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¹Leyla Medical Center, Baku, Azerbaijan**CYTOKINE PROFILE IN CERVICAL INSUFFICIENCY AS A PROGNOSTIC MARKER OF ADVERSE PREGNANCY OUTCOMES**

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Second-trimester pregnancy loss and preterm birth remain major obstetric challenges, and cervical insufficiency is an important contributor to adverse pregnancy outcomes. A prospective cohort study conducted from 2020 to 2025 included 101 pregnant women with threatened pregnancy in the second trimester and 25 controls; cervical secretions and pregnancy outcomes were evaluated. Women with cervical insufficiency had significantly higher concentrations of tumor necrosis factor alpha and interleukins 2, 4, 6, and 10 throughout pregnancy compared with controls. Cytokine concentrations decreased in the second trimester and increased again in the third trimester. Full-term delivery occurred in 78 % of the study group and 92 % of controls, while earlier deliveries were more frequent in the study group, although these outcome differences were not statistically significant. The findings indicate pronounced local immune activation and support the potential value of the cervical cytokine profile for identifying women at increased risk of adverse pregnancy outcomes.

Key words: cervical insufficiency, pregnancy loss, cytokine profile, preterm birth, local immunity, pregnancy outcomes.

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ПРОФІЛЬ ЦИТОКІНІВ ПРИ ІСТМІКО-ЦЕРВІКАЛЬНІЙ НЕДОСТАТНОСТІ ЯК ПРОГНОСТИЧНИЙ МАРКЕР НЕСПРИЯТЛИВОГО РЕЗУЛЬТАТУ ВАГІТНОСТІ

Втрата вагітності у другому триместрі та передчасні пологи залишаються актуальними проблемами акушерства, а істміко-цервікальна недостатність є одним із значущих чинників несприятливих наслідків вагітності. До проспективного когортного дослідження 2020–2025 років включено 101 вагітну жінку з загрозою переривання вагітності у другому триместрі та 25 жінок контрольної групи; оцінювали цитокіни цервікального секрету та результати вагітності. У жінок з істміко-цервікальною недостатністю концентрації фактора некрозу пухлин-альфа та інтерлейкінів 2, 4, 6 і 10 були статистично значуще вищими протягом усього періоду спостереження. У другому триместрі відзначалося зниження рівнів цитокінів із подальшим підвищенням у третьому триместрі. Доношені пологи зареєстровані у 78 % жінок основної групи та у 92 % контрольної групи; більш ранні пологи найчастіше спостерігалися в основній групі, проте відмінності не були статистично значущими. Отримані дані підтверджують виражену локальну імунну активацію та перспективність цитокінового профілю як прогностичного маркера несприятливих наслідків вагітності.

Ключові слова: істміко-цервікальна недостатність, втрата вагітності, цитокіновий профіль, передчасні пологи, локальний імунітет, наслідки вагітності.

Second-trimester pregnancy loss remains one of the pressing issues in modern obstetrics. Cervical insufficiency (CI) is considered one of the leading factors contributing to premature pregnancy termination and preterm birth. Despite significant advances in diagnosis and treatment, the mechanisms underlying this pathology remain an active area of research [3, 9, 10].

Pregnancy is characterized by a complex immunological adaptation aimed at maintaining the semi-allogeneic fetus. Maintaining a balance between pro-inflammatory and anti-inflammatory cytokines is a key condition for a normal gestational process. Disruption of this balance may contribute to cervical remodeling, activation of inflammatory cascades, and premature cervical dilation. In this context, the study of the local cytokine profile in cervical secretions is of particular interest, since alterations in cervicovaginal inflammatory mediators have been associated with spontaneous preterm birth and cervical changes [1, 3–5, 9]. Pregnancy loss significantly affects not only demographic indicators but also the somatic and psycho-emotional health of women and their children. Beyond its clinical implications, miscarriage and preterm birth are

associated with substantial socio-economic consequences, impacting the interests of both the family and society as a whole [8].

The etiology of this condition is multifactorial and includes a wide range of causes. One of the potentially modifiable factors is cervical insufficiency. CI is an important cause of second-trimester pregnancy loss and spontaneous preterm birth and is characterized by painless cervical shortening and dilation in the absence of regular uterine contractions [10]. Contemporary studies emphasize that cervical length, particularly a short cervix in mid-pregnancy, is an important marker associated with the risk of spontaneous preterm delivery [7, 11, 12, 15].

Timely and thorough prenatal diagnosis is therefore essential for identifying women at increased risk of adverse pregnancy outcomes. Current approaches increasingly combine clinical and ultrasonographic characteristics with biological markers in an attempt to improve prediction of spontaneous preterm birth [3, 11, 13–15]. In particular, cervicovaginal cytokines, inflammatory mediators, microbiome-related factors, and other biomarkers are being investigated as potential

components of individualized risk assessment [1, 4, 11]. Nevertheless, available evidence regarding the predictive value of cytokines remains heterogeneous, and some studies have not demonstrated sufficient predictive performance of maternal cytokine profiles [6]. This underscores the need for further investigation of the local cytokine profile in women with cervical insufficiency and its relationship with subsequent pregnancy outcomes.

The purpose of the study was to investigate the dynamics of pro-inflammatory and anti-inflammatory cytokine levels in the cervical secretions of pregnant women with cervical insufficiency and to evaluate their role as prognostic markers of pregnancy outcomes.

Materials and methods. Study Design and Setting. A prospective cohort study was conducted from 2020 to 2025 at the Department of Obstetrics and Gynecology, Azerbaijan State Advanced Training Institute for Doctors named after A. Aliyev, and the Leyla Medical Center (Baku, Azerbaijan).

The study included 101 pregnant women with second-trimester threatened pregnancy, with a gestational age of 12–28 weeks at the time of enrollment. Participants' ages ranged from 22 to 35 years (mean age 28.7 ± 4.06 years). Habitual miscarriage (HM) was defined as two or more consecutive spontaneous pregnancy losses before 22 weeks of gestation. Among the 101 women, 28 (27.7 %) had a history of HM, and 32 (31.7 %) received a confirmed diagnosis of cervical insufficiency (CI) based on clinical and ultrasound findings.

Inclusion criteria: Pregnant women in the second trimester (12–28 weeks of gestation) with a threatened pregnancy, aged 22–35 years, who provided written informed consent to participate in the study.

Exclusion criteria: women with malignant diseases of the reproductive system or other organs, stage 5 chronic kidney disease, grade 3 arterial hypertension, age <22 or >35 years, or refusal to participate were excluded.

The diagnosis of cervical insufficiency was based on clinical data and ultrasound criteria, including cervical length <25 mm before 24 weeks of gestation, funneling of the internal cervical os, and painless cervical dilation during the second trimester. Ultrasound examinations were performed using a Voluson E8 device (General Electric, USA).

The concentrations of TNF- α , IL-2, IL-4, IL-6, and IL-10 in cervical secretions were measured using the enzyme-linked immunosorbent assay (ELISA) method with commercial Human Cytokine ELISA Kits (manufacturer: BioVendor, Czech Republic), according to the manufacturer's instructions. The detection limits of the kits were as follows: TNF- α –5 pg/mL, IL-2–2 pg/mL, IL-4–1.5 pg/mL, IL-6–2 pg/mL, IL-10–3 pg/mL. The intra-assay coefficient of variation (CV) ranged from 5 % to 8 %, and the inter-assay CV ranged from 7 % to 10 %. Calibration was

performed using the standard concentration curves provided in the kits.

The primary outcome was pregnancy prolongation beyond 34 weeks. Secondary outcomes included the rate of full-term deliveries (≥ 37 weeks), gestational age at delivery, the rate of preterm deliveries (<34 weeks), postoperative complications, and perinatal outcomes (Apgar score <7 at 5 minutes, respiratory distress syndrome, need for continuous positive airway pressure or mechanical ventilation, and intracranial hemorrhage). Demographic characteristics, obstetric history, reproductive data, body mass index (BMI), history of systemic and infectious diseases, and previous cervical surgical procedures were recorded. The mode of delivery and neonatal outcomes were also documented.

Statistical analysis was performed using Statistica for Windows v6.1 (StatSoft Inc., USA). Continuous variables were expressed as mean $\pm$ standard deviation. Categorical variables were presented as absolute numbers and percentages. Group comparisons were conducted using the χ^2 test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Ethical considerations. The study was conducted in accordance with the Declaration of Helsinki (2013). The study protocol was approved by the local ethics committee of the Azerbaijan State Advanced Training Institute for Doctors named after A. Aliyev. All participants provided written informed consent.

Results of the study. A prospective clinical and laboratory evaluation was conducted in women at risk of second-trimester pregnancy loss, aimed at assessing their condition and identifying factors influencing the course of pregnancy (Fig. 1).

Analysis of gynecological morbidity revealed a higher prevalence of inflammatory diseases of the reproductive organs among patients in the study group compared to the control group. Among the identified pathologies, nonspecific colpitis was predominant, diagnosed in 45.6 % of women in the study group and 43.6 % in the control group, indicating a significant contribution of this condition to the overall structure of gynecological morbidity in the examined cohort.

In patients with a threat of pregnancy loss, pain in the lower abdomen and lumbar region was significantly more frequent in Group II (Fig. 2).

In Group I, mild pain was reported by 16 women (34.8 ± 7.0 %), and spasmodic pain by 7 patients (15.2 ± 5.3 %), while 23 participants (50.0 ± 7.3 %) reported no subjective complaints. In contrast, in Group II, symptoms were observed in almost all women: dragging pain in the lower abdomen and lumbar region was noted in 39 patients (70.9 ± 6.1 %), and spasmodic pain in 14 (25.5 ± 5.9 %; $p=0.0001$). According to the data obtained, cervical insufficiency developed in 27.5 ± 4.5 % of the participants, starting from the 18th week of gestation.

During the second trimester, the frequency of diagnosing threatened pregnancy loss and cervical insufficiency varied depending on gestational age. At 22–23 weeks, threatened pregnancy loss was observed in 27.3 ± 5.5 % of pregnant women, while CI

was detected in 34.3 ± 8.0 %. At 24–25 weeks, the corresponding rates were 31.8 ± 5.7 % and 40.0 ± 8.3 %, and at 26–28 weeks – 40.9 ± 6.0 % and 25.9 ± 7.4 %, respectively.

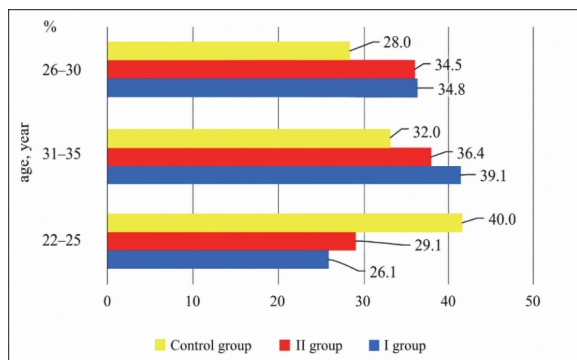


Fig. 1. Distribution of patients by age in the study and control groups.

Statistical analysis using the χ^2 test (1.28; 0.24; 0.78 at $p > 0.05$) revealed no significant differences between the compared values at any interval of the second trimester. These results indicate a comparable dynamic in the detection of threatened pregnancy loss and cervical insufficiency within the studied population.

Analysis of individual risk factors and their timely correction confirms the high clinical relevance of this study. In the first trimester, the most common complication in both women with a “true” threatened pregnancy loss and those with cervical insufficiency was threatened pregnancy loss, diagnosed in 34.8 ± 5.9 % and 28.6 ± 7.6 % of participants, respectively. The frequency of spotting was comparable between the two groups.

In the absence of clinical signs of bleeding, retrochorionic hematomas were detected in 24.2 ± 5.3 % of women in Group I and in 14.3 ± 6.0 % of women in Group II; no statistically significant differences were observed ($\chi^2 = 0.45$; $p > 0.05$). The presence of hematomas can be considered an additional risk factor for subsequent pregnancy loss in the second trimester.

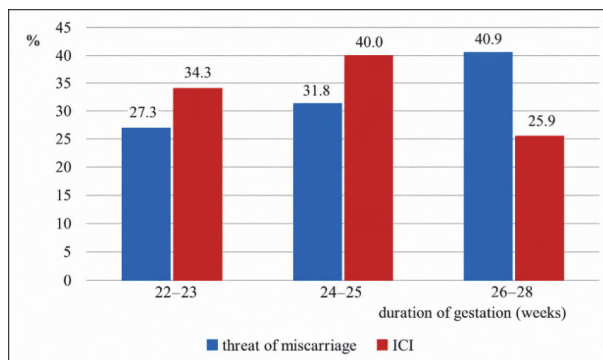


Fig. 2. Gestational age at the diagnosis of threatened pregnancy loss and cervical insufficiency in the second trimester.

Upon admission, patients with threatened pregnancy loss were characterized by increased uterine tone, which, according to external tocodynamometry, was observed in 36.4 ± 5.9 % of cases, in the absence of signs of regular contractile activity. Bloody discharge occurred with the same frequency in both groups, accounting for 50.0 % of cases. Thus, threatened miscarriage and retrochorionic hematomas were more frequent in Group I, whereas the frequencies of bloody discharge and increased uterine tone were identical in the two groups.

Analysis of the obtained data revealed pronounced intergroup differences during the first trimester. In the main group, concentrations of both pro-inflammatory and anti-inflammatory cytokines were more than twice as high as those in the control group.

Table 1 shows the concentrations of the main cytokines in cervical secretions of patients in the main and control groups during the first trimester of pregnancy. Women with cervical insufficiency exhibited a significant increase in all studied cytokine levels compared to the control group ($p < 0.05$).

Table 1

Cytokine concentrations in cervical secretions during the first trimester (pg/mL)

Cytokine	Control (n=25)	Main group (n=101)	p
TNF- α	15.8 ± 3.5	54.5 ± 5.4	< 0.05
IL-2	5.3 ± 2.3	24.0 ± 3.7	< 0.05
IL-4	2.6 ± 1.2	42.7 ± 5.4	< 0.05
IL-6	7.6 ± 2.7	57.2 ± 5.2	< 0.05
IL-10	23.7 ± 3.3	68.3 ± 6.6	< 0.05

The mean concentration of TNF- α in the main group was 54.5 ± 5.4 pg/mL versus 15.8 ± 3.5 pg/mL in the control group; IL-2– 24.0 ± 3.7 versus 5.3 ± 2.3 pg/mL; IL-4– 42.7 ± 5.4 versus 2.6 ± 1.2 pg/mL; IL-6– 57.2 ± 5.2 versus 7.6 ± 2.7 pg/mL; and IL-10– 68.3 ± 6.6 versus 23.7 ± 3.3 pg/mL.

These data indicate a pronounced activation of both proinflammatory and anti-inflammatory

components of the immune response in women with cervical insufficiency already at early stages of pregnancy. This emphasizes the potential of the local cytokine profile as an informative biomarker for the risk of adverse pregnancy outcomes and preterm birth. The dynamics of the local cytokine profile are presented in Table 2.

Table 2

Dynamics of the local cytokine profile in the main and control groups

Cytokine	Trimester	Main Group (n=101), pg/ml	Control Group (n=25), pg/ml	Intergroup Comparison (p)	Intragroup Comparison (p)
TNF- α	I	54.5 $\pm$ 5.4	15.8 $\pm$ 3.5	<0.001	—
	II	43.8 $\pm$ 5.6	12.4 $\pm$ 3.3	<0.001	I vs II: <0.05
	III	63.2 $\pm$ 7.5	16.4 $\pm$ 3.2	<0.001	I vs III: <0.05; II vs III: <0.05
IL-2	I	24.0 $\pm$ 3.7	5.3 $\pm$ 2.3	<0.001	—
	II	18.5 $\pm$ 3.2	5.2 $\pm$ 2.1	<0.001	I vs II: <0.05
	III	32.6 $\pm$ 4.2	4.1 $\pm$ 1.2	<0.001	I vs III: <0.05; II vs III: <0.05
IL-4	I	42.7 $\pm$ 5.4	2.6 $\pm$ 1.2	<0.001	—
	II	31.2 $\pm$ 4.3	3.2 $\pm$ 1.7	<0.001	I vs II: <0.05
	III	56.1 $\pm$ 5.6	4.5 $\pm$ 1.8	<0.001	I vs III: <0.05; II vs III: <0.05
IL-6	I	57.2 $\pm$ 5.2	7.6 $\pm$ 2.7	<0.001	—
	II	48.8 $\pm$ 5.3	3.5 $\pm$ 1.5	<0.001	I vs II: <0.05
	III	72.7 $\pm$ 6.8	6.8 $\pm$ 2.8	<0.001	I vs III: <0.05; II vs III: <0.05
IL-10	I	68.3 $\pm$ 6.6	23.7 $\pm$ 3.3	<0.001	—
	II	53.7 $\pm$ 5.2	19.5 $\pm$ 3.4	<0.001	I vs II: <0.05
	III	91.8 $\pm$ 6.5	29.6 $\pm$ 3.8	<0.001	I vs III: <0.05; II vs III: <0.05

Notes: Intergroup comparisons were performed using the independent samples t-test (or the Mann–Whitney U test if the normality assumption was not met); Intragroup comparisons (dynamics across trimesters) were conducted using repeated measures ANOVA with Bonferroni post-hoc correction for multiple comparisons; p-values <0.05 were considered statistically significant.

In all trimesters, the concentrations of TNF- α , IL-2, IL-4, IL-6, and IL-10 in the study group were significantly higher than those in the control group ($p < 0.001$). Intragroup dynamics showed a decrease in cytokine levels in the second trimester compared to the first trimester ($p < 0.05$), followed by an increase in the third trimester ($p < 0.05$). The most pronounced changes were observed for IL-6 and IL-10, reflecting the active involvement of these mediators in the regulation of inflammatory and immune processes throughout pregnancy. These findings confirm pronounced activation of the local immune response in women with cervical insufficiency and highlight the potential of the cytokine profile as a biomarker for predicting adverse pregnancy outcomes.

To assess the clinical significance of the identified immunological features, we analyzed pregnancy outcomes in the study cohort, including the frequency of preterm births and pregnancy prolongation. As shown in Table 3, the proportion of full-term deliveries (≥ 37 weeks) was higher in the control group compared to the study group (92 % vs. 78 %), whereas deliveries at 34–36 weeks and <34 weeks occurred predominantly in the study group (15 % and 7 %, respectively).

Pregnancy outcomes were as follows: delivery at ≥ 37 weeks occurred in 23/25 controls (92 %) and 79/101 women in the main group (78 %; $p = 0.312$); delivery at 34–36 weeks occurred in 2/25 controls (8 %) and 15/101 women in the main group (15 %; $p = 0.312$); delivery before 34 weeks occurred in 0/25 controls (0 %) and 7/101 women in the main group (7 %; $p = 0.180$).

Comparison between groups was performed using the χ^2 test ($\chi^2 = 1.021$ for 34–36 and ≥ 37 weeks; $\chi^2 = 1.79$ for <34 weeks; $df = 1$). Differences were not statistically significant ($p > 0.05$).

Despite these differences, statistical analysis using the χ^2 test did not reveal significant differences between the groups ($p > 0.05$), indicating a similar frequency of preterm births, although women with cervical insufficiency showed a tendency toward earlier onset of labor.

Discussion. Preterm birth and pregnancy loss remain among the most challenging problems in obstetrics and perinatology. Cervical insufficiency occupies an important place among the mechanisms contributing to second-trimester pregnancy loss and spontaneous preterm delivery, while contemporary research increasingly focuses on combining cervical characteristics with inflammatory and biochemical markers to improve risk prediction [3, 7, 14, 15].

Current literature emphasizes the significant role of infectious and inflammatory factors in the pathogenesis of preterm labor; the frequency of amniotic fluid infection, according to various studies, ranges from 25 to 80 %, highlighting the importance of the inflammatory component in the mechanisms of gestational complications [2, 9, 10].

The results obtained in the present study confirm that cervical insufficiency is accompanied by pronounced activation of the local immune response already at early stages of gestation. This observation is consistent with current evidence demonstrating an association between inflammatory activation of the cervicovaginal compartment and spontaneous preterm birth. Amabebe et al. (2024) demonstrated associations between pro-inflammatory

cervicovaginal cytokines, cervical extracellular matrix proteins, and spontaneous preterm delivery [1]. Similarly, Gentile et al. (2021), in a systematic review, emphasized the potential role of inflammatory markers in cervical secretions in predicting spontaneous preterm birth [4]. Herren et al. (2023) also investigated cervicovaginal cytokines as predictors of preterm birth in a prospective cohort, supporting the clinical relevance of assessment of the local inflammatory environment [5].

The marked elevation of pro-inflammatory cytokines, particularly tumor necrosis factor alpha, IL-2, and IL-6, observed in our study is biologically consistent with the concept of inflammation-mediated cervical remodeling. Menon et al. (2020) described cervical remodeling as a complex process involving immune mediators and structural alterations of cervical tissue in the pathogenesis of spontaneous preterm birth [9]. These mechanisms may contribute to changes in the extracellular matrix and progressive reduction in cervical mechanical resistance. The findings of Amabebe et al. (2024), demonstrating relationships between pro-inflammatory cervicovaginal cytokines and cervical extracellular matrix proteins, further support this interpretation [1].

Of particular interest in our study is the simultaneous elevation of the anti-inflammatory cytokines IL-4 and IL-10. Such changes may reflect a compensatory immunoregulatory response developing in parallel with pro-inflammatory activation. The coexistence of inflammatory and regulatory immune pathways indicates that cervical insufficiency cannot be regarded as the consequence of a single inflammatory mediator but is more likely associated with complex dysregulation of the local immune environment. Essilfie Opoku and Anumba (2022) similarly emphasized the multifactorial nature of biomarker changes associated with preterm birth and highlighted the interaction between cervicovaginal cytokines, the microbiome, and proteomic markers [3].

The decrease in the concentrations of most cytokines during the second trimester followed by their subsequent increase in the third trimester demonstrates the dynamic nature of the local immune response. At the same time, the interpretation of cytokine changes as independent predictors requires caution. Hornaday et al. (2024) reported that maternal cytokine profiles measured during the second and early third trimesters were not independently predictive of preterm birth [6]. This apparent discrepancy may be related to differences in the biological material examined, study populations, gestational age at sampling, and combinations of biomarkers evaluated. Importantly, our study focused on cytokines in cervical secretions, which may more directly reflect local processes occurring within the cervical microenvironment.

The clinical relevance of combining local biomarkers with cervical characteristics is also supported by recent studies. Ohori et al. (2024) demonstrated the potential usefulness of combining

cervicovaginal fluid cytokines with fetal fibronectin for predicting imminent preterm birth in asymptomatic women with a short cervix [11]. Yoo et al. (2017) likewise investigated non-invasive cervicovaginal biomarkers in women with cervical insufficiency or an asymptomatic short cervix and demonstrated their potential value for prediction of preterm birth [15]. These observations suggest that cytokine measurements may be most informative when interpreted together with clinical and ultrasonographic parameters rather than as isolated laboratory indicators.

Cervical length remains one of the most clinically established parameters for preterm birth risk assessment. Souka et al. (2024) demonstrated the importance of cervical length dynamic intervals during pregnancy for predicting preterm delivery, while Huang et al. (2024) incorporated mid-trimester short cervical length into a prediction model for spontaneous preterm birth before 32 weeks [7, 12]. More recently, multivariable approaches incorporating heterogeneous clinical data have also been investigated. Xiong et al. (2025) developed a machine-learning prediction algorithm using multi-source data, whereas the systematic review by Yan et al. (2023) demonstrated the growing number and diversity of prediction models for spontaneous preterm birth in asymptomatic women with risk factors [13, 14].

In the present study, full-term delivery was more frequent in the control group, whereas deliveries at 34–36 weeks and before 34 weeks occurred more frequently in women with cervical insufficiency. Although these differences did not reach statistical significance, the observed tendency toward earlier delivery is clinically relevant and is consistent with the established relationship between cervical insufficiency, cervical shortening, and spontaneous preterm birth [7, 10–12, 15]. The absence of statistical significance may, at least partly, be related to the relatively small control group and the distribution of pregnancy outcomes within the cohort.

Taken together, our findings indicate that the observed cytokine imbalance may represent a component of the inflammatory pathway associated with cervical remodeling and adverse pregnancy outcomes. However, the available literature suggests that no single cytokine is likely to provide sufficient prognostic accuracy when used in isolation [3, 4, 6]. Therefore, the greatest clinical potential may lie in an integrated approach combining the local cytokine profile with cervical length, obstetric history, fetal fibronectin, microbiological characteristics, and other clinical predictors [11, 13–15]. Such an approach may improve early identification of women at increased risk of spontaneous preterm birth and provide a basis for more individualized surveillance and preventive strategies.

Limitations. The study has several limitations. The control group was relatively small ($n=25$), and the single-center design reduces the generalizability of the results to other populations. The prospective observational design allows identification of

associations but does not establish causal relationships. Certain risk factors, such as endocrine disorders, lifestyle, and genetic predisposition, were not considered. Laboratory data were limited to the

local cytokine profile in cervical secretions, without assessment of systemic immune status. These limitations should be taken into account when interpreting the results and planning future research.

Conclusions

1. In women with cervical insufficiency, pronounced activation of the local immune response is observed in early pregnancy, manifested by a significant increase in the concentrations of both pro-inflammatory (TNF- α , IL-2, IL-6) and anti-inflammatory (IL-4, IL-10) cytokines in cervical secretions compared to the control group. The dynamics of cytokine levels throughout pregnancy indicate temporal fluctuations in the immune response, with a decrease in the second trimester followed by an increase in the third trimester.

2. Analysis of clinical pregnancy outcomes revealed a trend toward an increased frequency of preterm birth in women with cervical insufficiency: the proportion of deliveries ≥ 37 weeks was lower, while deliveries at 34–36 weeks and < 34 weeks were higher compared to the control group. No statistically significant differences were found between the groups ($p > 0.05$), indicating the need for further monitoring and consideration of individual risk factors.

3. The presence of inflammatory diseases of the reproductive organs, retrochorionic hematomas, and increased uterine tone in the first trimester should be considered additional risk factors for adverse pregnancy outcomes and the development of cervical insufficiency.

4. The obtained results confirm that the local cytokine profile in cervical secretions can serve as an informative biomarker for predicting pregnancy outcomes and for the timely identification of women at high risk of preterm birth.

5. A comprehensive assessment of the immune and clinical status of patients allows for the identification of high-risk groups and provides a basis for the development of preventive and therapeutic strategies aimed at prolonging pregnancy and reducing the incidence of preterm birth.

Prospects for further research. Future multicenter studies with larger cohorts should validate the prognostic accuracy of cervical cytokine profiles and determine clinically useful threshold values for predicting preterm birth.

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