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MEDICOLEGAL ASPECTS OF CHEMICAL TESTS OF ALCOHOLIC INTOXICATION

Comments on Dr. I. M. Rabinowitch's Paper*

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This discussion will be mostly confined to certain sections of Dr. Rabinowitch's paper which deal with questions that have been rather extensively studied in our laboratory.

1. *Plasma vs. Whole Blood (p. 229), and Serum Alcohol (p. 229).* If Dr. Rabinowitch will pursue his suggestion regarding the relationship of alcohol per cent and water content of body tissues and fluids and will calculate the alcohol concentrations in these materials, based on water content *per unit volume,* he will find the differences to be much less than he assumes. With average human blood (1, 2) the serum , or plasma, has a specific gravity of 1.027 and a water content of 90.7 per cent by weight, while whole blood has a specific gravity of 1.055 and 79.1 per cent of water by weight. This means that each 100 cc. of plasma or serum contains about 93.1 cc. of water, and that each 100 cc. of whole blood contains about 83.4 cc. of water. If the distribution of alcohol follows the water content, this would mean that the concentration of alcohol per cc. of plasma or serum would be about 12.5 per cent higher than the concentration of alcohol per cc. of whole blood. Based on weight, the difference would be somewhat greater; however, in this country we measure samples of body fluids *by volume* and not by weight, and the results are usually given as weight-volume and not weight-weight.

To support his view Dr. Rabinowitch cites papers by Elbel and Kunkele. Reference number 22 of his bibliography indicates that, for Kunkele's paper and probably also for the paper by Elbel, he did not read the original but depended upon a review article by McGrath (R's reference #6). Elbel analyzed serum and whole blood from ten drinking individuals, employing the Widmark method of analysis. He found serum/whole blood al-

* The original publication of Dr. Rabinowitch's paper was in this Journal, July-August (1948) issue, *38*(2):225-253.

cohol ratios of 1.05 to 1.25, with an average of 1.17. These figures are based on milligrams of alcohol per unit *weight* of serum or whole blood. Since the specific gravity of whole blood is about 3 per cent higher than that of serum, Elbel's ratios, calculated on the basis of milligrams of alcohol per cc. of serum or whole blood, become 1.02 to 1.21, with an average of 1.135. Kunkele analyzed serum and clot from four samples of human blood. Prior to being analyzed, the clot was washed briefly with distilled water and quickly dried with filter paper. In spite of this treatment, Kunkele found the clot to contain from 82 to 88 (ave. 86) per cent of the alcohol found in an equal weight of serum. Since the cells have a specific gravity of 1.090 (1, 2) as compared with 1.027 for serum, Kunkele's results, recalculated as milligrams per cc., would give serum/clot alcohol ratios of 1.07 to 1.15 with an average of 1.11. The clot usually represents about half the volume of whole blood, so this would mean an error of only 3 to 8 per cent if serum were substituted for whole blood. Kunkele further showed that longer washing of the clot resulted, as would be expected, in much lower alcohol concentrations in it. It is not clear why he needed to wash the clot at all.

We (3) have recently studied this question, employing large samples of blood drained from nine dogs which were decapitated following the administration of alcohol. After being well mixed, a portion of each blood sample was allowed to clot and a second portion was prevented from clotting by the addition of about ½ per cent of sodium fluoride. After being stored for a few hours in a good refrigerator, whole blood, plasma, and serum from each of the dogs were analyzed for alcohol content. Our plasma/whole blood alcohol ratios (wt.-vol.) ranged from 0.925 to 1.176 (ave. 1.050), and our serum/whole blood ratios varied from 0.906 to 1.120 (ave. 0.990). The lower ratios which we found for serum may be due to a little post-mortem destruction of alcohol in the blood samples which did not contain fluoride (4, 5). At any rate, our results certainly do not support Dr. Rabinowitch's statement that, with plasma compared to whole blood, "Differences of 20 to 25 per cent are the rule, and this applies to serum." As for the single blood sample reported by him where the plasma was said to contain a concentration of alcohol 31 per cent higher than the whole blood (wt.-vol.), this result could perhaps be explained by a technician's error. A recent survey by Belk and Sunderman (6) indicates that such errors by technicians in clinical laboratories are entirely too frequent.

2. *Capillary Blood (p. 232).* Dr. Rabinowitch refers to a paper by Haggard (R's reference #54) which reports tests with

one dog which he found to have a venous blood/arterial blood alcohol ratio of 0.47 one-half hour after receiving 3 grams of alcohol per kilogram,[1] and 0.74 one hour after receiving the alcohol. For intervals of 1½ to 5½ hours the ratio was close to 1.0. Haggard found heart blood to have practically the same alcohol concentration as arterial blood, which one would expect. We (7) have repeated this type of experiment using 17 dogs which received orally one to four grams of alcohol per kilogram and from which samples of peripheral venous blood and heart blood were taken simultaneously 15 minutes, ½ hour, 1 hour, 2 hours, and 3 hours after giving the alcohol. For the time intervals mentioned, we obtained the following results for venous blood/heart blood alcohol ratios, employing blood from the saphenous vein: 15 minutes 0.67-0.96, ave. 0.83; ½ hour 0.79-1.02, ave. 0.91; 1 hour 0.87-1.11, ave. 0.99; 2 hours 0.97-1.10, ave. 1.01; 3 hours 0.88-1.04, ave. 0.99. With 14 of the animals, we also drew blood from the femoral vein. These showed the following venous blood/heart blood alcohol ratios: 15 minutes 0.67-0.94, ave. 0.80; ½ hour 0.80-1.09, ave. 0.89. While our results also show a lag in venous blood for the 15 minute period, and a little for some of the dogs at ½ hour, the degree of lag with our animals was much less than that reported by Haggard, and our figures indicate that for periods of 1 hour or longer the two types of blood have almost idental concentrations of alcohol. It should also be pointed out that any lag which might occur in peripheral venous blood would be in favor of the person being tested, since it is customary to use peripheral venous blood and not heart blood or arterial blood.

3. *Blood vs. Brain (p. 236) and Equilibrium and Concentration (pp. 237-238).* Dr. Rabinowitch quoted from the work of Gettler, et al. who have published a few results which they claim cast some doubt on the reliability of blood alcohol levels for predicting brain alcohol concentrations. He also mentions that we (8) found in 10 of 53 dogs analyzed, blood alcohol concentrations 40 to 50 per cent greater than those found in the brain. As regards our work reported in this paper, we used peripheral venous blood and 14 of our dogs represented time intervals which do not permit equilibrium storage in the body, particularly in muscle tissue. With these 14 animals, the blood sample analyzed had just returned from the muscles and therefore exhibited the lag mentioned in the preceding section of my comments. The remaining 38 dogs of this series, which were killed after time

[1] For a 150 pound person, 3 grams of alcohol per kilogram would mean a total of almost 8½ fluid ounces of pure alcohol or 17 ounces of 100 proof whiskey.

intervals which would permit equilibrium storage in the entire body, had an average blood/brain alcohol ratio of 1.24 (range, 0.88 to 1.55), expressed as milligrams of alcohol per cc. of blood/milligrams of alcohol per gram of brain (1.18 for equal weights of blood and brain). Of these 38 animals which had reached equilibrium, 35 (92%) had blood/brain ratios within ± 20 per cent of the average of 1.24 and 27 (71%) within ± 15 per cent. Only one dog had a higher blood/brain ratio (+25%). Our venous blood/heart blood ratio results mentioned in the preceding section explain this lag in blood/brain ratio for the animals killed at short intervals after receiving the alcohol, because the circulation to the brain is much better than that going to the muscles and, therefore, the brain alcohol levels for these time intervals more nearly approach those of heart blood. Gettler, et al. (9, 10) have published heart blood/brain alcohol ratios for 36 dogs, 5 of which were killed at intervals of 7 to 11 minutes following administration of alcohol by stomach tube. His results for 32 of these animals agree well with ours, the blood/brain ratio (wt.-wt.) ranging from 0.77 to 1.44 (ave. 1.19). If Gettler's blood analyses are expressed as weight-volume, this average figure would be 1.255, while our corresponding figure was 1.24. With his remaining 4 dogs the time intervals, dosage of alcohol in grams per kilogram and blood/brain ratios were: 7 min., 2 Gm., *2.09*; 11 min., 5 Gm., *1.86*; 45 min., 4 Gm., *1.75*; and 47 min., 5 Gm., *1.82*. Had Gettler used peripheral venous blood instead of heart blood, his ratios for these 4 dogs would certainly have been lower and would have been more comparable with the type of blood samples used with human beings.

We (11) recently investigated this point using 13 dogs which were killed by decapitation 10 minutes after receiving 3 grams of alcohol per kilogram by stomach tube. Samples of peripheral venous blood and heart blood were drawn simultaneously a few seconds prior to decapitation. Immediately after the head was severed the brain was removed for analysis. The peripheral venous blood/brain alcohol ratios ranged from 0.75 to 1.15 (ave. 0.90), while the heart blood/brain alcohol ratios were 1.04 to 1.48 (ave. 1.24). Even in this series, we found no instances where the heart blood/brain alcohol ratio was as high as those of the 4 dogs reported by Gettler. We believe that Gettler's high figures for these dogs is due to the fact that his animals were killed with carbon monoxide and the blood sample taken from the heart after death. Even in rapid carbon monoxide poisoning, the blood pressure falls considerably prior to the cessation of respiration. This impaired circulation is particularly marked

in the extremities, and it seems quite probable that heart blood obtained following such a death would contain a much larger proportion of blood from the portal vein via the liver. Falconer and Gladnikoff (12) have reported that during the absorption period the concentration of alcohol in portal vein blood is considerably higher than in blood from the vena cava. Gatch and Culbertson (13) have shown that the venous blood from an intact section of small intestine, filled with 5 per cent alcohol in water, contained as high as 25 milligrams of alcohol per cc. If Gettler will repeat his dog experiments and use peripheral venous blood taken immediately before the death of the animal, we believe he will find no discrepancy whatever between his results and ours. As mentioned above, the blood/brain alcohol ratios of 32 of his 36 dogs all fall within the limits found in our series, using 53 dogs.

Blood/brain ratios for human beings have been reported by Ellerbrook and VanGaasbeek (14), Stratton (15), and others. Using autopsy material from 19 human cases, Ellerbrook and VanGasbeek found heart blood/brain alcohol ratios ranging from 0.88 to 1.29 (ave. 1.09). In one other human case when death occurred after the consumption of 5 pints of liquor, they found a ratio of 1.52 for heart blood/brain. Since the blood is constantly transporting alcohol to, or from, various parts of the body, one would not expect to find a perfect correlation between the concentration of alcohol in the blood and in various body tissues. However, the results given here do demonstrate that the level of alcohol in peripheral venous blood parallels that in the brain quite well. For dogs it is never more than 20 or 25 per cent above the equilibrium ratio of 1.24. For periods shorter than 15 minutes, it may be considerably below the equilibrium figure. This error would be *in favor* of the person being tested, but in practice very few drivers are going to drink, have an accident, and be tested all within a period of 15 minutes.

4. *Breath Alcohol (pp. 242-243).* In the 1938 paper describing our breath method (16), we gave *all* of our results for simultaneous analyses of blood and breath. These results included tests done during the preceding 5 years, some of the earlier breath analyses having been performed by internes with almost no training in this procedure. In this paper we frankly stated that the chart giving the correlation between the weight of alcohol in 1 cc. of blood and in breath containing 190 mgs. of CO_2 showed considerable scattering. We pointed out that the majority of errors would cause the calculated blood alcohol to be too low, probably due to passing the end point. We further

mentioned that increasing the volume of $\frac{N}{20}$ permanganate from 0.5 cc. to 1 cc. had improved the accuracy of the method. Since 1938 the apparatus and procedure have been considerably improved. A second series (17) of simultaneous breath and blood analyses conducted recently shows a much better correlation between calculated and observed blood alcohol. This represents 100 consecutive analyses run on that number of breath and blood samples simultaneously obtained from 33 subjects. With a given subject, at least 1 hour elapsed between tests. The deviation from unity between mgs. alcohol per 190 mgs. breath CO_2/mgs. alcohol per cc. of blood are given in the following table:

Within ± 10%	= 63
+ 11 — 15%	= 11
— 11 — 15%	= 6
+ 16 — 20%	= 7
— 16 — 20%	= 3
+ 21 — 25%	= 3
— 21 — 25%	= 0
+ 26 — 30%	= 2
— 26 — 30%	= 4
+ 32%	= 1
Total	100

It will be observed that this series contains no case showing such large errors as the 6 listed by Dr. Rabinowitch from the 1938 paper (16). The one subject where the calculated blood alcohol was 32 per cent higher than the level found on direct analysis, had clinical symptoms more nearly corresponding to the calculated alcohol figure, suggesting that perhaps his peripheral venous blood was lagging behind the blood in the pulmonary artery as regards the alcohol content. During the period of this lag in peripheral venous blood as compared with arterial blood, the breath alcohol would probably be superior to venous blood alcohol in predicting the level in the brain. In the 1938 paper (16) describing our breath method, we stated: "The method described in this paper will probably not predict the concentration of alcohol in the brain quite as closely as analysis of blood, but we believe that the results are amply accurate for practical purposes." The last clause was based upon improvements which we had made at the time the paper was published, which resulted in a better correlation between the calculated and observed figures for blood alcohol. While the results given in the above table show much improvement over our results published in 1938, it is believed that the sentence quoted above is still essentially correct.

Jetter and Forrester (18), from 79 simultaneous analyses of

breath and blood, and Fabre (19), who tested a few subjects, have confirmed our findings that the alcohol-CO_2 ratio of the breath will reliably predict the concentration of alcohol in the blood.

Dr. Rabinowitch mentions that the CO_2 content of alveolar air is not always precisely 5.5 per cent, and states that it may run as low as 4.7 per cent. While very few subjects will have a CO_2 content of alveolar air this low, the maximum positive error introduced would be only about 17 per cent. Alveolar air concentrations above 5.5 per cent would, of course, result in an error favoring the person being tested.

The possibility of regurgitation is brought up by Dr. Rabinowitch. After running many hundred breath tests on drinking subjects, I have yet to encounter a single case of regurgitation. If it should occur, this ought to be obvious to the operator who can quickly take care of the matter by having the subject rinse his mouth with water. As shown by us (8) the concentration of alcohol in stomach contents rather rapidly approaches that of the blood so that regurgitation an hour or so after drinking would produce very little error anyway.

As regards the general reliability of the alcohol-CO_2 ratio in predicting blood alcohol, I would say that the results of Jetter and Forrester, together with our more recent series are about as good as the correlations between urine alcohol and blood alcohol which have been published (20, 21).

5. *Alcohol Tolerance (p. 238).* No one who is at all familiar with this field can deny that some people are less affected by a given concentration of alcohol than are other people. The recognition of this fact is the reason why certain technical committees in this country have recommended that, for the purpose of interpreting the results of chemical tests, drinking drivers be divided into 3 groups and not into 2 groups (22, 23). Granting that individuals differ in their tolerance to alcohol, the only vital question involved in the interpretations recommended by these technical committees is whether the limit of 0.15 per cent blood alcohol is fair to all individuals. Most workers in this field feel that it is. Certainly the careful studies recently published by Newman (24) and Goldberg (25) do not show any exceptions to this rule. Newman's subjects with blood alcohols above 0.15 per cent exhibited decreases in driving skill ranging from 16 to 24 per cent. Goldberg's subjects with blood alcohols above 0.15 per cent, all of whom were heavy drinkers, exhibited adverse results after drinking which deviated from their normals by amounts ranging from 40 to 564 per cent (26).

6. *Expert Opinion (p. 245).* In our 1938 paper (16), we stated, "It should be emphasized that chemical tests for intoxication should not exclude evidence such as observations of eye witnesses and physical tests but that chemical tests will give additional information, which is often sorely needed." In this section Dr. Rabinowitch quotes largely from a few critics of chemical tests for intoxication located in various parts of the world. He fails, however, to mention reports from many technical and scientific people in the United States and Europe who, after much experience with these tests, are convinced that they represent a vast improvement over the old eye witness evidence regarding the sobriety of an automobile driver. In particular, he should have mentioned reports of the American Medical Association committee subsequent to 1937, especially the 1939 report (22). This report not only recommends 3 zones of body alcohol level and the interpretation for each zone but also summarizes the matter in the following language, "The medical profession is particularly fortunate in having these chemical tests at its disposal. They will enable the profession to avoid the well known 'disagreements of experts.' Their use is recommended whenever physicians are called on to diagnose degree of alcoholic influence for city and state enforcement departments." This report then went to the A.M.A. Reference Committee on Legislation and Public Relations, which reported as follows (27), "The application of chemical tests is made, and metes and bounds for medicolegal interpretation are set up. Your reference committee considers the standards thus raised to be fair and just and protective of the interests of both the individual and the authorities. It recommends the adoption of the report." Subsequently, the reports of the two above-mentioned committees were adopted by the House of Delegates of the A.M.A. The reports of this A.M.A. technical committee since 1939 have all reaffirmed the recommendations which they made in 1939 and earlier.

Most of the critics of the 0.15 per cent alcohol rule have overlooked one very vital point. The recommendation of the technical committees of the A.M.A. and the National Safety Council is that, for blood alcohol concentrations of 0.15 per cent or above, this evidence be given *prima facie* status only. Now prima facie does not mean the same as *absolute.* It simply means *presumptive* or *until proved to the contrary.* Therefore, any court which is convinced that a particular driver with a blood alcohol above 0.15 per cent is an exception to the general rule, may return a verdict of not guilty. This certainly renders unfounded any criticism that the 0.15 per cent rule is too rigid. In my own state

where the 0.15 per cent rule is incorporated into the state law, we have had several acquittals where the driver was shown to have a blood alcohol above 0.15 per cent.

Finally, Dr. Rabinowitch quotes from a 1940 paper by Professor A. T. Cameron of Winnipeg, who stated that some of the views expressed by the National Safety Council's committee on tests for intoxication remind him of the slogan of the Royal Canadian Mounted Police that they "get their man." To this one might reply that, judging from some of the rather flimsy objections raised by Drs. Cameron and Rabinowitch, our colleagues north of the border may be out to "get the chemical tests." However, this, too, would be both unkind and unfair to men of science who can have honest differences of opinion. I would suggest to our Canadian confreres that they spend an equal amount of effort in giving these various methods a fair trial, making sure that the directions are faithfully carried out. They might also employ their talents to develop improved tests. In the meantime, the disposition of the daily crop of drunken driving cases cannot await absolute perfection in the field of chemical tests.

REFERENCES.

1. Bodansky, Meyer, Introduction to Physiological Chemistry, Wiley & Sons, New York, 1938, p. 222.
2. Henderson, L. J., Blood, Yale Univ. Press, New Haven, 1927.
3. Harger, R. N., Hulpieu, H. R., Cole, V. V. and Forney, R. B., Unpublished work.
4. Harger, R N. and Goss, A. L., Am. J. Physiol., *112*:374, 1935.
5. Fleischmann, W. and Trevani, E. Biochem. Zeit., *232*:123, 1931.
6. Belk, W. P. and Sunderman, F. W., Am. J. Clin. Path., *17*:853, 1947.
7. Harger, R. N., Hulpieu, H. R. and Cole, V. V., Federation Proc., *4*:123, 1945.
8. Harger, R. N., Hulpieu, H. R. and Lamb, E. B., J. Biol. Chem., *120*:689, 1937.
9. Gettler, A. O. and Freireich, A. W., Am. J. Surgery, *27*:328, 1935.
10. Gettler, A. O., Freireich, A. W. and Schwartz, H., Am. J. Clin. Path., *14*:365, 1944.
11. Harger, R. N., Hulpieu, H. R., Cole, V. V. and Forney, R. B., Unpublished work.
12. Falconer, B. and Gladnikoff, H., Skand. Arch. Physiol., *68*:245, 1934.
13. Gatch, W. D. and Culbertson, C. G., Annals Surgery, *102*:619, 1935.
14. Ellerbrook, L. D. and Van Gaasbeek, C. B., J. Am. Med. Assn., *122*:996, 1943.
15. Stratton, F., Am. J. Med. Jurisprudence, *2*:21, 1939.
16. Harger, R. N., Lamb, E. B. and Hulpieu, H. R., J. Am. Med. Assn., *110*:779, 1938.
17. Harger, R. N. and Forney, R. B., Unpublished work.
18. Jetter, W. W. and Forrester, G. C., Arch. Path., *32*:828, 1941.
19. Fabre, R. and Leheuzey, P., Bull. soc. chim. biol., *26*:49, 1944.
20. Carlson, A. J., Kleitman, N., Muehlberger, C. W., McLean, F. C., Gullickson, H. and Carlson, R. B., Studies on the Possible Intoxicating Effect of 3.2 Per Cent Beer, Univ. of Chicago Press, 1934.
21. Bavis, D. F., J. Lab. Clin. Med., *25*:823, 1940.
22. Proceedings, House of Delegates, Am. Med. Assn., Report of Committee to Study Problems of Motor Vehicle Accidents, J. Am. Med. Assn., *112*:2164, 1939.
23. National Safety Council, Comm. on Tests for Intoxication, 1938 Rept., p. 10.
24. Newman, H. and Fletcher, E., J. Am. Med. Assn., *115*:1600, 1940; Newman, H. W., Acute Alcoholic Intoxication, Stanford Univ. Press, 1941, p. 170.
25. Goldberg, L., Acta Skand. Physiol., *5*, Suppl. 16, 1943.
26. Harger, R. N., Industrial Medicine, *17*:52, 1948 (see p. 56).
27. Proceedings, House of Delegates, Am. Med. Assn., Report of Reference Committee on Legislation and Public Relations, J. Am. Med. Assn., *112*:2175, 1939.