Contribution of Systemic Inflammation to the Pathogenesis of Endothelial Dysfunction

Iryna Sokolovska[a*], Nataliia Prybora[b], Valentyna Nechyporenko[a], Olena Pozdniakova[a], Nataliia Hordiienko[a], Yuliia Siliavina[a], Iryna Antonenko[a], Nataliia Serhata[a], Stanislav Statiev[c], Tetiana Kozar[c], Pavlo Vindiuk[c], Valentyna Zarytska[i], Igor Semeniv[d], Andriy Kotuza[d], Larisa Mykhalska[d], Oleksandr Pokropyvnyi[d], Olena Ibrahimova[d], Lesya Yanitska[e], Valerii Bulanov[h], Iryna Kryachok[f], Iryna Tytorenko[f], Maryna Burenko[a], Yaroslav Kmetyuk[d]

[a]Municipal Institution of Higher Education «Khortytsia National Educational and Rehabilitational Academy» of Zaporizhzhia Regional Council, Naukovogo Mistechka,59, Zaporizhzhia, 69017, Ukraine, [b]Dragomanov Ukrainian State University, [c]Classical Private University, [d]KL "Feofania" DUS», [e]Bogomolets National Medical University, [f]National Cancer Institut, National University Zaporizhzhia Polytechnic [h], Bohdan Khmelnytskyi Melitopol State Pedagogical University[i]

irinasokol10@meta.ua

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The study of the role of the endothelium in regulating physiological processes in the human body has been one of the most significant areas of medical science in recent decades. The vascular endothelium is a hormonally active tissue that regulates vascular tone by releasing vasodilatory and vasoconstrictor factors, modulating the contractile activity of smooth muscle cells. In various diseases, including inflammatory ones, the ability of endothelial cells to release relaxing factors is reduced, leading to the development of endothelial dysfunction, which, in turn, is a leading mechanism in the pathogenesis of the development and progression of cardiovascular diseases.

Introduction

Endothelial dysfunction is an important link in the occurrence and progression of cardiovascular diseases. In this regard, the study of the mechanisms of dyslipoproteinemia formation, changes in the functional activity of platelets, leukocytes and endothelial cells during the inflammatory process is of particular relevance [1].

Violation of the body's immune defense mechanisms during infections contributes to a prolonged, asymptomatic or chronic course of inflammation and, ultimately, its transition to systemic lesions of numerous organs and tissues [3]. In the development of the inflammatory process, along with plasma and cellular mediators (granulocytes, monocytes, lymphocytes), vascular endothelial cells play a significant role. In response to the action of pro-

inflammatory factors, the permeability of the vascular walls increases, the processes of neutrophil chemotaxis to the area of damage, phagocytosis and intravascular blood clotting are activated [2]. Such reactions simultaneously help to limit the focus of infection and cause microcirculation disorders, which are accompanied by secondary damage to endothelial cells (**Figure 1).**

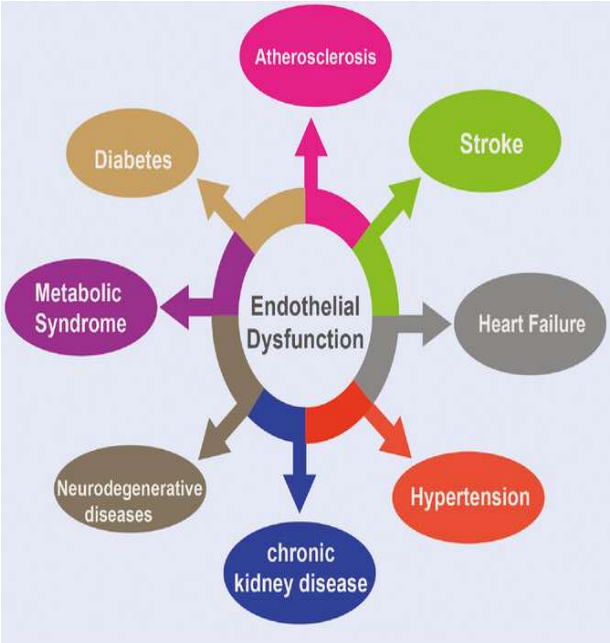

Figure 1. Endothelial dysfunction in specific disease conditions

During the development of inflammation, macrophages, blood cells, stromal tissues and endothelial cells produce a wide range of pro-inflammatory cytokines - interleukins (IL-1, IL-2, IL-6), tumor necrosis factors (TNF-α, TNF-β), chemoattractants, etc. (**Figure 2).**

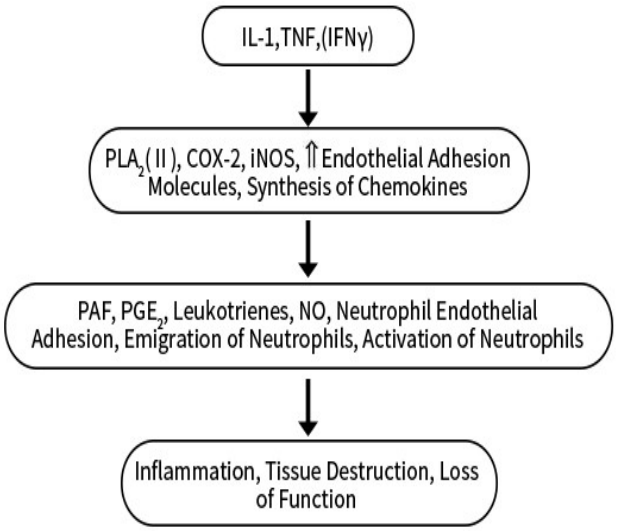

Figure 2. The inflammatory cascade triggered by IL-1 and TNF.

An increase in the level of these mediators activates the cytokine cascade, causes lipid metabolism disorders, stimulates the processes of adhesion and blood coagulation, enhances the "sticking" of formed elements to the endothelium and leads to its further damage [14]. As a result, atherogenesis develops, blood flow slows down, microthrombi and necrotic changes of endothelial cells are formed [4].

Under the influence of IL-1, the formation of granulocytes and monocytes increases, the number of neutrophils in the blood and directly in the area of inflammation increases [5]. This is accompanied by activation of the synthesis of adhesion molecules on the surface of endothelial cells and the appearance of chemoattractants [6]. In addition, IL-1 stimulates the synthesis of acute phase proteins - C-reactive protein, complement components, amyloid, fibrinogen, haptoglobin, etc. (**Figure 3).**

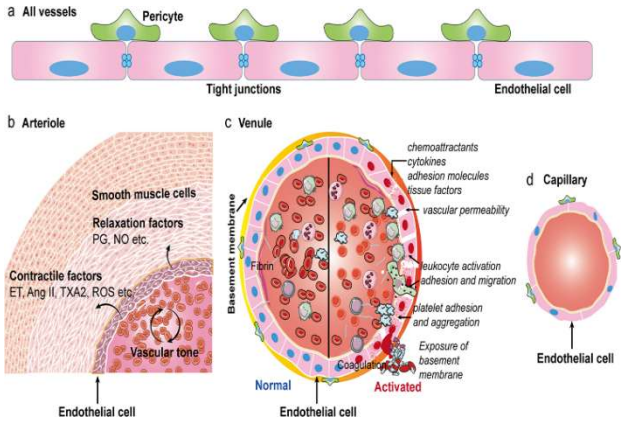

Figure 3. The regulation of vascular tone, and permeability upon activation are illustrated. Endothelial cells exist in the inner layer of blood vessels (**a**) such as arteries (**b**), veins (**c**), and capillaries (**d**)

Neutrophils in response to the action of interleukins activate the "respiratory burst" and intensively form reactive oxygen species, which also damage endothelial cells [7].

The biological effect of TNF is well studied. It has been proven that it is able to cause damage to the endothelium in almost all tissues and organs: form pulmonary edema, activate Kupffer cells in the liver, disrupt the blood-parenchymal barrier, cause fatty degeneration; in the kidneys - damage the capillaries and tubular epithelium [8]. TNF stimulates the production of endothelium-dependent relaxation factors, but at the same time it can inhibit the synthesis of nitric oxide, which disrupts normal vasodilation [9].

TNF also activates phospholipase A2, enhances lipid metabolism, stimulates the production of prostaglandins, growth factors, interleukins and other mediators [10].

It enhances the expression of adhesion molecules, which promotes the release of leukocytes into the tissues and deepens the inflammatory process (**Figure 4).**

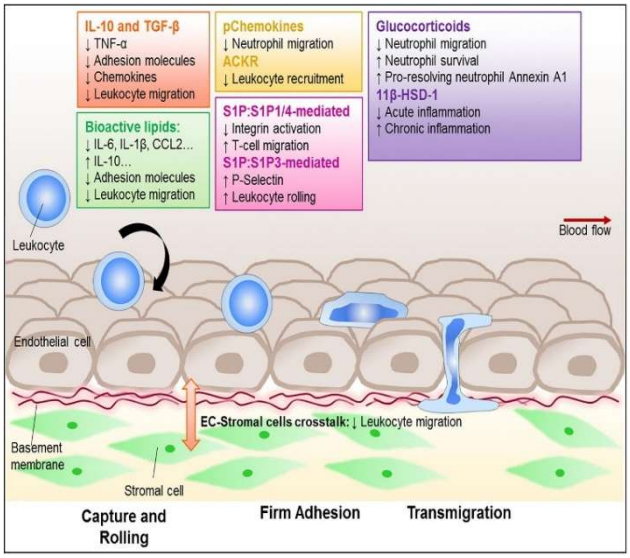

Figure 4. Scheme of migration of leukocytes from the bloodstream to the tissue, a process that is key to the immune response and inflammation.

Leukocytes, such as neutrophils, monocytes, and lymphocytes, are recruited to and migrate through the vessel wall to reach the site of inflammation. This process is tightly regulated and involves adhesion molecules and chemokine-chemokine receptor signal transduction, as well as interaction with the stromal compartment.

Interleukin-8 and interleukin-10 are less studied, but there is data on the protective role of IL-10, which is able to reduce inflammation and protect endothelial cells [11].

Separately, the positive effect of certain selectins expressed by the endothelium during inflammation and involved in the lymphocytic response is noted [12].

Interactions between cytokines and endothelium are extremely complex and depend on the localization of endothelial cells, the

characteristics of the immune response and the cellular microenvironment [15].

Endothelial cells are negatively affected by phagocyte enzymes, histamine-like substances, immune complexes, and activated leukocytes, which contributes to the formation of vascular wall defects and the penetration of macromolecules through it [16].

There is a close relationship between the intensity of inflammation, the level of C-reactive protein and the degree of endothelial activation. [17].

C-reactive protein, acting as an opsonin, binds to pathogens and low-density lipoproteins, after which the complex is transported through the endothelium to the subendothelial layer, where it is absorbed by macrophages **(Figure 5**).

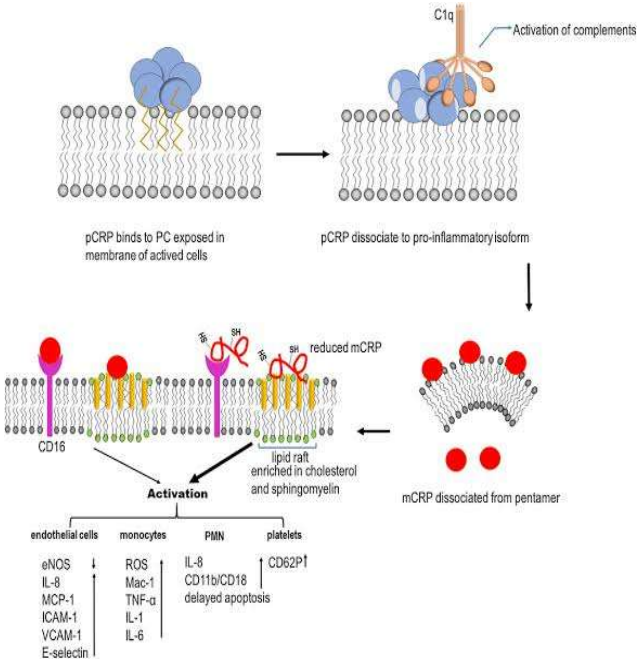

Figure 5. Regulation of C-reactive protein conformation in inflammation. Model of stepwise dissociation of pentrimeric C-reactive protein (pCRP) into its pro-inflammatory isoform (mCRP).

This contributes to changes in the thickness of the intima-media and impaired endothelial function, which may increase the risk of atherosclerosis [18].

Essentially, in damaged endothelium, antiendothelial antibodies may be present, which often exhibit cytotoxic effects [19].

The stench is formed in response to the enhanced expression of adhesion molecules and antigens on endothelial cells and subsequent stimulation of endothelial stimulation and activation of the internal vascular larynx **(Figure 6).**

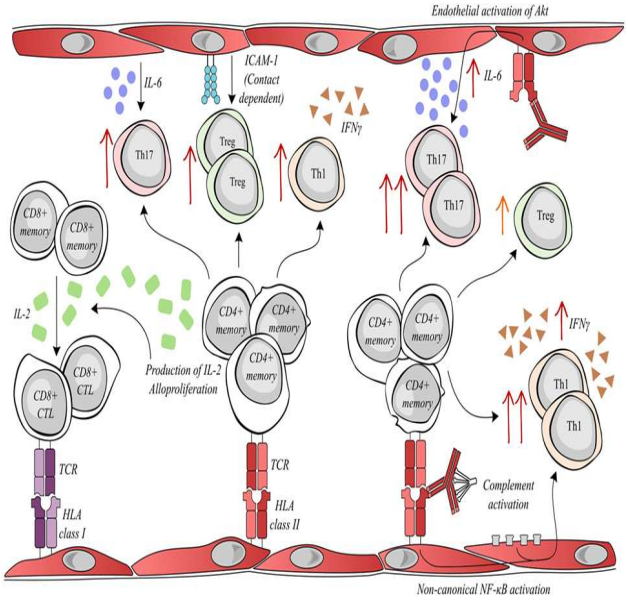

Figure 6. Endothelial activation is a process that represents an inflammatory state of cells in the inner lining of blood vessels.

It appears that during the course of immune inflammation, leukocytes, platelets and endotheliocytes produce platelet activating factor - a biologically active phospholipid that enhances adhesion between cells and seals transendothelial migration of leukocytes [20].

This results in the elimination of active forms of acid, cytokines, enzymes and lipid mediators, which suppresses the ignition process. [21] . It has been proven that the skin and mucous membranes also synthesize this factor **(Figure 7).**

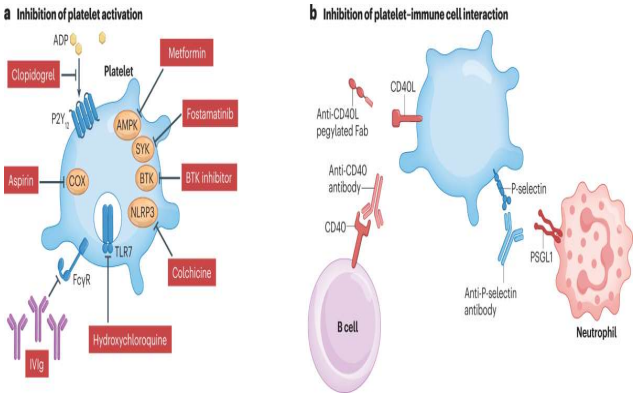

Figure 7. Mechanisms of inhibition of platelet activation and interaction of platelets with immune cells.

Platelet adhesion molecules and endothelium activate the adhesion of most leukocytes (except eosinophils), which prevents their penetration through the vessel wall and the destruction of the ear [22].

Endothelial dysfunction, which results from these changes, plays a key role in the development of cardiovascular disorders [23].

Therefore, further study of the pathogenesis of dyslipoproteinemia and disorders of endothelial cell functions in systemic inflammation, which leads to endothelial dysfunction, is very relevant [24]. **(Figure 8).**

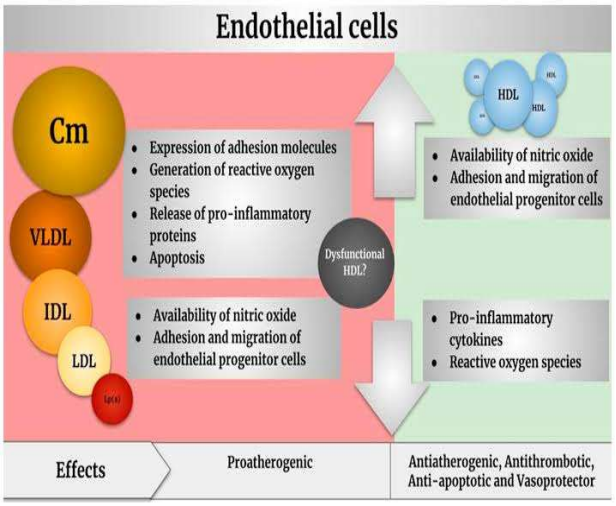

Figure 8. Factors influencing endothelial cell function and their pro- or anti-atherogenic effects.

Experimental part

Materials and methods. Analysis of the features of lipid metabolism disorders and the nature of dyslipoproteinemias in chronic inflammatory process

In order to determine the nature of dyslipoproteinemias in patients with chronic nonspecific inflammation of the reproductive system, lipid metabolism indicators were analyzed [13].

The level of total cholesterol was determined by the spectrophotometric method using reagent sets of CHNPP "Filisit Diagnostics" (Dnipro). The detection of chylomicrons and very low density lipoproteins was carried out by visual assessment of blood plasma after its storage at a temperature of 0–+4 °C. The concentration of low density lipoproteins was determined by the method of Burstein and Samay, high density lipoproteins - using reagents of the company "Cormay", the level of triglycerides - using reagent sets of "Lachema"

(Czech Republic). Identification of dyslipoproteinemia phenotypes was carried out in accordance with the current methodological recommendations for the diagnosis of cardiovascular diseases **(Figure 9).**

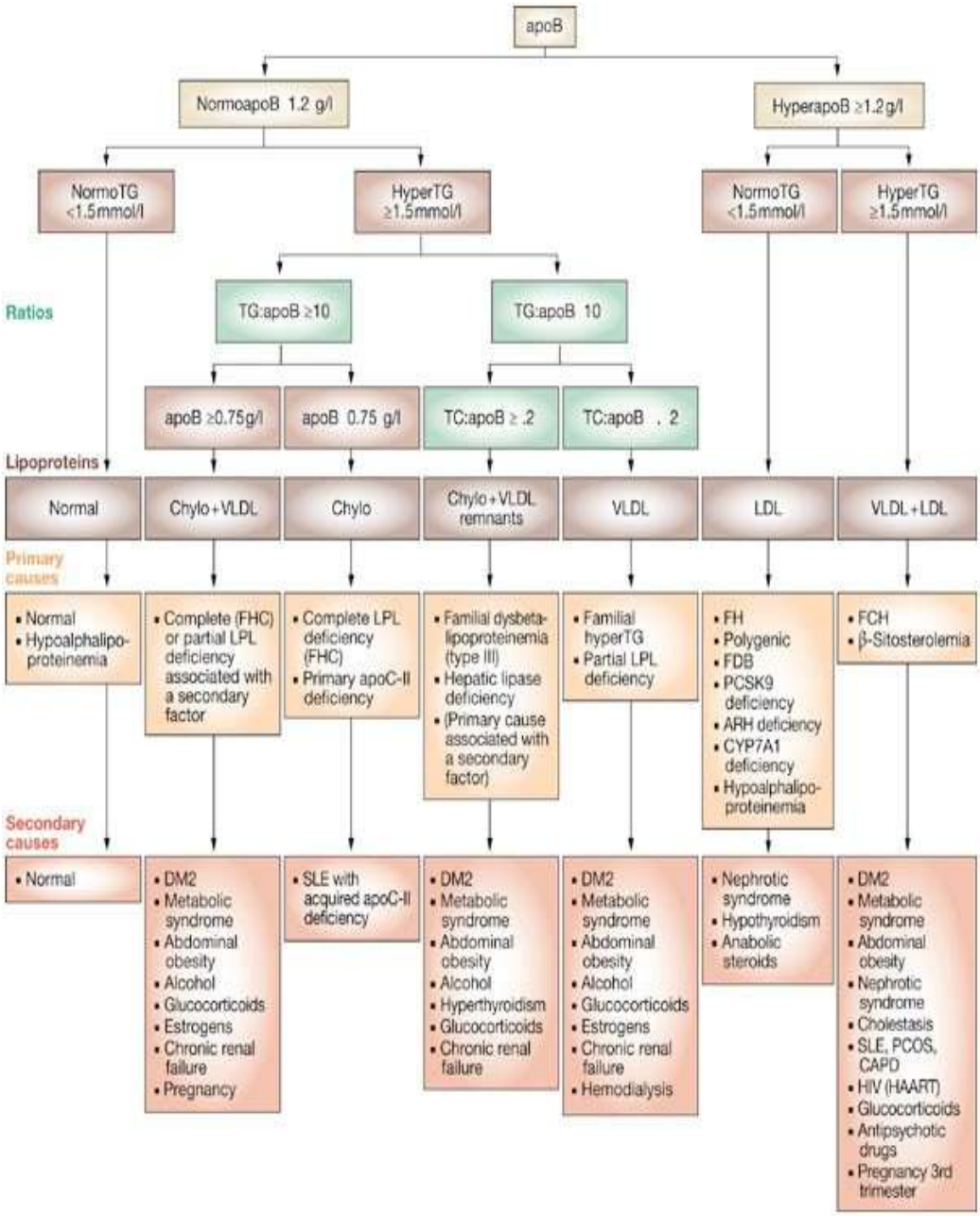

Figure 9. Classification of different types of dyslipoproteinemia based on apolipoprotein B (apoB), triglyceride (TG) and lipoprotein ratios.

The activity of lipid peroxidation processes was assessed by the content of malondialdehyde, which was determined by the reaction with thiobarbituric acid [6].

For biochemical and general clinical analyses, blood was collected before the start of the treatment course. The collection was carried out from a vein, after which the blood was stabilized with a 5% sodium citrate solution.

Clinical examination of patients and selection of biological material for laboratory studies were carried out together with a doctor from the Zaporizhia City Hospital. The control group (C) consisted of 95 practically healthy individuals (non-staff donors), among whom there were 50 men and 45 women (Table 1). The age distribution in the control group was as follows: 18–28 years - 30 people, 29–39 years - 35 people, 41–50 years - 30 people [25]. The main groups of the study included 180 patients with chronic nonspecific inflammatory diseases of the genital organs, including 83 men and 79 women (**Table 1**). The patients were distributed by age as follows: 18–28 years - 60 people, 29–39 years - 58 people, 40–50 years - 44 patients.

Table 1. Distribution of study participants by age and gender.

Group	CG 1	CG2	CG3	1	2	3
Age (years)	18-28	29-39	40-50	18-28	29-39	40-50
Men	15	20	15	28	30	25
Women	15	15	15	32	28	19

Characteristics of Dyslipoproteinemias in Chronic Inflammatory Processes

The table summarizes lipid metabolism parameters and the level of lipid peroxidation in men (M) and women (W) from the control group (CG) and three study groups (Groups 1–3) [13]. The analyzed indicators include ultra-low-density lipoproteins (ULDLn), very-low-density lipoproteins (VLDLn), low-density lipoprotein cholesterol (LDL, mmol·L^{-1}), high-density lipoprotein cholesterol (HDL, mmol·L^{-1}), total cholesterol (CHOL, mmol·L^{-1}), triglycerides (TG, mmol·L^{-1}), and malondialdehyde (MDA, μmol·L^{-1}). Results are presented as mean ± standard error (Table 2).

Table 2. Lipid profile of blood plasma of patients with chronic inflammation of the genital system in comparison with the indicators of donors.

Group		ULDLn	VLDLn	LDL, mmol.l^{-1}	HDL, mmol.l^{-1}	CHOL mmol.l^{-1}	*G* mmol.$^{-1}$	MDA, μmol.l^{-1}
CG 1	M	0	0	3,42±0,29	1,35±0,11	4,70±0,51	,98±0,07	3,88±0,31
	W	0	0	2,83±0,37	1,33±0,14	4,13±0,41	,25±0,12	3,18±0,36
CG 1	M	0	0	3,85±0,40	1,40±0,15	5,20±0,54	1,23±0,5	4,02±0,38
	W	0	0	3,09±0,27	1,37±0,13	4,52±0,38	,27±00,7	3,21±0,33
CG 1	M	0	0	3,69±0,32	1,75±0,20	5,45±0,43	,35±0,12	4,0±0,34
	W	0	0	3,31±0,29	1,40±0,29	4,60±0,33	,33±0,15	3,26±0,30
1	M	0	2	3,90±0,31	1,32±0,18	5,25±0,58	,29±0,09	4,92±0,21*
	W	0	0	3,34±0,61	3,34±0,61	1,60±0,14	1,99±0,32	1,45±0,15
2	M	4*	5*	4,17±0,55	1,28±0,19	5,45±0,44	,42±0,08	6,41±0,21*
	W	5*	9*	3,90±0,38	1,44±0,05	5,44±0,62	,62±0,12	5,23±0,44*
3	M	5*	12*	4,12±0,44	1,20±0,07	5,32±0,47	,58±0,06	6,47±0,71*
	W	5*	10*	4,49±0,23*	1,02±0,12*	5,51±0,45*	,68±0,05	5,93±0,62*

Notes:

1. n - number of positive results;

2.*- $p<0.05$, significance of differences compared to the control group

In the control group, both men and women showed stable lipid profiles with the absence of ULDLn and VLDLn and relatively constant LDL, HDL, total cholesterol, triglyceride, and MDA values. In group 1, moderate changes in lipid metabolism were observed. Men demonstrated the appearance of VLDLn and a slight increase in MDA compared with the control group, whereas women showed minimal deviations from control values [8].

Group 2 was characterized by significant increases in ULDLn and VLDLn in both sexes (marked with*), accompanied by higher triglyceride concentrations and a pronounced rise in MDA levels, indicating activation of lipid peroxidation processes [6].

The most severe alterations were recorded in group 3. Both men and women exhibited markedly elevated ULDLn and VLDLn, increased LDL, total cholesterol, triglycerides, and MDA levels, while HDL values tended to decrease, particularly in women. Statistically significant differences compared with the control group are indicated by an asterisk (*).

Overall, the table demonstrates a progressive worsening of lipid metabolism and enhancement of oxidative stress from the control group to group 3, with certain sex-related differences in the intensity of these changes. In particular, in women of group 3, the level of total cholesterol in plasma was 1.2 times higher than in the control group ($p < 0.05$) (**Table 2**).

It should be noted that the increase in plasma cholesterol concentration in both women and men occurred in parallel with an increase in the mean age of patients in the respective groups, whereas no such trend was observed in the control group [10].

Visual detection of chylomicrons in plasma was significantly more frequent in patients of both sexes in groups 2 and 3 (9 of 58 and 10 of 54, respectively) compared with the control group (1 of 35).

The frequency of cases in which cholesterol very-low-density lipoproteins (VLDL) were visually detected in the plasma of female and male patients of group 1 (5 of 64) showed a tendency toward an increase, whereas in patients of groups 2 (12 of 58) and 3 (22 of 44) it was significantly higher ($p < 0.05$) than in the control group (1 of 30 and 0 of 35, respectively). The concentration of low-density lipoprotein cholesterol (LDL) in the plasma of women in groups 1 and 2 tended to increase, while in women of group 3 it exceeded control values by 1.4 times ($p < 0.05$) [10].

Importantly, the level of LDL in women increased in accordance with the rise in mean age within the group. No significant changes in LDL concentration were observed in male patients. In women of group 3, a significant decrease in high-density lipoprotein cholesterol (HDL) concentration in plasma was recorded-by 1.4 times ($p < 0.05$). In men of all three age groups, no significant changes in HDL levels were detected. Plasma triglyceride concentrations in women increased with advancing mean age. In women of groups 2 and 3, this increase was significant and amounted to 1.3 times ($p < 0.05$). In men of group 2, plasma triglyceride levels were 1.2 times higher ($p < 0.05$) compared with the control group, while in patients of group 3 this increase was also significant, reaching 1.3 times ($p < 0.005$) [8].

Characteristics of dyslipoproteinemia types in patients with chronic inflammation **(Figure 10).**

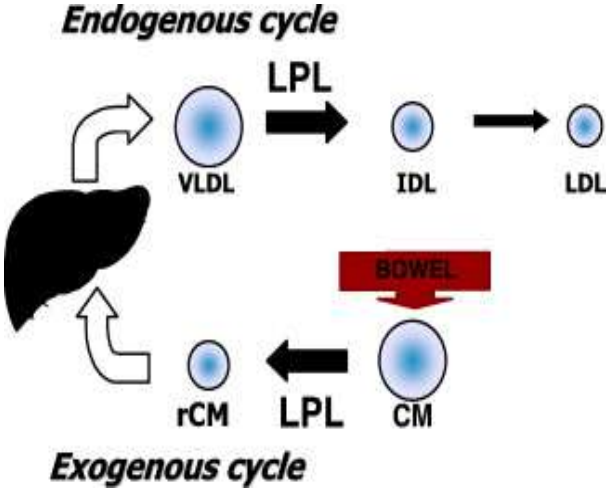

Figure 10. Scheme of endogenous and exogenous lipid transport cycles in the body

The **Table 3** presents the distribution of dyslipoproteinemia (DLP) types among patients with chronic nonspecific inflammation of the reproductive system, separated by group and sex. The groups include a control group (C) and three experimental groups (1–3). For each group, the total number of participants, the number of individuals without DLP, and the number of individuals with different types of DLP (types IIa, IIb, III, IV, and V) are shown.

Key observations include**:** in the control group (C), all participants - both males and females-did not exhibit dyslipoproteinemia. In experimental groups 1–3, a substantial portion of patients displayed various types of DLP (Table 3). In group 1, males primarily exhibited type IIa DLP, while females showed type IIa and IIb types, with statistically significant differences ($p<0.05$) compared to controls.

In group 2, both males and females showed increased prevalence of type IIa and type IIb, as well as type V DLP in some patients, with certain differences being statistically significant ($^p<0.05$) relative to the control and group 1.

In group 3, the highest prevalence of dyslipoproteinemia types III, IV, and V was observed, particularly among males, indicating a progression in DLP severity associated with chronic inflammation.

Females in this group also exhibited multiple DLP types, including statistically significant increases in types IIa and IIb ($p<0.05$) and type V ($^p<0.05$).

Overall, the table demonstrates that the prevalence and severity of dyslipoproteinemia increase in patients with chronic nonspecific inflammation of the reproductive system, with differences observed between sexes and among patient groups [13].

The data highlight statistically significant deviations from the control group, suggesting that chronic inflammation contributes to the development and progression of dyslipoproteinemia **(Figure 11).**

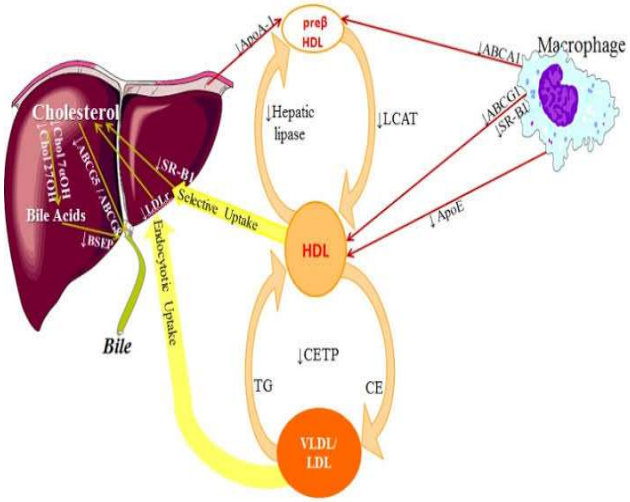

Figure 11. Reverse cholesterol transport. Cholesterol is transported from macrophages (immune cells) to immature (preβ) and mature HDL (high-density lipoprotein) particles via the transporter proteins ABCA1 and ABCG1, respectively

Table 3. Features of dyslipoproteinemia among patients with chronic inflammation of the reproductive system

Group		Group Size	Number of Individuals without DLP	Count of patients diagnosed with DLP				
				IIa type	IIв type	III type	IV type	V type
C	M	50	50	-	-	-	-	-
	W	45	45	-	-	-	-	-
1	M	22	12	7*	2	1	-	-
	W	38	33	1*	3	1	-	-
2	M	30	13	11	2	1	-	3
	W	28	12	7*	3	1	-	5^
3	M	22	2	3*	7*	5*	-	5^
	W	22	5	3*	5*	3	2	4^

Notes:

1.* - $p<0.05$ significance of differences, compared with control

2. ^ - $p<0.05$ compared with the control group and group №1.

During the analysis of dyslipoproteinemia types in the examined subjects, it was found that in men of the youngest group (group 1), dyslipoproteinemia occurred quite frequently, mainly of type IIa, while isolated cases were observed for types IIb and III (Table 3).

In women of group 1, dyslipoproteinemias of types IIa, IIb, and III were rare, although these types are characterized by high atherogenicity. In men of group 1, type IIa dyslipoproteinemia was significantly more frequent (7 out of 22) ($p<0.05$) than in women (1 out of 38), which is likely associated with the high estrogen levels in women aged 18–28 years.

In both men and women of group 2 (middle-aged), type IIa dyslipoproteinemia was also observed more frequently (18 out of 58) compared to the control group (0) ($p<0.05$), with isolated cases of types IIb and III.

Additionally, in some cases, type V dyslipoproteinemia was noted, occurring significantly more often in women (5 out of 28) ($p<0.05$) than in group 1 and the control group (0). In female patients of the 2nd and 3rd groups, as well as in male patients across all age groups, a significant elevation in malondialdehyde (MDA) levels was observed [8].

Specifically, MDA levels in men of the 1st group increased by 1.3-fold ($p<0.05$), whereas in the 2nd and 3rd groups, the increase was 1.6-fold. A similar 1.6-fold elevation ($p<0.05$) was observed in women of the 2nd and 3rd groups

Among patients in the 3rd group (the oldest cohort), type IIa dyslipoproteinemias were detected significantly less frequently (6 out of 44) ($p<0.05$) compared to the 2nd group (18 out of 58), in both men and women.

Concurrently, the prevalence of type IIb (12 out of 44) and type III (8 out of 44) dyslipoproteinemias was higher than in the control group in patients of both sexes within the 3rd group.

Type V dyslipoproteinemias in the 3rd group were observed significantly more often (9 out of 44) ($p<0.05$) than in the 1st group and in controls (0 cases). Additionally, two female patients in this group presented with type IV dyslipoproteinemias **(Figure 12).**

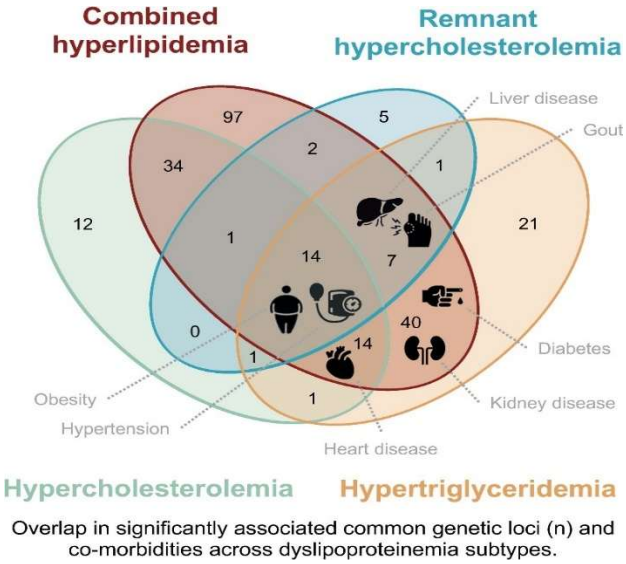

Figure 12. Comorbidities in various subtypes of dyslipoproteinemia, including combined hyperlipidemia, residual hypercholesterolemia, hypercholesterolemia, and hypertriglyceridemia

The analysis of the number of patients with hypercholesterolemia depending on age and gender revealed the following findings (**Table 4**). **Table 4** presents the distribution of hypercholesterolemia among patients of different age groups, stratified by gender. For each group, the total number of examined men and women is shown, along with the number of individuals with subnormal and elevated total cholesterol levels. In group 1, 28 men were examined, among whom 5 had subnormal cholesterol levels and 3 had elevated cholesterol. Among the 36 examined women in this group, subnormal cholesterol was detected in 11 cases, while hypercholesterolemia was observed in only 1 woman. In group 2, the male cohort consisted of 30 individuals. A significantly higher number of men in this group (20 cases) had subnormal cholesterol levels compared with the other groups ($p<0.05$), whereas elevated cholesterol was identified in 3 men. The female group also included 30 examined subjects, with 9 women showing subnormal cholesterol levels and 2 cases of hypercholesterolemia.

In group 3, 25 men were examined; 12 of them had subnormal cholesterol levels and 4 demonstrated elevated cholesterol. Among 29 examined women in this group, subnormal cholesterol was detected in 9 cases, while hypercholesterolemia was found in 1 woman. Overall, the table demonstrates that subnormal cholesterol levels were more common than hypercholesterolemia across all age groups and in both genders **(Figure 13).**

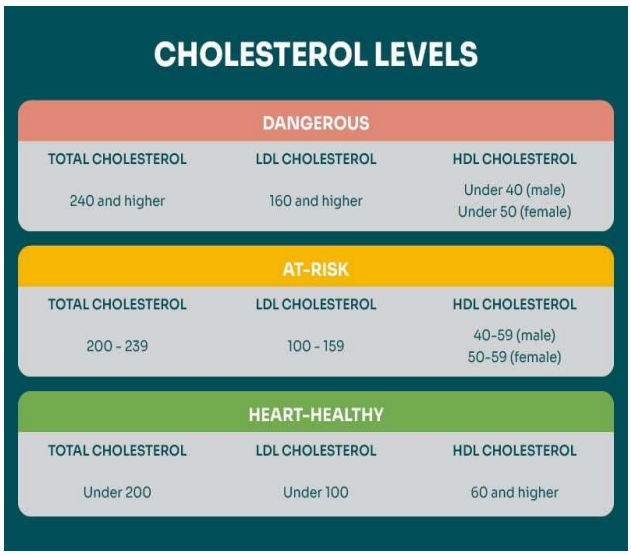

Figure 13. Blood cholesterol levels classified as dangerous, borderline, and heart-healthy.

Hypercholesterolemia was observed relatively infrequently, with a slightly higher prevalence among men compared to women, particularly in the older age groups.

Table 4. Occurrence of hypercholesterolemia by patient age and gender

Group	Number of Examined Persons					
	Men with H			Women with H		
	Examined Subjects	Men with Subnormal CHOL	Men with High CHOL	Examined Subjects	Women with Subnormal CHOL	Women with High CHOL
1	28	5	3	36	11	1
2	30	20*	3	30	9	2
3	25	12	4	29	9	1

Note. * - $p<0.05$ in comparison with all other groups;

Our findings indicate that the prevalence of dyslipoproteinemia, including highly atherogenic forms, increases with patient age. Among women, the occurrence of hypercholesterolemia was consistent across all age groups, with 29 out of 95 exhibiting subnormal cholesterol levels and 4 out of 105 showing elevated cholesterol levels.

In contrast, among men in the youngest age group (1st group), hypercholesterolemia with subnormal cholesterol levels was significantly less frequent (5 out of 28) compared to older male groups. In the 2nd (20 out of 30) and 3rd (12 out of 25) male age groups, the prevalence of hypercholesterolemia with subnormal cholesterol levels was markedly higher than in the 1st group.

Hypercholesterolemia with elevated cholesterol levels, however, was consistent across all male age groups (10 out of 83) and exceeded the corresponding values observed in women.

Conclusions

Recently, both scientific research and clinical practice have focused on studying the role of inflammatory processes in the development of atherosclerosis, thrombosis, and cardiovascular diseases [25]. Of particular relevance is the investigation of vascular endothelium damage, its causes, and consequences, since endothelial dysfunction represents the earliest stage in the development of dyslipoproteinemia and atherosclerotic changes. However, there is not enough data in the literature about the features of dyslipoproteinemia in patients with chronic inflammatory processes **(Figure 14).**

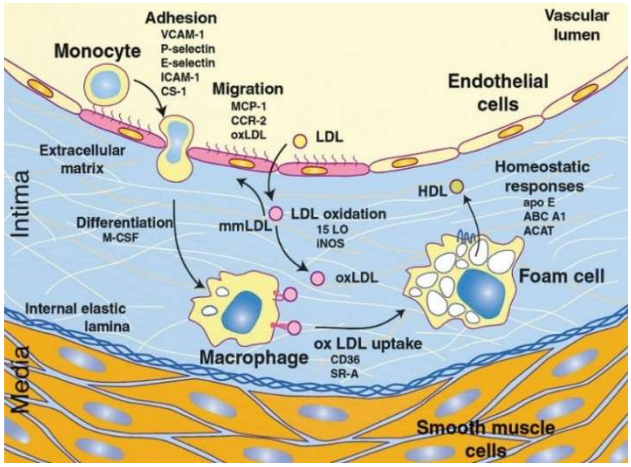

Figure 14. Cellular mechanisms of atherosclerosis development. Atherosclerosis is a chronic inflammation in which plaques composed of cholesterol, fats, and other substances accumulate in the artery walls. The process begins with damage to the endothelial cells lining the inner surface of the vessels. Monocytes (a type of white blood cell) adhere to the endothelium and migrate to the intima (the inner layer of the artery). In the intima, monocytes differentiate into macrophages, which engulf oxidized LDL cholesterol (oxLDL), transforming into foam cells. The accumulation of these foam cells promotes plaque growth, leading to narrowing of the arteries and impaired blood flow.

Lipid metabolism parameters in patients with reproductive system inflammation differed from those of clinically healthy individuals. In the 2nd and 3rd age groups, the plasma total cholesterol concentration in female patients was, on average, 1.2 times higher.

The frequency of detection of chylomicrons and very-low-density lipoprotein cholesterol was also higher than in controls. Furthermore, in women of the 3rd age group, low-density lipoprotein cholesterol concentration was 1.4 times higher, while high-density lipoprotein cholesterol concentration was 1.4 times lower. In women of the 2nd and 3rd age groups, as well as in men of the 3rd age group, triglyceride concentrations exceeded those in controls by 1.3 times.

The study revealed an age-related increase in proatherogenic lipid concentrations, a decrease in antiatherogenic high-density lipoprotein cholesterol, and an elevation of triglyceride levels.

Analysis of the overall prevalence of dyslipoproteinemias associated with a high risk of atherosclerosis showed that in men of all age groups and women of the 2nd and 3rd groups, type IIa dyslipoproteinemia occurred significantly more frequently than in controls, while in men of the 3rd group, types IIb and III dyslipoproteinemia were also significantly more common.

At the same time, type IIa dyslipoproteinemia was significantly more frequent in men of the 1st group compared to women.

The reasons for this phenomenon may be multifactorial. Among exogenous factors, lifestyle and diet in young men are important, whereas among endogenous factors, high estrogen levels in young women play a role. Notably, the highest frequency of hypercholesterolemia was observed in men of the 2nd, middle-aged group, which may also be associated with lifestyle and dietary habits.

Additionally, we observed an increase in malondialdehyde concentration in women of the

2nd age group and in patients of both sexes in the 3rd group, averaging 1.6 times higher..

Our results on triglyceride concentrations in different age groups correspond with the Münster study, which found that hypertriglyceridemia is more commonly diagnosed in men than women. In men, triglyceride levels rise between 30 and 50 years of age and then decline, whereas in women, levels increase gradually with age, with hypertriglyceridemia observed after 60 years. It should be noted that our study population did not include patients older than 50 years.

We observed a gradual increase in plasma triglyceride concentration in patients of both sexes with chronic inflammation, which corresponded with increases in total cholesterol, low-density lipoprotein cholesterol, and the frequency of very-low-density lipoprotein cholesterol detection. Therefore, since triglyceride elevation is associated with increased proatherogenic lipids, it may act as a risk factor for atherosclerosis in these patients.

Practical introduction: deepening of the understanding of endothelial dysfunction and atherosclerosis, development of new therapeutic agents aimed at correcting inflammation and vascular disorders.

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