying alcohol absorption, metabolism, and elimination for medical, diagnostic treatment, and forensic purposes. This research has shown that many variables are not statistically significant, regardless of their impact on human response and ability to be measured. That these concepts are incorporated into the present state of the law is obvious given the Legislature's identification of certain blood alcohol levels as the basis of legal presumptions, *e.g.*, the choice of .10 grams per 100 milliliters of blood[16] as a *per se* violation, regardless of the effect of that level of alcohol on driving ability.

Two major factors are subject to expert interpretation with retrograde analysis in a drunk driving case: whether the defendant was still absorbing alcohol at the time of driving and which elimination rate to apply to a particular defendant. Evidence regarding either factor can come from the defendant, the defendant's statement(s) to police, police observations, other witnesses, and, if known, the defendant's history with alcohol. An expert witness can take this evidence and apply elimination rates favorable to the prosecution or defense, as the case may be, and advise counsel or testify to his or her assumptions, conclusions, and opinions. The expert can also explore the effects on BAC of alternative elimination rates. The discussion that follows sets forth the substantial and significant scientific research supporting the concepts underlying retrograde extrapolation.

1. Onset of Post-Absorptive Stage[17]

A 1990 scientific article noted the scarcity of published studies demonstrating the position of the blood alcohol curve in suspected drunk drivers.[18] In an effort to generate a dialogue on the issue and propose an acceptable time frame for the assumption of post-absorptive state, the author recounted several studies and reports, including his own. The article compared the material by considering bolus dose[19] and urine/blood ratio studies. The author concluded that the scientific evidence reviewed justified a conclusion that the vast majority of drunk driving suspects are post-absorptive or on a plateau when blood is taken for quantitative determinations of alcohol content.[20]

2. Retrograde Extrapolation and Elimination Rates[21]

A study of 24 adult males replicated a social drinking scenario, seeking to standardize absorption factors such as period of consumption, activity, eating, and type of alcohol consumed.[22] Researchers drew blood from the subjects once before the subjects consumed alcohol; again, one hour after consumption; and a third time, 3.5 hours after consumption. After asserting that a .015 elimination rate was widely regarded as "normal," the authors cautioned that:

> *In any particular case, the formula available for BAC estimations should be used only as a starting point. The results given by the formula must be interpreted according to the circumstances surrounding the drinking situation. Good interpretation is unlikely to be made unless the forensic scientist has a thorough knowledge of the many factors which influence the absorption, distribution and metabolism of alcohol*.[23]

3. Statistical Determination of Post-Absorptive Stage (Breath Alcohol Concentration (BrAC))

In 1992, a study of 161 drunk driving arrests was conducted in Washington state.[24] Samples taken consisted of a preliminary breath test (PBT) at or near the time of arrest, two evidentiary tests within a few minutes of each other, and a second PBT test taken after the evidentiary tests with the times noted. Researchers plotted and studied the differences between the two PBT tests, the PBT and the evidentiary tests, and the second PBT with an extrapolated

PBT. Sophisticated statistical analysis of the data led researchers to conclude that forensic breath alcohol analysis that employs duplicates and other appropriate quality controls appears to provide very good estimations of BrAC values when conducted within two hours of driving.[25]

Statistical analysis of 15,493 additional field results in Washington led to the conclusion that retrograde extrapolation is not suggested for time periods of less than one-and-one-half hours. The large Washington study was also used to determine the standard deviation for each breath alcohol concentration. The mean of two known BrAC levels is used in conjunction with the standard deviation to arrive at the coefficient of variation, which is then used in a formula to determine the critical difference, or delta factor. The purpose of the delta value is to differentiate random error from real difference, and eliminate the random error. For example, BrAC measurements are subject to a certain known random variation called the normal distribution. Retrograde extrapolation is also subject to error due to various random variables. If retrograde extrapolation is conducted too soon after a subject's last drink, a variation in the BrAC, arrived at through extrapolation from the true BrAC, cannot be distinguished from a variation caused by a random variable such as metabolism.

4. Effect of Food on Post-Absorptive Onset

As indicated *supra*, a Washington study reviewed and examined prior research that had established that the "vast majority" of persons reached peak BAC within reliably measurable time periods after drinking.[26] Given an individual in a post-absorptive stage, the only variable requiring analysis will be elimination rate. Not all drivers are in a post-absorptive state, however, and for the small percentage of drivers still absorbing alcohol, variations in absorption rates and stages are critical.

A common criticism of retrograde extrapolation is the claimed variability of absorption due to the ingestion of food, but the criticism appears unfounded. A study in the early 1990s concluded that consumption of food is not a significant factor.[27] In the study, nine subjects were given a nearly bolus dose of alcohol and gave breath samples every eight minutes until they reached zero BrAC. The procedure was followed in two phases: during the first phase, subjects fasted for six hours and were tested on an empty stomach; during the second phase, one week later, subjects were fed the same type of pizza immediately prior to drinking. The subjects "started" drinking at the midpoint of eating, the time of which varied slightly among them.

As expected, consumption of food lowered the peak BrAC: the average time to peak BrAC across both phases was 41 minutes, with an outside range of 8 to 83 minutes with empty stomachs, and 11 to 53 minutes with full stomachs. The average time required to return to zero BrAC, however, was 5.01 hours on a full stomach, and 5.05 hours on an empty stomach, a difference of only 2 minutes, 24 seconds. One explanation offered for the failure of food to prolong the upward slope of the BrAC curve is that up to 43 percent of alcohol may rapidly diffuse through the stomach wall within the first 20 minutes after ingestion.[28] The study also cited research involving the infusion of fats into specific parts of the digestive tract, which significantly delayed gastric emptying and depressed maximum blood alcohol concentrations; maximum BAC was still reached within .5 hours.[29]

The authors also concluded that the presence of food in the stomach lowered the mean elimination rate versus an empty stomach from .020 BrAC/h to .017 BrAC/h. These rates with or without food in the stomach were within the range commonly used by forensic scientists in connection with retrograde extrapolation.[30]

5. Elimination Rate Research

The same researcher who argued for accepting as fact that the "vast majority" of subjects were post-absorptive when blood or breath was measured for law enforcement purposes,[31] published an article in 1993 exploring elimination

rates.[32] The author began by reference to Erik M. P. Widmark's 1932 ''seminal'' work that established a mean elimination rate for healthy, moderate drinkers at .016g/dL/h,[33] a conclusion reached *before* the physiological reasons were known. After a thorough analysis of the variables, the 1993 study concluded that the earlier assessment "remains a valid and realistic value for male moderate drinkers."[34] The author of the 1990 study declined to reject retrograde extrapolation outright, positing a more intellectually honest approach.[35]

6. Other Factors

Race. That the enzyme primarily responsible for ethanol disposal varies according to race is well documented. In spite of this conclusion, in controlled studies in which test subjects were carefully matched for age, body composition, use of drugs, and smoking and drinking habits, no statistically significant racial differences in the rate of ethanol disposal have been found.[36]

Aldehyde Dehydrogenase. The enzyme responsible for the second stage of alcohol metabolism is called aldehyde dehydrogenase, or ALDH. Some races have a type of ALDH that lacks enzymatic activity, others simply have a lower quantity of the enzyme. The range of elimination rates for subjects identified as having a lower quality or quantity of ALDH and "normal" ALDH subjects, were specifically .0158g/dL/h to .0136g/dL/h, an overall difference of only .0022g/dL/h.[37]

Gender. Erik Widmark posited a slightly faster elimination rate for women than men, in part because he expressed results differently from the standard "g/dL/h," accounting for the different ratio in women of fat to lean tissue.[38] When adjusted for this difference, there appears to be no statistically significant difference in elimination rates between men and women.[39]

Inter-individual Differences. When BAC decreases and reaches a concentration below .01g/dL, the elimination rate is now believed to follow a curvilinear disappearance profile instead of zero-order kinetics. The formula used to calculate this curvilinear disappearance profile is called the Michaelis-Menten equation, sometimes called dose-dependent or saturation kinetics, and has a long-established history in biochemistry and a solid theoretical basis for enzymatic reaction processes when a single enzyme is involved. The author of the study concluded that a range of elimination rates of .009g/dL/h to .025g/dL/h apply to the vast majority of individuals. For specifics of this calculation and its applications, which is beyond the scope of this article, readers are referred to the January 1993 Jones article regarding disappearance rates of ethanol in humans.[40]

Intra-individual Differences. A study of three men who drank 50g of alcohol on 10 separate occasions concluded that elimination rates varied as much with the subject as between them. All results, however, fell within the range published by Widmark in 1932, *i.e*., .011 to .024g/100g/h with a mean of .015g/g/h.[41]

Pathological Conditions. Subjects suffering from various metabolic diseases and liver cirrhosis still maintain their abilities to eliminate alcohol from the bloodstream.[42]

Acid-blocking Drugs. Acid-blocking drugs such as cimetidine and ranitidine appear to have no significant influence on the pharmacokinetics and bioavailability of small or moderate doses of ethanol.[43]

Tongue Piercing. Lest this discussion remain forever too dry, researchers have explored the effects of tongue piercing on breath testing. Although a study of only two subjects, the results indicated that the standard 15-minute waiting period was sufficiently effective in eliminating any effect of tongue piercing on BrAC.[44]

CONCLUSION

As the preceding review indicates, testimony of a qualified toxicologist will assist the trier of fact in a drunk driving trial in determining the weight to be given chemical test results. Notwithstanding the debate in the scientific community over the reliability of retrograde extrapolation, the principles underlying the procedure are clearly scientifically recognized, as the following statement points out:

> *It is appropriate to clarify from the outset that extrapolation from concentration-time data is not an academic theory or a mathematical process that is unique to the consideration of ethyl alcohol. The same principles of pharmacokinetics and pharmacodynamics that relate blood levels of alcohol to time are applied clinically every time drug doses are established for an individual. In these clinical situations, rate of absorption, rate of elimination, desired blood level, and body mass are considered in the same manner for calculation of the required dosing regimen, for example, once every 4 h or twice a day. Likewise, given the time needed parameters of rates, body mass, and drug blood levels, the time at which a specific dose should be taken can be calculated.*[45]

The elimination rate of .015 to .020g/dL/h is an accepted "normal" for forensic considerations.[46] In either the presence or absence of food, a conservative total time for complete absorption is 90 minutes after the last drink. "Retrograde extrapolation within the post-absorptive stage is straightforward" and "will yield a range of BACs that is firmly supported by scientifically sound tenets of pharmacology, toxicology, and physiology."[47]

Retrograde extrapolation is simply mathematics. Understanding the strengths and weaknesses of multiplying an elimination rate by a time factor, however, requires knowledge of toxicology, pharmacology, physiology, metabolism, or related fields, making it the province of expert witnesses. Disagreements between experts about the variables and correct elimination rates to be applied go to the weight of the evidence, as do the differences in the experts' credentials.

Footnotes

[1] MCL 275.625; MCL 257.904.

[2] 460 Mich 118; 594 NW2d 487 (1999).

[3] *Id.*

[4] MRE 702; see also *People v Williams*, 198 Mich App 537; 499 NW2d 404 (1993).

[5] *See, e.g., People v Whitfield*, 425 Mich 116; 388 NW2d 206 (1986).

[6] *See, e.g., People v Christel*, 449 Mich 578; 537 NW2d 194 (1995).

[7] *Whitfield*, 425 Mich at 124 (*quoting United States v Barker*, 533 F2d 1013, 1024 (CA 6, 1977)).

[8] 54 F 46 (DC Cir 1923).

[9] 343 Mich 348; 72 NW2d 269 (1955).

[10] 509 US 579; 113 S Ct 2786; 125 L Ed 2d 469 (1993).

[11] *Id*. at 593.

[12] *Id*. at 587.

[13] *Id*. at 591.

[14] *Id*. at 593

[15] 223 Mich App 485; 566 NW2d 671 (1997).

[16] A general knowledge of metric measurement is necessary for an understanding of this issue, but is beyond the scope of this article.

[17] Advocates must familiarize themselves with Michigan's three ways of reporting bodily alcohol content.

[18] Jones, *Status of Alcohol Absorption Among Drinking Drivers*, 14 J Analytical Toxicology 198 (1990).

[19] A "bolus" dose of alcohol is a measured amount of alcohol given at one time and differs from a dose of alcohol given over a period of time, as is the case in the normal social drinking situation.

[20] Jones, *supra* n 18, at 200.

[21] Elimination rates are expressed scientifically as the number of grams per 100 milliliters per hour, *e.g*., 015g/dL/h, representing grams per 100 milliliters per hour; hereinafter, they will be represented by the grams only, *e.g*., .015.

[22] Stowell and Stowell, *Estimation of Blood Alcohol Concentrations After Social Drinking*, 43(1) J Forensic Sci 14 (1998).

[23] *Id*. at 21.

[24] Gullberg and McElroy, *Comparing Roadside with Subsequent Breath Alcohol Analysis and Their Relevance to the Issue of Retrograde Extrapolation*, 47 Forensic Sci Int'l 193 (1992).

[25] *Id*.

[26] Three of the studies cited by the Washington author reported peak BACs in 75 minutes in 97 percent of subjects, 60 minutes in 92 percent of subjects, and 30 minutes in 81 percent of subjects. Jones, *supra* n 18.

[27] Holt, *Observations on the Relation Between Alcohol Absorption and the Rate of Gastric Emptying*, 124 Canadian Med Ass'n J 267 (1981).

[28] *Id.*

[29] *Id.* (citing McFarlane, Pooley, Welch, Rumsey, and Read, *How Does Dietary Lipid Lower Blood Alcohol Concentrations?*, 27 Gut 15 (1986)).

[30] Watkins and Adler, *The Effect of Food on Alcohol Absorption and Elimination Patterns*, 38 J Forensic Sci 285 (Mar 1993).

[31] A. W. Jones, *supra* n 18.

[32] Jones, *Disappearance Rate of Ethanol from the Blood of Human Subjects: Implications in Forensic Toxicology*, 38 J Forensic Sci 104 (Jan 1993).

[33] Widmark, *Die Theoretischen Grundlagen Und Die Praktische Verwendbarkeit der Gerichtlichmedizinischen Alkoholbestimmung*, Urban & Scharzenberg, Berlin 1932.

[34] Jones, *supra* n 32.

[35] Dr. Jones concluded that:

> *In forensic science practice the B-slope [elimination rate] might be as low as 8 mg/dL/h [.008] or as high as 36 mg/dL/h [.036]. This wide variation should be considered in legal proceedings dealing with retrograde estimations and related matters, for example by use of the concept of reference intervals from clinical chemistry. In this connection, it seems reasonable that the elimination rates of ethanol observed in heavy drinkers and alcoholics provides the relevant population when an interval estimate of B-slope for drunk drivers becomes an issue in forensic practice.*

Id. Dr. Jones' reference to "heavy drinkers and alcoholics" was not a casual reference. Elsewhere in his article, the author cites other studies that measured mean elimination rates in drinkers classified according to frequency of alcohol use. In one such study of 50 alcoholics, the average (mean) elimination rate was .023g/dL/h, with a spread of values from .012 to .040g/dL/h. In another study of 36 alcoholics, the mean elimination rate was .020g/dL/h, with a range of .014 to .032g/dL/h. Id. (citations to underlying studies omitted).

[36] *Medicolegal Aspects of Alcohol* (J Garriott ed, 3d ed 1996), at 93 (citations omitted).

[37] *Id.* at 94 (citations omitted).

[38] Widmark's research included the "r" factor, the ratio of water per kilogram of body weight and, therefore, the proportion of fat to lean tissue. When the "r" factor was considered, the difference in overall rate of elimination between women and men was not statistically significant because women tend to have a lower ratio of water per kilogram of body weight. *Id*. at 100-01 (citations omitted). Widmark's assessment of "r" values for men have been confirmed by recent studies, as has his assessment of the faster elimination rate for women. *Id*. at 101 (citations omitted).

[39] *Id.*

[40] Jones, *supra* n 32.

[41] *Medicolegal Aspects of Alcohol, supra* n 36, at 108 (citations omitted).

[42] *Id*. at 112

[43] *Id.* at 117-19 (citations omitted).

[44] Logan and Gullberg, Lack of Effect of Tongue Piercing on an Evidential Breath Alcohol Test, 43:1 J Forensic Sci 239 (1998).

[45] Montgomery and Reasor, *Retrograde Extrapolation of Blood Alcohol Data: An Applied Approach*, 36 J Toxicology Envtl Health 283 (1992).

[46] Ritchie, *The Aliphatic Alcohols*, in Goodman and Gillman's The Pharmacological Basis of Therapeutics (Gillman, Goodman, Tall, and Murad eds 1985).

[47] Montgomery and Reasor, *supra* n 45

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