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PECULIARITIES OF SODIUM HOMEOSTASIS REGULATION DURING WATER-SALT LOADING IN PATIENTS WITH TYPE I DIABETES MELLITUS WITH STAGE I CHRONIC KIDNEY DISEASE

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Abstract

The aim of the study was to study the state of renal regulation of sodium homeostasis during water-salt loading and the value of the possible functional insufficiency of the tubular part of the nephron by changing the excretion of sodium from the body in patients with type I diabetes mellitus with stage I chronic kidney disease.

We have studied the ability of the kidneys to regulate sodium homeostasis in patients with diabetic nephropathy in comparison with healthy people. The study involved 11 healthy people aged 24 to 53 years, an average of 38.3±5.63 years and 11 patients with type I diabetes with stage 1 chronic kidney disease aged 40 to 65 years, an average of 52±4.2 of the year. Renal function was studied under conditions of water-salt loading - drinking in the morning on an empty stomach after emptying the bladder of 0.5% aqueous sodium chloride solution in an amount of 0.5% of body weight for 3-5 minutes.

When studying the ion-regulating function of the kidneys, it was found that the kidneys differentially remove ions from the body. If in healthy people with spontaneous daily diuresis, on average, the excretion of sodium and potassium ions is the same in magnitude, then with a water-salt load, the kidneys excrete mainly sodium. Thus, the concentration of sodium and its excretion was 3-5 times higher than the excretion of potassium in the urine. Consequently, the ion-regulating system provides priority excretion of sodium in the urine, both in relation to potassium and water.

It has been established that in patients with type I diabetes mellitus with stage 1 chronic kidney disease, the same regulatory mechanisms are activated that provide osmotic homeostasis, as in healthy individuals. The increase in sodium excretion revealed by us in patients may indicate functional insufficiency of tubules for sodium transport.

All human studies were conducted in compliance with the rules of the Helsinki Declaration of the World Medical Association "Ethical principles of medical research with human participation as an object of study". Informed consent was obtained from all participants.

Keywords: *water-salt load, functional renal reserve, chronic kidney disease (CKD), sodium homeostasis, diabetes mellitus*

Introduction

Literature data and the results of our previous studies indicate that the leading link in the pathogenesis of kidney disease in most cases is the presence and degree of damage to the tubular section of the nephron, which is especially demonstrated in acute renal lesions [1-4]. Given that the main energy-dependent process in both the proximal and especially the distal tubules is sodium transport, it can be assumed that impaired sodium reabsorption may be an important diagnostic criterion that reflects the functional state of the tubular nephron. Traditionally, this can be judged by the excretion or reabsorption of sodium [5-9].

Meanwhile, although indeed in kidney pathology, as a rule, an increase in sodium excretion or a decrease in its reabsorption is recorded, however, these changes are not as significant, for example, a decrease in the glomerular filtration rate, which indicates violations at the level of the glomeruli, although it is damage to the nephron tubules that is the leading , especially with toxic nephropathies [1,10-12, 14].

Based on the foregoing, we set the task to study the state of renal regulation of sodium homeostasis during water-salt load and to identify possible functional insufficiency of the tubular nephron by changing sodium excretion from the body in patients with type I diabetes mellitus with stage I chronic kidney disease (CKD).

Methods

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Based on the foregoing, we set the task to study the state of renal regulation of sodium homeostasis during water-salt load and to identify possible functional insufficiency of the tubular nephron by changing sodium excretion from the body in patients with type I diabetes mellitus with stage I chronic kidney disease (CKD).

Results

Indicators of water diuresis obtained in healthy people indicate that the kidneys effectively regulate the water balance and remove from the body about half of the volume of water drunk - 47.3±15.3 ml, although there are isolated differences with a decrease or increase in diuresis, which may indicate the individual characteristics of the water balance in individuals (Table 1).

When studying the ion-regulating function of the kidneys, it was established (Table 2) that the kidneys differentially remove ions from the body. If in healthy people with spontaneous daily diuresis, on average, the excretion of sodium and potassium ions is the same in magnitude, then with a water-salt load, the kidneys excrete mainly sodium. Thus, the concentration of sodium and its excretion was 3-5 times higher than the excretion of potassium in the urine. Undoubtedly, this was a manifestation of the ion-regulating function, which provides ionic homeostasis of the body by removing the injected sodium. Since under conditions of fluid intake into the body, along with which an average of 25-40 mmol of sodium enters, while in ordinary drinking water the concentration is no more than 1-3 mmol/l, and daily consumption is in the range of 20-30 mmol/l .

Under these conditions, the ion-regulating system provides priority excretion of sodium in the urine, both in relation to potassium and to water. The excretion of sodium from the introduced amount is approximately 2 times higher than the excretion of water and it is at least 30% higher than in healthy individuals. At the same time, in more than half of the patients, sodium excretion from the body

exceeds its intake with a water-salt load by 50%, reaching a value of 3.3 times more than in the load.

When studying renal function in patients with type I diabetes mellitus with stage I CKD, their homeostatic function had the same direction. So, for 1 hour, urine was actively excreted from the patient's body, even in a slightly higher percentage. This was primarily due to a decrease in tubular reabsorption of water, which, although it was not statistically significant, had a tendency to do so.

The state of the ion-regulating activity of the kidneys was revealed to be very interesting. With the same amount of sodium that entered the body, the concentration and, especially, its excretion were significantly higher than that of potassium. So, the excretion of sodium increased on average 2 times, and potassium almost 4. At the same time, the kidneys per hour excreted from the body an average of 1.5 times more sodium than was ingested, and in 5 patients the excretion was 2 or more times exceeded the amount of sodium that was received during water-salt load (Table 3). It should be noted that in healthy individuals, none of them had such sodium excretion values.

Conclusions

Thus, it can be stated that with water-salt load in healthy individuals, both an osmoregulatory function is triggered, which ensures the excretion of water, both a water-salt load, and an ion-regulating load, which ensures the excretion of sodium from the body, which comes from a water-salt load. This ion-regulating function ensures that about 100% of the sodium that enters the body is of paramount importance to the body. In patients with type I diabetes mellitus with stage I CKD, unidirectional regulatory mechanisms are presented that provide osmotic homeostasis, as in healthy individuals. At the same time, one gets the impression that they are more intense than in healthy people, since diuresis increases a little more, and sodium excretion is more than 100% of the administered one, in several patients it is 2-3 times higher than in healthy individuals.

In our opinion, this cannot be explained by the presence of an excess of sodium in the body of patients with diabetes mellitus, since there are no data on hypernatremia in the literature. In addition, all patients are on a sodium-depleted diet. The only possible explanation may be the assumption that under conditions when the water-salt load, as previously shown, increases the glomerular filtration rate and, accordingly, the sodium filtration charge, which leads to an overload of the tubular section of the nephron. Under these conditions, apparently, functional insufficiency of the tubular section of the nephron, which manifests itself in the form of a decrease in sodium reabsorption, which is one of the increase in its excretion.

Acknowledgments

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Relationship of the publication with the planned research works. The work presented is a fragment of the research project "Diabetic nephropathy pathogenesis and substantiation of chronic kidney disease diagnostics, № state registration 0120U102210.

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Table 1. Indices of diuresis after water-salt load in healthy individuals and patients with type I diabetes mellitus with stage I CKD

Indicators	Healthy people, M±m	Patients with Type I Diabetes with CKD stage of I, M±m
Diuresis, l/min	0,221±0,022	0,210±0,017
Water removal,%	47,3±15,3	52,31±8,76
Urinary rate, ml/min	2,4±0,33	3,1±0,39
GFR by creatinine clearance, ml/min	151,8±39,8	201,2±27,2
Reabsorption,%	98,35±0,34	96,63±0,58

Note: p≤0,05

Table 2. Indicators of the volume and ion-regulating function of the kidneys during water-salt load in healthy patients

Indicators	M ± m
The entered number of Na +, mmol	30,3 ±2,20
Concentration of Na + in urine, mmol/l	115,35 ±14,51
Excretion of Na +, mmol/60 min	23,27±7,51
Concentration K + in urine, mmol/l	33,89±5,14
Excretion of K +, mmol/60 min	6,44±0,59
Excretion Na +,%	70,53±19,69

Note: p≤0,05

Table 3. The relationship between the indices of the volume and ion-regulating function of the kidneys during water-salt load in patients with type I diabetes mellitus with stage I CKD

№	Na content in 0.5% NaCl solution, mmol/l	Concentration of Na in urine, mmol/l	Na excretion, mmol/hour	Ratio outputted Na, %	Concentration K in urine, mmol/l	Excretion K, mmol/ hour
1	35	210	56,7	161,8	51	13,8
2	35	250	72,5	204,3	48	13,9
3	34	230	82,8	242,0	52	18,7
4	38	451	49,6	130,4	102	11,2
5	38	440	61,6	163,7	98	13,7
6	40	278	133,0	335,6	58	27,8
7	47	451	135,0	287,7	115	34,5
8	29	230	46,0	155,9	41	8,2
9	49	415	74,7	151,9	132	23,8
10	34	301	75,3	220,0	201	50,3
11	38	290	66,7	175,3	198	45,5
M±m	37,91±3,18	322,36±52,96	77,63±16,42	202,6±34,85	99,64±31,73	23,76±7,79

Note: p≤0,05