THE DISTRIBUTION OF CHLORIDES IN THE BLOOD OF THE DOG AFTER EXPERIMENTAL INTESTINAL OBSTRUCTION.

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Several questions have arisen in connection with the fall in blood chlorides which we have shown [1-3] is characteristic of high intestinal obstruction. All chloride determinations have been made on whole blood since it seems that changes in the body chlorides would be thus best shown. There is, however, no unanimity of opinion among laboratory workers as to whether estimates of chlorides are more desirable on whole blood or on plasma. The statement is usually made that changes in them are best reflected in plasma since the chloride content of the plasma is twice as great as that of the red cells. This is based largely on the relatively slight changes observed in chronic nephritis. Low blood chlorides have received scant attention in clinical medicine.

The low blood chlorides in intestinal obstruction are accompanied by a very low excretion in the urine. Some of the chlorides are lost in vomiting, but a large part is not accounted for in this way. It has seemed quite possible that some of the chlorine might be bound in some manner with the blood protein and thus precipitated in making the tungstic acid filtrate or possibly exist in the filtrate in some non-ionizable form and not be precipitated by silver nitrate. In either case the chlorine would not be detected by the usual technique of chloride determination. Van Slyke[4] has recently suggested a new technique for chloride estimation which is essentially an ashing pro-

[1] Haden, R. L., and Orr, T. G., *J. Exp. Med.*, 1923, xxxvii, 365.
[2] Haden, R. L., and Orr, T. G., *J. Exp. Med.*, 1923, xxxviii, 55.
[3] Haden, R. L., and Orr, T. G., *Surg., Gynec. and Obst.*, 1923, xxxvii, 465.
[4] Van Slyke, D. D., *J. Biol. Chem.*, 1923–24, lviii, 525.

cedure and he thus estimates all the chlorine present regardless of the combination in which it exists.

The following experiments have been made to determine the distribution of chlorides in the blood of the dog after experimental obstruction of the jejunum. The chlorides have been estimated simultaneously in whole blood, in plasma, and in the cells. In several instances estimations have been made by both the iodometric titration on protein-free filtrate and on whole blood and plasma by the Van Slyke technique.

Methods.

All chloride determinations on the tungstic acid filtrate have been done by the iodometric titration of McLean and Van Slyke as suggested by Gettler.[5] In preparing the filtrate of the cells one part of cells was laked with four parts of distilled water and two parts each of 10 per cent sodium tungstate and 2/3 N sulfuric acid added.[6] The determinations by the new Van Slyke procedure have been done on 1 cc. of plasma or blood.

EXPERIMENTAL.

In each dog an obstruction of the jejunum was made under ether anesthesia and with aseptic technique. One animal lived 5 days, one 6 days, and two 14 days. In the last two the obstruction was made quite low down. All animals showed the characteristic fall in chlorides (Table I). The most marked change is in the second 24 hour period following operation. There is a decrease in both cells and plasma. At first the fall is more marked in cells than plasma. The decrease is shown more characteristically, however, in whole blood than in cells or plasma.

The determinations by the iodometric titration on the tungstic acid filtrate show a close agreement with those made by the Van Slyke technique. This is true both with normal blood and with blood showing a very low chloride content after obstruction. The average of ten determinations on plasma by the iodometric titration is 430 mg. per 100 cc. as compared with 438 mg. by the Van Slyke technique. The average of six determinations on whole blood at

[5] Gettler, A. O., *J. Am. Med. Assn.*, 1921, lxxvii, 1652.
[6] Wu, H., *J. Biol. Chem.*, 1922, li, 21.

different stages of obstruction is 256 mg. per 100 cc. by the iodometric titration and 257 mg. by the Van Slyke.

TABLE I.

Distribution of Chlorides in Blood after Experimental Intestinal Obstruction.

Dog No.	Day after operation.	Plasma (hematocrit).	Chlorides as mg. of NaCl per 100 cc.		
			Whole blood.	Plasma.	Cells.
		per cent	*mg.*	*mg.*	*mg.*
1	0	54	470	540	260
	1	50	460	550	290
	2	51	350	470	190
	3	56	330	460	180
	4	56	310	450	180
	5	60	300	460	200
	6	61	295	400	190
2	0	60	475	570	290
	1	55	440	520	260
	2	60	350	460	180
	3	62	340	430	180
	4	62	290	420	160
	5	70	240	340	200
3	0	50	460	570	310
	2	45	360	400	220
	4	52	330	440	290
	6	46	300	410	200
	8	50	310	420	200
	10	55	296	370	180
	12	57	280	360	190
	14	66	210	280	150
4	0	54	450	290	310
	2	55	375	460	240
	4	58	325	440	270
	6	60	320	410	210
	8	65	300	400	200
	10	68	260	340	190
	12		250	300	160
	14	73	200	250	150

TABLE II.

Comparison of Blood Chloride Estimation by Iodometric Titration on Tungsten Acid Filtrate and by New Van Slyke Technique.

Dog No.	Whole blood. Amount per 100 cc.		Plasma. Amount per 100 cc.		Remarks.
	Iodometric titration.	New Van Slyke.	Iodometric titration.	New Van Slyke.	
	mg.	*mg.*	*mg.*	*mg.*	
1			575	591	Control normal.
2			590	605	" "
3			585	597	" "
Pooled.			590	588	" "
4	340	339	450	449	Obstruction jejunun 9 days.
	285	283	355	379	" " 11 "
	170	178	225	233	" " 15 "
5	290	297	365	368	" " 9 "
	273	277	325	344	" " 11 "
	175	189	235	228	" " 15 "
Average.....	256	257	430	438	

DISCUSSION.

The results here recorded show that the fall in blood chlorides in intestinal obstruction involves both the cells and plasma and almost equally so. The changes are best seen in the whole blood determinations. It seems evident that determinations on whole blood are more desirable than on plasma. The whole blood estimations have an added advantage. The nitrogenous bodies are always estimated on whole blood filtrate. The same filtrate may be used for the whole blood chloride determinations. A separate filtrate must be made for the plasma determination.

The very close agreement in chlorides by the iodometric titration and the Van Slyke digestion method shows definitely that the chloride does not exist in the blood in some undetermined form. We must look some place other than the blood for the retained chloride. The problem here is similar to that in pneumonia, a condition in which chlorides are retained to an equal degree, apparently, in all the tissues

of the body.[7] The results here also serve as an excellent check on the accuracy of the chloride determinations which we have previously reported.

SUMMARY AND CONCLUSION.

The results of simultaneous chloride determinations in whole blood, in plasma, and in cells of the dog after experimental intestinal obstruction are presented, and the chloride content of whole blood and of plasma is compared by two methods of estimation: the iodometric titration on protein-free filtrate, and the digestion technique of Van Slyke.

The chloride as determined on protein-free filtrate checks closely with that as determined by the digestion procedure. The iodometric determination shows accurately the level of chlorides in the blood. The total change in the chloride store of the body is best reflected in determinations on whole blood.

In intestinal obstruction the retained chloride is not present in the blood in some undetermined form.

[7] Peabody, F. W., *J. Exp. Med.*, 1913, xvii, 71.