EXCRETION OF ALCOHOL IN THE URINE AS A GUIDE TO ALCOHOLIC INTOXICATION.

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INTRODUCTORY NOTE.

BY

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WITHIN the range of forensic medicine there is no subject upon which medical evidence is more unsatisfactory than that appertaining to drunkenness. It is difficult to reduce a varying group of symptoms and appearances to a formula which can be stated; still more so to a definition which will convince a lay bench of magistrates that the symptoms described are really due to alcoholic consumption, and may not, individually and collectively, be ascribed to other causes; and yet the recognition of indulgence in alcohol presents few difficulties at the time. Every member of a social group can say with accuracy when a member of that group ceases to be normal and gives definite indications that sobriety has passed into insobriety. The picture is made up of many changes, subtle yet recognizable, in speech, appearance, manner, and conduct. It is something we can sense, but analyse and subsequently describe with difficulty.

When for legal purposes it comes to applying a number of tests—such as standing poised, toeing the line, standing immobile with closed eyes, repeating certain words or phrases, smelling the breath, and testing the memory of lapse of time, etc.—the results are very unsatisfactory. We have recently had experience of nerve specialists disagreeing with practitioners in court on the question of drunkenness, and all agreeing that our tests are inadequate and inconclusive.

No two men behave exactly alike under the influence of alcohol, or present the same combination of objective symptoms. The result is that many cases of accusation in the courts on the charge of drunkenness, where serious motor accidents have occurred, are wrongly dismissed for want of evidence which would be unanimously convincing to the bench.

I am sure that too much is made of one sign. It is almost the rule for the constable in charge to open his evidence by saying, "The accused smelt strongly of drink." Certainly my examination in many cases fails to confirm this. It is possible that it may be due to lapse of time since apprehension, but I think not. Does the smell of a man's breath, as regards alcohol, increase *pari passu* with the number of glasses of stimulant he has swallowed? I think not. At most the smell of the breath indicates that some alcohol has been consumed. Therefore I do not think the test is of much positive value; it is of importance in a negative sense. There are five signs to be observed in making an examination which influence me considerably, taken in association with the other symptoms. They are: (1) flushed face; (2) sweating; (3) dilated pupils; (4) congested eyes; (5) rapid pulse; and they are present in nearly all instances.

What we, and the courts, have to decide is, as Dr. Frederick Smith puts it in Taylor's *Medical Jurisprudence*: "Was the person's mental condition, which led to the proceedings, and caused him to behave in the manner he did, prior to his arrest, produced by alcohol? If so, he was drunk within the meaning of the proceedings."

In the majority of cases the police surgeon hears nothing of the charges of being drunk and disorderly which are considered every morning in the courts of our towns and cities, but of late years a more serious class of offence has

come into prominence in which the issues are of great moment morally and materially. I refer to charges of being drunk whilst in charge of motor cars. These offences are most frequently laid against people of some social standing. Serious or perhaps fatal injuries have been inflicted, as well as much damage done to vehicular property. Those charged realize the extreme importance to themselves of establishing their innocence under such serious accusations, and almost invariably make indignant denial. After the police surgeon has examined them they often demand the presence of their own medical advisers. Valuable time has been lost, even before the first doctor arrives at the charge office; more before the advent of the second. And this time factor is of great importance. All who have had experience of the class of case I am considering will agree that nothing sobers a man more quickly after a vehicular accident than finding himself in a police lock-up with the certainty of court proceedings in the morning. I am often impressed with this power of regained control, judging by a person's demeanour and behaviour in an hour's time, as compared with his proved state of instability when arrested and a knowledge of the things he has said and done. He will often go through the usual ambulatory, static, and oral tests with flying colours, so to speak, or fail in only one. Also he will take care to assert that any deviation from the normal which he may present is entirely due to the shock of a collision, with the added anger of the accusation made against him. Then comes further lapse of time, with its sobering effects, before the second medical examination is made. Afterwards in court the defending solicitor urges, in tones of indignant protest, that the cardinal signs of quick pulse, flushed face, and dilated pupils are but the result of an innocent man having been shaken by an accident, wrongly arrested, and charged afterwards with drunken conduct. If it be alleged that his breath smelt of alcohol he will probably state that he had partaken of a glass of liquor but was certainly not drunk.

I learnt from Professor E. Mellanby that Dr. Southgate,¹ who had done much work on the relation of alcohol in the blood and urine, was anxious to carry out an investigation to see if a knowledge of the concentration of alcohol in the urine was of any medico-legal value in the detection of drunkenness, but that for such work my collaboration was necessary. He suggested that it might be possible to state approximately the quantity of alcohol any person charged with drunkenness might have drunk, and that a study of the subject might lead to the determination of a figure representing the alcohol in the urine which would indicate a condition of definite intoxication of the individual, and certainly an unfitness to drive any vehicle on a thoroughfare with safety to himself and the public. Dr. Southgate was able to promise that, if I would procure specimens of urine from persons so charged, and give the time since the arrest, he would carry out the quantitative analyses and furnish me with the reports in an hour's time—that is, in time for the police-court proceedings. It seemed to me that the prospects of developing a simple test which could at least provide definite information that alcohol had been consumed was worth following up, and I gladly gave my assistance. In no work on forensic medicine could I find any reference to the estimation of alcohol in the urine, and it seemed to me probable that the development of the idea might be of service to this branch of medicine. It was at least clear that, in view of an examination of this kind, it would be of no use for a charged person to allege, as does happen, that he has not had any alcoholic beverage or only a small libation, for when alcohol is found in any quantity in the urine it has surely gone in at the mouth.

I arranged that a record should be kept, and an entry made in the police books, of the condition and appearance of persons when apprehended on the charge of drunkenness, and that specimens of urine should be obtained and sent to Dr. Southgate for analysis, so that it would be possible to compare the symptoms of intoxication as observed at the police station with the figures representing the alcoholic concentration in the urine. I obtained permission for a general order to be sent out to all stations within the city boundary that a sample of urine should be obtained in cases of this character as soon as possible after arrest.

A supply of blank labelled bottles was distributed with instructions for urines collected to be dispatched at once to the university, and I emphasized the necessity of quick bottling to prevent alcoholic evaporation. It was our desire to obtain if possible fifty samples before giving our results, but unforeseen obstacles were encountered. The number of specimens sent was so small that I instituted an inquiry into why instructions were not being carried out. Then a fact was brought to my notice, which I was soon able to verify—namely, that if there be one thing a drunken man will not do it is to empty his bladder when requested. He will make every excuse and tell you any manner of fairy tales, but he will not micturate to order, even with a distended bladder. I think he becomes suspicious. Stratagem was then my only resource. So we have set apart a particular cell for "drunks" at the central police station. The lavatory is boarded over loosely for a while. On one side wall a urinal has been affixed, the discharge pipe from which passes directly through to another cell and empties over a receptacle placed beneath it. Nothing is said to the suspect, no request is made, and we find that, in the seclusion of his temporary abode, Nature asserts itself, and we get our sample without difficulty or delay. On the bottle is placed the number from the charge book register, the time of arrest, and the hour when the urine was passed.

In cases of gross intoxication the condition is obvious, and hardly requires a medical man's examination, but still, even these cases are sometimes keenly contested. I think the great value of the urine tests will be in borderland cases, where alcohol has obviously been consumed, but in unascertained quantity, where the symptoms of intoxication are of moderate degree, and where it is alleged for the defence that so little alcohol has been consumed that the conduct complained of could not be attributed to that cause.

EXPERIMENTAL WORK.

BY

H. W. SOUTHGATE.

The idea of correlating the toxic effects produced by alcohol with the corresponding concentration of that compound in the urine is not new. Widmark² (1915) reported the results of examining the urines of 27 individuals arrested for alcoholic intoxication. The results varied from 450 to below 200 mg. of alcohol per 100 c.cm. of urine. Results with acetone were reported by him in 1919. Miles³ (1924) gave interesting comparisons of the toxic effects produced, with a corresponding alcohol urine concentration over a period of two hours, when a dilute solution of alcohol was given to six comparable subjects. During the last two years a study of the experimental data I had obtained of blood and urinary alcohol content in the case of three men convinced me that practical use could be made of the relationship between urine alcohol concentration and the corresponding toxic effect produced in the human subject. Miles had only worked with small doses of alcohol, the action of which could not be detected except by testing with instruments of precision, but the ratio results he obtained I have been able to confirm with much larger doses of alcohol, and extending over a much longer period.

In the light of results I had obtained in the case of my experimental subjects, whose consumption of alcohol was known, I thought it would be interesting to examine the alcoholic content of the urines of those arrested for intoxication. Before giving these data, and the symptoms of intoxication exhibited by the subjects when charged at the police station, I shall first state the experimental evidence upon which this method of examination is based. It will be more possible then to see in what ways the method can be developed by further work, what it is capable of indicating, and what are its limitations. I shall supply evidence on three points:

(1) The alcohol in the blood is related to the amount of alcohol consumed when this is imbibed under constant conditions.

(2) The relation of alcohol in the blood to alcohol in the urine is a fairly constant one in many circumstances.

(3) The concentration of alcohol in the blood is related to symptoms of intoxication of the central nervous system.

If these propositions can be established it is clear that the concentration of alcohol in the urine is also related to alcoholic intoxication. I shall describe and discuss the police-court results in the light of the experimental data.

1. Alcohol in the Blood.

It is important to realize that the behaviour of alcohol in the blood is different from other substances eaten as foodstuffs. Most foods after digestion and absorption from the alimentary canal are either stored or oxidized by the body fairly rapidly, so that soon the blood shows no distinctive signs of their presence. This can be seen to happen to glucose, the end-product of carbohydrate digestion, in Fig. 1. After taking 75 grams of glucose

FIG. 1.—Difference between blood alcohol curve and blood sugar curve.

the amount of this substance had sunk to normal in one and a half hours. After drinking a solution containing 75 grams of alcohol it can be seen that even six and a half hours later the blood of a man contains a good deal of this substance—namely, 75 mg. per 100 grams of blood—and from the rate of disappearance, as evident on the curve, it would be present in recognizable amounts even twelve hours after the time of drinking. Thus, although the maximum concentration of glucose and alcohol in the blood after these have been taken by mouth is reached about the same time, glucose disappears quickly and the alcohol disappears slowly. The straight line indicating the rate of disappearance of alcohol from the blood is no mere coincidence. E. Mellanby⁴ was the first to show on dogs that after alcohol has reached its maximum concentration it disappears at a uniform rate from the blood. He showed the further remarkable result that the rate of disappearance of alcohol is independent of the concentration. Thus, in the case of a dog, increasing the amount of alcohol by mouth brings about a corresponding increase in the alcoholic concentration in the blood. This animal was given on different occasions a 20 per cent. solution of alcohol by mouth, containing respectively 55, 50, 30, and 20 c.cm. of absolute alcohol. In each case the alcohol was given when the stomach was empty. The points of maximum concentration of alcohol in the blood on the different occasions are 372, 357, 212, and 120 mg. per 100 grams of blood; these figures do not differ greatly from the ratios of the amounts of alcohol drunk—namely, 2.75:2.5:1.5:1.

Having now seen that there is a relationship between the alcohol consumed and the alcohol in the blood, when the alcohol is taken by the same individual under the same conditions, it is necessary to see whether there are conditions which tend to depress the alcohol concentration; for these same conditions will probably depress also the symptoms of intoxication if these two are related. Some of these will now be briefly mentioned.

(a) *Dilution*.—If two solutions, say of 5 and 20 per cent. strength, containing equal quantities of alcohol are drunk by the same individual under the same conditions, the

TABLE A.—The Variation of the Alcohol Concentration in the Blood and Urine of the Resting Subject with Varying Dietetic Conditions.

Food Taken.	Subject.	Alcohol Concentration in the Blood after—			Alcohol in Urine.		Alcohol in Urine. Alcohol in Blood.		Total Vol. Urine in 6½ hrs.
		1 hr.	2½ hrs.	6½ hrs.	2½ hrs.	6½ hrs.	2½ hrs.	6½ hrs.	
(a) No food	J. H. B.	146	148	87	193	114	1.37	1.37	c.c.m.
	G. H. N.	151	148	78	199	103	1.39	1.34	1,700
	W. N.	160	154	85	212	126	1.38	1.40	1,559
(b) 530 c.cm. water	J. H. B.	142	145	81	205	127	1.41	1.56	2,316
	G. H. N.	130	141	74	199	104	1.41	1.40	2,290
	W. N.	170	154	92	197	125	1.28	1.35	2,123
(c) 530 c.cm. whole milk previously boiled	J. H. B.	114	130	58	186	87	1.43	1.50	2,313
	G. H. N.	123	134	62	184	100	1.37	1.40	1,878
	W. N.	Lost	141	71	195	101	1.39	1.42	2,655
(d) 530 c.cm. whole milk previously boiled and 183 grams bread	J. H. B.	106	116	48	161	70	1.39	1.46	1,513
	G. H. N.	125	116	45	162	58	1.40	1.26	2,086
	W. N.	128	123	49	180	82	1.46	1.67	2,251
(e) 530 c.cm. water and 183 grams bread	J. H. B.	Lost	125	58	163	83	1.30	1.43	1,905
	G. H. N.	137	126	62	164	92	1.30	1.48	1,788
	W. N.	159	143	70	191	114	1.34	1.63	2,160
(f) 50 grams separated milk powder, 183 grams bread, 500 c.cm. water	J. H. B.	101	117	44	146	67	1.60	1.50	1,836
	G. H. N.	140	123	52	154	76	1.25	1.46	1,847
	W. N.	157	130	52	182	78	1.40	1.50	1,936
(g) 50 c.cm. olive oil	J. H. B.	143	142	79	203	114	1.43	1.44	2,162
	G. H. N.	126	146	79	217	125	1.49	1.58	1,454
	W. N.	126	155	88	226	123	1.46	1.45	2,376

alcohol concentration will rise more rapidly and to a higher point in the case of the stronger solution, as Mellanby showed. In Fig. 2 will be seen the blood concentration curves of J. H. B. after 1,920 c.cm. of beer containing 5 per cent. alcohol, 1,200 c.cm. 8 per cent. aqueous alcohol, and after 235 c.cm. of whisky diluted with an equal volume of soda water, thus forming a 20 per cent. solution. In each of these three cases the equivalent of 96 c.cm. of absolute alcohol was taken on an empty stomach. The time of drinking was about the same in each case. It will be seen how the maximum concentration

FIG. 2.—J. H. B. fasting.

risers with increasing concentration of the alcohol drunk. Therefore the more dilute the solution, the less will be the concentration of alcohol in the blood.

(b) *Rate of Drinking.*—Diminishing the rate of drinking alcoholic beverages will delay the accumulation of alcohol in the blood. The effect on the maximum point of concentration of alcohol in the blood depends on various factors. For instance, drinking modern beer of 5 per cent. strength to bring about real intoxication must in any case be a slow process, because of the large volume that must be imbibed to supply the necessary amount of alcohol. The amount of alcohol in beer that will take a normal man two hours to drink will be drunk with ease in five minutes in the form of whisky. During these two hours oxidation changes will be taking place in the body, so that about 10 c.cm. of the alcohol consumed will be removed each hour from the body. Thus the maximum point of concentration, apart from the question of dilution discussed above, will be lowered when the more dilute beverage is drunk. In considering any particular instance of slow drinking, as compared with rapid drinking, the two points must be considered: (a) how rapidly can the alimentary canal absorb the alcohol of the particular beverage drunk? and (b) how much alcohol will dis-

appear from the body in the interval? In all cases it can be said that the slower the rate of drinking and the more dilute the alcoholic beverage, the lower will the maximum concentration of alcohol in the blood and the more slowly will this be attained.

(c) *Food.*—All foods tend to depress the rate of absorption of alcohol from the stomach and intestines, and thereby lower the alcoholic concentration of the blood, but some have such a potent action in depressing blood alcohol as to appear almost specific. Among these foods

FIG. 3.—Resting experiment.

bread and milk stands out pre-eminent, as Mellanby has shown. It will be seen in Table A and in Fig. 3 that both bread and milk individually have this characteristic effect. It is quite certain that food in the stomach and small intestine greatly depresses the concentration of alcohol in the blood.

(d) *Size of Individual.*—Although it may be taken as a rough guide that the bigger the man the lower will be the concentration of alcohol in the blood produced by a definite amount of alcohol when all other conditions are constant, it does not seem to be always true. In Table B can be seen the maximum concentration in the blood of

TABLE B.

	Amount of Alcohol Drunk.	Dilution.	Max. Conc. of Alcohol in Blood mg. per 100 gr. Blood.	Weight in Kilos.
J. H. B.	96 c.cm.	8 per cent.	123 mg.	72
G. H. N.	"	"	122 "	74
W. N.	"	"	130 "	61
A. B.	59 c.cm.	20 per cent.	75 mg.	50.5
"	"	"	62 "	70

different men of varying weights after drinking alcohol when their stomachs were empty.

It will be seen that although in the case of J. H. B., G. H. N., and W. N. the alcohol concentration was roughly inversely proportional to their weight, in the case of A. and B. the ratio was reversed, the heavier man

having the higher concentration of alcohol in the blood when the same quantity of alcohol was drunk by each. It may be stated that A. was fatter at the time this examination was made than usual, his normal weight being about 70 kilos, and this may partially explain the discrepancy. The point needs further investigation. The blood and urine concentration curves for A. and B. are shown in Fig. 4.

FIG. 4.

(e) *Tolerance.*—It has been shown by Schweisheimer⁵ that if abstainers, moderate drinkers, and heavy drinkers take the same quantity of alcohol when other conditions are equal, then the concentration of alcohol in the blood is highest in the abstainers and lowest in heavy drinkers. For some unknown reason the imbibed alcohol is never fully manifested in the blood stream of the alcoholic. Some of his results on these different classes of people are shown in Fig. 5. It will be seen that, although Case v drank

FIG. 5.—Four cases from Schweisheimer's paper.

about the same amount of alcohol as Case i (105 c.c.m. as against 102 c.c.m.), although their weight and ages were approximately the same, yet the maximum concentration of alcohol in the blood of Case v (heavy drinker) only reached 59 mg. per 100 grams of blood, as compared with 138 mg. per 100 grams of blood in Case i (abstainer).

The main conditions which influence the concentration of alcohol in the blood, so far as they are known, have now been described. It will be seen that, for a given quantity of alcohol drunk, increased dilution, slower drinking, food in the stomach and alimentary canal, and especially bread and milk, an increase in size of the individual (except possibly when increase in size is due to fat), and tolerance to alcohol as seen in the toper, all tend to depress the alcoholic concentration in the blood. It would appear that the maximum concentration of alcohol is produced by a given amount of this substance when a concentrated solution, say in the form of spirits, is rapidly drunk on an empty stomach by one unaccustomed to alcohol. It seems safe to say that if such a person of a known size develops a maximum alcoholic concentration in the blood of x mg. per 100 grams of blood when he has drunk y c.c.m. of alcohol, then any other person of similar size found to have a similar amount of alcohol in his blood must at least have drunk a similar quantity or more of alcohol. Thus, by taking a number of normal individuals, such as has been done in the cases above of J. H. B., G. H. N., and W. N., and determining their blood alcohol

after drinking definite quantities in a concentrated form on an empty stomach, it would be possible to find figures which would represent the minimum amount of alcohol which would produce a definite quantity of alcoholic concentration in the blood. For instance, a 20 per cent. solution of alcohol in the form of whisky containing 96 c.c.m. of alcohol, produced, when drunk rapidly on an empty stomach, a maximum concentration of:

136 mg. per 100 grams of blood in J. H. B.	
134 " " " " G. H. N.	
141 " " " " W. N.	

In these men, and in men of similar size, these concentrations of alcohol in the blood might be produced by imbibing similar quantities of alcohol, but, in practice, they would probably be due to drinking more than the quantity used in the experimental determinations, which are the optimum for producing the highest and most rapidly reached concentration.

Thus it would appear possible, from a determination of the blood alcohol in control cases known to have drunk specific quantities of alcohol under definite conditions, to decide that a concentration of alcohol in the blood of tested individuals could only have been produced as the result of drinking not less than a certain quantity of alcoholic beverage.

2. The Relation of Alcohol in the Blood to Alcohol in the Urine is Fairly Constant in many Circumstances.

Besides having the property of remaining in the blood for many hours after being drunk, alcohol has another characteristic in that, however small may be the quantity in the blood, a higher concentration appears in the urine within half an hour of ingestion. The kidneys cannot, in fact, restrain the passage of alcohol, but actually appear to concentrate it in its passage. So long, therefore, as alcohol is present in the blood after drinking this substance, alcohol can also be detected in the urine.

Nieloux,⁶ Widmark,² and Ambard⁷ found that the concentration of alcohol in the blood and urine at any time was the same, but Miles³ showed that this was only so for about the first half-hour after drinking alcohol. After this time the concentration in the urine is always higher. My own figures corroborate, with larger quantities of alcohol and over a longer period, what Miles found with small quantities. In Table A it will be seen that the ratio of alcohol concentration in the urine to alcohol concentration in the blood in the three subjects J. H. B., G. H. N., and W. N., after they had drunk an 8 per cent. solution of alcohol containing 96 c.c.m. of this substance on an empty stomach, varied between 1.34 and 1.40 in six samples taken. Since these figures were obtained the writer has

FIG. 6.—Blood and urine alcohol concentration curves of G. H. N.

carried out further estimations at the hour and two and a half hour intervals. The mean from seventeen results at the one hour interval works out at 1.32 for the ratio,

and the mean of the ratio at the two and a half hour interval in thirty-one experiments works out at 1.37. Some of these results are shown graphically in Figs. 6 and 7.

Fig. 7.—Blood and urine alcohol concentration curves of W. N.

In Fig. 4, which shows the alcohol concentration in blood and urine of two other subjects, A. and B., after drinking 144 c.c.m. of whisky containing alcohol in a dilution of 20 per cent., the mean ratio of alcohol in the urine to alcohol in the blood one hour after drinking the alcohol is 1.35. It may be accepted, therefore, that when alcohol is drunk on an empty stomach the ratio of these concentrations of alcohol after one hour is a fairly constant figure of the order of 1.35.

It is surprising how constant this figure is. In Table A it will be observed that, when the drinking of alcohol is preceded by drinking water or milk, or eating bread and milk, or bread and water, or olive oil, the ratio of the concentrations of alcohol in the urine and alcohol in the blood remains the same, the average being about 1.40. It would appear, in fact, that food makes no difference to this ratio.

It would be expected that diuresis would influence the ratio, but here again this does not seem to be the case. The following table gives the results of exactly similar experiments carried out on the same subject, but separated by an interval of seven months. In each case the man (J. H. B.) drank 1,200 c.c.m. of 8 per cent. alcohol on an empty stomach. The resulting blood and urine concentration curves were practically the same in each case, but on the first occasion, for some unknown reason, he passed 500 c.c.m. more urine in the experimental period. The following figures were obtained:

Ratio of Urine Alcohol to Blood Alcohol.			Total Volume of Urine passed in 6½ hours.	Mean Concentration in Urine.
1 hour.	2½ hours.	6½ hours.		
1.32	1.37	1.37	1,700 c.c.m.	148
1.34	1.35	1.39	1,208 "	146

The important point is that the increased flow of urine in the first experiment has not altered the ratio of the urinary and blood concentration of alcohol—a fact which Miles also noted. If, as seems to be the case, there is this fairly constant ratio between urinary and blood alcohol concentration under widely different conditions, all the circumstances described above as influencing alcohol in the blood can probably be regarded as having an equal and similar effect on the urinary alcohol. Thus slower rate of drinking, the dilute alcoholic beverage, the presence of food, and especially bread and milk in the stomach and intestine, tolerance as the result of constant drinking—all these conditions will tend to depress the alcohol concentration of the urine. On the other hand, a concentrated solution of alcohol drunk rapidly on an empty stomach will give the maximum concentration of urinary

alcohol for a given quantity of alcohol imbibed. Thus, in this case also, it ought to be possible to say, on the basis of control experiments, that a certain concentration of alcohol in the urine can only be produced as the result of drinking not less than x c.c.m. of alcohol.

3. The Concentration of Alcohol in the Blood is related to Symptoms of Intoxication of the Central Nervous System.

Increasing the amount of alcohol drunk increases both the alcoholic concentration in the blood and the symptoms of intoxication. Gréhan⁸ showed that with increasing quantities of alcohol drunk not only did the point of maximum concentration of alcohol in blood rise, but this remained for a longer time at a high level, thus forming a plateau—the so-called Gréhan plateau. At this stage the animal or man remained for long periods in the "dead drunk" condition.

In Fig. 5, which represents the result obtained by Schweisheimer on abstainers, and moderate and heavy drinkers, it is seen that the concentration of alcohol in the blood of heavy drinkers is much lower than that of abstainers when similar quantities of alcohol are drunk. Schweisheimer considered that this is the reason why the "topers" are less affected than the novices. The symptoms in each case are related chiefly to the amount of alcohol in the blood. One of his conclusions—for which, however, there is no actual evidence in his paper—is that symptoms of intoxication are exactly parallel to the increase and decrease of the alcohol in the blood. To illustrate this from an actual curve he maintained, for example, that the toxic effect of an alcohol concentration in the blood at A (Case iv), a point where the concentration is rising to a maximum, was the same as that at B, a point equal in concentration where the curve is falling. Mellanby pointed out as a result of his experiments that the intoxication at A is greater than at the same level B. Later Miles found a similar result with smaller amounts and weaker concentration of alcohol. This difference between the intensity of intoxication at points of equal alcohol concentration of the blood on the upward and downward curve is probably relatively small with higher concentrations of alcohol in the blood and urine, and does not prevent the blood alcohol being recognized as a fair measure of a man's condition of intoxication. How closely intoxication runs to the blood alcohol was shown by the amounts of alcohol in the blood of a subject of Mellanby who drank the same amount of alcohol under three different conditions: (A) in the form of 20 per cent. solution of whisky on an empty stomach; (B) in stout of strength 5.5 per cent. on an empty stomach; and (C) in stout of 5.5 per cent. strength, but taken two hours after the subject had eaten a basin of bread and milk. As might be expected from the earlier remarks, the concentration of alcohol in the blood was highest in (A), lower in (B), and more depressed in (C) by the bread and milk. Corresponding with these alterations in blood alcohol was the power of the subject to draw a simple diagram. After drinking whisky the rapid rise of alcohol in the blood was accompanied by great inco-ordination in the power to draw, and the descent in the curve by a corresponding recovery.

Referring back to Fig. 2, we see the difference in the maximum concentrations produced by different concentrations of alcohol, and the subject showed corresponding intoxication in the region of maximum concentration. After whisky he showed definite symptoms of gross intoxication. In the case of the 8 per cent. alcohol there were no symptoms of gross intoxication; but his powers of co-ordinating, as tested by Mellanby's method of getting the subject to reproduce a given diagram, were impaired for a considerable period. This same test, applied to the subject after he had drunk the beer, showed such small differences that they are not worth recording.

Method of Applying the Test.

From the experimental evidence given above it is concluded that a knowledge of the concentration of alcohol in the blood is the best guide to alcoholic intoxication. There are obvious objections to the direct method of obtaining the blood concentrations by taking blood

samples, but the above evidence shows that the indirect method of deducing the blood concentration from a knowledge of the urine alcohol concentration gives a close approximation. The problem is to estimate the blood alcohol concentration at the time of arrest. The time of arrest is always noted by the officer. On arrival at the police station the defendant is requested to empty his bladder completely. This specimen of urine should be kept and analysed, even though the resulting figure will give only the mean alcohol concentration over a previous period of unknown duration, but even this figure is of value. The important sample is the next one, which is obtained at the end of, for example, another fifteen minutes. Since only 5 c.cm. of urine are required for doing a duplicate test and for testing for sugar and albumin, the time interval required for this further secretion of urine is not a long one. Let us suppose it is fifteen minutes. Analysis of this sample will give the mean concentration for this interval, or the actual concentration at seven minutes from the time (which will have been noted) when the bladder was evacuated. If the figure 1.35 be taken as the ratio of urine alcohol to blood alcohol, the blood alcohol concentration at this seven-minute interval can be calculated. Knowing this figure and the time interval between the arrest and emptying the bladder, the blood alcohol concentration at the time of arrest is calculated from the fact that alcohol concentration in the blood falls at the rate of about 12 mg. per hour per 100 grams of blood.

There remains for discussion the question whether a blood alcohol concentration figure could be experimentally determined which could be considered as an upper limit as regards the fitness of a person to be in charge of a car. In the opinion of the present writer this is possible if suitable tests, especially those involving judgement, are carried out under actual driving conditions. It is suggested that a number of subjects, used to driving a car, be selected, among these being abstainers, moderate drinkers, and heavy drinkers. These could be put through a series of driving tests (to be decided upon) in such a school as, for example, that in which the drivers of the London General Omnibus Company are tested. If the efficiency of these individuals was determined by these tests before alcohol was given and then afterwards when alcohol had been given to each subject in sufficient quantity to produce approximately the same concentration in the blood and urine of each man, it is maintained that from the results obtained a maximum safety level could be fixed upon for the blood and urine alcohol concentration. It is suggested that this figure be used for comparison with that obtained at the time of arrest of the person accused of being drunk in charge of a car. The writer maintains that this is the only scientific method of estimating intoxication at the time of arrest. The experimental evidence given above shows that there is a basis for the method, which it is hoped may be tried out more fully and under actual driving conditions.

The method of estimating alcohol in the urine is that of Cannan and Sulzer.⁹ It is admirably adapted for such a test, as it can be carried out within half an hour and with as much accuracy as the fat in milk can be estimated. No bodies present in normal urine interfere with the estimation. The effect of the so-called acetone bodies is shown by Table C. It is obviously small, and a routine test with Fehling's solution at once puts one on guard.

TABLE C.

To Test the Effect of Substituting Acetone for Alcohol under the usual Conditions of Estimation.

26.5 mg. of acetone dissolved in 5 c.cm. of water were passed through the apparatus under the same conditions as when estimating alcohol. The result, calculated as alcohol, equals 3.1 mg. of alcohol.

Thus 8 mg. of acetone are equivalent to 1 mg. of alcohol under the experimental conditions.

Tests on Diabetic Urines, from Subjects who had had no Alcohol.

Case 1.—Symptoms severe—air hunger, etc. Urine contained 24 mg. (reckoned as alcohol) per 100 c.cm.

Case 2.—Symptoms not so severe. Urine contained 9 mg. (reckoned as alcohol) per 100 c.cm.

The result with pure acetone makes one doubt whether the 2 to 4 mg. of reducing substance present in normal blood is an acetone body, as has been suggested.

TABLE D.—Summary of Police Court Cases.

No.	Interval.	Urine Alcohol.	Police Remarks.
	mins.	mg.	
1	95	328	When arrested smelt of drink, was unsteady in his gait, and very talkative.
2	5	383	This man was unsteady in gait, incoherent in speech, and appeared dazed. Stated he had been drinking spirits. Completely drunk.
3	72	380.5	This man was not able to walk without assistance, and was in that condition when he leaned to his left side. His breath smelled of drink, and he was dazed. He was able to speak fairly clearly, and stated he had had at least eight pints of beer to drink.
4	15	257	This man had had a considerable amount of intoxicants. His breath smelled of drink. He was very talkative and inclined to be merry and boisterous. His speech was intelligent, and altogether I was of the opinion that he was a person used to taking quantities of alcohol. Certified to be fit to drive a car by police surgeon 45 minutes after arrest.
5	5	323	This man was unsteady in gait, particularly incoherent in speech, and very noisy. His breath smelled of alcohol, and he appeared a typical case of drunkenness. Said he had had six pints of beer.
6	5	232	Unsteady gait, breath smelled strongly of alcohol, quarrelsome.
7	30	366.5	Very talkative. Unable to walk without assistance and smelled strongly of drink.
8	10	316	Unsteady in gait, breath smelled strongly of drink. Inclined to be quarrelsome. Appeared a typical case of drunkenness.
9	10	349	Very unsteady in gait. Breath smelled of alcohol. Was quarrelsome and used obscene expressions.
10	4	315	Very unsteady in gait. Breath smelled very strongly of alcohol. Persisted in the use of obscene language in the cells. Also sang the "Red Flag" when not using foul language.
11	154	223.7	Face flushed, eyes bloodshot. Talked very excitedly, and refused to be seated when asked. Would persist in walking about the office. Smelled strongly of drink, and in order to try to keep a steady gait had to make forced movements of the muscles of his body.
12	23	321.6	Smelled strongly of drink, and stated he had been drinking bitter beer. Had almost lost control of his legs and could not walk without assistance. Did not show any stupidity, but talked all the time in a jocular manner.
13	7	361	Smelled strongly of drink, unsteady in gait. Had fallen and injured nose previous to arrest. Incoherent in speech; inclined to be merry and nasty alternately. Appeared generally to have had plenty of drink. Stated next morning he had had beer and then rum.
14	134	363.5	Unsteady in gait, smelled strongly of drink; said to have consumed several kinds of liquor. Was very drunk.
15	2	270	Unsteady in gait, smelled strongly of drink, sullen and rather quarrelsome. Was rather intelligent when spoken to, and able to give all particulars of himself.
16	13	326	Very unsteady in gait; incoherent in speech; breath smelled of alcohol (should say spirit). Eyes were not alert, but required effort to move. Used obscene expressions, alternating with snatches of song.
17	7	191	Very unsteady in gait; incoherent in speech. Appeared dazed and not able to speak intelligently; was not able to give any particulars of himself. Breath smelled strongly of drink.
18	10	331.6	Incoherent in speech; very unsteady in gait. Sullen and stupid; would give no particulars of himself. Breath smelled of alcohol.
19	128	329	Incoherent in speech; unsteady in gait; eyes not alert. Breath smelled of alcohol. Inclined to be quarrelsome. Said he had had beer and spirits.
20	169	220.4	Flushed face; very excited; unsteady gait. Breath smelled of alcohol. When placed in the cell started singing, then slept for two and a half hours.
21	10	436.8	Incoherent in speech; very unsteady in gait; eyes very dull; seemed very stupid. Too drunk to give any account of himself. Could not stand without support.

TABLE D (continued).

No.	Interval.	Urine Alcohol.	Police Remarks.
	mins.	mg.	
22	14	164	Had been found on tramcar two and a half hours before and taken to hospital, where stomach pump had been used, the doctor stating he was drunk. Pale face, unsteady in gait. Breath smelled of alcohol. Gave particulars of himself intelligently.
23	195	326	The prisoner was in a helpless condition. Her breath smelled strongly of alcohol. Speech was incoherent.
24	15	172	Very unstable; unable to stand without assistance. Flushed face, incoherent speech. Must have had a considerable amount of alcohol.
25	65	278	Face very pale; eyes very wild. Excited when she first entered the police office. Calmed down when questioned. Smelled of drink. Unsteady in gait; had to be assisted to walk. Stupid at times, but showed no violence.
26	50	360	
27	55	367	

The above table (D) is a summary of the twenty-seven police court cases examined.

Most of these are cases of pedestrians suffering from gross alcoholic intoxication. The alcohol concentration figure given is, with the exception of Case 4, the mean figure for a previous period of unknown length. The motorist cases are numbers 4, 11, 26, and 27. These results illustrate some of the weaknesses in the present-day methods. In Case 4 the defendant had a blood alcohol concentration when arrested of at least 180 mg. The charge of having been drunk three-quarters of an hour earlier was dropped when the police surgeon examined him forty-five minutes after arrest and certified him to be fit to drive a car. In Case 11 no special sample was obtained—the figure was a mean concentration. Having (unawares) driven his car on the pavement and knocked two people down, and on returning to the wrong side of the roadway having knocked down a cyclist, he could only confess his guilt. Case 26, one of those referred to in the introduction, is that of the defendant said to be suffering from the effects of influenza; Case 27 is that of No. 26's passenger, who admitted his guilt.

SUMMARY.

We have given evidence to prove:

- (1) The inadequacy of present-day methods of estimating alcoholic intoxication, particularly that of the motorist, who, while showing no signs of gross intoxication, may yet be unfit through alcohol to be in charge of a car.
- (2) That the concentration of alcohol in the blood is the best measure we have of alcoholic intoxication.
- (3) That the concentration of alcohol in the urine is proportional to that of the blood under all conditions so far examined, and have shown that a fairly constant ratio holds which enables us to deduce one concentration from the other.
- (4) That it is possible by this means to obtain a close approximation of the blood alcohol concentration of a person at the time of arrest, and therefore of the degree of alcoholic intoxication.
- (5) That the work justifies tests being carried out to establish an upper limit of blood alcohol concentration for a person to be fit, after taking alcohol, to be in charge of a car.

It is with pleasure that I acknowledge my indebtedness to Professor Edward Mellanby, in whose laboratory my work has been carried out, for his help and criticisms. Also my thanks are due to the True Temperance Research Committee, who have defrayed the cost of my work.

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PUERPERAL MORTALITY.*

BY

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I READILY accepted the invitation of your chairman, Dr. Rocyn Jones, to be present at this meeting of the Monmouthshire Division because, as one of my colleagues on the Welsh Consultative Council, I know him to be keenly interested in the subject of puerperal mortality, and I gather the intention is that I should offer some observations, by way of preamble to the discussion, by the Division, of the interim report of the Puerperal Morbidity and Mortality Committee of the British Medical Association, of which I have the honour to be chairman.

It is admitted, as regards both mortality and morbidity, that there is much room for betterment in this important sphere of medical practice, and that we in Wales and Monmouthshire have especial reason to give the subject our closest and most earnest attention. I feel sure, Sir, that you, in the influential role of county medical officer, must feel as I do in the capacity of a teacher, and as, I believe, those more highly placed in official circles must also feel—that it is easier to fulminate against the general practitioner or the midwife, or both, from the lectern or office chair than to strive, in season and out of season, to render available those conditions of service which are essential for the elimination of many of the factors contributory to the mortality and morbidity rates.

It is undoubtedly true that, if it were possible, a zealous, unvarying application in all the phases (including antenatal) of midwifery practice, and by all persons and bodies concerned therewith, of that knowledge which we already possess would result, even in prevailing environmental conditions, in striking improvement. It is true, too, that, short of this ideal unity of effort, each of us can contribute his quota toward improvement by conscientious use of that knowledge.

Unless, and until, however, further knowledge emerges to illumine some aspects of the problem, there will still always remain a mortality rate sufficiently large to engender concern. It was this consideration, I think, which led the Puerperal Morbidity and Mortality Committee of the Association to submit to the Council a recommendation urging that provision should be made for investigation into the factors which constitute and the conditions which vary resistance to disease, particularly as regards pregnancy and the puerperium. The Council readily concurred, and the recommendation has been referred to the Science Committee of the Association.

The principle underlying the oft-quoted legend which spans the portals of the New York Health Department—to the effect that public health is purchasable, and that, within limits, a community can determine its own death rate—has a very real application to the State responsibility aspect of this question.

To provide those requirements in personnel, equipment, and institutional accommodation, to name no others, which, by common consent, are essential to further lasting improvement in puerperal mortality and morbidity, means money in substantial amount; and let me add that whilst the professional services rendered must be met, in order to secure efficiency, with adequate remuneration, the expenditure under that heading would be by no means the largest item.

In health matters, as in some other concerns, it is extraordinarily difficult to arouse genuine and sufficiently sustained public interest. It took many years of propaganda work, acting on the principle of the summation of stimuli, to convince the public, and, indeed, many members of our own profession, of the need of the Midwives Act, and to bring home the fact that on the date of securing that enactment we were many years behind other civilized communities.

In its own effective, though perhaps undiscerning, way an aroused public opinion will ultimately insist on Parlia-

* Paper introductory to a discussion by the Monmouthshire Division of the British Medical Association, February 26th, 1925.