PHARMACOLOGY AND TOXICOLOGY

Morphological Characteristics of Peripheral Blood Erythrocytes in Rats Subjected to Chronic Inhalation of Ultradispersed Piezoelectric Ceramic Powder

E. A. Kayumova, N. M. Shevtsova, and S. V. Nizkodubova

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In albino rats subjected to chronic inhalation of ultradispersed piezoceramic powder, scanning electron microscopy revealed changes in membrane surface of peripheral blood erythrocytes manifested as decreased number of diskocytes and increased number of transitional, prehemolytic, and degenerating forms. These parameters returned to normal 1 month after termination of inhalations.

Key Words: *electron microscopy of erythrocytes; ultradispersed piezoelectric ceramic powder*

Ultradispersed powders (UDP) are widely used in the industry due to their unique physical, technical, and chemical properties. However, these powders contain some toxic substances, in particular, lead and bismuth oxides. Therefore, comprehensive studies of the effects of piezoceramic UDP on various organs and systems are necessary.

The purpose of the present study was morphological examination of erythrocyte surface in experiments with chronic inhalations of piezoceramic UDP.

MATERIALS AND METHODS

Toxic effect of piezoceramic UDP was experimentally studied on albino male rats weighing 180-200 g. Experimental group rats (n=36) were daily exposed to 4-h UDP inhalations in a 100-liter closed chamber during 4 months. Piezoceramic UDP contained 64% lead oxide, 20% zirconium oxide, 11% titanium oxide, and 0.5% bismuth oxide. The inhalation dose of UDP was 15 mg/m^3, which corresponded to class IV dangerous occupational exposure. This dose was chosen and corrected in acute experiments [2,3]. Control rats (n=36) were kept under the same conditions. The blood was obtained from the caudal vein before inhalations (background), 2 weeks, 1, 2, 3, and 4 months of inhalation course and 1 month after its termination (delayed effects).

Surface architectonics of erythrocytes was studied by scanning electron microscopy [1]. The preparations were examined under a scanning electron microscope REM-200 operated at 35 kV accelerating voltage, 0.63 A current strength, and 35° angle. The preparations were photographed under a JEM-100 electron microscope.

The data were processed using Student t test.

RESULTS

In control rats, functionally normal biconcave disks prevailed (Table 1), while degenerating cells comprised only 0.26±0.02% (Fig. 1, *a*).

Central Research Laboratory, Siberian State Medical University, Tomsk; Medical and Biological Department, Tomsk State Pedagogical University. ***Address for correspondence:*** lihachev@mail2000.ru. Kayumova E. A.

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The distribution of morphological types of erythrocytes in the control group did not differ from the baseline throughout the experiment.

In experimental rats, 2-week inhalation of UDP led to disorganization of the erythrocyte surface ultrastructure: the number of reversibly changed cells (mainly flat disks) decreased by 2.6% and the number of degenerating erythrocytes increased by 4.4% compared to the baseline.

One month after the start of UDP inhalation, morphological heterogeneity of the erythrocyte population increased: the number of normal diskocytes signifi-

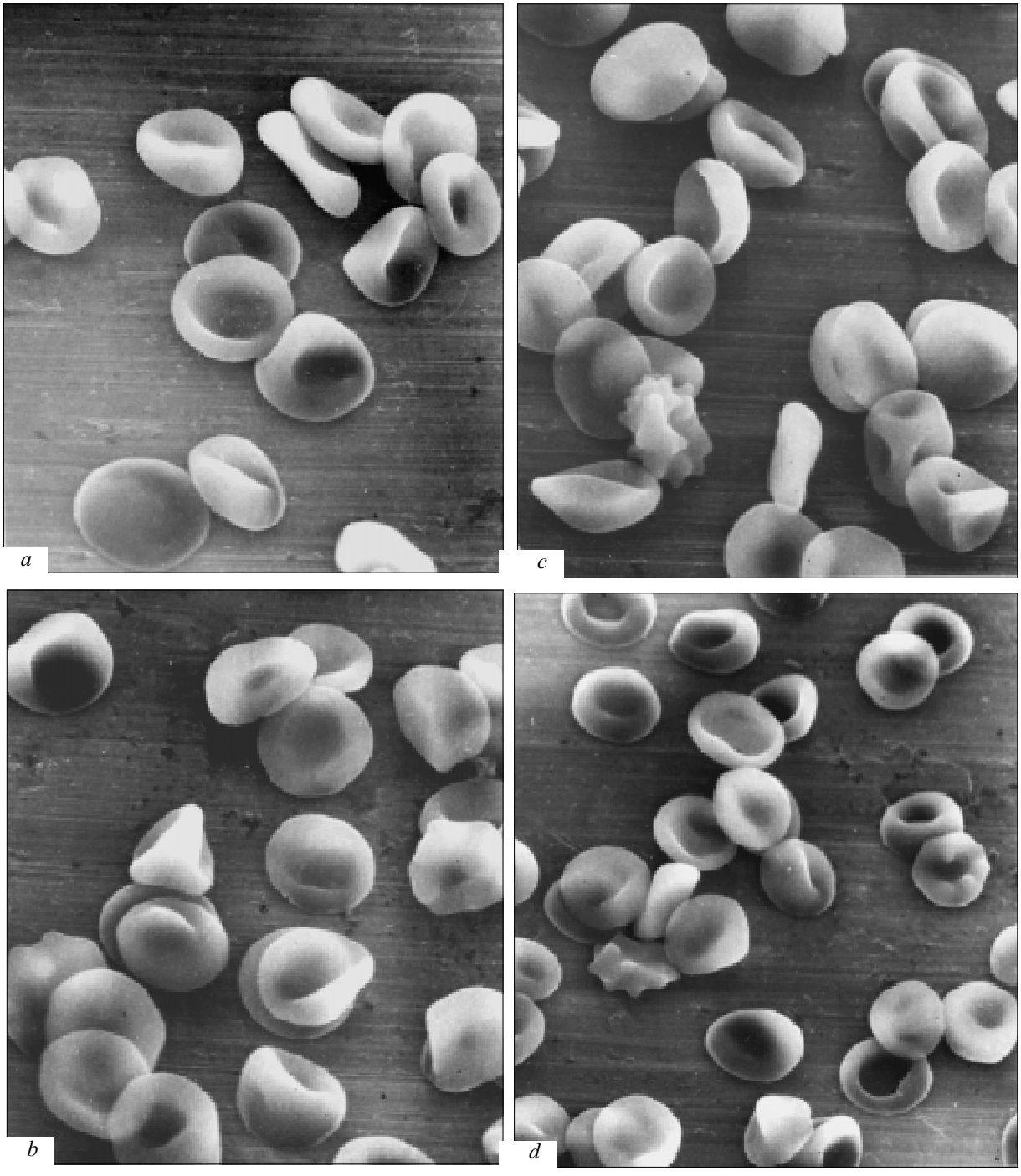

Fig. 1. Changes in surface architectonics of erythrocytes at different terms of inhalation treatment with piezoceramic ultradisperse powder. Scanning electron microscopy, ×2000 (*a*-*c*), ×1500 (*d*). *a*) before inhalation; *b*) 1 month after the start of the experiment: flat disk, erythrocyte with multiple processes, cupola- and drained ball-shaped erythrocytes; *c*) 4 months after the start of inhalation course: flat disks, ellipsis-shaped cells, erythrocytes with crest and one process, mulberry-, cupola-, and drained ball-shaped erythrocytes, degenerating form; *d*) 1 month after termination of inhalation treatment.

TABLE 1. Morphological Characteristic of Peripheral Blood Erythrocytes in Rats Chronically Exposed to Piezoceramic UDP (Numenator) and in Control Group (Denominator) ($M \pm m$)

Morphological form	Background	Time of observation					
		2 weeks	1 month	2 months	3 months	4 months	5 months
Diskocytes	86.00±0.12	86.12±0.08 86.00±0.10	84.12±0.20*+ 86.17±0.18	83.23±0.10*+ 85.99±0.23	83.0±0.12*+ 86.10±0.05	82.8±0.08*+ 85.43±±0.34	85.38±0.21* 85.83±0.23
Reversibly transformed erythrocytes:							
ellipses	0.49±0.04	0.47±0.04 0.48±0.05	0.63±0.05*+ 0.47±0.05	0.71±0.04*+ 0.48±0.50	0.80±0.50*+ 0.52±0.03	0.85±0.08*+ 0.48±0.05	0.37±0.07 0.48±0.05
flat disks	5.00±0.09	4.78±0.02* 5.02±0.11	5.33±0.07*+ 4.82±0.14	5.44±0.13*+ 4.70±0.15	5.40±0.08*+ 4.95±0.08	5.50±0.10*+ 5.07±0.06	5.13±0.04 5.02±0.11
diskocytes with process	4.03±0.10	4.12±0.12 4.02±0.15	4.15±0.08 3.97±0.08	4.21±0.11 4.15±0.11	4.63±0.10*+ 3.97±0.08	5.00±0.09*+ 4.44±0.24	4.37±0.18 4.27±0.11
diskocytes with crest	2.01±0.04	2.00±0.07 2.00±0.04	2.02±0.03 2.00±0.06	2.03±0.05 2.02±0.03	2.05±0.04 2.00±0.05	1.90±0.04 1.90±0.04	1.83±0.05* 1.92±0.03
diskocytes with multiple processes	0.61±0.04	0.47±0.07 0.60±0.07	0.77±0.03 0.57±0.07	1.01±0.03 0.62±0.05	0.93±0.42 0.50±0.05	0.93±0.03 0.63±0.05	0.85±0.07* 0.57±0.02
mulberry-shaped erythrocytes	0.07±0.02	0.05±0.02 0.07±0.02	0.10±0.02 0.07±0.02	0.13±0.02*+ 0.07±0.02	0.07±0.02 0.05±0.02	0.11±0.02 0.08±0.02	0.08±0.02 0.08±0.02
Irreversibly transformed erythrocytes:							
cupola-shaped	0.43±0.02	0.48±0.03 0.46±0.03	0.83±0.07*+ 0.53±0.04	0.76±0.04*+ 0.43±0.05	0.77±0.06*+ 0.48±0.03	0.83±0.06*+ 0.50±0.04	0.48±0.09 0.42±0.03
spherical	0.80±0.02	0.90±0.07 0.80±0.03	0.82±0.03 0.74±0.02	0.87±0.04 0.83±0.06	0.88±0.07 0.78±0.03	0.75±0.04 0.80±0.04	0.80±0.09 0.74±0.05
drained ball-shaped	0.30±0.04	0.28±0.03 0.29±0.05	0.58±0.05*+ 0.33±0.02	0.68±0.05*+ 0.38±0.05	0.50±0.03*+ 0.37±0.03	0.55±0.03*+ 0.32±0.03	0.38±0.05 0.37±0.03
degenerating	0.26±0.02	0.33±0.02* 0.26±0.04	0.65±0.02*+ 0.33±0.03	0.93±0.04*+ 0.33±0.06	0.97±0.02*+ 0.28±0.03	0.78±0.05*+ 0.35±0.05	0.33±0.05 0.30±0.03

Note. Significant differences *from the baseline and +from the control group.

cantly decreased and the number of transitional, prehemolytic, and degenerating forms increased (Fig. 1, *b*). The number of circulating biconcave disk-shaped erythrocytes progressively decreased with increasing the duration of treatment (2, 3, and 4 months), which was accompanied by accumulation of transitional, prehemolytic, and degenerating cells (Table 1, Fig. 1, *c*).

After termination of the inhalation treatment, the content of diskocytes in the experimental group significantly increased, but still remained below the baseline level ($p<0.05$, Table 1). The total number of transitional, nontransitional, and degenerating erythrocytes decreased and did not differ from normal (Fig. 1, *d*).

Thus, long-term inhalation of piezoceramic UDP significantly changed surface architectonics of blood erythrocytes and led to the appearance of irreversibly changed and degenerating erythrocytes in the circulation; one month after termination of inhalation treatment these parameters returned to normal.

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