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INFLUENCE OF NEGATIVE REDOX POTENTIAL ON FUNCTIONAL AND BIOCHEMICAL PROCESSES OF THE KIDNEYS AT THE POLYURIC STAGE OF SUBLIMATE NEPHROPATHY

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Abstract

Goal. To find out the effect of water load of negative redox potential on the functional and biochemical processes of the kidneys in comparison with induced diuresis with ordinary tap water at the poliuric stage of sublimate nephropathy in hyponatric diets.

Materials and methods. In experiments on 60 white non-linear mature male rats in a hyposodium diet at the poliuric stage of sublimate nephropathy 72 hours after subcutaneous administration of sublimate at a dose of 5mg/kg per load of water with a negative redox potential (-232.0±25.12 mV) compared to induced diuresis with ordinary tap water (redox potential 88.7±18.35 mV), which ORP-meter was measured, lipid peroxidation, tissue fibrinolysis, succinate dehydrogenase activity, β-2-microglobulin reabsorption, excretory, ionoregulatory functions were studied, glomerular-tubular and tubular-tubular balance of the kidneys.

Results and discussion. According to the experience installed protective, antioxidant effects of water negative redox potential, which was manifested by the decrease in the level of diene conjugates, malonic aldehyde, the degree of swelling and damage by the ratio of K+/Na+ to the cortical substance of the kidney, improve the reabsorption of sodium ions, β-2-microglobulin in the proximal tubules with a reduction in the loss of this cation from urine by increasing the supply of electrons to the tubules of the kidneys. Improving the energy status of the proximal nephron in conditions experience increased activity of succinate dehydrogenase in the cortical portion of the kidney has led to the improvement of tissue fibrinolysis and processes glomerular-tubular and tubular-tubular balance with loss correlations, the relative water reabsorption from the glomerular filtration, absolute proximal and distal reabsorbtion of sodium ions.

Key words: poliuric stage sublimate nephropathy; kidney; water diuresis; renal function; water negative oxidation-reduction potential.

Introduction

It is known that a decrease in the redox potential of water for every 59 mV leads to an increase in the number of electrons by 10 times. By reducing the redox potential of water by 118 mV, the number of electrons increases by 100 times, and by 177 mV – by 1000 times [1], etc. An increase in the number of electrons can improve the synthesis of ATP macroergs and, accordingly, positively effect kidney function [2]. Naturally, the question arises that loading the body with water of a negative redox potential should be energetically beneficial for cells, including for nephrocytes, whose main energy-dependent process is reabsorption of sodium ions [3, 4]. The influence of water with a negative redox potential on intact rats and in the oliguric stage of sublimate nephropathy was studied [5, 6]. At the same time, the question of the effect of water with a negative redox potential on kidney function at the polyuric stage of sublimate nephropathy in the hyponatric diet has not yet been clarified.

The aim of this study was to find out the effect of water load of negative redox potential on the functional and biochemical processes of the kidneys in comparison with induced diuresis with ordinary tap water at the poliuric stage of sublimate nephropathy in hyponatric diets.

Methods

In experiments on 60 male non-linear white rats weighing 0.16-0.18 kg, the effect of water loading of negative redox potential on the poliuric stage of sublimate nephropathy was studied, which was modeled in the conditions of hyposodium diet by subcutaneous administration of sublimate at a dose of 5mg / kg with the study after 72 hours [7, 8]. Water with a negative redox potential was obtained by treating tap water with microhydrin. The redox potential of water was determined by the ORP meter [1, 2].

Kidney function was studied under conditions of induced water diuresis with ordinary tap water and water of negative redox potential, for which the studied liquids in an amount of 5% of body weight were injected into the stomach of rats using a metal probe, followed by urine collection within 2 hours. The value of diuresis (V) was estimated in ml/2 h •100 g after water loading, animals were euthanized by decapitation under light ether anesthesia. In order to obtain plasma blood was collected in tubes with heparin. The concentration of creatinine in blood plasma and urine was determined by reaction with picric acid and sodium ions by flame photometry on FPL-1. Glomerular filtration rate (C_{cr}) was estimated by endogenous creatinine clearance, which was calculated using the formula:

$$C_{cr} = U_{cr} \bullet V / P_{cr}$$

where U_{cr} and P_{cr} are the concentration of creatinine in the urine and blood plasma, respectively.

The relative reabsorption of water (RH_2O %) was estimated using the formula:

$$RH_2O\ \% = (C_{cr} - V) / C_{cr} \bullet 100\%$$

Absolute reabsorption of sodium ions ($RFNa^+$) was calculated using the formula:

$$RFNa^+ = C_{cr} \bullet \cdot PNa^+ - V \bullet \cdot UNa^+$$

Proximal and distal reabsorption of sodium ions (T^pNa^+, T^dNa^+) was investigated. Calculations were performed using the following formulas:

$$T^pNa^+ = (C_{cr} - V) \bullet PNa^+$$

$$T^dNa^+ = (PNa^+ - UNa^+) \bullet V$$ [9, 10, 11, 12].

The state of the glomerular-tubular and tubular-tubular balance was studied by conducting a correlation analysis between the processes of glomerular filtration, absolute, proximal, distal reabsorption of sodium ions and relative reabsorption of water [13, 5].

In the cortical substance of the kidneys, indicators of lipid peroxidation were determined: diene conjugates and malone aldehyde [13]. The state of energy metabolism was assessed by the activity of succinate dehydrogenase [13]. β2-microglobulin was determined by chemiluminescent analysis on an automatic immuno-chemiluminescent analyzer MAGLUMI 1000 in blood serum and urine at the BSMU educational and scientific laboratory with the calculation of its reabsorption. Tissue fibrinolysis in the kidneys was evaluated by determining azofibrin lysis with determination of total (TFA), non-enzymatic (NFA) (incubation of samples in the presence of an enzymatic fibrinolysis blocker-ε-aminocaproic acid) and enzymatic fibrinolytic activity (EFA), which was determined by the formula: EFA=TFA-NFA [13].

All studies were performed in compliance with the Council of Europe Convention on the protection of vertebrates, which is used in experiments and other scientific purposes (from 18.03.1986), the EEC Directive N° 609 (from 24.11.1986), orders of the Ministry of health of Ukraine N° 960 from 23.09.2009 and N° 944 from 14.12.2009. Statistical data processing was performed using computer programs “Statgrafics “and”Exel 7.0".

Results

According to the data obtained, the effect of water load of negative redox potential on the indicators of kidney function at the poliuric stage of sublimate nephropathy was characterized by the absence of influence on the value of diuresis, glomerular filtration, and distal reabsorption of sodium ions (Fig. 1). At the same time, the loading of negative redox potential with water was accompanied by a decrease in the loss of sodium ions in the urine by improving its reabsorption in the proximal nephron, decreased the intensity of peroxide oxidation of lipids in the renal cortex with a decrease in the level of malon aldehyde, diene conjugates, decreased the degree of damage to the renal cortex with an increase in the K+/Na+ ratio, and decreased edema of the renal cortex with an increase in the dry matter content.

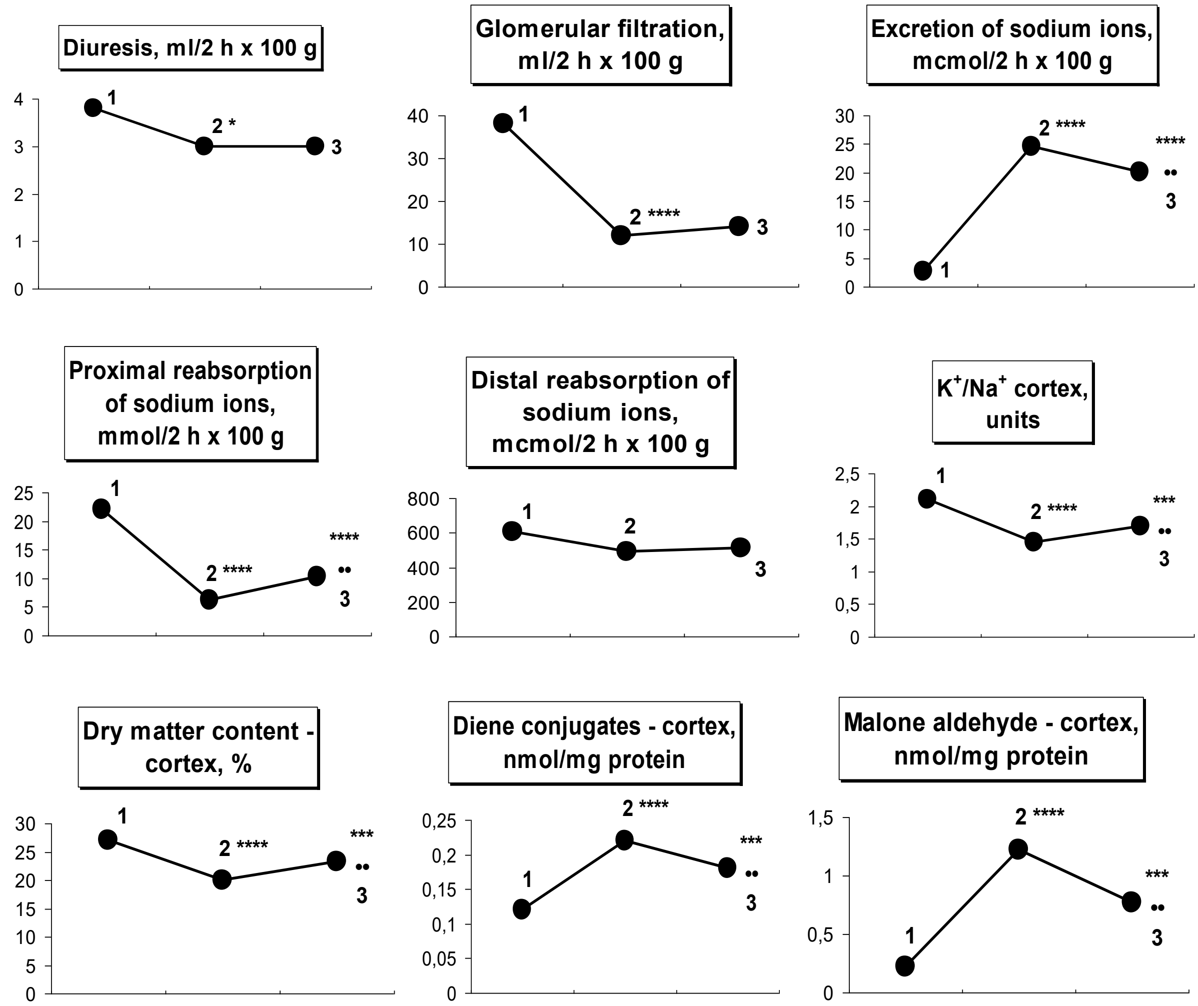


Fig.1. Influence of water load of negative (-232.0±25.12 mV) redox potential on indicators of lipid peroxidation, dry matter content, ratio of potassium ions to sodium ions (K+/Na+) in the renal cortex and indicators of kidney function in the hyposodium diet against the background of water load of 5% of body weight with urine collection for 2 hours at the poliuric stage of sublimate nephropathy.

1-control, intact animals with a load of ordinary tap water with a redox potential of 88.7±18.35 mV, 2-poliuric stage of sublimate nephropathy 72 hours after the introduction of sublimate with a load of ordinary tap water with a redox potential of 88.7±18.35 mV, 3-poliuric stage of sublimate nephropathy 72 hours after the introduction of sublimate with water load negative (-232,0±25,12 mV) redox potential. The probability of differences is marked: compared to control 1: * - $p < 0.05$; *** - $p < 0.01$; **** - $p < 0.001$; compared to poliuric stage sublimate nephropathy, group 2: • • - $p < 0.02$.

Evaluation of tissue fibrinolysis in the cortex, medulla, and papilla of the kidneys showed an increase in total, enzymatic, and non-enzymatic fibrinolytic activity due to water loading of the negative redox potential at the polyuric stage of sublimate nephropathy (Fig. 2).

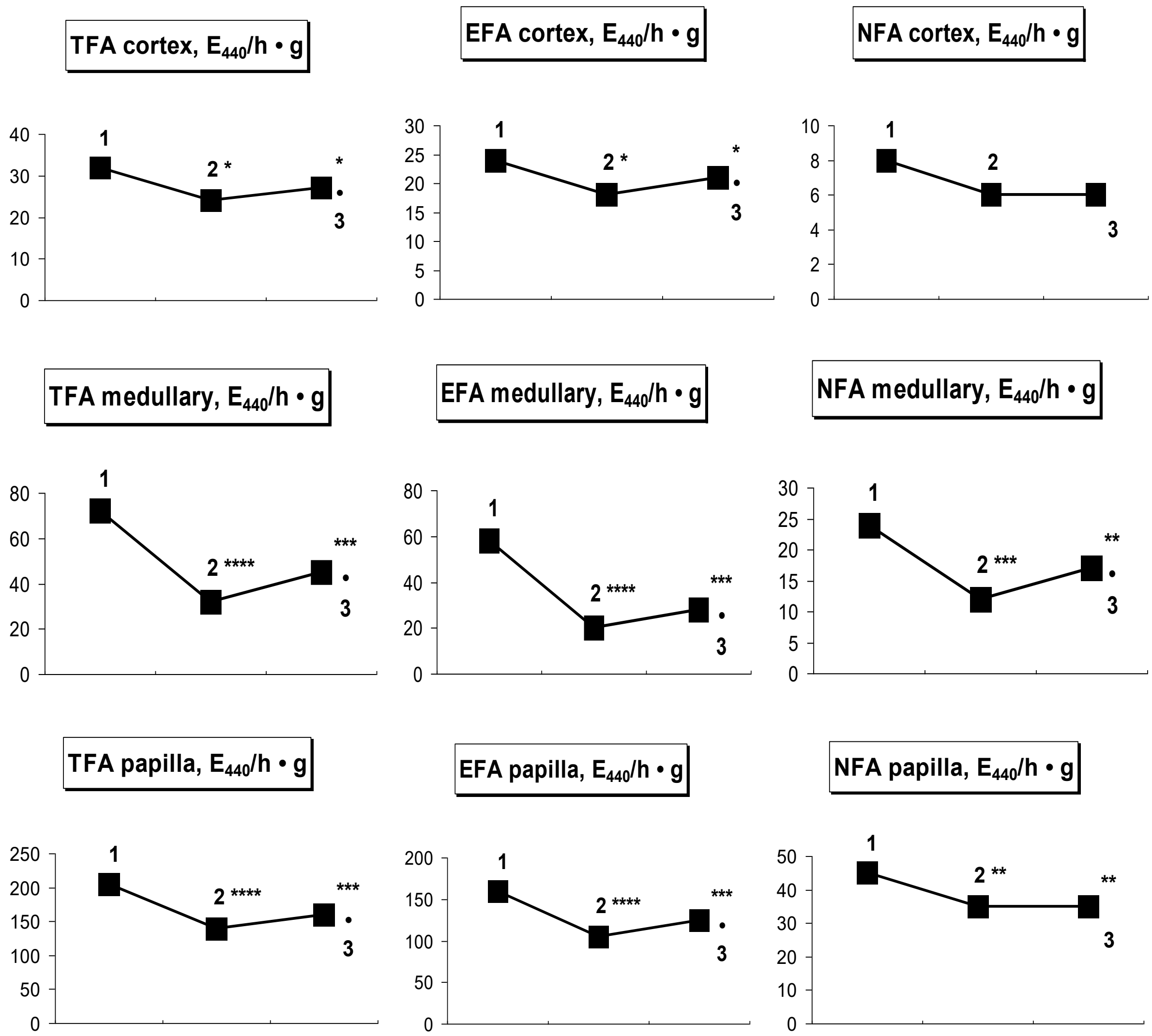


Fig. 2. Influence of water load of negative (-232.0±25.12 mV) redox potential on the indicators of fibrinolysis of TFA-total, EFA-enzymatic and NFA-non-enzymatic fibrinolytic activity in the cortical, medulla and papilla of the kidneys due to hyposodium diet on the background of water load of 5% of body weight with urine collection for 2 hours at the poliuric stage of sublimate nephropathy.

1-control, intact animals with a load of ordinary tap water with a redox potential of 88.7±18.35 th, 2-poliuric stage of sublimate nephropathy 72 hours after the introduction of sublimate with a load of ordinary tap water with a redox potential of 88.7±18.35 mV, 3-poliuric stage of sublimate nephropathy 72 hours after the introduction of sublimate with water load negative (-232,0±25,12 mV) redox potential. The significance of the differences was noted: compared to control 1: * - $p < 0.05$; * * - $p < 0.02$; * * * - $p < 0.01$; * * * * - $p < 0.001$; compared to the poliuric stage of sublimate nephropathy, group 2:
• - $p < 0.05$; • • - $p < 0.02$.

Improvement of the energy state of the proximal nephron under the influence of water of negative redox potential at the polyuric stage of sublimate nephropathy was characterized by an increase in the activity of succinate dehydrogenase in the renal cortex and an increase in the reabsorption of β-2-microglobulin (Fig. 3).

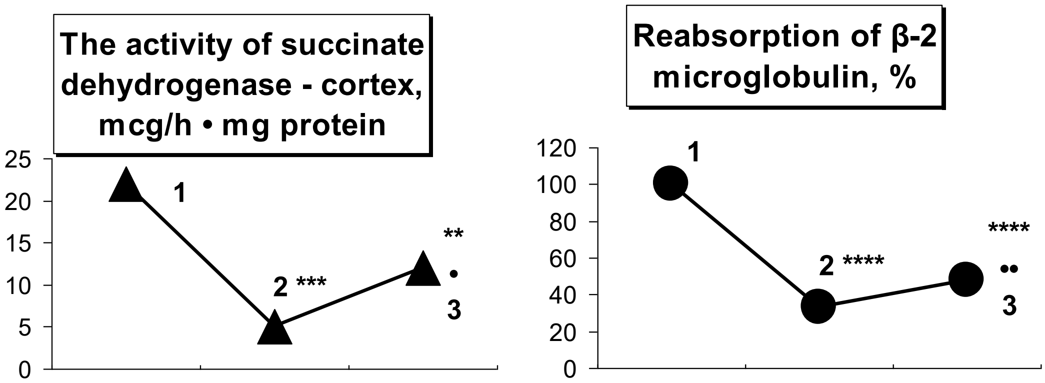
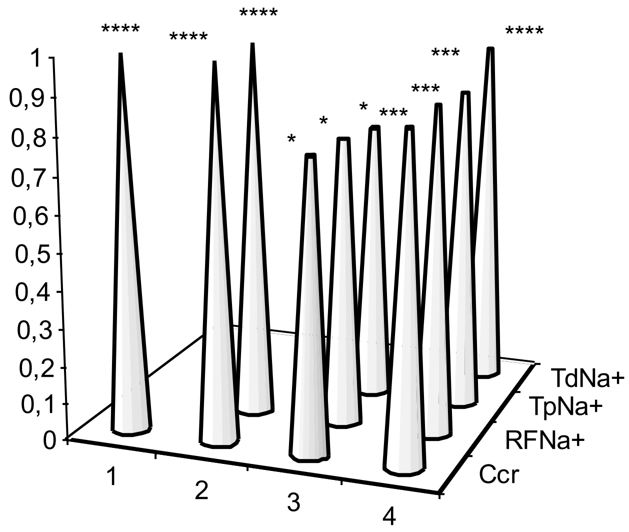


Fig. 3. The effect of water load of negative (-232.0±25.12 mV) redox potential on the activity of succinate dehydrogenase in the cortical substance of the kidneys and reabsorption of β - 2-microglobulin in the hyposodium diet against the background of water load of 5% of body weight with urine collection for 2 hours at the poliuric stage of sublimate nephropathy.

1-control, intact animals with a load of ordinary tap water with a redox potential of 88.7±18.35 mV, 2-poliuric stage of sublimate nephropathy 72 hours after the introduction of sublimate with a load of ordinary tap water with a redox potential of 88.7±18.35 mV, 3-poliuric stage of sublimate nephropathy 72 hours after the introduction of sublimate with water load negative (-232,0±25,12 mV) redox potential. The significance of differences observed in comparison to control 1: ** - $p < 0.02$; * * * $p < 0,01$; * * * * $p < 0.001$; compared with poliuric stage sublimate nephropathy, group 2: • $p < 0.05$; •• - $p < 0.02$.

In addition, under the influence of water with a negative redox potential at the poliuric stage of sublimate nephropathy, an improvement in the processes of glomerular-tubular and tubular-tubular balance was found with the loss of correlation dependencies of the relative reabsorption of water with glomerular filtration, absolute, proximal and distal reabsorption of sodium ions (Fig. 4).



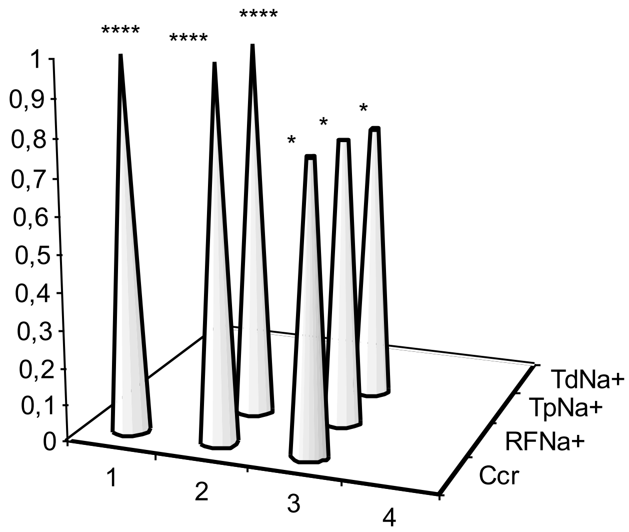


Fig.4. The effect of a negative water load (-232.0±25.12 mV) of the redox potential (lower figure) compared to a normal load (redox potential 88.7±18.35 MB) of tap water (upper figure) on the state of the glomerular-tubal and tubular-tubular balance of the kidneys at the poliuric stage of sublimate nephropathy.

C_{cr}-glomerular filtration (mcl/ min • 100g); RFNa+, 1-absolute reabsorption of sodium ions (mmol / min • 100 g); T^{p}Na+, 2-proximal reabsorption of sodium ions (mmol/2 h•100 g); T^{d}Na+, 3-distal reabsorption of sodium ions (mmol/2 h•100 g); 4-relative reabsorption of water (%); the reliability of the correlation was noted:
* - $p < 0.05$; * * * - $p < 0.01$; * * * * - $p < 0.001$.

Discussion

The polyuric stage of sublimate nephropathy is a dysregulatory pathological process with secondary damage proximal tubules as a result of accumulation of sodium ions in the body with an increase in the influence of factors with vasodilator mechanism of action and the implementation of reperfusion syndrome "no-reflow" [7, 14, 15]. Under these conditions, the effect of water loading of the negative redox potential with a decrease in losses of sodium ions in the urine by improving its reabsorption and β-2-microglobulin in the proximal nephron is due to the antioxidant properties of microhydrin [2, 5, 6]. This also explains the decrease in the intensity of peroxide oxidation of lipids in the cortical substance of the kidneys with a decrease in the level of malon aldehyde, diene conjugates, the degree of damage to the cortical area of the kidneys due to an increase in the K^+/Na^+ ratio and a decrease in edema of the cortical substance of the kidneys. The improvement in the proximal tubule with increased production of urokinase in the past [13] led to an increase in total enzymatic and nonenzymatic fibrinolytic activity in the cortex, the medulla and papilla of the kidneys over load water negative redox potential in poliuric stage of sublimate nephropathy. Improving the energy status of the proximal nephron in terms of the effects of water negative redox potential on poliuric stage of sublimate nephropathy increased activity of succinate dehydrogenase in the cortical substance of the kidneys due to increased supply of electrons and antioxidant effects. Improvement of glomerular-tubular and tubular-tubular balance processes with loss of correlation dependences of relative reabsorption of water with glomerular filtration, absolute, proximal and distal reabsorption of sodium ions under the conditions of negative redox potential of water at the poliuric stage of sublimate nephropathy is due to improvement of active energy-dependent transport processes due to reduction of passive reabsorption processes.

Conclusions

1. Loading water with a negative redox potential (-232.0±25.12 mV) in comparison with induced diuresis with ordinary tap water (redox potential 88.7±18.35 mV) at the poliuric stage of sublimate nephropathy due to its antioxidant properties causes a decrease in the level of diene conjugates, malon aldehyde, the degree of edema and damage in the ratio of K^+/Na^+ in the cortical substance of the kidneys, improves the reabsorption of sodium ions, β-2-microglobulin in the proximal tubules with reduced loss of this cation in the urine due to increased electron supply to the renal tubules.

2. Improving the energy status of the proximal nephron in conditions experience increased activity of succinate dehydrogenase in the cortical portion of the kidney has led to the improvement of tissue fibrinolysis and processes glomerular-tubular and tubular-tubular

balance with loss correlations, the relative water reabsorption from the glomerular filtration, absolute proximal and distal reabsorption of sodium ions.

Prospects for further research it is of interest to study the functional state of the kidneys due to water load of negative redox potential in the late period on the 30th day of the polyuric stage of sublimate nephropathy.

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