ON THE EQUILIBRIUM CONDITION BETWEEN BLOOD SERUM AND SEROUS CAVITY FLUIDS.

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INTRODUCTION.

There has been much speculation concerning the mechanism by which fluid accumulates in the serous cavities of the body. The presence of ascitic fluid in cirrhosis of the liver has been attributed to compression of the portal circulation. In certain types of renal disease, the retention of fluid has been attributed to some disturbance of kidney function. Fluid accumulations in serous cavities, in inflammatory conditions, have been ascribed to an increased permeability of the capillaries. Thus, it appears, that in the minds of investigators, these various types of edema are classified as unrelated phenomena.

We have made a preliminary study of several physicochemical properties of blood sera and edema fluids simultaneously obtained. The cases studied include heart disease and nephritis with ascites, hydrothorax, and subcutaneous edema; cirrhosis of the liver with ascites; and tuberculous pleurisy with effusion. The results seem to indicate that certain constant qualitative relationships exist between blood serum and fluids in the serous cavities (peritoneal and pleural), regardless of the nature of the fluids or the type of disease.

EXPERIMENTAL.

70 cc. of blood were removed from an arm vein and placed in large centrifuge tubes under oil without exposure to the air. After clotting and centrifugalization, the serum was removed. The patients were tapped immediately after the removal of the blood and the ascitic

TABLE I.

Case.	Diagnosis.	Nature of fluid.	Δ	Specific conductivity × 10^{-4}.	Molecular concentration of Cl × 10^{-2}.	Molecular concentration of HCO_3 × 10^{-2}.	Molecular concentration of Na × 10^{-2}.	Molecular concentration of K × 10^{-2}.	Molecular concentration of Ca × 10^{-2}.	Molecular concentration of glucose × 10^{-3}.	Molecular concentration of urea × 10^{-3}.	Non-protein N per 100 cc.	Protein content.
												mg.	*per cent*
Cl.	Cirrhosis.	Serum.	0.498	113.7	100.0	27.5	124.7	4.2		7.2		26	6.8
		Ascitic fluid.	0.509	132.5	108.2	26.3	138.2	2.4		7.2		24	0.9
K.	"	Serum.	0.490	117.7	103.8	23.8	133.8	4.7	2.4	8.2	7.8	33	5.2
		Ascitic fluid.	0.488	131.9	109.0	23.8	126.6	2.0	2.3	9.0	8.2	31	0.8
Co.	"	Serum.	0.518	115.9	105.6	26.4	112.2	2.7		7.3		30	7.0
		Ascitic fluid.	0.507	135.2	113.7	25.6	138.6	2.3		9.6		27	0.9
D.	Nephritis.	Serum.	0.535	127.5	110.9	27.0	149.4	3.5		6.3		38	5.0
		Chest fluid.	0.535	144.7	119.7	26.6	147.7	1.7		6.9		34	0.6
P.	Cardiorenal.	Serum.	0.549	125.5	115.3	16.9	139.8	4.7		5.1	19.0	74	6.0
		Ascitic fluid.	0.549	135.8	121.1	16.2	140.8	3.2		5.2	19.0	68	3.3
McF.	Cardiac.	Serum.	0.533	120.6	105.6	28.4	140.0	4.5		5.6		23	7.3
		Ascitic fluid.	0.534	130.0	112.7	28.4	141.3	3.1		6.8		25	4.5
H.	Tuberculous pleurisy.	Serum.	0.515	115.9	101.2	29.9	138.7	4.4		5.5		22	7.1
		Chest fluid.	0.512	121.0	104.4	29.3	142.1	2.7		5.9		21	5.6
Limit of error of analytical methods used.....					0.9	0.7	6.1	0.3		0.4	0.3	2.0	

or chest fluid was received under oil, to avoid any marked change in hydrogen ion concentration through loss of CO_2. The following physical and chemical determinations were made on the blood sera and the edema fluids; freezing point depression, specific conductivity, Cl, HCO_3, Na, K, glucose, non-protein nitrogen, protein per cent (by Kjeldahl and refractivity), and, in certain cases, urea and Ca. A description of the methods employed, and other details, will be published later. The results of these observations are collected in Table I.

In four cases, serum was placed in a thin collodion sac with a capacity of about 6 cc. and immersed in a bottle containing 250 cc. of edema fluid. This bottle was kept at 25°C. A manometer was placed in

TABLE II.

Case.	Diagnosis.	Molecular concentration of K × 10^{-2} in fluid.	Molecular concentration of K × 10^{-2} in serum.		Molecular concentration of Cl × 10^{-2} in fluid.	Molecular concentration of Cl × 10^{-2} in serum.		Protein in serum.	
			Before dialysis.	After dialysis.		Before dialysis.	After dialysis.	Before dialysis.	After dialysis.
								per cent	*per cent*
P.	Cardiorenal.	3.2	4.7	5.2				6.0	5.9
Co.	Cirrhosis.	2.3	2.7	2.6	113.7	105.6	107.2	7.0	6.7
H.	Tuberculous pleurisy.	2.7	4.4	3.9					
McF.	Cardiac.	3.1	4.5	4.6	112.7	105.6	109.8		

the collodion sac, and the serum level was so adjusted that there would be little or no change in level with the establishment of equilibrium. After 18 hours, the contents of the sac were analyzed for protein per cent, K, and Cl. The results of these analyses were compared with the original concentrations and with those of the edema fluid as shown in Table II. The bottle containing the edema fluid and collodion sac was kept closed with a rubber stopper and a soda-lime tube to prevent change in hydrogen ion concentration.

DISCUSSION.

From the data in Table I, the following relationships between blood serum and edema fluids are apparently constant. (*a*) The freezing

point depression of serum and of edema fluid is the same—within the limit of error of the method when applied to physiological solutions. (*b*) The conductivity of the edema fluid is always higher than that of the blood, but the greater the protein content of the edema fluid, the closer the conductivity approaches that of the serum. This is in accord with experiments on pure protein solutions, in which it was found that, at the pH of the body fluids, the higher the protein content, the lower the conductivity.[1] (*c*) The chloride content of the edema fluid is always higher than that of the serum. (This is at variance with findings of Epstein.[2]) This difference of Cl concentration in blood and edema fluids diminishes, in general, as the protein content of the edema fluid increases. (*d*) The concentration of potassium is greater in the serum than in the edema fluid. (*e*) The concentrations of HCO_3, Na, sugar, non-protein nitrogen, and Ca and urea, where these were determined, are approximately the same, in the determinations made thus far.

The experiments on the dialysis of serum against edema fluid reported in Table II, demonstrate that no new equilibrium is established when the two fluids are separated by a simple collodion membrane. The relatively high concentration of potassium inside and the relatively high concentration of chlorine outside the membrane are but slightly changed. The results suggest that these interesting relationships depend on a simple membrane equilibrium and are not entirely due to properties peculiar to living protoplasm.

CONCLUSIONS.

1. Comparative studies of blood serum and edema fluid from the same individual indicate that, regardless of the pathological condition present, whether the fluid be "transudate" or "exudate," certain definite qualitative chemical relations obtain.

2. The chief feature of these relations is that the edema fluid contains more Cl and less K than the blood serum; while the Na, HCO_3, Ca, urea, glucose, and non-protein nitrogen exist in approximately

[1] Palmer, W. W., Atchley, D. W., and Loeb, R. F., *J. Gen. Physiol.*, 1920–21, iii, 801; 1921–22, iv, 585.

[2] Epstein, A. A., *J. Exp. Med.*, 1914, xx, 334.

the same concentrations in the serum and in the edema fluid. The freezing point is also the same in both fluids, while the specific conductivity is constantly higher in the edema fluid.

3. The above mentioned variations between the edema fluid and the serum appear to be related to the difference in the concentration of protein in the two solutions.

4. The relationships between blood serum and edema fluid seem to result from a simple membrane equilibrium, influenced in part by the proteins present.