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SECTION MEETINGS

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Sodium and Potassium Exchanges During Dialysis of Bilaterally Nephrectomized Dogs.* (20767)

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Dogs subjected to bilateral nephrectomy and maintained by dialysis develop a series of abnormalities among which have been emphasized hypertension(1,2), cardiovascular lesions(3,4), hemolytic anemia(5), and a negative nitrogen balance(6). The present communication considers the relationship between external sodium and potassium balance and changes in the content of sodium and potassium in the "extracellular fluid" as measured by the distribution of radiosulfate in association with dialysis following bilateral nephrectomy of the dog.

Methods. All methods used have been identified in another presentation(7). The nephrectomies were performed one week apart and peritoneal irrigation was begun after the second nephrectomy. The control mean arterial pressures, which varied between 110 and 120 mm Hg, and the body weights were obtained by averaging the daily figures obtained during the week before the second nephrectomy. Dog Nos. 1 to 15 received a diet containing an average of 77 calories/kg/day and between 1.4 and 4.2 g protein (mainly casein)/kg/day (average 2.7 g/kg/day) given in an average volume of 191 cc/day. Dogs Nos. 16 to 19 were handled in a similar manner except that they received an average of 45 cals/kg/day and protein (casein) in an amount of 1 g/kg/day in an average volume of 140 cc/day. Vomiting was negligible in 7 dogs and diarrhea did not occur. External Na and K balances were determined by the quantities in the diet and the quantities entering and leaving the peritoneal cavity during the daily dialyses. Fluid equilibrium was maintained in most instances during the dialyses.

The radiosulfate (S^{35}) space was obtained

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by a modification of the method of Walser (8). Radioactive S^{35} as sodium sulfate was injected intravenously in doses of 100 μc or less and serum samples were taken at 15, 30, 60, and 120 minutes. Adequate mixing was obtained after 15 minutes; the minute count fell in a straight line with a slight slope when plotted on semilogarithmic paper. The counts were obtained with a flow counter as follows: A sample of undiluted serum (0.1 to 0.2 cc) was allowed to spread on a disc of lens paper (O.D. 2 cm) impregnated with a 5% suspension of aquadag®† and mounted on an aluminum disc. The aquadag aided in the uniform dispersion of serum over the counting surface and minimized self-absorption and back-scattering. The unknown sample was compared with a known sample of normal serum containing diluted radiosulfate treated in a similar manner. The samples were counted until 11 x 64 counts were obtained. The Na, K, and radiosulfate concentrations were expressed in the ECF water by correcting for the plasma protein concentration. The radioactivity was extrapolated back to zero time on semilogarithmic paper while measuring the radiosulfate space. Consideration has been given to the gain or loss of Na or K from or to the outside and the gain or loss of Na and K in the "extracellular fluid" as measured by radioactive sulfate. These two quantities (exogenous balance and extracellular fluid balance) have been considered to indicate the quantities of Na and K either leaving or entering the extracellular space for or from other compartments in the body, presumably cellular. Thus, the sodium gained from the outside and the sodium depleted from the extracellular fluid are considered collectively as the likely quantity of sodium gained by cells, and the potassium lost to the outside and the potassium gained by the extracellular fluid are considered collectively as the likely quantity of K lost by cells.

Results. The results are given in Table I. During the period of study (3 to 7 days) the radioactive sulfate space was either essentially unchanged or significantly lowered. In 16 dogs the total "extracellular" sodium decreased, while in 15 dogs there was either a negligible or definite gain of sodium from the outside. This indicated in 16 dogs an apparent gain in cellular sodium varying between 39 and 226 mEq, in 11 dogs it exceeded 50 mEq. In 8 dogs, which either lost up to 36 mEq of Na to the outside or gained up to 31 mEq, 5 showed apparent cellular gains varying between 21 and 49 mEq. Only 3 dogs revealed changes which might be commensurate with decrements in cellular sodium. The apparent shift in Na away from the ECF bore no constance relationship to the serum Na concentration.

All animals were maintained in a state of negative exogenous K balance, since the diet contained between 2 and 4 mEq of K per day and the input irrigating fluid was devoid of K while upon exit it contained between 3.5 and 7.8 meq/liter. However, there were special aspects of the loss of K to the outside. Sixteen dogs displayed an elevation of the serum K concentration, and of these 11 showed an increment in the total "extracellular" K. Thus, the negative exogenous K balance, mediated via the irrigation, appeared to be potentiated by a tendency toward the passage of K from some compartment, presumably cellular, into the extracellular fluid. By the methods used all animals displayed an apparent decrement in the cellular K.

Comment. The gain in exogenous Na plus a decrement of Na in the ECF as measured suggest the shift of Na into cells, while a loss of K to the outside and an increment of K in the ECF as measured suggest a shift of K out of cells. Even in certain animals displaying no exogenous sodium gain, there was a tendency for Na to be deviated out of the ECF.

No constant quantitative relationship was detected between the shifts of Na and K. Thus, certain animals accruing larger quantities of Na, lost lesser equivalent quantities of K, while some animals that lost greater quantities of K gained a lesser equivalent amount of Na. These discrepancies, which suggest that the entire study indicates a trend only, may result partly from internal factors. That

† Colloidol carbon in water, manufactured by Acheson Colloids Corp., Port Huron, Mich.

TABLE I. Data from 19 Dogs as Discussed in Text.

Wt, kg	No. days	Change ECF (S^{35}) space, cc	Change serum water Na, mEq/L	Change serum water K, mEq/L	Change ECF Na, mEq	Exogenous Na balance, mEq	Apparent cellular Na change, mEq	Change ECF K, mEq	Exogenous K balance, mEq	Apparent cellular K change, mEq	Change mean BP, mm Hg
16.5	5	— 55	—16	+2.3	—43	+ 6	+ 49	+4.0	—26	—30	+45
11.0	5	— 82	— 9	+2.4	—27	+ 16	+ 43	+3.7	—59	—63	+40
15.5	4	—164	—24	+1.4	—98	+103	+201	+3.6	—37	—40	+32
15.5	4	—295	—16	+1.5	—93	+ 46	+139	+2.4	—47	—49	+50
13.4	7	+ 92	+13	— .3	+44	+179	+135	— .1	—58	—58	+20
12.3	5	—437	— 1	— .8	—69	+157	+226	—4.7	—29	—24	+55
10.9	4	— 91	+ 3	+2.5	— 8	+ 31	+ 39	+3.6	—29	—33	+40
10.3	4	+ 29	+ 7	+1.3	+15	— 34	— 49	+2.3	—33	—35	+50
10.3	4	—261	— 3	+ .4	—44	— 23	+ 21	—1.0	—29	—28	+40
13.2	3	—510	+ 4	+ .7	—74	+ 78	+152	—1.4	—17	—16	+30
16.4	3	—642	+ 5	+ .8	—81	+ 61	+142	—2.2	—19	—21	+50
10.7	3	—125	+ 6	+2.1	—10	— 29	— 19	+2.5	—22	—24	+35
9.8	3	—277	+ 7	+2.4	—28	+ 11	+ 39	+2.3	—21	—23	+60
11.8	3	—253	+11	— .1	—19	— 36	— 17	—1.3	—18	—17	+35
8.4	5	—523	+ 4	+1.1	—76	+ 37	+113	—1.0	—46	—45	+30
9.9	4	— 93	+ 2	+1.6	—11	+ 73	+. 84	+2.0	—27	—29	+25
8.5	4	+ 32	+ 6	+1.4	+11	+ 67	+ 56	+1.4	—22	—23	+25
7.5	3	—347	+ 1	+1.9	—50	+ 95	+145	+1.0	—22	—23	+37
12.1	3	—731	+ 4	+1.2	—105	+ 76	+181	—1.1	—13	—12	+50

internal factors are involved in the movement of K is indicated by the relationship of the loss of nitrogen and K in the outflow irrigating fluid, as discussed elsewhere(7). By nitrogen balance studies it has been shown(7) that the quantity of nitrogen removed by the irrigating fluid, which apparently is derived from cellular breakdown, far exceeds the expected quantity of K derived from the tissues. This indicates that although K passes into the ECF some of it is deviated or combined elsewhere in the body.

Hypertension was sustained by all 19 dogs while cardiovascular lesions were observed in 90% of the animals studied morphologically. Whether the electrolytic changes were related to the heightened arterial pressure could not be ascertained by these studies.

Conclusions. 1. Bilaterally nephrectomized dogs subjected to dialysis, under the conditions described, tend to gain Na from the dialyzing fluid and lose K into the fluid while at the same time measurements of the ECF volume by radiosulfate suggest a tendency toward a decrement of total ECF Na and an increment of total ECF K. 2. These findings are in keeping with a tendency toward a gain of cellular Na and a loss of cellular K. 3. A movement of Na into cells may occur even in the absence of a positive exogenous Na balance.

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