Drinking produced by blood volume manipulation in weanling and adult rats

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Twenty-five- and 90-day-old rats were subjected to extracellular volemic stress induced by subcutaneous injections of formalin or polyethylene glycol. Young rats responded to volemic stress by increasing their intake of water, as did adults; however, young rats showed a hyperreactivity (exaggerated intake) to volemic stress. This finding may reflect a behavioral compensation for the immaturity of the young animals' excretion controlling mechanisms.

When the tonicity of extracellular fluid (ECF) is decreased, thirst seems to appear only when intravascular volume is also decreased. Formalin introduced subcutaneously produces this effect physiologically and produces drinking in adult rats (Stricker, 1966; Stricker & Wolf, 1966). Acute decreases in the volume without changes in ECF tonicity can be produced by subcutaneous administration of polyethylene glycol (PG) which is also a potent stimulus for drinking (Corbit, 1968; Stricker, 1966; Stricker & Wolf, 1966, 1969).

The mediational systems for regulating the volume of ECF have been reviewed elsewhere (Pitts, 1968; Woodbury, 1966). Briefly, the system involves some receptor sensitive to blood volume (distention of the left atrium or the thyro-carotid arterial junction) and/or to changes in the flow or pressure of the blood entering the kidney. Also involved are appropriate neural and hormonal components of the hypothalamic-pituitary-adrenal-kidney axis.

Mechanisms implicated in such a response by the adult are known to be immature in the young rat. Mikuláš et al (1961) have shown that mineral-corticoids produced by the adrenal glands, one of which is aldosterone, are secreted in very small amounts by young animals. If the young rat has an aldosterone "insufficiency," one might expect it to increase its intake of water when subjected to volemic stress as less water will be reabsorbed into the vascular system by the kidney than is necessary to restore the volume deficit. Immature functioning of the kidney as demonstrated by Falk (1955) would also place a greater burden on water intake as a mode of restoring the ECF volume deficit. There is, however, the possibility that mechanisms controlling renal function are also involved in mobilizing drinking. Fitzsimons (1969) has shown that renal extracts (probably containing renin) produce drinking and that angiotensin injected

intracranially (Epstein et al, 1969) or intravenously (Fitzsimons & Simons, 1969) also produces drinking. If the mechanisms controlling renal function (which also mobilize drinking) are immature in the young rat, then lessened intake would obtain.

The present study was designed to observe drinking in young animals when the dipsogenic stress was ECF volume reduction.

METHOD

Six independent groups of four Ss each were tested. Animals were maintained on ad lib food and water. Ss were injected subcutaneously with either polyethylene glycol (mol wt 40,000), formalin, or 0.9% NaCl (wt/volume) at 25 or 90 days. The

amounts of fluid injected into both the 25- and 90-day-old rats were: polyethylene glycol, 2.0% body weight (bw); formalin, 1.0% bw; and 0.9% NaCl, 1.7% bw (formalin and polyethylene glycol were injected in a 0.9% NaCl vehicle).

RESULTS AND DISCUSSION

Figure 1 depicts the means and ranges for water intake in 25- and 90-day-old rats at various times after injection. It can be seen that the curves are quite similar in shape and that young animals, as well as adults, increase their intake of water in response to ECF volume manipulations as compared with the effects of the isotonic-saline vehicle ($p < .05$, Fisher test, tested at 4 h after injection).

Table 1 shows water intake per unit body weight in 25- and 90-day-old rats. Water intake is higher in young animals ($p < .01$ in each case, Fisher test) for formalin, PG, and 0.9% NaCl.

Table 1
Water Intake (Percent Body Weight) in 25- and 90-Day-Old Rats 4 H After Subcutaneous Injection of Various ECF Volume Manipulants

Injected Substances	Age (Days)	
	25	90
Formalin	0.44	0.11
Polyethylene Glycol	0.42	0.10
0.9% NaCl	0.16	0.06

These data support the hypothesis that the young rat, even though its physiological mechanisms for regulating body water are incomplete by adult standards, is responsive to volume manipulations of ECF which lead to drinking. In addition, the young animal also shows a hyperresponsiveness to volume manipulations.

It is conceivable that this hyperresponsiveness is a release phenomenon reflecting functional immaturity of inhibitory systems (Stricker, 1969). On the other hand, noting that the mechanisms which control urine output are slow to mature in the rat, a more likely explanation of our findings is that the immaturity of excretory mechanisms places a greater burden upon intake as a way of coping with hydrational stress.

This latter hypothesis implies that intake mechanisms reach full competence before the excretory mechanisms do, and to that extent they are independent. Indeed, Čápek & Jelinek (1955) have shown that spontaneous urination does not occur until the rat is approximately 14 days of age, well after the time it has started suckling.

It is quite possible that, in behaving differently from the adult, the young

Fig. 1. Means and ranges for water intake in 25- and 90-day-old rats after subcutaneous injection with ECF volume manipulations. Connected points represent means; vertical lines represent ranges.

animal is behaving in a manner appropriate to the demands imposed by its characteristic environment and the maturational levels of its other regulatory mechanisms.

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