The structure of immunocompetent decidual cells in recurrent missed abortions

Struktura imunokompetentnih čeliija decidue kod ponavljanih spontanih pobačaja

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Abstract

Background/Aim. Recurrent or habitual missed abortions (RMA) are defined as three or more consecutive abortions. In the first trimester of pregnancy habitual missed abortions occur in about 1% of population. The aim of this immuno-histochemical study of decidua of unknown etiology was to identify subpopulations of decidual lymphocytes in recurrent miscarriages and compare the distribution of immunocompetent cells in artificial abortions and RMA. Methods. The study included 30 women with at least 2 consecutive miscarriages in the first trimester of pregnancy. Curettements of the third missed abortion were immunohistochemically analyzed. The control group consisted of 20 women without loaded reproductive anamnesis, with the abortion for social reasons. Criteria for exclusion from the study were diagnosed uterine anomalies, positive screening for thrombophilia and for social reasons. Criteria for exclusion from the study were diagnosed uterine anomalies, positive screening for thrombophilia and disorders in the function of the thyroid gland. Immunophenotyping was performed by immuno-alkaline phosphatase (APAAP) using monoclonal antibodies: CD 30, CD 45 RO, CD 56 and CD 57, CD 68. Results. The number of missed abortions (1,223) was on the average 9.7% of all deliveries during the test period. Among them RMA were registered in 52 (4.2%) patients and in 30 (57%) the exact etiology of abortions was not determined. RMA were most common in the 25–34 years of age group. The largest number of RMA showed the ultrasound characteristics of missed abortion in 60% of cases and was in nulliparous patients (76.7%). The number of natural killer (NK) CD56 positive cells did not differ significantly between the types of abortion. In the decidual tissue, a number of NK CD57 positive cells was significantly higher in missed abortions compared to artificial interruptions (p < 0.01). In artificial termination of pregnancy there was an absolute predominance of CD45RO lymphocyte subpopulations, whereas in the RMA group there was slightly greater predominance of CD30 positive cells. The completed analysis showed a significantly higher number of CD68 positive macrophages in a decidual tissue of RMA pregnancy (p < 0.01). Conclusion. The number and phenotypic structure of NK cells are significantly different in normal pregnancy decidua and in RMA. The NK cell dominance is present in the RMA group, in favor of natural macrophages in the decidual tissue of RMA pregnancy (< 0.01). Abortion, habitual; immunohistochemistry; uterus; killer cells, natural; abortion, missed; decidua.

Key words:
abortion, habitual; immunohistochemistry; uterus; killer cells, natural; abortion, missed; decidua.

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In introduction, recurrent or habitual missed abortions (RMA) are defined as three or more consecutive abortions. The causes of recurrent missed abortions are multifactorial, but may be divided into: embryonic, mainly due to pathological embryonic karyotype, and maternal affecting the endometrium and placenta.

Known maternal causes are anatomic, endocrine and immunological — auto- and allo-immune. Recent works talk about sperm quality as another factor that influences the frequent occurrence of abortion.

Despite knowing all the above mentioned etiological factors of recurrent spontaneous abortions, 50% of them were classified as recurrent spontaneous abortions of unknown etiology. It is believed that the largest number of them is the consequence of inadequate allogeneic response of a mother to pregnancy. Period from luteinising hormone (LH) jump to implantation to menstruation is critical for the transformation of the endometrium in terms of supporting implantation or the occurrence of menstruation. Endocrinological and the immunological systems are in a close interaction during the implantation and the maintenance of pregnancy. This communication is most striking on the endometrium of decidual pregnancy. Decidua makes a smaller part of the placenta and the only one that is of exclusively maternal origin. For this reason it does not show antigenic potential, but it is the place of significant process of establishment and maintaining gravid immunoregulation toward the fetal part of the placenta considering that it is a place of direct maternal fetal confrontion. It can be said that decidua is the place of selection, proliferation and maturation of unique population of uterine natural killer (NK) cells in pregnancy.

Apoposis important for the selection and favorising certain populations of immunocompetent cells also occurs in the decidua. Reorganization of decidual immunocompetent cells provides its immunosuppressive effect by regulating the activity of NK cells, which themselves undergo subpopulation recomposition under the influence of hormones and cytokines. Decidual cell populations are most important in the implantation NK cells, macrophages, dendritic cells (DCS) and T cells. B cells and neutrophils are insignificant in decidualization and implantation. Decidual composition of immunocompetent cells effectively establishes and maintains gravidity immunomodulation and probably control and guidance of placental growth. If fertilization and then implantation occurs on the day 20–24 of the cycle, granular NK cells rapidly proliferate and become dominant populations of lymphoid cells achieving close contact with invading trophoblast.

The tissue-specific differentiation of uNK cells is related to their function and may be a critical determinant for decidualisation or desquamation of the endometrium. Despite the changes in the number of these cells, a fundamental change is subpopulation precomposition. A dominant subpopulation of NK cells of peripheral blood is CD56 dim, CD16+ and they constitute the basic population of uNK cells of the proliferative phase of the cycle. uNK cells have high-level of CD56 expression, so they belong to the CD68 bright subpopulation. In addition to CD56 bright, uNK cells also express killer activating and inhibitory receptors but do not express any other typical NK cell markers, such as CD16 or CD57. In pregnancy, progesterone causes the reduction in the number of NK cells, activity and cytotoxicity through direct influence on NK cells or promoting TH2 cytokine activities, progesterone-induced blocking factor (PIBF) production in T lymphocytes. Also, progesterone facilitates the re-grouping of peripheral NK (pNK) cells in the endometrium by expression of receptors that induce vascular endothelial growth factor (VEGF) and macrophage inflammatory protein (MIP1β) in the endometrium. Endometrial stromal cells under the influence of progesterone produce IL15, prolactin and other factors that regulate uNK in their proliferation, differentiation and production of cytokines and other molecules that support placental trophoblastic development and promote local immunomodulation.

It was long thought that T lymphocytes affect decidualisation and implantation exclusively through the TH1/TH2 balance, i.e. favourisation of TH2 cytokine immune response. Pregnancy is considered a TH2 cytokine-mediated event. TH1 cytokines have been associated with miscarriage and infertility. These effects of TH1 cytokines in experiments were blocked by injection of TH2 cytokines IL-10. The conclusions of these experiments with mice were expanded to human population. But the discovery of regulatory T lymphocytes with detailed elaboration of cytokine profiling of T cell subgroups showed that the...
explanation is not so simple. It is evident that the TH1/TH2 hypothesis is not sufficient to explain the immune mechanisms during implantation. In human reproduction, TH1 cytokine activity is needed at several stages of pregnancy, especially during the early implantation period. During this period, the cytokines IL1 and tumor necrosis factor alfa (TNFα) make pregnancy possible by stimulating the production of leukemia inhibitory factor (LIF) and increasing angiogenesis. It is also interesting that TH1 environment stimulates the production of TH2 cytokine. T regulatory (Tregs) cells are specific for Foxp3 marker required for their function, and in the experiments it was significantly lower in infertile women. This supports the importance and fundamental role of Tregs in the cell population in implantation. Macrophages also play a role in implantation and decidualization. Macrophages in the endometrium in proliferative and secretory stage are fairly constant, but the number significantly increased in the decidua of early pregnancy. Their concentration is about 45% higher in the preimplantation region of decidua which is largely achieved through redistribution of these cells from other decidual regions. Chemotaxis of macrophages and their accumulation at the site of implantation are favored by primarily trophoblast proinflammatory factors at the site of the endometrial erosion, increased levels of steroid hormones and increased concentrations of cytokines stimulated by steroid hormones. Cytokine production of macrophages may help prepare the endometrium for pregnancy, cleaning apoptotic material of trophoblast cells which is very important because it prevents their presentation of immunocompetent cells and initiation of immune responses. Macrophages are likely to mediate the range of trophoblast invasion through TNFα and participate in the level of inflammatory reaction necessary in the early stages of pregnancy.

A number of systems are involved in creating a favorable environment for the acceptance of allogeneic blastocysts. The three most important ones involved in it are immune cells, cytokines and adhesion molecules in the place of decidua blastocyst contact.

The aim of this study was to identify subpopulations of decidual lymphocytes of recurrent spontaneous abortions by immuno-histochemical study of decidua in recurrent spontaneous abortions of unknown etiology and to compare the distribution of immunocompetent decidual cells in artificial abortion with those in recurrent spontaneous abortions.

**Methods**

The study included 30 women who had a history of 2 consecutive miscarriages in the first trimester of pregnancy, while the third miscarriage curettment was histopathologically immuno-histochemically analyzed with paraffin preparations. The control group consisted of 20 women without loaded reproductive anamnesis, where the abortion was done for social reasons. Criteria for exclusion from the study were diagnosed uterine anomalies, positive screening for thrombophilia and women who suffer from diabetes mellitus and disorders in the function of the thyroid gland.

Curettings were fixed in 10% formalin during 24 hours, and thereafter moulded in paraffin. Paraffin 5-micron sections were dyed using the hematoxylin-eosin method. Immunophenotyping was performed using immuno-alkaline phosphatase as a method (APAAP) with the following monoclonal antibodies (DAKO): CD30 (marker for activated cells); CD45 RO (marker for T lymphocytes); CD56 and CD57 (markers for NK cells); CD68 (marker for macrophages).

Visualization of the reaction products was performed using the new foshchina which resulted in red deposits in the places of positive reaction. The average number was determined at 10 high-power fields (hpf).

The results were statistically analyzed by forming a database. Statistical significance was tested by commercial software using appropriate tests-Student’s t-test and t-test with corrective approximate method by Cohen and Cox for small samples when necessary. The 5% level was taken as a borderline level of statistical significance.

**Results**

The number of missed abortions during the test period was 1,223. The percentage of missed abortions per year is shown in Table 1.

Out of 1,223 abortions during the test period, RMA was registered in 52 (4.2%) patients. Of that number, in 30 (57%) patients with RMA the exact etiology of abortion was not determined.

| Year      | Deliveries, n | Miscarriages, n (%) |
|-----------|---------------|---------------------|
| 2010      | 3,189         | 301 (9.7)           |
| 2011      | 3,167         | 305 (9.6)           |
| 2012      | 3,133         | 304 (9.7)           |
| 2013      | 3,109         | 313 (10.1)          |
| Total     | 12,598        | 1,223 (9.7)         |

Ultrasound features of RMA of unknown etiology are shown in Table 2.

| Ultrasonic (US) characteristics of recurrent or habitual missed abortions |
|-----------------------------|----------|--------|
| US finding                  | n        | %      |
| Missed abortion             | 18       | 60     |
| Abortion spontaneous incipiens | 6       | 20     |
| Blighted ovulum             | 6        | 20     |
| Total                       | 30       | 100    |

The largest number of RMA showed the ultrasound characteristics of missed abortions (in 60% of cases).

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Frequency distribution of RMA by age groups is shown in Table 3. 
RMA is most common in the 25–34 years of age group. Parity in patients with RMA is shown in Table 4. The largest number of RMA was in nulliparous patients (76.7%). Immunohistochemical studies of decidua in artificial abortions and recurrent miscarriages (the presence of cell subpopulations of NK lymphocytes) are given in Table 5.

### Table 3

| Age (years) | n  | %   |
|-------------|----|-----|
| 25–29       | 10 | 33.3|
| 30–34       | 11 | 36.7|
| 35–39       | 7  | 23.3|
| > 40        | 2  | 6.7 |
| Total       | 30 | 100.0|

### Table 4

| Previous deliveries | n  | %   |
|---------------------|----|-----|
| 0                   | 23 | 76.7|
| 1                   | 6  | 20.0|
| 2                   | 1  | 3.3 |

### Table 5

| Type of abortion | NK CD56 (\(\bar{x}\) ± SD) | NK CD57 (\(\bar{x}\) ± SD) |
|------------------|-----------------------------|-----------------------------|
| Spontaneous      | 85.03 ± 23.3                | 95.3 ± 26.1**               |
| Artificial       | 77.6 ± 13.27                | 15.2 ± 2.6                 |

**p < 0.01.

The number of NK CD56 positive cells did not differ significantly depending on the types of abortion (Table 5). In the decidual tissue, the number of NK CD57 positive cells was significantly higher in missed abortions compared to artificial interruptions (\(p < 0.01\)).

The average number of certain subpopulations of T lymphocytes in the decidual tissue (determined at 10 hpf) in RMA and artificial abortions is shown in Figure 1.

In artificial termination of pregnancy there was an absolute predominance of CD45RO lymphocyte subpopulations, whereas in the RMA group there was slightly greater predominance of CD30 positive cells (Figure 1).

The number of CD68 positive macrophages in decidual tissue in RMA and artificial abortions is shown in Figure 2.

The completed analysis showed a significantly higher number of CD68 positive macrophages in a decidual tissue of RMA pregnancy (\(p < 0.01\)).

Frequency percentage of leukocyte subpopulations in decidual tissue in RMA and the control group of artificial abortions is given in Figure 3.
Discussion

Stroma of the gravid endometrium, decidua, is an immunologically privileged position of the reproductive system of a woman with a dominant population of NK cells. Cell microenvironment, the environment in early pregnancy decidua of normal or completed by miscarriage is very important, especially in terms of intercellular contact and the success of establishing immune tolerance.

According to our results the total number of leukocytes in the decidua is 30% in artificial termination of pregnancy compared to 35% in RMA, which is a statistically significant difference. In addition to the increasing number of leukocytes, the most important results of our study show a significant difference in terms of subpopulation regrouping immunocompetent cells in the decidua of these two groups of patients. The total number of NK cells in the group of recurrent missed abortions comparing to artificial is significantly higher. If we look at the phenotypic structure in NK cells, our results show a significantly higher number of CD 56+ and CD 57+ of NK cells in the RMA group.

Our results show that CD 57 populations of NK cells occur in RMA decidua which is otherwise characteristic phenotype of NK cells of the peripheral circulation. We can say that a lot is known about the immunocellular population of decidua in normal pregnancy, but still not enough about the differences of the same population in RMA. There are several studies with the results similar to the results of this study in relation to the significant increase in the number of CD 57 cells in the decidua of pregnancies ended in miscarriage. The possible mechanism of increasing the number of CD57 NK cells in the endometrium of RMA would be the activating of cytokines attacking trophoblast. In a study from 2006, Ordi et al. investigated the presence of different subpopulations of immune cells in the decidua and endometrium in four groups of women: (I) women treated with progesterone disregarding pregnancy; (II) in extraterine pregnancy; (III) in intrauterine pregnancy of women with RMA; (IV) the group of women with RMA. Most of these studies speak in favor of the increasing number of leukocytes, the most important results of our study show a significant difference in terms of the number and phenotypic features of decidual NK cells. Shimada et al. in the 2004 study, using flow cytometry, reported no difference in the percentage of CD 56+ and CD 56, CD16+ compared to CD 56+, CD16 NK cells. Furthermore, 13. Michimata et al. in 2002, immuno-histochemically found no difference in the number of CD16+ compared to CD 56+ NK cells. There are two studies which show different results in terms of the number and phenotypic features of decidual NK cells. However, 13. Michimata et al. immuno-histochemically found no difference in the number of CD16+ compared to CD 56+ NK cells.

Our study included examination of the frequency of CD 30 and CD 45 RO T lymphocyte subpopulations in the group of intentional abortions for social reasons and in the group of habitual miscarriages. In artificial abortions we found a significantly higher number of CD45 RO T lymphocytes, and CD 30 in RMA. Studies that researched the distribution of CD45 RO T lymphocytes report that decidual lymphocytes are expressed in 90% of CD 45 antigen RO cases.

As far as the literature data on decidual CD 30 T lymphocytes are concerned, they show their increase in secretory stage of the cycle and possible hormonal influence on them. In the case of T lymphocyte activation, immune response that leads to the loss of pregnancy is taking place in lymphoid aggregates in the vicinity of endometrial glands, where decidual T lymphocytes are grouped. Our results show a slightly higher presence of macrophages in RMA decidua. The number of endometrial macrophages is partly under control of ovarian steroids and they possess estrogen and progesterone receptors. They are also the main cells that, beside trophoblasts, synthesize prostaglandins, whose immunosuppressive role in pregnancy is known. Macrophages are the most numerous at the site of implantation, and there are 45% of them more than in other parts of decidua.

In addition, they play an important role in the maintenance of pro- and anti-inflammatory cytokine balance. They are also essential in the response to infective agents and in the removal of apoptotic material. A slightly higher percentage of macrophages in RMA in our sample would indicate the presence of infection in a number of RMA. The normal phenotype of uNK cells with receptor system on their surface and cytokyne production encourage the development of pregnancy by adequate angiogenesis and anti-inflammatory reaction of the decidua. This role of uNK cell phenotype CD56brightCD16- is disrupted by their lack of or exposure to inflammatory agents (viruses and bacteria). Their insufficiency recruit T cytotoxic lymphocyte subpopulations with the beginning of inflammatory pathogenesis. Also, exposure to inflammatory agents causes the conversion of cytokine NK cell production with dominant TNF-α. In such environment there is a loss of immunotolerance with inadequate angiogenesis resulting in pregnancy loss.
Conclusion

The number and phenotypic structure of uterine NK cells is significantly different in normal pregnancy decidua and in that of RMA. Our results demonstrate NK cell dominance in the RMA group, with phenotypic structure in favor of CD56+ and CD57 subpopulations. Also, the prevalence of CD30 subpopulation of T lymphocyte is significantly higher in the RMA group. Macrophages are more numerous in the decidua of pregnancies ended in missed abortion, so that the cause of RMA of unknown etiology in a number of cases could be dysregulation of immunocompetent cells.

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