Microhemodynamic Parameters of Cortical Substance of Kidneys at Experimental Hydronephrosis

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Abstract

Under conditions of unilateral occlusion of the ureter, the development of microhemodynamic disorders of the cortical substance of the kidneys was studied both on the damage side and on the contralateral (opposite) side. It has been established that disorders on the side of occlusion depend on the duration of obstruction of the lumen of the ureter, which determines the development of tissue hypoxia and violates trophic renal parenchyma. Dynamically functional disorders of the microvasculature occur at the early (on the 1st, 3rd, and 5th day), and irreversible changes in the renal parenchyma at the later (on the 14th and 30th day) stages of the experiment. The contralateral one responds to turning off the function of one kidney by adaptive restructuring of the microhemocirculatory system, which is manifested by dilatation of microvessels and an increase in the linear velocity of blood flow in them, which ensures its hyperfunction.

Keywords: *Microcirculation, rheology, hydronephrosis.*

Introduction

Hydronephrotic transformation of the kidneys as a result of impaired passage of urine is one of the most common forms of pathology, leading, as a rule, to the destruction of the affected kidney, a complete loss of its function[5]. Most studies on the activity of the kidneys in obstruction of the urinary tract reveal various aspects of the pathogenesis of hydronephrosis[7], structural changes in the renal parenchyma[6], and mechanisms of sanogenesis during restoration of urinary tract patency[9]. Recently, researchers have been paying close attention to the pathogenesis of microhemodynamic tissue disorders[1]. Changes in microhemodynamics lead to a decrease in adequate tissue perfusion, which naturally causes deep metabolic disturbances[4]. Disorders in the microcirculation system are the central link in the chain of disorders leading to the development of dysfunction and irreversible structural changes[7]. In the kidney, which performs the function of fluid filtration and absorption and is a well-vascularized organ with two capillary networks, pathological changes in microcirculation become extremely important. However, until now, insufficient attention has been paid to the study of the role of microhemodynamic disorders in the dynamics of the development of hydro-nephrotic transformation, which is largely due to the unsatisfactory state of the methodological base for obtaining reliable results. The current level of development of television technology allows you to plan and conduct intravital studies of internal organs in the dynamics of the development of various pathological conditions. The purpose of the study was to study the dynamics of microhemodynamic disorders of the cortical section of the renal parenchyma with unilateral full ureteral occlusion.

Materials and Method

Under the conditions of the experiment, we studied the state of microhemodynamics of the cortical region of both kidneys during the development of unilateral hydronephrosis. The experiments were conducted on 90 (48 experimental, 36 false-operated, 6 intact) outbred adult males. Occlusion of the right ureter was carried out by its complete ligation. Microcirculation of the renal cortex was examined on the 1st, 3rd, 5th, 7th, 14th and 30th days after ureter ligation. Kidney bio microscopy was performed under general anesthesia with etaminal at a dose of 8 mg/100 g of body weight of the animal.

The control was animals that underwent a laparotomy with revision of the retroperitoneal space without ureter ligation. In order to optimize research and improve the quality of the results obtained, we used a system of television analogs of the digital conversion of microstructures with morphometry of the microcirculation parameters. The results of the study were recorded on digital media.

Results

Normally, under the microscope, single efferent arterioles and peritubular capillaries are visible. The diameter of arterioles varies between 18.7–25.8 μm. The bloodstream in them is jet, in a continuous flow. The linear velocity of blood flow in arterioles was (0.557±0.073) m. Peritubular capillaries extending from the efferent arteriole, widely anastomosing each other, form a network with polygonal cells, extend along the tubules. The boundary between the tubules and capillaries differed by: due to whitish crimped stripes that appear when light is refracted by the epithelium of the tubules. It is noteworthy that almost all capillaries visible in the field of vision function. The diameter of the capillaries is - (9.70±0.38) μm of blood flow in them in a continuous flow, jet, blood flow speed –(0.446±0.044) ms.

Discussion

During studying the microvasculature, after the first day, the angioarchitectonics of the vessels were preserved on the obturated side, the individual capillaries were turned off and filled with blood plasma. They alternated with dilated capillaries in which blood flow was slowed down by 61.2% compared with the values of intact animals (table). The contours of the capillaries are even, clear. During this period, on the contralateral side, all the vessels visible in the field of view functioned, which were somewhat dilated. In individual PICs, the colloidal contents of the blood stream are fine-grained. In the control group of animals, the microvasculature was characterized by a distinct contour of the vascular bed, an insignificant (by 19.1%) decrease in the linear velocity of blood flow.

Table 1: Morphometric parameters of microhemocirculatory channel of animal kidneys with occlusion of the right ureter

Term of the experiment, day	Diameter of the capillaries of PICs, μm		Blood flow speed, ms	
	Right kidney	Left kidney	Right kidney	Left kidney
Intact animals	9.70±0.38		0.446±0.044	
1st	$\frac{10.60 \pm 0.84}{9.20 \pm 0.66}$	$\frac{9.60 \pm 0.51}{9.10 \pm 0.72}$	$\frac{0.173 \pm 0.034*}{0.381 \pm 0.043}$	$\frac{0.361 \pm 0.023}{0.389 \pm 0.057}$
3rd	$\frac{10.12 \pm 1.09}{9.50 \pm 0.71}$	$\frac{9.80 \pm 0.34}{9.70 \pm 0.82}$	$\frac{0.195 \pm 0.045*}{0.397 \pm 0.093}$	$\frac{0.339 \pm 0.022}{0.410 \pm 0.062}$
5th	$\frac{11.20 \pm 0.33*}{9.60 \pm 0.59}$	$\frac{10.20 \pm 0.48}{9.90 \pm 0.76}$	$\frac{0.142 \pm 0.036*}{0.431 \pm 0.063}$	$\frac{0.427 \pm 0.039}{0.410 \pm 0.055}$
7th	$\frac{12.30 \pm 0.68*}{9.80 \pm 0.55}$	$\frac{10.70 \pm 1.37}{9.50 \pm 0.63}$	$\frac{0.126 \pm 0.031*}{0.428 \pm 0.026}$	$\frac{0.461 \pm 0.067}{0.425 \pm 0.055}$
14th	$\frac{13.70 \pm 0.92*}{9.30 \pm 0.72}$	$\frac{11.20 \pm 0.64}{9.40 \pm 0.66}$	$\frac{0.090 \pm 0.013*}{0.415 \pm 0.041}$	$\frac{0.526 \pm 0.028*}{0.427 \pm 0.034}$
30th	$\frac{}{9.80 \pm 0.65}$	$\frac{12.60 \pm 0.71*}{9.6 \pm 0.8}$	$\frac{}{0.435 \pm 0.059}$	$\frac{0.533 \pm 0.032*}{0.423 \pm 0.021}$

Note: Numerator - values of experimental group, denominator - false-operated.
*The results are reliable in relation to control (P<0.05)

Three days later the ligation of the ureter on the obturated side, the areas of dilated capillaries alternate with the areas that function normally: without signs of stagnation. The blood flow velocity in the capillaries is - (0.195±0.045) mm/s continuous, even flow. The contours of the vessels are clear, correct, without pathological changes. Observed separate sections of blood vessels, clogged stagnant blood, as well as the foci of the capillary network that are emptied, are erased in these sections of the boundary between the individual PIC loops. On the 3rd day of the experiment, in the opposite kidney, there was an expansion of blood vessels with streaming continuous blood flow and some homogenization and the disappearance of the characteristic glow of the PIC epithelium. On the 5th day of the experiment, the angioarchitectonics were disrupted on the obturated side, only a few sharply expanded capillaries function, the blood flow in them is grainy, the boundaries are somewhat blurred. Most of the capillaries are turned off from the bloodstream. The boundary between the capillaries and the PIC is blurred. The renal parenchyma in these areas is homogenized. From the side of the opposite kidney, total abrasion of the vessels was observed. The blood flow velocity in them exceeded the corresponding indicator at the previous study period by 25.9% (see table). Plots of diapedesis are marked in places, which indicates o increased permeability of capillaries PIC. In these areas, the PIC is filled with dense contents.

On the 7th day of the experiment, the angioarchitectonics of the kidneys was disrupted due to the disappearance of the microvessels and PIC circuits, which are homogenized in most areas. Along with this, there are areas of functioning capillaries, which are sharply expanded, the blood flow in them is slow, granular, sometimes segmented. Identified areas of clogging of capillaries of stagnant bloodstream. The boundaries between the PIC loops are erased. In contrast to the obstructed, contralateral night was characterized by areas of vasodilation.

The borders of vessels are clear, without turning off. The blood flow is-(0.461±0.067) mm/s, which is slightly higher values of the intact group of animals.

On the 14th day, the renal antioarchitectonics was preserved, the contours of the vessels were smooth and clear, alternation of half-blood capillaries with plasmatized, collapsed, non-functioning ones was noted. blood flow continuous, trickle, fast. Individual PIC capillaries are sharply expanded, overflows with stagnant blood. The contours of the non-functioning vessels are blurred. There are separate sections of perivascular hemorrhages. On the opposite side, the angio-architectonics of the kidney is preserved, all vessels visible in the field of vision are functional. The contours of the vessels are even, clear. Perivascular space without inclusions. The bloodstream is fast, stream, continuous its speed is 11.8% lower than the values of the intact group of animals.

On the 30th day of the experiment, almost complete destruction of the kidney parenchyma was observed at the occlusion side. The vascular bed of the cortical crown of the affected kidney was practically undetectable. A lot of scraps of starting plasmatized and hyalinized capillaries appeared in separate thrombus capillaries. In the opposite kidney, previously detected compensatory manifestations in the microhemocirculatory system were noted: the vessels were dilated, their circuits were clear continuous; a small tortuosity of the vessels due to an increase in pressure in them.

Thus, in animals experiment a progressive decrease in renal blood flow on the side of the obstruction was established, due to an increase in the resistance of the renal microvessels associated with thrombosis and the removal of most peritubular from the bloodstream, their destruction due to a sharp increase in hydrostatic pressure. These changes, in turn, lead initially to focal, and later dates (on the 14th and 30th days of the experiment) - to diffuse necrosis and atrophy of the kidney parenchyma. No disturbances were detected in the false-operated animals. During the entire study period, the vascular architectonics were preserved, the boundary between them and the loops of the proximal convoluted tubules was clear. The blood flow in the components of the microcirculatory system accessible for microscopy was jet, in a continuous flow. The mental blood flow indices in microvessels practically did not differ from those of intact animals.

Thus, a comparative analysis of the results of the study in the experimental group and the group of false-operated animals allows us to conclude that the characteristic dynamics of unidirectional changes in the early stages is really associated with the activation of the sympathetic-adrenal system. The absence of any changes in the microcirculatory system of the kidneys in the later stages of the experiment, when the influence of stress factors associated with operating trauma is completely

excluded, once again confirms the significance of stress factors in the occurrence of microcirculatory disorders.

Conclusion

Disorders of the microvasculature of the kidneys on the side of occlusion depend on the duration of obstruction, which contributes to impaired trophism of the renal parenchyma, the development of tissue hypoxia and the emergence of dynamic functional disorders in the early days (on days 1, 3, 5) and irreversible changes in the renal parenchyma at a later date (on the 14th and 30th day) of the experiment. 2. To turn off the function of one kidney, the other responds by adaptive restructuring of the microhemocirculatory system, manifested by dilatation of microvessels and an increase in the linear velocity of blood flow in them, which ensures its hyperfunction.

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