THE RENAL FUNCTION AFTER INJURY TO THE THALAMO-HYPOTHALAMIC REGION OF THE BRAIN

I. I. Zaretskii, I. A. Mikhailova* and N. S. Rozanova

Pathophysiological Laboratory (Head—Corresponding Member AMN SSSR Prof. N. A. Fedorov) of the Central Order of Lenin Institute of Hematology and Blood Transfusion (Director—Active Member AMN SSSR A. A. Bagdasarov) of the Ministry of Health of the USSR, Moscow
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There is an extensive literature on the question of the influence of the thalamus on the secretion of urine. In the regulation of the activity of the kidneys, great importance is attached to the grey matter of the brain situated in the tuber cinereum, the infundibulum, the corpora mammillaria and the region of the third ventricle. Experimental research has shown that injury to these divisions of the thalamus usually results in polyuria [1, 5, 9, 11, 13]. An increase in the secretion of urine may also be caused by puncture of the tuber cinereum and infundibulum in hypophysectomized animals [1, 7, 8].

It has been stated that the renal blood flow is under control of nerve cells situated in the tuber cinereum [2]. Strong evidence in favor of the participation of the thalamus in the regulation of the secretion of urine is given by the results of observations on patients with diabetes insipidus. In these cases pathological changes were found only in the hypothalamus; no organic changes were found in the hypophysis [4, 6, 10, 12, 13, 14].

In all these investigations, however, no consideration was paid to the renal mechanisms determining the character and degree of the changes in diuresis after disturbances of the subcortical nervous formations. The present work was devoted to the elucidation of this problem.

METHOD

Chronic experiments were carried out on dogs with ureteric fistulas, fashioned by I. P. Pavlov's method. We used two methods of causing injury to the brain: 1) mechanical destruction of part of the brain and 2) injection of alcohol into the brain substance. Hexobarbital was used as general anesthetic. The animals were bound in the prone position. The skin incision was usually made on

* Deceased.

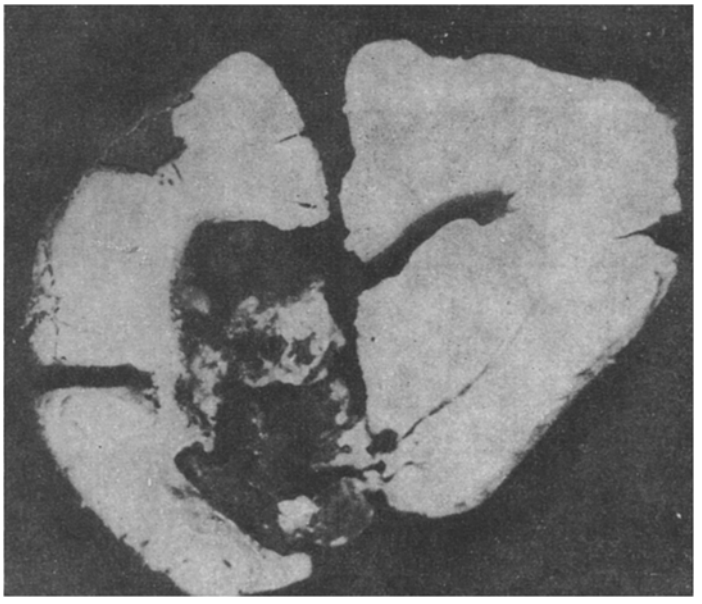

Fig. 1. Morphological picture of the left thalamo-hypothalamic region of the brain after mechanical injury.

the side of the skull where the brain was to be injured. After division of the skin and fascia, the temporalis muscle was mobilized with a raspatory, so far as possible without damaging it. A burr-hole was then made in the bone, 1-1.5 cm in diameter, at a previously calculated point. Hemorrhage was usually slight and easily stopped by one of the following measures: molten wax, hypertonic glucose solution and hemostatic gauze. When the bleeding was under control, the dura mater was opened. Mechanical injury to the brain was caused by means of a special device, contructed in É. A. Asratyan's laboratory, and the alcohol was injected by means of a syringe. The direction and depth of introduction of the cannula of the apparatus or of the needle of the syringe was determined in accordance with the size and shape of the dog's skull. The volume of alcohol injected was 0.5-0.7 ml. Finally, the wound was closed in layers. The experiments commenced not sooner than 2-10 days after the operation. The diuresis was studied after a known high water intake (60 ml of water/kg body weight of the dog), the glomerular filtration by means of inulin, the urea clearance, the renal blood flow and the maximum secretion by means of diodrast, the tubular reabsorption of water and urea and the plasma filtration fraction. A general analysis of the urine was also carried out.

RESULTS

Experiments were performed on seven dogs; in two of these animals the subcortical formations were destroyed mechanically, and in the remaining five by alcohol. This was because serious drawbacks appeared in the mechanical method of causing injury to the brain. The operation was very often fatal in its outcome. It was easy to damage other parts of the brain as well as the subcortical ganglia, and a large hematoma often developed (Fig. 1). The method of alcohol injection may to some extent limit the zone of injury and avoid further brain destruction and hematoma formation. By this method, moreover, the size of the zone of injury of the brain can be estimated to some extent, for it depends on the volume of alcohol injected, the rate of its injection and the pressure used.

Macroscopic examination showed that injection of alcohol caused injury to the nuclei of the optic thalamus and the subthalamic region, but in the cerebral cortex only small areas of damage were observed (Fig. 2).

After injury to the diencephalon, the animals for a few days displayed a pain reaction, low mobility, delay in taking food, disturbances of coordination of movement, disorders of the cardiovascular system, respiration and thermoregulation. These manifestations gradually became less pronounced and, finally, 10-15 days after operation, were no longer found.

The experiment showed that unilateral injury of the thalamo-hypothalamic region of the brain not only affects the animal's general condition, but also produces significant changes in renal activity (see Table). This was shown in the early period after operation by inhibition of the urine secreting function of the kidneys. In 5 of the 7 experimental animals in the first 5-10 days after injury to the diencephalon, a fall in diuresis was observed, amounting to 30.77-42.86%. A tendency not only toward an oliguric type of water diuresis, but also to a delayed and extended type was detected under these circumstances. Whereas in normal conditions the maximum urine secretion took place in the first two hours after intake of water, after injury to the diencephalon the diuretic process was drawn out, and the maximum diuresis was observed only after 2-3 hours or even later.

In individual animals, along with a fall in the diuresis there was a fall in the glomerular filtration, which, however, did not exceed 3.11-4.14%. Such a very slight fall in the glomerular filtration cannot, of course, be the essential cause of a comparatively large-scale fall in diuresis. In certain cases, moreover, the decrease in urine secretion was associated with an increase in the rate of glomerular filtration.

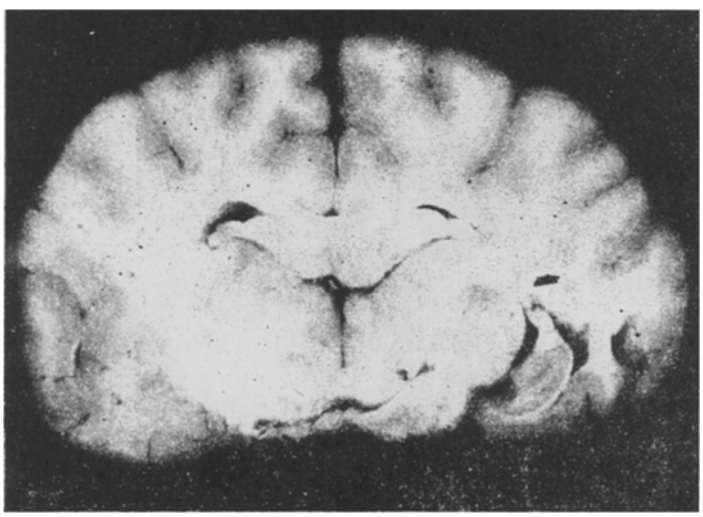

Fig. 2. Changes in the left thalamo-hypothalamic region of the brain after injury by injection of alcohol.

TABLE. Figures Relating to the Renal Function After Injury to the Left Thalamo-Hypothalamic Region of the Brain Due to the Injection of 0.3 ml of Alcohol (the dog Chita, Weight 10 kg)

Indices of the functional state of the kidneys	Before injury to the diencephalon (mean figures from 3 experiments)	After injury to the diencephalon		
		Day after operation		
		12th	16th	27th
Diuresis (in ml/min)	3,9±0,20	2,70	3,10	4,40
Plasma urea concentration (in mg%)	28,90	22,90	40,80	16,58
Glomerular filtration (inulin)(ml/min)	28,30±7,97	30,80	25,90	31,50
Urea clearance (in ml/min)	27,30	57,40	31,82	29,40
Renal blood flow (plasma flow) (diodrast) (in ml/min)	124,98±8,14	135,51	156,10	166,70
Reabsorption of water in tubules (in %)	77,44±3,39	88,60	86,10	73,33
Ratio between coefficient of urea clearance and coefficient of inulin clearance	0,72	1,86	1,22	0,93
Maximum tubular secretion, in mg iodine (per min)	17,56±2,87	21,08	25,80	31,00
Volume of plasma cleared of diodrast by a unit of functioning tubules (in ml/min)	7,38±1,68	6,50	6,10	5,30

According to our findings, the phenomenon of oliguria mainly developed in consequence of an increase in the reabsorption of water in the tubular portion of the nephron.

Side by side with decrease in glomerular filtration the presence of a disturbance of the intrarenal hemodynamics may be assumed. Immediately after injury to the diencephalon, the picture of disturbed renal circulation was apparent in the fall in the coefficient of diodrast clearance, which indicated a reduction in the blood flow through the kidney, and also in the increase in the fraction of the plasma filtered in the glomeruli. In several cases the fall in the renal blood flow was calculated to be 33.01-36.15% and the increase in the plasma filtration fraction reached 153.98-163.04%. This suggests that the fall in the blood supply to the renal parenchyma was greatest in the tubular portion of the nephron, and was due to constriction of the efferent arterioles of the glomeruli. It is very probable that the increase in the tone of the glomerular vessels and also the increase in the intensity of reabsorption of water in the tubules were associated with the production of adrenalin and of other vasoconstrictor substances. Meanwhile the decrease in the power of the tubules to secrete diodrast cannot be attributed purely to the disturbance of the renal circulation. This can be concluded from the fact that a fall in the maximum secretion to 13.94% was observed at the same time in the individual experiments.

It must be mentioned that injury to the thalamo-hypothalamic region of the brain did not always lead to the same type of result. Depending on the depth of the brain injury, either transient or more lasting disturbances of the renal function could be observed. The most marked abnormalities were observed after mechanical injury to the subcortical area of the brain. At subsequent periods of observation, a definite tendency toward polyuria was observed. In some experiments the secretion of urine exceeded the normal value by 14.64-25.26%. In the overwhelming majority of cases the increase in diuresis was accompanied by an increase in the glomerular filtration to 67.71-127.85%, of the urea clearance to 58.19-110.26%, of the renal blood flow to 24.90-33.58% and of the maximum secretion to 46.92-60.48%. Later the renal function was gradually restored, and two or three weeks after operation all the indices of the work of the kidneys were approximately at their original value.

The findings described thus afford further confirmation of the reports in the literature that the central regulation of the activity of the kidneys is effected by means of the diencephalon, and they demonstrated the reversibility of all the abnormalities of renal function arising after injury to the thalamo-hypothalamic region of the brain. This is evidence of the great powers of compensation possessed by the the nervous system in the regulation of the vegetative functions of the body. The role of the subcortical nerve centers is not confined to the regulation of the renal circulation. It seems that, independently of this activity, they also influence the specific functions of the tubules.

SUMMARY

The functional condition of the kidneys was studied in unilateral injury of the thalamo-hypopthalamic region of the brain in 7 dogs with Pavlov ureteric fistulae. At first, injury to the diencephalon provokes a fall in diuresis, glomerular filtration, urea clearance, renal blood flow and maximal secretion. Then on the 5th-10th postoperative day, a rise of the renal function indices is seen. The changes in the renal activity are reversible and functional in character. The role of the diencephalon is not limited to the control of the renal blood supply. Independently of this fact it influences the specific function of the tubules.

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