A STUDY OF EXTRA-CELLULAR FLUID COMPARTMENTS DURING HYPERTHERMIA IN NORMAL DOGS

By

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The thiocynate space and the plasma volumes were determined in dogs at rising body temperatures. It was observed that during hyperthermia both the plasma and the tissue fluid volumes increased. Fluid first appeared in the plasma and then in the tissue spaces. There was also evidence to indicate that extra red blood cells were also thrown into circulation along with the fluid that appeared in the plasma.

It was pointed out by Kumar (1956) that in dogs during hyperthermia heat is lost by evaporation of saliva from the mouth. He observed that the secretion of saliva and the respiration rate remarkably increased on opening the mouth during states of hyperthermia and thus compensate for the absence of effective sweat glands in these animals. For optimal secretion of saliva fluids should be readily available. It was, therefore, proposed to study as to how the extra-cellular fluid compartments behave during hyperthermia.

METHODS

Healthy dogs weighing between 6 kg to 14 kg of either sex were employed in this study. They were anaesthetised with chloralose, 80 mg/kg body weight given intravenously, and rendered hyperthermic by applying radiant heat from all sides. The extra-cellular fluid (ECF) was determined in 22 dogs by Crandall and Anderson's (1934) method with the incorporation of Bowler's (1943) suggestions for better colour development. Five ml of 5 per cent solution of sodium thiocyanate was used. The plasma volume was determined in 10 dogs by using 2.5 ml of 0 1 per cent solution of the dye T 1824 and the blood volume was calculated from the haematocrit value. As the dye T 1824 is rapidly removed from the circulation, a fresh amount of the dye was injected each time the estimation was to be made. A sample of blood was drawn before injecting the dye, and the serum acted as a blank for estimation of the dye. The initial body temperature was first recorded and then a mixture of the requisite amount of sodium thiocyanate and T 1824 was given intravenously. The thiocyanate was found not to disturb the optical density of the dye solution, and that the dye T 1824 came down completely with the proteins precipitated by trichloracetic acid. A single

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injection of sodium thiocyanate served for repeated estimations of the extra-cellular fluid, as it was earlier confirmed by actual estimations that when half hourly estimations of thiocyanate in serum were made after injection of a known amount of thiocyanate then its amount remained unaltered for three hrs. Since these experiments finished well within this time, a single injection of sodium thiocyanate served for repeated estimations of extra-cellular fluid. The difference between the thiocyanate space and the plasma volume was taken to be the volume of interstitial tissue fluid.

RESULTS

The results are reproduced below in the Tables I and II.

TABLE I

ECF per killogram of body weight at rising body temperature

Dog No.	ECF in ml per kg body weight					
	38°C	39°C	40°C	41°C	42°C	43°C
1	380	380	380	380	380	—
2	329	—	351	351	351	—
3	—	351	351	390	390	390
4	—	451	451	451	451	—
5	383	383	383	407	407	—
6	—	311	343	—	428	428
7	400	486	486	608	608	608
8	357	500	625	625	625	625
9	309	309	309	350	584	—
10	—	264	264	264	325	—
11	425	425	425	425	425	—
12	—	243	—	364	364	583
13	—	364	416	500	—	—
14	331	—	331	353	424	—
15	394	—	394	394	—	—
16	394	—	394	420	473	—
17	372	372	388	437	500	—
18	—	354	354	374	384	—
19	363	374	396	396	448	—
20	368	368	388	405	436	—
21	—	369	379	422	492	—
22	—	362	371	400	434	—
Mean	369	372	391	415	436	527

TABLE II

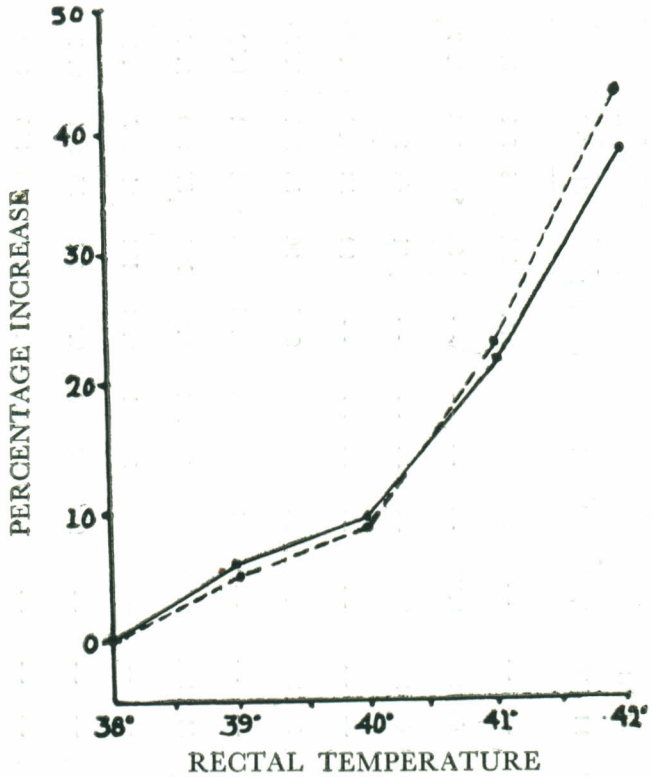
Blood (Bl), Plasma (Pl) and tissue fluid (Tf) volumes in ml per killogram body weight at rising temperature

Dog No.	38°C				39°C				40°C				41°C				42°C			
	Bl	Pl	Tf	Pl/Tf	Bl	Pl	Tf	Pl/Tf	Bl	Pl	Tf	Pl/Tf	Bl	Pl	Tf	Pl/Tf	Bl	Pl	Tf	Pl/Tf
13	—	—	—	—	97	52	312	0.17	121	65	351	0.18	125	69	431	0.16	—	—	—	—
14	80	48	283	0.17	—	—	—	—	80	48	283	0.17	90	58	295	0.19	122	78	346	0.22
15	81	45	349	0.13	—	—	—	—	81	45	349	0.13	109	60	334	0.18	—	—	—	—
16	—	—	—	—	—	—	—	—	99	58	336	0.17	114	68	352	0.19	140	90	383	0.23
17	90	52	320	0.16	93	54	318	0.17	96	56	332	0.17	110	63	374	0.17	129	75	425	0.18
18	—	—	—	—	91	50	304	0.16	95	52	302	0.17	99	55	319	0.17	—	—	—	—
19	91	51	312	0.16	97	53	321	0.16	106	57	339	0.17	106	57	339	0.17	122	66	382	0.17
20	—	—	—	—	102	57	311	0.18	112	61	327	0.19	121	66	338	0.19	134	72	364	0.20
21	—	—	—	—	95	52	317	0.16	101	55	324	0.17	120	65	357	0.18	135	74	418	0.18
22	—	—	—	—	96	53	309	0.17	103	56	315	0.18	118	65	335	0.19	134	72	762	0.20
Mean	85	49	316	0.15	96	53	313	0.16	99	55	325	0.17	111	62	347	0.18	131	75	383	0.19

DISCUSSION

Gregersen and Stewart (1939) had observed the ECF in dogs to vary from 230 to 435 ml/kg body weight. In the present study also it was found to vary between 243 to 451 ml/kg. Kumar (1953) had reported that the resting rectal temperature of these animals varied widely between 36.5 to 41.5°C. It was, therefore, thought that the ECF may be related to body temperature. Calculated in such a way the range of ECF reduced on both the sides (Table I) ; e.g., at 38°C the ECF varied between 309 to 425 ml/kg body weight.

When the temperature of the animals was raised the ECF gradually increased. This increase was due to increase both in plasma and tissue fluid volumes. The plasma tissue fluid ratio also gradually increased with the rise in body temperature. When the body temperature increased from 38°C to



ig. 1. Percentage increase in Blood (continuous line) and plasma (interrupted line) volumes at rising temperature.

39°C the tissue fluid remained almost the same, but the plasma to tissue-fluid ratio increased from 0.15 to 0.16, thus showing that whatever fluid was made available to the extra-cellular compartment was localized within the plasma ; and it was but natural that it was only from the plasma that it could be immediately made available for the purpose of heat loss. At temperatures beyond 39°C, the fluid was added both to the plasma and the tissue spaces, and the gradient, once again, was more towards the plasma. Kumar (1956) had observed the salivary secretions to increase at about 40°C body temperature. Increase in the plasma volume at 39°C seen now thus appeared to be important before the fluid could be made available for salivary secretions.

Upto 40°C rectal temperature the percentage rise of total blood volume and plasma volume kept pace with each other. Above 40°C body temperature there was a greater rise in plasma than in total blood volume (Fig. 1). This indicated that upto 40°C besides water, cells were also thrown into circulation but beyond this temperature, perhaps because of the depletion of the cellular store no more cells were available to account for the increase in blood volume.

REFERENCES

Bowler, R.G. (1943). *Biochem. Jour.*, **38**, 385.

Crandall, L.A. and Anderson, M.T. (1934). *Amer. J. Dig. Dis. Nutr.*, **1**, 126.

Gregersen, M.I. and Stewart, J.D. (1939). *Am. J. Physiol.*, **125**, 142.

Kumar, S. (1953). *Ind. J. Physiol. Allied Sc.*, **7**, 203.

Kumar. S. (1956). *Ind. J. Physiol. Allied Sc.*, **10**, 19.