CXII. EXPERIMENTAL ALTERATIONS IN THE CALCIUM CONTENT OF HUMAN SERUM AND URINE.

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THE most successful attempts to vary the calcium content of normal human serum seem to have been those of Blum, Aubel and Hausknecht [1921], who obtained rises of up to 13 % by the oral administration of calcium chloride, Grant and Goldman [1920] who obtained rises of from 4.4 to 11.9 % by forced breathing, and György [1922], who obtained still larger rises on spasmophilic children with ammonium chloride. In our own experiments, which were all carried out on J.B.S.H. (103 kilograms), we confirmed the above results, and also employed other methods for varying the calcium of the serum.

For serum estimations we used the method of Kramer and Tisdall [1921], the blood being allowed to clot by standing over-night (*i.e.* 18 hours) in a closed tube. All determinations were done in duplicate, and the maximum difference was only 2 % of the amount of calcium found. A few magnesium determinations in serum were also made by the same authors' method. For calcium in urine, the method of Shohl and Pedley [1922] was used.

The results obtained on the calcium and magnesium of the serum are summarised in the Table. In the last experiment with NaHCO_3 the deter-

Experiment	Time of drawing blood	mg. Ca per 100 cc. serum	mg. Mg per 100 cc. serum
Normal	—	9.5, 9.5, 9.6	2.48, 2.51
12.30–6.0 p.m. 30 g. CaCl_2 ingested	2.30 p.m.	11.7	—
	6.30 p.m.	11.9	2.51
	10.0 a.m. next day	11.1	—
90 minutes forced breathing	End of period	11.4	2.50
90 minutes breathing 6–7 % CO_2	“ ”	11.1	—
90 minutes breathing 6–7 % CO_2	“ ”	11.7	2.48
25 g. NH_4Cl ingested	Later in day	10.45	2.56
Day 1; 15 g. NH_4Cl ingested	Day 2	10.5	—
Day 2; 25 g. NH_4Cl ingested	“ 3	10.65	—
Day 3; 25 g. NH_4Cl ingested	“ 5	9.4	—
11.30 a.m.–2.30 p.m. 60 g. NaHCO_3 ingested	3 p.m.	9.8	—
	6 p.m.	8.7	2.36
8.30 a.m.–3.0 p.m. 60 g. NaHCO_3 ingested	3 p.m.	8.35	—
	5 p.m.	7.5	—
Overnight 30 g. NaHCO_3 ingested; 10 a.m.–2 p.m. 60 g. NaHCO_3 ingested	4.30 p.m.	8.1	—
		(6.2 “active”)	
12.30–1.15 p.m. 25 g. MgCl_2 ingested	3.0 p.m.	9.5	—
	6.0 p.m.	9.7	2.60

Urines were collected at 9.30 a.m. and p.m., the first sample being from 9.30 a.m.–9.30 p.m. 25 g. NH_4Cl were taken on days 1 and 2, 15 g. on day 3, and 15 g. $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ on the evening of day 7.

mination was very kindly made by Dr H. W. C. Vines by his method [1921]. The urinary output of calcium varied between 127 and 178 mg. on seven normal days, the mean being 156. After CaCl_2 ingestion Haldane, Hill and Luck [1923] found that it might exceed a gram per day. The effects of NH_4Cl are shown in the figure. NaHCO_3 produced no definite effect. On a day in which 90 g. were taken 201 mg. of calcium were excreted, but this small rise was perhaps due to a doubling of the urinary volume. The ingestion of 90 g. of hydrated sodium acetate, which was largely oxidised to bicarbonate, giving an alkaline urine containing acetone bodies but no increased diuresis, led to the excretion of only 103 mg.

DISCUSSION.

The changes in the magnesium of the serum are hardly significant. The increased calcium excretion caused by NH_4Cl resembles the increased sodium and potassium excretion described by Haldane, Wigglesworth and Woodrow [1924] in the same experiment, and is presumably due to demineralisation of the tissues. Changes in the calcium content of the serum may be due to at

least two causes. As most of the calcium is associated with colloids and indiffusible, a change in the colloid content of the serum will generally cause a change of calcium content in the same sense. The amount of free calcium may also vary, that associated with the colloids varying in the same sense. Such facts may explain the unexpected agreement between the effects of breathing CO_2 and of overbreathing. The effect of NH_4Cl is probably due at least in part to a concentration of serum colloids parallel with that of the haemoglobin observed by Baird, Douglas, Haldane and Priestley [1923], though presumably the calcium leaving the bones and other tissues must contribute to this increase. With CaCl_2 , which causes an acidosis like that of NH_4Cl , the observed increase is about half accounted for by this fact, the remainder being due to the calcium absorbed. The main interest of the experiments is that the calcium content of the serum can very easily be altered by a number of methods; but the causes of the alterations are by no means clear.

SUMMARY.

The calcium content of human serum can be raised by 10 to 20 % by ingestion of calcium or ammonium chloride, by breathing 6 to 7 % carbon dioxide, or by forced breathing. It can be lowered by 10 to 20 % by ingestion of sodium bicarbonate.

The urinary calcium output is increased by ingestion of ammonium chloride, little affected by sodium bicarbonate.

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