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Research Article

**FEATURES OF MATERNAL-FETAL BLOOD FLOW IN  
PREECLAMPSIA**<sup>1</sup>Tatiana V. Pavlova, <sup>2</sup>Alina V. Selivanova, <sup>2</sup>Liudmila O. Zemlianskaia<sup>1</sup>Belgorod State University, 85, Pobeda St., Belgorod, 308015, Russia<sup>2</sup> Regional state budgetary institution of health care

"City hospital №2 of Belgorod"

Gubkin street, house 46, Belgorod, 308036, Russia, e-mail: [pavlova@bsu.edu.ru](mailto:pavlova@bsu.edu.ru)**Abstract:**

*The examination of 85 pregnant women with preeclampsia has been performed. Along with standard clinical methods, the structure of vessels of myometrium, umbilical cord and villous chorion, as well as blood cells was studied using scanning atomic force and scanning electron microscopy with elemental analysis. It is shown that the number of normocytes in the disease has been reduced almost twice. Altered cells in the majority cannot perform the most important function of erythrocytes in full – the oxygen-transport and are functionally defective. This is confirmed by the presence of a statistically significant reduction in oxygen content in respect of a comparative aspect between the erythrocytes of control and main groups. The component start of DIC with subsequent disordered vital functions of the mother and fetus may be the disturbed circulation in the structural components of the studied tissues and organs, as well as the change in cytoarchitecture and functional properties of erythrocytes.*

**Keywords:** *preeclampsia, placenta, umbilical, uterus, erythrocytes, scanning microscopy***\* Corresponding author:****Tatiana V. Pavlova,**

Belgorod State University,

85, Pobeda St., Belgorod, 308015,

Russia

E-mail: [pavlova@bsu.edu.ru](mailto:pavlova@bsu.edu.ru)

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## INTRODUCTION:

Reproduction of healthy offspring is one of the priorities of modern humanity. This is one of the main tasks of the Russian government and the direction of health care. The level of erythrocytes in the blood is accepted to be the most important indicator of human health. The abnormality can evidence that negative changes occur in the organism. But, in creation of new methods of blood cells research, it becomes clear that an equally important indicator is the change of their form and structure. These indicators are especially significant when studying the issues of motherhood and childhood in view of their social value. Preeclampsia is one of the most serious pregnancy difficulty, which can lead not only to maternal and perinatal morbidity, but also to mortality [1-6]. The main cause of preeclampsia is the disturbance of placental blood flow, conditioned by the incomplete formation of the vascular system, resulting in the changes in placenta [7-15]. However, despite considerable interest in the study of uteroplacental blood flow, innovative methods make it possible to obtain new data for solving clinical problems of preeclampsia prevention and correction [16-18].

The scrutiny of uteroplacental blood flow in pregnancy against preeclampsia using scanning microscopy was the purpose of this study.

**Purpose.** The study of the erythrocytes of placenta, umbilical cord, endometrium, myometrium and maternal blood against the background of preeclampsia

## MATERIALS AND METHODS:

The clinical material of examination of the patients, whose pregnancy was complicated by preeclampsia, being in the perinatal center of the Belgorod Regional Clinical Hospital of St. Joasaph and the Moscow Regional Research Institute of Obstetrics and Gynecology (85 women) was used in this paper. The control group comprised 30 pregnant women. The obstetrical anamnesis accompanied by extragenital pathology, the course of pregnancy and delivery was studied. By using erythrocytometry, hemoscanning

and elemental analysis of blood elements, the study of the morphological properties of red blood cells by means of the scanning microscope "FEI Quanta 200 3D" was conducted. The blood samples were collected within the first hours after women's being admitted to hospital. The study was conducted 30 minutes after blood sampling.

To study the tissue samples using scanning electron microscopy (SEM), the fragments of umbilical cord, placenta and uterus (endometrium and myometrium) obtained during the cesarean operation, without additional treatment of the material in  $45 \pm 15$  min after the operation, which were examined with the help of scanning electronic microscopes «FEI Quanta 600 FEG» and «FEI Quanta 200 3D», were picked out. Using the detector to register the spectra of characteristic Xradiation of EPAX, which were integrated with the scanning electron microscope "Quanta 600 FEG", the elemental analysis of phosphorus, calcium, oxygen, carbon, magnesium, nitrogen, iron, aluminum, sulfur and sodium was carried out.

In addition, the examination of tissues using the microscope "Ntegra-Aura" was carried out, based on paraffin blocks. The studies were conducted in the modes of intermittent or permanent contacts. With the help of software "NOVA" (NT-MDT, Russia) and "Image Analysis" (NT-MDT, Russia), AFM images were built and processed.

## RESULTS AND DISCUSSION

We have performed probe and electronic scanning microscopy of red blood cells using large imaging regions with the fulfillment of topography of the surface and their morphometry. When performing electron microscope-assisted study, various forms of erythrocytes were examined depending on their surface architectonics and sizes. It was found that in the group of practically healthy pregnant women the absolute majority of red blood cells was represented by discocytes, their content was  $89.71 \pm 2.35\%$ , which is evident from the data in Figure 1,2,3 and Table 1.

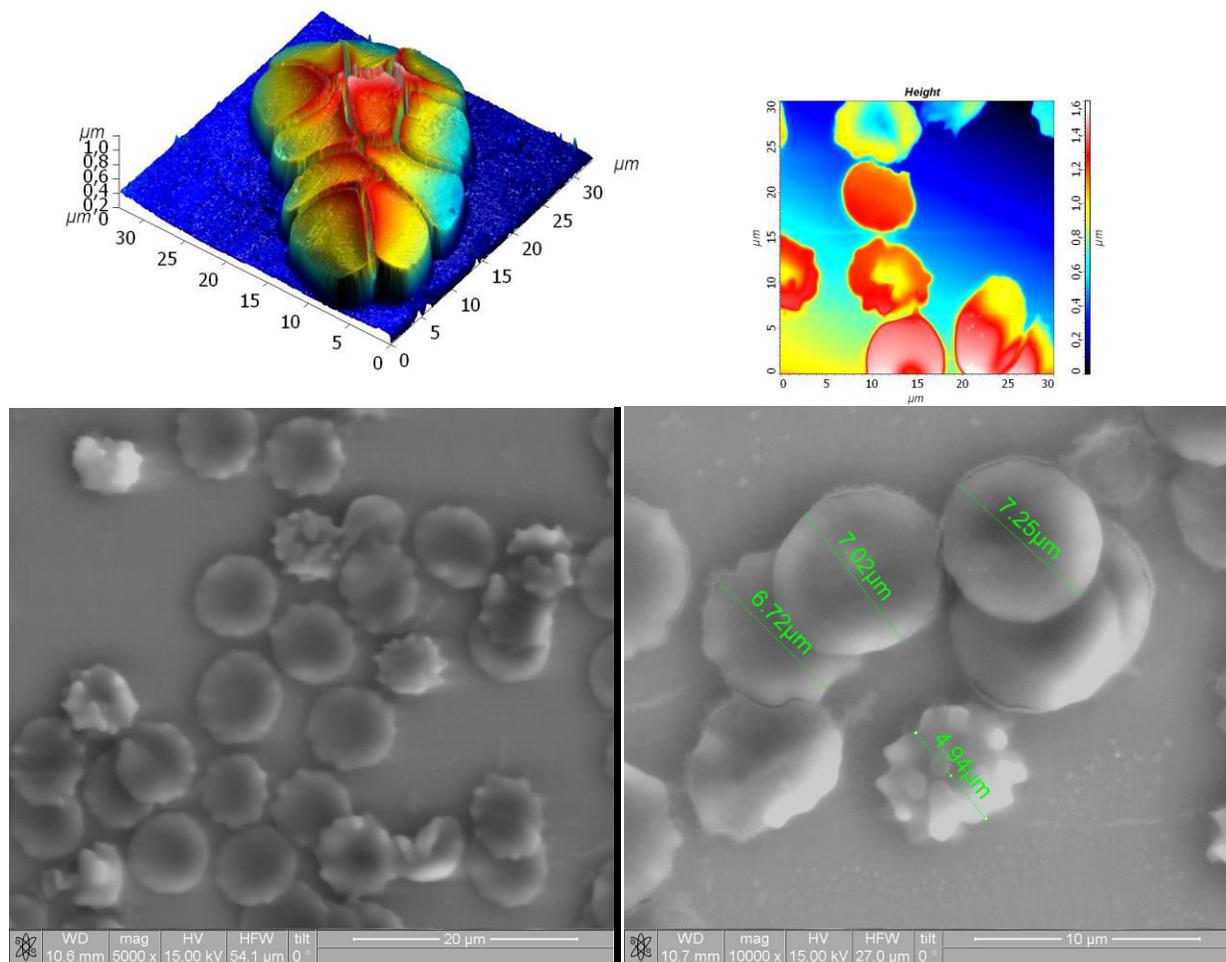


Fig.1. Erythrocytes in Maternal Channel in Preeclampsia.SLUDGE (B, G, D) and thrombosis (A).

A, B (atom-force microscopy), G, D (SEM) (X5,000, 10, 000).

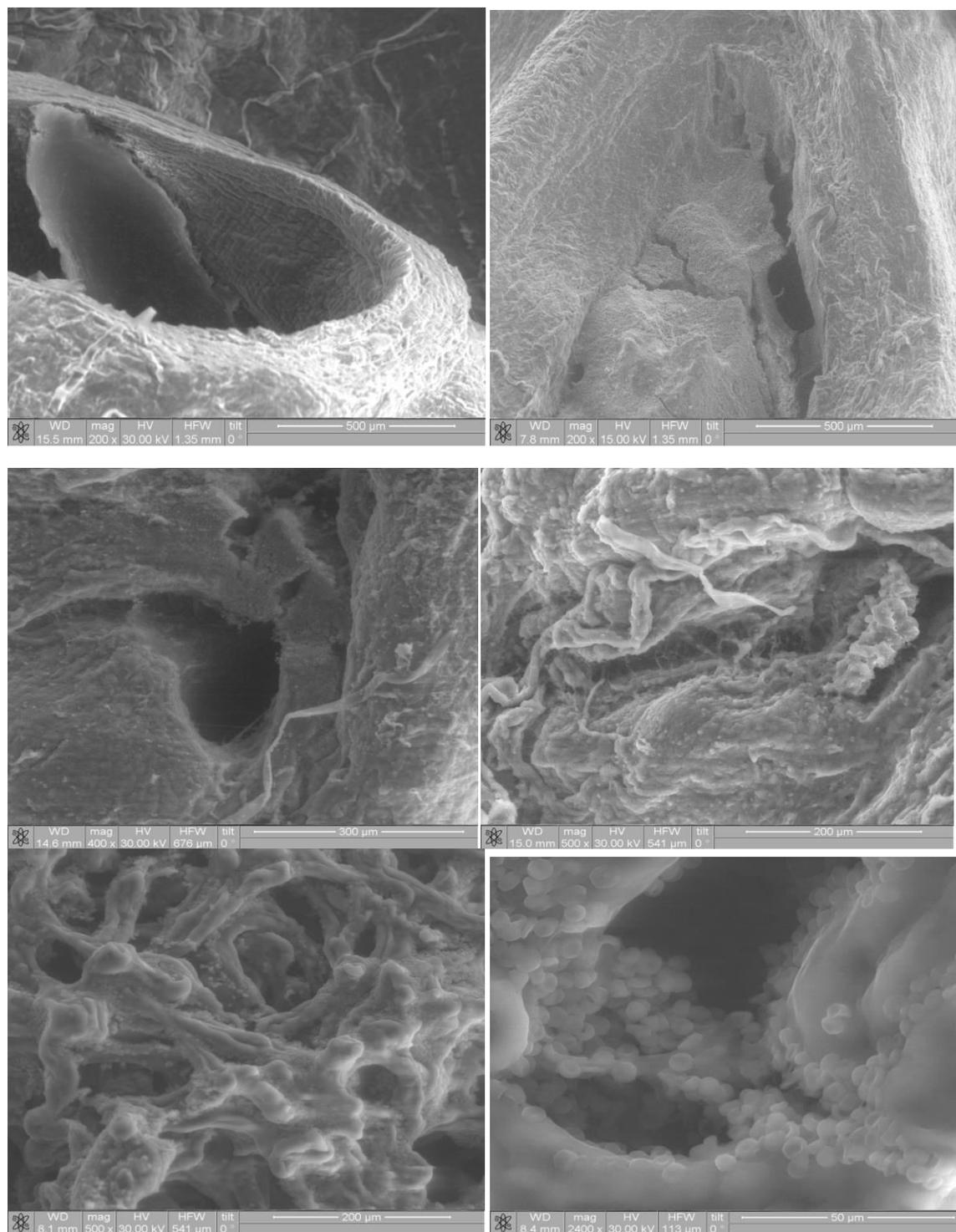


Fig. 2. Umbilical (AB) Myometrium (CD), Placenta (E F) in Preeclampsia.

A, B. Umbilical vascular thrombosis (SEM) (X200).

C, D. Thrombosis of the vessels of the myometrium. (SEM) (X10, 000).

E, F. Changing the shape of the villous chorion. Predominance of intermediate villi. Blood clots in the interwoven space (SEM) (X500, 2,400).

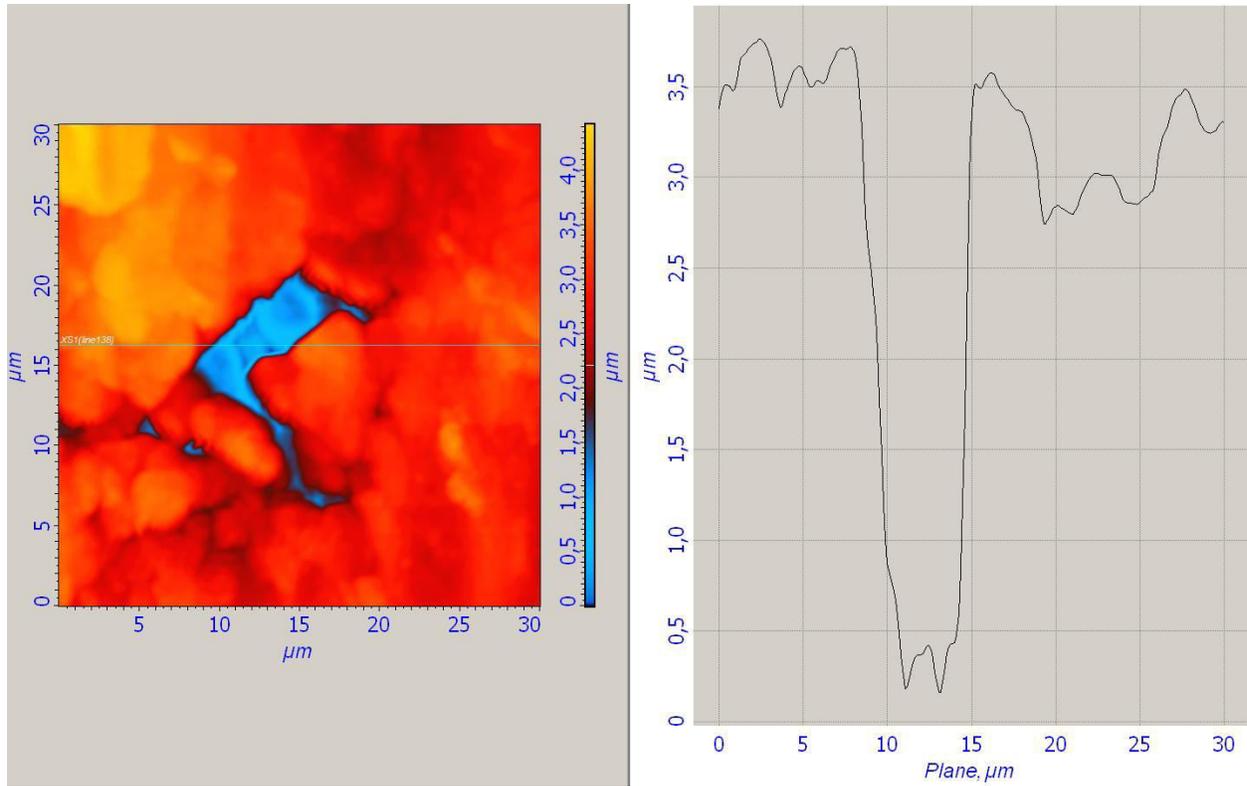


Fig. 3. Myometrium in Preeclampsia. Umbilical vascular thrombosis (atom-force microscopy).

Table 1: Change of the Ratio of Red Blood Cells in Pregnant Women with Preeclampsia

Morphological forms of red blood cells	Control group 20	Mildpreeclampsia 60	Pronounced preeclampsia 24
Discocytes(%)	89.71±2.35	70.61±2.44*	62.67±2.01* **
Reversibly abnormal (transitional) (%)	10.00±1.46	19.06±2.35*	21.00±2.31* **
Irreversible abnormal: (prehemolytic) (%)	0.15±0.16	6.19±1.10*	10.11±1.67* **
Involution forms(%)	0.15±0.15	4.15±0.56*	7.23±0.82* **

Note:

- <sup>x</sup> p < 0.05 in comparison with the control group;  
<sup>xx</sup> p < 0.05 In comparison between the groups with different preeclampsia;

When analyzing the results of the examination, it was shown that in the control group, in the majority of cases, the scans of round-shaped cells represented by biconcave cells with an even surface were obtained. They were mostly in the form of a right disk. Their diameter averaged  $7.10 \pm 0.94 \mu\text{m}$ , which is illustrated in Table 2.

Table 2: The Ratio of Discocytes in Pregnant Women without Pathology and with Preeclampsia

The ratio of cell volumes	Control group (±)	Mild preeclampsia (±)	Pronounced preeclampsia (±)
Meancell diameter (µm)	7.10±0.04	7.50±0.04	7.40±0.04
Diameter of microcytes(µm)	6.10±0.04	5.90±0.03	5.8±0.03
Diameter of normocytes (µm)	7.20±0.04	7.10±0.08	7.0±0.05
Diameter of macrocytes(µm)	9.20±0.07	9.40±0.06	9.4±0.06

Note:  
<sup>x</sup> p <0.05 in comparison with the control group;

According to the cell size, the cells were divided into normocytes, macrocytes and microcytes. The content of normocytes was within 84.30 ± 1.41% of the total number of discocytes. On average, their diameter was 7.20 ± 0.04 µm, and the thickness was -2.05 ± 0.20 µm. The presence of microcytes, especially macrocytes, can already be regarded as a pathology of size, but this phenomenon is usual for the course of pregnancy. In our studies, 14.30 ± 1.52% accounted for the proportion of microcytes (6.10 ± 0.04 µm for 1.58 ± 0.21 µm). 1.40 ± 0.14% were macrocytes (9.20 ± 0.07 µm for 2.39 ± 0.25 µm). The ultrastructure of erythrocytes was even. The cell membrane of the erythrocyte was the same all along.

When examining the surface of red blood cells with probe microscopy, it was shown that the depth of the discocyte hollow, calculated by studying the cell profile, averaged out 0.38 ± 0.05 µmµm. When calculating the ratio of the erythrocyte diameter to the concave diameter, this value was 25.5 units, which is seen in Table 3.

Table 3: The Surface of Unmodified Erythrocytes (Scanning Probe Microscopy) (100% - All Red Blood Cells)

Red blood cell volume	Control group (±)	Mild preeclampsia (±)	Pronounced preeclampsia (±)
The depth of the concave of discocytes (µm)	0.25±0.06	0.30±0.07*	0.40±0.05***
The ratio of the diameter of erythrocyte to the diameter of the concave (units)	21±2	16±2*	14±1*

Note:  
<sup>x</sup> p <0.05 in comparison with the control group;  
<sup>xx</sup> p <0.05 In comparison between the groups with different preeclampsia;

The curvature of the central recess in significantly varied. Regular rounded protuberances with a width of 0.28 ± 0.08 µm were found on the surface of unmodified discocytes. Their organization was similar in both the deepening and the top of the torus. With a change in the normal discoid form on the surface of red blood cells, alongside with such structures, larger protuberances were formed. In the central sections, crests located parallel to each other are also observed. There were pores on the surface of the cells, with relief prominences inside, which had a clear uniform pattern with dimensions of 0.61 ± 0.15 µm.

The level of cells with hemolysis increased. There was a disruption in the structure of the plasma cell membranes. The architectonics of the plasma processes was disturbed. When investigating macro- and microelements, it was found that the content of most of the agents analyzed did not differ significantly between the control group and the main group. However, as a percentage, the difference in the oxygen content within the erythrocytes in the main group was statistically significantly lower than in the control group and equaled 18%. In the vessels of the umbilical cord, their hyperemia

was noted, as a result of which a damage of the micro relief of the endothelium was observed. In addition, the deposits of fibrin filaments and adhesion of the formed elements of blood were disclosed. Thrombosis, sludge and stasis progressed. With preeclampsia, the number of normocytes decreased significantly up to 42% (85% in the control group). The microcytes with a diameter of  $5.5 \pm 0.5 \mu\text{m}$  and a thickness of  $1.95 \pm 0.4 \mu\text{m}$  prevailed among the blood cells. The number of erythrocytes increased, they had the form of a flattened and swollen disc, and the specular cells in the form of a full and not full sphere were also observed.

The change of the villous placenta tree is registered in all structural components. The area of the vessels was  $30.0 \pm 5.0 \mu\text{m}$  ( $26.0 \pm 2.0 \mu\text{m}$  in the control group). With a decrease in terminal villi, an increase in the content of intermediate villi in the pathology of pregnancy was observed. The full length of the vessels was spasmodic, their depth was reduced and was  $1.2 \pm 0.5 \mu\text{m}$  ( $1.9 \pm 0.4 \mu\text{m}$ ), while the other vessels were on the contrary plethoric.

The stem villi with serious preeclampsia are often surrounded by fibrin, the walls of their vessels are sclerotized and thickened, endotheliocytes are atrophied, the lumen is narrowed. The vessels are anemic; the content of platelets is increased. Along the luminal margin, the surface of the endothelium is free of folds and is smoothed, thrombi in the vessels are found in 20-25% of cases.

The terminal villi in the pathology of pregnancy in a part of the cotyledons placentae were full-blooded, and in other parts - with empty capillaries. In the terminal part, the content of full-blooded villi reached to  $52.0 \pm 0.8\%$  ( $40.0 \pm 0.8\%$  in the control group). The erythrocytes in the part of cotyledons were lysed. Fibrinoid-modified villi were  $45.0 \pm 0.7\%$  ( $8.0 \pm 0.7\%$ ). The number of edematous and sclerotized villi increased. In the fetomaternal disease ( $1.5 \pm 0.2 \mu\text{m}$ ), as a result of narrowing or complete absence of the lumen of the vessels, there was an insignificant difference in their relief, which was two times lower than in the control group ( $3.2 \pm 0.5 \mu\text{m}$ ). There was observed the desquamation of syncytiotrophoblast. The erythrocytes in the intervillous space and capillaries, were in the form of normocytes, a full and incomplete sphere, a swollen disc. Red blood cell aggregation was observed, and the number of deformed erythrocytes was reduced. In the intervillous space with serious preeclampsia, significant areas filled with fibrin were detected.

With preeclampsia, there was a significant difference

in the relief of the endometrium in the study of uterine biopsy specimens. Diapedesis hemorrhages and thrombosis were observed, the vessels of the myometrium are full-blooded. The Folding of endothelium is disturbed. Digitate processes appeared in erythrocytes. Both erythrocytes in the form of a sphere and deformed erythrocytes, as well as saddle and dichotomous, were found in the lumen. On the surface of the endometrium, an increase in the content of fibrin was observed, and vascular thrombosis was recognized.

### CONCLUSION:

Thus, against the background of preeclampsia, there are significant modifications in cytoarchitectonics and functional properties of erythrocytes in women, which are detected with the help of scanning microscopy. The number of normocytes has decreased almost twice. The modified cells are mostly dynamically defective and cannot fulfill the oxygen transport function of erythrocytes to full extent. There is a decrease in the oxygen content in respect of the comparative aspect between erythrocytes in the control and main groups.

The obtained data are an indication of the pathomorphological changes in placenta, endometrium, myometrium, umbilical cord, in favour of structural components disruption, which supplements the unfavourable picture of uteroplacental blood flow, leading to abnormality of fetus, mother and newborn.

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