DOI: http://doi.org/10.17816/2313-8726-2021-8-4-221-232
Original Study Article

Conformational changes in plasma proteins and erythrocytes in puerperal women and strategies of managing the perioperative period

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ABSTRACT

BACKGROUND: Cesarean delivery is associated with prolonged hospitalization compared to spontaneous delivery and the risk of intra- and postoperative complications. The introduction of an accelerated recovery program after a planned cesarean section contributes to the rapid recovery of the patient by optimizing various elements of care.

AIM: To study the effect of the components of the accelerated recovery program on the severity of oxidative stress during abdominal delivery at different stages of the perioperative period.

MATERIALS AND METHODS: This was a comparative study assessing conformational changes in plasma proteins and erythrocytes in the blood of puerperal women using fluorescence spectroscopy. The study included 81 patients from the perinatal center of Makhachkala who underwent a planned cesarean section under spinal anesthesia. The enrolled women were grouped into the following: control group (*n*=38), in which perioperative period was traditionally managed, i.e. fasting for 8 h before the operation and introducing an antibiotic after clamping the umbilical cord. Within this group, blood sampling was conducted in all 38 patients at different intervals. In total, 152 samples of the material under study were obtained from control mothers. The 2nd group was the main (*n*=43) and included women in labor; in this group, perioperative period was managed using accelerated recovery program, by introducing the antibiotic cefazolin and with the intake of a glucose-containing drink 2 h before the operation. In total, 172 samples of the material under study were obtained from the mothers of the 2nd group. Methods for the pre-preparation of biological material and spectral methods of analysis were used in this study.

RESULTS: At all stages of preparation of delivery by cesarean section (CS) after spinal anesthesia, minor conformational changes occur in the blood plasma proteins, including umbilical cord blood. In the main group, antibiotic use an hour before delivery increased the oxidative degradation of blood plasma proteins. In the control group, a change in the structural-dynamic parameters of erythrocyte membrane proteins was observed, as indicated by the blue shift in the maximum fluorescence spectrum. This was not observed in the erythrocytes of the main group of puerperal women who received a glucose-containing drink.

CONCLUSION: According to total fluorescence data of plasma proteins and umbilical cord blood, it can be assumed that using a glucose-containing drink 2 hours before CS along with an antibiotic helps restore some parameters of the fluorescence of erythrocyte membrane proteins. The data obtained do not indicate any persistent pathological phenomena in mother's body at all stages of preparation for CS delivery using spinal anesthesia against the background of antibiotic use.

Keywords: perioperative period; accelerated recovery program; carbohydrate drink; cesarean section; conformational changes in proteins.

To cite this article:
Medzhidova DR, Shifman EM, Abdullaev VR, Kulikov AV. Conformational changes in plasma proteins and erythrocytes in puerperal women and strategies of managing the perioperative period. *V.F. Snegirev Archives of Obstetrics and Gynecology.* 2021;8(4):221–232. (In Russ).
doi: 10.17816/2313-8726-2021-8-4-221-232

Received: 07.05.2021 **Accepted:** 29.07.2021 **Published:** 25.12.2021

DOI: http://doi.org/10.17816/2313-8726-2021-8-4-221-232
Оригинальные исследования

Конформационные изменения белков плазмы и эритроцитов крови у родильниц при различной тактике ведения периоперационного периода

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АННОТАЦИЯ

Обоснование. Родоразрешение путём кесарева сечения связано с длительной госпитализацией по сравнению с самопроизвольными родами и риском интра- и послеоперационных осложнений. Внедрение программы ускоренного восстановления после запланированного кесарева сечения способствует быстрому восстановлению пациентки путём оптимизации различных элементов ухода.

Цель исследования — изучение влияния компонентов программы ускоренного восстановления на тяжесть окислительного стресса при абдоминальном родоразрешении на разных этапах периоперационного периода.

Материалы и методы. Проведено сравнительное исследование конформационных изменений белков плазмы и эритроцитов крови родильниц методом флуоресцентной спектроскопии. В исследование включили 81 пациентку перинатального центра г. Махачкалы, которым проводилось плановое кесарево сечение в условиях спинальной анестезии. Выделены две группы родильниц: 1-я группа — контрольная (n=38), с традиционным ведением периоперационного периода (голодание за 8 ч до операции, введение антибиотика после пережатия пуповины); в пределах данной группы забор крови проводили у каждой из 38 пациенток в разные промежутки времени; всего у родильниц 1-й группы взято 152 образца исследуемого материала; 2-я группа — основная (n=43), включала родильниц, периоперационный период у которых вели по программе ускоренного восстановления с введением антибиотика цефазолина за час до операции и с приёмом глюкозосодержащего напитка (ГСН) за 2 часа до операции; всего у родильниц 2-й группы взято 172 образца исследуемого материала. При выполнении настоящей работы использовали методы предподготовки биологического материала и спектральные методы анализа.

Результаты и обсуждение. Обнаружено, что в белках плазмы крови беременных, в том числе в пуповинной крови, на всех этапах подготовки к родоразрешению путём операции кесарева сечения (КС) после проведения спинальной анестезии происходят незначительные конформационные изменения. В основной группе родильниц введение антибиотика за час до родоразрешения усиливало окислительную деструкцию белков плазмы крови. В эритроцитах у родильниц контрольной группы наблюдалось изменение структурно-динамических параметров мембранных белков, на что указывает синий сдвиг максимума спектра флуоресценции, чего не наблюдалось в эритроцитах крови родильниц основной группы, получивших глюкозосодержащий напиток.

Заключение. По спектрам суммарной собственной флуоресценции белков плазмы крови родильниц и пуповинной крови можно предположить, что применение глюкозосодержащего напитка за 2 часа до родоразрешения путём КС на фоне введения антибиотика способствует восстановлению некоторых параметров собственной флуоресценции мембранных белков эритроцитов крови. Полученные данные не указывают на какие-либо стойкие патологические явления в организме матери на всех этапах подготовки к родоразрешению путём КС с применением спинальной анестезии на фоне введении антибиотиков.

Ключевые слова: периоперационный период; программа ускоренного восстановления; углеводный напиток; кесарево сечение; конформационные изменения белков.

Как цитировать:
Меджидова Д.Р., Шифман Е.М., Абдуллаев В.Р., Куликов А.В. Конформационные изменения белков плазмы и эритроцитов крови у родильниц при различной тактике ведения периоперационного периода // Архив акушерства и гинекологии им. В.Ф. Снегирёва. 2021. Т. 8, № 4. С. 221–232.
doi: 10.17816/2313-8726-2021-8-4-221-232

Рукопись получена: 07.05.2021 **Рукопись одобрена:** 29.07.2021 **Опубликована:** 25.12.2021

ЭКО•ВЕКТОР

A cesarean section (CS) is one of the most common surgeries worldwide. Despite initiatives to reverse this trend, the number of deliveries via CS continues to increase globally [1]. Delivery by CS is associated with prolonged hospitalization when compared to spontaneous delivery as well as the risk of intra- and postoperative complications, the frequency of which varies within 20%–47% [2].

The introduction of an accelerated recovery program (ARP) after an elective CS facilitates the patient's rapid recovery by optimizing various elements of care to improve rehabilitation [2]. The widespread acceptance of the ARP treatment approach is due to the growing evidence of the benefits of this method, such as reduced maternal morbidity, shorter hospital stays, and a quick return to normal daily routines [3].

ARP protocol strategies include informing expectant mothers before conception, proper perioperative hydration, nutrition, maintenance of perioperative normothermia, prevention of postoperative gastrointestinal distress, early removal of urinary catheter, adequate analgesia, rational use of antibiotics as antibioprophylaxis, and early postoperative activation [4].

Currently, it is known that oxidative stress (OS) increases during normal pregnancy and that a woman in labor will experience varying degrees of OS during CS and vaginal delivery. Several studies have shown that CS causes less stress than spontaneous vaginal delivery [5, 6]. However, the results of a study published in 2011 by B. Paramita et al. [7] showed that OS is higher in CS delivery than in spontaneous vaginal delivery. In previous studies, we also found that CS is accompanied by an intensification of the oxidative modification of macromolecules against the background of a decrease in the antioxidant capacity of the blood [8, 9]. Concurrently, M. Wilinska et al. [10] showed that OS intensity does not depend on the mode of delivery. Thus, the results of studies published in this area and their conclusions are contradictory.

The present study aimed to investigate the effect of ARP components on OS intensity during abdominal delivery at different stages of the perioperative period.

MATERIALS AND METHODS

A comparative group prospective and retrospective study was conducted, and the study was approved by the ethical committee of the Dagestan State Medical University on April 17, 2018. Informed consent was obtained from all the patients regarding their participation in the study and the publication of their medical data.

The inclusion criteria were as follows: full-term pregnancy, uterine scar after two or more CSs, transverse position of the fetus, and pathology of the pelvic bones (anatomically contracted pelvis, contraction degree III–IV). The exclusion criteria comprised the following: premature birth, fetal macrosomia, multiple pregnancies, preeclampsia of any severity, massive blood loss (>30% of circulating blood volume [CBV]), high risk of purulent septic complications, diabetes mellitus, obesity, and other somatic and obstetric pathologies.

This study included 81 patients who underwent an elective CS under spinal anesthesia at the perinatal center in Makhachkala.

Two postpartum groups were distinguished.

- Group 1 — control group (*n*=38), with traditional management of the perioperative period (fasting 8 h before the surgery and antibiotic administration after clamping the umbilical cord). Within this group, blood was collected from each of the 38 patients at different time intervals; in connection with this, the following stages of the study were identified:
  - 1a — before the start of anesthesia (*n*=38);
  - 1b — after achieving anesthesia before the skin incision (*n*=38);
  - 1c — toward the end of the surgery (*n*=38); and
  - 1d — intraoperatively, cord blood (*n*=38).

Thus, 152 samples of the studied material were collected from the postpartum participants in Group 1.

- Group 2 — the main group (*n*=43) included postpartum individuals, the perioperative period of which was carried out according to the ARP with the administration of antibiotic Cefazolin (2 g intravenously 1 h before the skin incision) and with the intake of a glucose-containing drink (GCD) 2 h before the surgery.

In the main group, blood sampling was carried out at similar stages:

- 2a — before the start of anesthesia (*n*=43);
- 2b — after achieving anesthesia before the skin incision (*n*=43);
- 2c — toward the end of the surgery (*n*=43); and
- 2d — intraoperatively, cord blood (*n*=43).

In total, 172 samples of the studied material were collected from the postpartum participants in Group 2.

While conducting this study, we used pretreatment of biological materials and spectral methods of analysis. Blood samples for the analysis were collected from the cubital vein of the postpartum participants from both groups into the test tubes with an anticoagulant. Blood was centrifuged at 1,500 rpm for 10 min in an Eppendorf 5702R centrifuge (Germany). The resulting plasma was used for analysis, and 10.0 ml of chilled 0.9% sodium chloride solution or buffer (0.01 M Tris-HCl buffer, pH 7.4) was added to the erythrocyte sediment and mixed, after which the erythrocytes were centrifuged at 2,000 rpm for 5 min. Subsequently, the erythrocytes were repeatedly washed with 0.9% sodium chloride solution. All the sample processing was carried out at 4 °C. The isolated erythrocyte sediment was used to obtain erythrocyte membranes. Erythrocyte shadows were obtained according to the Doji method, with minor modifications according to A.N. Klenova [11].

Measurement of the intrinsic fluorescence of blood plasma proteins and erythrocyte membranes

The total intrinsic luminescence spectra of blood proteins and erythrocyte membranes were recorded on a Hitachi F-7000 spectrofluorometer (Japan). The luminescence spectra were obtained in the wavelength range of 290 nm ⩽ λ ⩽ 400 nm upon excitation with light at a wavelength of 280 nm. The fluorescence intensity spectra were graphically obtained, which were measured for 2 min. The spectral gap was 1.5/5 nm [12].

Statistical analysis of the results obtained in this study was performed using the Student *t*-test.

The spectra were processed using Microsoft Excel and Origin 9.0. The total fluorescence spectra obtained were averaged by adding the spectral lines obtained from repeated experiments in the Microsoft Excel program. Fluorescence spectral noise was eliminated using the Fourier method by 5 points, after which the parameters of the protein fluorescence spectra were analyzed (λ_{max} and I_{max}).

To increase the resolution of the bands overlapping in the initial spectra, the method of numerical differentiation was used by calculating the second derivatives of the fluorescence spectra (2DFS) [13].

RESULTS AND DISCUSSION

Regarding the clinical parameters, there were no statistically significant differences between the studied groups [14].

A sensitive OS parameter is a change in the structural organization of proteins. In the present study, we compared the effect of spinal anesthesia in both groups and the effect of GCD administered before surgery in Group 2 during elective CS on the total fluorescence spectra of blood plasma proteins and erythrocyte membranes.

Statistical analysis of the distribution patterns of amino acids in proteins revealed a high level of tyrosine and tryptophan in the transmembrane domains of all major classes of membrane proteins and at the points of contact between the proteins and the membrane, i.e., where the lipid density is the highest [15].

The fluorescent chromophore chosen in this study detected the structural and dynamic changes in both plasma proteins and erythrocyte membrane proteins. Regarding protein molecules, the amino acid tryptophan is the main chromophore, and its fluorescent characteristics provide information on the protein structure and its dynamics. Having a large dipole moment, the amino acid residue of tryptophan in proteins in the excited state becomes a sensitive parameter of the microenvironment, with a wide emission range at a maximum of 315–352 nm [16].

Another unique property of the amino acids tryptophan and tyrosine is their ability to react with considerably dangerous free radicals, reactive oxygen species (ROS), which also makes the total protein fluorescence a sensitive parameter of OS [15].

The fluorescence spectra of blood plasma proteins of the Group 1 participants at all stages of delivery, shown in Fig. 1*a*, *b*, *c*, *d*, have bell-shaped symmetry, with a maximum intensity of approximately 335 nm. As shown in Fig. 1*a*, *b*, *c*, the fluorescence intensity does not change at different stages. Concurrently, a low intensity of cord blood fluorescence spectra was observed (see Fig. 1*d*). Moreover, at the same time, the spectral characteristics of cord blood fluorescence (λ_{max}, spectral asymmetry) do not undergo significant changes, which indicate the absence of conformational changes in the protein macromolecules. The decrease in the fluorescence intensity is possibly associated with the level of total protein in cord blood (see Fig. 1*d*).

The intensity of the total fluorescence of erythrocyte membrane proteins in the Group 1 participants at different stages of the study is shown in Fig. 2.

The absence of changes in intensity and spectral asymmetry in the fluorescence spectra indicates that the tryptophan and tyrosine amino acid residues in the blood plasma proteins of Group 1 are not subject to oxidative degradation. In case of oxidation of the tryptophan and tyrosine amino acid residues in protein molecules, a decrease in the intensity of the total luminescence and spectral asymmetry would be observed, as the amino acid residues of tryptophan form a long wavelength wing and tyrosine a short wavelength wing in the total fluorescence spectrum of proteins [17].

CS is often complicated by surgical infections, endometritis, and urinary tract infection. Evidence-based WHO guidelines suggest the use of broad-spectrum antibiotics prior to surgical incision [2].

It has been suggested that the activity of bactericidal antibiotics results from a common mechanism associated with the formation of ROS. However, the involvement of ROS in antibiotic-mediated death of microorganisms has become the subject of numerous controversies [18].

The intensification of ROS generation processes against the background of antibiotic administration may be accompanied by an increase of OS in the body. One of the mechanisms of the bactericidal effect of an antibiotic is an increase in the generation of ROS in cells because of the Fenton reaction, which involves metals of variable valence [18].

Microorganisms generate NO and H_2S during their vital activity, which leads to the expression of antioxidant enzymes and the suppression of the Fenton reaction, through which the antibiotic resistance of Gram-positive and Gram-negative bacteria is developed [19].

Fig. 3*a*, *b*, *c* show the spectra of the total fluorescence of blood plasma proteins of the Group 2 participants (with the administration of Cefazolin and GCD 1 h before the CS).

As shown in Fig. 3, at all the stages of preparation and CS, the intensity of the intrinsic fluorescence of blood plasma

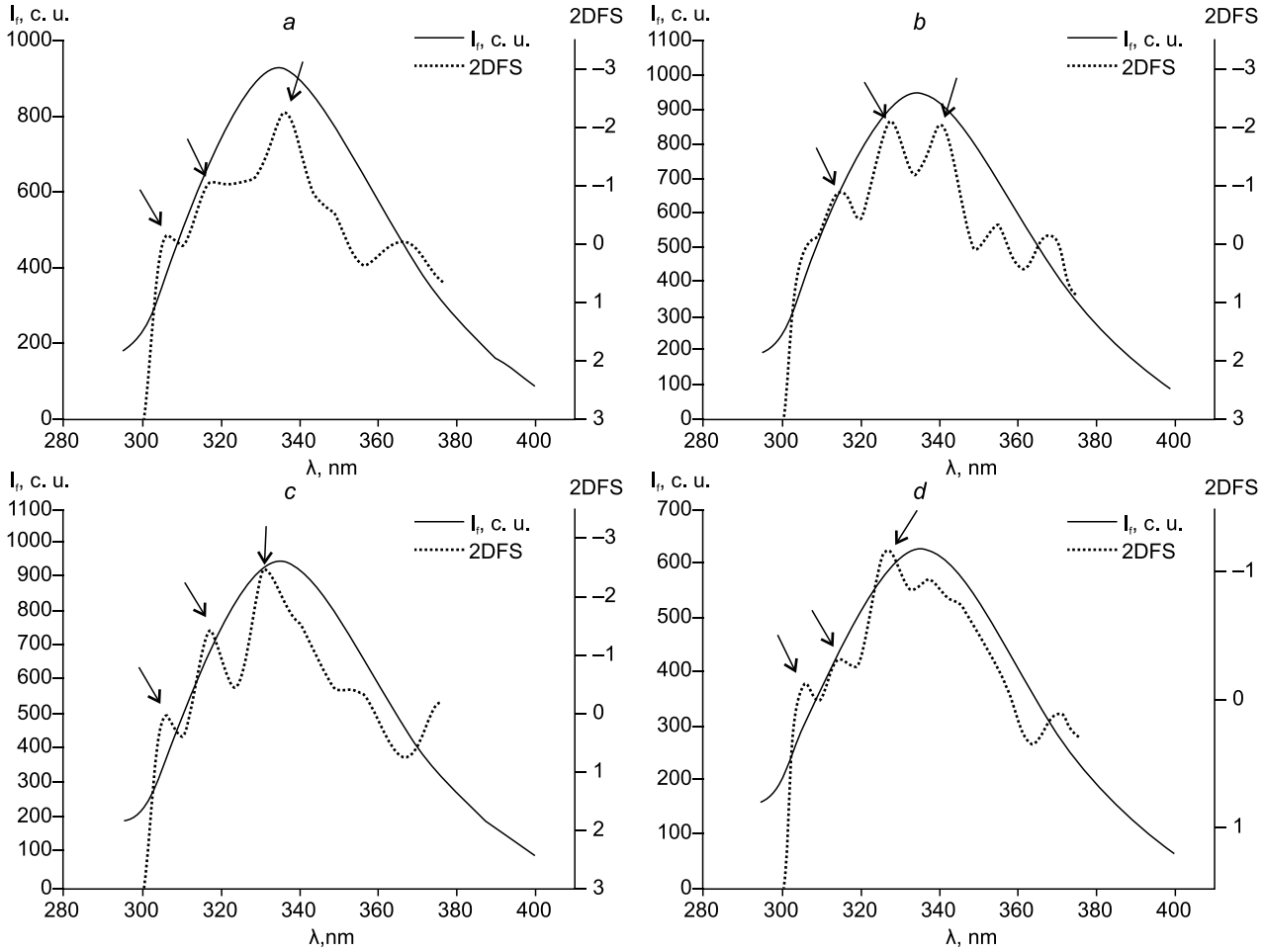

Fig. 1. The intensity of total and tryptophan fluorescence of blood plasma proteins of maternity patients of the 1st (control) group: *a* — before the start of anesthesia; *b* — after the development of anesthesia before the incision on the skin; *c* — by the end of the operation; *d* — intraoperatively, umbilical cord blood.
I_f — fluorescence intensity, conventional units; 2DFS — the second derivatives of the fluorescence spectra.

proteins of the postpartum women drops by 20% relative to that of the Group 1 participants (see Fig. 1). Based on the literature, we suggest that this decrease in the intensity of total fluorescence is caused by the mechanism of activation of ROS generation by antibiotics through the NADH dehydrogenase complex (complex I) in the mitochondria, which leads to the oxidation of tryptophan and tyrosine in the blood plasma protein molecules [19].

Oxidation of these amino acid residues may be accompanied by a violation in the structure of blood plasma protein macromolecules with the loss of their functional activity.

Such a decrease in the intensity of total fluorescence against the background of the administration of Cefazolin and GCD is not observed in cord blood plasma proteins (see Fig. 3*d*). It is known that the placenta has selective permeability and a high level of antioxidant protection.

There are three ways of protecting the placenta and fetus from high levels of OS, which leads to spontaneous abortion: reduction of OS with the help of the antioxidant system of the body, stimulation of trophoblastic invasion and angiogenesis, and suppression of apoptosis [20].

To increase the resolution of the bands overlapping in the original spectra, it is preferable to use the method of numerical differentiation by calculating the second derivatives of the fluorescence spectra (2DFS). This method of analysis provides more detailed information about conformational changes in the structure of protein macromolecules by isolating individual lines of tryptophan and tyrosine amino acid residues in the total fluorescence spectra. This is the most informative method in comparison with the initial total fluorescence spectra [13].

Analysis of the total intrinsic fluorescence spectra showed that in the blood plasma proteins of the Group 1 participants, under spinal anesthesia and delivery by CS, conformational changes are observed relative to stage *a*.

As seen from the 2DFS curve in Figs. 1 and 2, the contribution of the individual peaks of tryptophan and tyrosine fluorescence is observed at all stages. A characteristic difference between 2DFS in the control group (see Fig. 1) and the main group (see Fig. 3) is a more pronounced tyrosine peak, excluding cord blood (see Fig. 3*d*).

Tyrosine fluorescence in native proteins is practically absent due to quenching in a polar solution and efficient

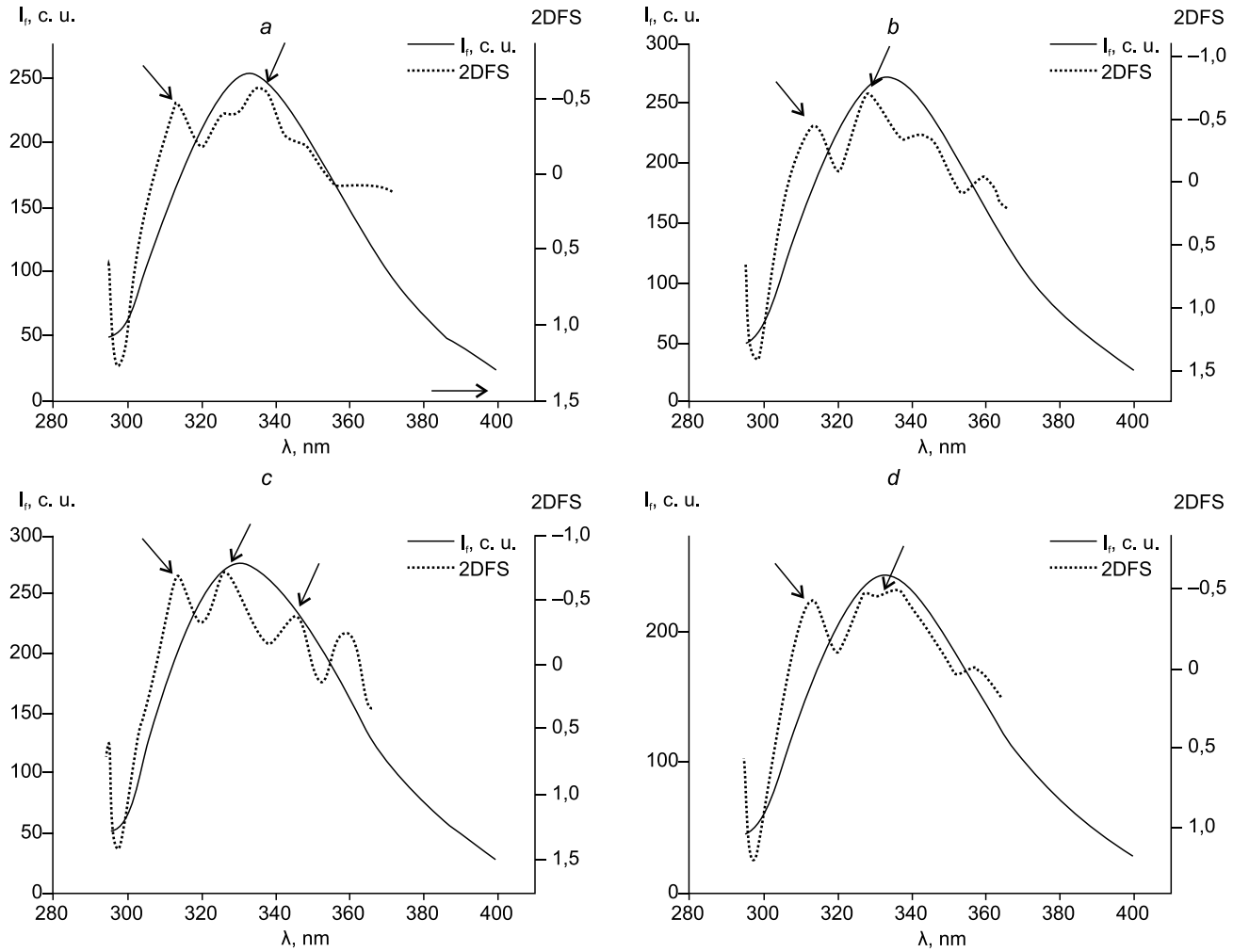

Fig. 2. The intensity of total fluorescence of proteins of erythrocyte membranes of the blood of maternity women of the 1st (control) group: *a* — before the start of anesthesia; *b* — after the development of anesthesia before the incision on the skin; *c* — by the end of the operation; *d* — intraoperatively, umbilical cord blood.

I_f — fluorescence intensity, conventional units; 2DFS — the second derivatives of the fluorescence spectra.

transfer of excitation energy from tyrosine residues to tryptophan (Förster resonant energy transfer).

It is known that the size of most proteins is approximately 14 Å, which corresponds to the effective energy transfer radius from tyrosine to tryptophan [21]. However, in any case, this indicates conformational rearrangements of blood plasma proteins, which can lead to disruption of the basic critical functions of plasma proteins [22].

The intrinsic fluorescence of tyrosine is absent in the plasma proteins of healthy people. This is because of the low quantum yield and the fact that there is a partial transfer of energy in the process of relaxation from the excited tyrosine residues to tryptophan (see Fig. 1a). This mechanism is not the only reason for the quenching of tyrosine fluorescence. Here, tyrosine fluorescence can also be quenched by closely spaced carboxyl groups or uncharged amino groups in proteins.

Therefore, the absence of tyrosine fluorescence or its minimal level in native body proteins may be based on various mechanisms. The exact mechanism of quenching of tyrosine fluorescence for any individual protein is unknown [16].

In addition to the tyrosine component in 2DFS of plasma proteins in the 1st and 2nd groups (see Figs. 1 and 3), we see both short- and long-wave fluorescence peaks at 320, 325, 340, and 355 nm, which correspond to the fluorescence of tryptophan amino acid residues in a protein macromolecule. The resulting individual bands indicate that the tryptophan residues in blood plasma proteins are partially or completely in contact with the polar solvent. Interestingly, in the umbilical cord blood of the Group 1 (control) and Group 2 (main) participants, one peak is clearly expressed at 325 nm and 340 nm, respectively (see Fig. 1*d*; Fig. 3*d*). The remaining peaks, which are pronounced in Group 1 (see Fig. 1*a*, *d*), become less pronounced in Group 2.

It is known from the literature that the antioxidant protection of umbilical cord blood is significantly higher than that of the venous blood of postpartum women. Nevertheless, newborns have a low protection against OS compared to their mothers [21]. In the blood plasma of newborns, there is a low content of vitamin E, β-carotene, melatonin, and sulfhydryl groups as well as a reduced level of proteins that indirectly

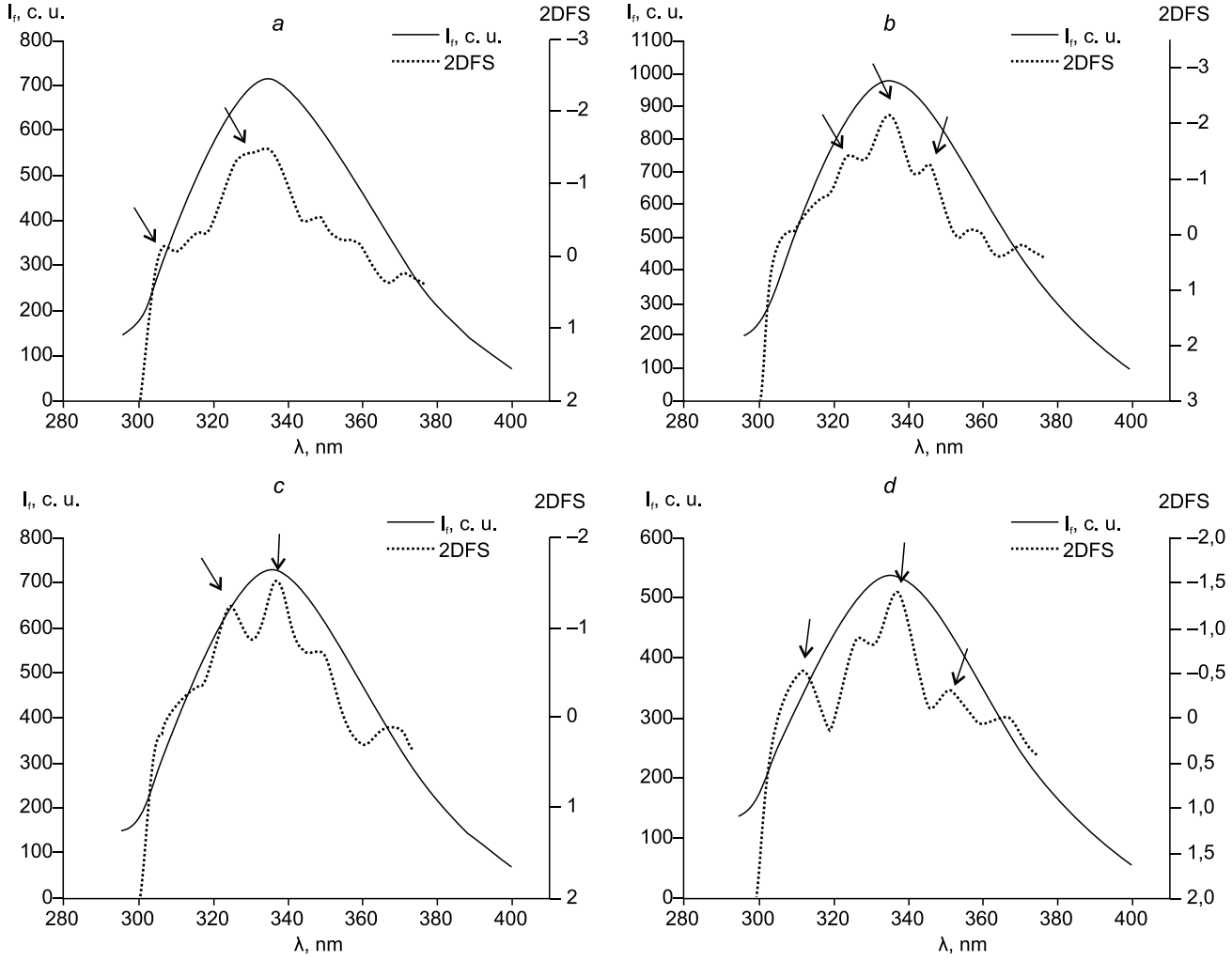

Fig. 3. The intensity of total fluorescence of plasma proteins of maternity mothers in the 2nd (main) group: *a* — before the start of anesthesia; *b* — after the development of anesthesia before the incision on the skin; *c* — by the end of the operation; *d* — intraoperatively, umbilical cord blood.

I_f — fluorescence intensity, conventional units; 2DFS — the second derivatives of the fluorescence spectra.

perform antioxidant functions, plasma metal-binding proteins, such as ceruloplasmin and transferrin, and the activity of erythrocyte superoxide dismutase [23].

A modern approach toward studying the effect of various chemical agents on the human body requires studying the mechanisms of OS not only at the level of proteins, enzymes, and enzyme systems but also at the level of cells and subcellular structures. Biological membranes constantly interact with various molecules of both endogenous and exogenous origins. Erythrocytes are the first to interact with chemical agents that enter the human body, which can disrupt the integrity of membranes and lead to inhibition of membrane and metabolic functions [24].

Several important points should be paid attention to, which were considered while organizing this study, namely, the study of the intrinsic total fluorescence (tryptophan and tyrosine) of erythrocyte membrane proteins.

Regarding soluble proteins, tryptophan is not a common amino acid but is quite abundant in membrane proteins because this aromatic amino acid plays a key role in the anchoring and positioning of membrane proteins. Tryptophan has the greatest driving force of all amino acids for the interfacial region between the lipid bilayer and the hydration shell of the protein, thereby providing significant stability to the protein structure [15].

The critical role of tryptophan in the stability of membrane proteins can be explained by several reasons. First, it is an amphiphilic molecule that has both hydrophilic and hydrophobic properties. Second, tryptophan can be a hydrogen bond donor in the hydrophobic region. The transition of amino acid residues of tryptophan in membrane proteins from the polar microenvironment to the lipid bilayer is accompanied by a blue shift from the emission maximum (when exposed to a polar solvent) from 350 to 330 nm (in the bilayer, hydrophobic microenvironment). This transition is accompanied by a significant increase in the luminescence quantum yield of the order of 1.5 times. These along with other dynamic properties make the fluorescent characteristics of tryptophan a suitable reporter for studying the structure and dynamics of membrane proteins [16].

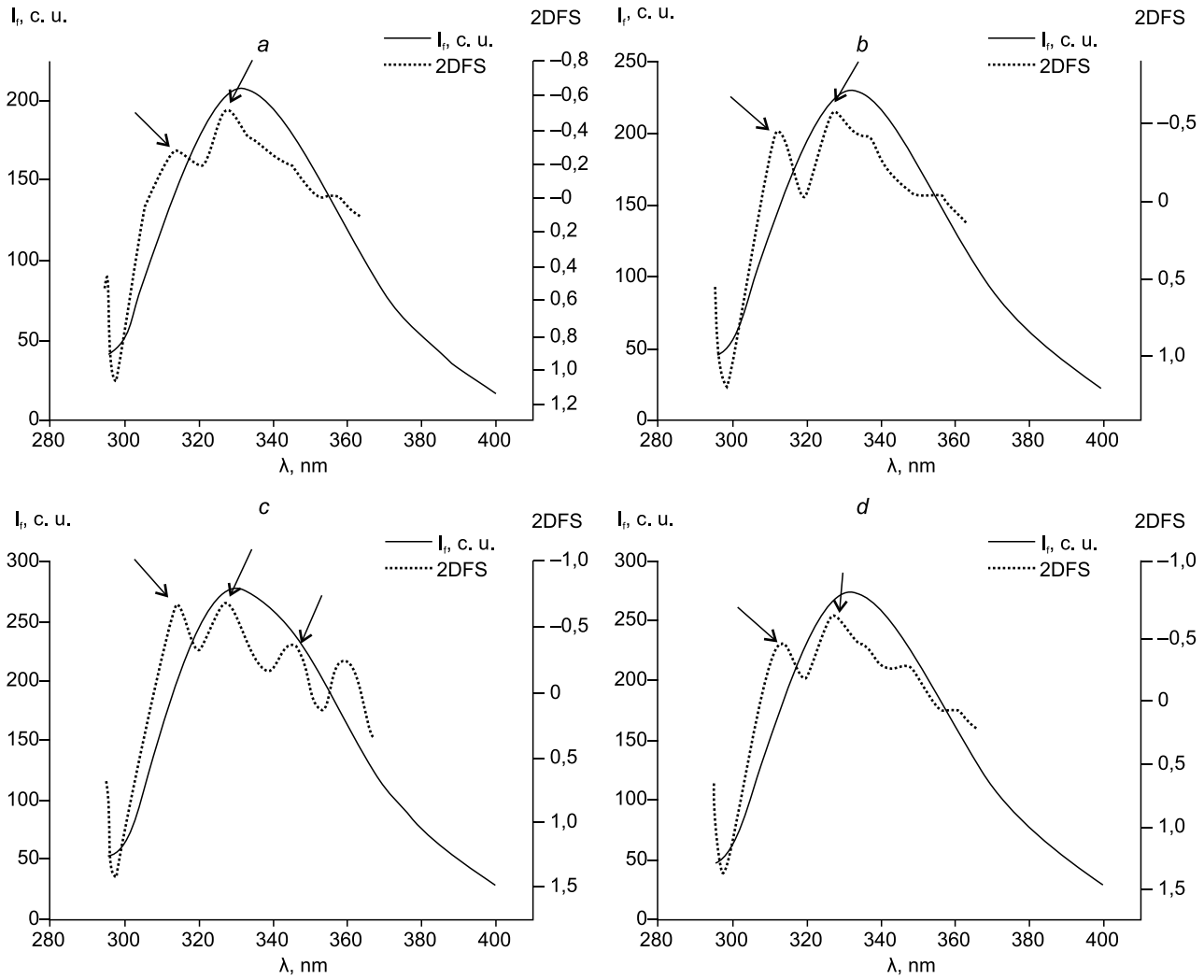

Fig. 4. The intensity of total fluorescence of erythrocyte membrane proteins in the 2nd (main) group: *a* — before the start of anesthesia; *b* — after the development of anesthesia before the incision on the skin; *c* — by the end of the operation; *d* — intraoperatively, umbilical cord blood.

I_f — fluorescence intensity, conventional units; 2DFS — the second derivatives of the fluorescence spectra.

As seen in Figs. 2 and 4, the intrinsic fluorescence intensity in the studied samples of both groups does not undergo significant changes. However, in Group 1, except for cord blood erythrocytes, we simultaneously observed a change in the magnitude of the Stokes shift toward short waves. Thus, the maximum intensity of fluorescence (λ_{max}) of erythrocyte membrane proteins at λ_{ex} 280 nm before anesthesia is 334 nm; after CS during anesthesia and antibiotic administration, λ_{max} is 330 nm. In the group of postpartum participants who received GCD, no change in the magnitude of the Stokes shift was observed.

The reason for the hypsochromic effect (blue shift) observed in the fluorescence spectra of erythrocytes can presumably be considered a complex effect of spinal anesthesia and antibiotic (λ_{max}=333 nm) and surgical intervention (λ_{max}=330 nm). The blue shift indicates that the polarity of the chromophore microenvironment is changing, which makes a total contribution to the intrinsic fluorescence of erythrocyte membrane proteins. This can occur both due to the lipid matrix of membranes, an increase in the hydrophobicity of the microenvironment as a result of the immersion of proteins in the lipid layer, and due to the conformational rearrangements of membrane proteins. In confirmation of this, in Group 2, in the second derivatives of the fluorescence spectra (see Fig. 4), the main peaks were observed in the left wing of the spectrum, which distinguishes them from 2DFS in the control and cord blood samples (see Fig. 2a, *d*).

Among the numerous mechanisms of protein molecules modification, the fastest is free radical oxidation, which plays an important role in the structural and functional changes in cell membranes and always leads to a violation of cellular homeostasis [25].

CONCLUSION

Therefore, according to the total intrinsic fluorescence spectra of blood plasma proteins of postpartum women and

umbilical cord blood, it can be assumed that at all stages of preparation for delivery by CS under conditions of spinal anesthesia, slight conformational changes occur in blood proteins. Increased oxidative degradation of blood plasma proteins occurs against the background of the introduction of antibiotics an hour before delivery. This is expressed not only by a decrease in the intensity of the intrinsic fluorescence of plasma proteins but also by the "loosening" of protein globules as indicated by a change in the fluorescence peaks in 2DFS.

Concurrently, in the control group, which consisted of postpartum participants with a traditional perioperative period (starvation 8 h before surgery, administration of an antibiotic after clamping the umbilical cord), a change in the structural and dynamic parameters of the membranes occurs in erythrocytes, accompanied by a change in the magnitude of the Stokes shift, which levels out the drop in the fluorescence intensity of the membrane proteins.

It is known that the oxidative degradation of proteins can be a trigger of pathological processes and the earliest marker of OS. According to the dynamics of conformational changes in plasma proteins and blood erythrocytes, one can judge the intensity of OS as well as the adaptive capabilities of the organism of postpartum individuals.

The data obtained herein do not indicate any persistent pathological phenomena in the patients' body at all stages of preparation for delivery by CS using spinal anesthesia against the background of antibiotics. This is evidenced by the tendency to restore some parameters of the intrinsic fluorescence of proteins through the administration of GCD.

ADDITIONAL INFO

Author contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

Funding source. This study was not supported by any external sources of funding.

Competing interests. The authors declares that there are no obvious and potential conflicts of interest associated with the publication of this article.

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