# Morphology of Hypertrophied Rat Kidney at High Altitudes

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Changes in the relative mass of kidney and in the mitotic activity in cortex and medulla are compared in nephrectomized rats under the valley and high altitude conditions. The rate of compensatory processes is lower at high altitudes than in the valley. At high altitudes, kidney hypertrophy and mitotic activity of kidney cells are decreased.

**Key Words:** *nephrectomy; high altitude; mitotic activity*

Compensatory-adaptive processes in the kidneys are a fundamental problem in biology and medicine. Although considerable investigative effort was focused on it [4,9,10], general laws of functional compensation after unilateral nephrectomy so far have not been formulated. The mechanisms responsible for stabilization of compensatory-adaptive processes associated with regulation of water-salt balance remain unclear. In addition, it is important to study physiological processes occurring under the extreme conditions of high altitude hypoxia.

In the adaptation of an organism to oxygen deficiency the kidneys play an important role due to participation in the regulation of water-salt balance [1,2,11]. The kidneys are known to have the highest gas exchange rate among other parenchymatous organs. Under conditions of oxygen deficiency, functional and structural disturbances in kidneys are accompanied by hyperemia and mass increase.

Hypoxia affects primarily the glomerular vessels, reducing glomerular filtration [5,7]. Acute forms of oxygen deficiency lead to termination of urine formation. There is evidence that ascend to the high altitudes induces no functional and structural changes in the kidneys [12]. Under the valley conditions, compensatory hypertrophy in the remaining kidney is intense and is characterized by a certain periodicity [3,6,8]. However, it is not clear how compensatory hypertrophy proceeds of the remaining kidney proceeds at high altitudes. Our objective was to study compensatory processes in the remaining kidney during adaptation to the high altitude conditions.

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## MATERIALS AND METHODS

Experiments were carried out at the Anzob pass (altitude 3375 m above the sea level) on 140 male Wistar rats weighing 110-150 g. The animals were divided into equal two groups. In experimental rats the right kidney was extirpated. To study changes in the mass of remaining kidney, body weight and mitotic activity (MA) in the kidney, the operation was always performed between 10:00 and 12:00. The rats were decapitated between 12:00 and 13:00, because during this period the number of cell divisions both in the kidneys and in other parenchymatous organs reaches the maximum.

The material for examination was taken on days 1, 2, 5, 10, 15, 30, and 60 after the operation. An increase in kidney mass in nephrectomized rats was calculated relative to the mean mass of two kidneys in control animals. Then the kidneys were fixed in 10% neutral formalin and embedded in paraffin. Middle transversal sections 5-6 μ thick were stained with Ehrlich hematoxylin and eosin. Mitoses were counted in the cortex and medulla. Two sections layers were always used with 5-6 sections between them. Cells and mitoses were counted under an

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**TABLE 1.** Dynamics of Renal MA in Nephrectomized and Control Rats under High Altitude and Valley Conditions (MI, %)

| Time after operation, days | Control rats | | Nephrectomized rats | |
|---|---|---|---|---|
| | cortex | medulla | cortex | medulla |
| **Valley condition** | | | | |
| 1 | 0.71±0.04 | 0.44±0.06 | 1.44±0.02 | 0.66±0.03 |
| 2 | 0.72±0.04 | 0.46±0.09 | 3.39±0.19 | 0.89±0.04 |
| 5 | 0.77±0.04 | 0.45±0.07 | 1.93±0.14 | 0.97±0.02 |
| 10 | 0.73±0.03 | 0.45±0.05 | 1.67±0.06 | 0.99±0.02 |
| 15 | 0.82±0.04 | 0.47±0.04 | 1.36±0.03 | 0.84±0.03 |
| 30 | 0.74±0.03 | 0.47±0.01 | 1.08±0.09 | 0.62±0.08 |
| 60 | 0.69±0.02 | 0.46±0.05 | 0.90±0.10 | 0.59±0.06 |
| **High altitude conditions** | | | | |
| 1 | 0.66±0.04 | 0.42±0.01 | 0.99±0.75 | 0.59±0.02 |
| 2 | 0.64±0.03 | 0.45±0.02 | 1.35±0.04 | 0.79±0.03 |
| 5 | 0.63±0.03 | 0.43±0.01 | 1.94±0.10 | 1.03±0.02 |
| 10 | 0.67±0.03 | 0.44±0.02 | 1.69±0.07 | 0.95±0.04 |
| 15 | 0.66±0.03 | 0.47±0.01 | 1.29±0.08 | 0.79±0.04 |
| 30 | 0.66±0.55 | 0.48±0.02 | 1.06±0.08 | 0.60±0.03 |
| 60 | 0.67±0.42 | 0.46±0.01 | 0.93±0.66 | 0.57±0.03 |

MBR-3 binocular microscope which had a diaphragm 8×8 mm inserted into the eyepiece. In each section, cells were calculated in the horizontal direction at 8 levels (the interlevel distance was two fields of view). The data obtained in two sections were used to determine the mitotic index (MI), i.e., the number of mitoses per 1000 cells.

## RESULTS

Analysis of the recovery compensatory processes in the kidneys of nephrectomized rats, which were accompanied by increase in kidney mass, showed that under the high altitude conditions the increase in the relative mass of kidney was 25.1 and 29.5% on days 30 and 60 after operation, respectively. However, renal hypertrophy under the high altitude conditions was smaller than under the valley conditions (28.8 and 33.5%). The difference was significant from day 10 till the end of study.

Table 1 shows the mean values of MA in cortex and medulla for control and nephrectomized rats under the high altitude and valley conditions. These data show that one day after operation, MA was significantly increased in both layers of the kidney compared with the control ($p<0.001$). The MI was significantly lower under the high altitude conditions in comparison with the valley conditions, being 68.7% ($p<0.05$) and 89.4% ($p<0.001$) in renal cortex and medulla, respectively.

Two days after operation, MI increased by 2.1 times in the cortex and by 1.8 times in the medulla ($p<0.001$). By this time, the MA in the rats kept under the valley conditions reached the maximum, while in the rats kept under the altitude conditions MA just started to increase.

Five days after operation, MI in the hypertrophied kidney began to decrease in the rats that were under the valley conditions, but under the high altitude conditions the level of MA reached the maximum both in the cortex and medulla (it was significantly increased by 3 times in cortex and by 2.4 times in the medulla).

Ten days after operation, MA was decreased in comparison with the 5th day in value, but it was increased relative to the control value by 2.5 times in the cortex and by 2.2 times in the medulla (the differences are statistically significant). In comparison with the data obtained under the valley conditions, there were no differences in MI. Relative to the data obtained on nonadapted animals, there was an increase by 1.3 times in the cortex and by 1.4 times in the medulla ($p<0.02$).

Fifteen days after operation, MA in both cases of compensatory hypertrophied kidney was somewhat decreased, but it remained statistically increased by 2 times in the cortex and by 1.7 times in the medulla ($p<$ 0.02). There were no differences relative the values of MI obtained in the valley conditions. In respect to the nonadapted animals, MI decreased in the cortex, but in the medulla it remained increased ($p<0.05$).

Thirty and sixty days after nephrectomy, MA in the remaining kidney was similar to that in the control. There were no differences in the values of MI for the valley and high altitude conditions.

Thus, our findings show that under the high altitude conditions the intensity of the recovery compensatory processes is lower than under the valley conditions. Concerning the relative mass of the kidney, this was most strikingly demonstrated on days 30 and 60. The MA of the remaining kidney under the high altitude conditions reached the maximum after 5 days, then it gradually decreased and approximated its control value 2 months after nephrectomy.

## REFERENCES


1. A. S. Asimov, A. Rakhimov, and L. M. Zadorina, in: *Circulation at High Altitudes and Experimental Hypoxia* [in Russian], Dushanbe (1990), p. 15.
2. A. I. Gozhenko, R. P. Koloskova, V. A. Kabashin, *et al.*, in: *Special and Clinical Physiology of Hypoxic Conditions* [in Russian], Vol. 1, Kiev (1979), p. 45.
3. V. M. Gontmakher, Z. Z. Sagdullaev, and A. K. Zufarov, *Arkh. Anat.*, No. 11, 87-92 (1989).
4. K. A. Zufarov, in: The Compensatory-Adaptive Processes in the Internal Medium Cells [in Russian], Tashkent (1992), pp. 17-21.
5. A. G. Kuznetsova, in: *Operation of Organism in Modified Gaseous Medium* [in Russian], Moscow - Leningrad (1955), pp. 172-199.
6. L. D. Liozner, in: *Biological Rhythms in the Compensatory Mechanisms of the Impaired Functions* [in Russian], Moscow (1973), pp. 164-175.
7. F. G. Popova, in: *Hypoxia and Ionizing Radiation* [in Russian], Voronezh (1960), pp. 27-33.
8. Z. Z. Sagdullaev, "Kidney compensatory hypertrophy in different periods of postnatal ontogenesis and its dependence on resection volume," Author's Synopsis of Doct. Med. Sci. Dissertation [in Russian], Tashkent (1992).
9. D. S. Sarkisov, *Klin. Med.*, **68**, No. 8, 7-12 (1990).
10. V. V. Serov and S. V. Yargin, *Ter. Arkh.*, **58**, No. 8, 4-9 (1986).
11. P. Abraham, S. Provoost, and C. Molenaar, *Pflugers Arch.*, **385**, No. 1, 165 (1980).
12. A. T. Coekott and E. Bors, *Urol. Int.*, **18**, No. 6, 357-361 (1964).