

Innovative Approaches to Studying the Microarchitectonics of Erythrocytes under Gestational Hypertension in Pregnant Women

Pavlova Tatyana Vladimirovna, Ikhtiyarova Gulchekhra Akmalovna,
Baxramova Shakhnoza Usmanovna

Bukhara State Medical Institute, Bukhara, Uzbekistan

Abstract Introduction: The work was carried out in the city maternity hospital of the city of Bukhara, 25 pregnant women were tested: 15 women with gestational hypertension and 10 patients without it. As a result of examination during pregnancy, which develops with gestational hypertension, the main part of red blood cells, as in the control group (89.60±5.60%), was represented by normocytes (65.40±3.50%). At the same time, the development of poikilocytosis was also observed. We have shown that during pregnancy with existing gestational hypertension in erythrocytes there was a significant ($p<0.05$) increase in the space index of the width of the cell by its height in the center (Area), which amounted to $64.84\pm 2.50 \mu\text{m}^2$ ($46.08 \pm 2.60 \mu\text{m}^2$). The cell volume values changed even more ($10153.19\pm 250.00 \mu\text{m}^3$ _ $8443.50\pm 223.50 \mu\text{m}^3$). Thus, it can be stated that the deformability of erythrocytes shown by us is a decisive factor in changing the state of the blood. At the same time, a decrease in the elasticity of the erythrocyte, that is, an increase in their rigidity, leads to an increase in its viscosity. **Results:** During pregnancy formed during PG, the main part of erythrocytes, as in the control group (89.60±5.60%), was represented by normocytes (65.40±3.50%) (Fig. 1,2,3,4). At the same time, the development of poikilocytosis was also visible. **Conclusion:** Changed erythrocytes can take an active part in the formation of DIC syndrome. The presence of deformability of erythrocytes affects the development of hypoxia. Violation of cell architecture leads to toxic processes leading to hemolysis of red blood cells, which leads to a decrease in the number of red blood cells and hemoglobin. This contributes to the development of anemia not only in the mother, but also in the fetus, which must be taken into account in protocols for the management of patients with this pathology.

Keywords Microarchitecture of erythrocytes, Hypertensive disorders during pregnancy

1. Introduction

Protecting the health of mothers and children is a priority direction of state social policy around the world. Preserving and strengthening the health of the younger generation is one of the priority areas among state social tasks. Hypertensive disorders, in particular pulmonary embolism and HELLP syndrome, continue to be an urgent problem in modern obstetrics, being one of the main causes of maternal and perinatal mortality and long-term adverse consequences [1,2,7]. The risk of perinatal mortality with this disease increases 5 times. Preeclampsia is thought to be responsible for 75,000 maternal deaths worldwide each year [3,6]. The problem of prevention and treatment of hypertensive disorders is extremely important due to the exceptional influence of this pathological process on adverse obstetric and perinatal pregnancy outcomes and long-term adverse

consequences [10,13].

In the pathogenesis of many diseases, including those developing during pregnancy, an important place is occupied by changes in the state of red blood cells, in particular, their shape and relationships between cells [4,9,11,12]. These metamorphoses can lead to disruption of microcirculation and rheological characteristics of the blood. Innovative research methods make it possible to clarify a number of issues related to changes in blood cells, including erythrocytes. Scanning, including atomic force microscopy (AFM), is an effective innovative method for assessing the shape and components of these structures [5,7,8]. This brings new opportunities in monitoring the structural and functional status of red blood cells to identify the severity of the disease and coordinate treatment protocols [14]. One of these aspects is hypertensive disorders, including during pregnancy, which are widespread throughout the world, including in the Republic of Uzbekistan.

In this regard, the purpose of this study was to study the microarchitecture of erythrocytes in pregnant women with primary hypertension (PH) using innovative research methods

(atomic force microscopy).

2. Methodology

A diagnosis of 25 pregnant women was performed: 15 women with PG exceeding two years and 10 patients without it in the city nursing home of the city of Bukhara. Blood was drawn in the morning, before meals. The isolation of red blood cells was realized. For the purpose of their analysis and recording, an AFM of Russian production “Ntegra-Aura” of a corporation of associations was used, whose work is aimed at the creation and production of scientific equipment, including for AFM (NT-MDT). Si and SiN cantilevers of the “NSG 01” variant were used. We used the software product “ImageAnalysis”.

3. Results

During pregnancy formed during PG, the main part of erythrocytes, as in the control group (89.60±5.60%), was represented by normocytes (65.40±3.50%) (Fig. 1,2,3,4). At the same time, the development of poikilocytosis was also visible (Fig. 3).

However, the existing cell transformation pathway had the following vectors. One of them was directed towards hypercoagulation, with stasis and adhesion of particles (Fig. 3, 4), leading to thrombosis. The foundation for this was a change in the configuration of the structures being studied, some of which received an ellipse variant. Moreover, they often had a significantly stretched configuration, when the perimeter was more than twice the diameter.

The foundation of these transformations was a change in the walls of blood vessels and the joints between them, as well as spasms characteristic of this pathology. In addition, there was a deviation from the standard structure of the plasmalemma with the revealed inferiority of pores on its territory. Protrusions were observed on the surface of the studied cells, scale 0.28±0.08 μm.

A progression in the number of cytoplasmic processes of unequal shape and configuration, involved in the formation of connections between erythrocytes, was also revealed in some cells. However, we have also shown their absence in other loci.

The second vector was based on the common tendency to hemolyze red blood cells. This was manifested in the

presence of different heights of the structures. In particular, this occurred as a result of partial hemolysis of a number of cells. However, there were also structures with almost complete hemolysis, and accumulations of hemoglobin were also detected. And finally, the appearance of spherical cells formed due to their edema was observed (Table 1).

We have shown (Table 1, Fig. 2,4) that during pregnancy with existing PG in erythrocytes there was a significant (p<0.05) increase in the space index of the width of the cell by its height in the center (Area), which was 64, 84±2.50 μm² (46.08±2.60 μm²). The cell volume values changed even more (10153.19±250.00 μm³ _ 8443.50±223.50 μm³).

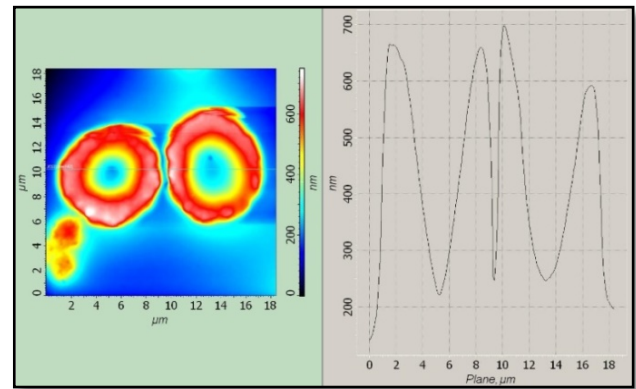


Figure 1. Erythrocytes of pregnant women in the control group Regular disc shape. Moderate depth of the cell cavity. AFM. Rice. A - three-dimensional image. Rice. B - two-dimensional. Rice. B - graphical representation of Fig. B The shape of a regular disk. Moderate cell cavity depth

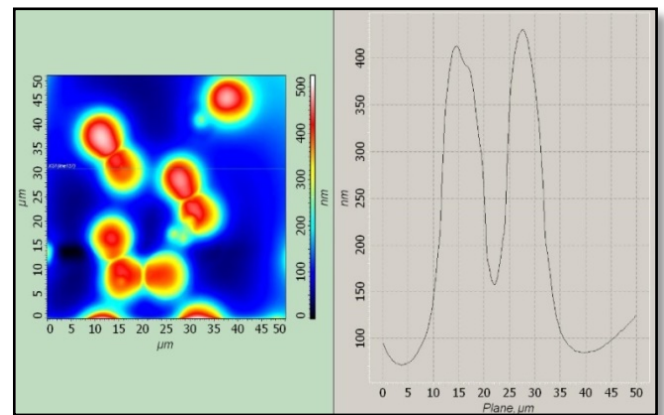


Figure 2. Red blood cells of pregnant women in the control group. Histogram of diameter distribution by number of objects. The shape of the cells is in the form of a regular disk. Moderate cavity depth of the AFM cage. Fig.A-B - outlines of cells, Fig. B

Table 1. The state of erythrocytes in the venous bed in women during pregnancy with the presence of PG

Studygroups	Area, μm ²	Volume μm ³	MaxZ, μm	Perimeter, μm	Diameter, μm
Control	46.08±2.60	8243.50±223.50	642.0±6.20	47.65±2.32	7.65±1.30
Pregnancywith PG	64.84±2.50*	10153.19±250.00*	451.13±0.90*	44.6±1.80	11.13±0.90*

Note. *p<0.05 in relation to the control group: Area – cross-sectional area of the particle, Volume – its volume, Max Z – variant of the local maximum, Perimeter – end perimeter, Diameter – effective diameter of the circle, the space of which is the same as the cross-sectional indicators.

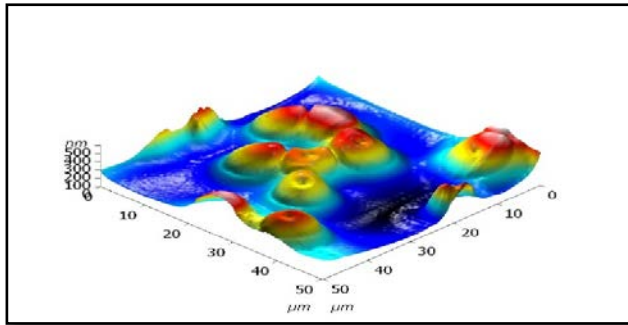


Figure 3. Erythrocytes of pregnant women with primary hypertension. The shape of the cells is changed. In some structures – the beginning of hemolysis. Violation of the depth of the cell cavity. Sludge of red blood cells. Edema ASM. Rice. A three-dimensional image. Rice. B - two-dimensional. Rice. B - graphical representation of Fig. B

	Area	Volume	MaxZ	Perimeter	Diameter
Unit	um*um	um*um*nm	nm	um	um
Average	46.923	8029.457	652.400	48.862	7.729
SD	0.906	414.052	9.700	1.225	0.0746
1	46.017	8443.509	662.100	47.637	7.654
2	47.830	7615.405	642.699	50.087	7.803

Figure 4. Erythrocytes of pregnant women with primary hypertension. Histogram of diameter distribution by number of objects. The shape of the cells is changed. Violation of the depth of the cell cavity. Sludge of red blood cells. AFM. Rice. A. B - outlines of cells, C - digital indicators, D - graphic image

Variants of the local maximum (Max Z), as well as the perimeter (Perimeter), showed the opposite trend in pathology, although they did not have significant differences. And the effective diameter indicator (Diameter), on the contrary, significantly ($p < 0.05$) progressed from $7.65 \pm 1.30 \mu\text{m}$ to $11.13 \pm 0.90 \mu\text{m}$. We also performed an analysis of the discocyte concavity index. It was shown that it is within the range of $0.15 \pm 0.05 \mu\text{m}$ ($0.25 \pm 0.06 \mu\text{m}$ - without pathology). When considering the parity of the erythrocyte diameter to the indicators of the cavity, the required coefficient was 18 ± 2 (21 ± 2).

4. Conclusions

Thus, it can be stated that the deformability of erythrocytes shown by us is a decisive factor in changing the state of the blood. At the same time, a decrease in the elasticity of the erythrocyte, that is, an increase in their rigidity, leads to an increase in its viscosity. These properties are closely related to the surface architecture of red blood cells. At the same time, the change in their morphological constants and the violation of architectonics clearly correlates with the clinical manifestations of hypertension.

Changed erythrocytes can take an active part in the formation of DIC syndrome. The presence of deformability of erythrocytes affects the development of hypoxia. Violation of cell architecture leads to toxic processes leading to hemolysis of red blood cells, which leads to a decrease in the number of

red blood cells and hemoglobin. This contributes to the development of anemia not only in the mother, but also in the fetus, which must be taken into account in protocols for the management of patients with this pathology.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interests

All the authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The authors thank the Bukhara State Medical Institute for its support of this study and for providing the data through the Central Library of the Bukhara State Medical Institute.

Ethics Approval and Consent to Participate

Not applicable.

REFERENCES

- [1] Arslanova, D.R. Effect of femtosecond laser radiation on red blood cells IN VITRO // Laser medicine. - 2011. - T. 15. - No. 2. - P. 215-215.
- [2] Abdrakhmanova A.I., Yu.V. Oslopova, R.N. Khasanova, N.A. cibulkin A.I. arterial hypertension in pregnant women Textbook Kazan – 2017.
- [3] Agababyan L.R., Negmadzhanov B.B., Makhmudova S.E. Prediction and features of the course of severe preeclampsia during the COVID 19 pandemic // Problems of biology and medicine. – 2021. - No. 1.1 (126). - pp. 17-20.
- [4] Adamyan L.V., Artyumuk N.V., Bashmakova N.V. and others. Hypertensive disorders during pregnancy, childbirth and the postpartum period. Pre-eclampsia. Eclampsia: Clinical guidelines (Treatment protocol). - M., 2016. - 19 p.
- [5] Atabaeva, Kh.L. Basic principles of preparation for pregnancy and its management in pregnant women with preeclampsia against the background of identified thrombophilia // Obstetrics, gynecology and reproduction. – 2016. – T. 10, No. 4. – P. 30-38.
- [6] Baibekov, I.M. Erythrocytes in normal conditions, pathologies and under laser influences / I.M. Baibekov, R.Sh. Mavlyan-Khojaev, A.G. Erstekis, S.V. Moskvina. - Tver: Triad, 2008. - 255 p.
- [7] Bakhranova Sh.U. Identification of a group of risk in the structure of antiphospholipid syndrome: to prevent obstetric

- complications // *TibbiyotdaYangi kun.* – Bukhara, 2021. - Vol. 3(35/1). -P. 47-49.
- [8] Bakhramova Sh.U., Ikhtiyarova G.A. Therapeutic and preventive measures for complications of antiphospholipid syndrome combined with gestational hypertension. // *Tibbiyotdayangi kun.* 2022. -P. 100-104.
- [9] Bukhonkina Yu. M., Stryuk R. I., Chizhova G. V. Functional state of erythrocyte membranes in pregnant women with hypertension, possibilities of correction // *Far Eastern Medical Journal.* 2010. No. 2.
- [10] Gushchina, Yu.Yu. Study of differences in morphological parameters of human blood cells using scanning probe microscopy / Yu.Yu. Gushchina, S.N. Pleskova, M.B. Zvonkova // *Surface. X-ray, synchrotron and neutron studies.* - 2005. - No. 1. - P. 48-53.
- [11] Drozd, E.S. Atomic force microscopy of structural and mechanical properties of erythrocyte membranes / E.S. Drozd, S.A. Chizhik, E.E. Konstantinova // *Russian Journal of Biomechanics.* - 2009. - T. 13. - No. 4 (46). - pp. 22-30.
- [12] Ikhtiyarova G.A., Yarmatova Sh.Z., Khafizova D.B., Bakhramova Sh. U. Adverse outcomes of assisted reproductive technologies in women with miscarriage in the presence of antiphospholipid antibodies // *Frontiers in Bioscience-Landmark.* - Singapore 2022. – R. 1093-9946. Scopus.
- [13] Pavlova T.V., Kaplin A.N., Goncharov I.Yu., Zemlyanskaya L.O. // *Uteroplacental blood flow in maternal diabetes mellitus.* *Pathology archive.* 2021. T. 83, No. 1. P. 25-30.
- [14] Pavlova TV, Pilkevich NB, Pavlova LA, Kaplin AN New aspects in the study of clinical and morphological features of uterine blood flow in type 1 diabetes mellitus in the mother // *European Journal of Molecular and Clinical Medicine.* 2020. Vol. 7. No. 2. P. 105-109.