THE CAUSE OF THE EXCESSIVE CALCIUM EXCRETION THROUGH THE FECES IN INFANTILISM.*

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Many clinical investigators have called attention to cases of failure of development in children and of diseases of the bones in adults following certain forms of intestinal disturbance,[1] and a large proportion of the investigators interested in rickets and various forms of arthritis deformans insists that disturbances in the intestinal canal cause these conditions. But the relationships observed in most of these cases have been rather obscure. The most definite relationship between failure of development and disturbance of bone growth on the one hand, and a disturbance of intestinal function on the other, has been found in the cases of infantilism of the type of Herter. In infantilism of this type there is general retardation in the growth of the body and our observations seem to indicate that this general retardation in growth is secondary to a retardation of the growth of the skeletal system. The bones are frail and thin and fracture easily, and chemical investigation shows disturbances of the calcium metabolism.[2] Complete metabolism experiments show a negative calcium balance in spite of which it is surprising to note that the urine is almost free from calcium, the excess passing off almost entirely in the feces which contain large amounts of this element. In view of the great importance of the subject, this definite finding of a flux of calcium into the intestine in a condition in

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[1] Schütz, R., Sammlung klinischer Vorträge, 1901, No. 318 (Innere Medizin, No. 94), 607; *Jahrb. f. Kinderheilk.*, 1905, lxii, 794; *Deutsch. Arch. f. klin. Med.*, 1908, xciv, 125.

Heubner, O., *Jahrb. f. Kinderheilk.*, 1909, lxx, 667.

Koll, E., *Deutsch. Arch. f. klin. Med.*, 1910, c, 487.

[2] McCrudden, F. H., *Jour. Exper. Med.*, 1912, xv, 107; McCrudden, F. H., and Fales, H. L., *ibid.*, 113, 450, 457.

which there is a general retardation of growth and a special disturbance of bone growth seemed worth following further. What is the cause of this flux of calcium?

The analyses reported in the present paper were made with the object of testing three hypotheses relating to the cause of the loss of calcium through the feces. The first is that in this condition there is a primary disturbance of the fat digestion leading to the excretion of large quantities of calcium through the feces in the form of calcium soaps. This hypothesis, suggested by Herter,[3] was based on the finding of large quantities of fats and especially soaps in the feces in certain cases. A second hypothesis is the one to which loss of calcium in rickets is sometimes attributed, namely, that excessive quantities of phosphate in the feces lead to a large loss of calcium phosphate; and a third is that increased intestinal fermentation gives rise to the formation of large quantities of volatile fatty acids which lead to the excretion of calcium in the form of calcium salts of these acids.

In order to determine if the quantities of fatty acid, phosphate, or volatile acid were in great enough excess to account for the losses of calcium, the following substances were determined quantitatively: fats, fatty acids, volatile acids, calcium, magnesium, nitrogen, and sulphur. The following method of calculation was used. The quantity of phosphate necessary to neutralize the magnesium was subtracted from the total phosphate present. The amount of calcium necessary to combine with the remainder of this phosphate was subtracted from the total calcium. The calcium remaining was expressed as centimeters of normal calcium oxide, and from this was subtracted the sum of the fatty and volatile acids expressed in the same terms, which gives the quantity of calcium not combined with phosphate, fatty acid, or volatile acid. This method of calculation is not intended to indicate that the elements are supposed necessarily to be combined in exactly this way in the feces. There are small amounts of chloride present,[4] some of the magnesium is un-

[3] Herter, On Infantilism from Chronic Intestinal Infection, New York, 1908.

[4] The amounts of chloride, silicic acid, potassium, sodium, and iron in the feces are small (Schmidt, A., and Strasburger, J., Die Faeces des Menschen im normalen und krankhaften Zustande, 3d edition, Berlin, 1910, chapter XVIII).

doubtedly present as soap and some of the fatty acid is probably combined with small amounts of the potassium, sodium, and ammonium present.[5] It is not intended that the method of calculation should be considered as having a general application. But for the purpose of the present tests, namely, to determine if phosphates, fatty acids, or volatile acids are in excess of calcium and magnesium, the method of calculation is correct.

The patients reported as F. S. and F. H. in the table are cases of infantilism of the type of Herter. Wm. McC. is a normal boy of the same age as F. S. E. B. is a case of achondroplasia. J. P. is seventeen years old and has infantilism probably of the type of Lorraine. In the last three of these cases no disturbance of calcium metabolism was observable. They were studied for comparison. The table shows the results.

Column 15 gives the amount of phosphate calculated as phosphorus necessary to combine with magnesium oxide to form magnesium ammonia phosphate. The results in column 16 are obtained by subtracting those of column 15 from those of column 5 and give the amount of phosphorus left after subtracting that combined with magnesium oxide. Column 17 gives the amount of calcium oxide necessary to combine with all the phosphate not combined with magnesium oxide. The results in column 18 are obtained by subtracting the values in column 17 from those in column 3 and give the amount of calcium oxide not combined as phosphate. Columns 12 and 14 give respectively the amounts of fatty acid and volatile acid in terms of cubic centimeters of normal acid. Column 19 gives, in the same terms for comparison, the calcium oxide which is not combined as phosphate. Column 20 is obtained by subtracting the results in column 19 from those in column 14 and represents the quantity of calcium left over, not combined as either phosphate or soap and expressed in terms of cubic centimeters of normal solution. In column 21 these results are expressed in grams of calcium.

The amount of calcium combined as sulphate is more difficult to estimate. The ratio of sulphur to nitrogen (1:10) is about the average ratio in which these elements occur in various protein materials, and so is probably mostly in organic combination; but even if we assume that the sulphur occurs almost entirely as sulphate and is not at all combined with other bases, it would account for very little of the calcium.

[5] Ammonia was determined in scattered specimens but not in large amounts.

TABLE I.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
					Total fat.		Neutral fat.		Fatty acid and soap.								Calcium oxide not combined with phosphorus.		Calcium oxide not combined with phosphate or fatty or volatile acids.			
	Total weight of stool.	Calcium oxide.	Magnesium oxide.	Phosphorus.	Per cent.	Weight.	Per cent.	Weight.	Per cent.	Weight.	As normal stearic acid in c.c.	Volatile fatty acid as normal acid in c.c.	Fatty acid plus volatile acid.	Phosphate combined with magnesium oxide.	Phosphate left to combine with calcium oxide.	Calcium oxide combined with phosphorus.	In gm.	As normal calcium oxide in c.c.	As normal calcium oxide.	In gm.	Nitrogen.	Sulphur.
F. S. 6 days.	231.1	10.26	1.700	7.34	14.80	34.20	3.40	7.86	11.40	26.35	92.80	9.54	102.34	2.99	4.35	3.44	6.82	243.6	141.3	3.95	13.52	(1.220)[6]
F. H. 6 days.	117.3	8.785	1.841	(8.14)[6]	16.00	18.38	10.70	12.55	5.35	6.27	22.08	6.69	28.77	3.24	4.90	3.86	4.93	176.1	147.3	4.13	5.40	0.676
Wm. McC. 6 days.	122.6	10.19	1.618	4.39	23.20	28.45	5.80	7.11	17.30	21.20	74.60	10.57	85.17	2.84	1.55	1.22	8.97	320.4	235.2	6.59	6.49	0.580
J. P. 10 days.	156.9	5.93	1.466	3.04	11.66	18.30	8.30	13.02	3.36	5.26	18.52	11.76	30.28	2.58	0.46	0.36	5.57	198.9	168.6	4.72	8.76	0.859
E. B. 8 days.	160.4	5.19	1.900	5.60	9.81	15.75	7.29	11.69	2.52	4.04	14.22	14.90	29.12	3.34	2.26	1.78	3.41	121.7	92.6	2.59	8.65	0.917

[6] This result was calculated from an average of other stools.

It will be seen that the fats, fatty acids, and volatile acids do not vary very much in any of the cases, and, furthermore, that a very large part of the calcium,—about half in all cases,—cannot be combined with either phosphate or volatile fatty acid, but must be combined with substances at present not known. As far as our results go, the calcium seems to be combined in about the same way in the abnormal as in the normal cases, and one might be tempted to say that the disturbance does not lie in the intestine. We are not justified in saying this, however, since the mode in which about half the calcium is combined is still unknown. In view of our present ignorance concerning the form of combination of the bases in normal feces, and until we have more information on this point, it is futile to engage in speculation concerning the form in which the calcium is lost in the feces in these cases of infantilism.

SUMMARY.

Analyses of the principal known bases and acids of the feces in cases of infantilism in which excessive amounts of calcium are being lost, and comparison with cases which are normal in this respect, show that the fats, fatty acids, and volatile acids are not high, and lead to the conclusion that the loss of calcium is not secondary to the presence of large quantities of phosphates, fatty acids, or volatile acids.