THE SIGNIFICANCE OF NERVOUS INFLUENCES FROM THE UPPER DIVISION OF THE DIGESTIVE TRACT UPON THE MECHANISM OF WATER DIURESIS

E.B. Berkhin

From the Department of Pharmacology (Chairman: Prof. A. A. Lyubushin) Chkalov Medical Institute and the Laboratory of General Physiology (Director: Acting Member Acad. Med. Sci. USSR Prof. V.N. Chernigovsky) Physiological Inst. Acad. Med. Sci. USSR, Moscow.

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Our observations [3] and also the findings by other authors [1, 6, 7, 8] indicate the role of reflex mechanisms from the upper portions of the digestive tract upon the mechanism of diuresis following drinking. In the present work we set ourselves the aim not only of finding new evidence for this supposition, but also to consider the more exact significance of the various parts of the digestive tract in the stimulation of water diuresis.

EXPERIMENTAL

Initially, we wanted to clarify whether the length of time that water was kept in the mouth, and especially the number of swallows taken during drinking, has any influence upon the character of water diuresis.

For determining this question we used a method which we called "prolonged" drinking.

The experiments were conducted upon dogs with urinary catheters in place. The animals were compelled to drink a predetermined quantity of water slowly, not as they usually do within 3-4 minutes, but gradually over 10-15 minutes. This goal was attained by a very simple device by means of which water preheated to the necessary temperature entered the dish continuously but in small amounts. As a result of this, the dog was compelled to make numerous licking movements swallowing each time only a small quantity of water. The regulation of the quantity of water entering could be controlled during drinking by the aid of a tap. The beginning and end of this drinking period was so regulated that its middle coincided with the giving of water in the control experiments. Urine was collected for 15 minutes, one hour before beginning drinking and 3 hours after cessation of drinking.

Experiments With "Prolonged" Drinking

We showed in 65 experiments conducted upon 4 dogs (5 series of experiments) that with "prolonged" drinking a 3-hour diuresis is somewhat increased (from 3-8%), but exclusively in the period of the first hour. If we view the diuretic reaction for the first hour, then the increased diuresis in comparison with the control experiments attains a greater volume (see Table 1).

From the table it can be seen that the diuresis in the first hour and in the majority of cases for 3 hours is elevated during "prolonged" drinking. Only with Dame was the three hour diuresis definitely diminished, but not in the period of the first hour, which even in this case gave a somewhat higher diuresis.

It can be said that the beginning of watery diuresis depends in these experiments on a summation of impulses, coming to the nerve centers from the region of the mouth and the swallowing apparatus, insofar as the quantity of swallowing movements varies in the usual and "prolonged" drinking. Thus, the dog Astra, with ordinary drinking of 500 cc made approximately 280 swallowing movements, while with "prolonged" approximately 800. The dog Playful, in whom was observed the greatest diuresis in the first hour after

Average Results with "Prolonged" Drinking
(Diuresis indicated in percent of the quantity of water drunk)

Name of dog	Number of experiments	Diuresis			
		In the first hour		After three hours	
		Control experiment	Experiment ("prolonged" drinking)	Control experiment	Experiment ("prolonged" drinking)
Irma	8	48.0	53.2	90.5	89.7
Astra	14	23.5	31.2	86.8	93.4
Dame	15	38.8	40.8	91.6	87.0
Astra	15	39.8	51.0	96.6	101.0
Playful	13	32.6	45.8	92.8	96.2

"prolonged" drinking, had respectively 200 and 990 swallowing movements (approximate figures).

The results of experiments with "prolonged" drinking are interesting when compared with the findings of I. N. Zhuravlev [5], obtained on calves both with rapid and slow drinking of milk. Slow drinking, i.e. "prolonged" action upon the external receptors of the mouth, curtailed the usual calf phase as a consequence of their sucking on surrounding objects.

Results obtained by us confirm the fact that the upper division of the digestive tract and the swallowing apparatus could be reflex zones for beginning diuretic stimulation.

The following experiments had as their object the comparison of the volume of diuresis with the introduction of water through the mouth or directly into the stomach (either through a tube or a fistula).

There were 36 experiments on 3 dogs. Each dog, after the determination of its pattern of diuresis over 2 hours, received a water load – in some experiments water was introduced into the stomach through a fistula, in others by way of ordinary drinking. Urine was collected for 4 hours.

In all experiments under comparable conditions the diuresis was reduced when water was introduced directly into the stomach (Fig. 1), and the initial diuresis was less intense. Thus, the diuresis for the first hours after direct introduction of water into the stomach, as compared with the diuresis after drinking, in the dog Gilda was 87.5%, in Yunon 88.1%, in Mimosa 59.4%.

In the experiments above we did not introduce water into the stomach by means of a catheter, as this manipulation provokes a defensive reaction on the part of the dog and, besides that, it is inevitable that numerous receptors of the oral and esophagal regions are stimulated, and this and the other must have an influence upon the character of the diuresis. It is interesting to observe that in cases of water intoxication, as observed by L. O. Reznikov [9] in overloading puppies with water, his experiments were all conducted by giving the water through a catheter: with ordinary drinking he could not produce it.

The taking of water is frequently accompanied by a diuresis noticed in as little as 15 minutes. For such a diuresis upon the introduction of water by mouth and by fistula we studied the results of 117 experiments on 3 dogs (51 with drinking and 66 experiments by introduction through a fistula), subjecting them to a statistical analysis (see table).

The comparison of these figures shows that with direct introduction into the stomach the increase in diuresis is considerably less than with drinking.

Statistical work-up of the material shows that the difference in the volume of diuresis in the first 15 minutes before and after natural drinking appears to be authentic, while the introduction of water through a fistula into the stomach gives a difference bordering on the permissible deviation.

It was only after we had completed our experiments that we became acquainted with the work of A. P. Kandel and S. N. Kneller [6] in the laboratory of G. P. Konrad, in which they compared human diuresis upon drinking water and introducing it into the stomach by means of a catheter. The introduction of water by means of a catheter gave a diuresis level on the average 30% lower. Thus, these clinical observations completely coincide with ours, obtained by experiments upon dogs.

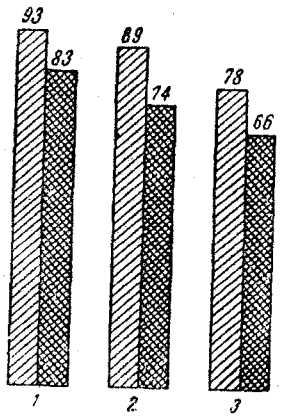

Fig. 1. Diuresis for 3 hours after giving a water load.
Clear columns - diuresis after drinking; dark ones - diuresis after introducing water through a stomach fistula (in % of the introduced quantity). Indicated columns: 1) dog Gilda; 2) dog Yunon; 3) dog Mimosa.

The Volume of a 15-minute Diuresis Before and After Giving Water by Mouth and Introducing it Into the Stomach Through a Fistula

The time and conditions of experiments	Average volume of diuresis (in cc)
Before introduction through mouth	3.45 ± 0.26
After introduction through mouth	8.00 ± 1.11
Before introduction into stomach	4.29 ± 0.29
After introduction into stomach	5.60 ± 0.56

In the literature there are indications of the influence upon diuresis exerted by stimulation of the mucous membrane of the stomach. In part, K. A. Chukin (1944) noted a diminution of diuresis with water irrigation of the mucous membrane of the stomach, which was also confirmed later by Ya. A. Altman [1] and N. N. Pronina and Ya. A. Altman [8]; these last, however, observed a heightened diuresis upon the introduction of water into the stomach by means of a fistula and emptying it a minute later or by the introduction of the same quantity of water by means of a rubber balloon. Filling the balloon with twice as large an amount of water diminished the diuresis. According to the findings of A. A. Lebedev [7], a small distention of the stomach does not have a definite influence upon diuresis, while a large one leads to its diminution. Thus, the literature indicates no clear picture of the significance of interoceptive stimuli of the stomach upon diuresis.

We made 54 experiments upon 5 dogs with fistuli of the stomach and exteriorized urinary bladders (22 experiments by irrigating the stomach, 27 with stretching, 5 controls).

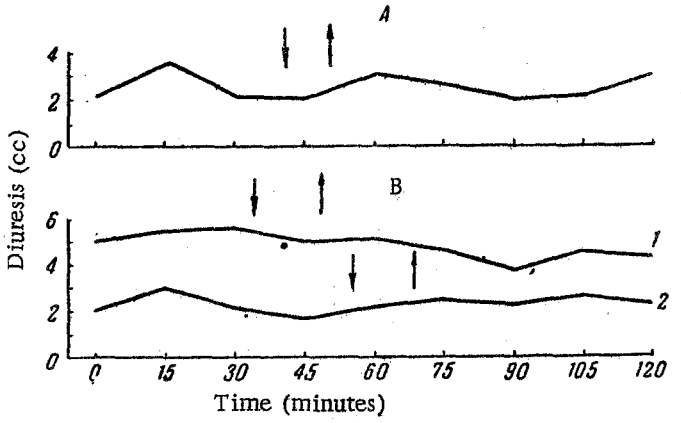

Fig. 2. The influence of watering and stretching the stomach upon diuresis:
A) experiment on dog Yunon on 7/23/54 (↓ - beginning and ↑ - end of irrigation). B) 1) experiment on dog Mimosa on 9/7/54, 2) experiment on dog Yunon on 8/9/54 (↓ - beginning, ↑ - end of stretching stomach).

Irrigating the mucous membrane of the stomach with warm water for 10 minutes in the majority of cases produced no material changes in the conditions of diuresis (Fig. 2). In several experiments part of the water during irrigation was evacuated from the stomach; in these cases there was observed a marked rise in diuresis, but not greater than occurs with introduction of the same amount without irrigation.

Our conclusions agree with the observation of K. M. Bykov [4] that water irrigation of the mucous membrane of the mouth without previous reinforcement by actual introduction of water has no influence upon diuresis.

In the experiments on stretching a stomach there was introduced through the fistula into an empty stomach a small thin rubber balloon, into which was introduced warm water equivalent in volume to the usual water load. The length of time taken to introduce this water was approximately the same as it would have been had the water been drunk. After a few minutes removal of water from the balloon in small portions was begun, thus imitating the usual evacuation of it from the stomach. Such "evacuation" begins in 2-5 minutes and ends after 15-30 minutes. The diuresis, however, fluctuated within normal limits. Only in 2 experiments did stretching of the stomach produce a noticeable rise in diuresis.

These experiments tell us that the interoceptive stimulation from the stomach has much less influence upon the beginning of diuresis than stimuli coming from higher lying regions. We cannot agree with the insistence of A. S. Yakovlev [10] that the most powerful receptors participating in the regulation of water exchange are in the stomach.

It is interesting to compare our experiments with the results obtained by Adolph [2]. This author showed that introduction of water directly into the stomach of a dog does not diminish thirst; if the dog receives water immediately after this, it will drink its usual amount. This is in view of the fact that a minimal amount of drinking will remove thirst for some time.

However, to deny completely any role of the stomach in the mechanism of water regulation is impossible, as in our experiments stimulation of the stomach was not accompanied by introduction of water into the organism. It is possible that under natural conditions stimulation of stomach receptors, accompanied by the preceding and following stimuli from other parts of the digestive tract might have a definite influence upon the determination of the intensity of diuresis.

Summarizing what has been said, we might conclude that the upper region of the digestive tract (including the swallowing apparatus) is a reflexogenic zone for the initial stimulation of diuresis, the stomach playing a relatively lesser role as compared with the oral region.

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