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# Physiological Features Of Surface Properties Of The Erythrocyte Membrane In Newborn Piglets.

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**ABSTRACT**

The rheology of blood in mammals is largely due to the state of the surface of the erythrocyte membrane. It strongly influences hemodynamics in the smallest vessels and the level of inflow of the necessary volume of oxygen to the tissues. Erythrocytes of productive animals under the influence of many environmental factors are able to change their form. This greatly affects their functional activity at the very onset of the ontogenesis of animals, sometimes creating conditions for the development of various dysfunctions and the formation of pathology. The features of the surface properties of the erythrocyte membrane during the neonatal phase in healthy piglets have not been adequately studied. The study found that healthy newborn piglets are characterized by optimal lipid composition of erythrocytes and low activity in them of lipid peroxidation. In the first 5 days of life, they are characterized by a high content of discoid forms of erythrocytes in the blood and a low level of reversibly and irreversibly altered varieties. The revealed features of the surface properties of the erythrocyte membrane in newborn piglets play an important role in their transition to extrauterine existence and promote the adaptation of their organism to this stage of development.

**Keywords:** erythrocytes, surface geometry, piglets, newborn phase, physiology.

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## INTRODUCTION

The viability of the organism depends to a large extent on the optimality of the various parameters of its blood [1, 2]. Among its particularly important indicators include parameters of hemostasis [3, 4] and its rheological properties [5, 6]. Studies of the characteristics of these indices in various living organisms and their dynamics under environmental changes are the subject of modern research [7].

It is known that the liquid properties of blood in mammals are largely due to the state of surface features of erythrocytes [8]. They greatly influence hemodynamics in the smallest vessels and strongly determine the flow of the required volume of oxygen to the tissues [9,10]. Erythrocytes of mammals, including productive animals, under the influence of many environmental factors are often able to reversibly change their shape, and with strong action, the onset changes in red blood cells are irreversible. This greatly influences the functional activity of erythrocytes in mammals at the very onset of ontogenesis, creating conditions for the development of various dysfunctions and the formation of pathological conditions. At the same time, the features of cytoarchitectonic properties of erythrocytes during the phase of newborn in healthy piglets have not been studied enough. At the very beginning of an optimally current ontogenesis, they still do not have a relationship between discoid erythrocytes and their reversibly and irreversibly altered forms. In this connection, our goal was to define the features of erythrocyte cytoarchitectonics in healthy newborn piglets.

## MATERIALS AND METHODS

The research was conducted in strict accordance with ethical principles established by the European Convent on protection of the vertebrata used for experimental and other scientific purposes (adopted in Strasbourg in March, 18th, 1986, and confirmed in Strasbourg in June, 15th, 2006), approved by the Local Ethics Committee of K. I. Skryabin Moscow State Academy of Veterenary Medicine and Biotechnology (record №14, dated December, 1st, 2015), the Local Ethics Committee of Russian State Social University (record №11, dated December, 4th, 2015), the Local Ethics Committee of Peoples Friendship University of Russia (record №11, dated December, 4th, 2015) and the Local Ethics Committee of All-Russian Scientific Research Institute of Physiology, Biochemistry and Animals' Nutrition (record №11, dated December, 4th, 2015).

The work was performed on 36 healthy newborn pigs of large white breed, obtained from healthy sows by the second to third farrow after the normally flowing pregnancy. Piglets did not have deviations in the objective status and results of their examination.

All piglets in washed and resuspended erythrocytes have been determined by enzymatic colorimetry using the Vital Diagnosticum (Russia) cholesterol assay and total phospholipids in terms of the amount of phosphorus in them, followed by calculation of the cholesterol / total phospholipids ratio. Activity of intra-erythrocyte lipid peroxidation (LPO) was recorded according to the content of malonicdialdehyde in washed and resuspended erythrocytes and the content of acyl hydroperoxides. Functional capabilities of intra-erythrocyte antioxidant enzymes were elucidated for catalase and superoxide dismutase [11].

Surface properties of the erythrocyte membrane were evaluated during light phase-contrast microscopy. In the study, the ratio of pathological and normal forms of erythrocytes was determined and the transformation index was calculated = (percent of reversibly deformed erythrocytes + percent of irreversibly deformed erythrocytes) / percentage of discocytes. The value of the reversible transformation index was calculated = percentage of reversibly deformed erythrocytes / percentage of discocytes; the calculation of the index of irreversible transformation was carried out = percentage of irreversibly deformed erythrocytes / percentage of discocytes; Also, the level of the reversibility index was determined = percentage of reversibly deformed red blood cells / percent of irreversibly deformed red blood cells. Statistical processing of the results is carried out by Student's t-test.

## RESULTS OF INVESTIGATION

In the erythrocyte membranes of the piglets observed during the neonatal phase, the stability of the lipid composition was noted. Thus, in them the amount of cholesterol and total phospholipids averaged 0.89±0.004 umol/$10^{12}$ erythrocytes and 0.68±0.004 umol/$10^{12}$ erythrocytes, respectively, with a

cholesterol/total phospholipid level of 1.30±0.005. This created the conditions for their constant level of LPO in red blood cells, ultimately ensuring their optimal microcirculatory properties in the first phase of individual development.

The number of acyl hydroperoxides in the erythrocytes of diurnal piglets was 2.94±0.08 $D_{233}/10^{12}$ erythrocytes, significantly unchanged up to 5 days of age (2.89±0.07 $D_{233}/10^{12}$ erythrocytes). At the same time, the level of malonicdialdehyde in erythrocytes - the final product of LPO - also remained stable and averaged 0.99 ± 0.06 nmol/$10^{12}$ erythrocytes per phase.

The consistency of LPO in the erythrocytes of newborn piglets was provided by the stably high activity of their antioxidant system, estimated by the functional capacity of catalase and superoxide dismutase. The activity of catalase and superoxide dismutase in erythrocytes taken under the supervision of piglets averaged 10968.0±16.6 IE/$10^{12}$ erythrocytes and 1718.0±5.72 IE/$10^{12}$ erythrocytes, respectively, for the phase of newborns.

In the blood of newborn piglets, an optimal amount of discocytes was recorded (on average for the phase of 85.3±0.17%) with a constant value of the transformation index: 0.17±0.010 for 1 day and 0.17±0.008 for the 5th day of life (Table).

**Table: Surface geometry of erythrocytes in newborn piglets**

| Registered parameters | Newborn phase, n=36, M±m | | | | | Mean values |
|---|---|---|---|---|---|---|
| | 1 day of life | 2 day of life | 3 day of life | 4 day of life | 5 day of life | |
| Erythrocytes-discocytes, % | 85.3±0.12 | 84.9±0.21 | 85.2±0.14 | 85.6±0.12 | 85.7±0.24 | 85.3±0.17 |
| Reversibly modified erythrocytes, % | 9.2±0.08 | 9.4±0.04 | 9.3±0.06 | 9.4±0.03 | 9.4±0.07 | 9.3±0.06 |
| Irreversibly modified erythrocytes, % | 5.5±0.04 | 5.7±0.02 | 5.5±0.08 | 5.0±0.11 | 4.9±0.03 | 5.3±0.06 |
| Index of transformation | 0.17±0.010 | 0.18±0.008 | 0.17±0.006 | 0.17±0.002 | 0.17±0.008 | 0.17±0.007 |
| Index of reversible transformation | 0.11±0.004 | 0.11±0.007 | 0.11±0.005 | 0.11±0.002 | 0.11±0.007 | 0.11±0.005 |
| Index of irreversible transformation | 0.06±0.003 | 0.07±0.008 | 0.06±0.005 | 0.06±0.008 | 0.06±0.003 | 0.06±0.005 |
| Index of reversibility | 1.67±0.007 | 1.65±0.005 | 1.69±0.010 | 1.88±0.008 | 1.91±0.014 | 1.76±0.009 |

Note: the reliability of the dynamics of indicators was not revealed.

In this case, piglets of mollusc nutrition showed a retention of up to 5 days of life in the blood of reversibly altered erythrocytes (9.3±0.06% on average). The invariance of the low content in the blood of the examined animals of reversibly altered erythrocytes ensured the constancy of the index of reversible transformation between 1 and 5 days of life (on average 0.11±0.005). Moreover, in piglets during the first phase of ontogeny, the blood content of irreversibly altered erythrocytes did not experience significant dynamics, accompanied by the constancy of the index of irreversible transformation (on average 0.06±0.005). At the same time, the index of reversibility did not change in the phase of newborns during the neonatal phase (on average, for the phase 1.76±0.009).

## DISCUSSION

In all living organisms, the course of ontogeny is often accompanied by complex hematological changes [12,13], which significantly affect the rheological properties of blood [14,15]. The high activity of

antioxidant enzymes in young pigs in their red blood cells provides a low intensity of LPO in them. In combination with a low content of cholesterol in their membranes, this ensures optimal microrheological properties of the erythrocytes in piglets at this age. This is the physiological basis for maintaining in their bloodstream a low number of reversibly and irreversibly altered forms of red blood cells with the invariance of the shape of their main mass. Unexpressed changes in the properties of the surface membrane of erythrocytes lead to a low aggregation, providing the best rheological properties of blood and sufficient perfusion of the internal organs [16], which creates conditions for optimal growth of animals.

The low variability of the surface properties of red blood cells in the blood of healthy newborn piglets is undoubtedly an important element in the process of adaptation of their organism in the onset of extrauterine life. It provides an adequate supply of nutrients and oxygen to the developing tissues of the animal's body [17-22]. At the same time, a low change in the surface of erythrocytes in the vascular bed of piglets during the phase of neonatal is an important element of their body's resistance to all possible adverse environmental factors [23-27].

The constancy of optimal microrheological properties of erythrocytes provides newborn piglets with the necessary conditions for perfusion of their internal organs at this stage of ontogeny. This creates the conditions for the level of metabolism necessary for their organism and for further growth.

## CONCLUSION

The liquid properties of blood in mammals are largely due to the state of surface features of the erythrocyte membrane. They strongly influence hemodynamics in the smallest vessels and the level of inflow of the necessary volume of O2 to the tissues. Erythrocytes of productive animals under the influence of many environmental factors are able to change their form. This largely affects their functional activity in productive animals at the very onset of ontogenesis, sometimes creating conditions for the development of various dysfunctions and the formation of pathology. At the same time, the features of the surface properties of the erythrocyte membrane during the neonatal phase in healthy piglets have not been adequately studied. The study found that healthy newborn piglets are characterized by optimal lipid composition of erythrocytes and low activity in them of lipid peroxidation. In the first 5 days of life, they are characterized by a high content of discoid forms of erythrocytes in the blood and a low level of reversibly and irreversibly altered varieties. The revealed features of the surface properties of the erythrocyte membrane in newborn piglets play an important role in their transition to extrauterine existence and contribute to the formation of the necessary degree of adaptation of their organism at this stage of development.

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