

these experiments prolonged action of a single injection of histamine was obtained by suspending the histamine particles in a beeswax mixture.

11500

Salt After Adrenalectomy. I. Growth and Survival of Adrenalectomized Rats Given Various Levels of NaCl.*

EVELYN ANDERSON, MICHAEL JOSEPH AND VIRGIL HERRING.
(Introduced by Herbert M. Evans.)

From the Institute of Experimental Biology and the Department of Medicine of the University of California, Berkeley and San Francisco, California.

It is well known that the administration of sodium chloride to animals deprived of their adrenals considerably delays the onset of adrenal insufficiency, but the importance of the amount of sodium chloride given such animals has not received adequate attention. There is an "optimal" amount of sodium chloride from which such an animal derives benefit; an excess of sodium chloride is injurious. Moreover, inadequate study has been given the matter of the degree to which functional restoration occurs in adrenalectomized animals given salt. These are the problems which concern us here. This study deals with the growth and survival of adrenalectomized animals in response to varying amounts of sodium chloride. Two succeeding reports deal with the urinary excretion of Na and K and with the storage of fed carbohydrate by such rats.

Adrenalectomized rats fed a standard diet and allowed to drink 1% NaCl take in an amount of salt which appears to be optimal for maintaining growth and health. For this study male rats were used; they were 10 weeks of age at the time of adrenalectomy, and weighed approximately 200 g. Controls were subjected to a sham operation in which the adrenals were dissected free of the surrounding tissue but not removed. From a group of 25 adrenalectomized rats given 1% NaCl solution, 15 had an average survival of 45 days (range 12-80 days) and 10 lived beyond the 110th day post-operative. During the course of the experiment all of the animals were tested for completeness of adrenalectomy by withdrawing salt and allow-

* We wish to acknowledge the assistance of the Federal Works Progress Administration, Project No. OP 65-1-08-62, Unit A-5, and the Christine Breen Fund.

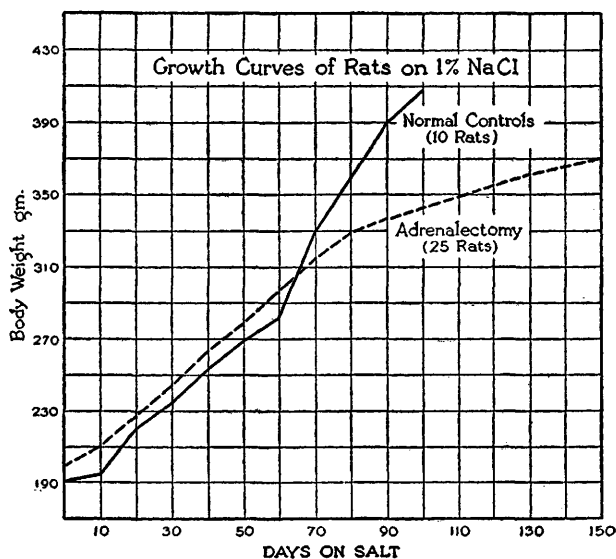


CHART I.

Showing the growth response of adrenalectomized rats given 1% NaCl to drink.

ing the animals to go into a state of adrenal insufficiency. The average daily intake of sodium in food and drinking water was estimated to be about 290 mg (725 mg NaCl). The growth curve of these animals is shown in Chart I. The adrenalectomized rats on 1% NaCl continued to grow at the same rate as the control animals for about 2 months; after that the growth rate was diminished. These animals were used from time to time for testing the excretion of radioactive sodium and potassium. This entailed keeping the rats on a restricted regimen of Locke's solution with glucose for 3 days at a time. A temporary loss of body weight occurred with each experiment. The electrolyte excretion of these animals is reported in another communication.¹

Adrenalectomized rats given 1% NaCl *ad libitum* consume as much food as normal rats. The intake of food and of salt solution and the gain in body weight were measured on 2 groups of adrenalectomized rats and on 2 control groups for a period of 30 days. These data are shown in Chart II. The stock diet given these animals contained 1.6% sodium by analysis (=4% NaCl). The animals were kept in individual cages in a chamber kept at a constant temperature of 28.5°C. One group of 5 adrenalectomized rats was given tap water to drink. Their NaCl intake in the food averaged

¹ Anderson, E., Joseph, M., and Herring, V., *Proc. Soc. Exp. Biol. and Med.*, 1940, **44**, 482.

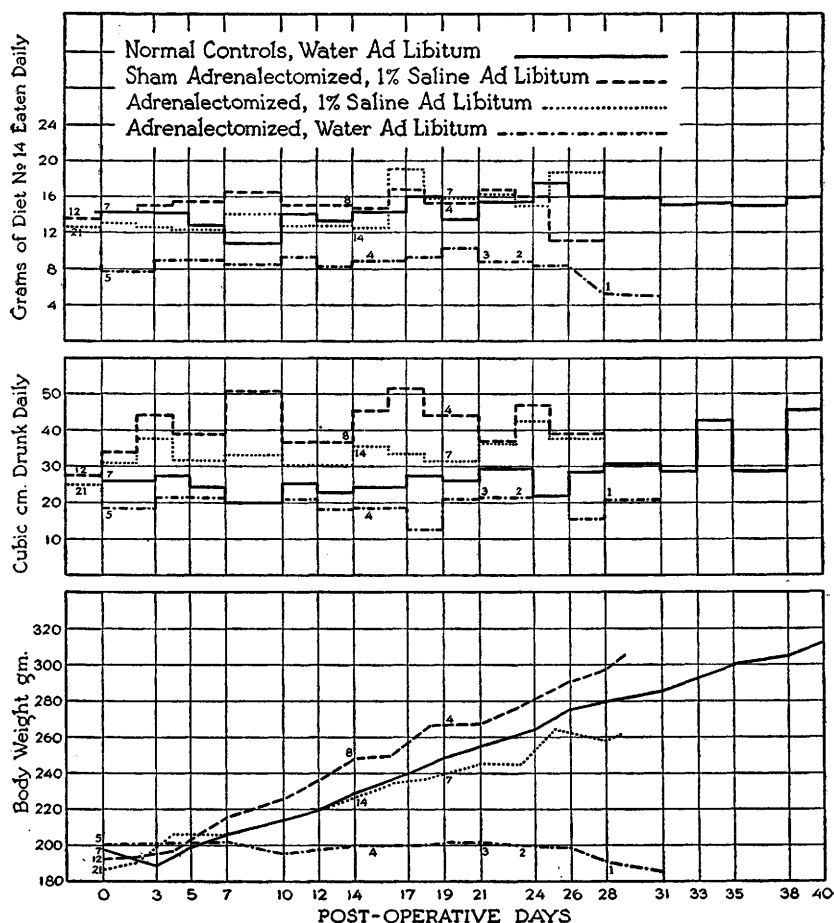


CHART II.

Showing the growth response and the food and fluid intake of adrenalectomized rats on 1% NaCl. Normal controls on tap water: total NaCl intake 601 mg daily. Sham adrenalectomized rats on 1% saline: total NaCl 1121 mg daily. Adrenalectomized rats on 1% saline; total NaCl 940 mg daily. Adrenalectomized rats on tap water: total NaCl 339 mg daily.

339 mg daily. Another group of 21 adrenalectomized rats was permitted to drink 1% NaCl *ad libitum*. Their total NaCl intake was 940 mg daily. One control group had been subjected to a sham adrenalectomy. This group was given 1% NaCl *ad libitum*. Their total NaCl intake was 1121 mg daily. The other control group consisted of normal rats which were given tap water to drink. Their NaCl intake was 601 mg daily. The adrenalectomized rats which had a total NaCl intake of 339 mg daily failed to grow and the animals died between the 14th and 31st days post-operative. The adrenalectomized rats with a higher NaCl intake, namely 940 mg, grew as

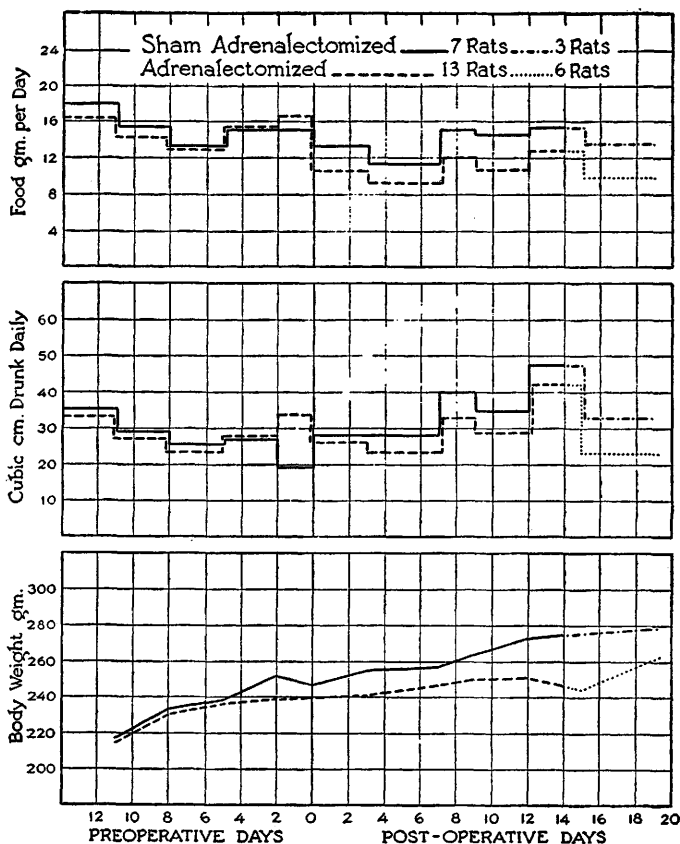


CHART III.

Showing the growth response and the food and water intake of adrenalectomized rats, given 16 cc of 5% NaCl daily. Sham adrenalectomized rats: total NaCl intake 1352 mg daily. Adrenalectomized rats: total NaCl intake 1234 mg daily.

well as normal animals. These animals were sacrificed on the 10th, 15th, 20th and 30th days post-adrenalectomy in order to determine the carbohydrate stores after feeding glucose. This is reported in another communication.²

In contrast to the beneficial effects of a 1% NaCl solution upon the growth and survival of adrenalectomized rats, it was found that larger amounts of NaCl in the drinking water proved to be injurious to such animals. This was tested out as follows: When adrenalectomized rats were given 4 cc of a 5% NaCl solution by stomach tube twice a day and allowed to drink tap water *ad libitum* and offered

² Anderson, E., Herring, V., and Joseph, M., *PROC. SOC. EXP. BIOL. AND MED.*, 1940, to be published.

a standard diet which contained .7% sodium by analysis (=1.75% NaCl), they grew and remained in good health for an indefinite period. They resembled the adrenalectomized rats reported above which were kept on 1% NaCl. The total NaCl intake was practically the same for both groups, averaging about 650 mg. Another group of adrenalectomized rats was given 4 cc of 5% NaCl four times a day and allowed to drink tap water *ad libitum*. Their NaCl intake amounted to more than one gram per day. These animals resembled untreated adrenalectomized rats; they failed to grow and their average survival period was 19.5 days (with a range of 5-28 days). When 4 cc of 5% NaCl was given 6 times a day to adrenalectomized rats, the animals were all dead within 2 days. The urinary excretion of sodium and potassium in this group of animals is reported separately.¹

The higher amounts of NaCl decreased the food intake slightly for both adrenalectomized and control rats. Food records and water intake were kept on a group of 13 adrenalectomized rats and 7 controls which were given 4 cc of 5% NaCl 4 times a day. The NaCl intake for the adrenalectomized rats was 1234 mg daily, for the controls 1352 mg (Chart III.). The difference in food intake in these two groups was slight. There was no significant growth in either group. The animals were sacrificed on the 15th and 20th days post-adrenalectomy, in order to determine the ability of these animals to store carbohydrate. These data are reported separately.²

Summary. A daily intake of 650 to 940 mg NaCl for an adult adrenalectomized rat seems to be "optimal" in maintaining growth and apparent health. A daily intake of 339 mg is not sufficient for growth or survival. Large amounts of NaCl such as 1200 mg a day are injurious.