MECHANISMS OF FORMATION AND CLASSIFICATION OF SECONDARY IMMUNODEFICIENCY STATES IN UVEITIS

Panchenko M.V., Bezditko P.A., Honchar O.M., Duras I.G., Panchenko H.Y., Boieva Y.Y., Ivzhenko L.I., Kitchenko I.V.

Kharkiv National Medical University, Kharkiv, Ukraine

https://doi.org/10.35339/ic.10.2.pbh

ABSTRACT

Background. The role of immunological disorders in the pathogenesis of uveitis has been proven by numerous studies. However, there are different views on the timing and methods of immunocorrection. In our opinion, this issue should be solved on the basis of determining the mechanisms of the formation of immunodeficiency states in uveitis.

The purpose of this work was to develop a classification of secondary immunodeficiency states in uveitis according to the mechanism of formation.

Materials and Methods. The paper presents the results of the examination of 370 patients with uveitis (416 eyes; 179 were men, 191 were women, aged from 16 to 87 years; the duration of the disease ranged from 1 month to 32 years) who were treated in Kharkiv Regional Clinical Hospital, were under dispensary supervision at Kharkiv Regional Anti-Tuberculosis Dispensary and Kharkiv Regional Dispensary for Radiation Protection of the Population, or were examined, consulted and treated on an outpatient basis. The observation period was up to five years.

Results. Based on the study of immunological changes in patients with uveitis, the dynamics of immunological disorders in relapses of the inflammatory process in the uveal tract, clinical and immunological features of various forms of uveitis, and the results of correction of immunological disorders in patients with uveitis, a classification of secondary immunodeficiency states in uveitis according to the mechanism of their formation was proposed. On its basis, the principles of correction of immunodeficiency states in patients with uveitis were developed.

Keywords: *infectious uveitis, noninfectious uveitis, cellular immunity, humoral immunity, correction principles, immunological disorders.*

Introduction

The role of immunological disorders in the pathogenesis of uveitis has been proven by numerous studies [1–9].

However, there are different views on their correction, which has become an integral part of treatment in uveitis [10–16]. The timing and tactics of immunocorrection in uveitis, which some researchers recommend using in the remission stage, need to be clarified [14]. Meanwhile, there is convincing evidence of the high efficacy of immunocorrective therapy in the active stage of the disease [11; 12; 15; 17; 18].

Corresponding Author:
Panchenko Mykola Volodymyrovych – MD, Professor, DMedSc; Professor at the Department of Ophthalmology, Kharkiv National Medical University.
Address: Ukraine, 61204, Kharkiv, Peremohy Avenue, bldg. 70, apt. 161.
E-mail: panchenko0802@gmail.com

In our opinion, this issue should be resolved on the basis of determining the mechanisms of the formation of immunodeficiency states in uveitis.

The Purpose of this work was to develop a classification of secondary immunodeficiency states in uveitis according to the mechanism of formation.

Materials and Methods

The paper presents the results of the examination of 370 patients (416 eyes) with uveitis who were treated in Kharkiv Regional Clinical Hospital, were under dispensary supervision at Kharkiv Regional Anti-Tuberculosis Dispensary and Kharkiv Regional Specialized Dispensary for Radiation Protection of the Population, or were examined, consulted and treated on an outpatient basis. Among these patients, there were 179 were men, 191 were women (aged 16–87 years). The duration of the disease ranged from 1 month to 32 years. The observation period made up to five years.

To study the role of immunosuppression in formation of complicated forms of uveitis, we investigated the features of the clinical picture, course, and immunological disorders in 36 patients (45 eyes) with uveitis who were exposed to increased levels of radiation as a result of Chornobyl nuclear power plant accident (as an example of exogenous immunodepression), and in 39 patients (60 eyes) with uveitis of tuberculous etiology and pulmonary tuberculosis (as an example of endogenous immunodepression). 46 of them were men, 29 were women; ages from 26 to 87 years.

Statistical processing of the obtained results was carried out using a package of application programs (STATISTICA 9.0, USA). Informed consent to participate in the study was obtained from all patients.

Results and Discussion

The analysis of the mechanisms of the formation of immunodeficiency states in patients with uveitis showed that depression of the immune system can be caused by various factors.

Thus, the presence of immunodeficiency in patients with uveitis can be caused by adverse environmental factors, the most important of which is the increased level of radiation pollution [19–21].

Our studies have shown that exogenous immunodepression (in particular, due to exposure to high levels of radiation pollution) plays an integral role in the onset and development of complicated forms of uveitis. Thus, uveitis against a background of exogenous immunodepression (due to Chornobyl accident) in the patients we examined more often was complicated by uveal cataract (by 18.4%) and macular edema (by 14.9%) compared to patients who were not exposed to elevated levels of radiation.

Inflammatory diseases of the uveal tract often occur against a background of chronic inflammatory diseases of other organs and systems, the presence of which also causes immunodeficiency syndrome, which exists even before the onset of uveitis [22–25].

We have found that endogenous immunodepression plays an important role in formation of complicated forms of uveitis, in particular, in patients with uveitis of tuberculosis etiology (pulmonary tuberculosis). Thus, uveitis occurring against a background of endogenous immunodepression (tuberculosis etiology on the background of pulmonary tuberculosis) is more often complicated by uveal cataract (by 42.4%) and uveal glaucoma (by 10.9%) compared to uveitis in patients without chronic inflammatory diseases.

Thus, immunodeficiency states in the body can occur as a result of external and internal factors that are not related to uveitis. In our opinion, immunodeficiency states that are formed in the body before the onset of uveitis (conditionally "primary") can be considered one of the etiopathogenetic factors of its development.

According to many authors, infection plays the role of a triggering factor in the pathogenesis of uveitis, and the further course of the disease is determined by immunological and autoallergic mechanisms formed as a result of uveitis [3; 26; 27]. Immunodeficiency states arising from the inflammatory process in the ocular vascular tract have their own characteristics.

The first attack of uveitis in such patients occurs and sometimes progresses against a background of normal immune system parameters or transient adaptive immunological changes. However, the inflammatory process in the vascular membrane induces a functional depression of immunity with formation of suppressor factors in the inflammatory focus, a decrease in natural killer activity [28], and the activity of antibody-dependent killer cells.

The recurrence of the inflammatory process (which is common in [31.0–68.5]% of uveitis cases [29; 30]) leads to more severe disorders in the immune system with the gradual formation of suppressor immunodeficiency and the occurrence of more severe lesions [31] and complications. As a typical example of the occurrence of immunodeficiency syndrome due to uveitis, we present the results of observation and immunological examination of patient O., who was treated in the ophthalmology department of Kharkiv Regional Clinical Hospital for left eye iritis, which proceeded without complications against a background of normal immune status (*Fig. 1, 2*).

Two months later, patient O. came to the ophthalmology department of Kharkiv Regional Clinical Hospital with recurrent iridocyclitis complicated by macular edema with cellular immunity indices at the lower limits of normal. The second relapse of uveitis in patient O. occurred against a background of a significant decrease in the total number of T lymphocytes and T helper cells with an increase in the content of T suppressors and a decrease in the immunoregulatory index. During the third exacerbation of uveitis complicated by macular edema (a year after the "first attack" of uveitis), patient O. developed cellular immunodeficiency of the suppressor type. Thus, immunodeficiency conditions in the body can occur as

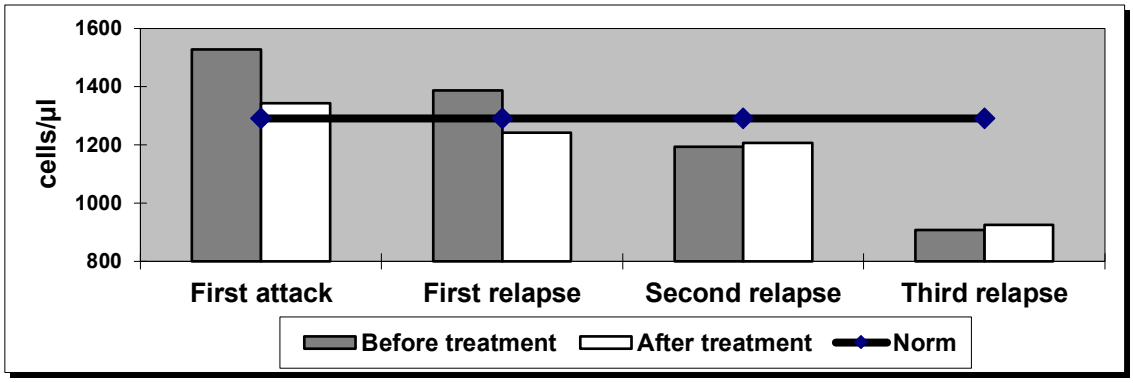

Fig. 1. Dynamics of the total number of T-lymphocytes in patient O.

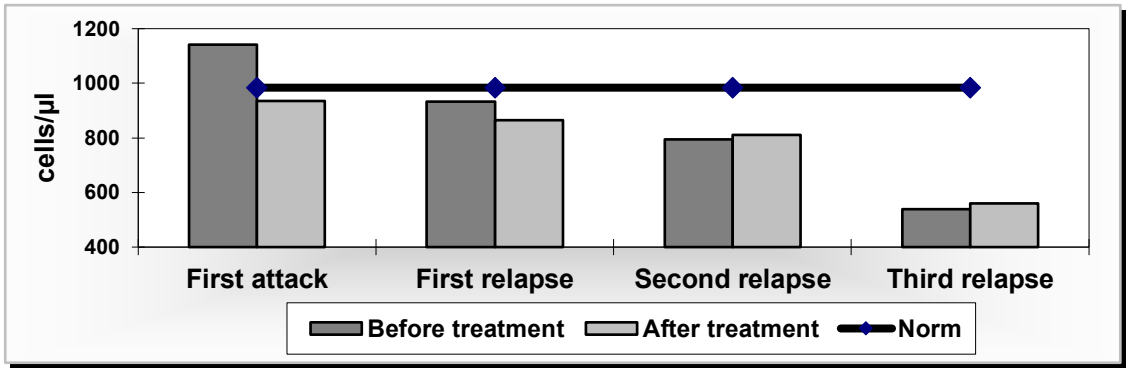

Fig. 2. Dynamics of the number of T-helper cells in patient O.

a result of uveitis. Several factors contribute to the possibility and presence of immunodeficiency states that form simultaneously with uveitis but are not a consequence of the inflammatory process in the choroid. First, immunodeficiency can be caused by infections that cause uveitis. Thus, according to the literature, retroviruses (including HIV-I and HTLV-I viruses), which are one of the most common causes of uveitis [32; 33], can play a key role in the occurrence of autoimmune reactions [34; 35].

Researchers have shown that complicated uveitis in HTLV-I infection is caused by immune-driven mechanisms, and further in the pathogenesis of uveitis infectious and autoimmune mechanisms are intertwined [34].

Second, immunodeficiency in uveitis can be formed as a result of a genetically determined inadequate response of the immune system to the inflammatory process. This position is supported by data about the role of immunogenetic factors in the pathogenesis of endogenous uveitis. Thus, it has been established that the immune response genes are linked to the major histocompatibility complex, and their functions are directly related to the regulation of cellular interactions by the HLA histocompatibility system [36; 37], and the occurrence of autoimmune reactions is controlled, at least in part, by the genes of the major histocompatibility complex [38]. It has been shown that the presence of certain HLA antigens in patients with uveitis determines the peculiarities of the immune system and some clinical characteristics of uveitis [39]. An example of immunodeficiency that developed simultaneously with uveitis can be seen in the case report of patient S. with central chorioretinitis of the right eye of cytomegalovirus etiology, complicated by ophthalmic hypertension. Despite the therapy, the number of T lymphocytes, T helper cells, and immunoregulatory index decreased, and the deterioration of these parameters continued over the next 3 months (*Fig. 3, 4*).

A month after the discharge from the hospital, patient S. developed secondary immunodeficientcy syndrome, and a significant improvement in immunological parameters was achieved only one year later (in the absence of exacerbations of the inflammatory process in the uveal tract).

Thus, immunodeficiency states in the body can form simultaneously with uveitis.

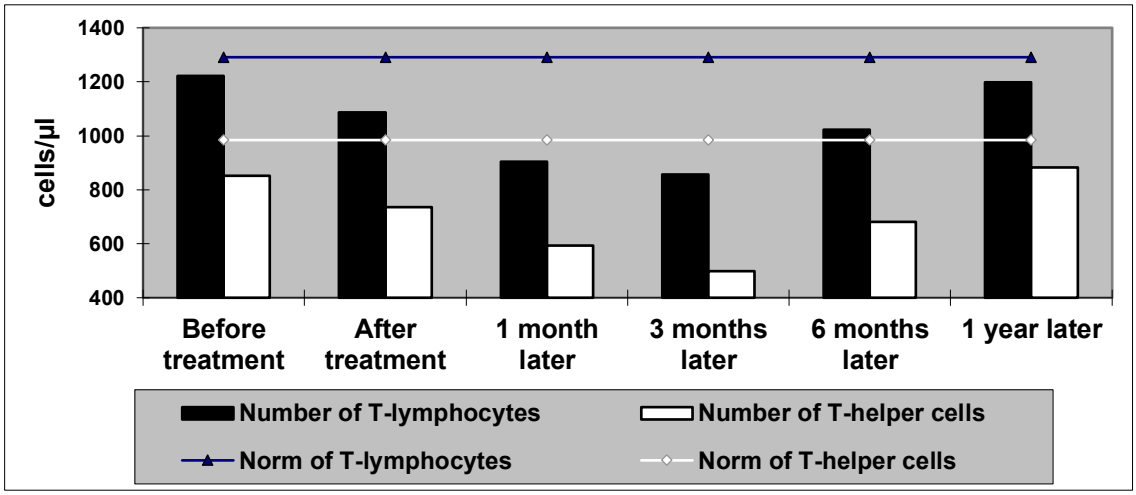

Fig. 3. Dynamics of T-lymphocytes and T-helper cells in patient S.

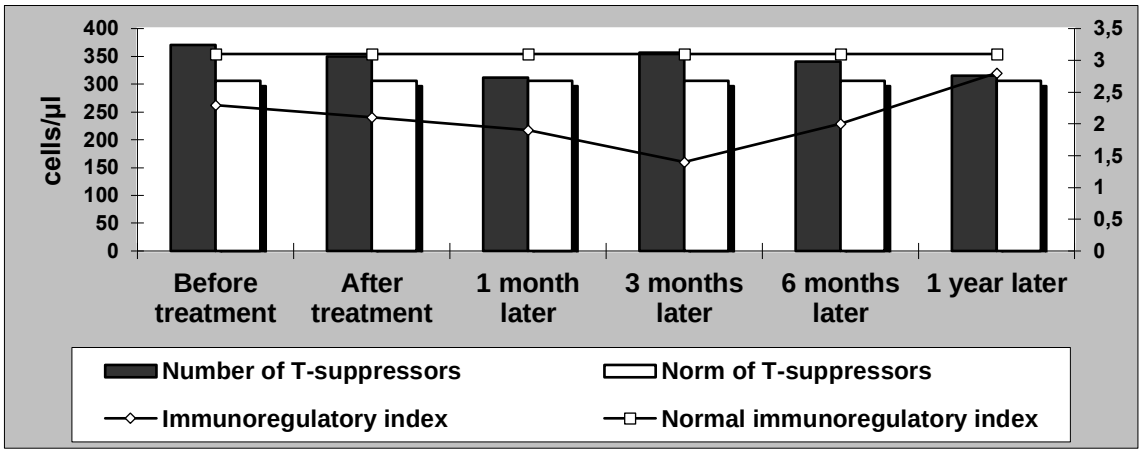

Fig. 4. Dynamics of T-suppressors and immunoregulatory index in patient S.

These features make it possible to diagnose the type of immunodeficiency in specific patients.

Based on the study of immunological changes in patients with uveitis, the dynamics of immunological disorders in relapses of the inflammatory process in the uveal tract, clinical and immunological features of various forms of uveitis, and the results of correction of immunological disorders in patients with uveitis, we propose the following classification of secondary immunodeficiency states in uveitis.

I. By the mechanism of formation.

1. Immunodeficiency states, "primary" in relation to uveitis:

a) caused by the influence of environmental factors;

b) caused by chronic infectious and other diseases.

2. Immunodeficiency states arising from uveitis.

3. Immunodeficiency states that form simultaneously with uveitis:

a) caused by infections that cause uveitis;

b) formed as a result of genetically determined inadequate response of the immune system to the inflammatory process.

II. By the degree of immune system depression:

1. minor;

2. expressed.

The proposed classification of secondary immunodeficiency states in uveitis also allows us to determine the timing for the correction of immunodeficiency states in patients with complicated forms of uveitis.

Immunodeficiency states "primary" to uveitis, caused by environmental factors or existing chronic diseases, are more likely to be of a suppressor or effector type and require adequate correction in the active phase of the inflammatory process since the correction of existing immunological changes in patients with complicated forms of uveitis will have a positive effect on the course of the inflammatory process and reduce the likelihood of relapses and chronicity of uveitis.

Immunodeficiency states resulting from uveitis may be transient, and the subsidence (under the influence of therapy) of the inflammatory process in the uveal tract may improve the immunological status. In such cases, immunocorrection in patients with complicated forms of uveitis is justified in the remission stage to prevent exacerbations of the inflammatory process.

Immunodeficiency states that develop simultaneously with uveitis require balanced and cautious therapy. In cases where the presence of immunodeficiency syndrome is due to infections that cause uveitis or due to a genetically determined inadequate immune system response, immunocorrective therapy, in the active phase of the disease, should only prevent the occurrence of profound changes in the immune system, since active immunostimulation can lead to exacerbation of the inflammatory process, and "residual" immunological changes can be corrected in remission.

When prescribing immunocorrective therapy based on peripheral blood parameters, the greatest attention should be paid to the type of T-cell subpopulation disorders based on the ratio of immunocompetent cells, since the type of these disorders [40] and the changes [41] are the same in the blood and intraocular fluid, unlike the content of immunoglobulins, which is due to the possibility of their local synthesis in uveitis [42; 43].

The principles of correction of the main types of immunologic disorders in complicated forms of uveitis were substantiated. Thus, researchers have shown the selenium origin of antibody-producing cells in the eye in experimental uveitis. Several studies have simultaneously determined immunecompetent cells (activated T lymphocytes with interleukin-2 receptors [44]) in both the anterior chamber fluid and peripheral blood of patients with uveitis. In patients with acute uveitis, the same type of immunological disorder was found [40] in the study of T lymphocyte subpopulations in the peripheral blood and anterior chamber fluid.

Studying the changes in T lymphocytes in the intraocular fluid, vitreous and peripheral blood in patients with uveitis of various etiologies, researchers [41] found that changes in aqueous humor significantly corresponded to similar changes in the peripheral blood, and the ratio of T helper and T suppressor cells in the blood, pre-chamber fluid and vitreous was almost the same.

Unlike indicators of cellular immunity, the content of immunoglobulins in aqueous humor, where they can appear as a result of plasma ultrafiltration [42], does not always correlate with their concentration in the blood serum, due to the possibility of local synthesis of immunoglobulins in uveitis [42; 43].

Conclusion

We have proposed a classification of secondary immunodeficiency states in uveitis according to the mechanism of their formation. On the basis of the proposed classification, the principles of correction of immunodeficiency states in patients with uveitis were developed.

DECLARATIONS:

Disclosure Statement

The authors have no potential conflicts of interest to disclosure, including specific financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Data Transparency

The data can be requested from the authors.

Statement of Ethics

The authors have no ethical conflicts to disclosure.

Funding Sources

There are no external sources of funding.

Consent for publication

All authors give their consent to publication.

References

1. Wu X, Tao M, Zhu L, Zhang T, Zhang M. Pathogenesis and current therapies for non-infectious uveitis. Clin Exp Med. 2023;23(4):1089-06. DOI: 10.1007/s10238-022-00954-6. PMID: 36422739.

2. Barros Ferreira L, Ashander LM, Ma Y, Appukuttan B, Williams KA, Best G, Smith JR. Effects of tumor necrosis factor-α and interleukin-1β on human retinal endothelial cells. Cytokine. 2024;173:156407. DOI: 10.1016/j.cyto.2023.156407. PMID: 37924741.

3. Zhang J, Kamoi K, Zong Y, Yang M, Ohno-Matsui K. Cytomegalovirus Anterior Uveitis: Clinical Manifestations, Diagnosis, Treatment, and Immunological Mechanisms. Viruses. 2023;15(1):185. DOI: 10.3390/v15010185. PMID: 36680225.

4. Panchenko NV, Samofalova MN, Friantseva MV. Anti-inflammatory cytokines content in different clinical uveitis course complicated by the optic nerve inflammation. J. ophthalmol. (Ukraine). 2016;(1):24-6. DOI: 10.31288/oftalmolzh201612426.

5. Panchenko MV, Nikolaienko MM, Honchar OM, Prykhodko DO, Pereiaslova HS, Sokol OO. Serum TNF-α and IL-1β levels in patients with RNFL thinning in uveitis complicated by optic nerve inflammation. J. ophthalmol. (Ukraine). 2020;(6):14-8. DOI: 10.31288/oftalmolzh202061418.

6. Zhang T, Han X, Zhong Y, Kam HT, Qiao D, Chen Z, et al. Regulatory T cell intravitreal delivery using hyaluronan methylcellulose hydrogel improves therapeutic efficacy in experimental autoimmune uveitis. Biomater Adv. 2023;151:213496. DOI: 10.1016/j.bioadv.2023.213496. PMID: 37290283.

7. Choi JK, Egwuagu CE. Analysis of Regulatory B Cells in Experimental Autoimmune Uveitis. Methods Mol Biol. 2021;2270:437-50. DOI: 10.1007/978-1-0716-1237-8_23. PMID: 33479912.

8. Panchenko NV, Samofalova MN, Gonchar EN, Prykhodko DO, Arustamova GS, Lytvyshchenko AV. Alterations in the expression of tumor necrosis factor-alpha in the uveitis with optic nerve inflammation. J. ophthalmol. (Ukraine). 2016;(5):18-21. DOI: 10.31288/oftalmolzh201651821.

9. Maria DM, Ulrike K, Gerhild W. The immunopathogenesis of chronic and relapsing autoimmune uveitis – Lessons from experimental rat models. Prog Retin Eye Res. 2018;65:107-26. DOI: 10.1016/j.preteyeres.2018.02.003. PMID: 29496590.

10. Putera I, Schrijver B, Ten Berge JCEM, Gupta V, La Distia Nora R, Agrawal R, et al. The immune response in tubercular uveitis and its implications for treatment: From anti-tubercular treatment to host-directed therapies. Prog Retin Eye Res. 2023;95:101189. DOI: 10.1016/j.preteyeres.2023.101189. PMID: 37236420.

11. Penkov MA, Zubarev SF, Avrushchenko NM, Panchenko NV. Comparative assessment of clinical effectivity of immunocorrecting therapy using thymoptin, T-activin and decaris in treatment of patients with endogenous uveitis. J. ophthalmol. (Ukraine). 1993;48(1):31-5.

12. Iwahashi C, Fujimoto M, Nomura S, Serada S, Nakai K, Ohguro N, et al. CTLA4-Ig suppresses development of experimental autoimmune uveitis in the induction and effector phases: Comparison with blockade of interleukin-6. Exp Eye Res. 2015;140:53-64. DOI: 10.1016/j.exer.2015.08.012. PMID: 26297802.

13. Velazquez-Villoria D, Macia-Badia C, Segura-Garcia A, Pastor Idoate S, Arcos-Algaba G, Velez-Escola L, Garcia-Arumi J. Efficacy of immunomodulatory therapy with interferon-β or glatiramer acetate on multiple sclerosis-associated uveitis. Arch Soc Esp Oftalmol. 2017;92(6):273-9. DOI: 10.1016/j.oftal.2016.11.018. PMID: 28188020.

14. Degtyarenko TV. Modern approaches to immunorehabilitation of patients with ophthalmopathology. J. ophthalmol. (Ukraine). 1992;5-6:332-5.

15. Garcia-Geremias M, Carreno E, Epps SJ, Lee RW, Dick AD. Clinical outcomes of intravenous immunoglobulin therapy in refractory uveitis. Int Ophthalmol. 2015;35(2):281-5. DOI: 10.1007/s10792-015-0051-0. PMID: 25708281.

16. Wechsler B, Le Thi Huong DU, Godeau P. Medical treatment of Behcet's disease. J Mal Vasc. 1988;13(3):262-9. PMID: 3049885.

17. Li S, Liu F, Zhang K, Tong Y, Liu X. Research Progress on the Mechanism of Natural Product Ingredients in the Treatment of Uveitis. J Immunol Res. 2021;2021:6683411. DOI: 10.1155/2021/6683411. PMID: 34778467.

18. Kaburaki T, Zhang Q, Jin X, Uchiyama M, Fujino Y, Nakahara H, et al. Effects of Japanese herbal medicine Sairei-to on murine experimental autoimmune uveitis. Graefes Arch Clin Exp Ophthalmol. 2013;251(12):2733-9. DOI: 10.1007/s00417-013-2473-6. PMID: 24126677.

19. Heidarian M, Jensen IJ, Kannan SK, Pewe LL, Hassert M, Park S, et al. Sublethal whole-body irradiation induces permanent loss and dysfunction in pathogen-specific circulating memory CD8 T cell populations. Proc Natl Acad Sci U S A. 2023;120(27):e2302785120. DOI: 10.1073/pnas.2302785120. PMID: 37364124.

20. Standish LJ, Torkelson C, Hamill FA, Yim D, Hill-Force A, Fitzpatrick A, et al. Immune defects in breast cancer patients after radiotherapy. J Soc Integr Oncol. 2008;6(3):110-21. DOI: 10.2310/7200.2008.0018. PMID: 19087768.

21. Yamaoka M, Kusunoki Y, Kasagi F, Hayashi T, Nakachi K, Kyoizumi S. Decreases in percentages of naïve CD4 and CD8 T cells and increases in percentages of memory CD8 T-cell subsets in the peripheral blood lymphocyte populations of A-bomb survivors. Radiat Res. 2004;161(3):290-8. DOI: 10.1667/rr3143. PMID: 14982485.

22. Chinen J, Shearer WT. Secondary immunodeficiencies, including HIV infection. J Allergy Clin Immunol. 2010;125(2 Suppl 2):S195-203. DOI: 10.1016/j.jaci.2009.08.040. PMID: 20042227.

23. Srivastava S, Wood P. Secondary antibody deficiency - causes and approach to diagnosis. Clin Med (Lond). 2016;16(6):571-6. DOI: 10.7861/clinmedicine.16-6-571. PMID: 27927823.

24. Panchenko HY. Correction of cellular immunity disorders in patients with chronic hepatitis. Bulletin of problems of modern medicine. 1993;1:28-30.

25. Daoud AK, Tayyar MA, Fouda IM, Harfeil NA. Effects of diabetes mellitus vs. in vitro hyperglycemia on select immune cell functions. J Immunotoxicol. 2009;6(1):36-41. DOI: 10.1080/15476910802604564. PMID: 19519161.

26. Shpak NI, Savko VV. [Basic principles for the diagnosis and treatment of patients with endogenous uveitis]. Oftalmol J. 1986;(2):65-7. PMID: 3714178.

27. Martenet AC. Application en thérapeutique oculaire des connaissances actuelles de l'immunologie [Application of current immunological knowledge in ocular therapy]. Klin Monbl Augenheilkd [Clinical Monthly Newsletters for Ophthalmology]. 1985;186(6):428-33. DOI: 10.1055/s-2008-1050951. PMID: 4046449.

28. Roberge FG, de Smet MD, Benichou J, Kriete MF, Raber J, Hakimi J. Treatment of uveitis with recombinant human interleukin – 13. Brit. J. Ophthalmol. 1998;82(10):1195-8. DOI: 10.1136/bjo.82.10.1195. PMID:9924310.

29. Hadjadj J, Dechartres A, Chapron T, Assala M, Salah S, Dunogue B, et al. Relevance of diagnostic investigations in patients with uveitis: Retrospective cohort study on 300 patients. Autoimmun Rev. 2017; 16(5):504-11. DOI: 10.1016/j.autrev.2017.03.006. PMID: 28279837.

30. Ferrara M, Eggenschwiler L, Stephenson A, Montieth A, Nakhoul N, Araujo-Miranda R, Foster CS. The Challenge of Pediatric Uveitis: Tetriary Referral Center Experience in the United States. Ocul Immunol Inflamm. 2019;27(3):410-7. DOI: 10.1080/09273948.2017.1420202. PMID: 29333911.

31. Bosch-Driessen EH, Rothova A. Recurrent ocular disease in postnatally acquired toxoplasmosis. Am J Ophthalmol. 1999;128(4):421-5. DOI: 10.1016/s0002-9394(99)00271-8. PMID: 10577582.

32. Yang M, Kamoi K, Zong Y, Zhang J, Ohno-Matsui K. Human Immunodeficiency Virus and Uveitis. Viruses. 2023;15(2):444. DOI: 10.3390/v15020444. PMID: 36851658.

33. Terada Y, Miyata K, Shoji N, Mochizuki M. Human T-cell Leukemia Virus Type 1 (HTLV-1)-induced Uveitis. Ocul Immunol Inflamm. 2023;31(7):1416-24. DOI: 10.1080/09273948.2023.2175697. PMID: 36803501.

34. Mochizuki M, Tajima K, Watanabe T, Yamaguchi K. Human T lymphotropic virus type 1 uveitis. Br J Ophthalmol. 1994;78(2):149-54. DOI: 10.1136/bjo.78.2.149. PMID: 8123625.

35. Towler H. Retroviruses – a clue to autoimmunity? Br J Ophthalmol. 1994;78(3):161-2. DOI: 10.1136/bjo.78.3.161. PMID: 8148328.

36. Davey MP, Rosenbaum JT. The human leukocyte antigen complex and chronic ocular inflammatory disorders. Am J Ophthalmol. 2000;129(2):235-43. DOI: 10.1016/s0002-9394(99)00433-x. PMID: 10682977.

37. Schwartz R.H. Functional properties of I region gene products and theories of immune response (Ir) gene function. Ia Antigens. 1982;1:161-218.

38. Campochiaro PA, Lim JI. Aminoglycoside toxicity in the treatment of endophthalmitis. The Aminoglycoside Toxicity Study Group. Arch Ophthalmol. 1994;112(1):48-53. DOI: 10.1001/archopht.1994.01090130058017. PMID: 8285892.

39. Bosch-Driessen EH, Lardy NM, Rothova A. Antinuclear antibody and HLA-B27 positive uveitis: combination of two diseases? Br J Ophthalmol. 1997;81(9):771-3. DOI: 10.1136/bjo.81.9.771. PMID: 9422931.

40. Toledo de Abreu M, Belfort R Jr, Matheus PC, Santos LM, Scheinberg MA. T-lymphocyte subsets in the aqueous humor and peripheral blood of patients with acute untreated uveitis. Am J Ophthalmol. 1984;98(1):62-5. DOI: 10.1016/0002-9394(84)90189-2. PMID: 6234809.

41. Deschenes J, Freeman WR, Char DH, Garovoy MR. Lymphocyte subpopulations in uveitis. Arch Ophthalmol. 1986;104(2):233-6. DOI: 10.1001/archopht.1986.01050140087026. PMID: 2936325.

42. Hamel CP, De Luca H, Billotte C, Offret H, Bloch-Michel E. Nonspecific immunoglobulin E in aqueous humor: evaluation in uveitis. Graefes Arch Clin Exp Ophthalmol. 1989;227(5):489-93. DOI: 10.1007/BF02172904. PMID: 2806935.

43. Ronday MJ, Ongkosuwito JV, Rothova A, Kijlstra A. Intraocular anti-Toxoplasma gondii IgA antibody production in patients with ocular toxoplasmosis. Am J Ophthalmol. 1999;127(3):294-300. DOI: 10.1016/s0002-9394(98)00337-7. PMID: 10088739.

44. Deschenes J, Char DH, Kaleta S. Activated T lymphocytes in uveitis. Br J Ophthalmol. 1988;72(2):83-7. DOI: 10.1136/bjo.72.2.83. PMID: 2964862.

Received: 02 Aug 2023
Accepted: 26 Oct 2023

Cite in Vancouver style as: Panchenko MV, Bezditko PA, Honchar OM, Duras IG, Panchenko HY, Boieva YY, Ivzhenko LI, Kitchenko IV. Mechanisms of formation and classification of secondary immunodeficiency states in uveitis. Inter Collegas. 2023;10(2):23-30. https://doi.org/10.35339/ic.10.2.pbh