THE EXCRETION OF SODIUM CHLORID SOLUTION , INJECTED SUBCUTANEOUSLY *

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Hypodermoclysis as a means of replacing the loss of fluid which occurs in severe diarrhea, protracted vomiting or as a result of hemorrhage has been employed for a number of years with an increasing appreciation of its value in these conditions. Our studies of diarrheal stools showed great loss of salts, especially the more soluble ones, sustained in these intestinal conditions. It seemed to us, therefore, that benefit should result from the restitution not only of the water lost, but also of some of the salts themselves. The nature of the variations in weight after hypodermoclysis suggested that these were due to something more than simply a retention of the water injected. Moreover, in view of the necessity in many cases of repeating the injections, it was desirable to know exactly what the salt retention was. The observations which are included in this paper were undertaken to determine if any of the salt so given was retained, or how rapidly it was eliminated.

The solution employed was made from freshly distilled water and sterilized in the hypodermoclysis flask. This is an ordinary small-necked flask of about 250 c.c. capacity, fitted with a two-hole rubber stopper carrying short pieces of glass tubing, one of which is connected by rubber tubing with an ordinary hypodermic needle. The bottle containing the solution, heated to body temperature, is fastened, inverted, near the bed at a suitable height and kept sufficiently warm by being wrapped in a cloth. The needle is usually inserted in the back, preferably between the scapulae, and held in place by strips of adhesive plaster. The entire apparatus as well as the solution is sterilized and the injection is made with aseptic precautions.

Generally a physiologic salt solution was used; but in several instances a special solution, one suggested by Dr. Jacques Loeb, was employed as more nearly approximating the salt content of the blood than does a normal saline. The composition of this solution was sodium chlorid 0.86 gm., potassium chlorid 0.02 gm., calcium chlorid

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0.64 gm. (including water of crystallization), and distilled water 100 c.c.

In the cases here reported about 200 c.c. of the solution was allowed to run into the tissues. This usually required from one to three hours according to the degree of dehydration of the body of the infant, those most dehydrated taking up the solution most readily. Also, the first injections were taken up more rapidly than those given on succeeding days. The rate of absorption varied greatly, the time required for complete disappearance of the fluid from the site of injection ranging from four to twelve hours. The rate was slower in subsequent than in first injections.

Careful temperature records after injection were kept by Dr. C. B. Crawford of the resident staff in a large series of cases. A slight febrile reaction occurred in about one-fourth the children, even when the strictest precautions in preparing the solution were observed. The average temperature was about 101.5 F., though occasionally in susceptible infants temperatures as high as 103 were recorded. The rise of temperature commenced four or five hours after the beginning of the injection and continued on an average for six hours.

Whether the injection of the solution affects the volume of the urine and the number and character of the stools is a question regarding which there has been very little positive knowledge. Nor have many observations been made on the elimination of the salts after hypodermoclysis.

The literature of the last ten years contains numerous contributions on sodium chlorid metabolism. The point which has received most attention is the influence of salt on the body temperature. Besides this there have been a number of studies on the effect of the salt intake on the body weight. Several papers have discussed the difference in the effect of salt given by mouth and that given by hypodermic injection. A number of metabolism studies have been made on adults after salt injections, but we have been able to find only a single paper which gives metabolism figures in infants after salt injections.

Friberger[1] reports on five infants (four of whom were healthy) who received from 60 to 80 c.c. of a normal salt solution hypodermically. He found some increase in the salt excretion on the first day; the maximum excretion, the second day, and an excessive excretion continuing for two or three days longer. These observations, as far as they go, agree with our findings; but the number of cases is small, the amount injected was much less than in the cases reported here, and all of his observations, with but one exception, were on healthy children.

1. Friberger: A Study of So-Called Salt Fever and Chlorin Excretion in Infants, Arch. f. Kinderh., 1910, **53**, 17.

The series of investigations here reported was made with the view of determining the effect of hypodermoclysis on salt metabolism, and as far as possible on water metabolism in infants. For the last three years hypodermoclysis has been in daily use at the Babies' Hospital in a wide variety of conditions and has been given to many hundreds of children. Out of this number, twenty-four have been selected for special study. Of these, nine represent the type for whom hypodermoclysis is most frequently employed therapeutically; while fifteen, who may be considered normal children, were studied as controls. The age, food and general condition of these children are given in Table 1.

In eleven of the children the special salt solution mentioned was used; in the others the ordinary physiologic salt solution. The use of the Loeb solution was discontinued, because no clinical difference or unusual variations in metabolism could be discovered with its use.

In every instance the child was placed in the metabolism bed and total twenty-four hours' urine and feces were collected for one or two days before the salt solution was injected, and as a rule for three days after the injection. It would doubtless have been better to have had longer periods of observation, but it commonly happened that after five or six days conditions rendered it desirable to make changes in the treatment, thus necessitating comparatively short metabolism periods. It is also to be regretted that the intake by mouth unavoidably varied so much in some of the cases. It was the desire to make the observations under natural conditions and no attempt was made to force food when it was refused. The injection was always given at the beginning of a metabolism day.

In the first eleven cases complete metabolism studies were made of water, nitrogen, total ash, calcium oxid, magnesium oxid, phosphorus pentoxid, chlorin, potassium oxid and sodium oxid. In the remaining thirteen cases, however, only water and chlorin were determined. The separate determination of sodium oxid was omitted, being laborious and apparently of no importance for our purposes. If the sodium chlorid equivalent is desired it is obtained by multiplying the figure for chlorin by 1.648. In speaking of a water balance, it must be kept in mind that the water lost in the respiration and perspiration was not considered.

The methods used are the same as those reported in former papers from these laboratories.[2]

The only salt which could be expected to show a marked difference in the elimination after hypodermoclysis, even when the Loeb solution is used, is sodium chlorid, as this is the only one injected in any con-

2. Holt, Courtney and Fales: Chemical Composition of Diarrheal as Compared with Normal Stools in Infants. Am. Jour. Dis. Child., 1915, **9**, 213.

TABLE 1.—Age, Food and General Condition of Infants Used in Investigations of Effect of Hypodermoclysis on Salt and Water Metabolism

Name	Age,	Initial Weight, Gm.	Condition	Food	Stools
1. L. O.	10¼	5,285	Previously normal, but developing diarrhea	Protein milk	Watery and semiformed with fat-curds and mcus, yellow-brown and green
2. R. S.	12	7,143	Normal.....	Whole milk, 2 eggs, 1 oz. beef juice.....	Brown, soft, formed
3. H. R.	6	5,651	Normal, except for rickets	Fat 2.2, carbohydrate 6, protein 2, including dextrimaltose	Partly constipated, hard, brown; partly pasty, granular, with fat-curds and mucus
4 Jos. M. ..	17	10,305	Normal.....	Whole milk, 2 oz. cereal, 2 eggs.....	Pasty, semiformed with fat-curds and mucus, brownish yellow; later becoming watery and fermentative
5 Jos. S. ...	17½	9,615	Normal, after eczema	⅔ milk, ⅓ barley water, ⅔ water; 2 eggs; ½ oz. scraped beef	Thin, with mucus, yellow-brown
6. H. B.	13	6,998	Normal.....	Whole milk, cereal, bread, 12 c.c. malt soup extract	Partly formed, constipated, brown; partly pasty, granular with mucus and fat-curds, greenish brown
7. S. J.	9	4,897	Normal, but developed diarrhea during period	Fat 2.4, sugar 3, Protein 2.2, from condensed milk; barley flour 45 c.c.; cane sugar 15 c.c.	Partly formed, partly pasty; later becoming fermentative, with curds
8. T. M.	13¼	7,749	Normal.....	Whole milk, 2 oz. cereal.....	Partly pasty; partly watery, with fat curds, greenish
9. J. T.	9	6,650	Normal, except for rickets	Fat 3, sugar 4, protein 2.8; barley flour 45 c.c. ..	Partly constipated; partly softer, semiformed; brown
10. J. M.	11	7,359	Convalescent from scurvy	Skimmed milk; orange juice.....	Partly formed; partly pasty and watery, with fat-curds; yellow and gray
11. W. C.....	6	7,179	Normal.....	Fat 2.4, sugar 4, protein 2.2; ½ egg.....	Mostly formed; partly pasty, with mucus; yellow-brown and yellow

12. P. D., 1..	3½	3,686	Convalescent from diarrhea and vomiting	Protein milk	Partly formed; partly watery, with fat-curds; greenish yellow and gray
13. P. D., 2..	7½	4,761	Normal.....	Fat 2.8, sugar 4, protein 2.6; ¾ oz. malt soup extract; 75 c.c. uncooked barley flour	Soft, formed, brown
14. M. di G.	5¼	4,305	Normal.....	Fat 2, sugar 2.5 protein 1.8, from condensed milk; imperial granum 30 c.c.; cane sugar 15 c.c.	Partly pasty, partly watery, with fat-curds and mucus; pale yellowish green
15. P. M.	3½	3,670	Normal.....	Protein milk, 5 feedings; and 2 feedings, fat 1.6, sugar 5, protein 1.4; 30 c.c. imperial granum in protein	Partly formed, brown; partly pasty and watery, greenish
1. I. G.	2½	2,814	Losing weight.....	Fat 1.8, sugar 2.25, protein 1.6, from condensed milk; barley flour 30 c.c.; cane sugar 8 c.c.	Loose, pasty, fermentative, with curds and mucus, greenish yellow
2. E. K.	6	3,765	Vomiting and losing weight	Fat 1.2, sugar 4, protein 2.2.....	Hard, formed, smooth, gray; later becoming softer, semiformed
3. J. C.	3½	4,358	Diarrhea.....	Protein milk	Watery, with fat-curds and mucus, greenish yellow
4. T. M.	2¼	2,855	Marasmus with diarrhea	Protein milk, barley water.....	Very watery, fermentative, with fat-curds and mucus, yellowish green
5. V. V.	2¼	2,953	Vomiting and losing weight	Fat 1.6, sugar 5, protein 2.2.....	Partly pasty, partly watery, with fat-curds and mucus; greenish yellow
6. J. B.	4½	3,716	Marasmus with diarrhea	Protein milk; 30 c.c. dextrimaltose.....	Very watery, with fat-curds and mucus
7. L. M.	5	4,432	Diarrhea and vomiting	Protein milk	Watery, with curds and mucus, greenish yellow; later becoming pasty and gray
8 J. P.	8	6,778	Diarrhea and vomiting	Protein milk; albumin water.....	Watery, with fat-curds and mucus, yellowish green and brown
9. C. B. ...	2	2,759	Marasmus with diarrhea	Protein milk; barley water; breast milk.....	Very watery, with fat-curds and mucus, greenish

TABLE 2.—METABOLISM STUDIES OF WATER—

Name	Period	Water Balance, C.c.							Chlorin Bal., Gm.	
		Intake by Mouth	Injected	Total Intake	Urine	Feces	Total Excretion	Retained	Intake by Mouth	Injected
1. L. O.	Before injection (daily aver,)	1,231	.....	1,231	470	187	657	574	0.8773	.....
	1st day after....	1,149	193	1,342	450	358	808	534	0.6199	1.351
2. R. S.	Before injection	921	.....	921	300	24	324	597	1.1726	.....
	1st day after....	1,113	198	1,311	577	38	615	696	1.1808	1.1286
3. H. R.	Before injection	1,015	.....	1,015	620	13	633	382	0.7046	.....
	1st day after....	1,131	212	1,343	700	63	763	580	0.7192	1.1872
	2d day after....	1,121	.....	1,121	795	39	834	287	0.7262	.....
4 Jos. M.	Before injection	771	.....	771	255	65	320	451	1.7956	.....
	1st day after...	400	230	630	410	72	482	148	0.925	2.852
	2d day after....	521	.....	521	385	268	653	—132	1.0802	.....
5. Jos. S.	Before injection	625	.....	625	140	137	277	348	1.0203	.....
	1st day after....	649	235	884	220	93	313	571	1.0678	1.2925
	2d day after....	695	.....	695	330	154	484	211	0.7807	.....
6. H. B.	Before injection (daily aver,)	1,035	.....	1.035	660	50	710	325	1.6876	.....
	1st day after....	980	160	1,140	720	99	819	321	1.6265	0.8840
	2d day after....	1,005	.....	1,005	478	73	551	454	1.6543	.....
	3d day after....	1,010	.....	1,010	550	59	609	401	1.6598	.....
7. S. J.	Before injection (daily aver,)	955	.....	955	305	81	386	569	0.835	.....
	1st day after....	1,055	180	1,235	630	191	821	414	0.923	0.994
	2d day after....	1,105	.....	1,105	420	200	620	485	0.966	.....
	3d day after....	1,130	.....	1,130	290	284	574	556	0.988	.....
8. T. M.	Before injection	920	.....	920	175	194	369	551	1.3685	.....
	1st day after....	845	209	1,054	305	170	475	579	1.2523	1.0805
	2d day after....	830	.....	830	380	149	529	301	1.2301	.....
	3d day after....	970	.....	970	378	135	513	457	1.4375	.....
9. J. T.	Before injection (daily aver,)	858	.....	858	248	36	284	574	0.628	.....
	1st day after....	845	190	1,035	435	27	462	573	0.619	1.0877
	2d day after....	855	.....	855	500	29	529	326	0.625	.....
	3d day after....	800	.....	800	480	28	508	292	0.586	.....
10. J. M.	Before injection	952	.....	952	285	68	353	599	0.8480	.....
	1st day after....	1,030	206	1,236	235	89	324	912	0.7920	1.5553
	2d day after....	1,123	.....	1,123	410	82	492	631	0.8949	.....
	3d day after....	962	.....	962	400	75	475	487	0.8546	.....
11. W. C.	Before injection	865	.....	865	630	76	706	159	0.5420	.....
	1st day after....	1,065	215	1,280	700	0	700	580	0.5280	1.1610
	2d day after....	1,125	.....	1,125	830	48	878	247	0.4716	.....
	3d day after....	1,130	.....	1,130	790	21	811	319	0.5744	.....

Chlorin Balance, Gm.					Summary
Total Intake	Urine	Feces	Total Excretion	Retained	
0.8773	0.0086	0.4678	0.4764	0.4009	All injected chlorin and water were eliminated in 24 hours; the water mainly through the feces, the chlorin equally in urine and feces
1.9709	0.5175	1.0498	1.5673	0.4036	
1.1726	0.492	0.0117	0.5037	0.6689	More than the amount of injected chlorin was eliminated in 24 hours; not more than half the water; the increased excretion was practically all in the urine
2.3094	1.7577	0.0228	1.7805	0.5289	
0.7046	0.4464	0.0081	0.4545	0.2501	The elimination of injected water and chlorin was slightly greater in the second 24 hours than in the first; somewhat more than the amount of injected chlorin was lost in 48 hours, but only half the water. The increased chlorin excretion was mainly through the urine, the water in both urine and feces
1.9064	0.9932	0.0540	1.0472	0.8592	
0.7262	1.0922	0.0338	1.1260	−0.3998	
1.7956	1.3158	0.0939	1.4097	0.3859	The injected chlorin was eliminated largely through the urine, the greater part in the first 24 hours; the injected water also in the first 24 hours' urine and a large amount besides in the feces of the second 24 hours; much more than the amount of both water and chlorin injected lost in 48 hours
3.7770	2.7267	0.0272	2.7539	1.0231	
1.0802	1.8446	0.1898	2.0344	−0.9542	
1.0203	0.4928	0.2262	0.7190	0.3013	Nearly all the injected chlorin eliminated in the first 24 hours and greatly increased excretion for 36 hours longer (the period of observation); increased water elimination in the second 24 hours, but not all the injected water lost; the increased excretion was in the urine
2.3603	1.7795	0.1620	1.9415	0.4188	
0.7807	1.4100	0.0777	1.4877	−0.7070	
1.6876	1.6104	0.0256	1.6360	0.0516	All the injected water and chlorin eliminated, mainly in the urine of the first 24 hours, after which the excretion was greatly decreased from the normal; retention therefore increased
2.5105	2.5200	0.0552	2.5752	−0.0647	
1.6543	1.2650	0.0409	1.3059	0.3484	
1.6598	1.4410	0.0327	1.4737	0.1861	
0.835	0.5216	0.0451	0.5667	0.2683	All the injected water and chlorin eliminated in the first 24 hours, the water and most of the chlorin through the urine; further loss of both chlorin and water through the feces, but to an increasing diarrhea following hypodermoclysis; diarrhea possibly due to feeding of high carbohydrate
1.9170	1.4364	0.2480	1.6844	0.2326	
0.966	0.7182	0.2610	0.9792	−0.0132	
0.988	0.6560	0.3690	1.0250	−0.0370	
1.3685	0.6720	0.0287	0.7007	0.6628	Practically all the injected water and chlorin lost in the first 24 hours' urine; but increased excretion of both water and chlorin continued 48 hours longer, resulting in greatly reduced average daily retention; feces somewhat reduced in both water and chlorin
2.3328	1.6000	0.0190	1.6190	0.7138	
1.2301	1.3440	0.0167	1.3607	−0.1306	
1.4375	1.1760	0.0151	1.1911	0.2464	
0.628	0.4695	0.0267	0.4962	0.1318	All injected water eliminated in urine in the first 24 hours; but increased excretion continued during period of observation (three days); about half the injected chlorin eliminated in first 24 hours' urine; increased excretion continued through period of observation, but not quite all injected chlorin was lost in 72 hours
1.6567	1.0266	0.0164	1.0430	0.6137	
0.625	0.7000	0.0172	0.7172	−0.0922	
0.586	0.6000	0.0171	0.6171	−0.0311	
0.8480	0.4418	0.0140	0.4558	0.3922	No injected water eliminated; chlorin excreted in part the first day, the maximum amount on the third day; nearly all the increased excretion was through the urine, both water and chlorin in the feces being only slightly increased; part of the chlorin was retained at the end of the third day, though increased excretion was continued
2.3473	0.8037	0.0185	0.8222	1.5251	
0.8949	0.7134	0.0159	0.7293	0.1656	
0.8546	0.9000	0.0304	0.9304	−0.0758	
0.5420	0.3780	0.0685	0.4465	0.0955	No injected water eliminated during time of observation; feces decreased and urine not increased so much as the intake by mouth; more than the amount of injected chlorin was eliminated in three days, somewhat more on the second and third days than on the first; increased excretion entirely through the urine
1.6890	0.8536	0.0000	0.8536	0.8354	
0.4716	0.9482	0.0264	0.9746	−0.5030	
0.5744	0.9408	0.0086	0.9494	−0.3750	

TABLE 2.—METABOLISM STUDIES OF WATER AND

Name	Period	Water Balance, C.c.							Chlorin Bal., G	
		Intake by Mouth	Injected	Total Intake	Urine	Feces	Total Excretion	Retained	Intake by Mouth	Inject
12. P. D., 1.....	Before injection	651	.....	651	400	70	470	181	0.4626	.....
	1st day after....	806	196	1,002	405	37	442	560	0.5603	1.372
	2d day after....	798	.....	798	400	90	490	308	0.4351	.....
	3d day after....	811	.....	811	335	67	402	409	0.4805	.....
13. P. D., 2.....	Before injection (daily aver,)	1,101	.....	1,101	617	28	645	456	0.7280	.....
	1st day after....	1,035	210	1,245	575	23	598	647	0.6940	1.186
	2d day after....	1,006	.....	1,006	670	65	735	271	0.6940	.....
	3d day after....	1,065	.....	1,065	675	43	718	347	0.7160	.....
14. M. di G.	Before injection	895	.....	895	445	177	622	273	0.7151	.....
	1st day after....	875	144	1,019	495	125	620	399	0.7000	0.754
	2d day after.... (2d injection)	930	206	1,136	725	159	884	252	0.7430	1.071
	3d day after....	965	.....	965	480	101	581	384	0.7710	.....
	4th day after....	945	.....	945	390	148	538	407	0.7560	.....
15. P. M.	Before injection (daily aver,)	807	.. ..	807	535	25	560	247	0.5420	.....
	1st day after....	920	100	1,020	515	24	539	481	0.5199	0.700
	2d day after.... (2d injection)	804	200	1,004	700	30	730	274	0.4861	1.420
	3d day after....	902	.....	902	520	16	536	366	0.4231	.....
	4th day after....	938	.....	938	530	25	555	383	0.5489	.....

siderable amount. It is, therefore, to this and to the water that the attention was especially directed.

As already stated, with eleven of the children complete metabolism studies, both before and after injection, were made of calcium oxid, magnesium oxid, phosphorus pentoxid and potassium oxid, as well as of sodium oxid and chlorin; but except as regards sodium oxid and chlorin, the differences between the retention before and after hypodermoclysis were no greater than the variations ordinarily observed when no injection of salt has been given. Moreover, there was no uniformity in the elimination of calcium oxid, magnesium oxid, phosphorus pentoxid and potassium oxid after the injections; sometimes the retention was practically unchanged, at other times there was a slight increase in retention, and in still others a slight decrease. In view of the indefinite character of the results of this part of the observations, the tables for these constituents have not been included in this report.

-CHLORIN IN NORMAL CHILDREN—(*Continued*)

Chlorin Balance, Gm.					Summary
Total Intake	Urine	Feces	Total Excretion	Retained	
0.4626	0.0720	0.1634	0.2354	0.2272	No injected water eliminated during period of observation (three days); less than half the injected chlorin lost through the urine on the first day and successively smaller amounts on the second and third days; a large part of the injected chlorin retained at the end of the period of observation
1.9323	0.7047	0.0543	0.7590	1.1733	
0.4351	0.3600	0.1218	0.4818	—0.0467	
0.4805	0.2211	0.1463	0.3674	0.1131	
0.7280	0.555	0.0164	0.5714	0.1566	All of the injected water eliminated on the second and third days, chiefly through the urine; about half the injected chlorin excreted in the first day's urine and a smaller amount on the second day, with normal excretion on the third day, leaving a part not eliminated
1.8805	1.0439	0.0074	1.0513	0.8292	
0.6940	0.8945	0.0209	0.9154	—0.2214	
0.7160	0.5902	0.0141	0.6043	0.1117	
0.7151	0.3827	0.0567	0.4394	0.2757	Very little of the injected water lost on the first day; on the following day, after a second injection, there was excreted through the urine an amount equal to the second injection; on the third and fourth days excretion through both urine and feces was so reduced that in the period of observation an additional amount of water was retained about equal to the two injections. All the injected chlorin was eliminated, mostly through the urine, in the first three days, the largest amount on the second day; on the fourth day there was normal excretion in the urine, but increased chlorin in the feces
1.4546	0.8800	0.0861	0.9661	0.4885	
1.8142	1.4210	0.1093	1.5303	0.2839	
0.7710	0.6048	0.1113	0.7161	0.0549	
0.7560	0.3520	0.1641	0.5161	0.2399	
0.5420	0.3373	0.0197	0.3570	0.1850	No injected water was lost on the first day; on the following day, after a second injection, there was excreted through the urine an amount about equal to the second injection, but on the third and fourth days, excretion was so reduced that in the period of observation an additional amount was retained more than equal to the two injections. A small part of the injected chlorin was excreted through the urine on the first day, a much larger amount on the second day; on the third and fourth days excretion was little more than normal, so that in the period of observation a considerable part of the injected chlorin was retained
1.2199	0.5305	0.0243	0.5548	0.6651	
1.9061	1.3020	0.0337	1.3357	0.5704	
0.4231	0.3172	0.0354	0.3526	0.0705	
0.5489	0.4664	0.0233	0.4897	0.0592	

Tables 2 and 3 give the results of metabolism studies of water and chlorin in normal and abnormal children. The accompanying illustrations (Figs. 1 and 2) represent graphically some of the fairly typical cases.

Among the fifteen normal children, seven eliminated all the injected water during the period of observation — six in the first day and one in three days; five excreted a considerable part during the period of observation, that is, two or four days; and three lost none in three days. Of the injected chlorin, ten children lost the entire amount during the period of observation—six on the first day, two in two days and two in three days; five excreted part of the chlorin in the period of observation—three days or four days. In four cases the water loss and in five the chlorin loss for the whole period was considerably more than the amount injected. In three cases the water loss and in one the chlorin loss was made up for by a subsequent decreased excretion, which caused an abnormal retention.

TABLE 3.—METABOLISM STUDIES OF WATER-

Name	Period	Water Balance, C.c.							Chlorin Bal., Gm	
		Intake by Mouth	Injected	Total Intake	Urine	Feces	Total Excretion	Retained	Intake by Mouth	Injected
1. I. G.	Before injection (daily aver,)	725	.....	725	273	115	388	337	0.5467	.....
	1st day after....	805	210	1,015	285	205	490	525	0.6070	1.160
	2d day after....	825	.....	825	450	101	551	274	0.6221	.....
2. E. K.	Before injection (daily aver,)	603	.....	603	383	15	398	205	0.3260	.....
	1st day after....	710	210	920	570	25	595	325	0.3840	1.1598
	2d day after....	730	.....	730	390	65	455	275	0.3950	.....
	3d day after....	785	.....	785	450	47	497	288	0.4240	.....
3. J. C.	Before injection (daily aver,)	553	.....	553	113	195	308	245	0.3526	.....
	1st day after....	595	220	815	163	216	379	436	0.2654	1.650
	2d day after....	679	.....	679	140	234	374	305	0.4805	.....
	3d day after....	553	.....	553	160	220	380	173	0.4002	.....
4. T. M.	Before injection (daily aver,)	828	.....	828	278	303	581	247	0.5887	.....
	1st day after....	1,067	208	1,275	830	199	1,029	246	2.5909	0.520
	2d day after.... (2d injection)	660	160	820	450	98	548	272	0.2194	1.200
	3d day after.... (13½ hr. only)	540	.....	540	335	85	420	120	0.1659	.....
5. V. V.	Before injection (daily aver,)	623	.....	623	393	31	424	199	0.3670	.....
	1st day after....	620	210	830	320	85	405	425	0.3654	1.160
	2d day after....	625	.....	625	360	26	386	239	0.3684	.....
	3d day after....	630	.....	630	260	27	287	343	0.3713	.....
6. J. B.	Before injection	985	.....	985	393	262	655	330	0.8570	.....
	1st day after....	885	205	1,090	450	200	650	440	0.7837	1.025
	2d day after....	1,095	.....	1,095	450	176	626	469	0.8953	.....
	3d day after....	1,010	.....	1,010	600	257	857	153	0.6319	.....
7. L. M.	Before injection	550	.....	550	93	133	226	324	0.4175	.....
	1st day after....	535	180	715	105	166	271	444	0.4061	0.9936
	2d day after.... (attempt at 2d inj.)	530	30	560	100	202	302	258	0.4023	0.1218
	3d day after....	550	.....	550	190	101	291	259	0.4175	.....
	4th day after....	545	.....	545	180	45	225	320	0.4137	.....
8. J. P.	Before injection	384	.....	384	54	240	294	90	0.2565	.....
	1st day after....	440	200	640	40	85	125	515	0.2536	0.8480
	2d day after.... (2d injection)	485	220	705	205	472	677	28	0.4560	1.2950
	3d day after.... (3d injection)	450	220	670	200	274	474	196	0.4230	1.100
	4th day after.... (4th injection)	570	225	795	250	411	661	134	0.5370	0.960
	5th day after....	165	.....	165	95	396	491	—326	0.1550	.. ...
	6th day after....	185	.....	185	65	230	295	—110	0.1740	.....
9. C. B.	Before injection (daily aver.)	543	.....	543	283	94	377	166	0.6142	.....
	1st day after....	595	205	800	355	166	521	279	0.6757	1.1816
	2d day after.... (2d injection)	545	225	770	270	200	470	300	0.5757	1.1070
	3d day after....	620	.....	620	360	133	493	127	0.3334	.....
	4th day after.... (3d injection)	530	220	750	275	124	399	351	0.2768	1.2540
	5th day after....	610	.....	610	395	91	486	124	0.3274	.....
	6th day after....	645	.....	645	345	148	493	152	0.3418	.....

Chlorin Balance, Gm.					Summary
Total Intake	Urine	Feces	Total Excretion	Retained	
0.5467	0.1840	0.1410	0.3250	0.2217	Less than half the water and chlorin injected eliminated in 48 hours; the water excreted in the urine, the chlorin in both urine and first day's feces
1.7670	0.4480	0.2118	0.6598	1.1072	
0.6221	0.5240	0.1044	0.6284	—0.0063	
0.3260	0.3734	0.0080	0.3814	—0.0554	Part of the injected water eliminated the first day, mainly in the urine; on the two following days excretion so reduced in relation to intake by mouth that more than the amount injected was retained; no injected chlorin eliminated during the period of observation
1.5438	0.4390	0.0195	0.4585	1.0853	
0.3950	0.2690	0.0512	0.3202	0.0748	
0.4240	0.4050	0.0374	0.4424	—0.0184	
0.3526	0.0093	0.5539	0.5632	—0.2106	A small part of both water and chlorin injected was eliminated, mainly through the feces, in the three days of observation; the urine excretion was very low throughout the period
1.9154	0.0360	0.6212	0.6572	1.2582	
0.4805	0.0180	0.7268	0.7448	—0.2643	
0.4002	0.0120	0.6720	0.6840	—0.2838	
0.5887	0.3660	0.0482	0.4142	0.1745	The injected water was mostly eliminated through the urine the first and second days, the water in the feces being greatly reduced; no injected chlorin eliminated; the somewhat increased chlorin excretion in both urine and feces removed only part of the large chlorin intake by mouth of the first day, due to a mistake in adding salt to the barley water
3.1109	0.5271	0.1089	0.6360	2.4749	
1.4194	0.6075	0.0889	0.6964	0.7230	
0.1659	0.1977	0.0933	0.2910	—0.1251	
0.3670	0.3062	0.0171	0.3233	0.0437	No injected water eliminated in the period of observation; all the injected chlorin excreted, mainly through the urine of the first and second days
1.5254	1.040	0.0763	1.1163	0.4091	
0.3684	0.6320	0.0230	0.6550	—0.2866	
0.3713	0.3960	0.0245	0.4205	—0.0492	
0.8570	0.2223	0.3788	0.6011	0.2559	Not all the injected water eliminated in the three days of observation; the increased excretion in the urine; practically all the injected chlorin eliminated in the urine of the first day and in the feces of the third day
1.8087	0.8235	0.3291	1.1526	0.6561	
0.8953	0.1260	0.3653	0.4913	0.4040	
0.6319	0.1080	0.7580	0.8660	—0.2341	
0.4175	0	0.2016	0.2016	0.2159	All the injected water eliminated, partly in the feces of the first and second days, and partly in the urine of the third and fourth days; about half the injected chlorin eliminated through the feces of the first and second days; no excretion of chlorin in the urine during the period of observation
1.3997	0	0.4878	0.4878	0.9119	
0.5241	0	0.5934	0.5934	—0.0693	
0.4175	0	0.2161	0.2161	0.2014	
0.4187	0	0.0951	0.0951	0.3186	
0.2565	0.0912	0.1141	0.2053	0.0512	All the water of the four successive injections eliminated through the urine and feces, beginning the second day; increased excretion was continuing on the sixth day; nearly all the injected chlorin eliminated through both urine and feces, the increased excretion beginning on the second day; with decreased intake by mouth, excretion through the urine decreased, returning to normal on the sixth day; that through the feces was still high on the fifth and sixth days
1.1016	0.0960	0.0474	0.1434	0.9582	
1.7510	0.7200	0.2646	0.9846	0.7664	
1.5230	0.8960	0.4750	1.3710	0.1520	
1.4970	0.8800	0.7110	1.5910	—0.0940	
0.1550	0.3440	0.6840	1.0280	—0.8730	
0.1740	0.0800	0.3970	0.4770	—0.3030	
0.6142	0.3840	0.1409	0.5249	0.0893	Less than half the injected water eliminated during the period of observation, practically all the increased excretion being in the feces, which were still greater than normal on the sixth day; the larger part of the injected chlorin was eliminated during the period of observation by a small daily increase in both urine and feces; excretion was nearly normal in the urine, slightly increased in the feces on the sixth day
1.8073	0.5920	0.3440	0.9360	0.8713	
1.6827	0.6000	0.4160	1.0160	0.6667	
0.3384	0.5920	0.2170	0.8090	—0.4756	
1.5308	0.5280	0.2020	0.7300	0.8008	
0.3274	0.5796	0.1470	0.7266	—0.3992	
0.3418	0.3400	0.2400	0.5800	—0.2382	

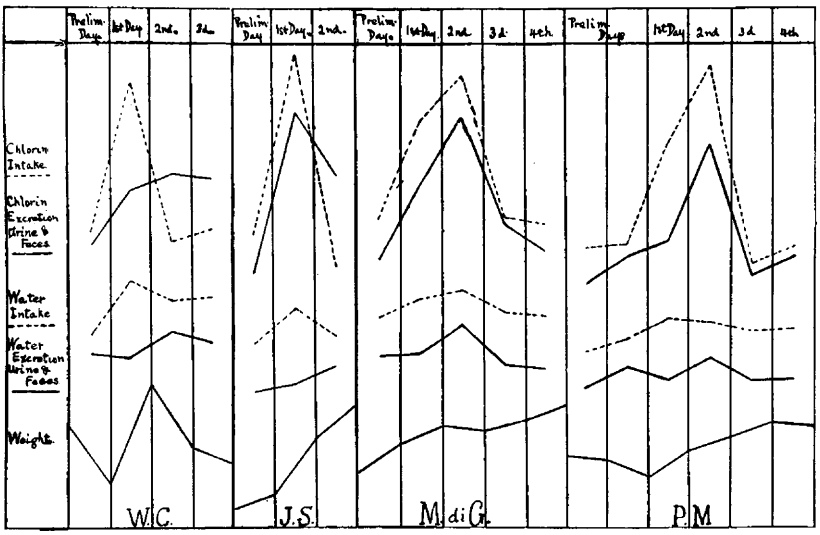

Fig. 1.—Chlorin and water intake and excretion in four normal children.

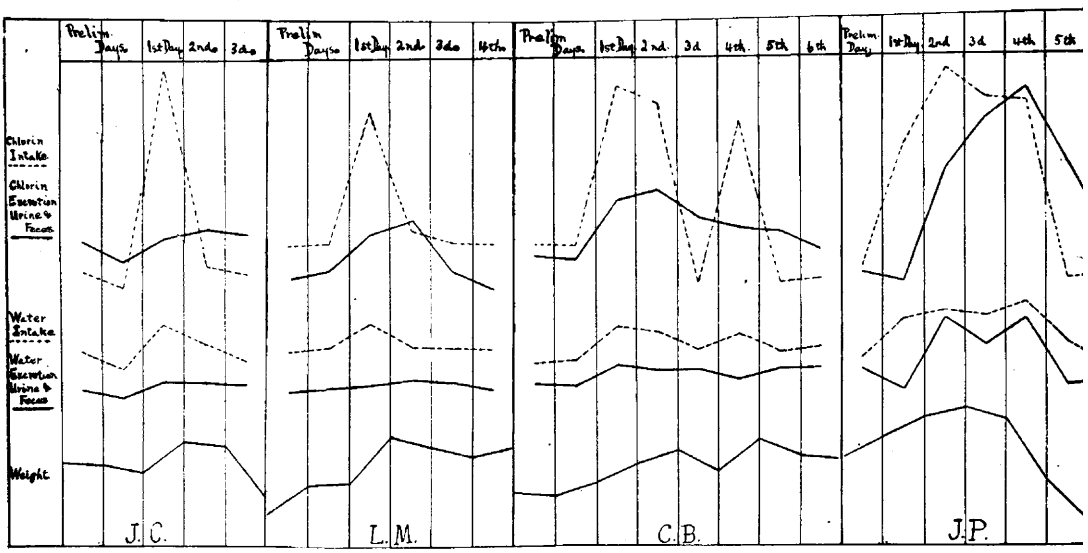

Fig. 2.—Chlorin and water intake and excretion in four abnormal children.

Among the nine abnormal children, only three lost all the injected water during the time of observation—one in the first day, one in four days and one in six days; four excreted part of the water in the period of observation—two, three or six days; two lost little or none in three days. Of the injected chlorin, one infant eliminated all in two days, one in three and one in six days; three excreted only part in the period of observation — two, four or six days; three lost practically none in the three days of observation. No excessive loss beyond the amount injected of either water or chlorin took place with any of the abnormal children. In one case there was an abnormal retention of water after the elimination of part of that injected.

TABLE 4.—EXCRETION OF WATER INJECTED IN THE CASE OF TWENTY-FOUR CHILDREN

	Normal	Abnormal
All excreted in one day	6	1
Not entirely excreted in period of observation	8	6
Practically none excreted in period of observation	3	2

TABLE 5.—EXCRETION OF CHLORIN INJECTED IN THE CASE OF TWENTY-FOUR CHILDREN

	Normal	Abnormal
All excreted in one day	6	0
Not entirely secreted in period of observation	5	6
Practically none excreted in period of observation	0	3

The loss of the water injected in the normal children took place in ten cases through the urine, in one mainly through the feces, and in one through both. The chlorin in fourteen cases was excreted through the urine; in one equally in the urine and feces. In one of the normal children, in whom diarrhea had developed shortly before the injection, excretion of the injected water took place wholly, and the chlorin partly, through the feces. The injected water and chlorin with the abnormal children was excreted mainly through the urine in two cases, through the feces in two, and about equally through both in three cases. With the children in whom elimination took place through the feces, diarrhea was always present before hypodermoclysis. In one normal child, to whom an unintentionally large amount of salt had been given, diarrhea developed on the second day, the injected water having already been eliminated in the urine.

The cases in which several injections were made on successive days

merit special consideration. Two patients (C. B. and J. P., Table 3) received, respectively, three and four injections in four days. Both were suffering from diarrhea and both were very ill. The one with the most severe diarrhea (J. P.) excreted slightly more water than the amount injected, and nearly all the chlorin. The other (C. B.) retained a significant amount of both water and chlorin during the period of observation.

TABLE 6.—SODIUM CHLORID EXCRETION IN-

Period	R. S., Day Beginning 12 M.				H. R., Day Beginning 10 A. M.				J. M., Day Beginning 10:30 A. M			
	Water, C.c.		Chlorin, Gm.		Water, C.c.		Chlorin, Gm.		Water, C.c.		Chlorin, Gm.	
	Intake*	Urine	Intake	Urine	Intake	Urine	Intake	Urine	Intake	Urine	Intake	Urine
1st day 1	.....	262	.....	0.9777	.....	135	.....	0.2295	.....	160	.....	0.786
2	.....	80	.....	0.0992	.....	210	.....	0.2940	.....	90	.....	0.781
3	.....	125	.....	0.4113	.....	165	.....	0.2360	.....	90	.....	0.666
4	.....	110	.....	0.2695	.....	190	.....	0.2337	.....	70	.....	0.492
Total..	1,311	577	2.3094	1.7577	1,343	700	1.9064	0.9932	630	410	3.7770	2.726
2d day 1	.....	.....	.....	.....	.....	300	.....	0.4230	.....	100	.....	0.708
2	.....	.....	.....	.....	.....	155	.....	0.2403	.....	80	.....	0.592
3	.....	.....	.....	.....	.....	155	.....	0.2356	.....	110	.....	0.134
4	.....	.....	.....	.....	.....	185	.....	0.1933	.....	95	.....	0.410
Total..	.....	.....	.....	.....	1,121	795	0.7262	1.0922	521	385	1.0802	1.844
3d day 1	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....
Total..	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....

* The figures for the intake of water include the amount taken by injection.

The inference from these two cases seems warranted that repeated injections may be made without harm, and in some patients the water and salt is retained long enough to be of positive benefit. The increase in the diarrhea noted in the case of J. C. could hardly, under the conditions existing, be attributed to the injection. The beneficial effects of repeated injections in diarrheal cases have been abundantly confirmed by clinical observations.

Since in some cases the injected salt was entirely eliminated in the first twenty-four hours, it seemed desirable to collect the urine in shorter periods, in order to see how soon the increased excretion began. With six children, therefore, the collection of urine following hypodermoclysis was made in six-hour periods. The results are shown in Table 6.

A study of the water and chlorin excretion in this series showed

SIX-HOUR PERIODS FOLLOWING HYPODERMOCLYSIS

'. S., Day Beginning 9:15 A. M.				W. C., Day Beginning 11:30 A. M.				P. D., Day Beginning 10 A. M.			
Water, C.c.		Chlorin, Gm.		Water, C.c.		Chlorin, Gm.		Water, C.c.		Chlorin, Gm.	
itake	Urine	Intake	Urine	Intake	Urine	Intake	Urine	Intake	Urine	Intake	Urine
....	40	.....	0.1920	.....	140	.....	0.1456	.....	65	.....	0.1277
....	70	.....	0.6328	.....	195	.....	0.2496	.....	170	.....	0.3689
....	75	.....	0.6705	.....	155	.....	0.2232	.....	210	.....	0.3276
....	35	.....	0.2842	.....	210	.....	0.2352	.....	130	.....	0.2197
884	220	2.3603	1.7795	1,280	700	1.6890	0.8536	1,245	575	1.8805	1.0439
....	20	.....	0.1264	.....	240	.....	0.1440	.....	190	.....	0.1824
....	225	.....	0.8460	.....	205	.....	0.1968	.....	80	.....	0.0984
....	60	.....	0.3096	.....	155	.....	0.3038	.....	235	.....	0.3596
....	25	.....	0.1280	.....	230	.....	0.3036	.....	165	.....	0.2541
695	330	0.7807	1.4100	1,125	830	0.4716	0.9482	1,006	670	0.6940	0.8945
....	130	.....	0.6578	.....	190	.....	0.1976	.....	205	.....	0.1825
....	70	.....	0.3178	.....	190	.....	0.1444	.....	40	.....	0.0352
....	...	.....	.....	.....	180	.....	0.2952	.....	210	.....	0.1701
....	...	.....	.....	.....	230	.....	0.3036	.....	220	.....	0.2024
....	...	.....	.....	1,130	790	0.5744	0.9408	1,065	675	0.7160	0.5902

a striking want of uniformity. This was true not only of the different children, but of the same child on different days. One child (R. S.) eliminated a very large part of his chlorin intake in the first six hours; very little in the second six hours; and again, quite large amounts in the third and fourth periods. H. R. and J. H. excreted almost uniform amounts in all the periods of the two days. The other three children were alike in eliminating little or none of the injected chlorin in the

first period, but differed greatly in the distribution of the excretion after that.

Again, there was no uniform relation of water excretion to that of chlorin. Although the excretion of the two frequently ran parallel, there were many instances in which the opposite was true. Among the individual factors influencing the manner of excretion of the hypodermoclysis solution, the rate of absorption is probably a very important one.

CONCLUSIONS

1. In acute diarrhea much salt and water are lost from the body. A similar condition is seen in marasmus, and after protracted vomiting, etc. When saline solutions are injected in such subjects a considerable amount of the salt is usually held for two or three days, and occasionally for a longer period.

2. If in these infants the variations in the loss of water by the skin and lungs can be ignored, the retention of water usually follows closely that of the salt.

3. Our metabolism studies support the clinical conclusions as to the beneficial effects of repeated saline injections in the conditions mentioned.

4. With normal children and with convalescents without evidence of dehydration, great variation is observed in the excretion of the injected water. It may be excreted very rapidly in the course of the first twenty-four hours, or part or all of it may be held for several days. The salt, however, is usually excreted rapidly, sometimes a large part of it in the first six hours.