CLXXXII. p_H OF BLOOD OF PSYCHOTICS MEASURED BY THE GLASS ELECTRODE.

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THE constant p_H of the blood is normally dependent on two mechanisms, renal and respiratory. It has been shown by Golla *et al.* [1928], Golla [1929], Mann *et al.* [1928], Mann and Marsh [1928], Marsh [1929] and Robertson [1927] in a series of papers from this laboratory, that in the psychotic the renal mechanism is intact, but that there is a disturbed regulation of the respiratory mechanism for the control of acid-base equilibrium, as evidenced by delayed response to the stimulation of breathing CO_2 -air mixtures. The object of the work described in this paper is to see whether such a tolerance of increased alveolar CO_2 pressure is reflected in a decreased blood- p_H either in the resting subject or when he is submitted to a stress.

The patients selected for experiment were certified cases of schizophrenia with a few other pathological cases for comparison. A series of normal controls was obtained and this was supplemented by discharged general paralytic patients all of whom were active and in reasonably good physical and mental condition.

For resting values of blood- p_H , the subject was always in the post-absorptive state and was either in bed, or had rested for at least 30 minutes.

The stress consisted, firstly, of ingestion of 20 g. of NaHCO_3 dissolved in half a pint of water, thereby causing a temporary increase in p_H , and secondly, of performing exercise by running or standing running, causing a temporary decrease in p_H .

EXPERIMENTAL.

Blood was obtained from the brachial artery, the median basilic vein and, in a few cases, from the jugular bulb. The samples were collected under paraffin in an all-glass syringe, on the plunger of which a trace of anticoagulant was placed. The blood was run immediately into tubes containing paraffin and a small amount of either heparin or Evans's 9 : 1 mixture of potassium oxalate and sodium fluoride, previously moistened with saline. After stirring the blood with a thin glass rod the tubes were placed in an ice-box.

The apparatus used for p_H measurements was the glass electrode outfit described by Kerridge [1926]. The glass electrode vessels were made from soft laboratory glass tubing of about 9 mm. diameter, the relatively wide opening enabling the lower chamber to be filled or emptied without the necessity of a second arm. After standing in cleaning mixture for a short time they were soaked in distilled water for several days and in some cases it was an advantage to leave them filled with phosphate buffer solution for a few hours before use.

The insulated stand holding the calomel and glass electrodes was contained in an ordinary incubator kept at 38° and connections were made by means of insulated cable wire running through the thermometer hole of the incubator. The inner casing of the incubator was earthed by means of wire connected to the water overflow pipe. This arrangement, whilst by no means so efficient as the large air-oven with fan as used by Kerridge, proved satisfactory for the technique which was adopted.

The calomel electrodes contained saturated KCl and considerable trouble was experienced at first from the crystallisation and creeping of KCl. The difficulty was overcome by allowing the ends of the tubes to dip into saturated KCl solution contained in wide tubes and bridging over from these to the glass electrode chambers by means of saturated KCl-agar tubes. This added to the speed with which it was possible to prepare the electrodes for successive observations and, since readings were made only to the nearest millivolt, did not entail any loss of accuracy.

In the time available, particularly if several determinations had to be carried out on the same day, it was impossible to wait until the blood, run at room temperature into the glass electrode chamber, had reached a temperature of 38°. In spite of the fact that the oven containing the electrode, although momentarily cooled when opened, quickly regained its original temperature, the blood took much longer. The further complication of the "first acid change," noted by Havard and Kerridge [1929], made it essential for readings to be made fairly quickly at temperatures approaching 38°.

It was found very convenient, especially in winter, to work at a blood temperature of 32° to 33°, equilibrium being reached rapidly. This required the application of the Kerridge correction of $-0.015 p_H$ per °C., but had the advantage that it was possible to carry out duplicate determinations on a specimen of blood and the standard buffer solution, all in the same electrode.

The lower chamber of the glass electrode was filled with phosphate buffer solution of p_H about 6.0, and the standard buffer for comparison was always of a p_H to give a potentiometer reading approximating to that of the blood specimen. This was necessitated by the fact that the particular electrodes used seldom gave quite accurate readings when comparing two buffer solutions of widely varying p_H values. Thus, for p_H determinations of the blood of resting subjects, the standard buffer p_H was 7.40 at 33°. This was checked by means of the quinhydrone electrode.

The potentiometer reading for the buffer solution in a clean glass electrode often differed from that of the same solution in the same electrode contaminated with liquid paraffin. To minimise errors therefore the reading for the blood sample was taken first, followed by that of the standard buffer also delivered into the electrode under paraffin, and then a duplicate result was obtained for the blood sample. Hot distilled water was used for washing out the chamber between these operations. Under these circumstances the duplicate readings for the blood sample were taken as sufficiently accurate if they differed by not more than 1 mv., or 0.2 p_H . The results were calculated to 38° by the formula:

$$p_{H\ 38^\circ} = p_{H\ \text{Buffer soln. } 33^\circ} + \frac{(V_1 - V_2)}{60.7} - 0.075,$$

where V_1 is the potentiometer reading in mv. for the blood sample at 33°, and V_2 is that of the standard buffer solution at the same temperature.

On some of the specimens the alkali reserve of the plasma was determined by the indirect (back titration) method.

On the blood samples which were obtained after exercise, lactic acid determinations were carried out by the method of Friedemann, Cotonio and Shaffer [1927], modified by Friedemann and Kendall [1929], the apparatus used being that designed by Davenport and Cotonio [1927]. The percentage recovery of lactic acid was between 95 and 98. When sodium tungstate and sulphuric acid were used for deproteinising, it was found unnecessary to treat the filtrate with copper sulphate and lime, the error involved being negligible within the limits of accuracy of the experiment. This extra stage was, however, necessary when trichloroacetic acid was used as deproteinising agent.

DISCUSSION.

The results obtained with resting subjects are shown in Table I. These show that on the average the p_H of the blood in schizophrenia is quite normal, although the variation appears to be greater than in the normal.

It should also be pointed out that some of the patients became very agitated when being prepared for puncture and this may have caused increased ventilation, with a corresponding small rise in p_H .

The figures for alkali reserve again show no departure, on the average, from the normal.

The next step was to determine the response to bicarbonate ingestion. The figures recorded in Table II show that here again the psychotic behaves in a normal manner, at least in the early stages after ingestion.

A very different condition is seen when the psychotic performs exercise. Many of the patients are, of course, badly out of training and the figures for lactic acid shown in Table III are in the majority of cases out of all proportion to the amount of work actually done. In some cases exercise had to take the form of being pulled along by a male attendant. In Case No. 48 a sample of

Table I. p_H and (alkali reserve in vols. % CO_2) of blood of resting subjects.

Case Nos.	Condition	Arterial	Venous
1-12	Normal, highest	7.39 (57.6)	7.35 (64.9)
	„ lowest	7.35 (53.5)	7.32 (60.5)
	„ mean	7.37 (55.7)	7.33 (62.5)
13-49	Schizophrenia, highest	7.44 (62.0)	7.39 (77.4)
	lowest	7.32 (50.0)	7.29 (57.2)
	mean	7.36 (55.6)	7.32 (63.5)
50-60	Miscellaneous:		
	Paranoia (H.G.D.), resting	7.37	7.32
	Induced tetany, before spasm	—	7.33
	„ „ after „	—	7.35
	„ „ before „	—	7.32
	„ „ after „	—	7.37
	Myasthenia gravis, resting	—	7.33
	Epilepsy, immediately after fit	—	7.44
	Border line D.P., resting	7.31	—
	Imbecile, resting	7.35	—
	„	7.38	—
	Certified G.P.I.	—	7.32
	„ depressive	—	7.31
	Uraemia (severe)	7.25	—
	„ (recovering)	7.32	—

Table II. p_H of venous blood before and after ingestion of $NaHCO_3$ (20 g.)

	Case No.	Before	35 minutes after
Discharged G.P.I.	11	7.33	7.37 (10 g.)
„	12	7.32	7.38 (20 g.)
Certified G.P.I.	58	7.32	7.37 „
Depression	61	7.31	7.36 „
Schizophrenia (active)	38	7.29	7.35 „
„ (stuporose)	39	7.30	7.33 „
„	49	7.31	7.35 „

Table III. p_H of venous blood before and after exercise.

(Figures in parentheses refer to lactic acid content of whole blood in mg./100 cc.)

	Case No.		Resting	5 minutes after exercise
Normal	5	Standing running 1 minute (restrained)	7.33 (13)	7.27 (24)
„	2	Standing running 1 minute (less restrained)	7.34 (10)	7.25 (40)
„	4	Standing running 1 minute (all-out)	7.33 (13)	7.20 (79)
„	4	„	7.35 (12)	7.23 (53)
Schizophrenic	40	Ran with nurse	7.33 (13)	7.18 (84)
„	42	Standing running 1 minute	7.33 (17)	7.20 (63)
„	43	Ran with nurse	7.30 (13)	7.18 (57)
„	45	„	7.32 (11)	7.16 (97)
„	47	„	7.33 (12)	7.18 (88)
„	64	Standing running 1 minute	7.31 (10)	7.25 (29)
„	65	Ran with nurse	7.36 (10)	7.19 (59)
„	48	„	7.37 (23)	7.25 (50)
				(10 minutes after exercise)
Male nurse accompanying No. 48				7.30 (27)
				(8 minutes after exercise)

the attendant's blood taken after the exercise showed only half the lactic acid content of that of the patient. This patient and No. 45 were very agitated.

The length of time after exercise in which the blood-lactic acid concentration reaches a maximum depends on the duration and severity of the exercise. After standing running for 1 minute the maximum occurs between 3 and 7 minutes and for comparable results, therefore, the needle was inserted into an arm vein exactly 5 minutes after exercise. The results indicate that for a given amount of lactic acid in the blood after exercise the p_H is definitely below that of the normal. This is shown more clearly by the graphical representation in Fig. 1.

Fig. 1. p_H and lactic acid content of whole venous blood, 5 minutes after exercise.

In view of the normal figures for alkali reserve, this can only be accounted for by decreased ventilation on the part of the patient and supports the contention of Golla and Mann that in the psychotic there is a diminished excitability of the respiratory centre to carbon dioxide. It remains an open question, however, how far the results obtained could be interpreted purely on the ground of lack of training.

SUMMARY.

1. The use of the glass electrode for semi-routine determinations of p_H is described.
2. The p_H of arterial and venous blood of normals and psychotic patients has been determined when the subject is in the resting condition and when he is submitted to the stress of alkali ingestion or of acid accumulation due to exercise.
3. The results, which are tabulated, show no significant difference of schizophrenics from the normal either in the resting condition or in the early stages after alkali ingestion.
4. It is shown that as a result of exercise the schizophrenic has a blood- p_H lower than that of the normal for a given lactic acid content, and it is argued that this is due to diminished excitability of the respiratory centre.

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