opinion

CLIN. CHEM. 34/5, 888–889 (1988)

Medicolegal Alcohol Determination: Widmark Revisited

G. Simpson

Several concepts and principles advanced by Widmark over 50 years ago are briefly compared with results of recently published experimental work. His conclusions—that breath alcohol analysis can lead to overestimates of actual blood alcohol concentration, and that ±2 standard deviations about the average should be used to estimate certain pharmacokinetic parameters for medicolegal alcohol determinations—are supported by these more-recent experimental results.

Recent Letters and responses (*1, 2*) have emphasized disagreements about proper scientific approaches for medicolegal alcohol determination. The seminal work in this field was done by Widmark over 50 years ago, and a monograph including his collected works is available (*3*). While some of the contents are out of date, it is nevertheless a valuable reference work, containing much useful information. It also sheds considerable light on current disagreements.

At the time these papers were published, analysis for alcohol in breath was still a laboratory procedure. Widmark concluded (*3*):

"[a]nalysis of alcohol in expired air has also served as a means for estimating the degree of intoxication. Such investigations were carried out by Bogen[4] and later by Liljestrand and Linde[12]. It appears from the reports of the latter authors that air analysis can be used very well for determining alcohol content of the blood in laboratory experiments. Use of this method for forensic purposes, though, has certain problems. From the theoretical view—it must be emphasized that from the air analysis one can primarily calculate the alcohol content of the lung capillaries. As long as absorption from the intestine continues, this can be considerably higher than the alcohol content in the blood of the major circulation and also in the blood flowing to the brain. As one does not know, in the practical case, whether absorption from the intestine is ended or not—it is very often a case of large amounts of alcohol, perhaps consumed during several hours of drinking—one is always faced with the possibility that air analysis will give excessively high values, giving a false picture of degree of alcoholic influence and of the amount consumed."[1]

He also pointed out that, "[t]he time for absorption is not represented solely by the rising part of the [blood alcohol] curve. Absorption occurs even during the falling part of the curve if the sum of diffusion and conversion is greater than the absorption."[2]

These "certain problems" with breath analysis, as well as others outlined by Widmark, have not been solved to this day. For example, Dubowski recently concluded (*4*), ". . . it is not possible to establish whether an individual is in the absorption or elimination phase, or to establish the mean overall rate of alcohol elimination from the blood or breath, from the results of two consecutive blood or breath alcohol measurements, however timed." And, ". . . the peak alcohol concentration cannot be validly predicted or established in an individual instance without frequent and timely measurement of alcohol concentrations." In spite of this, it has been concluded by Jones (*2, 5*), and others that, for medicolegal purposes, individuals can be considered to be postabsorptive, because absorption is complete within about 30 min of the last drink. Such a claim is rationalized by the belief that absorption times are effectively shorter under conditions involving "normal social drinking" than they are under single-dose laboratory conditions. Currently, there are insufficient data in the literature to confirm such a belief, primarily because of the difficulties associated with duplicating "normal social drinking" conditions[3] (*6*).

Widmark's work (*3*) indicated that the pharmacokinetic parameters associated with alcohol metabolism and distribution vary significantly among subjects and within the same subject from time to time. More recently, Dubowski stated (*4*), "[a]lcohol is unusual, if not unique, among drugs in several aspects of its pharmacokinetics. Particularly striking are the great biological intersubject variabilities in alcohol consumption tolerance and in alcohol elimination, in the pattern of short-term fluctuations from the trend line of the time course of the blood and breath alcohol concentrations and in alcohol partition between blood and other body fluids and tissues, even at equilibrium." To properly account for this variability in medicolegal applications, Widmark used ±2 standard deviations (SD) about the average. For example, in using r, the ratio between the alcohol content of the whole organism and the alcohol content of the blood (assuming instantaneous absorption and distribution), he explained, "[t]he individual value of r is, to be sure, unknown. One must, then, consider that it may be larger or smaller than the average. If the average value of r is increased or reduced by twice the standard deviation, one obtains the statistical limits within approximately (*sic*) 95% of all cases will lie."[4]

Even though the average is the most probable value in a normal distribution, Widmark did not assign the average to an individual for whom the value of r was unknown. This is because the probability that an individual's value is the same as the average is quite low. To illustrate this, ±1 SD from Widmark's data gives values of r from 0.59 to 0.77 and includes about 68% of the sample. And ±0.1 SD represents a range from 0.67 to 0.69 and includes about 8% of the sample.

P.O. Box 1551, Thousand Oaks, CA 91360.

[1] Page 99 of reference *3*.

[2] Page 61 of *3*.

Received January 13, 1988; accepted February 16, 1988.

[3] "Normal social drinking" also must include the "last call" situation at closing time. This more closely approximates the single-dose experiments done under laboratory conditions.

[4] Page 107 of *3*.

Use of the average, r = 0.68 for men, means that it will be correct for fewer than eight individuals out of 100.

Because the SDs associated with human alcohol pharmacokinetic parameters are so large, average values are very poor indicators of individual values. Widmark considered it necessary to allow ±2 SD to estimate unknown values of r or to calculate alcohol consumption at some earlier time. It follows that whenever parameters such as absorption time, elimination rate, or blood/breath ratios are estimated in an individual for medicolegal purposes, at least ±2 SD about the average should be used,[5] assuming a normal distribution. The SDs for these parameters are available and given as normal distributions (*4*), but they are based on homogeneous samples under controlled laboratory conditions. As pointed out by Dubowski (*4*), "[a] 14-fold variation between absorption times to the peak blood alcohol concentrations in different subjects was demonstrated even in a reasonably homogeneous healthy population. Total population variability is obviously much greater." To allow for variability in the heterogeneous general population, under field conditions, it can be argued that ±3 SD should be applied in medicolegal applications. It seems clear, as concluded earlier (*7*), that ±2 SD is the minimum uncertainty to be used in estimating pharmacokinetic parameters for medicolegal purposes in a random individual.[6]

[5] Such allowances also need to be taken into account in alcohol research and job-related measurements, not just in medicolegal applications.

[6] This and previous related work was funded solely by the author. There are not, nor have there been, any private or public commercial or governmental interests in any of this work.

References

1. Jones AW. Concerning accuracy and precision of breath-alcohol measurements [Opinion, with response by G Simpson]. Clin Chem 1987;33:1701–6.

2. Jones AW. Reliability of breath-alcohol measurements during the absorption phase [Letter, with response by G Simpson]. Clin Chem 1987;33:2128–30.

3. Widmark EMP. Principles and applications of medicolegal alcohol determination. Davis, CA: Biomedical Publications, 1981. Available from PSG Publications, Littleton, MA. (Originally published as "Die thereotischen Grundlagen und die praktische Verwendbarkeit der gerichtlich-medizinischen Alkoholbestimmung." Fortschr Naturwiss Forschung 1932;11:1–140.)

4. Dubowski K. Absorption, distribution and elimination of alcohol: highway safety aspects [Review]. J Stud Alc 1985;Suppl 10:98–108.

5. Jones AW. Variability of the blood:breath ratio in vivo. J Stud Alc 1978;39:1931–9.

6. Cole-Harding S, Wilson JR. Ethanol metabolism in men and women. J Stud Alc 1987;48:380–7.

7. Simpson G. Accuracy and precision of breath alcohol measurements for a random subject in the postabsorptive state. Clin Chem 1987;33:261–8.