

# HEMATOLOGICAL DISORDERS IN PATIENTS WITH AUTOIMMUNE THYROIDITIS

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## Abstract

**Objective.** Identify the frequency of occurrence of various morphological types and different degrees of severity of anemia in patients with autoimmune thyroiditis.

**Material and methods.** Were analyzed 97 case histories of patients operated for autoimmune thyroiditis (AIT) in 2012. When assessing hematological parameters, two groups were identified: group 1 – patients with AIT with mild anemia (n = 72), age 45.7 ± 1.6, men - 5 (6.9%), women - 67 (93, 1%); group 2 - patients with AIT with moderate anemia (n = 25), age 40.0 ± 2.3, men - 1 (4%), women - 24 (96%). In the clinical analysis of blood, hemoglobin, hematocrit, the number of erythrocytes and erythrocyte indexes of MCV, MCH, MCHC were determined.

**Results.** By morphological type in patients with AIT with mild anemia, the hypochromic type was observed in 56 (77.8%) patients, normochromic - in 16 (22.2%) patients. In moderate anemia, this tendency was more pronounced: hypochromic type of anemia was detected in 23 (92%) patients, normochromic type - in 1(4%) and hyperchromic in 1(4%). Thus, in patients with AIT, mild anemia was more often determined (in 72.4%), then moderate anemia (in 25.7%). With moderate severity of anemia, microcytic (84%) and hypochromic (92%) types of anemia were more often observed. With mild anemia, the same types of anemias were observed, but with a lower frequency (76.4% and 77.8%, respectively).

**Conclusion.** The hemogram in patients with AIT was characterized by a more frequent development of mild anemia (72.4%). With mild anemia, hematological disorders were characterized by microcytic (76.4%) and hypochromic (77.8%) types of anemia. Similar, but more pronounced disorders were observed in moderate anemia: microcytic 84% and hypochromic 92%, which is characteristic for iron deficiency anemia.

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## Conflict of interest

The authors declare that they have no conflicts of interest

**Keywords:** autoimmune thyroiditis, anemia, severity of anemia, morphological types of anemia

## Аутоиммунды тиреоидитпен ауыратын науқастардағы гематологиялық өзгерістер

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## Аңдатпа

**Мақсаты.** Аутоиммунды тиреоидитпен ауыратын науқастарда анемияның әртүрлі морфологиялық түрлерінің және ауырлық дәрежесінің жиілігін анықтау.

**Материал және әдістер.** 2012 жылы аутоиммунды тиреоидит (АИТ) бойынша ота жасалған 97 науқастың сырқат тарихының деректері талданды. Гематологиялық көрсеткіштерді бағалау кезінде екі топ бөлінді: 1-топ – жеңіл дәрежелі анемия (n=72) жасы 45,7±1 АИТ бар науқастар жас шамасы 40,7±1,6 ерлер – 5 (6,9%), әйелдер – 67 (93,1%) және 2-топ – анемияның орташа ауырлықтағы (n=25) АИТ бар науқастар, жасы 40,0±2,3, ерлер – 1 (4%), әйелдер – 24 (96%). Клиникалық қан анализінде гемоглобин, гематокрит, эритроциттер саны және MCV, MCH, MCHC эритроциттердің индекстері анықталды.

**Нәтижелер.** Морфологиялық түрі бойынша жеңіл дәрежелі анемиямен ауыратын АИТ бар науқастарда гипохромды түрі 56 (77,8%) науқаста, нормохромды – 16 (22,2%) науқаста байқалды. Орташа ауырлықтағы анемия кезінде бұл тенденция сақталды және айқынырақ болды: анемияның гипохромдық түрі 23 (92%) науқаста, нормохромды түрі 1 (4%) және гиперхромды түрі 1 (4%) науқаста анықталды. Сонымен, АИТ бар науқастарда жеңіл дәрежелі анемия 72,4% жағдайда, ал орташа ауырлықтағы анемия 25,7% жағдайда жиі анықталды. Анемияның орташа ауырлық дәрежесінде анемияның микроцитарлы (84%) және гипохромдық (92%) түрлері жиі байқалды. Жеңіл анемия кезінде анемияның бірдей түрлері байқалды, бірақ жиілігі төмен (миісінше 76,4% және 77,8%).

**Қорытынды.** АИТ бар науқастардағы гемограмма жеңіл дәрежедегі анемияның жиірек дамуымен сипатталды (72,4%). Анемияның жеңіл дәрежесінде гематологиялық бұзылулар анемияның микроцитарлы (76,4%) және гипохромды (77,8%) түрлерімен сипатталды. Ұқсас, бірақ айқынырақ бұзылулар темір тапшылығы анемиясына тән орташа ауырлықтағы (миісінше микроцитарлы (84%) және гипохромды (92%)) анемияда байқалды.

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## Гематологические изменения у больных аутоиммунным тиреозитом

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### Аннотация

**Цель.** Выявить частоту встречаемости различных морфологических типов и различных степеней тяжести анемий у больных аутоиммунным тиреозитом.

**Материал и методы.** Проанализированы данные историй болезни 97 пациентов, прооперированных по поводу аутоиммунного тиреозита (АИТ) за 2012 г. При оценке гематологических показателей были выделены две группы: 1-ая группа – больные АИТ с анемией легкой степени ( $n=72$ ) возраст  $45,7 \pm 1,6$ , мужчин – 5(6,9%), женщин – 67(93,1%) и 2-ая группа – больные АИТ с анемией средней степени тяжести ( $n=25$ ), возраст  $40,0 \pm 2,3$ , мужчин – 1(4%), женщин – 24(96%). В клиническом анализе крови определяли гемоглобин, гематокрит, количество эритроцитов и эритроцитарные индексы МСV, МСН, МСНС.

**Результаты.** По морфологическому типу у больных АИТ с легкой степенью анемии гипохромный тип отмечался у 56 (77,8%) больных, нормохромный – у 16 (22,2%) больных. При анемии средней степени тяжести данная тенденция сохранялась и была более выраженной: гипохромный тип анемии определялся у 23(92%) больных, нормохромный тип – у 1(4%) и гиперхромный у 1 (4%). И так, у больных АИТ чаще определялась анемия легкой степени в 72,4% случаев, а анемия средней степени тяжести в 25,7% случаев. При средней степени тяжести анемии чаще отмечались микроцитарный (84%) и гипохромный (92%) типы анемий. При анемии легкой степени наблюдались те же типы анемий, но с меньшей частотой (соответственно 76,4% и 77,8%).

**Выводы.** Гемограмма у больных АИТ характеризовалась более частым развитием анемии легкой степени тяжести (72,4%). При легкой степени анемии гематологические нарушения характеризовались микроцитарным (76,4%) и гипохромным (77,8%) типами анемий. Аналогичные, но более выраженные нарушения наблюдались и при анемии средней степени тяжести (соответственно микроцитарным (84%) и гипохромным (92%)), что характерно для железодефицитной анемии.

Existence of combined anemia and thyroid disease is an important problem which is tried to be solved by hematologists and thyroidologists for a long time. First of all this is due to the fact that thyroid pathology is the most widespread among endocrine diseases. Effect of thyroid hormones on hematopoiesis is widely described in literature. However, the exact mechanism of impact of thyroid hormones to blood system is not completely studied yet [1, 2]. Conducted in vitro experiments showed that the thyroid hormones have a direct effect on the proliferation of erythrocyte precursors and stimulate bone marrow erythropoiesis [1, 3, 4]. That is why we have to deal with a combination of anemic syndrome and thyroid disease in patients [1, 5, 6, 7, 8, 9, 10, 11]. Anemia development is observed both in persons with both hypothyroidism and hyperthyroidism [1, 2, 3, 5, 6, 11]. Data of several research works confirm the possibility of developing anemia already with an initial decrease in thyroid function [9, 12, 13]. Hypothyroidism (subclinical and overt) is a risk factor of anemia, i.e. the frequency of anemia cases is higher among people with hypothyroidism than in other part of population [6, 9, 14, 15]. Fatima Q. et al. found out that the overall prevalence of anemia among patients with hypothyroidism was 56%, and this indicator is higher than WHO data on prevalence of anemia in the world [11]. According to the information given in the literature, anemia in hypothyroidism has

different pathogenesis, can occur as the result of bone marrow depression, decreased production of erythropoietin, concomitant deficiency of iron, vitamin B12, or folic acid [1, 12, 14, 16]. Low absorption of iron in the gastrointestinal tract and excessive blood loss, especially with menorrhagia can be reasons for development of anemia. It has been shown that iron absorption in hypothyroidism is reduced, however, this rate can be increased in response to thyroid hormone therapy [17]. If some author think that while compensating of functional activity of thyroid the blood picture is usually completely restored and it additional interventions are rarely required [3], but others found out that, only stimulation of erythropoiesis takes place against the background of replacement therapy, while hematological changes after achieving euthyroidism are not eliminated [14]. According to Omar S. et al. (2010) a combination of iron and levothyroxine preparations is necessary [18].

The relationship between the erythrocyte index and the level of thyroid hormones is observed in normal function of thyroid [12, 13]. M'Rabet-Bensalah K. et al (2016) found that only in 5% of cases of anemia is combined with a violation of the level of thyroid hormones [19]. Connections between autoimmune process in the thyroid gland and hematological diseases are being studied only during the last decade. There are separate informations about combination

of AIT and autoimmune processes in the system of hematopoiesis [20].

The correct interpretation of erythrocyte indices let us to obtain additional information about the morphological types of anemia while diagnosing the anemia. Erythrocyte index – is an average volume of erythrocytes (MCV– it is a qualitative indicator. Its value below 80 fl is assessed as microcytosis, which is observed in iron deficiency anemia (IDA), thalassemia, chronic diseases, hyperthyroidism. MCV over 95 fl is assessed as macrocytosis and mostly is observed in patients with anemia with vitamin B12 or folic acid deficiency. The normal volume of erythrocytes (normocytosis) is observed with anemia as the result chronic diseases, autoimmune hemolytic diseases [1].

Erythrocyte index – average concentration of HGB in erythrocyte (MCH)-quantitative indicator that almost always correlates with MCV. Changing of these indicators is closely interconnected and often happens in parallel. MCH corresponds to the color index (CI), therefore hypo-, hyper- and normochromic anemias are associated with MCH. Indicators of average concentration of HGB in erythrocytes (MCHC) more objectively determines the concentration of hemoglobin. This is a hard option, which has small spread of values. Decreasing of MCHC is observed in patients with moderate and severe IDA, and increases in hereditary hematological diseases.

**The purpose of the study:** is to identify the frequency of occurrence of various morphological types and different degrees of severity of anemia in patients with autoimmune thyroiditis.

#### Material and methods

We determined hemoglobin (HGB), hematocrit (HCT), erythrocyte count and erythrocyte indices MCV, MCH, MCHC in a clinical blood test. Anemia was diagnosed in patients with hemoglobin level less than 120 g/l (WHO, 2001). In correspondence with existing recommendations mild anemia when HGB level was

more than 90g/l (but less than 120 g/l), moderate anemia when HGB level is within 70–90 g/l, severe when Hb level is less than 70 g/l was diagnosed. MCV less than 80 fl was considered as microcytic anemia, MCV within 80–95 fl - as normalcytic anemia, MCV more than 95 fl – as macrocytic anemia. Normochromic anemia was considered with MCH 27–31 pg, hypochromic anemia with MCH less than 27 pg, and hyperchromic anemia with MCH more than 31 pg. 97 case histories of patients, operated for AIT in 2012 in the department of endocrine surgery of the Scientific Center of Surgery named after acad. M.A. Topchubashov, were analyzed for studying the prevalence of anemia combined with AIT. Two groups have been detected while assessment of hematological parameters: the 1<sup>st</sup> group – patients with AIT with mild anemia (n=72) age – 45.7±1.6 years, male –5(6.9%), female –67 (93.1%) and the 2<sup>nd</sup> group – patients with AIT with moderate anemia (n=25), age – 40.0±2.3 years, male – 1(4%), female –24 (96%).

Mathematical analysis of the achieved results was carried out using the software package Excel 2017. Structural characteristics of the variation series were used (mean, mean error), for assessment of differences between samples we used nonparametric Wilcoxon-Mann-Whitney test. Differences at values  $p < 0.05$  were considered as statistically significant [21].

#### Results

97 patients with AIT aged between 17-78 years (average age was 43.9±1.3 years) have been examined. Mild anemia was observed in 72 (74.2%) patients, moderate anemias – in 25 (25.7%) patients. Average age of patients with mild anemia was 45.7±1.6 years, 5 (6.9%) of them were men, 67 (93.1%) were women. The average age of persons with anemia of moderate severity was 40.0±2.3 years, 1(4%) of them was men, 24 (96%) were women. As seen from the above mentioned information, then frequency of anemia among women is higher – 91(93,8%), than in men – 6 (6,2%).

Results of studying of anemia of different severity in patients with AIT are given in Table 1.

Parameters		Almost healthy (n=15)	All patients (n=97)	Mild anemia (n=72)	Moderate anemia (n=25)
HGB, g/l	Hemoglobin concentration	133,2±1,8	100,6±1,1*	105,0±0,9*	87,8±0,9*^
RBC× 10 <sup>12</sup> /l	RBC count	4,3± 0,07	4,02±0,04*	4,14±0,05	3,64±0,07*^
HCT, %	Hematocrit	39,8±0,5	30,4±0,3*	31,5±0,3*	27,2±0,7*^
CI	Color index	0,92±0,006	0,76±0,006*	0,77±0,006*	0,74±0,01*^
MCV, fl	Average volume of erythrocytes	91,9 ±0,6	76±0,6*	76,5±0,7*	74,6±01,3*
MCH, pg	Average content of HGB in erythrocyte	30,8±0,2	25,4±0,2*	25,6±0,2*	24,9±0,4*
MCHC, g/dl	Average concentration of HGB in erythrocyte	33,4±0,04	33,4±0,07	33,3±0,07	33,5±0,2

\*- statistical significance of differences in data of practically healthy people<sup>^</sup>

- statistical significance of differences between groups of patients

**Table 1.**  
The hemogram in patients with AIT (M±m)

The study of hemogram parameters in the group "all patients" let us to identify the decrease in HGB level to  $100.6 \pm 1.1$  g/l ( $133.2 \pm 1.8$  g/l in healthy people). In patients with mild anemia HGB levels were reduced by 24.5%, in anemia of moderate severity – by 1,5 times ( $p < 0,05$ ). The average number of erythrocytes in the "all patients" group was  $4.02 \pm 0.04$  ( $4.3 \pm 0.07$  in healthy people). In patients with a mild degree of anemia, the decrease in red blood cells was not statistically reliable and insignificant - by 3.7%, with an average degree of 15.3% ( $p < 0,05$ ). Hematocrit values were significantly low. The average value of hematocrit in the "all patients" group was  $30.4 \pm 0.3\%$  ( $39.8 \pm 0.5\%$  in group of healthy persons,  $p < 0,001$ ). In cases of mild anemia hematocrit was reduced by 20.9%, in cases of moderate anemia – by 31.7%.

The study of erythrocyte indexes showed that in the "all patients" group, the average volume of erythrocytes was  $76.0 \pm 0.6$  fl., which is statistically significantly different from the indicators of control group ( $91.9 \pm 0.6$  fl.). In AIT patients with mild anemia

MCV was  $-76.5 \pm 0.7$  fl, what is 16.8% lower than in control group, and in patients with moderate anemia this indicator was  $-74.6 \pm 1.3$ , what is lower by 18.9% than norm.

The average content of HGB in erythrocytes of the "all patients" group was statistically significantly lower than in the control group ( $30.8 \pm 0.2$  pg) and was  $25.4 \pm 0.2$  pg. With a mild severity of anemia, a decrease in MCH by 16.9% relative to the control data was noted, and with moderate severity - by 19.2%. The average concentration of hemoglobin in erythrocytes (MCHC) changed in the groups statistically unreliably related to the control and among them.

### Discussion

The tendency of decreasing in hemogram parameters depending on the severity of anemia was observed in patients with AIT. Comparative analysis showed the statistically reliable difference between anemia of mild and moderate severity according the following indicators: hemoglobin, red blood cell count, hematocrit, color index (Table 1).

Correlation analysis between hemogram parameters of patients with AIT with anemia of mild and moderate severity is given in Table 2.

**Table 2.**  
Matrix of correlation coefficients of patients with AIT with anemia of mild and moderate severity

Parameters	«All are sick» (n=97) HGB	Mild anemia (n=72) HGB	Moderate anemia (n=25) HGB
Erythrocytes	0,64	0,54	0,39
Hematocrit	0,87	0,97	0,5
MCV	0,28	0,26	0,35
MCH	0,3	0,28	0,37
MCHC	- 0,03	- 0,22	- 0,22

Correlation analysis on the Chaddock scale with mild anemia showed a positive moderate relationship between HGB and erythrocytes ( $r=0.54$ ), between HGB and hematocrit ( $r=0.97$ ), weak HGB and MCV ( $r=0.26$ ) and HGB and MCH ( $r=0.28$ ) were observed. Correlations in patients with AIT with moderate severity of anemia were less pronounced. The positive

moderate relationship between HGB and hematocrit ( $r=0.39$ ), between HGB and hematocrit ( $r=0.5$ ), a positive moderate relationship between HGB & MCV ( $r=0.35$ ) and HGB & MCH ( $r=0.37$ ) were observed. A weak negative relationship was determined between MCHC and HGB in case of anemia of mild and moderate severity.

**Table 3.**  
Morphological types of anemia in case of AIT

Morphological type of anemia	All patients (n=97)	Mild anemia (n=72)	Moderate anemia (n=25)
Microcytic	76 (78.3%)	55(76.4%)	21(84%)
Normocytic	21(21.7%)	17(23.6%)	4(16%)
Macrocytic	-	-	-
Normochromic	17(17.5%)	16(22.2%)	1(4%)
Hypochromic	79(81.4%)	56(77.8%)	23(92%)
Hyperchromic	1(1.0%)	-	1(4%)

The achieved results indicate the presence of abnormalities in the hemogram of patients with AIT. According to the volume of erythrocytes (MCV), in the group "all patients" anemia was distributed as follows: microcytic anemia was diagnosed in 76.0 (78.3%) patients, normocytic anemia was detected in 21 (21.7%) patients, and macrocytic anemia was not detected. In patients with AIT with mild severity of anemia microcytic anemia was determined in

most cases - in 55 (76.4%) patients, normocytic - in 17 (23.6%). In patients with anemia of moderate severity, microcytic anemia was determined in 21 (84%) cases, normocytic anemia - in 4 (16%) cases (Table 3). Hypochromic type of anemia (according to the MSI index) in the "all patients" group was noted in 79 (81.4%) patients, normochromic type in 17 (17.5%) and hyperchromic type in 1 (1%) patient. Among patients with AIT with mild severity of anemia the



hypochromic type was observed in 56 (77.8%) patients, normochromic in 16 (22.2%) patients according to the morphological type. In patients with moderate anemia this trend remained and was more pronounced: hypochromic type of anemia was diagnosed in 23 (92%) patients, normochromic type in 1 (4%) and hyperchromic in 1 (4%) patient. An increased number of hypochromic red blood cells indicates an iron deficiency, what means that the erythrocyte works in conditions of its deficiency (Table 3).

Thus, in patients with AIT, anemia of mild severity was determined more often - in 72.4% of cases, and anemia of moderate severity in 25.7% of cases. With an moderate severity of anemia, microcytic (84%) and hypochromic (92%) types of anemia were more

often observed. In mild anemia, the same types of anemia were observed, but with a lower frequency (respectively 76.4% and 77.8%).

### Conclusion

1. Hemogram of patients with AIT was characterized by more frequent development of mild anemia (72.4%).
2. Hematological disorders were characterized by microcytic (76.4%) and hypochromic (77.8%) types of anemia were observed in cases of anemia of mild severity. Similar, but more pronounced disorders were observed in moderate anemia (respectively microcytic (84%) and hypochromic (92%), what is characteristic for iron deficiency anemia.

### References

1. Szczepanek-Parulska E., Hernik A., Ruchala M. Anemia in thyroid diseases // *Pol Arch Intern Med.* – 2017.- 127(5).- P. 352-360. DOI: 10.20452/pamw.3985
2. Jafarzadeh A., Poorgholami M., Izadi N., Nemati M., Rezayati M. Immunological and hematological changes in patients with hyperthyroidism or hypothyroidism//*Clin Invest Med.* -2010.-33(5).-P-271–279. DOI:10.25011/cim.v33i5.14352
3. Hegazi M.O., Ahmed S. Atypical Clinical Manifestations of Graves' Disease: An Analysis in Depth Hindawi // *Journal of Thyroid Research* Volume 2012, Article ID 768019, 8 pages doi:10.1155/2012/768019
4. Fandrey J., Pagel H., Frede S., Wolff M., Jelkmann W. Thyroid hormones enhance hypoxia-induced erythropoietin production in vitro. *Exp Hematol.* 1994;22(3):272–277 PMID: 7509290
5. Daisy M Wopereis, Robert S. Du Puy, Diana Van Heemst, John P. Walsh, Alexandra Bremner, Stephan J.L. Bakker, et al. The Relation Between Thyroid Function and Anemia: A Pooled Analysis of Individual Participant Data/ *The Journal of Clinical Endocrinology & Metabolism*, Volume 103, Issue 10, October 2018, P. 3658–3667 <https://doi.org/10.1210/jc.2018-00481>
6. Gu Y., Vu Thi Quynh Chi, Qing Zhang, Li Liu, GeMeng, Hongmei Wu et al. Low-Normal Thyroid Function Predicts Incident Anemia in the General Population With Euthyroid Status /*J Clin Endocrinol Metab*, November 2019, 104(11):5693–5702 <https://doi.org/10.1210/jc.2019-00888>
7. Floriani C., Feller M., Aubert C.E., M'Rabet-Bensalah K., Collet T.H., den Elzen W.P.J., Bauer D.C., Angelillo-Scherrer A., Aujesky D., Rodondi N. Thyroid dysfunction and anemia: a prospective cohort study and a systematic review. *Thyroid.* 2018;28(5):575–582. <https://doi.org/10.1089/thy.2017.0480>
8. Wopereis D.M., Du Puy R.S., van Heemst D., Walsh J.P., Bremner A., Bakker S.J.L. et al. Thyroid Studies Collaboration. The relation between thyroid function and anemia: a pooled analysis of individual participant data. *J Clin Endocrinol Metab.* 2018;103(10):3658–3667. Pubmed ID 30113667
9. Erdogan M., Kosenli A., Ganidagli S., Kulaksizoglu M. Characteristics of anemia in subclinical and overt hypothyroid patients. *Endocr J.* 2012; 59: 213-220. DOI:10.1507/ENDOCRJ.EJ11-0096
10. Olt S., Selchuk M., Tutak A., Akbash F., Oznas O. Investigation the effect of hypothyroidism on hematological parameters Mustafa Kemal Üniv Tıp Derg 2016; 7(25): 23-27 Doi: 10.17944/mkutfd.73132
11. Fatima Q., Dotasara P. and Gauri L.A. Hematological profile in primary hypothyroidism. *International Journal of Medical and Biomedical Studies.* 4, 1 (Jan. 2020). DOI:<https://doi.org/10.32553/ijmbs.v4i1.840>
12. Bremner A.P., Feddema P., Joske D.J., leedman P.J., O'leary P.C., Olynyk J.K., Walsh J.P. Significant association between thyroid hormones and erythrocyte indices in euthyroid subjects *Clin Endocrinol (Oxf)*: 2012 Feb;76(2):304-11. DOI: 10.1111/j.1365-2265.2011.04228.x PMID: 21913954
13. Mijin Kim, Bo Hyun Kim, Hyungi Lee, Min Hee Jang, JeongMi Kim, EunHeui Kim et al. Association between Serum Free Thyroxine and Anemia in Euthyroid Adults: A Nationwide Study *Endocrinol Metab* 2020;35:106-114 <https://doi.org/10.3803/EnM.2020.35.1.106>
14. Goncharova O.A. *Reproductive endocrinology [Reproduktivnaja jendokrinologija]*. No. 1(51), birch 2020. [WWW.REPRODUCT-ENDO.COM/WWW.REPRODUCT-ENDO.COM.UA](http://WWW.REPRODUCT-ENDO.COM/WWW.REPRODUCT-ENDO.COM.UA)
15. Shchekotova, A.P. «Diagnosis of Anemia.» *Therapy* 5 (2016): 76-86
16. Nekrasova T.A., Strongin L.G., Ledentsova O.V. Hematological disorders in subclinical hypothyroidism and their dynamics during replacement therapy [Gematologicheskie narusheni japrisub klinicheskom gipotireozei i dinamika v processe

- zamestitel'nojterapii]. *Clinical Medicine*. - 2013. - No. 9. – S. 29 – 33
17. Balabolkin M.I., Klebanova E.M., Kreminskaya V.M. *Fundamental and clinical thyroidology [Fundamental'najai klinicheskaja tireoidologija]*. Tutorial.M.: Medicine, 2007
  18. Omar S., Hadj Taeib S., Kanoun F. et al. Erythrocyte abnormalities in thyroid dysfunction. *Tunis Med*. 2010; 88 (11): 783–788. [PUBMED]
  19. M'Rabet-Bensalah K., C. E. Aubert, M. Coslovsky, Tinh-Hai Collet, C. Baumgartner, Wendy PJ den Elzen, R. Luben et al. Thyroid dysfunction and anemia in a large population-based study. *Clinical Endocrinology* 2016; 84(4): 627-631 DOI: 10.1111/cen.12994
  20. Pesotskaya L.A., Palets V.A., Gavrilyuk A.I. The pathogenesis of anemia in hypothyroidism [Patogenez anemii pri gipotireoze]/ *World science: problems, prospects and innovations Abstracts of VII International Scientific and Practical Conference Toronto, Canada 24-26 March 2021*, c. 659-665
  21. Trukhacheva N.V. *Mathematical statistics in biomedical research using the Statistics package [Matematicheskaya statistika v mediko-biologicheskikh issledovaniyakh s primeneniym paketa Statistica]*.: M.: GEOTAR. Media. 2012. - 384S. DOI: <http://dx.doi.org/10.5281/zenodo.1461661>