THE OSMORECEPTORS OF THE HINDLIMBS

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Osmotic pressure in blood and interstitial fluid is delicately maintained at a constant level by the osmoregulatory reflex mechanism. Its afferent part comprises specific structures—the osmoreceptors, which were first discovered by Verney [9] in the supraoptic nucleus of the hypothalamus. In A. G. Ginetsinskii's laboratory, results were obtained which conflicted with Verney's view, and receptors sensitive to a change of osmotic pressure were found to be widely distributed throughout the body [1, 2, 3]. Later workers [4, 5, 6] confirmed these results, and it was shown that osmoreceptive fields are present in tissues of the liver, kidney, pancreas, and other viscera.

The object of the present investigation has been to study the osmoreceptive fields in the hindlimbs.

The work was carried out on dogs weighing 8 - 16 kg which had been prepared previously. A two-stage operation was carried out under morphine-ether anesthesia. In the first stage, the gastric fistula was established, and the ureters were brought to the outside by the method of Pavlov-Orbeli. In the second state, the left kidney was removed, and a polychlorovinyl cannula-probe inserted through the renal artery into the abdominal aorta in such a way that fluid introduced into it reached the vessels of the hindlimbs. A steady diuresis of 4 - 5 ml/minute per m^2 of body surface was maintained by repeated injection of small amounts of water into the stomach.

After 20 - 40 minutes from the start of the experiment, a control physiological saline solution was infused through the renal artery so as to pass to the posterior portion of the trunk, and as a further investigation, the reaction was found to the injection of 3 - 10 ml of a 3 - 7% sodium chloride solution.

In another set of experiments we used 8.2% urea and 27.5% glucose which were isosmotic with 5% sodium chloride solution.

RESULTS

The injection of the hypertonic sodium chloride solution into the renal artery (directed toward the hindlimbs) inhibited diuresis. The greatest effect was produced by the injection of 5 - 6 ml of 5% sodium chloride. However, physiological saline or 2 - 3% sodium chloride had no such effect (Fig. 1). In this series of experiments, altogether 38 observations were made, and the results were all in agreement.

The rate of development and the extent of the inhibitory reflex varied. The effect was shown as a reduction of diuresis, on average of 56 ± 2.8% of the original rate, and the inhibitory effect lasted 29 ± 2.14 minutes.

In order to be sure that the oliguric effect was really due to excitation of the osmoreceptors of the hindlimbs, and not to any generalized physico-chemical change in the blood, we carried out the control experiments in which the osmotic pressure of blood collected from the hindlimbs was measured. The osmotic pressure was determined cryoscopically, by means of an apparatus operating on a thermoelectrical principle to measure the freezing point of the solution. The blood was collected from the saphenous vein and from the inferior vena cava at the moment that the solution was injected, and at intervals of 20 seconds for the next 2 - 4 minutes. It was found that the concentration of the osmotically active substances in these vessels scarcely changed during the whole period of observation.

In the next set of experiments, an 8.2% solution of urea or a 27.5% glucose solution was injected into the vessels of the hindlimbs. After the injection of the urea, either there was no change in urinary excretion, or else there was a small increase. Glucose produced a very marked effect (Fig. 2).

Urea readily penetrates the vessel walls, and therefore cannot effectively increase the osmotic pressure. Glucose and sodium chloride penetrate the protoplasm of the cells very slowly, and appear to set up differences of concentration which act as a stimulus for the osmoreceptors.

The results we have obtained allow us to conclude that the antidiuretic response to the injection of the solutions results from stimulation of osmoreceptors, and not of the ordinary chemo- or baroreceptors.

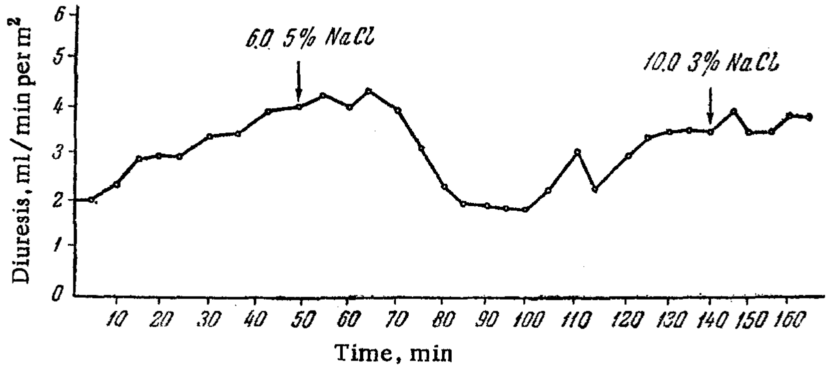

Fig. 1. Change in diuresis in a dog after the injection of different concentrations of sodium chloride into the renal artery.

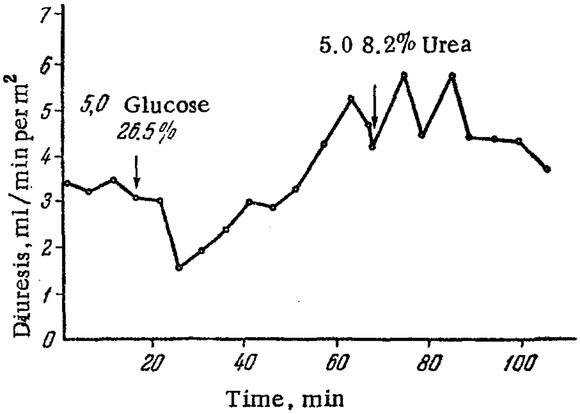

Fig. 2. Change of diuresis in a dog after injection into the hindlimbs of glucose and urea.

The injection of a hypertonic solution into the abdominal aorta of dogs in which the spinal cord had been sectioned at the level Th_{5-6} produced no antidiuretic reaction. These experiments indicate that the osmoreceptors of the hindlimbs influence the hypothalamo-hypophyseal system by a reflex involving the normal afferent pathways. There is no humoral influence from these receptors, such as occurs on stimulation of the osmoreceptors of the liver [5, 6, 7, 8].

SUMMARY

In this investigation, we showed that specific osmoreceptors are present in the hindlimbs of dogs. Stimulation of these receptors with a hypertonic solution (5% sodium chloride or 27.5% glucose) inhibited diuresis. This reaction disappeared after division of the cord at the level Th_{5-6}, indicating that the reaction must be reflex in nature.

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